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MODERN ELECTRONICS™

SEPTEMBER 1987 $2.50
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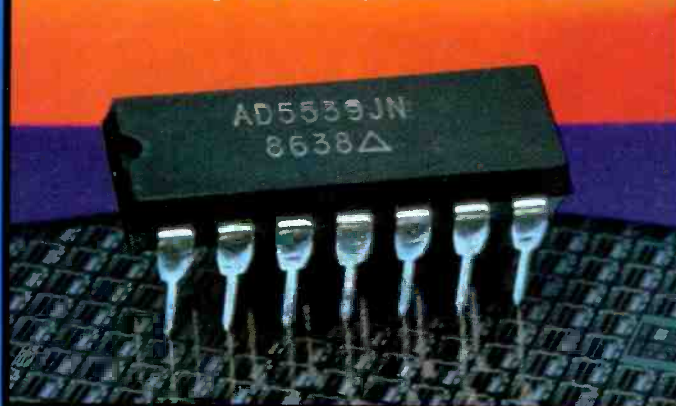
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

■ Newest Home-Entertainment Electronics:

* Super-VHS VCRs
* Digital Audio Tape Machines
* Audio/Video Discs

■ Process Control With Personal Computers

Introducing "New Developments" Column (p. 82)



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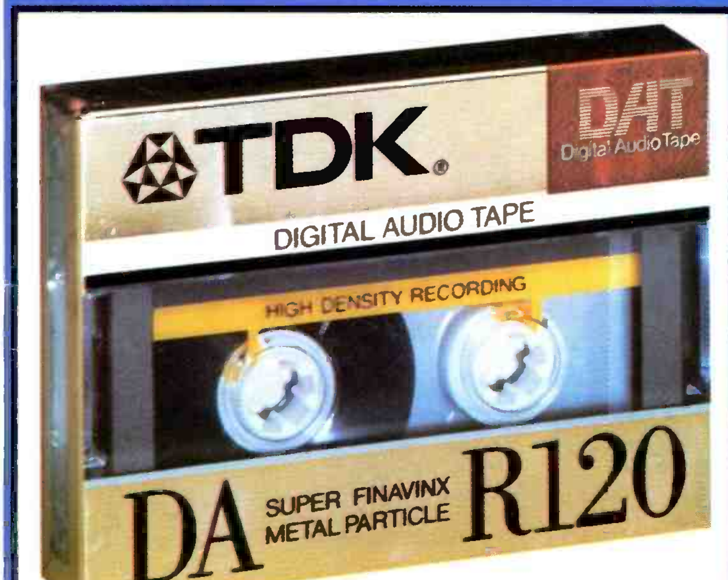
- ■ Audible Pellet-Gun Target
- ■ AM Broadcast Loop Antenna
- ■ PC Speedup Beyond 8 MHz
- ■ A License-Free Transmitter



A Promising New Audio Advance (p. 22)

Process Control With Personal Computers (p. 16)

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Also: Using Current-Differencing Operational Amplifiers ● Forrest Mims on Experimenting With Hall-Effect Devices ● "New Developments" Column Looks at Latest Technical Advances ● "Cruise Control" Software Review ● Latest Technical Books & Literature ● Electronic & Computer News . . . and more.

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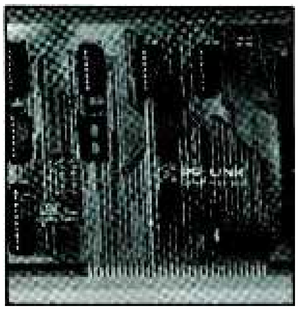
SEPTEMBER 1987 **VOLUME 4, NUMBER 9**



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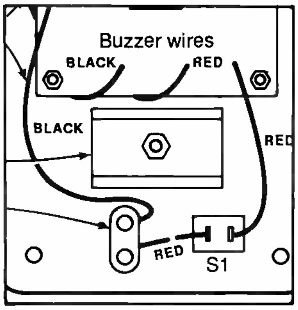

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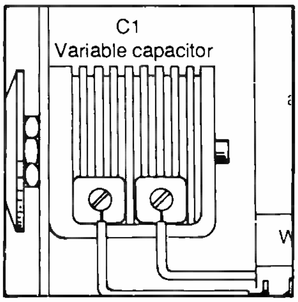

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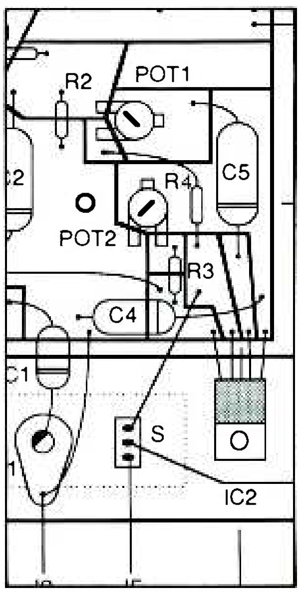

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CIRCLE 53 ON FREE INFORMATION CARD

EDITORIAL

Buying Confusion

What and when to buy a home-entertainment product or computer becomes more challenging every year as new developments continue to surface. It's an age-old story, of course: should you buy now and enjoy the benefits immediately or wait until the newest ballyhooed technically advanced models fill dealers' shelves . . . and then wait for their usual premium prices to drop? By the time this happens, there might even be another advancement to induce one to wait just a bit longer again.

My own feeling on this is to buy *now*, at least in most instances. There's nothing wrong with products that are not right up to the leading edge of technology. They aren't obsoleted overnight, you know, and you can get many years of enjoyment at lower initial costs when you buy more matured equipment. Nor will you have to wait until source material catches up to the machine you've got.

For example, S-VHS ("S" is for "Super") VHS videocassette recorders and S-VHS video tape cartridges will be coming on the scene soon. So will a competitive offering from Sony called ED-Beta ("ED" stands for "Extended Definition"). The former ups the horizontal resolution capability you can see on a video screen from about 240 lines to 430 lines, while ED-Beta promises 500 lines. (They're not compatible, but that's a whole other story in making a buying choice.)

Though I'd love to get one of them, if I was presently in the market for a VCR (I own three), I'd buy the standard type now for a few hundred dollars and reap its entertainment benefits. The super machines, that will debut with $1,500 or so prices, would just have to wait for an eventual upgrade or additional machine purchase. Buyers of this latest technology will have to pay premium prices (about three times more) for super tapes to garner its high-resolution capability (or even to record in the standard 240-line-maximum mode). Further, to gain higher resolution, you have to have a TV set or monitor that'll reproduce all the extra resolution lines. Additionally, to extract the best video quality from the super video machines and tapes, the TV set/monitor has to have separate input/output connections for luminance (brightness) and chrominance (color) signals to be sent along their merry ways from the super VCRs. This minimizes crosstalk interference. The TV connection is called a Y/C connector (for luminance and chrominance, respectively), which is popularly called an "S" connector (for "super").

Other obstacles to top-notch video from these machines is the fact that the TV broadcast industry transmits its video signals with 330 lines of horizontal resolution, which, unless you're buying prerecorded super tapes (not yet available and you can be sure it'll take some time to build up a rental library), wastes the higher-resolution capability of the super machines. That is, until High Definition TV is adopted here (Japan will get it first). But that will require buying yet another TV receiver . . . .

Nonetheless, if you're really flush with discretionary money or you're one of our many readers who want to be first with the best, by all means, get yourself a "super" video recorder and all the trappings. You can still play back your old, less-sharp video tapes on the new machine, as well as record in the old mode (with premium tape), until everything else catches up.

For details on the Super VHS video recorders, see Len Feldman's article in this issue, which also discusses digital audio tape recorders and Compact Disc machines that play both audio and video.

Art Salsberg

Auto Fan Improvement

• I find Mr. Caristi's article in your May 1987 issue, "Automatic Fan Control for Small Cars," most interesting. The author makes several worthy observations concerning the delicate load balancing act that is inherent with most small cars. I would like to offer an additional thought that might further extend the usefulness of his design.

Increasingly, manufacturers are equipping their air-conditioned models with a "second" or "supplementary" electric fan to assist with the additional load imposed by air conditioning. Such fans are often cycled by the cooling thermostat so that they run whenever the compressor is engaged. While this is desirable and necessary for city driving, the additional help is generally not needed at highway speeds or in mild temperatures.

If the additional fan were disabled when not needed, the electrical load on the engine could be considerably lessened. To that end, I would suggest that the circuit be constructed in the "relay version" with the contacts wired in series with the existing secondary air-conditioner condenser fan.

If the temperature and/or flow of ambient air is sufficient to keep the liquid line temperature down, then the fan would not operate. If the liquid temperature rose sufficiently to merit the additional air flow, then the fan would be engaged. This would seem a logical extension of this clever device that would bring its benefits to a wider range of vehicles. Keep up the good work!

Dr. James W. Trott, Jr.
Baton Rouge, LA

$77.22 Per Chip

• Talk about a timely editorial! ("Electronic Surprises," Feb. '87). I needed 256K RAMs to upgrade my computer, so I ordered nine chips from a mail-order house. The invoice was for $695.00!! That boils down to $77.22 for each chip! Needless to say, the ICs and bill went back.

Outstanding magazine! Forrest Mims got me going five years ago because he stirred my interest, and now I'm going to college at night shooting for an electronic engineering degree. Keep it up guys.

Dave Hamilton
Toms River, NJ

Billing for the RAMs was obviously an error. Someone probably got $695 worth of gear for peanuts. Our electronics experimenting guru, Forrest, has inspired many people like yourself to pursue electronics as a career.—Ed.

Wrong Number

In your May 1987 issue, "An Automatic Fan Control for Compact Cars" had inside Fig. 4 an asterisk with the explanation "Install jumper wire for Fig. 5 circuit only." There are only four figures in the article.

James Oken
Los Angeles, CA

Sorry for the typo. The circuit is shown in Fig. 3.—Ed.

CIRCLE 54 ON FREE INFORMATION CARD

CONSUMER ELECTRONICS GROWS. The latest EIA statistical study indicates that sales of consumer electronics products grew again in 1987 with a projected total factory sales of $30-billion, up $1.3-billion from the previous year. The category that showed the greatest growth in terms of dollars was, surprisingly, "Related Products"--blank tape cassettes, home computer software, video accessories, etc. It registered about an additional $1-billion. New product-buying trends coming up strong are reported to be do-it-yourself home security systems, which is predicted to be in 20% of all U.S. households by 1990; personal copiers/ printers; and electronic typewriters. About 93% of households have at least one color television set, while home radios have a 98% penetration and audio systems an 89% penetration. On the latter, only 42% represent component systems, while compact disc players have reached only the 7% mark. Even video cassette recorders are not as ubiquitous as one would think since they are still in less than half the households with 45%. And home computers reached only the 18% mark, nowhere near its promise.

COMPACT DISC INTERACTIVE PROGRAMS. The public will soon be able to tap selected Smithsonian Institution publications that take advantage of compact disc technology. The library will be created under a publishing agreement by the Smithsonian and American Interactive Media. The discs will be able to be viewed on a new stereo system, with viewers interacting with the program by means of a joystick or pointing device, enabling users to enjoy high-quality sound, pictures and text. Moreover, optional programs may be chosen as well as the level of detail desired. The first publication to be issued as a CD-I title will be based on Treasures of the Smithsonian, which will cover 300 of the institution's most famous artifacts.

LOW-COST VOICE RECOGNITION. Covox, Inc. (Eugene, OR) has introduced $29.95 "Voice Key" software for Commodore 64/128 Computers, designed to work with the company's $89.95 "Voice Master" hardware. The machine-language voice-recognition program resides behind BASIC in the machine's memory, leaving the language's workspace available. Spoken program commands can be applied to a variety of application programs, says Covox, boosting productivity.

VIDEO GAMES REBOUND. According to game maker Nintendo of America, video-game sales reached $430-million in 1986. Projected 1987 sales are expected to hit $825-million, with Nintendo claiming it will account for $650-million of it. At its peak in 1982 and 1983, overall video-game sales were $3-billion, dropping to a low of $100-million in 1985, so there's reason for optimism.

NEW MERCHANDISING MOVES. Heath/Zenith retail stores will be carrying the Fischertechnik Corp.'s line of plug-together models, which includes robotics simulations that can interface with most personal computers.... Levi™ jeans will soon be merchandised through ByVideo's transactional video merchandising centers in ten retail stores. By touching the center's video screen, customers can view audio and video presentations of different Levi clothing lines, make a selection, and get a print-out of the item's description, price, and order and stock number. The jeans are then delivered to the customer's home within two weeks.

For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.

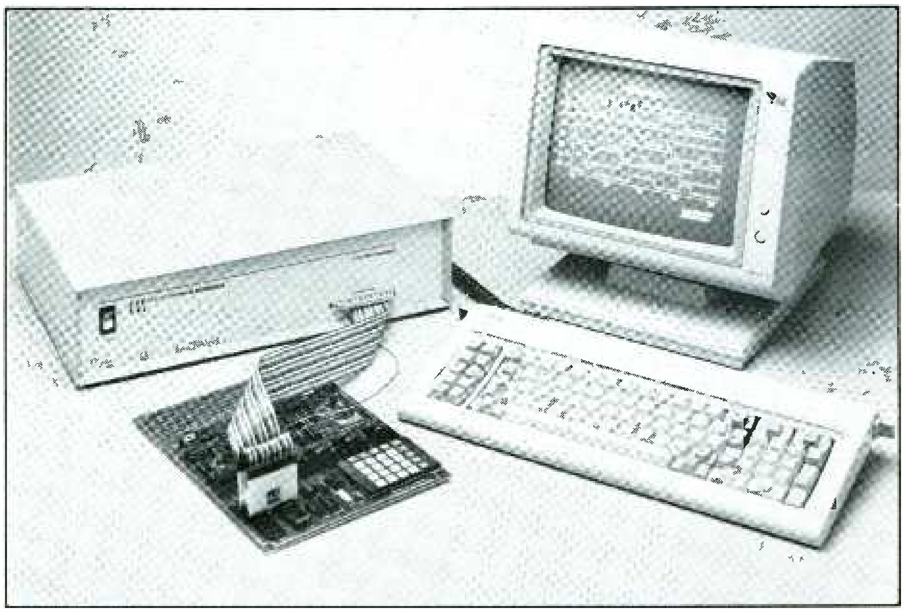
48-Channel Logic Analyzer

A low-cost 48-channel logic analyzer that operates with IBM PC and compatible keyboards and monochrome video monitors has been introduced by Waterloo Distance Education, Inc. (Waterloo, Ontario, Canada).

The LA48C analyzer is claimed to provide highly flexible timing and state analysis at clocking speeds up to 20 MHz. Menu-driven setup and operation simplify use, and the data display format is user defined.

Featured in the analyzer are an RS-232 serial port and a high-speed parallel port. The latter allows the LA48C to be operated with an IBM PC computer when used with an optional interface card and cable. $1,495.

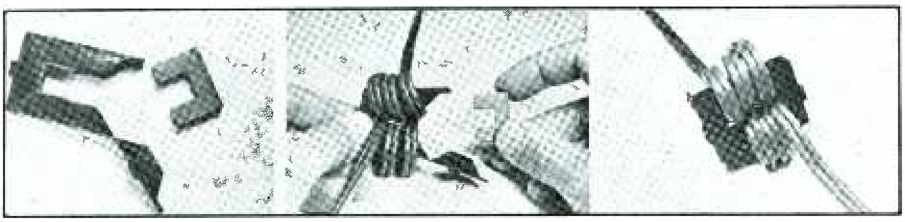
CIRCLE 82 ON FREE INFORMATION CARD



RFI-Free Choke Kit

A kit to eliminate rfi (radio-frequency interference) problems in TV receivers, stereo systems and other electronic devices has been introduced by MFJ Enterprises (Starkville, MS). The new MFJ-701 rfi-free choke kit consists of four ferrite toroids and instructions for their use in eliminating rfi. Designed to have the right properties for eliminating rfi, each toroid separates into two halves that make it easy to wind around it nearly any kind of wire or cable. After a computer ribbon cable, coaxial cable, power cord, etc. has been wound on a toroid, the halves then mount in a snap-together plastic frame. Individual toroids can also be snapped together into a stack arrangement to increase the effectiveness of large-diameter wires when only a few turns can be wound on a toroid. $14.95.

CIRCLE 83 ON FREE INFORMATION CARD



Electronic Still Camera

An electronic still camera capable of both recording and playback of images on a standard TV receiver has been announced by Casio. Unlike photographic cameras that use film on which to "record" an image, the new VS-101 electronic camera uses 2" reusable video floppy disks that require no chemical processing for development and printing. Therefore, you can view stills immediately after shooting them.

The camera has a ⅔" MOS image sensor that has a 280,000-pixel resolution. It uses an f/2.8, 11-mm lens with fixed 1.0-mm-to-infinity focus. Its output can be connected directly to a standard TV receiver or monitor for playback. Built in is a high-resolution automatic-exposure system with lock function. You can snap up to five frames per second and place up to 50 frames on a single floppy disk. An erase function permits floppy disks to be reused.

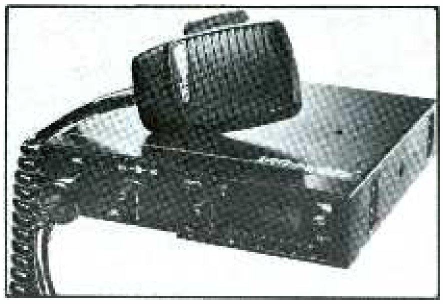
Supplied with the camera is a wireless remote controller that controls forward, reverse and direct track access for playback of any frame. Power options include rechargeable battery pack and through an ac-line-operated adapter/battery charger. On full charge, the battery allows you to take up to 800 still frames and runs the camera in playback mode for about 30 minutes. The camera measures 6¼"D × 3⅞"W × 3⅜"H and weighs just 2.1 lbs. About $1,000.

CIRCLE 84 ON FREE INFORMATION CARD

CB Transceivers

Regency Electronics has reentered the CB market with two new Informer Series transceivers that are fully synthesized (no crystals needed) and feature phase-locked-loop circuitry for transmitting and receiving on all 40 channels. The lower-cost ($69.95) INFO CB-1 features a highway/city switch for adjusting sensitivity settings according to receiving conditions, automatic gain control, hand microphone, digital channel display, large volume and squelch controls, and a LED signal-strength/r-f-output display.

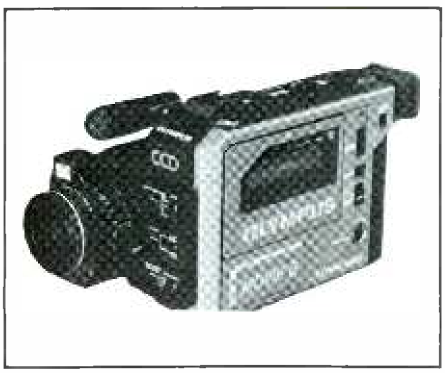
INFO CB-2, the company's deluxe model ($159.95), has all the features of the INFO CB-1, except that it substitutes a signal-strength/r-f-output meter for the LED display. In addition, the INFO CB-2 has a switch for instantly accessing emergency channel 9; rear-panel jacks for adding a PA system; a noise blanker that is said to eliminate ignition noise and static; dual-level digital display; and a microphone gain knob.



CIRCLE 85 ON FREE INFORMATION CARD

8-mm Camcorder

A two-speed electronic high-speed shutter, piezoelectric auto-focus system, improved ½" CCD imaging device and new construction combine to make Olympus's new Model VX-802 a 2.6-lb. 8-mm movie-making system for all occasions. The Movie 8 camcorder can record up to two hours of action that can be played back directly through a TV receiver or monitor or through the camera's built-in ⅔" B&W electronic viewfinder. Features include: auto focus (with manual override), power zoom, auto exposure, auto while balance and low-light shooting capability. Two user-selectable auto-focus zone modes, manual focus and focus lock are provided. The 6× power zoom lens has a focal-length range of from 9 to 54 mm, and there is a macro setting for close-ups. The lens/CCD image sensing system gives the camcorder a low-light shooting capability of 7 lux.



Electronic high-speed shutter settings are ⅕₀₀ or ⅒₀₀ second. Three video heads reproduce detailed images in standard playback and jitter-free stills in freeze frame and frame by frame advance. A flying erase head produces smooth transitions between scenes and when editing with special effects, and an insert button permits editing in scenes from another video source.

Movie 8's FM recording system makes possible hi-fi sound reproduction. Two rotary heads produce a wide dynamic range with minimum interference. The unidirectional microphone is switchable between normal and high sensitivity, and an external microphone jack is provided.

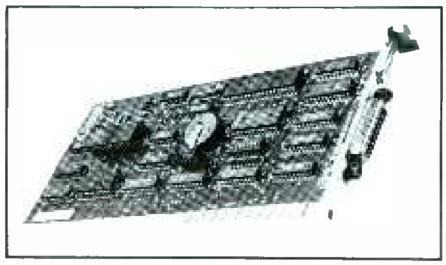
Provided are an ac adapter/battery charger that enables playback through a conventional TV receiver or monitor; a quick-charge battery pack (provides up to one hour of continuous recording); a remote-control unit to operate the record and pause modes; and a shoulder strap.

CIRCLE 86 ON FREE INFORMATION CARD

Smart GPIB Controller Card

A plug-in card that turns IBM PC, XT, AT and compatible computers into GPIB (IEEE 488 bus) controllers able to operate up to 14 independent test and measurement instruments and other devices has been announced by ICS Electronics Corp. (San Jose, CA). The 488-PC™ card has all required software in EPROM and provides 2K × 8 static RAM for extra work space. All GPIB controller functions are on-board to make the card independent of the computer's operating system. It does not require space in the computer's RAM or on its disks, which are used only to store test and measurement programs.

Supplied is a battery-backed time-of-day clock for precise measurement and control operations. The user can change the standard mnemonics of the GPIB command set, which consists of 21 IEEE 488 commands, into words of any programming language or spoken language. The commands have few arguments, which makes it easy to initialize full IEEE 488 functionality.

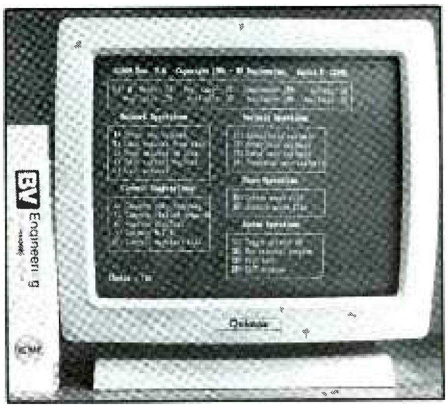


Operating speed is claimed to be three times faster on sample routines and significantly faster on individual commands when compared to other leading controller cards. Data transfer rate is up to 67K baud on I/O and up to 300K baud on DMA operations. The card accepts standard IEEE 488 cabling. Powered from the host computer, it draws 600 mA at 5 volts dc. In its standard version, it supports IBM BASIC, BASICA and compiled BASIC. Other versions are available to support a variety of languages, including C and Turbo Pascal. $395.

CIRCLE 87 ON FREE INFORMATION CARD

NEW PRODUCTS . . .

Electronic Circuit Analysis



ACNAP3 from BV Engineering (Riverside, CA) is a general-purpose program that analyzes electronic circuits containing up to 200 components and 50 nodes in a single pass. Larger circuits can be analyzed by chaining. Features include unlimited-length user-definable macro operations, double-precision accuracy, unattended AUTO execute and BATCH mode operations, subcircuit capability, iterate component value capability, execution of external programs from within ACNAP3 and component libraries. The program automatically computes magnitude, phase and delay at any node in the circuit and includes Global Worst Case. Monte Carlo, Input and Output Impedance calculations, Noise Equivalent Bandwidth and Sensitivity analyses.

Free-format input, interactive menus and input error trapping are said to make ACNAP3 easy to learn and use. Low-cost graphics modules can be added to upgrade the program to drive high-resolution graphics screens, graphics printers and pen plotters. The ACNAP3 program is available for both PC/MS-DOS and Apple Macintosh computers. $125.

CIRCLE 88 ON FREE INFORMATION CARD

"Disguise" Mobile Antennas

A new series of 800-MHz mobile antennas covering trunk, conventional and cellular applications has been announced by The Antenna Specialists Co. Each antenna is a cosmetic match for standard-equipment AM/FM broadcast antennas and has a 31" taper-ground stainless-steel whip on look-alike mounts. Different models are available for Ford (Series ASP-1827) and Chrysler (Series ASP-1828) cars. Also, available are the Series ASP-1829 compact universal mount for fenders only 1" wide with up to 15-degree slope and the Series ASP-1823 fully universal mount. The Ford versions include an 806-to-866-MHz model and two 821-to-896-MHz cellular models.

All of the new antennas can accommodate up to 50 watts of power and are designed for universal application with swivel mounts in ⅞" holes. The Ford and Chrysler versions are adjustable for up to a 35-degree slope on the mounting surface. Each antenna is furnished with 15 feet of low-loss Proflex 800™ cable for maximum signal from the 2.3-wavelength high-angle radiators. An optional broadcast coupler, Model ASP-929, permits two-way and AM/FM equipment to be used on the same antenna.

CIRCLE 89 ON FREE INFORMATION CARD

(Continued on page 92)

NEW! CB Radios & Scanners

Communications Electronics,™ the world's largest distributor of radio™ scanners, introduces new models of CB & marine radios and scanners.

NEW! Regency® TS2-RA

Allow 30-90 days for delivery after receipt of order due to the high demand for this product.

List price $499.95/**CE price $339.95**
12-Band, 75 Channel • Crystalless • AC/DC
Frequency range: 29-54, 118-175, 406-512, 806-950 MHz.
The *Regency* TS2 scanner lets you monitor Military, Space Satellites, Government, Railroad, Justice Department, State Department, Fish & Game, Immigration, Marine, Police and Fire Departments, Aeronautical AM band, Paramedics, Amateur Radio, plus thousands of other radio frequencies most scanners can't pick up. The *Regency* TS2 features new 40 channel per second *Turbo Scan™* so you wont miss any of the action. Model **TS1-RA** is a 35 channel version of this radio without the 800 MHz. band and costs only $239.95.

Regency® Z60-RA

List price $299.95/**CE price $148.95/SPECIAL**
8-Band, 60 Channel • No-crystal scanner
Bands: 30-50, 88-108, 118-136, 144-174, 440-512 MHz.
The *Regency* Z60 covers all the public service bands plus aircraft and FM music for a total of eight bands. The Z60 also features an alarm clock and priority control as well as AC/DC operation. Order today.

Regency® Z45-RA

List price $259.95/**CE price $139.95/SPECIAL**
7-Band, 45 Channel • No-crystal scanner
Bands: 30-50, 118-136, 144-174, 440-512 MHz.
The *Regency* Z45 is very similar to the Z60 model listed above however it does not have the commercial FM broadcast band. The Z45, now at a special price from Communications Electronics.

Regency® RH256B-RA

List price $799.95/**CE price $329.95/SPECIAL**
16 Channel • 25 Watt Transceiver • Priority
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Sidelit liquid crystal display • EAROM Memory
Direct Channel Access Feature • Scan delay
Bands: 29-54, 118-136, 144-174, 406-420, 440-512 MHz.
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List price $349.95/**CE price $178.95/SPECIAL**
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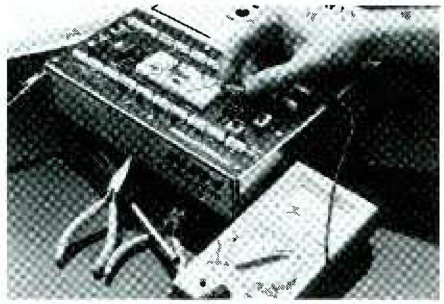

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Process Control with Personal Computers

(Part 1)

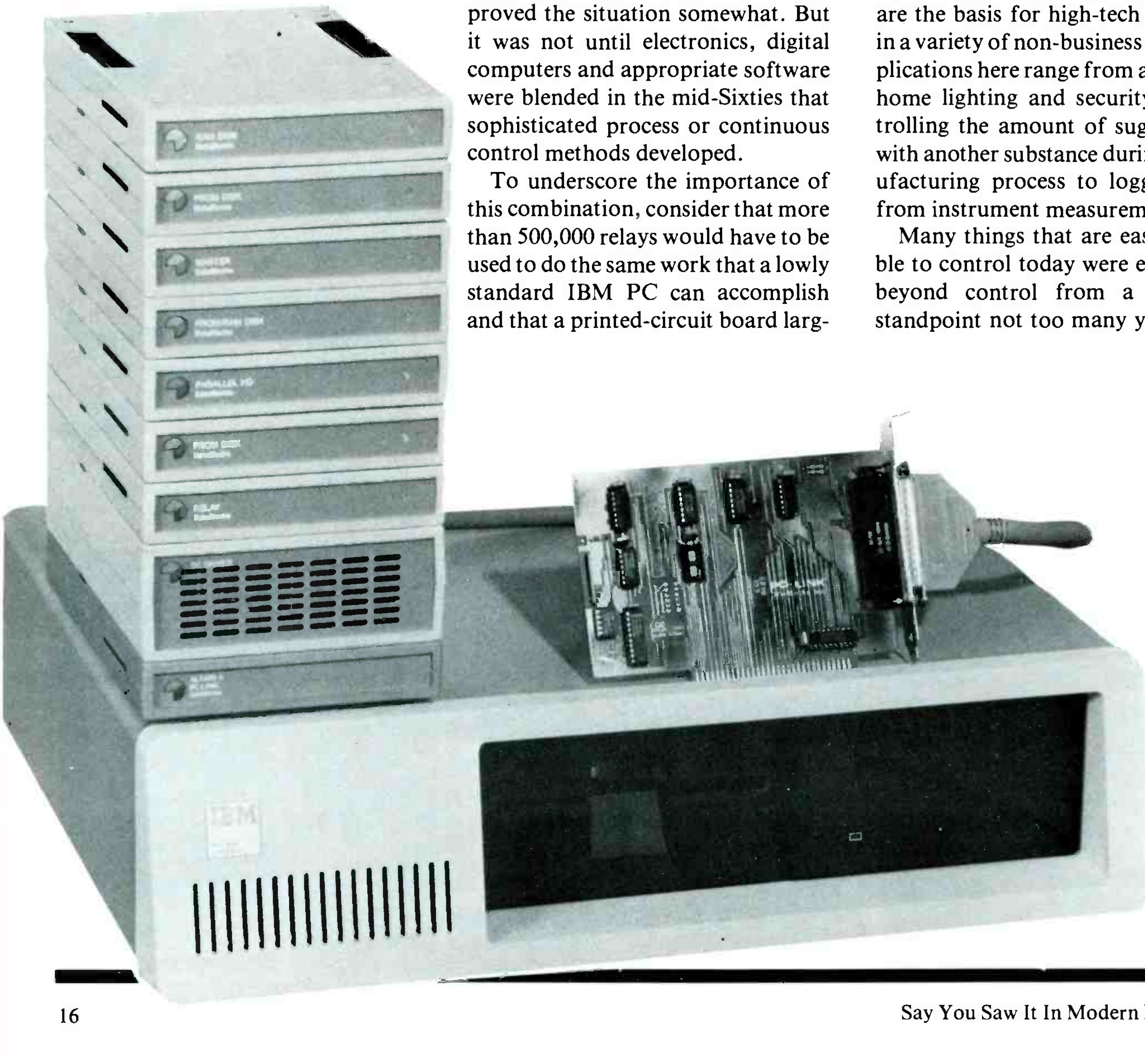
How electronics/computers can be used to provide real-world process control, data acquisition and automated test measurements

By Dr. H. Edward Roberts

Automation systems have a grand old history, starting out with pure mechanical methods, such as the use of cams. These controllers were unable to make complex logical decisions based on a variety of inputs, of course. The use of relays and other electromechanical devices, which blossomed after World War II, improved the situation somewhat. But it was not until electronics, digital computers and appropriate software were blended in the mid-Sixties that sophisticated process or continuous control methods developed.

To underscore the importance of this combination, consider that more than 500,000 relays would have to be used to do the same work that a lowly standard IBM PC can accomplish and that a printed-circuit board larger than a football field would be needed to emulate 640K of memory with relays. Of course, most people think of computers as machines used for word processing, spread sheets, data bases and super calculating. But computers, in one form or another, are the basis for high-tech advances in a variety of non-business uses. Applications here range from automatic home lighting and security to controlling the amount of sugar mixed with another substance during a manufacturing process to logging data from instrument measurements.

Many things that are easily feasible to control today were essentially beyond control from a practical standpoint not too many years ago.



This series of articles will explore how modern electronic and computer equipment can be used for a variety of non-business purposes in home and work environments. It will embody control with various physical devices such as stepping motors, sensors, test instruments, etc., to handle applications such as alarm systems, energy management, robotics, automated testing, data logging and report generation, among others.

Computerized Control Equipment

A collection of computer types are available for control purposes. They may be broken down into three categories: programmable controllers and industrial computers, single-board computers (SBC), and personal computers.

The first group comprises rugged computer controllers specifically geared to industrial use. They come in all sizes and capabilities. Many employ relay-ladder programming, which uses electrical/mechanical relay symbols instead of mnemonic words. This is a carry-over from an era when relays were set up to perform logical sequences. Use of programmable controllers is burgeoning, especially since their makers often provide applications support. Some companies, such as Pro-Log Corp. (Monterey, CA) have developed industrial computers for multitasking industrial control that provide the added flexibility of running standard MS-DOS software as well as the relay language system. Machines in this category are especially durable and incorporate high-reliability components. They don't come inexpensively, though.

The second group, single-board computers, belies its name. They often require more than one board to make up a system. The STD bus structure is commonly used here, which is a standard that has wide-spread support. A Z-80 processor is routinely employed, though 16-bit CPUs with an STD-8088 standard bus have now been introduced so that MS-DOS software can be used. Hallmarks of these computers, which generally require a card cage with bus slots and power supply to form a comprehensive control system, are large memory capacity, powerful input/output capabilities, and great application design flexibility that makes use of a wide assortment of plug-in boards. (Commonplace on-board features include 128K EPROM, RS-422 high-speed serial ports, real-time clock, IEEE-488/GPIB ports, and CMOS versions.) A variety of computer languages can be used here, depending on the manufacturer's product. The FORTH System language is popular, as is BASIC. Some SBCs have languages incorporated into ROM. SBC prices start at a few hundred dollars and may extend to the cost of high-end controllers for a full-blown, extensive system.

Lastly, we have personal computers—IBM PC/XT/AT and compatibles, Apple II + and IIe, Apple Macintosh, and Commodore 64/128. Such general-purpose microcomputers are prevalent today. There appears to be much more hardware plug-in board and software choices for the IBM-type computer at this time in the control and data acquisition area. Moreover, PC clones for a system's heart are priced at amazingly low figures.

In addition to the foregoing, there are computer-control systems that are, in a sense, hybrids. These employ interface boards that plug into a

IBM BUS

B1	GND	A1	−I/O CH CK
B2	+ RESET DRV	A2	+D7
B3	+5 V	A3	+D6
B4	+IRQ2	A4	+D5
B5	−5 V	A5	+D4
B6	+DRQ2	A6	+D3
B7	−12 V	A7	+D2
B8	−CARD SLCTD	A8	+D1
B9	+12 V	A9	+D0
B10	GND	A10	+I/O CH RDY
B11	−MEMW	A11	+AEN
B12	−MEMR	A12	+A19
B13	−IOW	A13	+A18
B14	−IOR	A14	+A17
B15	−DACK3	A15	+A16
B16	+DRQ3	A16	+A15
B17	−DACK1	A17	+A14
B18	+DRQ1	A18	+A13
B19	−DACK0	A19	+A12
B20	CLK	A20	+A11
B21	+IRQ7	A21	+A10
B22	+IRQ6	A22	+A9
B23	+IRQ5	A23	+A8
B24	+IRQ4	A24	+A7
B25	+IRQ3	A25	+A6
B26	−DACK2	A26	+A5
B27	+T/C	A27	+A4
B28	+ALE	A28	+A3
B29	+5 V	A29	+A2
B30	+OSC	A30	+A1
B31	+GND	A31	+A0

Fig. 1. The 62-line PC bus.

computer's expansion slot or an I/O port and establish a proprietary external bus to which application boards or modules are connected. Thus, they're a cross between SBC and personal computer configurations. Among makers of this type are Burr-Brown Corp. (Tucson, AZ) and DataBlocks (Glenwood, GA). We'll be using such a controller system here.

