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A Discrete-Component HF Op Amp

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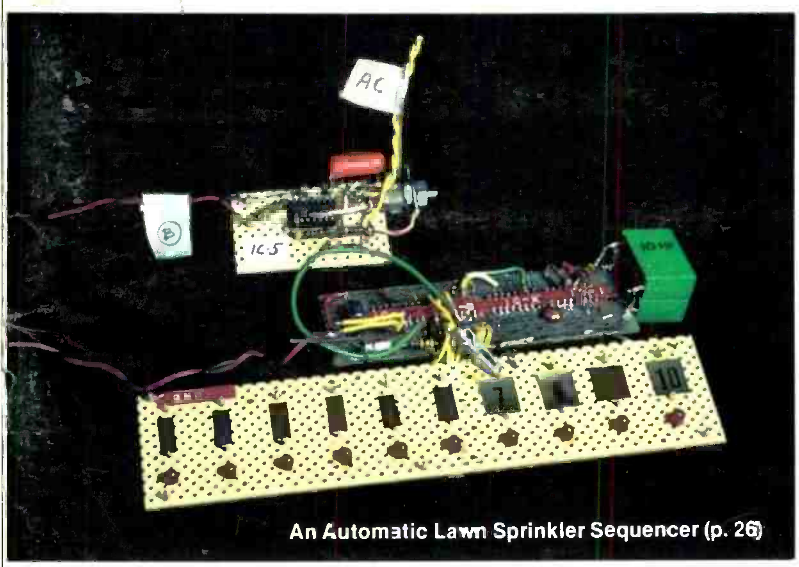

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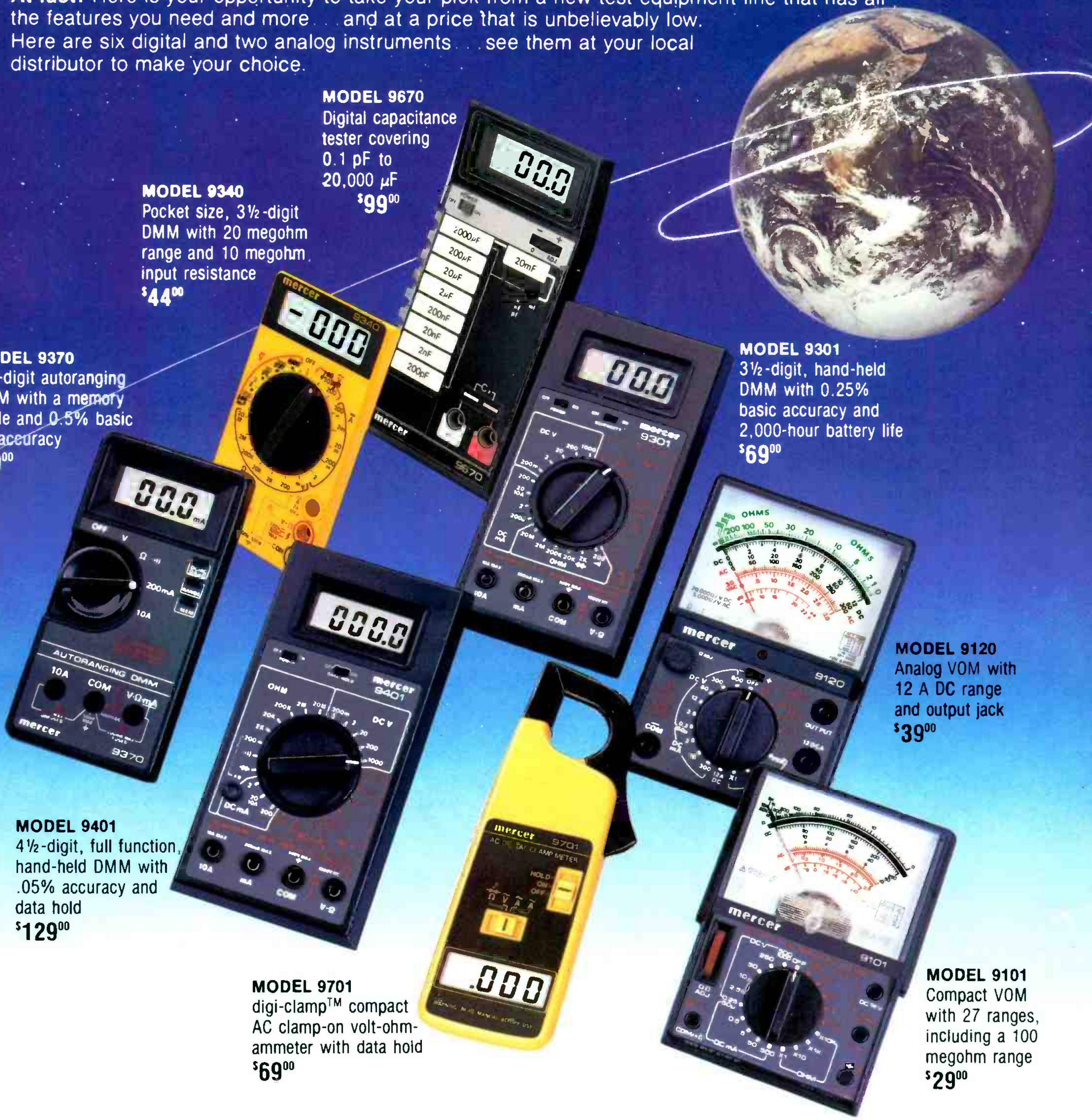