The Modern Electronics Controller

For the sake of convenience and economy, the "Modern Electronics Controller" used in this series will consist of an IBM PC/XT/AT or compatible and a DataBlocks LINK system. The latter consists of two parts: a LINK board that plugs into any available PC slot and an A-II (Altair-II) external bus structure that's in a shielded case. (The combination retails for only $187, assembled and tested, while a kit version costs $118; plans for rolling your own are available, too.)

This adds 2,048 addresses to the computer's committed or reserved 1,024, thereby providing the user with the potential of more than 2,000 I/O ports. These are fully supported by the computer's microprocessor, which can address 65,536 ports. Additionally, one still has full use of the computer for normal computing purposes. Moreover, the external bus permits use of Datablocks' A-II line of encased control modules, which number more than 30 models at this time. These unique circuit building blocks, which are in electromagnetic-shielded cases, can be stacked neatly atop each other. In doing so, its A-II bus connections are automatically made as contrasted to plugging boards into the limited number of bus slots available inside the computer. The modest-cost system operates in the familiar MS-DOS environment, with modules available for A/D and D/A conversion, IEEE-488 (GPIB) bus, parallel I/O, and so on.

The PC Link boards are double-sided with plated-through holes; the computer side's plug-in board has gold-over-nickel plating on the edge-connector contacts. Full schematics and pc art are available from the manufacturer for $8 (DataBlocks Inc., P.O. Box 449, Alamo, GA 30411).

The LINK card, which plugs into any of the computer's slots, completely buffers all signals on and off the bus using CMOS logic. This buffering accomplishes two things: (1) It makes sure that no additional loads are placed on the PC's bus by any external cards and (2) it "cleans up" any noise from the system bus by use of Schmitt-triggered inverters. The A-II side of the LINK is connected through a 37-conductor cable to the LINK card's connector that's on the back of the computer. It performs three functions: (1) It re-inverts incoming signals from the PC; (2) removes any cable noise; and (3) it converts incoming PC addresses to addresses 0-255 for the stack. Each A-II bus allows for 256 input/output (I/O) ports. By making this conversion, programming and set-up of the stack addresses are simplified.

There are no special electronic devices used in the system, and they should be widely available. They should be assembled on pc boards using standard MOS static precautions, of course. No adjustments or special alignment techniques are required, so it's simple to build. A switch on the LINK card is used to select which of the 8 available spaces the LINK is to address. Each address space contains 256 ports and up to a maximum of 8 spaces can be defined. Accordingly, once the foregoing is done, you are now ready to start adding function blocks to the stack.

Note that the FCC requires r-f emissions from all digital equipment to be within certain limits. The LINK meets these requirements and is, indeed, certified. However, this applies only if it is installed within a computer that complies with FCC requirements and that the A-II side of the LINK is inside its shielded case.

Control Concepts

When a printed-circuit board is plugged into a PC's expansion slot it's connected to 62 wires by the board's edge connector. These wires contain all the signals required by the central processor for communication with the added card(s). Collectively, the wires or lines are known as the system bus. Included in the PC bus are 20 address lines, 8 data lines, control signals and power lines, as shown in Fig. 1. We need only concern ourselves with a few of these lines, specifically the address, data and I/O ones.

A computer "moves" a variety of information on the bus lines, such as memory read and write signals, interrupt commands, input/output data, etc. Only one type of data is transferred at a time, however. For example, input operations will not be mixed with memory reads. Each operation is called a cycle; an example would be an output cycle. Since a wide variety of different cycle types share the bus, controls must be provided so that each device connected to the bus can determine if the data being sent is meant for it. Since our major interest is in input/output operations, let's look at this area.

A computer "talks" to the outside world through these input and output (I/O) ports. They can be thought of as a private telephone system, in fact, with each port being the same as a phone in the system. In a phone system, each instrument has a unique address or number and each phone can either talk or listen. A computer operates in much the say way: each port has a unique address and can either talk (output) or listen (input).

In order to determine if the current cycle on a bus line is an I/O operation, we look for the presence of a

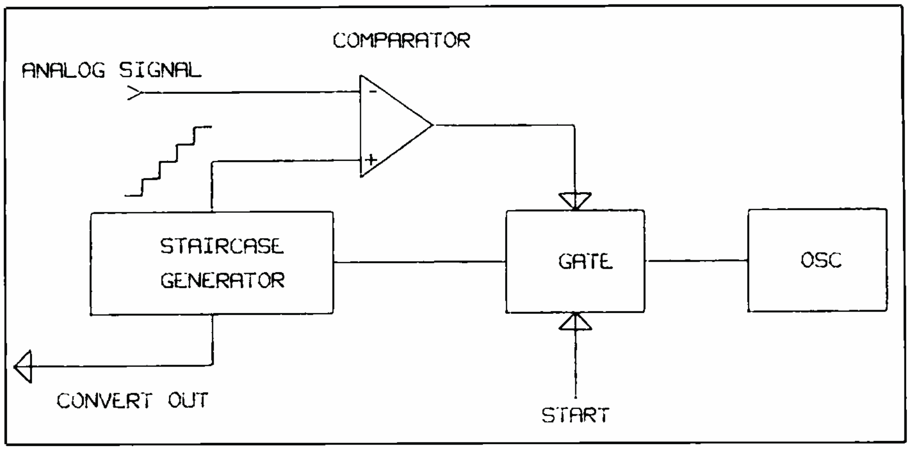


Fig. 2. A staircase generator is often used for A/D conversion.

logical "0" on either the IOW or IOR lines. If the IOW line is a "0," this cycle is an I/O cycle and specifically an I/O write (output). Similarly, a "0" on the IOR line indicates that the current cycle is an input/output read cycle (an input).

Next, our I/O controller must determine if the input or output is correct. The easiest way to do this is to use a comparator to compare the address on the bus with the address of the device. If they match, the controller reads the data on the bus for an output cycle or writes onto the bus for an input cycle.

If all conditions are met, the data transfer takes place in a flash and the cycle is completed. The IBM PC uses a data bus that contains 8 bits or lines. Therefore, each I/O operation either reads or writes 8 bits of data each cycle. If we wish to read more than 8 bits of data, say, 16 bits, then we must make two transfers or have to read two cycles.

Sampled Data. Digital control systems, due to their discrete nature, must operate on sampled or periodically read data as compared to continuously changing (analog) signals. The sampled rate must be significantly faster than the rate at which the data changes value for it to be of value. To illustrate, let's assume that we wish to control the steering of a car moving at 60 mph. Further assume that we are adjusting the steering based on a light sensor pointed at a white line on the road.

To control the car, we design a photodetector that measures the car's location relative to a white line painted on the road. If we measure our location sample at the rate of once per second, the car will travel 88 feet between samples.

This sample rate obviously isn't fast enough. Now let's assume that we increase the sample rate to 10,000 samples per second, (that is, we'll provide the computer with new data every 100 microseconds). This will update the car's location each time it travels 0.1 inch. As a practical matter, this sampling rate will be as good as having continuous data in this application.

As a general rule, to get high accuracy the system should sample at least 7 to 10 times faster than the fastest component in the signal. (Reconstruction of an analog signal can be obtained if the sampling rate is only twice the highest frequency, however, per Nyquist's theorem.) For example, if we wished to accurately control a signal that varied 60 times a second, a sample rate of 600 would be desirable. No matter how fast your conversion rate, however, you still have to process the sampled data with the computer. The time required to process each sample is dependent on the complexity of the calculations to be made. But about 10,000 samples per second is a reasonable upper limit to expect from an IBM PC. An IBM AT, in turn, would operate two or three times faster than this.

An electrical analog may be thought of as a signal that by its magnitude, frequency, etc., represents some physical quantity such as temperature or pressure. For instance, the resistance of a photoresistor decreases as the light striking the resistor increases. Therefore, the resistance of the photoresistor is an analog of the light striking it. Note that this resistance will change *continuously* as the light changes.

Regrettably, most analog signals are of a nature that can't be directly used by a digital computer, which works with discrete on/off-type signals. The good part is that we can take care of this problem by using an analog-to-digital converter.

An A/D converter circuit converts incoming analog signals into digital code numbers that can be used by a computer. A number of clever techniques have been developed to perform A/D conversions. The most straightforward method samples the incoming signal and then compares it with a digitally generated staircase voltage. When the two signals are equal, the digital staircase is stopped. The count of the staircase generator corresponds to the digital value of the analog signal. See Fig. 2.

This procedure often has to be reversed to enable a computer to control a physical device, so digital-to-analog conversion is frequently needed. Examples are varying the brightness of a lamp, varying the speed of a motor, etc. This is relatively easy to accomplish using the staircase generator concept cited previously. In this case, the computer simply presets the staircase generator to the appropriate count. This results in a dc voltage that corresponds to the number output by the computer.

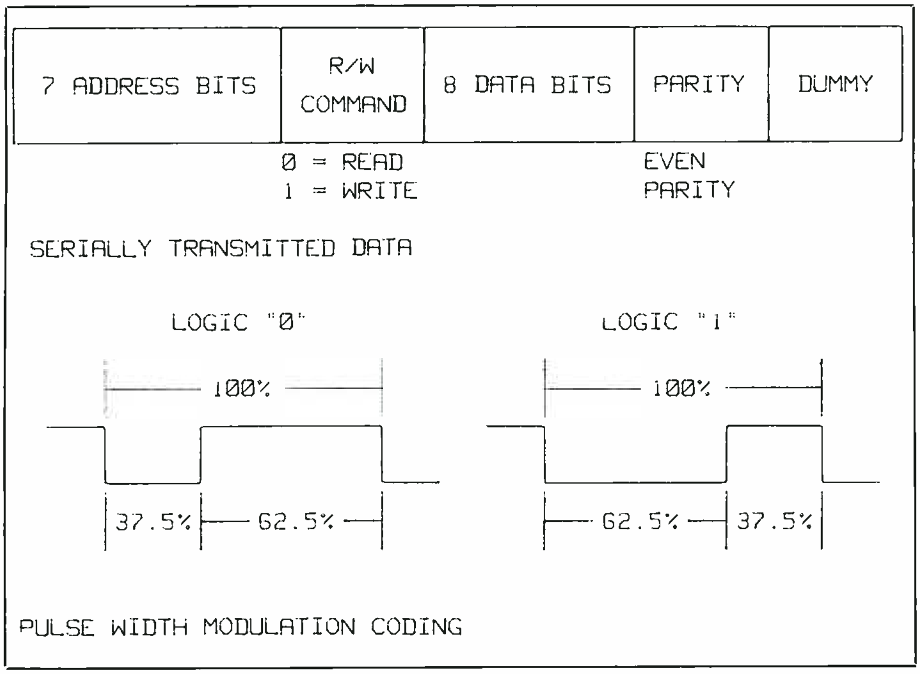


Fig. 3. A master/slave bit pattern is shown above. Address bits are preceded by a start bit. Logic pulses are below.

These converters are designed to convert dc voltages, which is the type device we'll be working with. You should be aware, though, that there are other types of converters. For example, a frequency-shift keyer, used in modems, converts frequency to "1's" and "0's."

Feedback. Understanding basic feedback principles is necessary in order to design any control system, analog or digital. Feedback is the process where the device being controlled tells the controller what it's doing. This allows the controller to make adjustments in its drive signals to correct for errors in the control system. The implication is that the controlled device doesn't perform in a totally predictable manner, which of course is correct. An example will help to illustrate the problem and the feedback solution.

Let's say that we have a radio-controlled toy car that we wish to drive through an obstacle course. We know how to control the car: one switch makes it go forward, one right, one left, and so forth. If we tried to drive the car through the course with our eyes closed, however, we would be unsuccessful. Our sight provides us, the controller, with the feedback necessary to control the car and successfully get through the obstacle course.

This doesn't mean that every control function must have feedback. For example, suppose we wish to turn on a security light at night in a home burglar protection system. This particular application might operate perfectly okay without feedback. But the addition of feedback might significantly improve the system's reliability. For instance, if we added an independent light sensor to the above example, we could detect a system failure, such as a burned out bulb, or defective wiring. Control systems without feedback are known as open-loop systems. In general, open-loop systems are used in relatively crude or non-critical applications.

Remote Control. A remote device may be connected to the computer with a wide variety of techniques, such as wire, radio link, light beam, etc. We will look at a typical remote-control system using plain wire as the connecting link, but the basic techniques apply to any type of link.

A typical A-II Master/Slave system consists of a master connected directly to the computer and up to 128 slaves located remotely from the computer. Each master is connected to all of its slaves with the same single pair of wires. The computer supplies the master with three pieces of information: the address of the slave with which it needs to communicate, whether it's to read from or write to the slave, and, lastly, the data it wishes to transmit if the current operation is a write. This is essentially the same principle used by the computer when communicating with its internal I/O ports, though a computer uses dozens of wires instead of just a single pair.

Such a system is able to operate with a single wire-pair by converting all of the bus's parallel signals to serial data. The master normally maintains a "1" on the interconnecting cable. Each slave unit is connected to the same wire and, as long as the incoming signal is a "1," nothing happens. When the master wishes to communicate with peripherals, it sends a sequence of "0's" and "1's" over the single wire pair connected to the slaves. The first change from a "1" to a "0" starts the communication sequence. This change from a "1" to a "0" is called the start bit. The next seven bits that are transferred are the address bits.

All slaves attached to the master continually monitor the incoming address. If a slave detects its address, it monitors the remainder of the transmission: otherwise, it ignores the rest of the data. Next comes the bit which identifies whether the master is going to send information or if it expects the slave to transmit data to it. Now the eight data bits are sent,

(Continued on page 89)

What's New In Consumer Electronics

A detailed report on recently introduced revolutionary and evolutionary home-entertainment equipment such as super-VHS VCRs, digital audio tape recorders, and a video disc/compact disc combination

By Len Feldman

This has been one of the busiest years in the history of consumer electronics technology. At least three major new product categories have been introduced; one is an audio breakthrough, another a video breakthrough, and a third innovation involves both audio and video in a new integration of those two home entertainment media. The new audio development is called R-DAT, or just plain DAT, and it stands for Digital Audio Tape recorders. The new video format is called S-VHS, or Super VHS, and it runs rings around all previously available home video recording formats as far as video quality is concerned. The third important development in home entertainment electronics is called CD-V, which combines the technologies of laservision video discs with that of digital compact discs.

Digital Audio Tape Recorders

In late March of 1987, the first digital audio tape decks went on sale in Japan. As of now, however, you still can't buy a Digital Audio Recorder in any store in this country. (To understand the delay, see "What's Holding Up DAT," accompanying this article.) Before discussing how DAT machines work, let's review the brief history of DAT.

TDK Electronics Corp. is prepared for the U.S. future with its new Digital Audio Tape cassette that measures a compact 79 × 55 × 10.5 mm. No price or availability has been made for the new DAT format, though it is being marketed in Japan.

Anyone who has listened to the new digital compact discs knows that the digital method of recording audio signals offers a much wider and more realistic dynamic range, ruler-flat frequency response, low distortion and the total absence of any background noise or hiss. The same advantages apply to digital audio tape recording. But there's one added benefit. That's the ability to make your own digital recordings at home or anywhere else for that matter! That's something you can't do with Compact Discs—at least not yet. And, of course tape recordings, whether analog or digital, can be erased and the tape can be used over and over again.

Professional recording studios have been using digital tape recorders for many years to make the multitrack master tapes from which analog LPs and now Compact Discs or CDs are ultimately pressed. Such machines used in studios cost thousands, even hundreds of thousands of dollars. Thus, those of us who like to record our own high-quality music at home have, in fact, also been able to realize the advantages of digital tape recording for nearly a decade, though very few people are aware of the technique.

Today, in the United States, if you want to record audio digitally, outside of a professional recording studio, you have to use two separate pieces of equipment: a video recorder and an add-on device called a PCM processor. Available from such companies as Sony and Sansui, PCM processors convert analog audio signals into a stream of digital information (number samples or values) in accordance with an agreed-on formula. The resulting millions of pulses per second are not unlike video signals. Both require a

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Just call toll-free **1-800-321-2155** (in Ohio, 1-800-362-2105) storage medium that can record such a high density of signals. The VCR is ideal for both purposes, thanks to its rapidly rotating head drum. Although the tape itself moves very slowly from reel to reel within its cassette housing, the rotating head drum spins across the surface of the tape at 1,800 rpm. In effect, the relative tape-to-head speed is not one inch or less per second, but more nearly 35 to 40 feet per second! Given this fast tape "writing speed," the high pulse rate of digital audio (or high frequency content of video signals) is easily accommodated on video tape. Therefore, the PCM processor adds these digital signals to a standard video signal format and the combination is recorded using a VCR. Instead of pictures, the tape stores digital "bits" or number samples that, during playback, are converted back into high-quality analog audio signals.

Although this VCR/PCM processor approach works quite well, engineers felt that a dedicated audio tape recording system would make more sense. Such a system would not need two separate pieces of equipment. The need to superimpose the digital data onto a video-format signal could be eliminated. (Right now, the digital data must be chopped up into small blocks that fit between the horizontal and vertical synchronizing pulses of a standard TV picture format.) A new and much more compact tape cassette package could be standardized for such a dedicated DAT system. Finally, the quality and dynamic range of a dedicated system could be improved. After all the technology of PCM processor/VCR combination recording was introduced more than a decade ago, and a lot has happened in digital technology since then.

It's been more than three and a half years since representatives from 84 companies sat down in Japan to try to establish new standards for home digital audio tape recorders. After the experience of having to live with multiple formats for video tape recording (Beta, VHS and now 8 millimeter), no one wanted to see multiple DAT formats evolve. Despite the need for a single DAT standard, the members at the June 1985 DAT Conference (including 60 Japanese companies and 24 companies from Europe, North America and elsewhere) compiled tentative specifications for two types of DAT recorders after all. But don't despair! One of the two systems, known as S-DAT (for Stationary-Head Digital Audio Tape) will more than likely be used only for professional or studio applications. The other one, known as R-DAT (for Rotating-Head Digital Audio Tape) is the one that's been selected for use in home recorders. It's also the one that the manufacturers are already offering for sale in Japan and in Europe.

Digital-to-Digital Copying

Some recording enthusiasts who learned about DAT when it was still being discussed by the 84 company committee known as the DAT Conference were excited at the prospect of being able to transcribe their CDs onto Digitally Recorded tape. They assumed that it would be possible to do this within the digital domain. That is, they expected to be able to take the digital output from a CD player (some CD players do provide such a direct digital sub-code output) and to copy that digital code right onto a digital tape without having to go through the digital-to-analog decoding process and the analog-to-digital re-encoding process. Such a direct digital-to-digital recording would, of course preclude any degradation of audio quality that might be caused by the analog steps in the process. Well, if that's what you were hoping for, you'll be out of luck.

With all the fuss that audio recording companies have been making lately about so-called private "pirating" of copyrighted music onto analog cassette tapes by individuals, the DAT committee probably wanted to ensure that owners of CD players would not be able to plug into their R-DAT recorders and transcribe their CDs onto digital cassette tapes. One way of preventing this is by using a different digital sampling rate for home DAT recorders. The rate

Table 1. R-DAT System Specifications

NUMBER OF CHANNELS (CH)	2	2	2	4	2
SAMPLING FREQUENCY (kHz)	48	44.1	32		
QUANTIZATION (BIT)	16	16	16	12	
TAPE WIDTH (MM)	3.81 (+0/ -0.02)				
TYPE OF TAPES	MP	OXIDE	MP		
TAPE THICKNESS (μM)	13 ± 1				
TAPE SPEED (MM/S)	8.15	12.225	8.15	8.15	4.075
TRACK PITCH (μM)	13.59	20.41	13.59		
TRACK ANGLE (TAPE RUNS) (DEG)	6°22'59.5"				
RECORDING TIME (MIN)	120	80	120	120	240
HEAD GAP AZIMUTH ANGLE (DEG)	±20				
RECOMMENDED CYLINDER SPECIFICATIONS	φ 30, 90° WRAP 2000 RPM				1000 RPM
WRITING SPEED (M/S)	3.133	3.129	3.133	3.133	1.567
MODULATION SCHEME	8 - 10				
RECORDING DENSITY	61kBPI				
ERROR DETECTION AND CORRECTION CODE	DOUBLY-ENCODED RSC (C,32, 28 5 / C,32 26 7)				
REDUNDANCY (%)	37.5	42.6	58.3	37.5	37.5
TRANSMISSION RATE (MBPS)	2.46				1.23
SUB-CODING (CAPACITY) (kBPS)	273.1				136.5
TRACKING SYSTEM	ATF				
DIMENSION OF THE CASSETTE (MM)	73 X 54 X 10.5 (W X D X H)				

chosen is 48 kHz as against 44.1 kHz used for Compact Discs. The committee also agreed upon an alternate sampling rate of 32 kHz where the ultimate in fidelity is not required.

When this sampling rate is used along with a lower number of bits-per-sample (12 instead of 16), maximum recording time can be extended to 240 minutes as compared to the 120 minutes available at the higher sampling and higher "bit" rate. Naturally, using the lower sampling rate reduces the bandwidth or frequency response of the system back to around 15 kHz; about the same cutoff frequency that the 8-millimeter video-tape format provides when used for digital audio recording. A second inhibition against digital-to-digital copying was also provided. A special "bit" flag (in what's known as the sub-code area of the digital data block recorded on tape) signals the recorder that the material you are attempting to record is copyrighted. The result is that the recorder will not go into the record mode when that "bit" flag is present!

Despite major recording companies' current boycotting of the DAT format, you can expect some small, enterprising recording companies to begin to issue prerecorded digital audio tapes just as soon as there are a substantial number of DAT machines out there that can play them. For such prerecorded fare, the sampling rate will be—you guessed it—44.1 kHz, exactly the same as it is for Compact Discs. Owners of such tapes won't be able to copy them either (at least not digital-to-digital) because of the difference in sampling rate. Even if someone gets around the sampling rate disparity, as already mentioned, the special copy-prohibit flag code can be added to prerecorded DAT software just as it is on CDs.

How R-DAT Works

Table 1 summarizes operating system specifications for the R-DAT digital audio tape recording format. Figure 1, in turn, shows the R-DAT track layout and dimensions. A 30-millimeter-diameter rotating drum, spinning at 2,000 rpm, is equipped with a pair of record/playback heads. The "gap" of one of these heads is angled at +20 degrees, while that of the other is angled at −20 degrees. That way, adjacent "tracks" don't cause any crosstalk or interference with each other.

You will notice that several options and combinations of sampling frequency, digital quantization and recording or playback times are provided for in the standard. The mandatory record/play mode calls for a 48-kHz sampling rate, which means the frequency response could actually extend beyond the 20-kHz limit imposed by the 44.1-kHz sampling rate of Compact Discs. (Highest recorded frequency in any digital recording system can never exceed half the sampling rate.) In the playback-

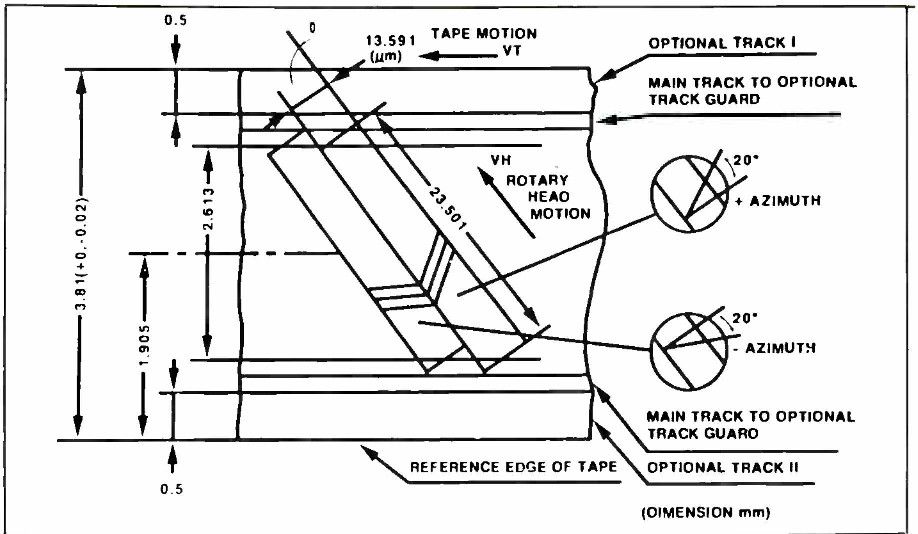

Fig. 1. An R-DAT track pattern (simplified).

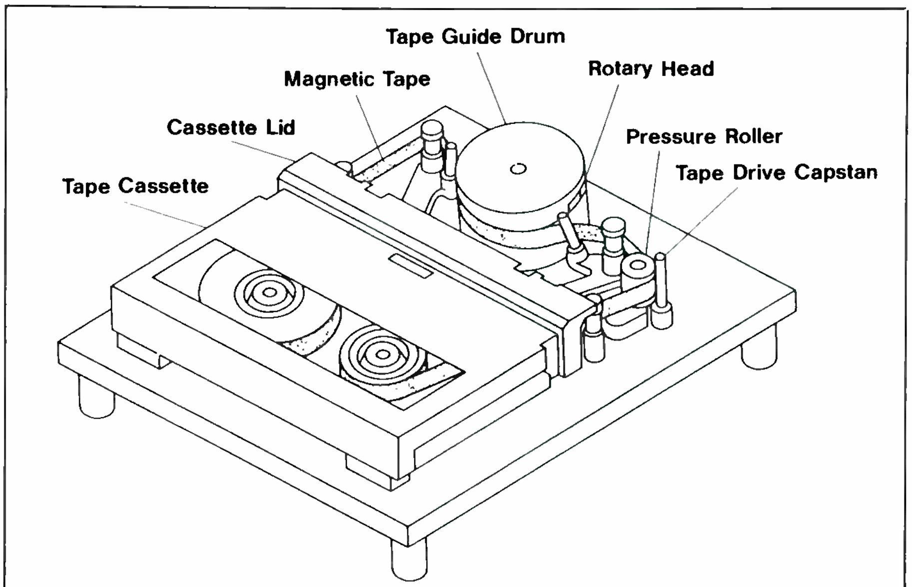

Fig. 2. A schematic diagram of R-DAT.

What's Holding Up DAT?

DAT recorders have been available in Japan and elsewhere for many months. Yet you still can't walk into your local audio shop and buy one. The reason for this has to do with a controversy that has made its way right up to the Congress of the United States. Major record companies, represented by the RIAA (Record Industry Association of America) maintain that the introduction of DAT machines would encourage people to make copies of recordings using DAT recorders so that they wouldn't need to buy the records.

Despite the fact that digital-to-digital "cloning" has already been prohibited in the DAT standard and in machines now being offered for sale overseas, these record companies want to make it impossible to record copyrighted recordings (future releases of CDs, LPs, pre-recorded analog audio cassettes and, perhaps, even radio and TV broadcast audio programming) via the analog inputs of DAT players. Such recordings could not really be considered "digital clones" anyway. Furthermore, home recording for non-commercial purposes has been recognized as a legal activity time and time again.

Holding back the new DAT technology, the RIAA endorsed a system developed some years ago by the former CBS Technology Center. While the Technology Center was closed last year as an economy measure at CBS, the anti-copy system developed by them is now being refined and championed by the researchers at CBS Records Division of CBS. Simply stated, the system works as follows: recording companies would, if they so desire, introduce a narrow-band filter in the signal path during mastering of a recording. This filter would "notch out" or remove a narrow band of musical frequencies centered around 3,838 Hz, well within the audibly frequency range. The exact width and depth of the notch seems to be a jealously guarded secret of its proponents, though some two years ago, when the system was fully revealed, the notch had a bandwidth of 250 Hz, as shown in Fig. A.

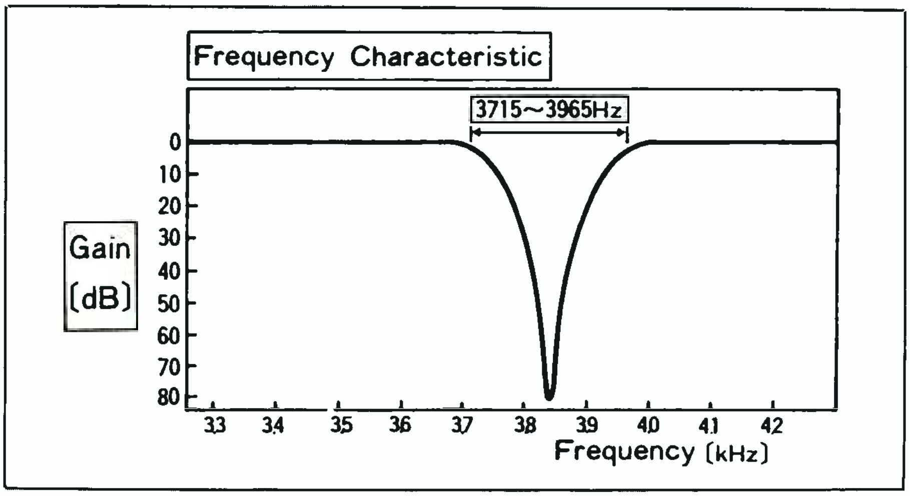

Fig. A. Approximate characteristics of the "anti-copy" notch that would be "encoded" in future recordings if record companies have their way.

Two pieces of legislation currently before the Congress (S506 in the Senate and HR1384 in the House of Representatives) would require that any DAT machines imported into the U.S. be equipped with a scanning circuit that would sense the absence of program material in the frequency band if an attempt were made to copy program material containing this notch. In order to avoid shutdown during soft passages or silent moment of program material, the scanner would also need to find program material above or below the frequencies of the notch. The proposed

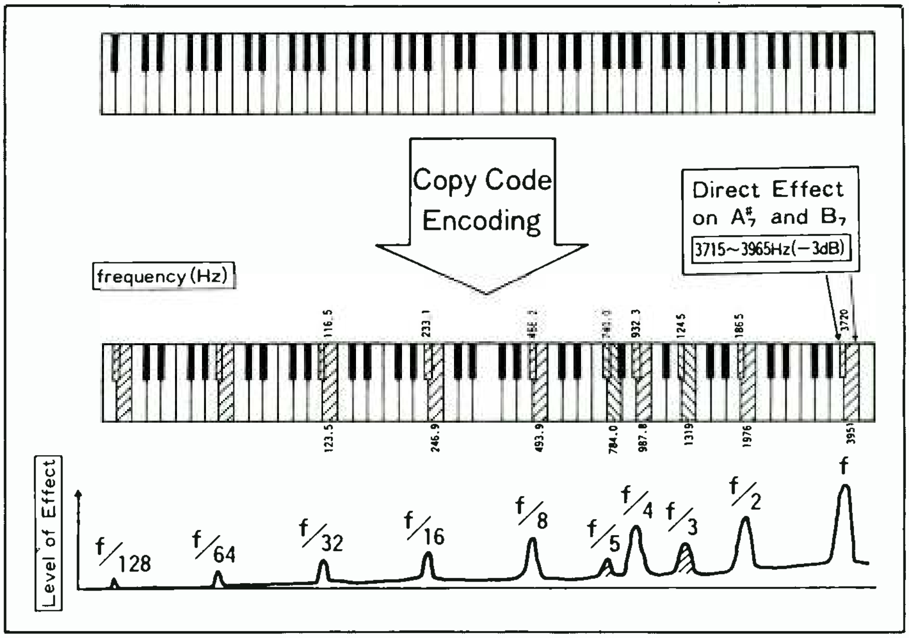

Fig. B. Notes of piano keyboard shown with cross-hatched pattern would be affected, to greater or lesser degree, by presence of frequency "notch" in recordings. Relative level of the effect is shown graphically below keyboard.

legislation would actually make it a criminal offense to import or sell DAT units that are not equipped with the anti-copy circuit and would also make it a criminal offense to try to defeat this special circuitry.

Opponents of the scheme, besides maintaining that the right to make a recording in one's own home for noncommercial purposes is no different in the case of DAT recorders than it has been for analog reel-to-reel or cassette tape decks, have demonstrated repeatedly that the "notch" would affect overall sound quality, since it falls within the audio range. Figure B shows a piano keyboard and illustrates which notes would be directly affected (the uppermost A-sharp and B-natural) and which would be affected in terms of their harmonics or overtones. CBS representatives, on the other hand, maintain that the system would not be audible. Then, in an apparent contradiction, they point out that if indeed it is audible, the recording company would have the option of not putting the notch in at all, or of turning it off intermittently during those moments when it might have an adverse effect upon musical accuracy.

While the debate goes on, makers of DAT recorders have been understandably reluctant to start selling the product in the United States, despite the fact that to do so would be entirely legal at this time. In fact, it is common knowledge that many visitors to Japan, eager to obtain these incredibly good recorders, have been bringing them back with no customs restrictions whatsoever.

As of the time this is being written, the debate as to audibility or inaudibility of the "notch" is being turned over to the National Bureau of Standards, at the request of members of Congress. It may take months before this organization can complete its tests and, even then, there is no guarantee that Congress will act based upon the outcome of the tests. Meanwhile, the rest of the world is beginning to enjoy the benefits of DAT while we, and the makers of DAT machines, wait impatiently for a resolution of the debate.

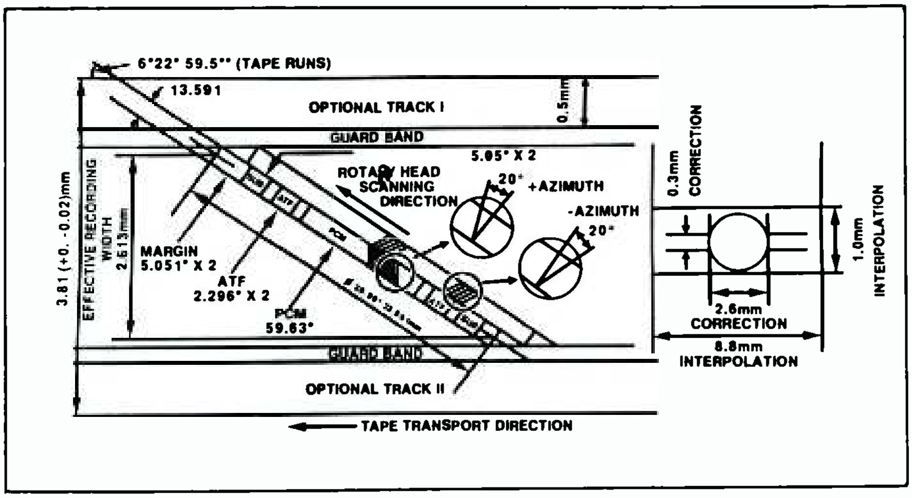

Fig. 3. A detailed cross-section look at R-DAT's track pattern.

only mode (reserved for prerecorded cassettes that will be available some day), a recording time of 80 minutes will be available in addition to the longer 2-hour recording time.

Notice, too, that there are two playback modes for prerecorded tapes. The "Normal" mode is for tapes recorded in real-time with a 44.1-kHz sampling rate. The "Wide" mode is for tapes duplicated at high speed. The high-speed duplicating process fast-winds a blank tape together with a similarly fast winding master tape. At the point of contact, using specialized magnetic field focusing, the blank tape assumes the same magnetic pattern as the master tape. This makes it possible to duplicate tapes at about 200 times normal playback speed!

The resulting signal level that will be available using the contact method is not as great as that on a tape dubbed in real time. So, the track width is made 1.5 times that of the normal mode to compensate for that decrease in output level. Since the track width is higher, the recording square density will be lower, allowing for use of ferric-oxide tape, as opposed to pure metal-particle tape that must be used for the other recording and playback modes.

One of the most important advantages of the of the R-DAT format is its high recording density. The system will use similar heads and tape as the current 8-millimeter video systems, though the cassette package size itself will be unique. Tape thickness is the same as that of a C-90 analog audio cassette, and the same width as well.

A diagram illustrating how the tape travels across the spinning head drum is shown in Fig. 2. Because the tape wrap around the drum is only 90 degrees and the rotating drum has only two heads mounted on it, the signal must be time-compressed during recording. The recorded signal goes into a temporary buffer memory, and is released to the head in blocks when either of the two heads is in contact with the tape. During playback, a similar buffer circuit is used to stretch the data back into a continuous digital bit stream.

The R-DAT system has a dedicated tracking correction method. Figure 3 shows the cross-section of the tape indicating five basic data fields per track. The sub-code portions (upper- and lower-most along each track) include data for tape time, music selection, indexing, etc. On either side of the main digital PCM data block are two additional portions, labeled ATF, for Automatic

Track Finding. These are dedicated to head-to-tape positioning. During tracking, the head overscans the main track so that a small portion of the adjacent tracks is read. This overscan is detected by the ATF portion. The intensity of the signals on the two adjacent tracks is compared. If one is different from the other, a voltage will be detected and the tracking mechanism adjusts the head's positioning accordingly.

Error correction, so important in CD players, is even more important in DAT recorders. As shown in Fig. 3, full detection and correction is possible over a region on the tape encompassing a diameter of 2.6 mm and a tape width of 0.3 mm, while interpolation (inserting approximate data based upon previous and subsequent digital data when dropouts are too great for full correction) can extend over a tape length of 8.8 mm and 1.0 mm wide.

Machines already on sale in Japan have many of the convenience features found on CD players, such as direct access to a desired selection on a tape, either by number or by time, display of time, remaining time, selection number, etc. Wireless remote controls are generally supplied with these machines, and they usually duplicate most of the control and access functions that are available on the front panels of the machines. Prices for the first generation of DAT recorders are around 200,000 Yen. At a conversion rate of 145 Yen to the dollar, that puts the cost at around $1,380. By the time you add shipping costs, import duties and local distributor profit, it means that you can expect to pay somewhere between $1,500 and $2,000 when those first DAT players finally arrive in this country.

Are they worth it? That depends, of course, on what you plan to (and are able to) record with a DAT machine and how important flawless, distortion-free, noise-free, wide dynamic range recordings are to you.

Maxell's Super VHS videocassette has a prominent "S" preceding the VHS on its label, denoting its suitability for use in the new S-VHS machines. It is available in ST-120, ST-60 and ST-30 lengths.

S-VHS—A Video Breakthrough!

The video industry was completely taken aback last winter when, during a consumer electronics trade show in Las Vegas, JVC in Japan announced development of a new VHS video recording and playback format called Super VHS, or S-VHS. At that time,

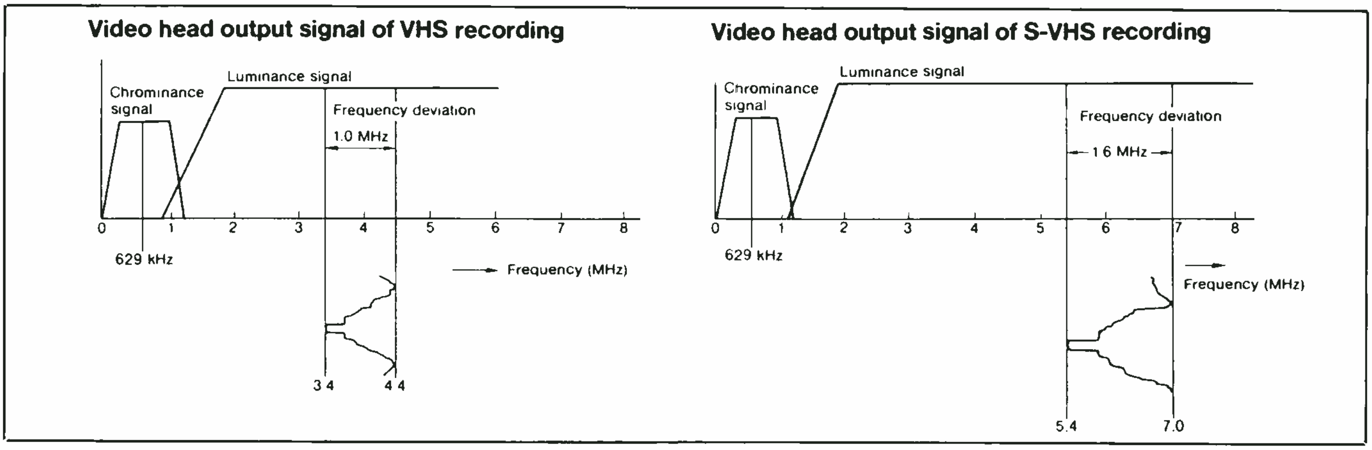

Fig. 4. Comparing VHS and S-VHS recordings, illustrating super-VHS's higher resolution, signal-to-noise ratio and wider bandwidth.

few details of the new system were disclosed other than its ability to record and play pictures having 400 lines or more of horizontal resolution. This is far greater resolution than is available on any home video recording format and better even than the resolution offered by NTSC TV broadcasts. JVC also conceded during its initial disclosure that the system was only one-way compatible; new VCRs or camcorders employing S-VHS can play "old" VHS tapes, but older VHS machines are unable to handle S-VHS tapes made on S-VHS machines.

JVC's HR-S7000U Super VHS Hi-Fi Stereo videocassette recorder.

Several months later, additional technical specifications for S-VHS have been released by JVC in collaboration with Hitachi Ltd., Matsushita Electric Industrial Co., Ltd, Mitsubishi Electric Corp., and Sharp Corp. The tape used for S-VHS is of a higher grade than currently used in VHS equipment. Tape cassettes housing this new tape are equipped with an identification hole so that S-VHS machines will be able to automatically distinguish between them and ordinary VHS tapes. (The latter will also be playable on those new machines.) S-VHS machines will cost somewhat more than top-performing, conventional VHS machines.

Only two tape speeds are foreseen at the present time. They are identical to the current SP and EP speeds used on ordinary VHS machines and offer the same recording time (2 or 6 hours for a T-120 cassette).

It's when we get into details of the actual video signal recording method that major differences become obvious. Video input and output signals may be either composite NTSC signals, as in VHS systems, or they may be separated Y (luminance or brightness) and C (chroma, or color) signals that, in combination, conform to NTSC signal standards.

Although Super VHS will use the same frequency-modulated recording method used in the older VHS format for luminance signal recording, the FM frequency has been changed from the conventional format's 3.4-MHz to 4.4-MHz range to a greater range—5.4 MHz to 7.0 MHz—that has also been "shifted" up in frequency. A comparison between the frequency and bandwidth of VHS and Super VHS is illustrated in Fig. 4. These are the most significant changes that contribute to the realization of more than 400 lines of horizontal resolution. Additional picture quality improvement is derived from the use of separated luminance and chrominance signals, as shown in Fig. 5. This separation helps to eliminate interference that might otherwise take place between brightness and color signals.

In order to see this additional, if minor, improvement, you will need to have a TV monitor or monitor/receiver that incorporates a special multi-pin connector known as an S-connector. Some manufacturers of TV sets are already beginning to incorporate this standard connector into their higher-priced sets. However, you don't need that special connector to get most of the visible benefit of S-VHS. What you need is a direct video input jack on your TV monitor. If you connect a new S-VHS VCR to your TV set via the antenna input and tune to channel 3 or 4, you will still see some improvement in picture quality, but the improvement will be limited to the approximately 330-line horizontal resolution of the broadcast NTSC system. That would still be better than the usual 240- to 250-line resolution offered by standard VHS VCRs, but would fall short of the 400-line resolution that the new S-VHS system can deliver.

In further examining the diagram, comparing the recording signal spectrum for VHS and S-VHS (Fig. 4), it appears as though no change has been made in the way the chrominance portion of the signal is recorded; nor in its bandwidth, which extends from 0 to 629 kHz in both formats. As for white-clip level, it is set at 210 percent, while dark-clip level is set at 70 percent. You may recall that higher white-clip level was one of the elements that were involved in the HQ enhancement system introduced by JVC (and subsequently by most other VHS licensees) some three years ago.

As far as audio signal recording is concerned, there seems to be no change in technique compared with conventional VHS recording systems. Ordinary ac high-frequency bias recording will continue to be used for linear track recording, while frequency-modulated "depth multiplex" recording will continue to be used for recording Hi-Fi signals.

S-VHS VCRs are equipped with

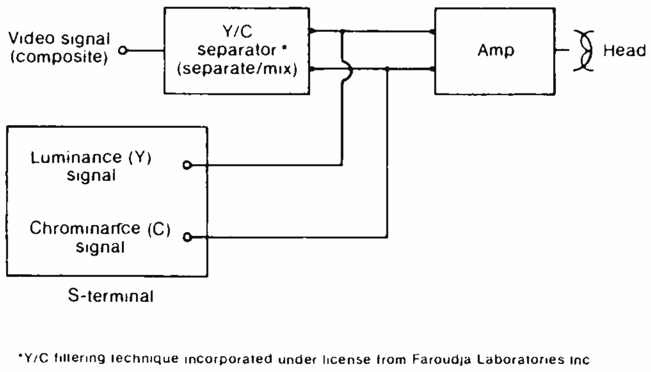

Fig. 5. Super VHS's Y/C separated input/output.

recording modes for both conventional VHS and S-VHS systems to enable users to select either mode. Furthermore, an S-VHS blank cassette will be usable with any conventional VHS VCR. 3M (Scotch), among other tape manufacturers, is already marketing Scotch Super VHS tape in standard full sizes and in the compact VHS-C package used by many camcorders. Quasar and many other manufacturers of camcorders have announced availability of camcorders, or combination video camera/recorders, that are configured for the smaller S-VHS tape package. In describing its new tape formulation that is suitable for S-VHS, Mike Sheridan, of the 3M Laboratories, explained that tape suitable for S-VHS recording and playback has higher coercivity and higher magnetic retentitivy than standard VHS tapes. Increased surface smoothness is another property associated with the new S-VHS formulations. (S-VHS tape is only about a fourth as "rough" in its surface as standard VHS video tape!) This results in more intimate heat-to-tape contact, which, in turn, results in improved picture quality.

You have to see an S-HVS picture to believe it! Small details that were lost, even when reproduced during live broadcast or from the very best VHS tapes, suddenly are crystal clear and sharp. Of course, much of the success of S-VHS will depend upon how quickly producers of software (motion pictures and other prerecorded video programs) start issuing program material using the new format. From all indications, however, S-VHS, unlike DAT, is a technology that has been engendered equal enthusiasm from both hardware and software makers.

Merging CD & Videodisc

The third item on my list of new technological innovations is called CD-V. To begin with, let's be completely hones about it. Unlike S-VHS or R-DAT, CD-V combines two technologies that have been with us for several years: CD technology and optical video laser disc technology. Furthermore, the capacity to handle both of these software types—LV and CD—is not new, either. Nearly three years ago, Pioneer introduced its first combination CD/LV player, the Model CLD-900. This unit was able to play 12-inch laser video discs, then newly introduced 8-inch laser video discs, and ordinary digital audio discs.

Since laser optics were involved in both CD and LV technology, it seemed to make a great deal of sense to offer a single player that could handle both CDs and LVs. The fact is, however, that cost savings for such a combination player were minimal. That's because once you get past the laser pickup and its servo motors, the rest of the electronics needed for digital audio decoding and reproduction is totally different from the electronics needed to translate optically read video signals (and the analog tracks associated with them) into picture and sound. Consequently, the first Pioneer CD/LV combination model as well as the second-generation Pioneer Model CLD-909 were fairly expensive. All the while, however, prices of dedicated CD players kept dropping as CD player production volume and sales increased geometrically.

In an effort to revive interest in optical laser video, Philips, the inventors of the laservision system (and, for that matter, the co-inventors of the Compact Disc) decided to integrate the two types of software into a single disc in much the same way that Pioneer had decided to integrate hardware for playing video and compact discs. Taking the standard-size CD (12 cm in diameter or about 4¾ inches) they've divided the disc into two parts. The first part, recorded in complete conformance with the CD standard set more than five years ago, is recorded near the center of the disc and allows for about 20 minutes of digital audio-only recording. That leaves enough room further towards the outer edge of the disc for about five minutes of full-motion video, together with a digital audio sound track. A diagram of the layout of these two segments and of the required rotational speeds is shown in Fig. 6.

One-Way Compatibility

The audio program, near the center of the disc, is in every way compatible with audio recorded on regular CDs. In fact, you can take one of those new, gold colored CD-V singles and play its audio portion on any CD player. But if you want to enjoy the picture portion of the disc, you'll need a new, combination player. Even older Laservision players won't be able to decode and play that video portion. For one thing, the turntable must spin at a very high beginning rate of 2,250 rpm to play the video, decreasing its rotational speed as the laser pickup moves further and further out towards the perimeter of the disc in order to maintain constant linear velocity.

Moreover, the video signal is analog in format, whereas the audio portion is digital. That explains why a CD player cannot deliver video pictures to your TV screen; it lacks the needed electronics as well as the higher rotational speed. As I mentioned, while more recent vintage videodisc players can actually play CDs and some can decode the digital sound tracks of videodiscs, none can play the new short video programming of the CD-V single. In that sense, the CD-V may be said to be partly compatible or, as the folks at Philips like to think of it, "forward" compatible.

There's also another aspect of compatibility that seems to have been overlooked by most of the enthusiastic supporters of CD-V. One of the big advantages of the Compact Disc is the fact that its format is a world standard. Any CD can be played on any CD player in any country in the world, so long as the power line voltage is correct for the player. That won't be true with the CD-V players—even the newer combination units—because of the different TV standards used in different parts of the world. Manufacturers of software and hardware are going to have to supply NTSC system machines and discs for the U.S. and Japan, and PAL players and discs for much of Europe. Warren N. Liberfarb of Warner Home Video, commenting on this matter during the Nethelands launch of CD-V some months ago, told us that this sort of multiple inventory problem has been

(Continued on page 81)

Using Current-Differencing Operational Amplifiers

A specialized op amp that can simplify circuit designs by eliminating the need for a second power supply

By Bob Mostafapour

Wide-range versatility, low cost and ease of use have made the op amp the most frequently used active element in both analog and digital circuits. Among the op amp's attractive characteristics are extremely high input impedance and gain and low output impedance. Ease of use is guaranteed by very simple gain and impedance equations (see Fig. 1), which eliminate the need for the user to be versed in higher mathematics to be able to use op amps. Even so, op amps are not a panacea. General-purpose op amps like the common 741 require a dual-polarity power supply. In some circuits (a 5-volt dc TTL digital circuit, for example) a separate negative (V −) power supply must be provided for any op amps being used—even if only one. The added supply increases the cost of the project, as well as its size, weight and circuit complexity—all needlessly, because there is a low-cost practical alternative. It comes in the form of the Norton operational amplifier, which requires just a single-polarity power supply, usually the same one used for the rest of the circuitry in the project, or at worst, a slight modification of the existing supply.

In this article, we will explore how the Norton op amp works, discuss its relative advantages and disadvantages, and show a number of practical applications for it.

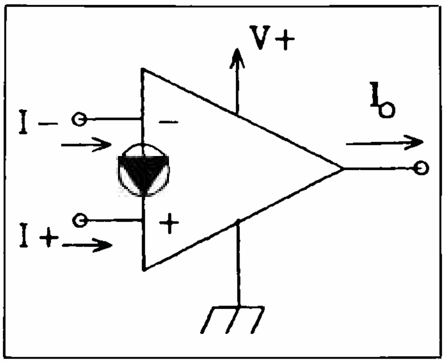

Fig. 2. Schematic symbol for single-polarity power supply Norton current-differencing op amp. Note arrow symbol between inputs.

Technical Details

Shown in Fig. 1 is the schematic diagram of a common general-purpose operational amplifier with its input/feedback network in place. With negative feedback, the gain of this circuit is calculated using the formula Gain = R1/R2 and input impedance is simply the value of *R2*. The major significance of the Fig. 1 circuit for purposes of this examination of the Norton current-differencing op amp is the existence of the V + and V − terminals, both of which are referenced to a common circuit "ground" point. Now contrast Fig. 1 with the current-differencing op amp shown in Fig. 2 (disregarding the input/feedback resistor network). Here you find that all that is needed is V + referenced to circuit ground.

The Norton op amp is called a "current-differencing" amplifier because its output current is the difference of the currents applied to the inverting (−) and noninverting (+)

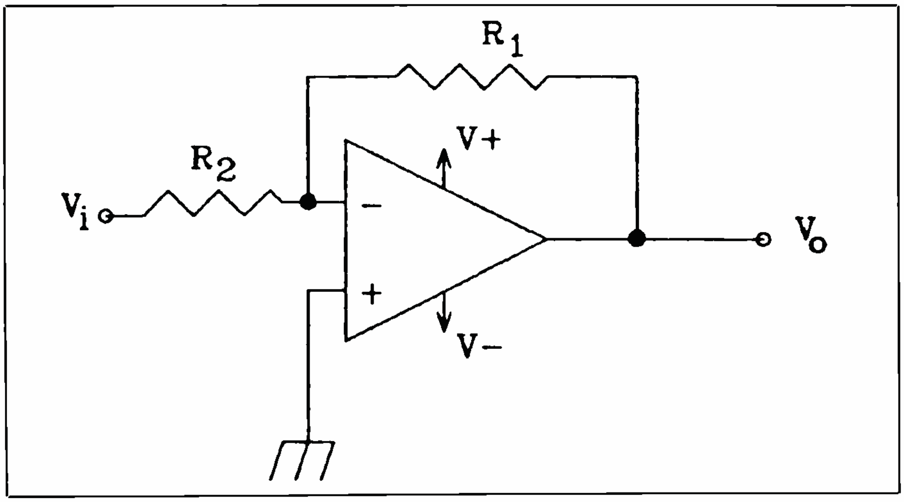

Fig. 1. Standard operational amplifier circuit with negative feedback requires a dual-polarity power supply. Simple gain (A) and input-impedance (Z_{in}) formulas simplify designing it into circuits.

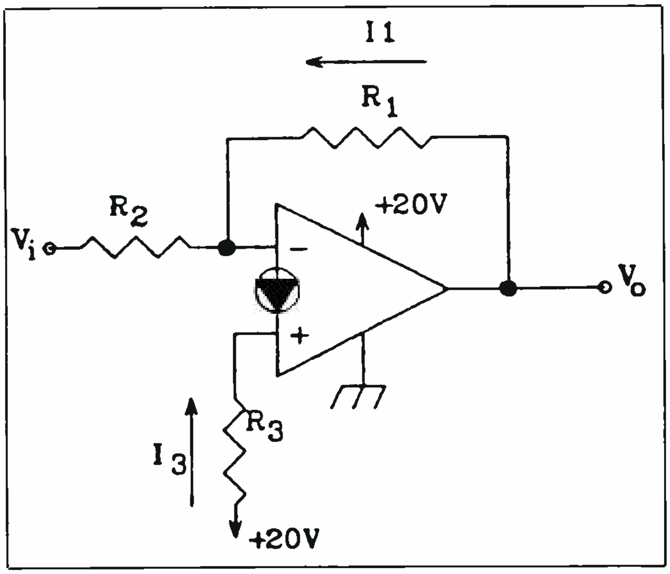

Fig. 3. Biasing for inverting Norton op amp circuit is slightly different from that of standard operational amplifier.

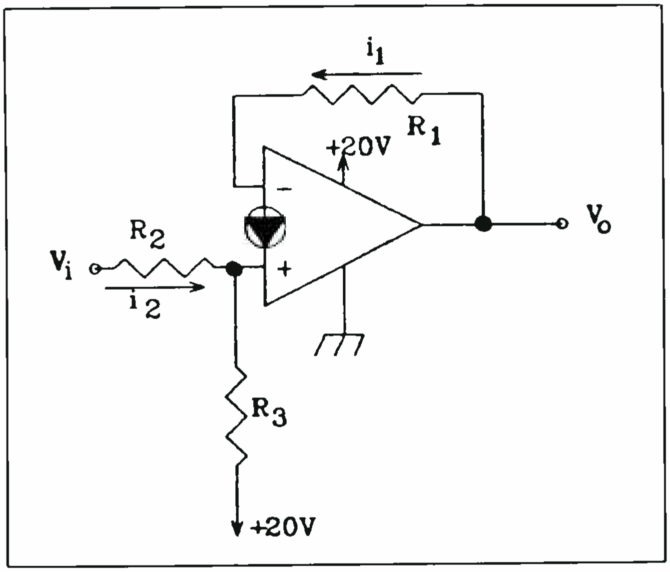

Fig. 4. Noninverting Norton op amp circuit.

inputs when the device is connected in an open-loop configuration. Conversely, the conventional op amp is a *voltage*-differencing amplifier because its output is the difference of the voltages applied to its two inputs.

Obviously, because the Norton op amp does not need a dual-polarity power supply, its use can simplify circuits that otherwise do not need dual supplies.

For proper operation, the Norton current-differencing op amp requires biasing, which is accomplished very simply by applying a voltage through a single resistor, shown as *R3* in Fig. 3. Both op amp input terminals are at one diode drop above ground, which is typically 0.6 volt. Therefore, to bias the steady-state output voltage to half the power-supply voltage, the value selected for *R3* should be twice that of *R1*.

If *R3*'s value is 1 megohm, I_3 will be 20 microamperes. The negative-feedback property of the Norton op amp makes the current going into the amplifier's input terminals equal. This is the analogy of the typical operational amplifier that has both input voltages equal with negative feedback. Hence, I_3 will be equal to the same 20 microamperes of I_1. So output voltage V_o is set to 10 volts if *R1* is 500,000 ohms. It is easy to see that the Q point of this amplifier can be changed at will simply by changing the value of *R3*. In this example, 10 volts was chosen because it allows for a maximum swing of 10 volts peak-to-peak.

Gain calculation is almost as straightforward and simple. Since the input currents to the Norton op amp must be equal, any fluctuating current through *R2* must be compensated for by an equal but opposite fluctuation through *R1*. Therefore, the current through *R2* is equal to but opposite of the current through *R1*. Mathematically, this works out to $V_i/R2 = -V_o/R1$, and gain is simply $A = V_o/V_i = -R1/R2$, just as with the conventional operational amplifier.

A noninverting amplifier is as simple as a single connection change from the original Fig. 3 inverting circuit, as shown in Fig. 4. Gain calculation with the Norton op amp connected as shown is the same as for the inverting version. That is, changes in current through *R2* are compensated for by changes through *R1*. This time, however, they are equal in magnitude and direction (they do not

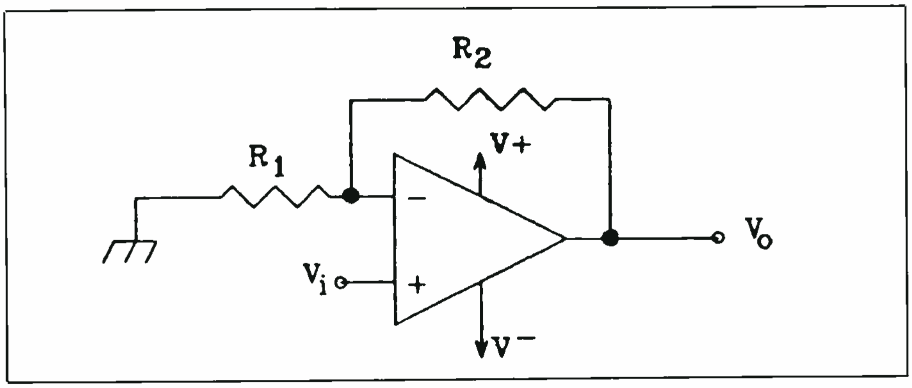

Fig. 5. Noninverting conventional op amp circuit.

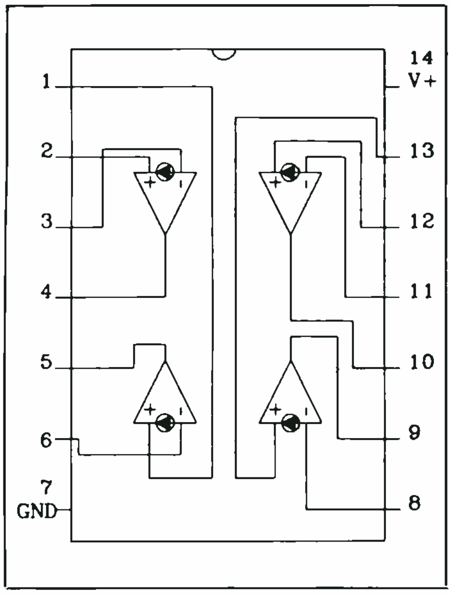

Fig. 6. Pinouts and internal details for the LM3900 quad Norton current-differencing op amp.

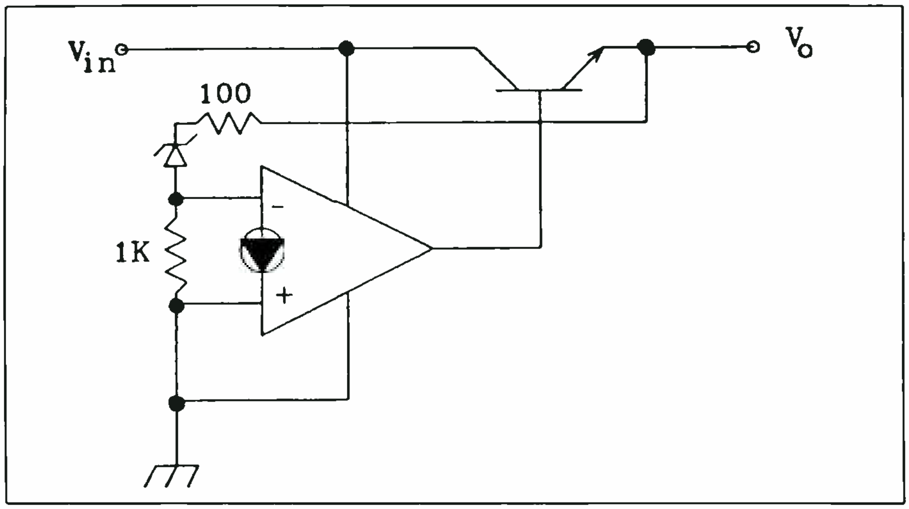

Fig. 7. Norton op amp voltage regulator.

oppose each other). Therefore, gain is $V_i/R2 = V_o/R1$ or $V_o/V_i = R1/R2$. The conventional op amp connected for noninverting amplification has a gain of $(R1/R2) - 1$, as illustrated in Fig. 5. This gain formula is not nearly as "clean" as is possible with the Norton op amp.

Current-differencing op amps may not be as common as conventional op amps, but they are available. A typical such one is the LM3900, which is a quad current-differencing op amp housed in a 14-pin dual in-line package (DIP). Pinouts and internal details for the LM3900 are shown in Fig. 6.

A wide supply voltage range that spans 4 to 36 volts dc is featured for the LM3900. Furthermore, the outputs of each of its amplifiers are short-circuit protected to assure durability.

Practical Applications

Typical applications for this device include inverting and noninverting amplifiers, voltage regulators, oscillators, Schmitt triggers, voltage comparators, logic gates and active filters. In the remainder of this article, we will explore these applications. As you work with the Norton current-differencing op amp, other applications are almost certain to suggest themselves.

• *Voltage Regulator.* The schematic diagram of a very simple voltage regulator built around the current-differencing operational amplifier is shown in Fig. 7. The zener diode provides feedback for proper regulation and bias of the pass transistor whose base is driven by the output from the op amp.

The input to the Fig. 7 circuit must be at least 2 volts greater than the intended regulated voltage to obtain proper operation. Also, the pass transistor must be a power type that can easily handle 25 percent greater than the maximum current you wish to obtain from the regulator.

• *Voltage Comparator.* Figure 8 shows the schematic of a simple current-differencing voltage comparator circuit. Use of this circuit eliminates the need for additional integrated circuits in applications where a voltage comparator is required. Output voltage-swing range can be as wide as the supply voltage in this comparator circuit.

• *High-Pass Filter.* An active filter can provide gain as well as filtering and has traditionally used operation-

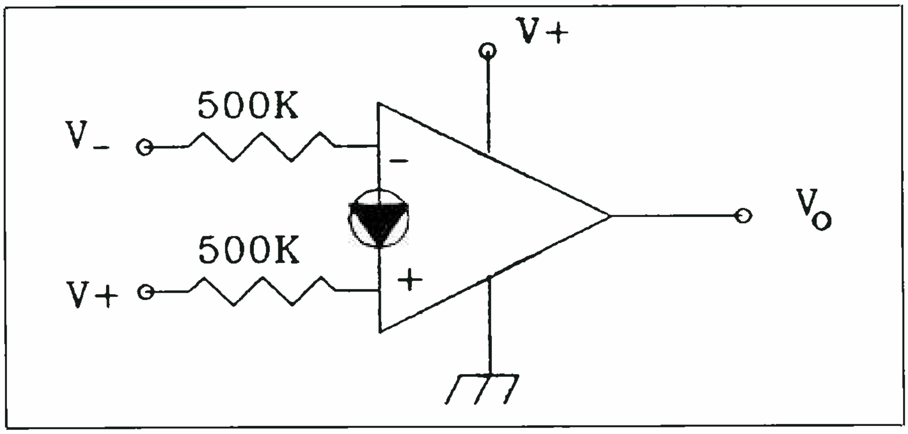

Fig. 8. Norton op amp voltage comparator.

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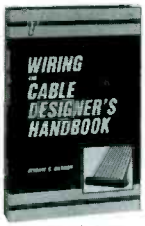

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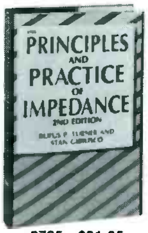

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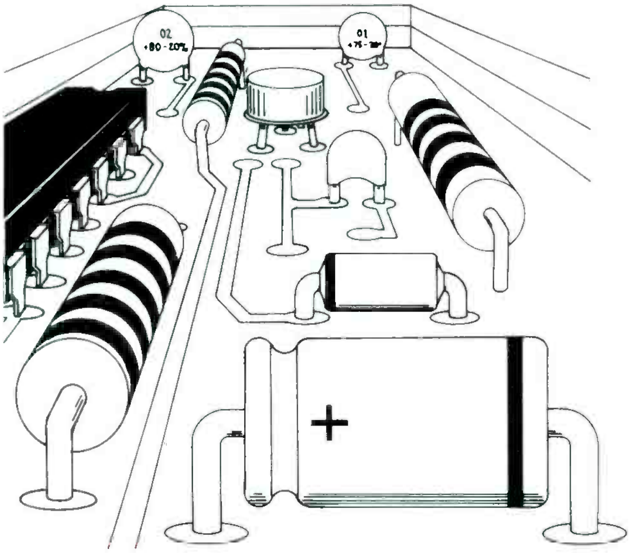

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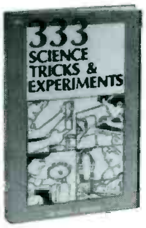

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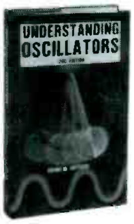

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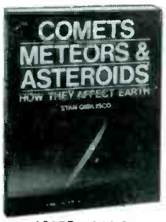

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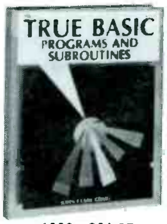

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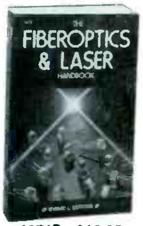

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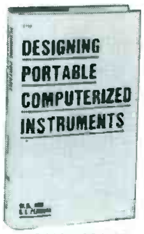

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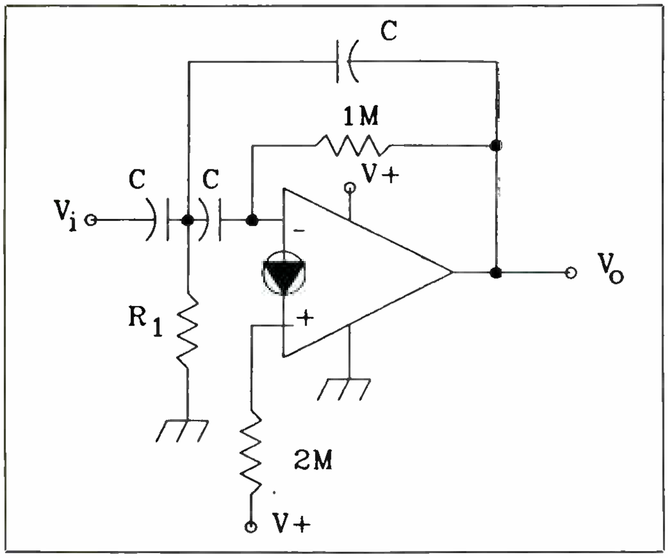


Fig. 9. High-pass active filter built around a Norton current-differencing op amp.

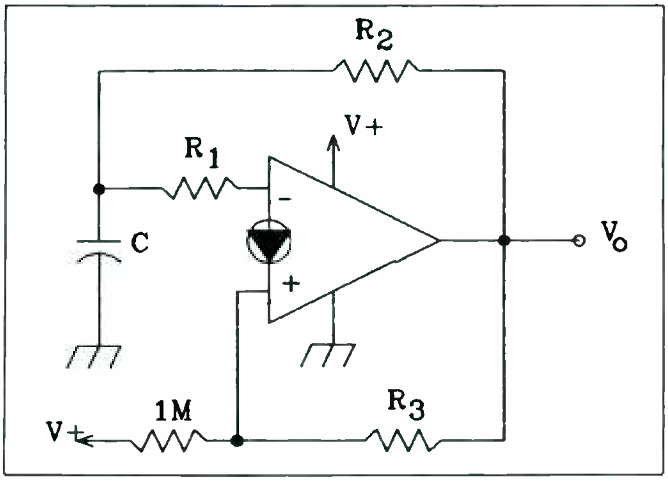


Fig. 10. Norton op amp square-wave oscillator circuit.

al amplifiers as the active element. A passive filter, on the other hand, provides no greater than unity gain from input to output (usually less, due to inherent circuit losses). Figure 9 is the schematic diagram of a high-pass active filter built around the LM3900 current-differencing op amp. Its cutoff frequency is calculated using the formula:

$$f = \frac{2\sqrt{R2/R1} - R3}{4\pi R2C} \text{ Hz}$$

Feedback resistor *R2* in Fig. 9 is set at 1 megohm due to the biasing requirements discussed above. This being the case, the values of *R1* and *C* determine the cutoff frequency (the frequency at which gain is very low below this value). Some common cutoff frequencies/*R1* values (the value of *C* is 470 picofarads in all cases) include: 5 kHz/3,300 ohms, 3 kHz/10,000 ohms and 1 kHz/47,000 ohms.

Different resistor and capacitor values will yield different cutoff frequencies. In fact, by judiciously selecting component values, you can tailor a cutoff frequency that is within a cycle or two of what you need for any given application.

• *Square-Wave Oscillator.* Figure 10 is the schematic diagram of a square-wave oscillator built around a current-differencing op amp. This oscillator's output can swing over the entire supply voltage range at the selected frequency.

Frequency of oscillation of the square-wave oscillator is calculated using the formula:

$$f = \frac{R3 - R1 - R2}{2\pi R1R2C} \text{ Hz}$$

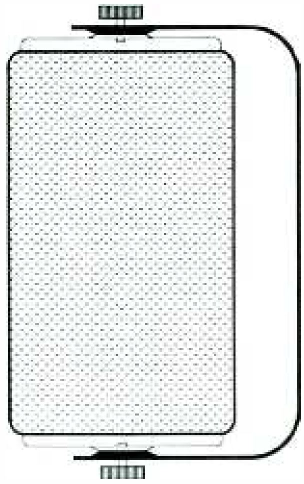
The output voltage from the Fig. 10 oscillator will swing from reference ground to approximately the entire level of the V+ supply line. The values of *R1* and *R2* are 470,000 and 30,000 ohms, respectively, for biasing purposes. Therefore, the values of *R3* and *C* determine actual frequency of oscillation.