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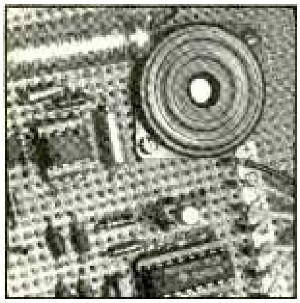

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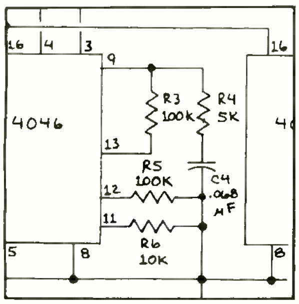

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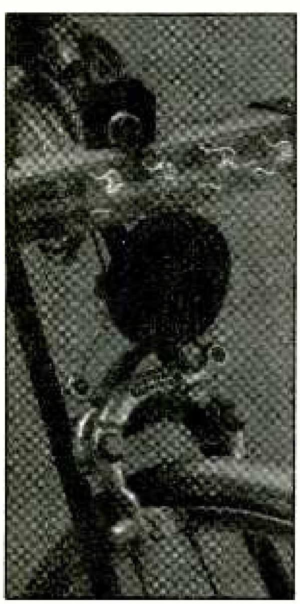

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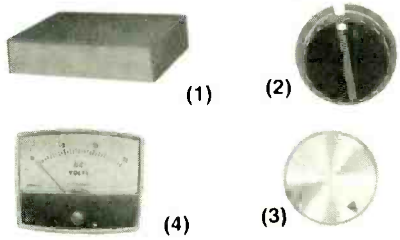
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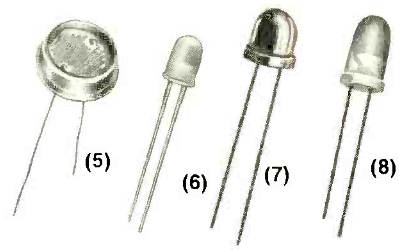
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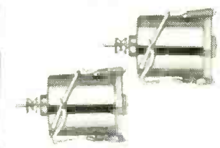

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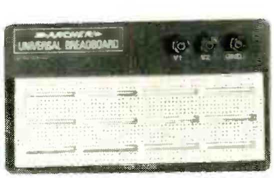

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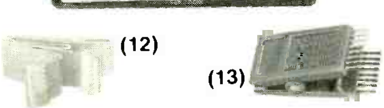

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EDITORIAL

We Know You!