In Summary

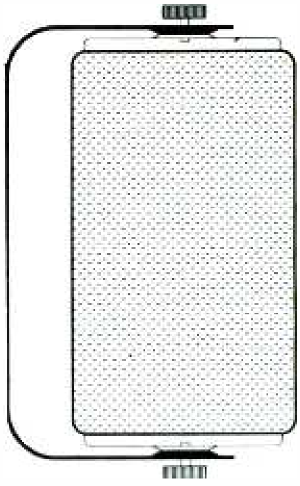
The Norton current-differencing operational amplifier is a versatile building block with which everyone involved in circuit design should become familiar. Its broad range of applications reach far beyond the few discussed here. Our coverage was geared more toward giving you an idea of this device's versatility than toward a run-down of actual practical applications to which it can be put. In this light, our discussions are meant to get you started in using a practical alternative to the conventional op amp by providing the theory needed as a launch point.

Our focus has been on the real-world extension of the current-differencing operational amplifier in the form of the LM3900 quad Norton current-differencing op amp in an easy-to-use DIP package. In addition to being readily available, this device is easy to use in terms of both physical hookup and biasing theory and practice. Having four current-differencing op amps in a single integrated-circuit package is a benefit, too, because it saves space in a circuit and reduces socket requirements in circuits where more than one op-amp stage is needed.

So the next time you need an operational amplifier in your circuit design and cannot justify the added expense, size, weight and circuit complexity of a second power supply, remember that the LM3900 current-differencing op amp offers a low-cost, practical alternative to the conventional op amp. Its use also eliminates the need for more complex gain and biasing equations. ME



Building & Applying Active Minispeakers



By installing a driving amplifier inside its aluminum enclosure, you can greatly enhance a minispeaker's versatility

By Joseph O'Connell

Aluminum minispeakers are generally characterized by good sound as well as compact size. Originally designed for use in home hi-fi systems, they have found their way into automobiles and other vehicles, where space is more at a premium than in the home, and attached to the sides of portable radios, where size and weight are important. As versatile as they are, though, a pair of minispeakers can be greatly enhanced by building into each its own driving amplifier, as described here. This will make the speakers operate with signal sources that ordinarily cannot drive them, such as personal radio/cassette players, portable CD players and similar low-power devices. The amplifiers boost the signals from these sources to drive the speakers to quite loud levels. With greater power and high-quality signal sources, these "active" speakers produce better sound at higher volume than do typical boom boxes.

Applications for these active speakers are not limited to portable listening. For example these speakers can be used as the heart of a temporary stereo system in a car or other vehicle without requiring a separate power booster. They are also simple to remove to prevent theft and can easily be moved around inside a vehicle to obtain the best acoustical effect. Electronics enthusiasts can also use one on their testbenches as an audio signal tracer and hum detector. Around the home, an active speaker can be used as an intercom station and for setting up a stereo system for best effect.

Because power requirements are flexible, plenty of other uses suggest themselves. Finally, none of the minispeakers' original usefulness is lost when amplifier circuits are added. These speakers can still be used with a stereo system the way they were designed to be simply by flipping a switch.

About the Circuit

Use of a pair of power integrated circuits (*IC1* and *IC2*) greatly simplifies the amplifier circuit shown in Fig. 1. Few discrete components are needed, and the project is easier to build. Also, the low component count makes for an amplifier circuit that requires very little real estate. This is an important consideration when the amplifier is to be installed inside a tight enclosure from a mechanical point of view because the amplifier takes up less of the speaker's internal volume so that it has only a minimal effect on sonic characteristics.

A single LM383 power amplifier IC and a few passive components could have been used to make a simple amplifier circuit. However, the two shown in a bridged configuration allow the speaker output to be taken from across the outputs of two nearly identical amplifiers (instead of between an output and ground) to provide increased maximum power and eliminate the need for a bulky and distortion-producing output capacitor.

In the Fig. 1 circuit, the two amplifier ICs are connected so that they are out-of-phase with each other. When the output of one is positive, the output of the other will be negative. Placing a speaker between the IC outputs allows current to flow from one to the other. The advantage of this arrangement is that the speaker can receive almost the full power supply voltage in either direction on full-excursion input signals. This arrangement is necessary in mobile applications where the available supply voltage is relatively low (12 volts dc) and must be carefully maximized in an amplifier circuit.

With a 12-volt dc power supply, the unloaded output of the the amplifier circuit can theoretically be ±10 volts, for a total swing of 20 volts. Because they get a good deal of power from a low-voltage supply, bridged circuits like the one shown in

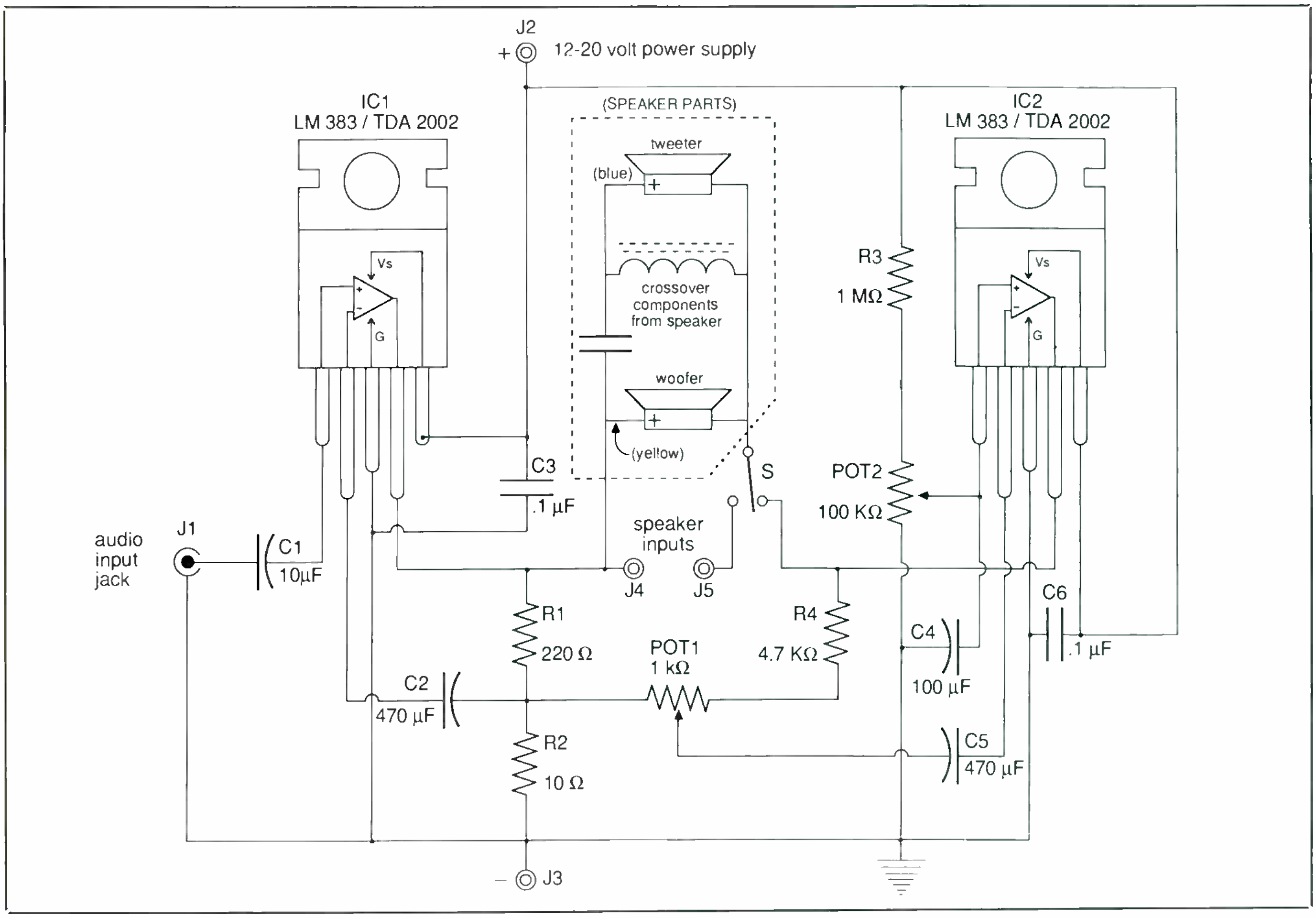


Fig. 1. Schematic diagram of amplifier required for each minispeaker.

Fig. 1 are commonly used in car stereos and power boosters.

Input signals are fed into the amplifier circuit through *J1* and are then capacitively coupled to the noninverting (+) input of *IC1* through *C1*, which blocks dc and passes only the audio signal. After undergoing amplifications, the audio signal at the output of *IC1* is applied to the *R1/R2* voltage divider. The divider feeds a portion of the amplified output signal back into *IC1* through its inverting (−) input to set the gain via the usual negative-feedback method. Hence, the voltage gain of *IC1* is set by (R1 + R2)/R2. Capacitor *C2* blocks blocks ac and feeds back only the audio signal component.

The voltage divider also applies a portion of *IC1*'s output signal to the inverting input of *IC2* through *POT1* and *C5*. Because the inverting input is now being used, the output of *IC2* is out-of-phase with the output of *IC1*. Negative feedback that sets *IC2*'s gain comes from the voltage divider made up of *R4, POT1* and *R2*. During calibration, the gain of *IC2* can be adjusted by *POT1* to precisely match the gain of *IC1*.

Resistor *R3* and trimmer potentiometer *POT2* apply a small dc bias to the noninverting input that is greatly amplified by and appears at the output of *IC2*. Potentiometer *POT2* provides a means for adjusting the amount of dc in *IC2*'s output to allow the dc offset between the two ICs to be nulled to zero.

As designed, the amplifier's specifications make it suitable for portable use. With a 13.8-volt dc power supply, which is typical for automotive electrical systems, the amplifier will produce a clean 8 or 9 watts of driving power into 4 ohms. The limitation on output power depends primarily on the supply voltage—not the ICs. The ICs can safely accommodate up to 20-volt dc power supplies. The greater the supply voltage—up to the 20-volt maximum, of course—the greater the power delivered to the speaker load.

At 13.8 volts dc, playing a music signal at maximum volume into 4 ohms, the amplifier draws an average of about 500 mA. Quiescent current (no input signal) is approximate-

PARTS LIST (for one speaker)

Semiconductors

IC1,IC2—LM383 or TDA2002 audio amplifier (Radio Shack Cat. No. 276-703 or equivalent)

Capacitors (25-volt)

C1—10-μF electrolytic

C2,C5—470-μF electrolytic

C3,C6—0.1-μF disc

C4—100-μF electrolytic

Resistors (¼-watt, 10% tolerance)

R1—220 ohms

R2—10 ohms

R3—1 megohm

R4—4,700 ohms

POT1—1,000-ohm pc-mount trimmer potentiometer

POT2—100,000-ohm pc-mount trimmer potentiometer

Miscellaneous

J1—Phono jack

J2 thru J5—5-way binding post

S—Spdt miniature toggle switch

Two aluminum minispeakers (Radio Shack Realistic Minimus 7 or similar—see text); printed-circuit board, plus extra pc blank for switch panel (see text); materials for making portable carrier (see text); machine hardware; audio cable; speaker cable; hookup wire; solder; etc.

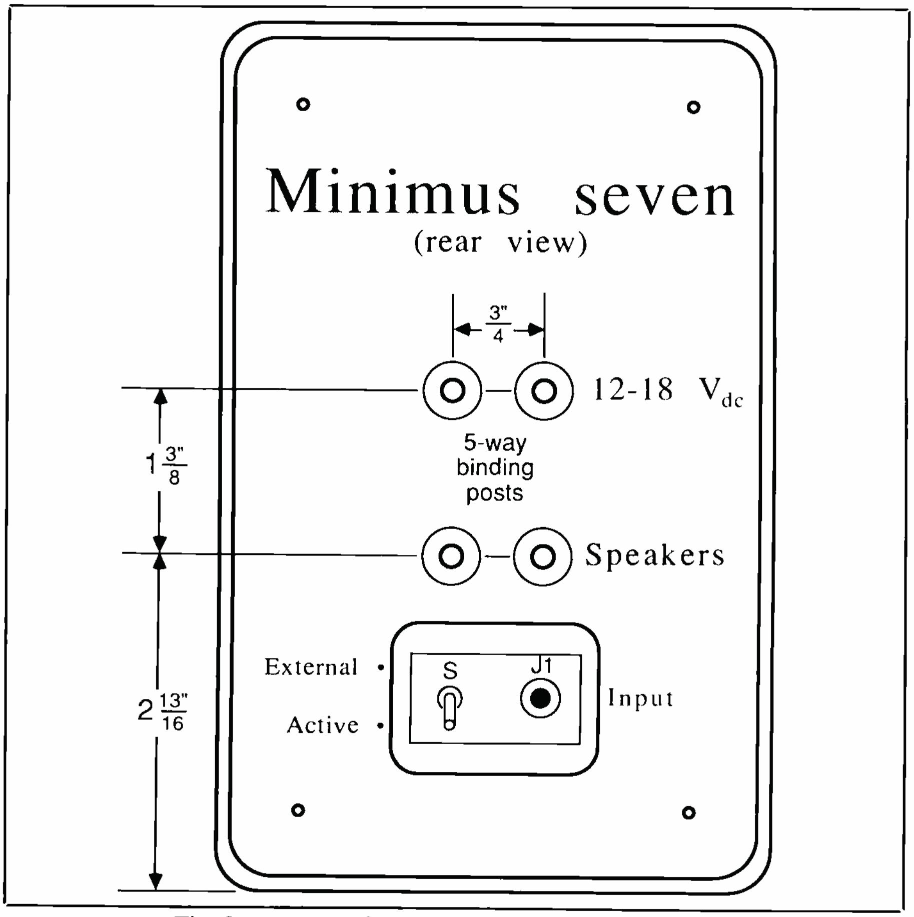


Fig. 2. Rear panel details of modified minispeaker.

ly 125 mA. The low current drain makes the amplifier suitable for portable use with rechargeable cells.

Modifying the Speakers

The first step in building the circuit is to open the speaker (or speakers if you are modifying a pair for stereo use) to gain access to the interior. With some minispeakers, you might be able to remove a few screws and drop off the back. However, the backs of the Realistic Minimus 7 speakers specified in the Parts List are sealed. (If you use a minispeaker other than the Minimus 7, make sure it has an aluminum enclosure and has sufficient room inside to accommodate the amplifier circuit assembly without interfering with the drivers, crossover network or any connectors there might be.) This means that all access to the interior of the enclosure must be through the holes in which the drivers are mounted. Therefore, you will first have to pry off the protective aluminum grille. The following modification procedure is based on the Minimus 7 speaker; if you are using a different speaker, make suitable adjustments in the procedure.

The best place to start prying off the grille is at one of the corners where the risk of deforming the grille is minimal. Small pieces of sticky clay are all that hold the grille in place. So the grille should release without much persuasion.

Once the drivers are exposed, carefully remove them. As you remove each driver, make a note on a piece of paper its physical orientation and which color wire goes to which terminal. You will need this information to successfully reassemble the speaker system.

Set aside the drivers in a safe place. Then reach into the enclosure and remove the fiberglass batting that serves as acoustical damping. It is a good idea to wear gloves for this step, especially if your hands are particularly sensitive or have small cuts. The type of fiberglass batting used in minispeakers produces small splinters of glass when handled. If the splinters pierce your skin, they will be painful and difficult to remove.

Inside the enclosure on the rear wall is a plastic plate on which are mounted the crossover components. Remove this panel, which will be replaced by the amplifier circuit-board assembly. Desolder from the panel the crossover capacitor and inductor coil and set both aside for mounting on the amplifier circuit board later. It is also a good idea to save the wires from the crossover network, since they are easily removed and have the proper connectors for the speakers.

You might want to replace the original crossover capacitor with a better-quality one. An audible improvement can be heard if you replace the nonpolarized capacitor that comes with the speaker with a polystyrene or film type of the same value. For a substantial improvement without going to extreme lengths, almost any type of replacement capacitor is better than the original.

Referring to Fig. 2, drill four holes through the rear of the enclosure for mounting 5-way binding posts. Size these holes to accommodate the threaded mounting screws and the shoulders of the insulating fiber washers that come with the binding posts. Set aside the enclosure.

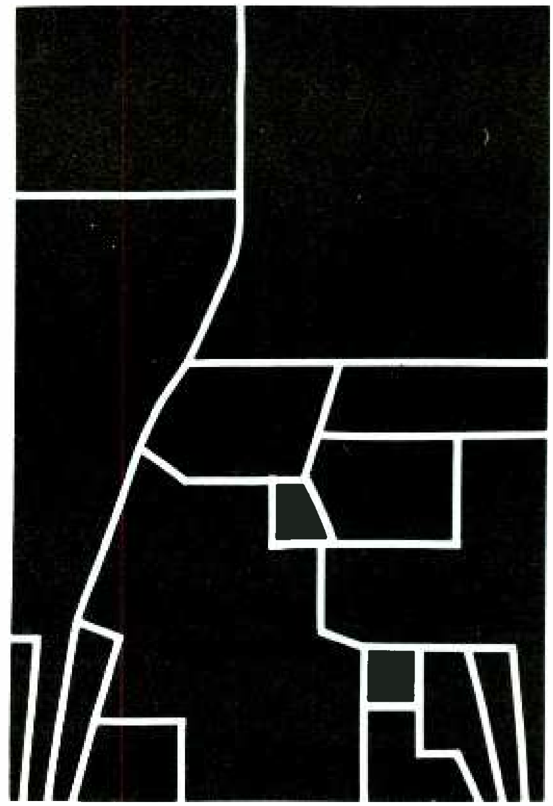


Fig. 3. Actual-size etching-and-drilling guide for printed-circuit board.

Building the Amplifier

Printed-circuit board construction is highly recommended for the amplifier circuits. As you can see in the actual-size etching guide in Fig. 3, holes must be drilled only for the two potentiometers and the resistors. Since all components mount on the foil side of the board, no holes are needed for the leads of the larger components and wires that go on the board; these can simply be "spot" soldered to the copper lands in much the same manner as you would solder surface-mount components in place.

Prepare a 3¼" × 1¼" × ⅛" aluminum plate by drilling the mounting holes for the ICs, phono jack *J1* and switch, as illustrated at the bottom in Fig. 4. Then drill the holes for the mounting hardware that will secure the plate to the inside rear wall of the enclosure using the same locations used by the screws that secured in place the plastic panel on which were mounted the crossover-network components. (Use the plastic crossover-network plate as a template for locating and marking the mounting holes on the aluminum plate.) Also, drill a ⅛" hole in one of the lower corners of the plate. Locate the aluminum plate so that it completely fills the opening in the enclosure and *J1*'s and *S1*'s holes are centered in the cutout area. Loosely mount *IC1* and *IC2*, using 4-40 × ¼" machine screws lockwashers and nuts. Then solidly mount *J1* (along with its solder lug) and the switch on the aluminum plate, using the hardware supplied with them. Do not use insulators between the ICs and the aluminum plate.

Once the board has been etched and is ready for wiring, mount the amplifier and crossover components on the foil side exactly as shown in Fig. 4. As you solder one lead of a component to the board's land, hold it in place with your fingers, without moving, until the liquid solder has set. Then solder the other lead into place. (Note: It will be easier if you pretin the land locations and component leads and wires to which they attach with solder prior and then "sweat" the connections as you go.)

Secure the crossover coil to the surface of the board with double-sided tape, silicone cement or hot-melt glue. Pay close attention to electrolytic capacitors *C2, C4* and *C5* as you solder their leads into place. Use small-diameter insulating tubing on all leads that cross more than one copper land and insulated hookup wire for the wire jumper between the IC1/J2 and IC2/R3 lands. Mount the components with their bodies flat

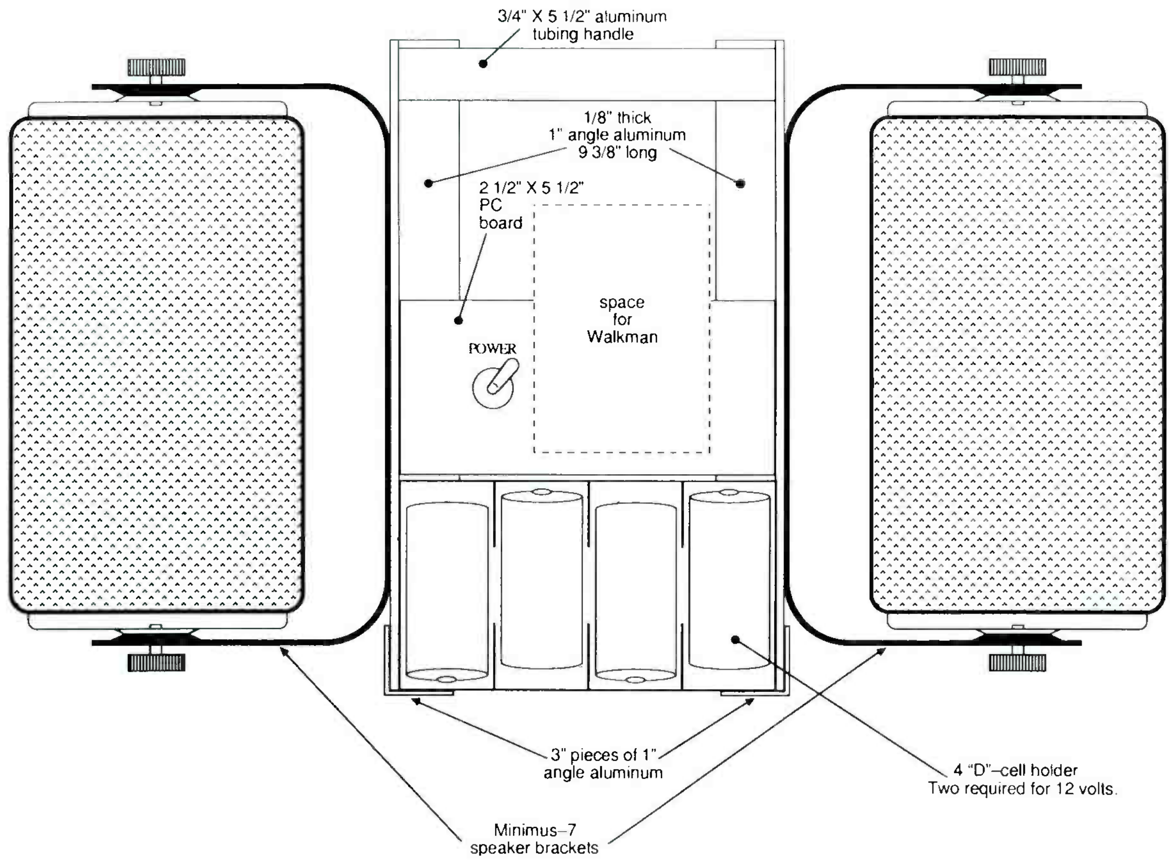
Building a Portable Carrier

An arrangement that has a handle and built-in battery power supply will let you use a Walkman-type radio/cassette player or portable Compact Disc player in a fully portable configuration. The portable carrier arrangement shown in the illustration provides vastly improved sound quality with lower distortion and noise and greater volume level, allows the speakers to be separated by up to 12 feet for better stereo separation, and allows you to tilt the speakers for best sonic effect without removing them from the carrier.

To be able to build the carrier, you need a pair of swivel-mount brackets for the Minimus 7 speakers (or whatever minispeakers you use instead). These brackets should also be used in your home or vehicle.

Since the power supply cells and signal-source device will have a direct effect on the size of the carrier, no dimensions are given in the drawing. Simply adjust the sizes of the elements that make up the carrier as needed for your particular combination of power supply and signal-source device.

Power Considerations. You want to build into the carrier a rechargeable battery supply that can deliver at least 12 volts to drive the active minispeakers. For reasonably long playing time, the cells selected should be no smaller than "D" size. If you use nickel-cadmium cells, you need 10 cells in all (each delivers 1.2 volts) for a 12-volt output. Specific battery requirements depend on how loud and how long you wish the speakers to be able to play between recharges. D-size Ni-Cd cells are available in different capacities, ranging on up to 4 ampere-hours (AH), though most of the commonly available ones are rated at only 1.2 AH. The 4-AH cells should keep the active minispeakers going for several hours but are quite expensive when you can find them. Lower-capaci-



Details of portable carrier show active minispeakers mounted via swivel brackets to both sides and spaces for battery power supply, signal-source device and power- switch/connector panel.

ty D-size Ni-Cd cells should be adequate for most applications.

If you really need long playing time at loud volume, it is more economical to use a 12-volt battery pack rather than make up a supply using individual cells and holders. Battery packs have other advantages, too. They are more compact, have higher current ratings and have fewer problem-causing contacts than do individual cells and holders. Common current ratings for battery packs are 1.8, 3, 5, 6 and 10 AH. Good sources for suitable rechargeable battery packs are Mouser Electronics and other mail-order houses.

If you want long playing time and do not mind the extra expense involved, you can use gelled lead-acid—or so-called "gel"—cells. These generally have higher current capacities than Ni-Cd cells. Each has an output of 1.5 volts, reducing the number of individual cells needed for a given power-supply output voltage, and is available either singly or as part of multiple-cell batteries. Three 6-volt gel cells in series make an 18-volt battery that is near the maximum recommended voltage for the power lines to the active minispeakers. The only real difficulty with gel cells is finding a source for them.

If you do not plan to use the minispeakers as a portable sound system very often, separate cells (as opposed to a battery pack) is probably a better idea. When not in use, you can remove the cells from their holders and use them in other battery-powered devices. An advantage of separate cells is that it is easy to tap off a lower voltage between cells (typically 3 to 6 volts) to power whatever is being used to drive the speakers. If you do use a low-voltage tap for this purpose, make sure you take it from between cells referenced to the negative side of the battery to give the signal source and minispeakers' amplifiers the same "ground" reference.

Physical Considerations. The carrier illustrated in the drawing can be built from six pieces of aluminum. Two pieces of angle aluminum form the sides to which the speaker brackets attach. Each side piece can be supported by a 3-inch "foot" made of angle aluminum attached at a right angle to the bottom. The aluminum brackets at the bottom are the only points that provide support and can be equipped with small rubber feet to prevent marring any surface on which the carrier is placed.

Four-cell battery holders attach front and rear to the side pieces, which can be moved closer together or farther apart to accommodate a battery pack, if desired. It is the size of the dc power supply that has the most influence on the size of the carrier.

In the middle of the carrier, a piece of pc board can be attached to provide the means for mounting the power switch for the battery supply (wire it in series with the supply's positive line) on the front and two more D cells on the rear, for a total of 10 cells with the two four-cell units attached to the side pieces. You can etch and drill the pc board to provide a convenient means for making the connections to the battery supply, power switch and speaker cables. Your signal source can also be hung off the pc board via its belt clip or be fastened to it more securely with machine hardware.

For a handle, you can use a ¾-inch-diameter aluminum tube slid onto a length of aluminum bar stock mounted by its ends to the side pieces of the carrier. Alternatively, you can shape a piece of wood into a comfortable handle or use a nylon or leather strap or even a door handle.

Use 6-foot lengths of standard speaker cord to deliver power from the battery supply to the speakers. When wiring the cord into the supply and fastening the connectors to the other end, make sure to observe proper polarity. Also, use 6-foot-long shielded audio cable with a phono plug at the speaker end and an appropriate connector to match the output of whatever device you are using to drive the active speakers at the other end.

against the surface of the board. Trim away any pin length of the potentiometers and lead lengths of any other components whose leads plug into holes in the board flush with the bottom of the board.

Orient the aluminum-plate assembly with respect to and about ⅛" from the pc assembly as shown in Fig. 4, carefully spread the pins on the ICs so that they match up with the lands on the pc board, and solder the leads to the lands. Note that the center lead of each IC does not go to any land on the pc board. These ground leads are tied directly to the metal mounting tabs on the ICs and to each other through the aluminum plate and to circuit ground through the wire that connects *J1*'s ground lug to circuit-board ground.

Do not cut off the center pins of the ICs. Instead, bend them upward at a right angle to the ends of the ICs. Trim both leads of the two 0.1-microfarad capacitors (*C3* and *C6*) to ½" in length. Form a small hook in one lead of each and wrap these leads separately around the center leads of the ICs. Tack solder the other lead of *C3* to the J2 (lower-left-most) pad on the pc board. Similarly, tack solder the other lead of *C6* to the pad to which *R3* and the jumper wire connect.

Now solder appropriate lengths of insulated hookup wire between the points indicated on the circuit-board assembly and the switch and *J1*'s ground lug. Cut each lead of *C1* to 1" in length, slip over each a ½" length of insulating tubing, and solder the capacitor between the indicated pc-board land and the center contact of *J1*. Solder the free ends—not the connector ends—of the wires removed from the speaker's crossover network to the indicated lands on the pc board. Then strip ¼" of insulation from both ends of four 5"-long stranded hookup wires, twist together the fine wires at both ends and tin with solder. Solder one end of each wire to the J2 and J4 lands on the pc board, the lower lug on the switch and the solder lug on *J1*.

Mount the four binding posts on the rear wall of the enclosure via the holes you drilled earlier. Three of these binding posts must be fully insulated from the metal of the enclosure with the shoulder fiber washers or plastic bushings supplied with them. If such washers or bushings are not supplied, you must obtain them separately. The fourth binding post should not be isolated from the metal enclosure. Eliminate its shoulder fiber washers or bushing, if any, and replace them with a pair of lockwashers.

Adjustments

Before an amplifier circuit can be installed inside a speaker enclosure it must be adjusted so that it will work properly. For this step, you need a bit more heat sinking than the aluminum plate on which *IC1* and *IC2* are mounted can provide, which is the reason why you drilled that extra hole in one of the corners. Bolt the assembly to a metal object—even a much larger aluminum plate than you are using in the project—to assure good heat sinking.

To perform the adjustment of the amplifier, you also need an oscilloscope, audio signal generator, voltmeter and 8-ohm power (say, 20-watt or more) resistors. You need two resistors for each amplifier you built, one for each speaker driver. The voltmeter and resistors should be easy to come by. If a signal generator is not available, a signal source playing a slow piano will do. However, there is really no adequate substitute for the oscilloscope.

Connect a power resistor to the amplifier circuit where each driver will be connected and plug the signal generator's output cable into the amplifier's input. Set the signal for a 50-millivolt rms output at about 1,000 Hz (1 kHz). Then connect an adequate dc power supply to the amplifier circuit, observing proper polarity. Turn on the signal generator and use the oscilloscope to check each IC's output separately.

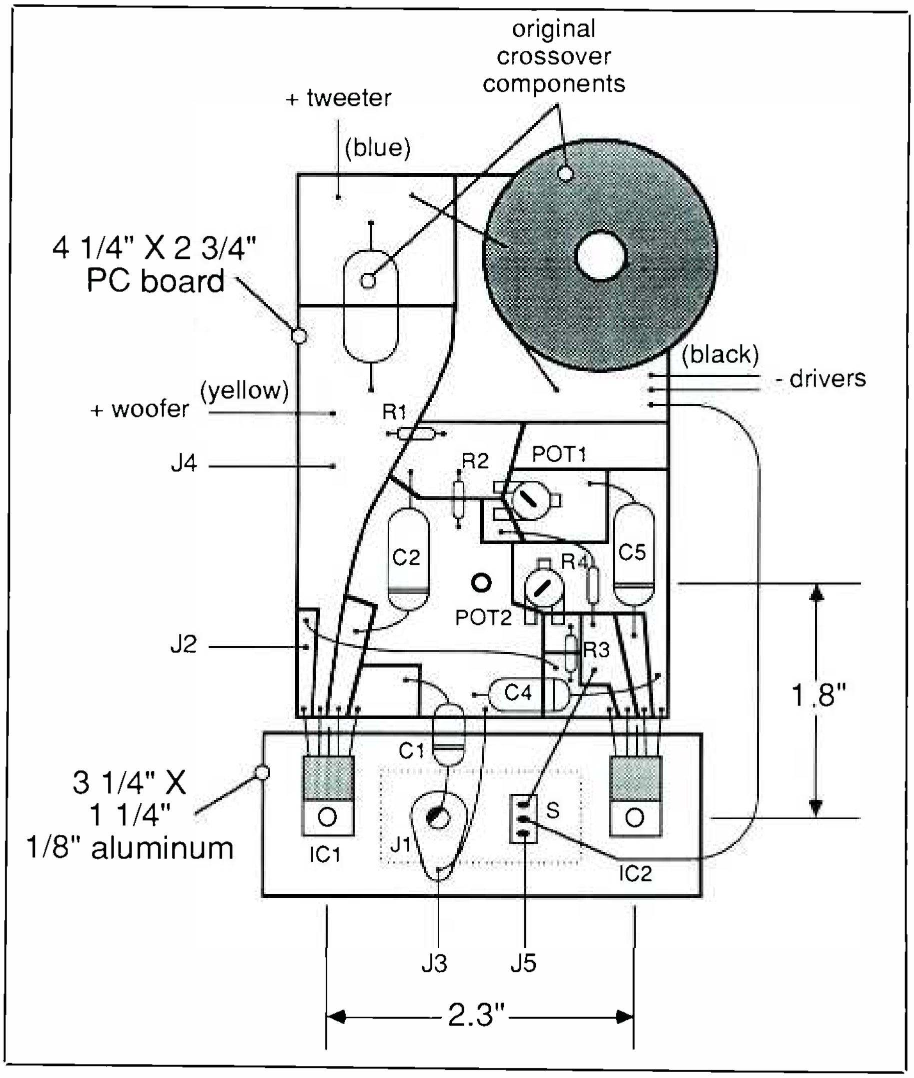


Fig. 4. Wiring guide for pc board. All components mount on foil side of board.

When checking the IC outputs, set the oscilloscope for ac input, attach its ground wire to amplifier circuit ground and use the "signal" input probe to verify that the amplifier's output resembles its input. Adjust *POT1* so that the outputs of the two ICs are roughly equal in amplitude.

Next, connect the oscilloscope between the outputs of both ICs. Before doing this, however, disconnect the scope's ground. Because neither output of a bridged amplifier is tied to ground, it should not be measured with a grounded device. Since the signal generator and oscilloscope probably share the same three-conductor ac power line, they will have the same ground. This being the case, connecting the oscilloscope across the amplifier's outputs in the next step would short out whichever IC got the scope's ground wire. To prevent this from happening, temporarily unground the oscilloscope at its power outlet. Use a three-conductor adapter with its third terminal not connected between the scope's line-cord plug and the ac receptacle. (Caution: Do not forget and leave the scope permanently ungrounded.)

(Continued on page 90)

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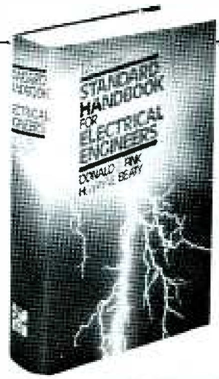

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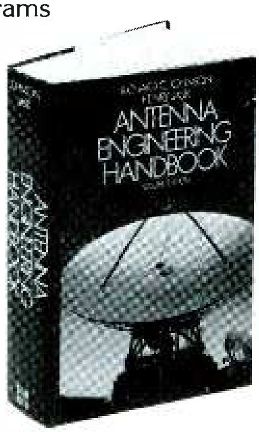

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PC Express Revisited

Author illustrates how to break the 8-MHz barrier and cures some reported boot-up problems

By Crady VonPawlak

Readers who implemented the "PC Express" (Modern Electronics, May 1987) on their personal computers have already entered the world of "turbo" computing. To those of you who had difficulty obtaining the 8-MHz 8237-2, your existing 5-MHz version (i.e., an 8237-5) of that integrated circuit will suffice.

Since writing about the PC Express, I learned that a very few of you had boot-up problems in the "turbo" mode, which will be addressed here. Also, some readers have expressed interest in increasing operating speed beyond the 8-MHz barrier, which can be done, as you shall see.

Boot-Up Problems

It seems that some clone motherboards utilize too brief a power-up reset delay, causing erratic boot-up. All PCs and compatibles have a "power-up reset circuit" that holds pin 21 of the microprocessor "high" for at least four clock cycles (usually one or two seconds, which is quite a few more than two clock cycles). This allows all the associated circuitry to "settle down" before accessing the system BIOS in ROM and getting under way. This being the case, why should anyone experience cold-start problems?

The difficulty starts when this seemingly adequate reset period is still not long enough. When a system is designed to operate at, say, 4.77 MHz and you push it to, say, 8 MHz or even 12 MHz, something must be modified to accommodate the higher clock rate. Often this is simply a matter of upgrading key components, as was the basis of the PC Express. In some cases, however, we must go a step further. If you performed the PC Express modification precisely and your system boots properly only in the "slow" mode, the problem is likely to be in the power-up reset.

The schematic shows one method of achieving a longer reset period on power-up. The components used are not critical, but they should at least be very close to those noted. Point-to-point wiring, Wire Wrap or etched-board construction are all fine. When completed, simply solder the three leads from your reset board with a 25- to 30-watt grounded pencil soldering iron directly to the solder pads on the underside of your motherboard at the points indicated (keep in mind that when you look at the pins from the underside of the motherboard that their numbering scheme is the reverse of the top-view scheme!) and then carefully assemble your computer.

As for installation, use care and work slowly. Motherboards are not cheap! The only advice I can offer as to the reset board location is to be sure that its components do not come into electrical contact with anything. You could enclose the finished assembly in a small plastic box and hide it between a disk drive and the power supply as one alternative.

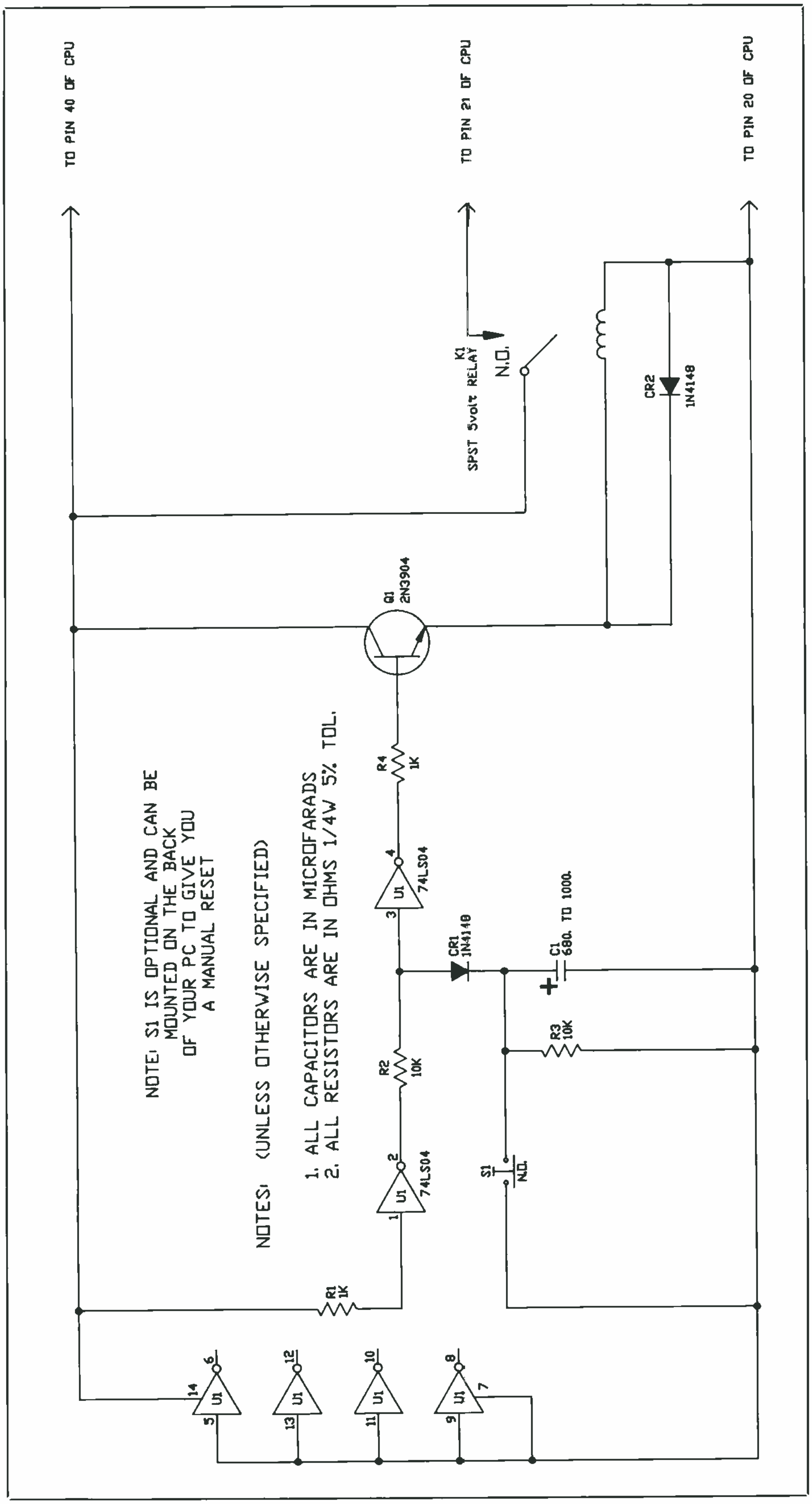
Breaking the 8-MHz Barrier

Once you get used to working at 8 MHz *that* will seem slow, especially if you use Microsoft Windows or do any serious number crunching or graphics-intensive CAD work. One very practical alternative once you have completed the PC Express modifications is to push your system clock speed to 10 MHz or even 12 MHz! It *can* be done!

The extra mile you need to go to break the 8-MHz barrier consists mainly of replacing your 8284A clock generator with the 8284A-1 (this is the 10-MHz version, which generally works very well up to 12.5 MHz) version of that IC. These ICs are readily available at modest cost from a number of sources. If you have difficulty locating one, you can contact Intel PC products directly by calling 1-800-538-3373 for a distributor in your area.

Next, replace your 24-MHz Fox oscillator (or equivalent) with a 36-MHz version (as the 8284A-1 divides this frequency by three for stability, the output will be 12 MHz). If this proves to be too fast, then use the 30-MHz clock IC. (If you have difficulty getting this part, call Hamilton-Avnet at 203-643-3950, who assure me that they would sell it in single quantities.)

If you followed my recommendations for IC replacement in PC Express, the only anchors that may pre-



Power-on reset circuit for PC Express speed-up.

vent you from getting under way at 10 or 12 MHz are:

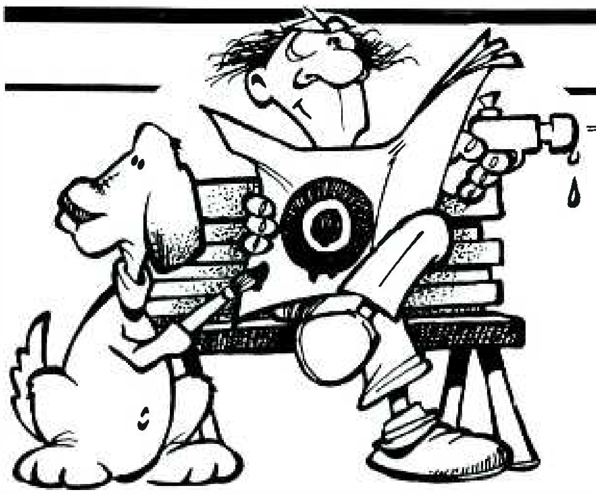
(1.) Your RAM chips, which may have to be upgraded from 150-nanosecond -15s to 120-nanosecond -12s

(2.) Your 8087 math coprocessor that now must be a -2 version (or -8 version, depending on manufacturer)

(3.) A NEC V20-8 that will not go beyond 10 MHz (unlikely)

(4.) You need the power-on circuit described above. This can be determined by wiring a normally-open pushbutton switch between pins 20 and 40 of the CPU. Hold the switch closed for a few seconds during boot-up and see if it clears the problem.

Boosting speed to get full turbo power might take some experimentation, but I highly recommend you make the effort. The end results are amazing! The time you save in computing will pay you back over and over. **ME**



Audible Target

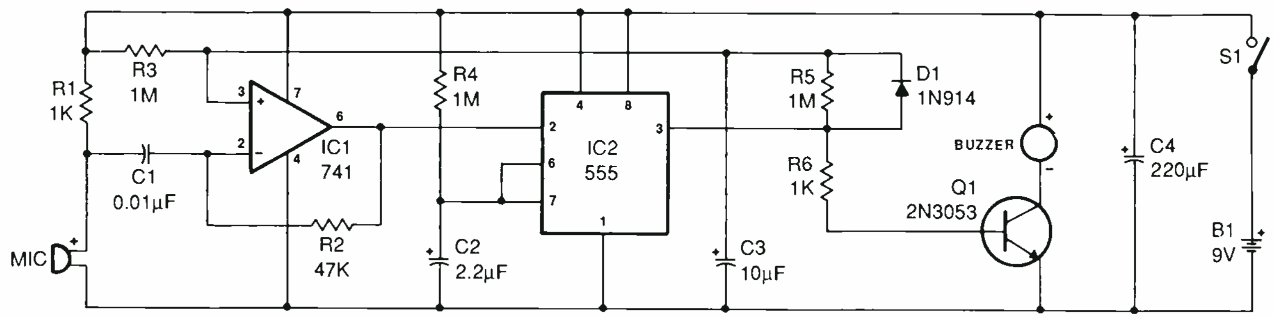
Sounds a tone when it detects a "hit" from a BB or pellet

By James H. Brown

Many people practice shooting at a target (with all safety precautions taken, we hope) that is located too far away to know if it was hit or not. Our Audible Target is designed to overcome this problem by sounding a piezoelectric buzzer when a hit is score by, say, a pellet fired by a BB or pellet gun. Electronic circuitry that detects the hit is housed inside an enclosure that is, in turn, mounted on a block of wood that protects it from damage.

About the Circuit

The Audible Target's circuit (Fig. 1) is designed to respond to only sharp-attack sounds like those produced when a hard object like a BB or pellet strikes a block of wood. The sharp-attack sound produced by a single "hit" from a BB or pellet impacting the wood block travels through the block and is picked up by electret microphone element *MIC*. The microphone element converts the sound in-



PARTS LIST

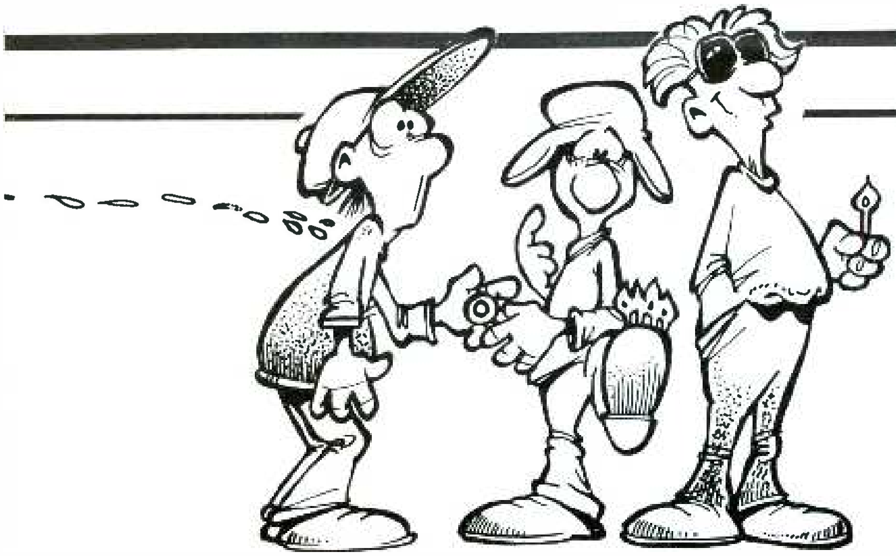
Semiconductors
D1—1N914 switching diode
IC1—741 operational amplifier
IC2—555 timer
Q1—2N3053 medium-power npn transistor

Capacitors
C1—0.01-µF disc
C2—2.2-µF, 15-volt electrolytic
C3—10-µF, 15-volt electrolytic
C4—220-µF, 15-volt electrolytic

Resistors (1/4-watt, 10% tolerance)
R1—10,000 ohms
R2—47,000 ohms
R3,R4,R5—1 megohm
R6—1,000 ohms

Miscellaneous
B1—9-volt transistor battery
MIC—Electret microphone element (Radio Shack Cat. No.270-090 or 270-092—see text)
S1—Spst pc-mount toggle switch
Two-tone piezoelectric buzzer (Radio Shack Cat. No. 273-070 or similar); pc board or perforated board and suitable Wire Wrap and/or soldering hardware or solderless breadboarding socket (see text); sockets for ICs; holder and snap connector for B1; suitable enclosure (Radio Shack Cat. No. 270-233 or similar); 7" × 6" × 1" wood block (see text); cable clamp; small rubber grommet; ½" spacers; 4-40 × ¾" machine screws, nuts and lockwashers; 6-32 × 1¼" machine screws, nuts and flat and lockwashers (see text); color-coded stranded hookup wire; solder; etc.

Fig. 1. Full schematic diagram of Audible Target project.



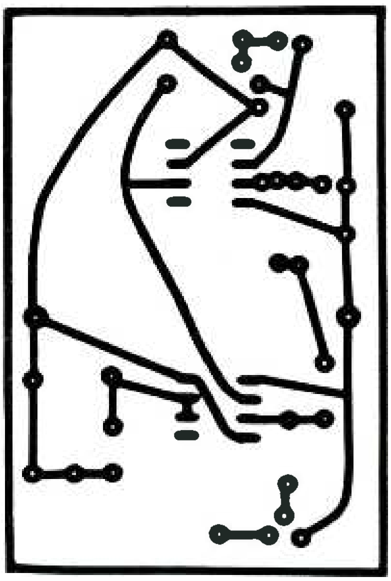


Fig. 2. Actual-size etching-and-drilling guide for fabricating printed circuit board.

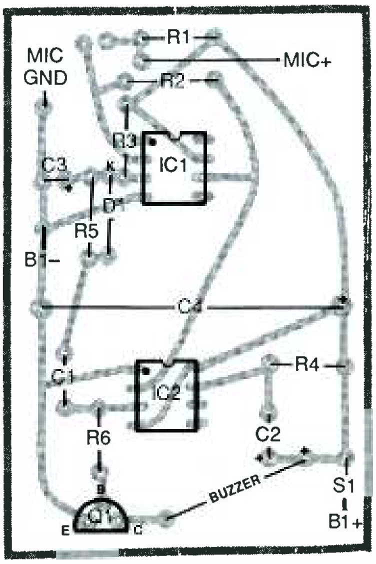


Fig. 3. Wiring guide for pc board. Use this for component layout if you wire on perforated board.

to an electrical signal that is then coupled through capacitor *C1* and fed into the inverting (−) input of operational amplifier *IC1* at pin 2. The negative peak of the amplified signal at *IC1*'s pin 6 output is then passed to the pin 2 "trigger" input of timer *IC2*, which is configured as a monostable multivibrator. The trigger pulse delivered to *IC2* is then internally stretched to about 2 seconds in duration.

Triggering *IC2* causes a positive output to appear at output pin 3. This positive signal sends transistor *Q1* into conduction to complete the electrical circuit from the positive side of battery *B1* through the two-tone piezoelectric buzzer to circuit ground. The result is that the buzzer sounds to audibly register the hit. Once pin 3 of *IC2* goes high, *IC1*'s noninverting (+) pin 3 input is taken more positive through diode *D1*.

When *IC2* times out, *D1* becomes reverse biased, causing *Q1* to stop conducting and silencing the piezo buzzer. With *D1* reverse biased, the voltage at pin 3 of *IC1* starts to discharge through the RC network made up of *R3, R5* and *C3*. The voltage at pin 3 of *IC1* will remain high long enough to allow the buzzer to completely turn off. The RC network and capacitor *C4* prevent the piezo buzzer from falsely triggering.

Construction

Since there is nothing critical about circuit layout, assembly of the Audible Target can be accomplished using any traditional wiring technique. If you wish, you can etch and drill a printed-circuit board on which to mount and wire the majority of the components that make up the project, using the actual-size artwork shown in Fig. 2. Alternatively, you can mount the components on a piece of perforated board with 0.1″ hole spacing and use Wire Wrap, soldering or a combination of the two types of hardware to wire the circuit. As a final choice, you can assemble the circuit on a solderless breadboarding socket.

Whether you use a printed-circuit board or a perforated board and hardware, it is a good idea to use sockets for the integrated circuits. (No sockets are needed or desirable if you assemble the project on a solderless breadboarding socket.) When you are ready to install the components on the board, follow the wiring guide given in Fig. 3. You can also use Fig. 3 as a rough guide to component placement if you are assembling the circuit on perforated board. Install the components exactly as shown, paying particular attention to the orientations of the integrated circuits, transistor and electrolytic capacitors.

Start wiring the board by plugging in and soldering into place the IC sockets. Use only enough solder on each pin to assure a good mechanical and electrical connection. Avoid using excess solder; otherwise, you might create short-circuiting solder bridges between the closely spaced

SAFETY FIRST

Any target-shooting game in which a BB or pellet is propelled at high velocity should be given the same respect one would give to a firearm. Though a BB or pellet fired by spring or compressed air (CO_2) or launched by heavy-duty elastic bands might not have the same power behind it as a bullet fired by an explosive charge, it can be dangerous nevertheless. Therefore, you should never fire these devices at anything but a properly set up target, such as the Audible Target described in this article.

Set up your target in the same manner as you would set up a firing range for true firearms. That is, make sure there is a safety backdrop to prevent off-target shots from going astray. Additionally, locate your "range" so that people cannot casually cross it and step into the line of fire. If your firing range is out of doors, post the area to alert others to its existence.

Make it a practice to conduct your target shooting with safety foremost in mind. Never fire at anything but your target. Never fire indiscriminately into the air. Always point your ready-to-fire gun or slingshot downrange, whether or not you are planning to fire it at the moment.

A final word of caution: *Never* fire an explosively propelled bullet from a hunting rifle or pistol at the Audible Target. If you do so, you will destroy the Target.

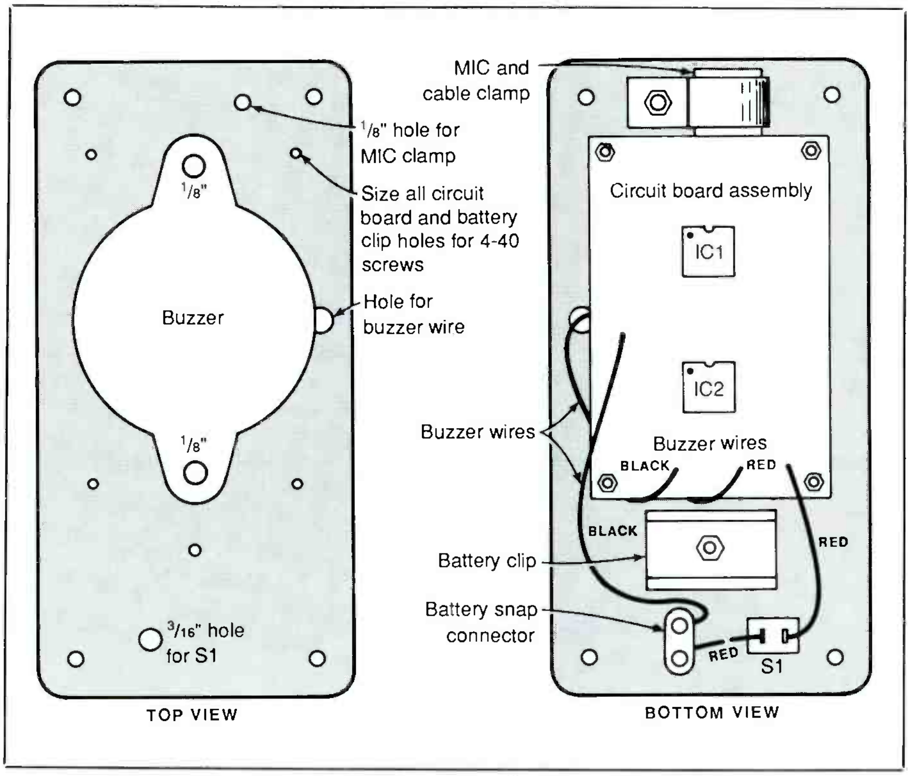


Fig. 4. Mounting details for components on lid of project box.

copper pads on the pc board. Continue populating the board by plugging in and soldering into place the resistors, the diode, and the transistor. Plug the 741 op amp into the *IC1* socket and the 555 timer into the *IC2* socket. Make sure these devices are properly oriented and that no pins overhang the sockets or fold under between sockets and IC bodies as you seat them solidly into place.

Trim ¼" of insulation from the ends of both leads of the battery snap connector, piezoelectric buzzer and microphone element wires. You have a choice between two electret microphone elements. The Radio Shack Cat. No. 270-092 element has leads already attached to it, while the Cat. No. 272-090 has no leads. If you use the leadless element, you can mount it directly on the board or solder wire leads to allow off-the-board mounting. If you go the latter route, prepare two 3" lengths of hookup wire, preferably stranded and with different colored insulation, and solder the ends of the individual wires to the contacts on the element, as shown in Fig. 3. Prepare a 3" length of red-insulated stranded wire by removing ¼" of insulation from both ends. In all cases, tightly twist together the fine wires at all prepared ends and sparingly tin with solder.

Plug one end of the red-insulated wire into the vacant hole near *C4*'s positive lead and solder it into place. Similarly, plug the black-insulated lead from the battery connector into the vacant hole near *C4*'s negative lead. Observing polarity, plug the positive (+) wire coming from the microphone element into the vacant hole between *R1* and *R2* and the ground wire into the hole at the edge of the board just above *C2*'s negative lead and solder both into place. The free ends of the red-insulated wire and the red battery connector lead will be connected later. Do not connect the buzzer leads into the circuit until after the buzzer has been mounted. Then install and solder into place the wire jumper.

Set aside the circuit-board assembly. Now prepare the metal lid of the enclosure in which you will house the project (see Parts List). First, use the circuit board as a template to mark the locations for and drill the four mounting holes. Similarly, drill the holes for the buzzer and its leads, battery holder, microphone element clamp and mounting switch.

Line the buzzer's lead entry hole with a small rubber grommet. Pass the buzzer's leads through the grommet and mount the buzzer on the lid of the enclosure with appropriate machine hardware. Plug into the appropriate holes in the circuit-board assembly the buzzer's leads (black to vacant hole near *Q1* and red to vacant hole near lower-right with board oriented as shown in Fig.3) and solder both into place. Mount the circuit-board assembly to the lid of the enclosure with ½" spacers and 4-40 × ¾" machine screws, lockwashers and nuts.

Place a cable clamp around the body of the microphone element and mount it with machine hardware. Mount the switch on the panel with its own supplied hardware. Locate the free end of the battery connector's black wire and connect and solder this to one switch lug. The free end of the red-insulated wire coming from the board now goes to the other lug on the switch. See Fig. 4.

Strike a line down the center of the plastic enclosure's bottom. Measure 1" in from both narrow ends of the enclosure and strike a cross line on the center line. Drill a ⅛" hole at both crossed locations. Then center the plastic enclosure all around on 7" × 6" × 1" wood block (you can use any solid hardwood or pine lumber or plywood, as long as it is 1" or more in thickness) and mark the locations of the holes. Similarly, drill a ⅛" hole through both marked hole locations.

Place a flat washer on each of two 6-32 × 1¼" machine screws and feed the screws through the holes in the wood block. Place the plastic enclosure over the wood block with the screw ends aligned with the holes. Drop onto each screw end a lockwasher and follow with a machine nut. Solidly tighten the hardware to secure the plastic enclosure to the block of wood. See Fig. 5 for enclosure mounting details.

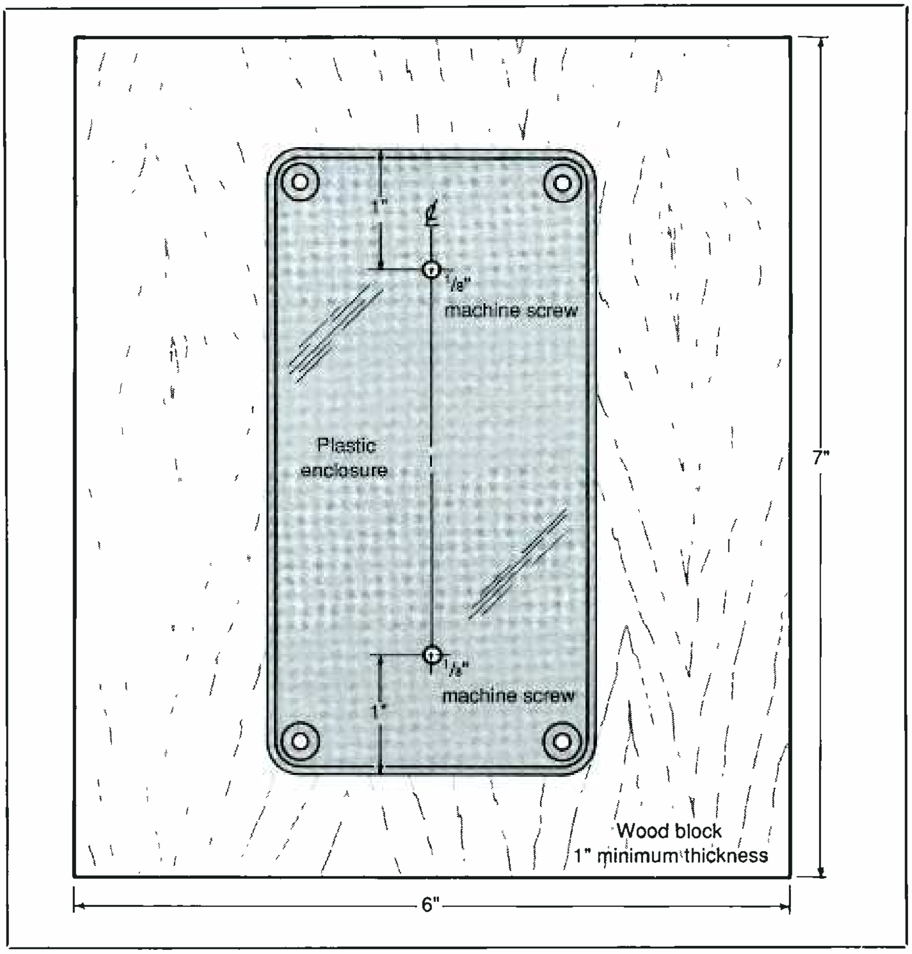


Fig. 5. Details for mounting project box on wood block.

Testing and Use

Connect a 9-volt transistor battery into the circuit by plugging it into its snap connector and flip *S1* to ON. The buzzer should immediately sound and, after about 2 seconds, should shut off. Now sharply rap the wood block with a hard object to produce a sharp-attack sound to which the circuit can respond. If everything is working properly, the buzzer should cycle on and then off. If you get these results, the Audible Target is operating properly. If not, power down the circuit and recheck all wiring and component orientations and all soldered connections.

Once the circuit is operating as described, you can finish assembly. This done, all you have to do to put the project into service is set up the Audible Target in a safe location at the distance from the "firing line" you want it to be and turn it on.

When using the Audible Target for target practice, always locate the project where there is a solid back wall to prevent BBs and/or pellets from going astray and where there is no access from the sides for casual pedestrians to pass as you are shooting at the target (also see the "Safety First" box). ME

AM Broadcast-Band Loop Antenna

Pulls in distant AM broadcast signals and lets you tune out strong interfering local signals

By Brad Thompson

A century ago, Dr. Heinrich Hertz made history by broadcasting radio waves across his laboratory. His spark-gap receiver detected the transmitted wave through a single-turn loop antenna. Ever since then, the loop antenna has been with us.

The modern loop antenna, commonly known as a "loopstick," consists of many turns of wire wound on a powdered-iron or ferrite core. Considering its small size, this type of antenna does a surprisingly good job of capturing radio signals. However, a larger antenna is sometimes needed for pulling in weak and distant AM signals. In this article, we will describe how the loop antenna works and show you how to fabricate a low-cost AM broadcast-band add-on loop that can improve your AM receiver's performance.

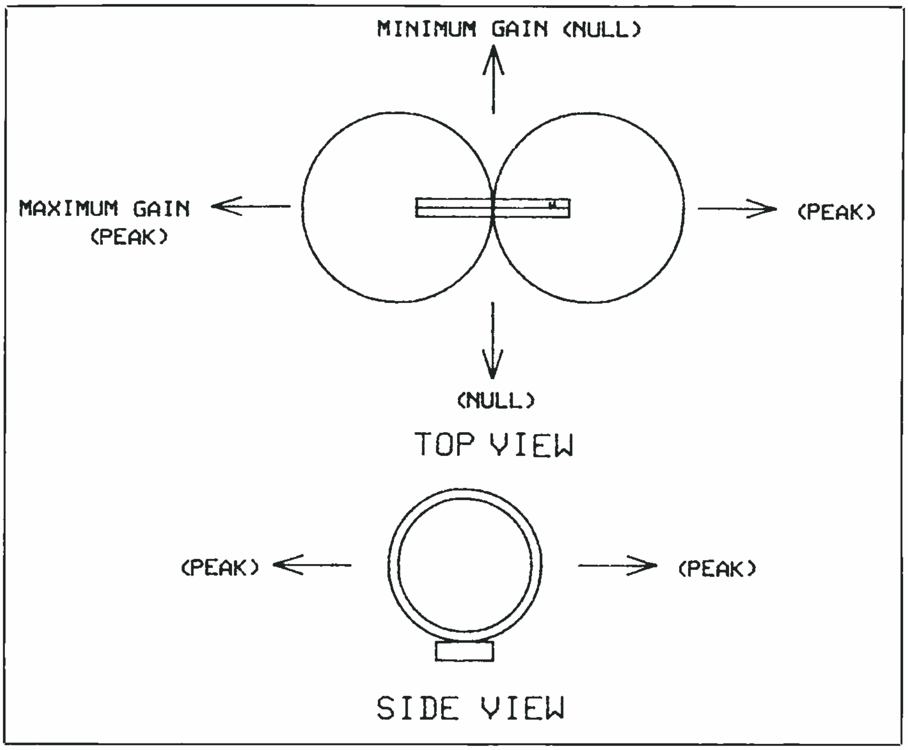


Fig. 1. Orientation of loop antenna for obtaining maximum gain.

Theory of Operation

A loop antenna typically consists of a number of turns of insulated wire (usually enameled or so-called "magnet" wire) wound on a round or square insulating frame. Loop size and number of turns are governed by the frequency range to be covered and assembly method used.

The loop antenna is basically a large inductor. Adding a variable capacitor to it produces a resonant circuit. By tuning the loop with the capacitor, unwanted off-frequency signals can be rejected to prevent overloading the receiver with which the antenna is being used.

When an electromagnetic (radio) wave is intercepted by a loop antenna, the wave induces a current in the antenna that, in turn, develops a voltage across the antenna's terminals. In general, the larger the loop, the more energy it intercepts and the greater the voltage it produces at its terminals.

If the loop is oriented broadside to an incoming radio signal, no voltage is developed across it because the amount of wire intercepting the signal energy is very small. By aiming the loop at the transmitting station, you can minimize the loop's pickup. Figure 1 shows the orientation of the loop antenna for maximum gain.

Sometimes, you may be less interested in obtaining maximum gain than in nulling out (eliminating) an interfering station's signal or a source of radio-frequency noise. The loop antenna produces a deep null when it is aimed broadside to the interfering

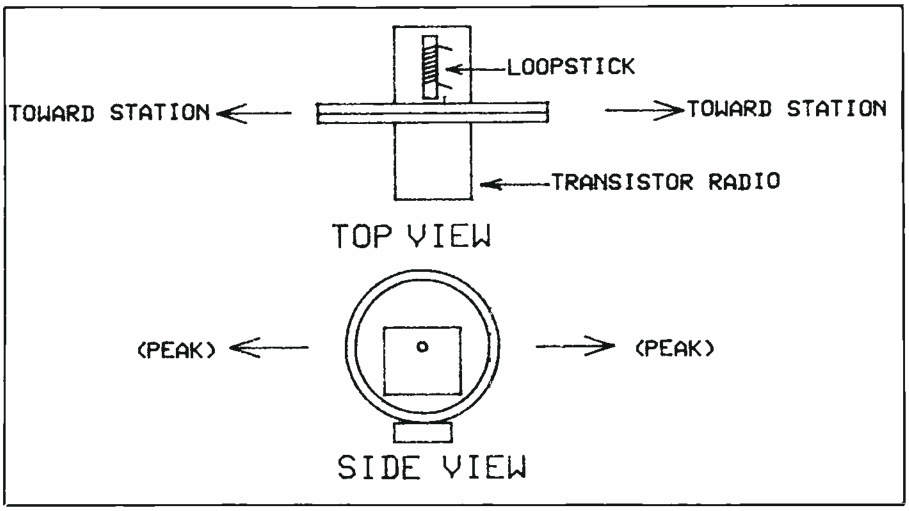


Fig. 2. Simplest method of connecting a loop antenna to a radio receiver.

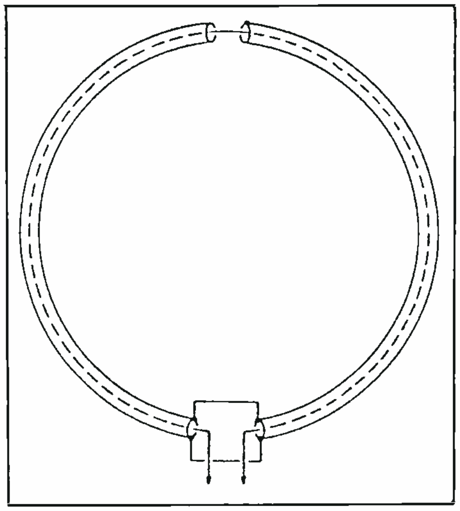


Fig. 4. One way of dealing with unwanted signal pickup is to use electrostatic shield around antenna windings. Note required gap in shield at top of drawing.

signal source. By orienting the antenna in this manner, a strong r-f interference source's signal can often be reduced so that a weaker, more-distant station's signal can get through.

There are several ways to connect the loop antenna to a radio receiver. Figure 2 shows the simplest way. Here, you place a transistor radio in the center of the loop so that the radio's loopstick antenna is aligned at a right angle to the external loop. Then you tune the radio to a station and adjust the loop's tuning capacitor for maximum signal strength, as indicated by an increase in volume and audio clarity. Be prepared for a surprise because the external loop antenna's much greater signal capture area will produce a dramatic increase in signal strength.

In this arrangement, the transistor radio's loopstick antenna serves as the secondary of a transformer whose primary is the external loop antenna. An incoming radio signal induces a current in the loop. The current creates an electromagnetic field that is then coupled into the radio's loopstick antenna.

Another way to couple the loop antenna to a radio uses an extra turn or two on the loop itself as the secondary winding of the transformer, as shown in Fig. 3. The extra winding reduces the detuning effect, which results when a low-impedance receiver is connected directly across the high-impedance tuned loop.

Unfortunately, adding a direct connection or even a pickup winding degrades the loop's performance. Stray capacitance from the loop to the grounded end of the pickup

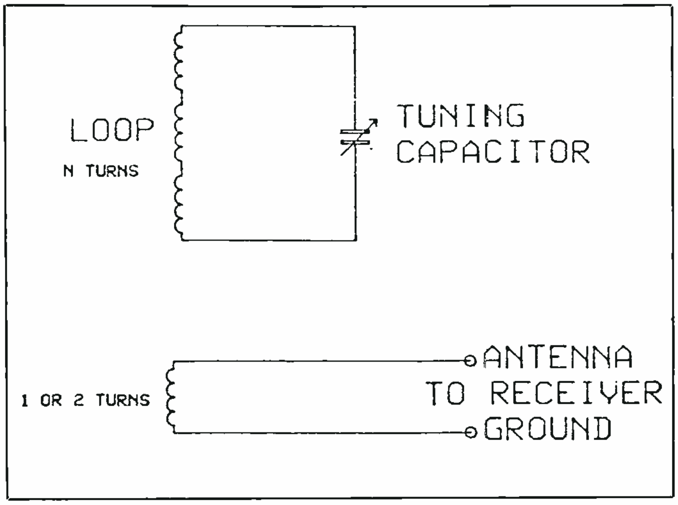


Fig. 3. Loop antenna and radio's loopstick antenna form primary and secondary of a transformer.

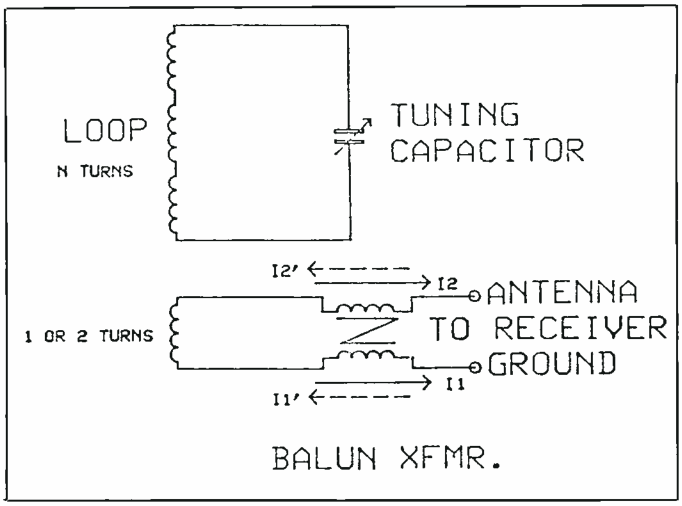


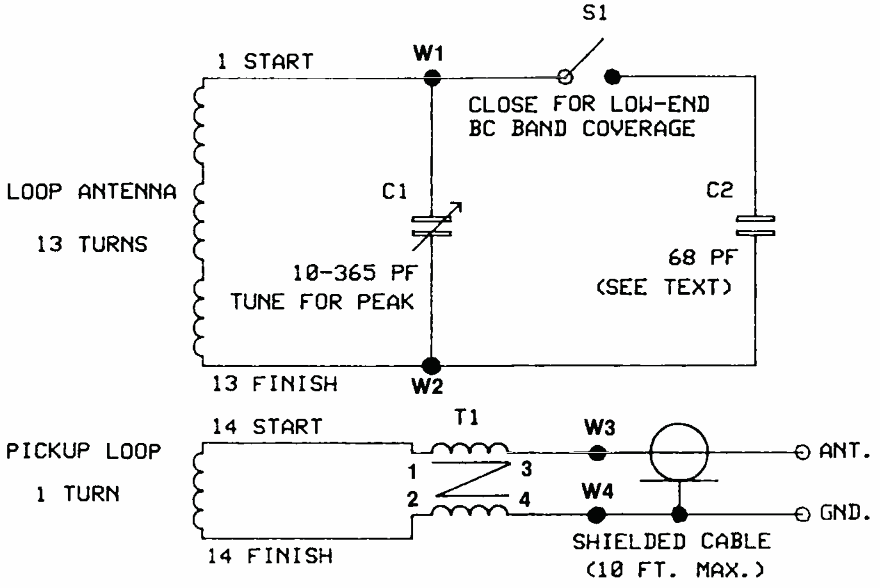
Fig. 5. Another approach to dealing with unwanted signal pickup is to use a balun transformer.

winding bypasses some of the signal. The grounded side of the pickup loop receives more energy and behaves as a short vertical antenna. The voltage developed by the vertical antenna distorts the loop's "figure-8" reception pattern and degrades performance.

One way of dealing with unwanted pickup is to provide an electrostatic shield around the loop's windings, as shown in Fig. 4. The gap shown at the top of the shield is important because without it, the shield would prevent any r-f energy from entering the loop. Adding an electrostatic shield to a loop antenna can be mechanically messy, though, and usually more trouble than it is worth if you are building the antenna yourself.

Another approach is to add a "balun" (for balanced input to unbalanced output) transformer to the antenna's cable, as shown in Fig. 5. Unwanted capacitive signal pickup develops a voltage across the entire antenna. Equal currents I_1 and I_2 attempt to flow into the antenna and ground terminals through the windings of the balun transformer. If the transformer's two windings are identical, current I_1 induces current I_2', which cancels out I_2. Likewise, current I_2 produces current I_1', which cancels out I_1. Voltage developed across the pickup loop's terminals passes through untouched.

Adding a balun transformer makes a noticeable and worthwhile improvement in performance over an unshielded loop antenna and is the approach we will take here in building our loop antenna. However, you will still notice some hand capacitance effects during tuning.



PARTS LIST

C1—10-to-365-pF tuning capacitor (see text)
C2—68-pF, 100-volt silver-mica or NPO ceramic capacitor (see text)
S1—Miniature slide or toggle switch
T1—Balun transformer (hand-wound on Fair-Rite Part No. 283002402 or equivalent; see text)

Misc.—Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware (see text); two 14-pin IDC DIP plugs (3M Part No. 3406-0000 or equivalent); two 14-pin DIP sockets; 18″-diameter × 0.75″-wide by about 0.5″-thick wood embroidery hoop (see text); 60″ of 14-conductor ribbon cable; 12″ AWG No. 34 bifilar wire or two strands AWG No. 34 magnet wire twisted together for balun transformer (see Fig. 10); insulated control knob; plastic or Masonite for control panel; ¾″ or 1″ pine or plywood for base plate; two pieces 3¾″ × ¾″ × ⅞″ pine to secure sides of loop; double-sided tape; varnish; No. 6 × ½″ woodscrews; miscellaneous hardware; hookup wire; solder; etc.

Note: Details of the inductance calculation method and a 12″ sample of AWG No. 34 bifilar magnet wire are available free by sending a SASE to: Brad Thompson, GMT Interface Products., 56-A Main St., Suite 233, Maynard, MA 01754.

Fig. 6. Actual schematic diagram of loop antenna you can build from details given in text.

Electrical Considerations

The virtues of the loop antenna were fully recognized in the early days of radio, and many a primitive radio was equipped with a wood-and-wire spiderwork loop antenna. Making a duplicate of such a vintage antenna required woodworking skills and a lot of experience and patience. Fortunately, a little ingenuity and use of modern materials eliminate the need for a shop filled with woodworking tools, the need to be a master woodworker, and long construction time.

The loop antenna whose construction details follow is shown schematically in Fig. 6. Note that this circuit is made up of the basic multi-turn loop consisting of 13 turns of wire wound on an 18″-diameter form, a secondary pickup loop consisting of a single turn of wire and connected to a balun transformer *(T1)*, a 10-to-365-picofarad tuning capacitor *(C1)*. The purpose of the switch *(S1)* and capacitor *(C2)* arrangement will be made clear presently.

Note in Fig. 6 that the basic antenna actually consists of 13 turns of wire plus a one-turn loop that is used as a coupling link to a low-impedance receiver input. That one-turn coupling loop causes the antenna to lose some inductance so that instead of tuning down 540 kHz as it should when *C1* is fully meshed, tuning will bottom out at about 574 kHz. To compensate for this, *C2* adds another 68 picofarads in shunt with *C1* when *S1* is closed. You close *S1* when tuning the low end of the broadcast band and open it when tuning the high end of the band.

Construction

A wooden embroidery hoop, used as the frame on which to wind the turns of wire that make up the antenna, eliminates the need for woodworking skills on your part, as well as the need for specialized tools. You can buy such a hoop in any sewing center and most housewares stores for about $8.50 or so, depending on make.

The embroidery hoop consists of two separate wood rings, one continuous and the other split at one point. The latter is sized to fit around the former. At the split are blocks of wood through which a long bolt is passed so that tightening a wing nut clinches the larger ring tight around the smaller with fabric between the two. Neither the screw nor the wing nut are used in this application.

The space between the inner and outer rings that make up the embroidery hoop provides a convenient protected place to locate the loop antenna's windings. While it would be possible to wind the antenna's loop with enameled magnet wire, keeping the wire under tension as you attempt to maintain proper turn-to-turn spacing is difficult to do. Fortunately, there is a better way to "wind" the turns.

Multiconductor flat ribbon cable of the type commonly used as a means for interconnecting computer subassemblies can be used in place of the usual enameled magnet wire used for winding the loop antenna. The ribbon cable consists of a number of No. 28 tinned conductors that are separated from each other on 0.05" centers by a coating of ridged PVC plastic insulation. By wrapping a length of ribbon cable around the wood hoop form, each conductor can be connected to provide a loop with the next. (By a fortuitous combination of circumstances, a loop of 14-conductor ribbon cable wound on an 18"-diameter circular form resonates over the entire AM broadcast band from 540 to 1,620 kHz when tuned with a 10-to-365-picofarad capacitor, as in Fig. 6. The Table details the inductance of the antenna, loop by loop, when No. 28 ribbon cable is used.)

Inductance vs. Number of Turns*

Number of Turns	Calculated Inductance in microhenries
1	1.74
2	5.56
3	14.08
4	24.07
5	36.36
6	50.82
7	67.35
8	85.84
9	106.23
10	128.43
11	152.40
12	178.07
13	205.40
14	234.33

*With loop made from No. 28 ribbon cable wound on 18"-diameter wooden form as described in text.

To make each successive turn, you simply connect the finish end of the first conductor to the start end of the second conductor, the finish end of the second conductor to the start end of the third conductor and so on until all conductor ends are connected, except the start end of the first and the finish end of the last. If properly done, you will end up with a series of continuous, equally spaced loops.

If you were to simply twist together the conductor ends at each point and solder each connection, you might run into difficulties. This is because once the individual conductors are separated (as they would have to be to prepare them for end-to-end connection), any attempt to solder the connections with a hot soldering iron would cause the insulation to melt and shrivel away from the wires. Once again, there is a simpler—and better—way to make the required connections.

The 14-conductor cable used to make the antenna's windings makes it an easy proposition to use dual in-line package (DIP) plugs. These greatly simplify the connection task and eliminate direct soldering of the cable altogether. You simply attach a 14-pin plug to each end of the ribbon cable and then insert the plugs into matching sockets on a circuit-board assembly on which all soldering is safely performed. Assembly details for the loop and circuit board are shown in Fig. 7.

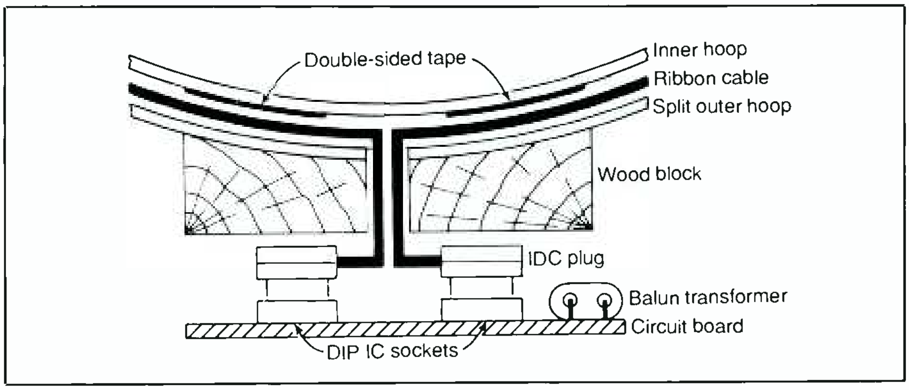


Fig. 7. Mechanical assembly details for loop and circuit-board assembly.

To attach the connectors to the ends of the 60″, 14-conductor ribbon cable required for this project, you will have to sacrifice a 14-pin DIP integrated-circuit socket. Before doing anything else, cut off the socket (not plug) pins flush with the bottom of the frame (or bend them flat against the frame). Plug a connector into the socket, place one end of the ribbon cable against the IDC pins on the socket and follow up with the socket cap. Holding the assembly firmly together, place it in the jaws of a bench vise and slowly force the cap into place. When the cap snaps into place, the IDC (insulation-displacement connection) points in the plug will pierce the ribbon cable's insulation and make positive connection with the correct pins of the socket. Repeat with the remaining IDC connector at the other end of the cable, using the same 14-pin IC socket to protect the connector pins from damage.

If you prefer not to make your own connector-terminated cable yourself, you can have one made by a computer cable supplier or electronics wholesaler. Whether you order the cable ready-made or make it yourself, make sure that it measures 60″ long between connectors.

Balun transformer *T1* consists of six turns of AWG No. 34 bifilar wire wound on a "binocular" core, as shown in Fig. 8. Similar cores can also be found on old vhf TV tuners, where a balun is used to match the 300-ohm twinlead transmission line from the antenna to the single-ended input of the tuner. Depending on the characteristics of the core used, you may have to wind more than six turns if the balun transformer does not appear to be working during the checkout procedure.

Once you have terminated the ribbon cable in DIP plugs, make a printed-circuit board, using the actual-size etching-and-drilling guide shown at the top in Fig. 9. Alternatively, you can use perforated board, suitable Wire Wrap or soldering hardware and point-to-point wiring in place of the pc board. If you take this route, make sure to carefully follow the conductor pattern shown in the etching-and-drilling guide when wiring the board.

Install the IC sockets on the circuit board now and solder their pins to the copper pads. If you are using perforated board, wire the pins of the sockets now, and install appropriate pins for the balun transformer *(T1)*, ANTENNA and GND transmission-line tie points, tuning capacitor *C1* and the *S1/C2* network. (In Fig. 9, the wiring guide at the center details component location, the drawing at the bottom how the ribbon cables are formed into a series of continuous loops when the DIP plugs are inserted into the sockets on the board.)

Separate the wooden rings of the embroidery hoop, remove and discard the bolt and wing nut and give each ring a couple of coats of varnish to seal out moisture. When the varnish has dried, attach the ribbon cable to the inner hoop by pressing 4″-long pieces of double-sided tape between the two, starting and ending where the ribbon cable ends come together (see Fig. 7).

Lay the cable/ring assembly on a flat surface and place the split outer hoop over the ribbon cable. Orient the opening so that the ends of the ribbon cable pass through the split and are of equal length. Then attach strips of wood to the sides of the outer hoop's mounting blocks to hold everything solidly together. Use No. 6 × ½″ woodscrews to fasten the strips in place.

Final mechanical assembly will depend on how you plan to use the loop antenna. Avid broadcast-band DX'ers will want to devise some sort of turntable so that they can easily rotate the antenna to orient it for best reception. Those who wish to receive only one station can mount the antenna in a fixed orientation. Keep in mind that your choice of tuning capacitor for *C1* in Fig. 6 will affect final assembly details.

Mount tuning capacitor *C1* and

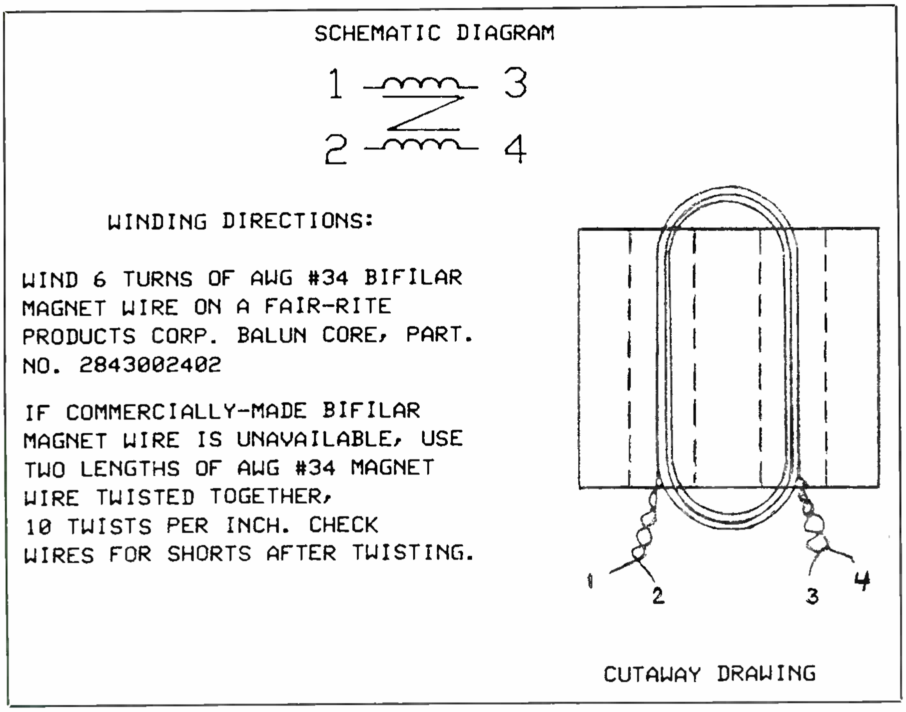


Fig. 8. Balun transformer is wound on a "binocular"-shaped ferrite core using bifilar magnet wire.

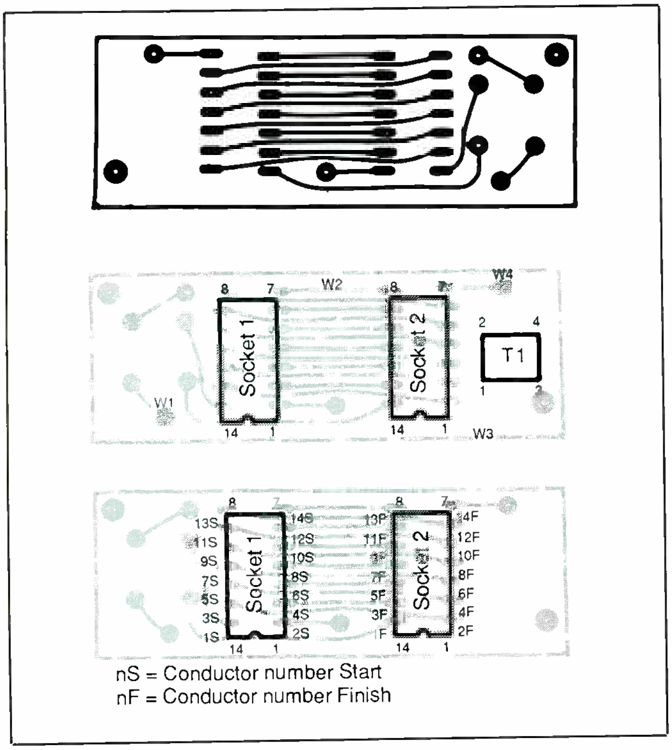
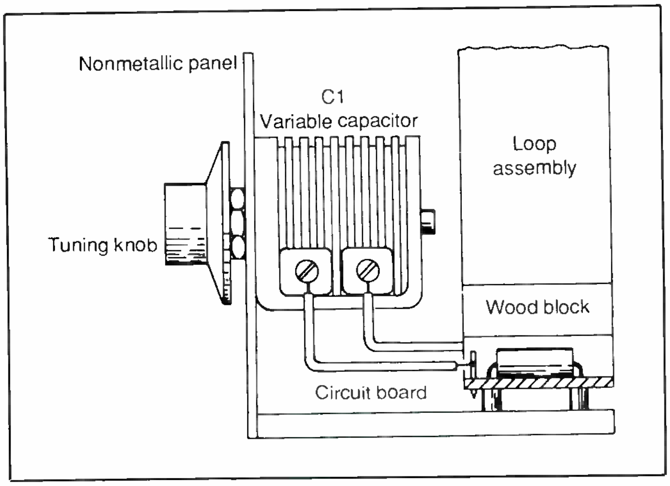


Fig. 9. Actual-size etching-and-drilling guide for printed-circuit board (top), wiring guide for board (center) and how conductor pattern completes ends of ribbon cable's conductors to form multi-turn loop (bottom).

Fig. 10. Mechanical details of final assembly. Use nonmetallic control panel and keep all wiring as short as possible.



switch *S1* on a nonmetallic panel and install the panel near the base of the loop. Connect and solder one lead of *C2* to one lug of the switch and the other lead, via a short length of insulated hookup wire if needed, to one side of *C1*. Then connect and solder a short length of hookup wire to the other lug of the switch and the free end to the unused lug of *C1*. Finally, connect short lengths of hookup wire between the two lugs of *C1* to points W1 and W2 on the circuit board (see Fig. 9). Keep the wiring from the capacitor to the loop connector panel as short as possible to avoid any "antenna" effects.

Install an insulated tuning knob on the shaft of tuning capacitor *C2*. Then mount the circuit board assembly on a board and fasten the tuning panel to the board as illustrated in Fig. 10. Insert the loop's plugs into the sockets on the circuit board.

Checkout and Use

Tune a transistor radio to a weak station in the middle of the AM broadcast band and place it in the center of the loop, as shown in Fig. 2. Now tune the loop antenna by adjusting its variable capacitor until you hear an increase in the radio's volume. You may have to reorient the loop antenna if it is not pointing toward the tuned station.

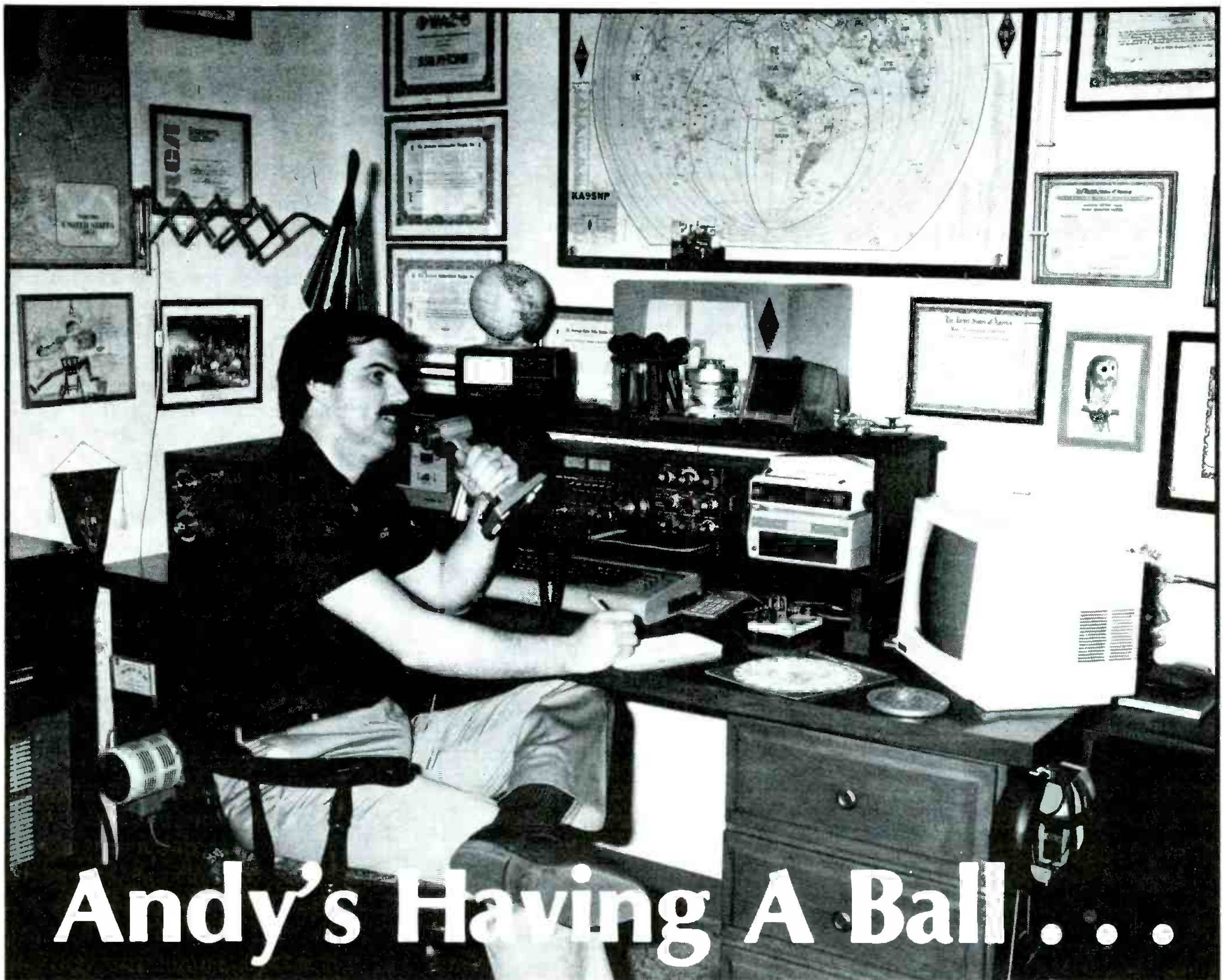
If you hear no increase at any setting of the tuning capacitor, check all wiring for shorts and opens or poorly soldered connections. One potential trouble source is the mica tuning capacitor located on the side of older variable capacitors. If the trimmer's adjusting screw has been over-tightened, the mica may be punctured, resulting in a shorted capacitor.

To check the balun transformer, tune the radio to a weak station near the middle of the band, tune the loop's capacitor for maximum signal, and move the loop until peak signal is obtained. If no peak is noted, wrap your hand around the loop; now if you note a significant drop in signal strength, the balun transformer has a reversed winding or lacks inductance.

Once the loop antenna is working properly, tune the radio to a weak station at the upper end of the broadcast band and retune the loop's tuning capacitor for maximum signal. If there is no increase in signal strength when the capacitor's plates are fully separated, loosen the capacitor's trimmer adjustment screw.

Retune the radio and loop to a weak station at the lower end of the band. Use a well-shielded cable to connect the loop to the receiver, and close the switch to put shunt capacitor *C2* into the circuit. For best results, keep the cable to less than 10 feet in length. Otherwise, signal pickup by the cable may defeat the loop's directional pickup characteristic. Retune the loop to compensate for cable capacitance.

This easy-to-build loop antenna readily lends itself to experimentation. Try using it as a tuning coil for a crystal or a regenerative receiver. Also, frequency range of the loop can be extended by cutting away turns to raise the range or adding tuning capacitance to lower the range. **ME**



and you can too!

Andy is a Ham Radio operator and he's having the time of his life talking to new and old friends in this country and around the world.

You can do it too! Join Andy as he communicates with the world. Enjoy the many unique and exclusive amateur bands . . . the millions of frequencies that Hams are allowed to use. Choose the frequency and time of day that are just right to talk to anywhere you wish. Only Amateur Radio operators get this kind of freedom of choice. And if it's friends you're looking to meet and talk with, Amateur Radio is the hobby for you. The world is waiting for you.

If you'd like to be part of the fun . . . if you'd like to feel the excitement . . . we can help you. We've got all the information you'll need to get your Ham license. Let us help you join more than a million other Hams around the world and here at home. Who are we? We're the American Radio Relay League, a non-profit representative organization of Amateur Radio operators.

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circle number 110 on the reader service card or write to:

AMERICAN RADIO RELAY LEAGUE Dept CQ, 225 Main Street
Newington, Conn. 06111.

SOFTWARE FOCUS

"Cruise Control" Cures Cursor Movement Problems

By Art Salsberg

Revolution Software's (Randolph, NJ) "Cruise Control" program promises to turn a sluggish-moving cursor into a speedy one and to provide dead stops when a key is released. The $50 RAM-resident program, which is not copy-protected in keeping with current software-maker philosophy, performs right up to the hilt of its claims, and adds a few extras as well.

It's compatible with IBM PC, XT and AT computers and true compatibles that use DOS 2.0 or higher, supporting IBM's monochrome, color graphics and enhanced graphics adapters, the Hercules graphics card, and AT&T and Compaq graphics cards. Also, it's not a memory-hungry program, as so many RAM-resident ones are, using less than 5K of user memory.

In-Use Experiences

Installing Cruise Control is a simple chore. The only real consideration is to set up the proper "Control Strategy" for application programs to avoid operating conflicts that might occur due to different software schemes. To maximize compatibility, therefore, one sets up a specific Control Strategy that's labeled A, B or C. Virtually all popular programs use strategy A.

The latest WordStar Professional version, 4.0, however, is listed on an update insert card under Control Strategy B, whereas a Readme file indicated that A was proper. Neither worked, however! Nor did C, under which the earlier WordStar 3.31 was listed. Calling the company as a normal buyer, a courteous technical service person advised that all strategies listed were incorrect for WordStar. A new Control Strategy, Z3, had to be used. Typing in this choice, which did not change the listed configuration, which remained as A, did the trick.

The cursor zipped along at breathtaking speed and stopped in its track when I released a cursor-arrow key! In fact, I chose to decrease the speed a bit, a modification that can be done within an application. Control strategy can be changed any time.

The "5" key on the keyboard's numeric section is used as the hot key to make any changes (Number Lock is off, of course). This key sits in the middle of the cursor arrow keys and doesn't activate anything under normal conditions. So it was a good choice by Cruise Control's software developers.

Cruise Control has a bevy of other features, too. For example, the cursor key can be made to automatically move in any direction by pressing hot key 5 and the appropriate arrow key. Doing this, you don't have to hold down the key. The cursor continues to move until you press any key to stop it. It does the same for page up or down and for key repeating. It's all hands-free, which is a real pleasure.

Another feature is screen dimming, which has a default of 30 minutes, at which time the screen blanks out. The "Auto Dimmer" can be set to activate from 1 to 60 minutes. Moreover, you can disable or enable this function at any time within an application. Cruise Control in its entirety can be disabled and enabled, too, or completely removed from memory at the DOS prompt. The program also includes a time and date stamp that allows you to insert either or both within an application by pressing hot-key 5 and T or D.

After working with Cruise Control for a few weeks, I have to conclude that it's a great little program that overcomes the frustrations of cursor run-on that plagues computer users due to keyboard buffer problems. The extra cursor-movement speed and automatic key operation are a boon, too, as are the extra features, such as screen dimming and time and date stamping. Furthermore, its operation appears to be flawless and changes can be made with the utmost convenience.

Coupled with Cruise Control's low price, absence of copy protection and fine customer service support, it's a program that every IBM-type computer owner should definitely have. **ME**

On-Line Help Panel			
CRUISE	Cruise Control Panel	[5][+]	Faster Cursor
CRUISE/(A-C)	Control Strategy	[5][-]	Slower Cursor
CRUISE/(1-60)	Auto-Dimmer Delay	[5][Delete]	Dim Display Screen
CRUISE/O	Disable Auto-Dimmer	[5][Key]	Cruise With [Key]
CRUISE/X	Remove From Memory	[+]/[-]	Alter Cruise Speed
CRUISE/R	Redefine [5] Key	[5][Tab]	Control Strategy
CRUISE/W(1-8)	Select Repeat Delay	[5][*PrtSc]	Auto-Dimmer On/Off
CRUISE/#(1-8)	Select Date Format	[5][D]	Insert Date
CRUISE/@(1-6)	Select Time Format	[5][T]	Insert Time
CRUISE/S(1-8)	Select Cursor Speed	[5][Insert]	Program On/Off

Cruise Control Version 3.02	
Auto-Dimmer delay is 30 minutes.	Control Strategy is A.
The [REV] key definition is [5] on the numeric keypad.	
For help type: CRUISE/H [Enter]	May 13, 1987 10:45 AM

Screen printout of Cruise Control's options and default/user-selected parameters.

BOOKS

Electronic Connections by Martin Clifford. (Prentice-Hall. Hard cover, 429 pages, $24.95.)

"Electronic Connections," with the subtitle "Home and Car Entertainment Systems," is a long-overdue book that concerns interfacing home entertainment components. With an increasing number of components being integrated, such as adding a VCR to a TV set and then adding audio components, there are many in's and out's that have to be understood in order to make all the parts work together properly as a system.

The initial quarter of the book concentrates on the electrical/mechanical connectors and wire used, as well as some theory such as voltage standing-wave-ratio and impedance calculations. With this as an underpinning, the wide variety of plugs and jacks used to interconnect today's equipment is examined in detail and complemented by excellent drawings. Here you'll be shown XLR and the DIN connections with pinouts, the BNC connector, VCR camera connectors, and so on.

Following this, a variety of add-on devices are introduced, from baluns to block converters to interference filters. Then, in Chapter 4, TV and VCR connections are detailed, including a host of cable TV hookups, frequency conversion, etc. The next chapter digs into all manner of video connections: connecting a VCR and a TV set to a multiple antenna, pay-TV connections, connecting a TV monitor for surveillance, connections for closed captioning, and so on.

Various connections required for car radio sound systems, high-fidelity components and satellite-TV connections are illustrated in the remaining chapters.

This is a beautifully complete book whose very fine drawings and clearly written copy shows the reader just how to make all the proper connections between a variety of components in different circumstances. It's highly recommended.

Creative Sound Recording on a Budget by Delton T. Horn. (Tab Books. Soft cover. 210 pages. $11.95.)

This book provides the reader with all the information needed to make professional-quality sound recordings on a low-cost open-reel recorder with only a limited budget. Beginning chapters deal with the nature of sound, tape recorders in general and how signals are recorded on the magnetic tape medium. Then a chapter on dB and VU brings in important technical details. A later chapter discusses the importance of microphones in taping live performances.

About 75 percent of the book deals with the practical aspects of home recording, including setting up a home recording studio, making live recordings and caring for tapes and recorders. Proper splicing equipment and techniques come in for detailed analysis as well. Mixing covers sound-on-sound and sound-with-sound recording techniques, use of 4-channel decks and the multideck approach, overdubbing and editing a mix. Covered under special effects and accessories are such diverse topics as equalization, noise reduction, speed effects, reversing tape direction, echo and reverberation, and creating simple effects electronically. The book closes, appropriately enough, with a chapter on the types of tape available and which to use—and not use—for a given recording application. All in all, this is a well-rounded reference book for the serious tape recordist.

Understanding CAD/CAM by Daniel J. Bowman and Annette C. Bowman. (Howard W. Sams & Co. Soft cover. 300 pages. $15.95.)

Another in the "Sams Understanding Series," this book is a general introduction to computer-aided design and computer-aided manufacturing (CAD and CAM) for professionals. Its basic overview of CAD and CAM is for those professionals who are not familiar with the disciplines. Starting with a brief history of CAD/CAM, the book quickly leads into a generalized discussion of what CAD/CAM is and what it can do for designers and manufacturers.

Without going into actual step-by-step details on procedures used in CAD/CAM, the book discusses automation, graphics workstations, input, output, data highways, artificial intelligence and how engineers communicate within the CAD/CAM environment. CAD and the personal computer, applications, and cost justification each have chapters of their own. The applications chapter includes an interesting discussion on integration of CAD and CAM with computer-integrated manufacturing.

Well-written and informatively illustrated, the text gives the reader a valuable insight into CAD/CAM as applied to modern design and manufacturing operations. Each chapter begins with a paragraph or two that tells what will be covered and ends with a series of quiz questions, answers for which are at the back of the book. In keeping with the "professional" nature of this book, extensive glossaries of standards and technical terms and a chapter-by-chapter bibliography for further reading are included.

NEW LITERATURE

Supplies for Electronics Catalog. The 1987 General Catalog from Contact East contains 108 pages of listings for products for electronics engineers, technicians and hobbyists, including entries for more than 140 products new to this edition. Featured are such test instruments as DMMs, oscilloscopes, counters, power-line monitors, disk-drive testers, etc.; precision screwdrivers, pliers, wrenches, crimpers and other hand tools; soldering supplies; the latest in static protection; and the company's exclusive line of tool kits. All products are fully described by specifications, full-color photo and price. For a free copy of the General Catalog and one year of technical supplements, write to: Contact East, P.O. Box 786, N. Andover, MA 01845.

Oscilloscope Literature & Video Tape. Tektronix has just released a library of support material for its lowest-cost Model 2225 50-MHz portable oscilloscope that includes a free demonstration video tape, full-color brochure, 36-page primer ("The XYZ's of Using a Scope") and five technical briefs on oscilloscope measurements. The video tape gives action demonstrations of the 2225 scope in use, while the primer serves as a study guide that expands on all aspects of the scope's operation and use. The technical briefs provide further details on specific measurement methods. (An Operator's Video Tape, available for $60, provides full details on usage of the 2225.) For a copy, call the Tektronix National Marketing Center at 800-433-2323 (in Oregon, call 503-617-900).

Electronic Chemicals Catalog. Specifications and applications information for more than 200 products for high-tech manufacturing and field service are included in a new catalog from Chemtronics. The colorful 1987 full-line catalog can serve as a comprehensive single source for most chemicals and related materials used in electronics. It provides detailed information essential to the production, reworking and maintenance of high-technology electronic equipment. In addition to describing cleaning agents, flux removers, conformal coatings and solder masks, the catalog introduces clean-room wipes, precision dusters, premoistened pads and swabs and instant adhesives. For a free copy, write to: Chemtronics, 681 Old Willets Path, Hauppauge, NY 11788.

Experimenting With Hall-Effect Devices

By Forrest M. Mims III

Hall-effect devices are the principal solid-state sensors of magnetic fields. Last month, I discussed magnetic fields, the compass and the Hall effect in some detail. This month, I will present several experimental and practical applications for Hall-effect devices.

Basic Magnetic Field Indicator

It is sometimes necessary to know when a tool or other piece of hardware possesses a magnetic field. For example, magnetized tools and hardware should ordinarily not be used near mechanical clocks and watches, instruments that have steel gears and both magnetic disk and tape drives.

The presence of a magnetic field is obvious if small ferrous objects adhere to the implement in question. A small compass can also be used as a sensitive indicator of a magnetic field.

A digital Hall-effect sensor can also be used to detect magnetized tools and implements. Figure 1 shows a simple circuit that turns on an LED when a magnetized object is placed near a Hall-effect sensor. This circuit can be assembled in a small plastic box and placed near a computer disk drive. Objects that might be magnetized can then be checked before being placed near floppy disks.

Using a Calibrated Hall Sensor

Several makers of Hall-effect sensors sell specially calibrated devices designed to measure magnetic flux densities. These devices can be used to make calibrated gaussmeters. One such device is the calibrated version of Sprague's 3503U.

The 3503U is a linear-output Hall-effect sensor that includes a built-in amplifier. Figure 2 shows how the 3503U is connected to an external power supply and a voltmeter. A calibrated 3503U is supplied with a calibration curve, such as that shown in Fig. 2 for a typical 3503U. Calibration is performed in both a north and south 500-gauss magnetic field. According to Sprague, calibration can be reliably extrapolated to 1,000 G. Therefore, the flux density given in Fig. 2 extends from +1,000 G to −1,000 G. Beyond 1,000 G, however, extrapolation may not be valid due to inherent nonlinearities.

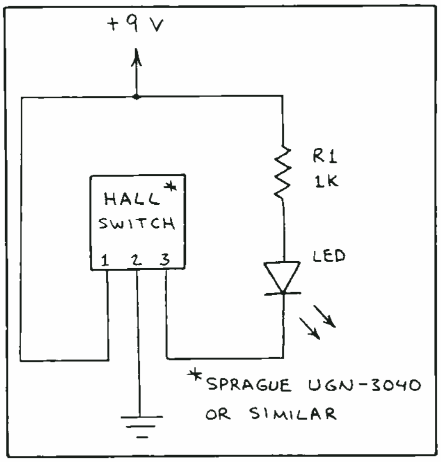


Fig. 1. Simple magnetic field indicator.

A carefully regulated power supply is required for utmost accuracy when making magnetic flux density measurements with a calibrated 3503U. Sprague recommends a 5-volt supply regulated to a tolerance of ±10 millivolts. Since Hall-effect devices are temperature-sensitive, Sprague recommends that the ambient temperature be maintained within the range of 21 to 25 degrees Celsius.

Before using the 3503U to make a flux measurement, the circuit should be powered up and allowed to stabilize for at least a minute. The sensor can then be placed in the field to be measured. The output voltage can then be compared with the sensor's calibration curve to determine the flux density.

Alternatively, the device's sensitivity coefficient (sens), which is printed on the calibration chart, can be used to deter-

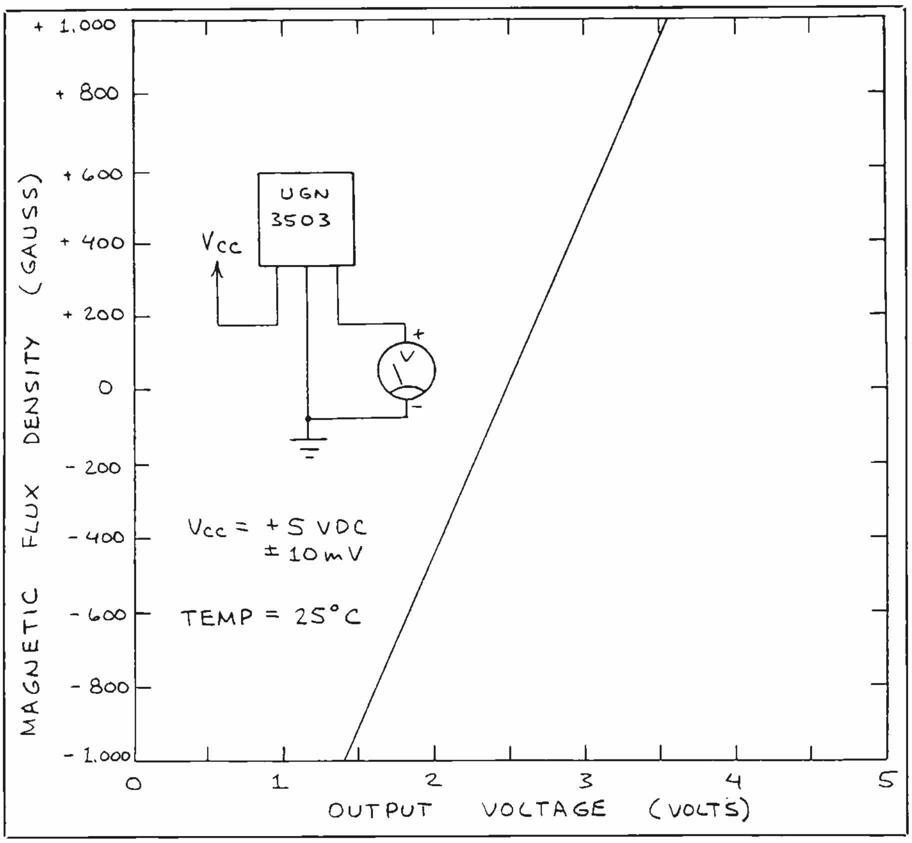


Fig. 2. Typical calibration curve for Sprague 3503U Hall sensor.

mine flux density. First, the output voltage when no magnetic field is present, the null voltage (V_{00}), is measured. The sensor is then placed in the magnetic field being measured and the resultant output voltage (V_{oB}) is measured. Flux density in gauss (B) can be calculated according to:

$$B = [(V_{oB} - V_{o0}) \times 1{,}000]/\text{sens}$$

The sensitivity coefficient for the device whose calibration is plotted in Fig. 2 is 1.087 mV/G. Its null voltage is 2.485 volts. Therefore, an output of 2.83 volts indicates a magnetic flux density of 317.39 gauss.

Detecting the Earth's Magnetic Field

The use of flux concentrators to increase the sensitivity of Hall-effect devices was discussed last month. A suitable flux concentrator will enable a Hall device to detect the Earth's magnetic field. The F.W. Bell Co. makes a high-sensitivity Hall device (Model BH-850) suitable for this purpose. The sensor is installed at the center of a 9-inch-long flux concentrator.

Figure 3 is the schematic of a simple circuit that uses a linear-output Hall sensor to detect the Earth's magnetic field. A 2.5-inch-long steel nail or lag screw can provide sufficient flux concentration to cause the LED to switch off and on when the plastic breadboard on which the circuit is installed is rotated. This high degree of sensitivity, however, is possible only with a very careful adjustment of the reference voltage via *R1*.

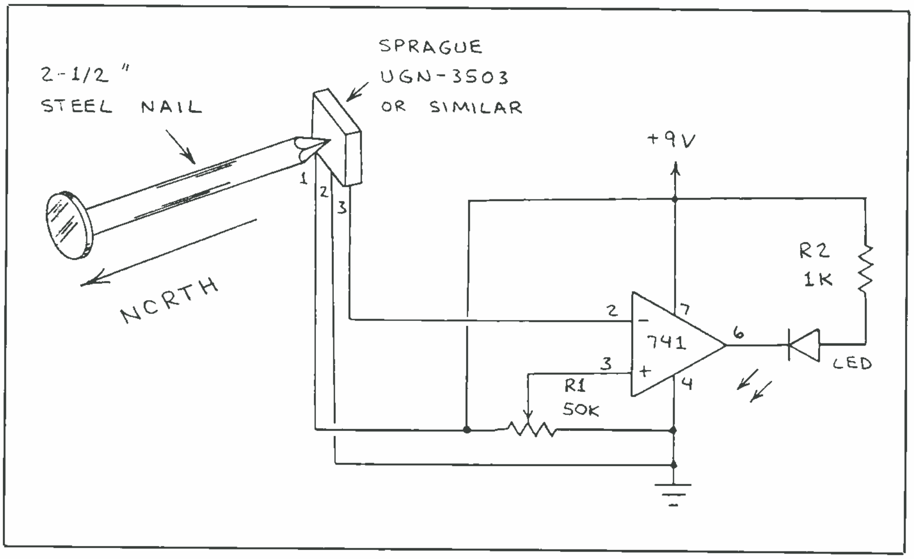


Fig. 3. Earth's magnetic field sensor.

After the circuit is assembled, apply power and adjust trimmer *R1* until the LED just switches off. Now the LED should switch on when the south pole of the magnet is placed within an inch or two of the front surface of the Hall-effect device.

When the circuit is operating, move the magnet and all other ferrous materials a foot or more away. Then place the circuit on a piece of cardboard that can be rotated on your workbench. The circuit should be rotated until the front face of the Hall sensor faces north. Now *carefully* readjust *R1* until the LED just switches off. When the pointed end of the steel nail is touched to the center of the front surface of the Hall device, the LED should switch on when the head of the nail points anywhere within a few tens of degrees of north (see Fig. 4).

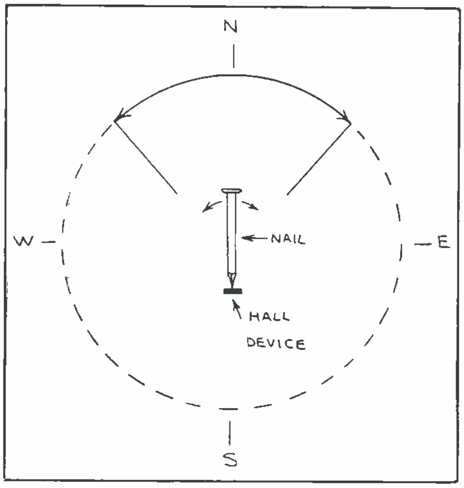


Fig. 4. Detecting the Earth's magnetic field.

If the LED fails to glow, try readjusting *R1*. If the circuit still fails to respond, use a larger nail or try a steel lag screw with a pointed tip. A 5.5-inch-long steel lag screw having a pointed end should provide so much flux concentration that the LED will glow when the screw and Hall sensor are rotated as much as 60 degrees from due north.

A pair of Hall devices equipped with optimized flux concentrators can be used to make a solid-state compass. The hall devices should be arranged at right angles to each other and their signals fed into a phase-detector circuit. In the late 1960s, Airborne Navigation Corp. manufactured an early version of such a compass that was used in an aircraft inertial navigation system or autopilot. The flux concentrators for this system were made of ferrite.

Keep in mind that the basic circuit in Fig. 3 can be used for applications other than sensing the Earth's magnetic field. For instance, it can detect a magnet at a much greater range than can a Hall sensor alone.

Nail Finder

The simplest way to locate studs in a wall is to locate the nails that anchor the wallboard (or plaster lath) to the studs. The traditional method of finding these nails is a gadget called a stud finder. This simple device consists of a small magnet mounted on a swivel or axle. As the stud finder is moved across a wall, the magnet will swing toward any nearby steel nails.

Figure 5 shows how a Hall sensor can

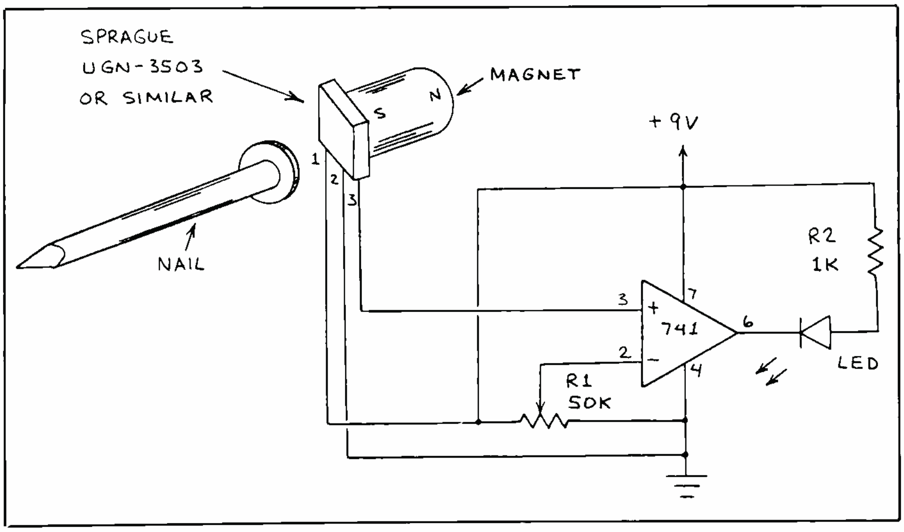


Fig. 5. Hall-effect stud finder circuit.

be used as a sensitive solid-state stud finder. Of course, the circuit can also be used in many other applications where it is necessary to detect either magnets or ferrous materials.

Referring to Fig. 5, a 741 operational amplifier is configured as a noninverting voltage comparator. Trimmer R1 is connected as a voltage divider that supplies an adjustable reference voltage to the inverting (−) input of the comparator. The output from a linear Hall-effect sensor is connected to the comparator's noninverting (+) input. Normally, the reference voltage is set just below the voltage from the Hall sensor. Therefore, the output of the comparator is high, and the LED is not forward biased. When the voltage from the Hall device falls below the reference voltage, the output of the comparator switches from high to low, thereby causing the LED to turn on.

Note that this circuit requires that the south pole of a small bias magnet be placed behind the Hall sensor. Even a piece of inexpensive flexible magnet material will permit the circuit to detect a steel nail a centimeter away.

Operation of this circuit can be reversed by reversing the input connections to the comparator. The LED will then glow until the Hall sensor is placed near a nail. The advantage of this operating mode is that the LED doubles as an on/off indicator. A disadvantage is that the LED is continuously on, constantly drawing current from the battery.

Another way to reverse the circuit's operating mode is to place the south pole of the bias magnet adjacent to the *front* of the Hall sensor, rather than its back surface. The back of the sensor will then sense the presence of a nearby nail.

Hall-Effect Pushbutton Switch

Some computer keyboards use Hall-effect devices at each keyswitch location. A small magnet inside each key actuates the Hall device when the key is pressed. An important advantage of this kind of switch is the total absence of the electrical bounce inherently produced by mechanical switches.

Figure 6 shows how a simple bounceless pushbutton switch can be assembled from a Hall-effect sensor and readily available materials. The plunger and barrel can be machined from plastic tubing and rod stock available from a hobby shop. Alternatively, the plunger can be cut from a length of solid rod and the barrel from a length of tubing. The protruding collars on the plunger and barrel can be formed from rings cut from plastic tubing and cemented in place.

A small magnet should be cemented in a receptacle bored in the end of the plunger. A short section of inexpensive flexible magnet material should work fine, but be sure to test the magnet you select before completing assembly of the switch. The switch's return spring can be a disk of foam plastic or an actual spring slipped inside the barrel.

Ideally, the lower end of the barrel should be threaded to accept a threaded retainer. If this is not practical, the retainer can be a disk cut from a solid rod that has the same diameter as the barrel. The disk should be cemented to the end of the barrel.

Output Interfacing for Hall Sensors

Each of the preceding circuits uses an LED to indicate the output status of a Hall-effect device. Often, it is necessary to interface Hall-effect sensors, especially the digital-output kind, to other types of devices.

The output of digital Hall-effect devices is often the collector of an npn transistor. This type of output is very easy to interface. In the case of the output LEDs

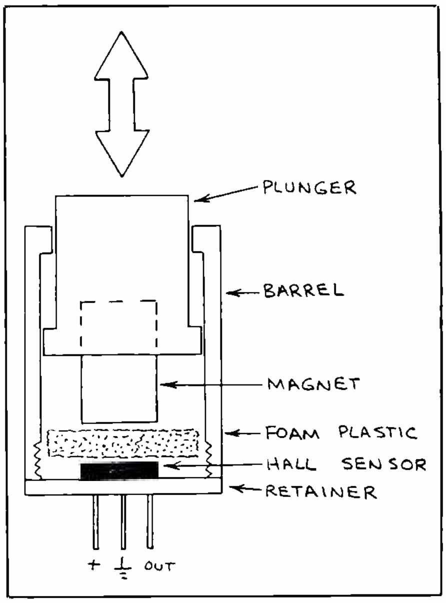


Fig. 6. Details of simple do-it-yourself Hall-sensor switch.

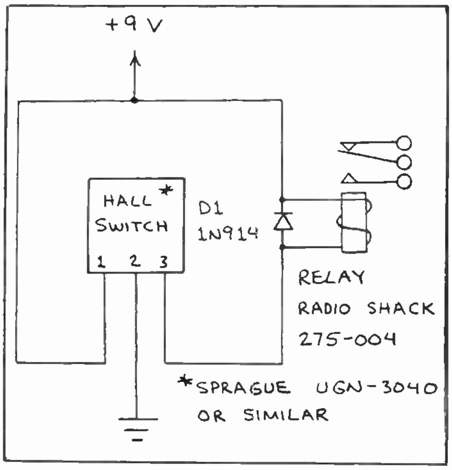


Fig. 7. Adding a relay to a magnetic field detector.

used in the circuits discussed above, the open collector is connected to V_{cc} through a current-reducing series resistor and an LED. The output transistor then acts as a switch that either applies or interrupts the current through the LED.

Figure 7 shows how a Hall-effect sensor with an open-collector output can directly drive a small relay. This permits the Hall sensor to switch both dc and ac loads at much higher currents and potentials than can be safely handled by the output transistor alone. Diode *D1* protects the sensor from the voltage spike spontaneously generated in the relay's coil when the output transistor is switched off.

Figure 8 shows how to interface a Hall-effect sensor with an open-collector output to both CMOS and TTL logic elements. In both cases, all that is necessary is a pull-up resistor of appropriate value. The values given in Fig. 8 for pull-up resistors are those recommended in *Hall Effect IC Applications* (Sprague Electric Co., 1986).

Going Further

Last month's installment of this column discussed the operating principles of Hall-effect devices. Sprague's *Hall Effect IC Applications* is an excellent introduction to Hall-effect devices. A more detailed reference is *Hall Effect Transducers*, a 280-page book published in 1982 by Micro Switch. **ME**

MANUFACTURER ADDRESSES

F.W. Bell
6120 Hanging Moss Rd.
Orlando, FL 32807

Micro Switch
A Honeywell Division
Freeport, IL 61032

Sprague Electric Co.
70 Pembroke Rd.
Concord, NH 03301

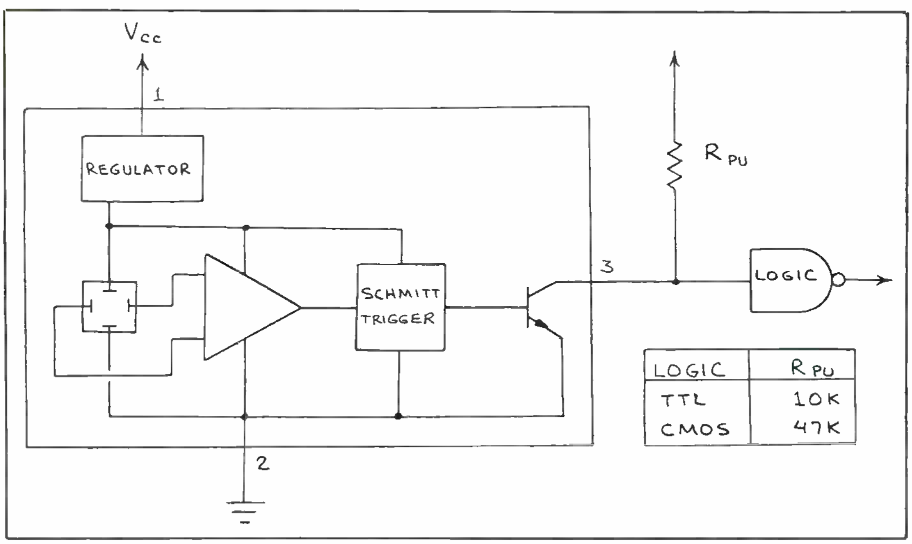


Fig. 8. Digital logic interfacing for a digital Hall-effect sensor.

A License-Free Transmitter for 1,700 Meters

By Chuck Steer, WA3IAC

You may already know that the Federal Communications Commission has set aside a license-free band of frequencies on which anyone interested in radio communications can operate—whether or not he or she has a license. The frequencies lie between 170 and 190 kHz on the 1,700-meter band. The only restrictions are that the transmitting antenna must be 50 feet or less in length and output power must be 1 watt or less, not to exceed 50 microvolts per meter measured at 300 meters. Other than this, you're free to use any form of modulation and operate on the band for any purpose.

Though the above operating guidelines must be rigidly adhered to on the transmitting end, no restrictions are placed on the receiving end. For example, you can use any length antenna for maximum signal pickup. Unfortunately, most hf receivers don't tune down to where you want to listen. If you have a newer amateur radio rig that tunes from 150 kHz to 30 MHz, you're in business. However, if you have an older receiver that can't tune down to 150 kHz, you're not locked out of working this band. All you need is a converter that can go that low but put out a signal on 80 meters to which your receiver can tune. One such converter is listed in the Heathkit catalog; and there are other sources, too.

All converters cover from about 10 kHz to 500 kHz. With them, and using 80 meters as the output. Most hf rigs will allow you to read the tuned frequency directly from the dial. That is, if the dial reading is 200, for example, the tuned frequency is 200 kHz.

Since receivers or/and converters for the 1,700-meter experimenter band are readily available, the remainder of this column will be devoted to a low-cost transmitter you can build. This transmitter is built around two state-of-the-art components, one a CMOS integrated circuit and the other a VMOS power transistor. Parts cost should be less than $20—less still if you have a well-stocked spare-parts box.

As designed, the transmitter accepts a key for operating CW. However, with just a little bit of ingenuity, you can easily modify it to use a modulator for voice.

Transmitter Details

As shown in Fig. 1, two inverters in CMOS hex inverter *IC1* are cascaded to form a series oscillator that is crystal controlled by *XTAL1*. The frequency of the crystal determines the operating frequency of the oscillator and, hence, the transmitter. A third inverter is used for output buffering and inversion of the oscillator signal. The final three inverters in *IC1* are tied together in parallel to provide enough drive for VMOS output power transistor *Q1*.

CD4069 CMOS hex inverters are commonly available. If you can't locate a VN66AF or VN67AF VMOS transistor, you can contact Siliconix at 1327 Butterfield Rd., Suite 620, Downers Grove, IL

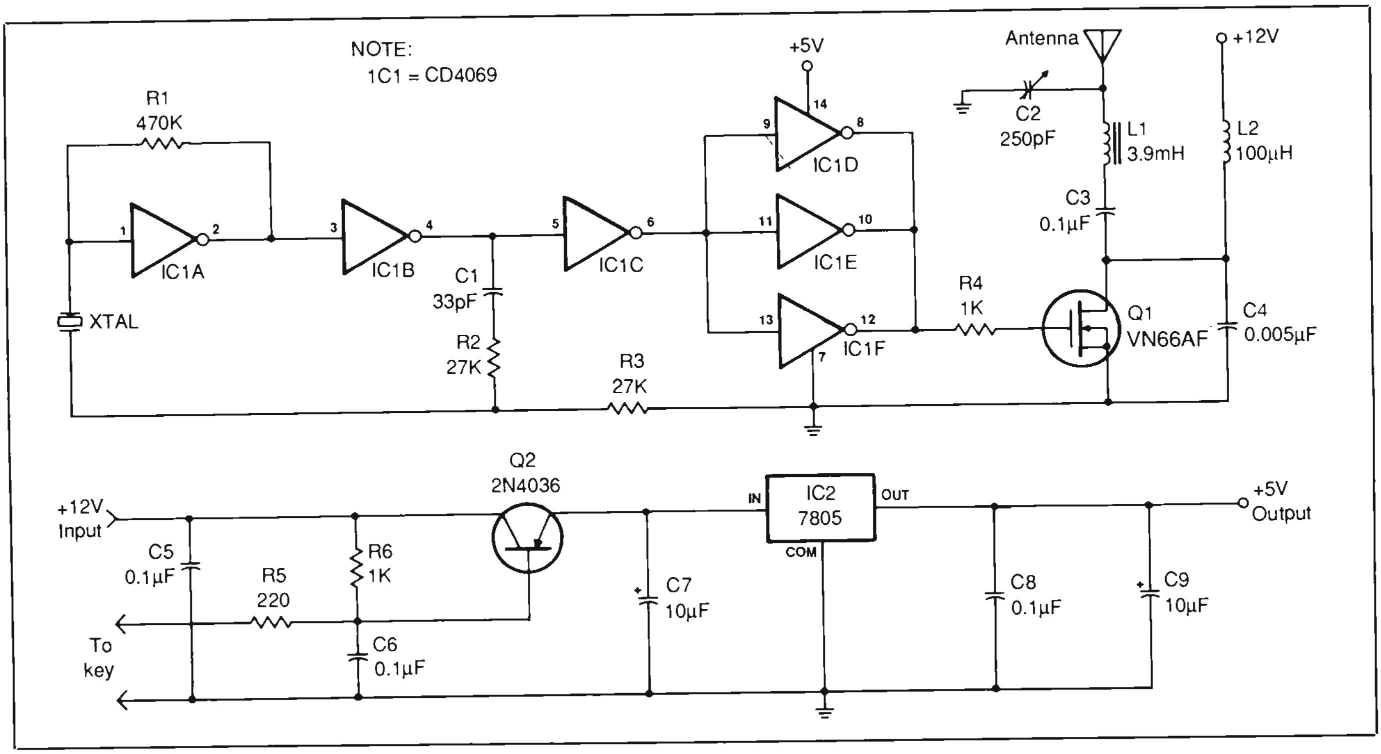


Fig. 1. Schematic diagram of transmitter and dc power supply.

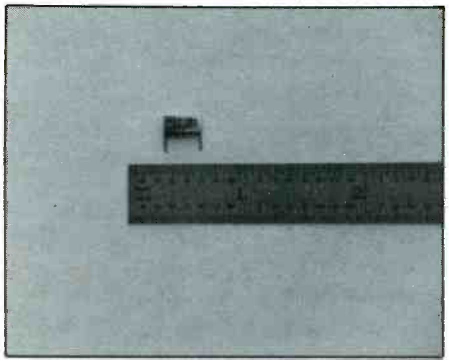


Fig. 2. The low-cost miniature crystal used in the transmitter's oscillator.

60515 or GE Semiconductor Sales, One Micron Dr., Research Triangle Park, NC 27709 (tel. 919-549-3100) and ask for a location of a distributor in your area.

A CX-1X type crystal that's designed for rapid start-up and high reliability in a series oscillator is used in the transmitter's oscillator. Most crystals for this band cost about $20. However, Statek (512 N. Main St., Orange, CA 92668; tel. 714-639-7810) makes the miniature size one shown in Fig. 2 that's ideal for this application and costs only $8.

Component values given in Fig. 2 are for a frequency range of 120 kHz to 199.9 kHz. This will keep the transmitter within the range specified by the FCC for the experimenter band, assuming you use a crystal of appropriate frequency.

Power for the transmitter's circuit comes from a conventional regulated dc supply. This supply starts with 12 volts dc at its input, which can be any 12-volt dc source from a simple battery arrangement to an automotive electrical system to a dedicated ac-operated power supply. The 12 volts is used directly to power the *Q1* VMOS amplifier stage. The 12 volts is also delivered through series-pass transistor *Q2* to voltage regulator *IC2*, which outputs +5 volts to power the *IC1* CMOS section of the transmitter.

Keying for the CW transmitter is provided by biasing *Q2* on and off with a standard Morse key. The transistor can handle 60 mA continuously, which is more than enough current to run the circuit at full legal output. Closing the key's contacts biases on *Q2* to power *IC1*, while opening the contacts cuts off the transistor.

Building the Transmitter

Though the transmitter can be built using perforated board and point-to-point wiring (an early version I built in this manner still works), it is far easier to use printed-circuit board construction. An actual-size etching-and-drilling guide for the board is shown in Fig. 3.

Reactance of the crystal is capacitive in any series oscillator arrangement. Therefore, circuit layout requires care to avoid having circuit capacitance create a low-Q feedback path that can degrade oscillator performance. Any large value of stray capacitance will reduce loop gain and lower circuit stability. In a pc layout, no circuit traces should be longer than 1 inch and none should be paralleled. As you can see from my pc guide in Fig. 3, I strayed a bit from good layout practice. However, I built two different versions of the basic transmitter circuit using this guide and have experienced no ill effects.

Wire the board exactly as shown in Fig. 4. Use a socket for IC1 and make sure that the electrolytic capacitors, ICs and transistors are properly oriented before soldering them into place. Also, install 2-inch insulated hookup wires at the locations labeled KEY, ANTENNA, +12V INPUT and GND; the free ends of these wires will be connected later.

No heat sinking was used in my transmitter prototype for *Q1*, though the VMOS transistor does run warm. During one test of the transmitter, I used an XR2209 as a 1-Hz, 50-percent duty cycle oscillator to see if 2N4036 transistor *Q2* or VN66AF VMOS transistor *Q1* would become hot in operation. Running the circuit in this manner for about 30 minutes yielded very good results.

The Antenna

As mentioned earlier, antennas for transmitting on the 1,700-meter experimenter

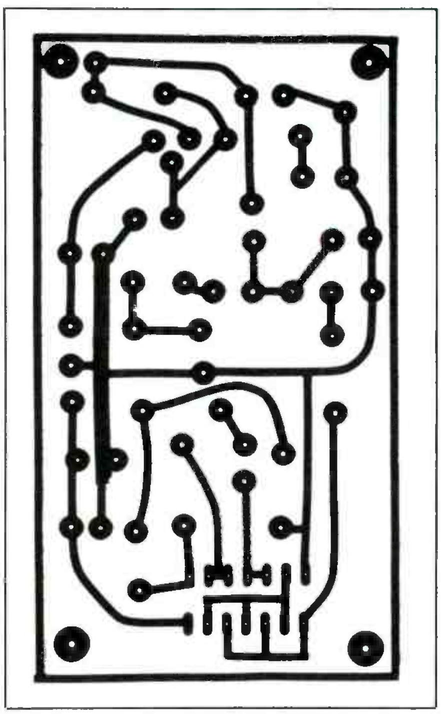


Fig. 3. Actual-size etching-and-drilling guide for fabricating a pc board.

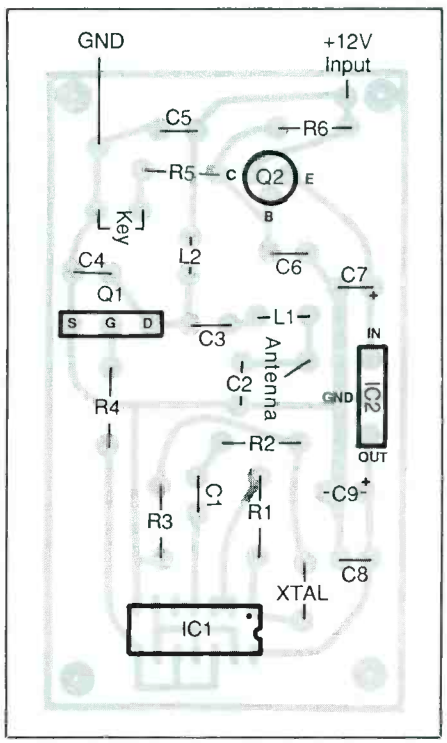


Fig. 4. Wiring diagram for pc board.

band of frequencies must be no longer than 50 feet, though those for receiving can be any length you desire. The easiest way to go in a transmit/receive system is to use a single 50-foot maximum antenna suitable for transmitting and receiving. This will keep the antenna to legal length, though reception might suffer.

An alternative is to use a loop antenna, which some enthusiasts use to receive on 160 meters. If you go this route, you'll have to tune the antenna for vlf reception. A Navy direction-finding antenna might also be okay to use as-is.

An active antenna is a good choice. You can get one that operates on 1,700 meters from MFJ and Palomar, among others. Not all active antennas will be suitable for use on the 1,700-meter band. For example, Heath's covers 300 kHz to 30 MHz. So keep this in mind when you're shopping for an active antenna.

Best results are obtained with a dedicated 50-foot wire for transmitting and any other antenna that will provide maximum signal pickup for receiving. Since a long-receiving antenna for 180 kHz at ¼-wavelength will be 1,300 feet long, it's better to use a base-loaded inverted L or a top-loaded vertical antenna for receiving.

Tuning & Testing

With the transmitter powered, the first thing to do is use an oscilloscope or frequency counter to check the oscillator to ascertain that it's operating. If you don't have access to either instrument, don't despair; you can listen for the oscillator signal with a nearby receiver or converter/receiver arrangement tuned to the proper frequency for the tone that indicates proper operation.

With an SWR or watt meter in the antenna line, adjust 250-pF trimmer capacitor *C2* for maximum indicated output. Then check the current in the antenna circuit to be sure that it doesn't exceed 100 mA. Remember that power is equal to voltage times current.

Fig. 5. The finished 1,700-meter experimenter's transmitter.

When you're satisfied that the transmitter is operating as it should and is properly tuned, house it inside a suitable enclosure. As shown in Fig. 5, this can be an ordinary plastic project box with a removable aluminum panel. Drill holes in the panel for and mount a phono jack for the antenna input and a suitable connector for the 12-volt dc power source you plan to use with the transmitter. Drill a third hole, in one of the box's walls, and mount in it a phone jack for the key you'll be using.

Use the circuit-board assembly as a template to mark the locations of its mounting holes on the floor of the box. Drill the holes at the marked locations and mount the board with spacers and machine hardware. Finish up by connecting and soldering the free ends of the wires coming from the circuit board to the jacks, referring to Figs. 1 and 4 for details. **ME**

 (from page 35)

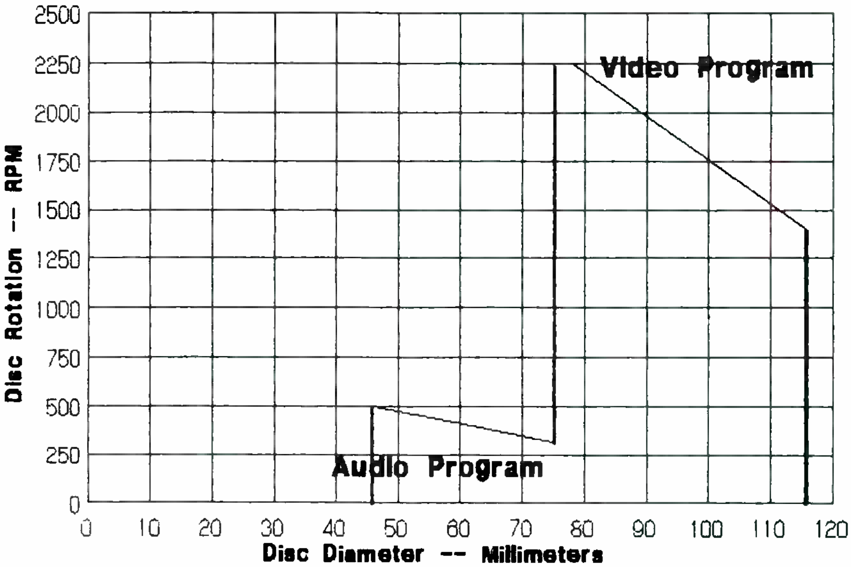


Fig. 6. A CD-V "Single's" distribution of video and audio signals and rotational speeds.

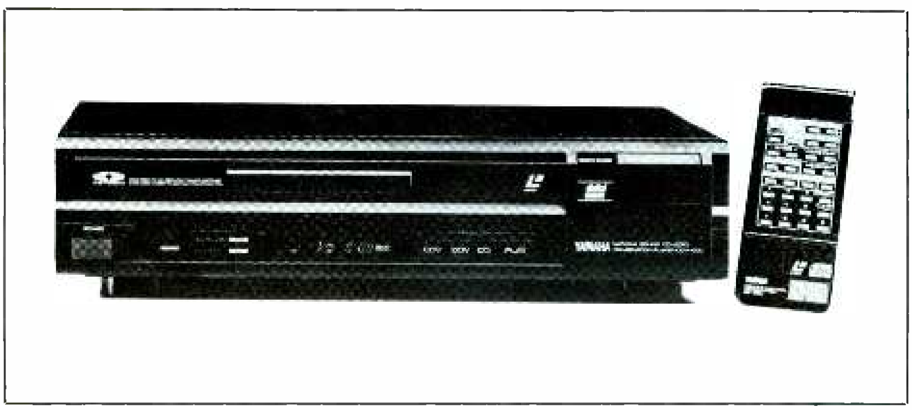
with the record and motion-picture companies right along. For example, at Warner they have had to issue their motion pictures in dozens of different languages, with different subtitles and even with multiple forms of sound dubbing. So having to deal with a couple of incompatible video systems really won't be anything new to many such software suppliers. Nor should TV system incompatibility really worry U.S. future purchasers of these new players and the new CD-V discs. After all, we never worried much about the fact that our TV sets wouldn't operate properly if we plugged them in in Europe, either.

The video portions of these CD-V singles need not be confined to pop and rock music videos, of course. In early demonstrations of the system it was clear that other subject matter, such as a short ballet sequence in the video portion of a CD-V demonstration disc or an excerpt from an orchestral classical work, could be shown. The fact that you can see the performers—even if only for about five minutes—really helps you to enjoy the rest of the disc even more.

Since the new format is a play-only medium, its success will, of course, depend upon simultaneous availability of program material ("software") and universal CD-V players ("hardware"). Most of the world's largest record companies have confirmed their support for the new Compact Disc Video format and plan to have music video titles available before the end of the year. Polygram, A&M, Capital, EMI, Manhattan, Angel, Chrysalis, Island, MCA, RCA/Ariola, Virgin and the Warner Communications Group plan to release music video titles on the new CD Video 5-inch configuration. The CBS Record group is also interested in CD Video and is actively participating in the launch of the new discs.

As for CD-V players, at least three different types of players are now envisioned. The first of these to become available is the so-called combination or "combi" player because it can handle all four types of discs: CDs, CD-V 5-inch singles, 8-inch laservision and 12-inch laservision video discs. In addition to this type of player (already available from Yamaha, Pioneer and others), manufacturers will more than likely offer a dedicated player that will play digital audio compact discs as well as CD-Video singles. We can also forsee a CD-Video "boom box" that will play 5-inch CD digital audio and CD Video single discs and incorporate a radio or a cassette deck as well.

Is there any chance that we might see a "portable" CD-V player in the future—one that might be analogous to the portable CD players that can be carried along outdoors, in cars, on the beach? Very likely. CD-V portables may well be on the market sometime in 1988. As envisioned now, they will have some form of pop-up screen—perhaps an improved sort of LCD display—for the video portion of a CD-V and the regular circuitry for the digital audio section, just as we have now in portable digital audio Compact Disc players. As for how much such a CD-V portable might cost, that's still anybody's guess. **ME**



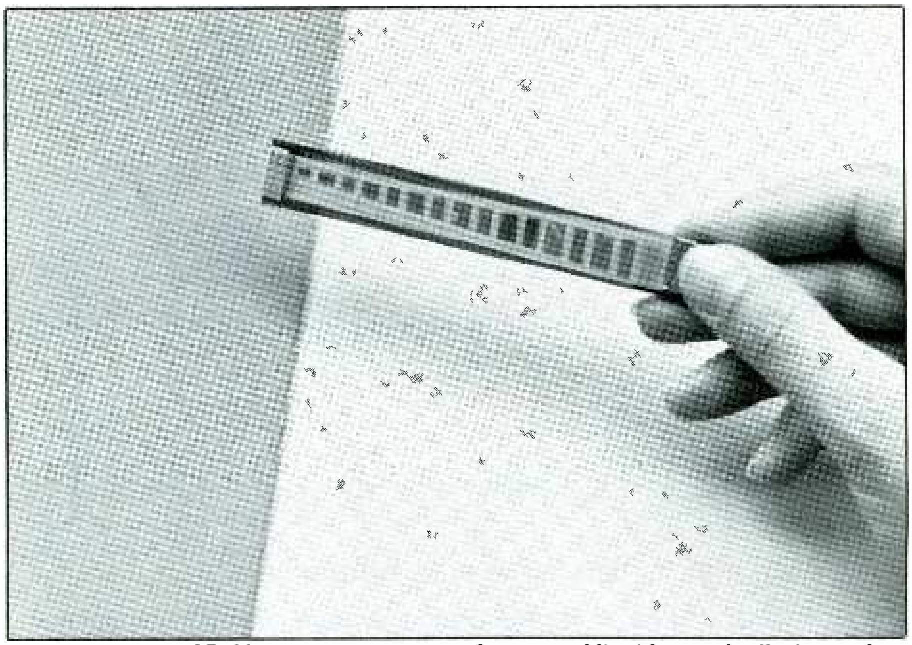
Yamaha's CDV-1000 combination CD video player.

By Art Salsberg

New liquid-crystal display (LCD) technology from Raychem Corp. (415-361-6248) is said to make possible a host of innovative applications for detecting electrical charges.

The film offers high impedance while requiring only a small amount of operating energy. Consisting of a liquid-crystal emulsion spread between layers of conductive film, some or all of the cells become activated in the presence of static electricity or voltage. They undergo an optical change to reveal their existence. Prototype systems developed use two types of LCD film. One changes from opaque to transparent only temporarily, while the other stays changed when the electric field is removed.

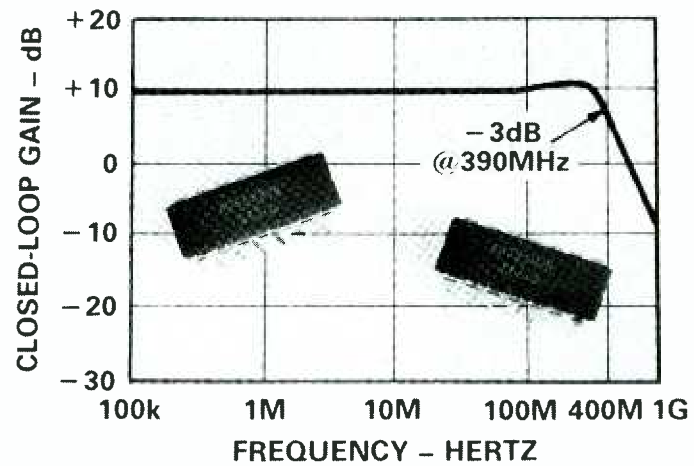
Raychem has combined its new LCD with a simple electronic circuit to achieve an economical insulated "hot stick" that shows the presence of line voltage and its amount when held several inches away from the line. The device doesn't require batteries, amplifiers or similar elements and performs under extreme high-voltage conditions without a voltage divider or transformer.



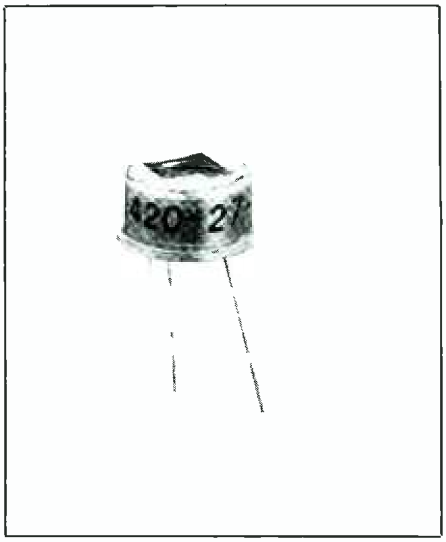
Raychem's new LCD film contains an array of connected liquid-crystal cells that undergo a visual change from opaque to transparent in the presence of ac and dc electrical fields when a strip of the film is held close to the source. Here it's being used to determine electrostatic discharge capacity that might damage sensitive electronic devices.

• Analog Devices (617-329-4700) has introduced a high-speed monolithic op amp with an extremely fast settling time of 12 ns. The AD5539 has a typical gain-bandwidth product of 1.4 GHz, slew rate of 600 V/μs and full-power response of 82 MHz. It's claimed that these specs excel against GaAs amplifiers, which are expensive, noisy and have poor dc performance . . . . Uses include fast pulse amplification, video signal processing and use in r-f oscillators, as well as for video displays where the device is optimized for 75-ohm and 150-ohm input and output impedance . . . . Cost is $1.65 in 100's.

• Eltec Instruments (800-874-7780) has introduced its Model 420 pyroelectric laser detector, which senses medium- to high-power pulsed or modulated laser energy from the UV to 1000-micron infrared . . . . It's packaged in a TO-5 case and uses a special element mounting method to heat sink the sensing element . . . . $44 each or $14.95 in 100's.



Analog Devices' AD5539 high-speed op amp offers a typical 220MHz small signal bandwidth.



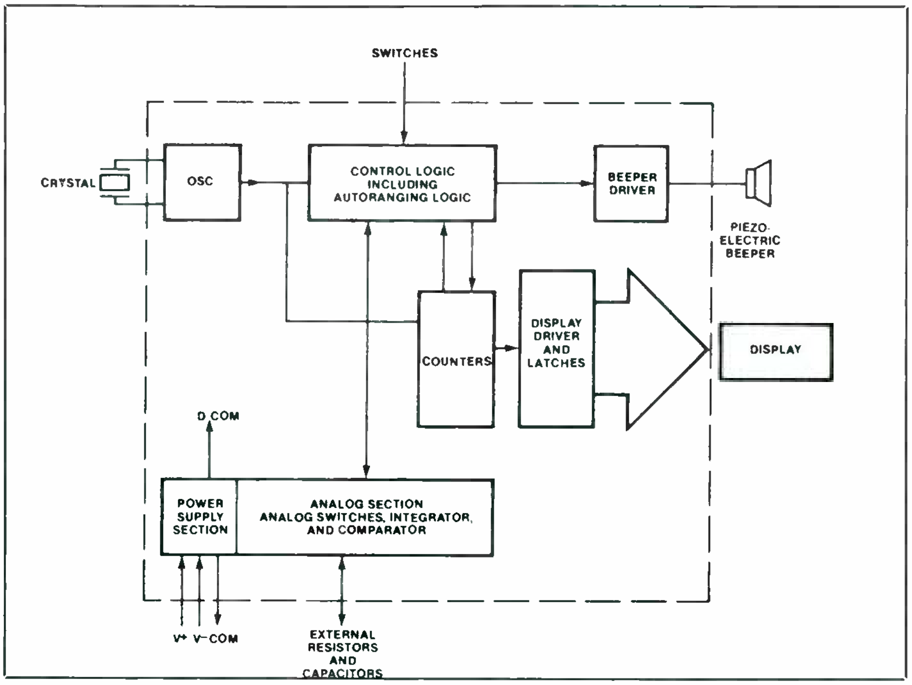
Eltec's Model 420 Pyroelectric Laser Detector in a TO-5 package.

• Intersil, Inc. (owned by GE) has a new CMOS 3¾-digit digital multimeter chip with more than half the normally required external components built into it. Designated the ICL7139, the 40-pin device is directly compatible with a duplex liquid-crystal display.

According to Intersil, the IC eliminates noticeable "range hunting" in the display, with the first reading said to always be on the correct range. Low power dissipation of less than 20 mW gives 1,000-hour typical battery life. There's a piezoelectric beeper that sounds for continuity and a display annunciator for on-chip detection of low battery voltage. $13.50 in 100 quantities . . . . Also announced by Intersil are new families of enhanced chopper-stabilized operational amplifiers. The two basic devices are ICL7650S, a super chopper-stabilized op amp, and the ICL7652S, a low-noise version. The "S" designation is for "super." It's claimed that the devices provide the lowest guaranteed maximum input offset voltage specs over all temperature ranges among competitive devices, and offer a minimum output source and sink current guarantee. Both have a very high gain of 150 dB. Applications that the devices are headed for include precision amplifiers for instrumentation, process control and medical instruments.

• Linear Technology Corp. (408-942-0810, Ext. 361) introduced the LT1088 wideband rms-to-dc converter. It can convert rms voltages up to 9.5 V at frequencies up to 300 MHz to their dc equivalents . . . . Previous monolithic circuits that converted rms waveforms to dc equivalents used logarithmic methods that limit waveforms to below 1 MHz and a crest factor of 10:1. The LT1088 is a direct-acting, thermoelectronic analog computer with a crest factor of 50:1 and an accuracy of one percent from dc to 50 MHz; two percent at 100 MHz . . . . The 14-pin side-brazed DIP is priced at $28.65 in 100 quantities.

• Motorola Semiconductor Products' (512-440-2035 for microcomputer IC; 602-244-4911 for discrete IC) microcomputer and discrete ICs are being used in new Canon 35mm cameras. The surface-mount-packaged devices incorporated are the MC68HC11 8-bit microcomputer unit, which enhances the camera's metering programs; two MPC1710 smart power motor controllers, one for shutter-spring rewind and the other for film advance and rewind functions; and the SFX10 custom TMOS power FET to control the camera's power bus.



A functional diagram of GE/Intersil's new autoranging multimeter IC.

• National Semiconductor's (408-721-3982) first analog-output detector for non-flammable fluid levels, the LM1042, uses a thermo-resistive probe sensor. The device can perform single-shot or repeated measurements and is designed for a power-supply range of 7.5 to 18 V. According to National, the LM1042 can be built as a fluid-level sensor with the addition of only a wire probe with a high temperature coefficient and low thermal time constant, passive components and an indicator . . . . Supplied in a 16-pin plastic DIP, it's priced at $1.25 each in 25K quantities. **ME**

The innards of a new Canon 35mm camera reveals the important uses of electronic devices for photographic equipment. In this case, the various surface-mount devices highlighted are from Motorola's semiconductor sector in Phoenix.

Consumer Products, Portables and Personal Favorites

By Eric Grevstad

The PC Popular; Brother, can you spare $549?

Except for compact discs that play five-minute MTV videos as well as songs (who needs them?) and a Casio watch that not only stores but dials telephone numbers (I need it), June's Consumer Electronics Show for the trade was memorable mainly for MS-DOS. PC clone prices continue to fall, past discount-store levels and heading for the sub-basement.

I hadn't heard anyone complaining that Korea's Hyundai-built Blue Chip computer was too expensive—in fact, the one I tried a few months ago was the first computer I'd describe as too cheap or vaguely flimsy—but importer Blue Chip Electronics must think so. Blue Chip's new PC Popular runs at 8 MHz as well as the old-fashioned 4.77 MHz; its a phenomenal $549 with 512K, one floppy drive, parallel and serial ports, two slots, and a mouse.

An extra $49.95 buys a graphically cute but basically crummy (no word wrap) notepad, calculator, and game disk along with demo programs from MicroPro, WordPerfect, and other publishers. A second floppy drive is $139.95 and a Hayes-compatible 1,200-baud modem is $99.95, or you could wait another year and get one free in a box of Cheerios.

You think I'm kidding? Epson makes the Equity I Plus, one of the best low-cost clones, but the Equity is sold in computer stores. To break into mass-market outlets, Epson came to the show with the Apex. It's got the same 8088-2 chip, 512K of memory, and two free slots as the PC Popular, but it comes with two disk drives and truly usable beginner's software, PFS:First Choice. Expect dealers to knock something off its list $899.

Leaving Korea and Japan, don't overlook Hong Kong, where Video Technology and its U.S. affiliates have upset Apple and devastated Franklin with a remarkably cheap, well-equipped Apple IIe compatible, the Laser 128. They've now squeezed a PC clone with 512K, one drive, one expansion slot, parallel, serial and external disk ports, CGA color and Hercules monochrome video, and an 8088 running at 10 MHz, all into the same Apple IIc-style case.

The Laser Compact XT costs $599; the Laser XTE has 640K, EGA color graphics, a clock, and a built-in EMS expanded memory card for $649. If the Lasers hold together, they could shake up an already riotous consumer market. Let corporate-office types worry about IBM and the Personal System/2; there's a street fight going on. Any bets on Tandy's doing something about this Asian invasion?

Portable Wars

In other news, international electronics giants are scrambling like puppies trying to get into your lap. I mean the metaphor literally, as one look at the MS-DOS portable market will indicate. NEC, hearing that an ordinary LCD screen was the only fault with its wondrous MultiSpeed, installed a backlit display and renewed my laptop lust with the MultiSpeed EL ($2,499).

Meanwhile, archrival Zenith has heard raves for the Z-181's backlit LCD, but boos for everything else. For the Z-183, Zenith improved the keyboard, boosted the speed, and added a battery-powered 10-megabyte hard disk. Unfortunately, the keyboard layout is still second-best and the price has soared to $3,339.

The battling duo has taken attention from the former category champion, the still highly desirable Toshiba T1100 Plus, but Toshiba's latest machine might slip into a nice niche below the proud por-

The Laser Compact XT: A desktop with a carrying handle.

tables. Yes, the T-1000 has a non-backlit display and only one 3.5-inch drive, but it has something I've been waiting for all portable makers to supply—MS-DOS in ROM, so one drive is enough. It also weighs only 6.4 pounds, half as much as its competitors, and costs a lot less ($1,199). Compared to other portables, the T1000 looks easier on your thighs and easier on your back pocket.

Park Hard Disk, End Session

It's been two years, 24 columns, and nearly 60 hardware and software products plus remarks and wisecracks about many more. This is my last "PC Papers" column, and time to thank the *Modern Electronics* editors for their support and tolerance of a series that's gyrated between enthusiasm, cynicism, and monthly harangues against high-priced gadgets that few users really need.

It's been too much fun for mushy goodbyes. I'm still using an even paid for a printer, two expansion cards, and several pieces of software from past columns; since there are many more computers and programs I wish I could pay for, I'll stick around as a freelancer for occasional "Software Focus" or hardware evaluations. Still, I can't resist a final step onto the soapbox.

Pundits will tell you that the last two years in personal computing have been marked by the triumph of the Apple Macintosh, but don't overlook the power of plain old PC thinking. The Mac didn't take off until it gained expanded memory, plug-in options, hard disks, and other features of obsolete MS-DOS systems. As for software, I've spent three years listening to sages scream that PC owners can't wait for Mac-style windows and icons. Meanwhile, PC owners have made monochromatic old Lotus 1-2-3 a titanic, unbeatable institution—from application to complete operating environment with add-in accessories and word processors; from operating environment to myth or legend.

Similarly, shouts of "The new DOS is coming!" and "The 80386 is here!" distracted people from what was really the biggest trend, the plunge of hardware prices to supermarket levels. I downplayed the Amiga in my first column and wrote "You've had it, Commodore" last summer; today, the Laser and Blue Chip are only the latest signs that the word at

Light weight, low price, DOS in ROM? Sounds good to me.

Wal-Mart, where home and game companies used to make the C64 their first priority, is MS-DOS.

As an affordable workhorse with lots of family or educational software plus expansion slots for upgrades and hackers, the PC is precisely where the Apple II used to be, with a big edge in powerful business programs to complement a home or school library rapidly matching the II's. Meanwhile, enthusiasts like us can now afford AT clones—no, the 286 will probably never get the dream DOS they promised us in '84, but it sure runs our old software fast while we wait for the OS/2 and PS/2 furor to sort itself out.

What's the worst computer I've seen these two years? The IBM PC Convertible, going away. The best? The NEC MultiSpeed. The worst software? JumpStart, Able One, and Lotus' upgrade prices and copy protection in the face of honorable competition like SuperCalc 4 and Words & Figures. The best software? Tornado Notes, edging out Framework II, Textra, and PFS:First Choice. All four support my creed that you don't need graphics and mouse control, just fast performance, a simple, keystroke-minimizing menu structure, and an ingenious idea.

There are lots of ingenious ideas in this industry. Thanks for letting me examine some of them with you, and stay skeptical about the loudly hyped ones. **ME**

NAMES & ADDRESSES

Blue Chip Electronics
7305 W. Boston Ave.
Chandler, AZ 85226
(602) 961-1485

Epson America Inc.
2780 Lomita Blvd.
Torrance, CA 90505
(800) 421-2526

Video Technology Computers
400 Anthony Trail
Northbrook, IL 60062
(312) 272-6760

NEC Home Electronics
1225 Michael Dr.
Wood Dale, IL 60191
(312) 860-9500

Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(312) 391-9849

Toshiba America Inc.
9740 Irvine Blvd.
Irvine, CA 92718
(714) 380-3000

followed by a parity bit. The master then pulls the line back to a "1" and holds it there, indicating the end of the "word." This last bit is known as the stop bit; its width is variable from one bit time to infinity. Figure 3 shows the Serial Data Format bit pattern.

The computer controls each master by using four of its I/O ports. Since the PC LINK adds 2048 ports to the system, at least 512 masters could reside on a PC. If these masters were each connected to 128 slave relay blocks, a total of 524,288 relay contacts could be controlled with a single PC. As a practical matter, you would not assign a task that large to a single machine, but it does give you an idea of the enormous power of the IBM/LINK combination.

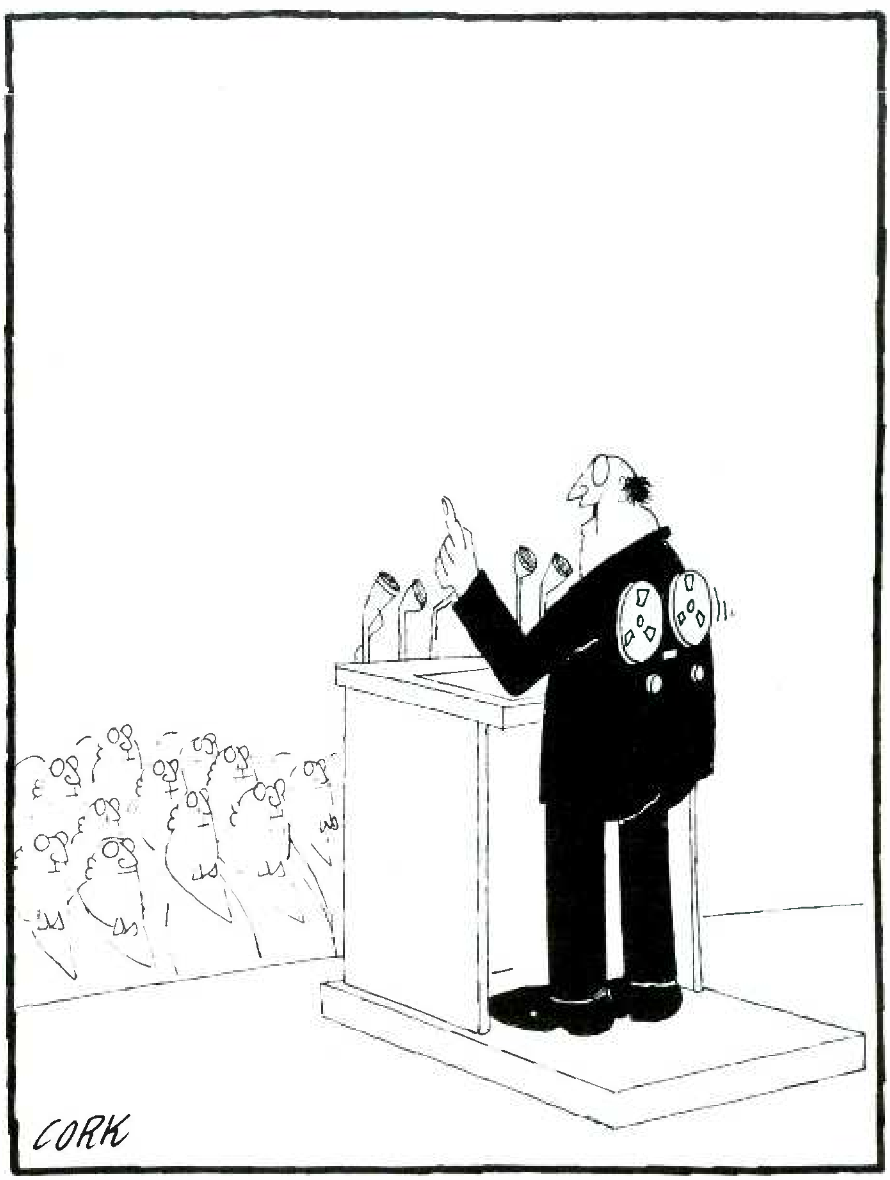
The major disadvantage of the master/slave concept is speed, which is inhibited as compared to a parallel system because only one conductor is used to carry data. Also, since the information may have to travel over a great distance, the data rate is designed to be significantly lower in order to minimize noise problems. (Using plain telephone wire, we've reliably transferred signals a thousand feet away using National Semiconductor's MM54240 pulse-width serial data string.). The net effect is that a serial data system, such as the one used here, will operate at rates 10 to 100 times slower than the equivalent parallel bus system.

Nevertheless, when designing these types of remote-control systems, I find that it useful to remember that radio control for model airplanes operates at data rates as low as 10 updates per second. This rate is rapid enough to easily allow precision control of a model doing high-speed aerobatics. The blinding speed that we normally associate with computers is not required in many cases involving mechanical devices.

As a result, it's more than sufficiently fast for control applications such as temperature sensing, timing events such as for security monitoring, controlling personal robots, etc. It would not be satisfactory for, say, controlling a factory milling machine used for precision work, however, nor for analyzing fast transient signals. For very high speed control, costlier direct memory access (DMA) controllers are needed.

Next month we'll discuss the role of various external devices, such as sensors and stepping motors, as well as software control, that are typically used in computerized control systems. We'll also design and build two process control systems. One will be for controlling the environment and security in a home, and the other for automatic testing and data logging while using the IEEE-488 interface.

The author, H. Edward Roberts, developed and produced the Altair computer that sparked the personal computer revolution. The company that he founded, MITS, was sold to Pertec in 1977, whereupon Roberts entered medical school. He's now an M.D. and is practicing medicine as an internal-medicine resident. The energetic and creative physician hasn't forsaken his electrical engineering/computer background, however. He founded and is president of Data-Blocks, Inc. ME



Building and Applying Active Minispeakers *(from page 48)*

Once you have ungrounded the oscilloscope, connect it across the outputs of the amplifier. Adjust *POT1* for maximum undistorted output as observed on the scope's CRT screen. Increase the input level of the signal source until the output waveform just begins to clip. Readjust *POT1* for maximum output level without clipping of either positive or negative peaks.

Finally, connect a dc voltmeter across the amplifier's output and adjust *POT2* for a 0-volt reading. Because of the presence of *C4*, the meter may take a few seconds to settle down after each change of the pot's setting. With patience, you should be able to trim the offset to 10 mV or less. If a large offset adjustment must be made, it will be necessary to go back and readjust *POT1* for maximum undistorted output level.

Once the amplifier has been properly adjusted, disconnect the oscilloscope, meter and signal generator. Then power down the amplifier and remove the power resistors connected across its speaker outputs. Install the amplifier in the speaker enclosure.

Before mounting the amplifier in the enclosure, however, connect and solder the free ends of the wires coming from the pc board lands to the appropriate binding posts, since the latter will not be accessible after the amplifier board is installed. Refer to Fig. 4 for wiring details.

Slip the board into the speaker enclosure through the hole in which the woofer mounts. Mount the circuit-board assembly to the rear of the enclosure with the three screws that originally held the crossover network in place.

Minispeakers are mostly acoustic-suspension types that depend on an airtight enclosure of fixed volume to work properly. To obtain maximum possible benefit from them, you should strive to maintain the original conditions. Therefore, to maintain a good air seal between the aluminum plate on which the ICs are mounted and the enclosure, seal the perimeter of the cutout with a small amount of Plasticine or other sticky clay. Also, to assure an airtight enclosure when *J1* is not being used, plug into the jack a dummy phono plug (stop up the hollow center pin with solder).

After mounting the amplifier assembly, replace the fiberglass batting in the enclosure. Pull the ends of the four speaker wires attached to the amplifier board through the fiberglass and their respective speaker holes (yellow for woofer, blue for tweeter and one each black "drivers" for each—see Fig. 4). When all the fiberglass batting has been replaced, connect the free ends of the wires to the speakers. Either slip the attached connectors onto the speaker lugs or—if you are a purist who believes that such connectors detract from the quality of the sound—clip off the connectors and solder the wires to the speaker lugs.

Observing the original orientations, reinstall the speakers in their respective holes, using the original screws to secure them into place. Replace the protective aluminum grille, gently tapping it with a mallet or through a board with an ordinary hammer until it is fully seated. You can discard the sticky clay that originally held the grille in place because it is not really needed. The grill will be held in place by friction.

Accessory Inputs

Obviously, any audio signal source that has line-level outputs can be used to drive the active minispeakers, including the preamp outputs of a home hi-fi system, the outputs from a tape or CD player, the headphone outputs of a portable radio/tape player, etc. Additional input devices and accessories can extend the usefulness of the active minispeakers. For example, a telephone pickup coil plugged into the input of one minispeaker can be used to enable more than one person to share in a phone conversation. Substituting a crystal microphone for the pickup coil turns a minispeaker into a continuous sound monitor for a baby's room.

With a probe and alligator clip connected across a potentiometer's outer lugs and a shielded cable connected between the pot's center and either outer lug and terminated at the other end in a phono plug, you have a convenient means for tracing an audio signal in an audio circuit. When using the minispeaker in this manner, always start with the pot set for minimum output signal into the amplifier circuit and adjust as needed for a loud enough signal from the speaker.

You can also use an active minispeaker to trace magnetically induced hum to its source by using a coil-type pickup. Again, start with minimum signal going into the speaker's amplifier and adjust accordingly with the potentiometer.

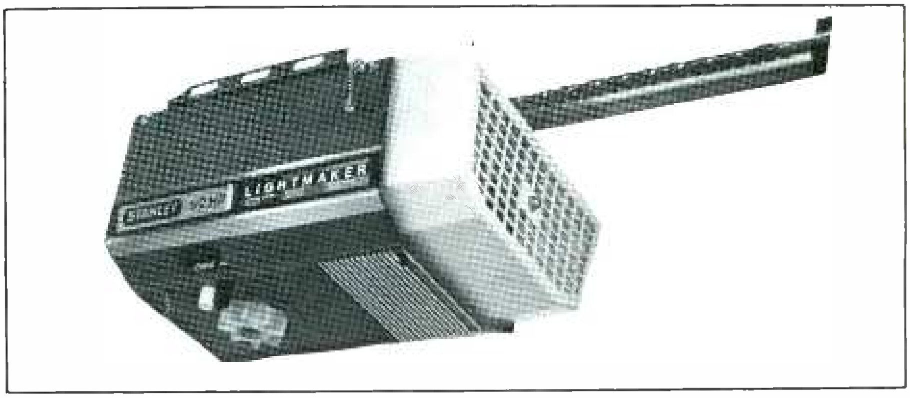
One or both active minispeakers can be used to amplify the audio outputs available from some computers. Additionally, these speakers can temporarily replace headphones at a test bench when it would be too much effort to build a dedicated amplifier (make sure to include the attenuator potentiometer).

As a final note, do not overlook non-portable applications for the active minispeakers. If you plan to use the minispeakers where ac power is available, it is a good idea to use an ac-line-power instead of a battery supply. You can easily put together such a supply using a 12.6-volt transformer, four rectifier diodes, a filter capacitor or two and a bypass capacitor in a classical unregulated circuit. Due the wide range of supply voltages that can be used and the low current drain of the amplifier/speaker arrangement, no regulation is needed. Properly designed, such a power supply will yield an 18-volt or so dc output that is near the maximum recommended for the active minispeakers. **ME**

NEW PRODUCTS • • • *(from page 10)*

Garage Door Opener Safety Light Control

LightMaker™ is a new series of automatic garage door openers from Stanley that allows the user to control both indoor and outdoor lighting. LightMaker is available in ⅓- and ½-hp versions that can be installed by the buyer. It can be used with both track-type and trackless doors up 18 ft. wide by 7.5 ft. high.



Stanley's lighting control system uses line-carrier technology in which signals are sent from the hand-held transmitter (that turns house lights on as it triggers the door-opening system) to the opener powerhead, then through existing house wiring to any preselected incandescent light. Using house wiring to control lighting eliminates costly radio receivers.

The system comes with a plug-in module to control a lamp. A Signal-Block™ security feature electronically shuts off the opener from the car. Three built-in door closing safety features include the new Safe-T-Close™ option. Other features are variable light time delay, lighted wall-mounted pushbutton switch and steel chain drive.

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11-MHz Function Generator

New from Iwatsu Instruments is the Model SG-4111, an 11-MHz function generator that can simultaneously display the oscillating frequency plus the output or dc offset. The generator can output sine, triangle and both symmetrical and asymmetrical square waves over a 0.1-Hz to 11-MHz range with a rated accuracy of within ±2% of programmed values. Features include wide oscillation bandwidth; vcf with 1,100 times frequency sweep range and variable waveform symmetry; less than 25-ns square-wave rise and fall times; 20-volt peak-to-peak maximum output signal; and a sync output for TTL drive.

All controls and output connectors are located up front below a large (0.6"-high) LED display window for convenient access. The compact, lightweight instrument has a bail that serves as a carrying handle and doubles as a convenient tilt stand on the testbench. $995.

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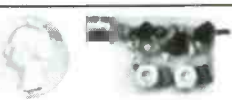

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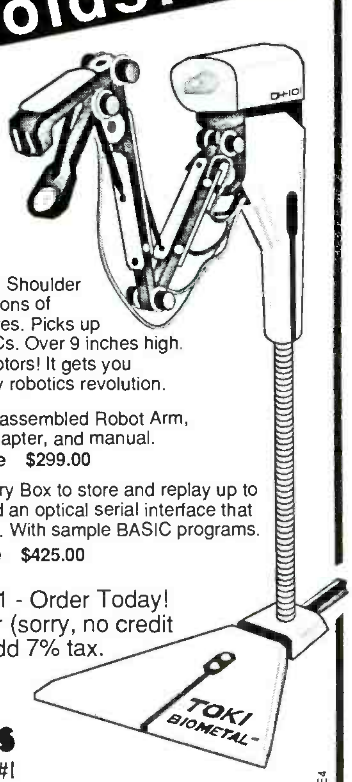

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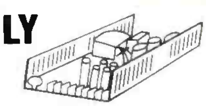

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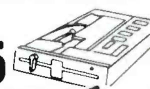

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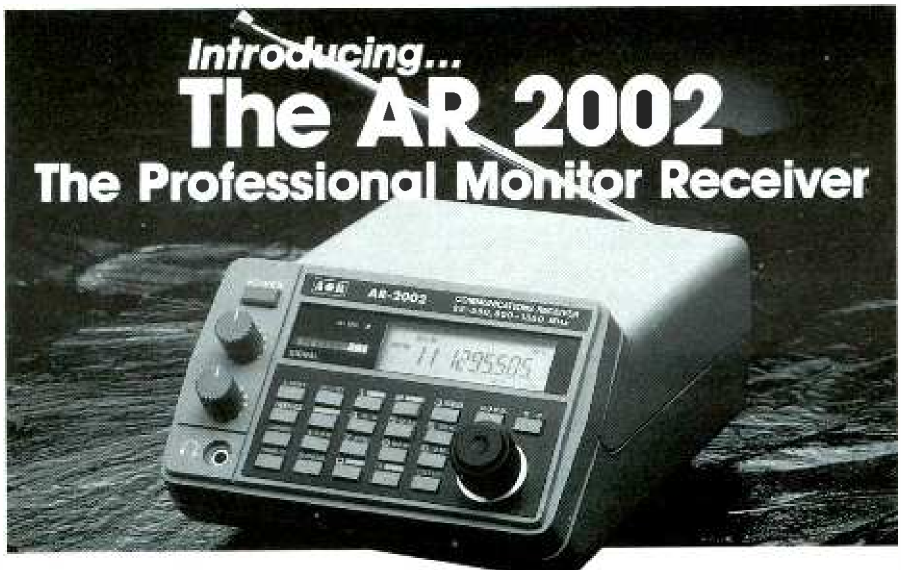

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