"Know thy reader" is every editor's imperative. To pinpoint information about you so that we can sagely fine-tune our editorial material, we embarked on an intensive reader study by mailing 2,000 four-page questionnaires to a random sampling of MODERN ELECTRONICS subscribers. This yielded a net response at our 30-day cutoff period of 49.5% or 989 completed questionnaires, which is a very healthy sampling for purposes of accuracy.

We had speculated that more than 10% of you earned a post-graduate degree or had some work toward it. What a pleasant surprise it was to learn through our survey that your educational level is substantially higher than this—22.6% (11.6% post-graduate degree, 11% post-graduate work). In all, 47.9% of our respondents indicated they are college graduates, while an additional 35.5% attended or are attending college. Thus, 83.4% of our subscribers are college trained. We're impressed!

Our expectations on how many of you work in a technical or professional area were too low, also. Whereas we were confident that more than two-thirds of our readers were technical people (electronics/computers) or professionals such as educators, scientists, physicians, etc., our survey results indicate a much higher percentage—70.8% technical plus 13.4% professional and other technical, for a grand total of 84.2%.

More than half of you, we felt, would surely be employed in the electronics or an allied industry, where many had purchasing authority or influence on buying company equipment, parts and supplies. This is confirmed by our study which reveals that more—fully 65.4%—of our subscribers are employed in electronics or a related field, while 59.5% are involved in company OEM purchases.

As to age and income, the former was anticipated to be in the mid-thirties, which it was with a median age of 36 years old. The largest percentage total in an age range was 32.8% between 25 and 34 years old. Under 18 years accounted for only 2.1%. So clearly, you're both seasoned in the work world and at the peak of your powers. Household income median (1985) was $36,846, with 19.9% over $50,000 and the $30,000 to $50,000 category leading with 39.0%.

Where you live and work broke down as expected, with East North Central, Mid-Atlantic, South Atlantic and Pacific competing for the top regional percentage. Among individual states, California leads with 12.5% of respondents, followed by New York with 8.9%, Pennsylvania with 4.9% and Ohio with 4.0%.

The foregoing only scratches the surface of what we gleaned from this large-scale subscriber study. We'll tell you more about you next time around. Many thanks to all you fine readers who responded so enthusiastically to our request for filling out our detailed questionnaire.

LETTERS

Operation Assist

•After a number of years of good service, my Concord open-reel tape recorder is giving me problems. I'd like to repair it, but the dealer from whom I purchased it can't help because he can't get the parts needed, and Concord is no longer in business. Can you or any of your readers help me?

Herbert G. Fikes
8032 State St.
Garrettsville, OH 44231

•Can anyone supply me with the assembly instructions and/or schematic diagram for the Fairchild FTK0101 clock calendar kit?

Lowell Ray Anderson
Box 67
Cody, WY 82414

•I'm trying to rebuild an old Model CRO-2 oscilloscope made by Jackson Electrical Instrument Co. of Dayton, OH

(Continued on page 93)

NEW! Lower Price Scanners

Communications Electronics,™ the world's largest distributor of radio scanners, introduces new lower prices to celebrate our 15th anniversary.

Regency‡ MX7000-EA

List price $699.95/**CE price $399.95/SPECIAL**
10-Band, 20 Channel • Crystalless • AC/DC
Frequency range: 25-550 MHz. continuous coverage and 800 MHz. to 1.3 GHz. continuous coverage.
The *Regency* MX7000 scanner lets you monitor military, F.B.I., Space Satellites, Police and Fire Departments, Drug Enforcement Agencies, Defense Department, Aeronautical AM band, Aero Navigation Band, Fish & Game, Immigration, Paramedics, Amateur Radio, Justice Department, State Department, plus thousands of other radio frequencies most scanners can't pick up. The *Regency* MX7000 is the perfect scanner for intelligence agencies that need to monitor the new 800 MHz. cellular telephone band. The MX7000, now at a special price from CE.

Regency® Z60-EA

List price $299.95/**CE price $179.95/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-EA

List price $259.95/**CE price $159.95/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® RH250B-EA

List price $613.00/**CE price $329.95/SPECIAL**
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The *Regency* RH250B is a ten-channel VHF land mobile transceiver designed to cover any frequency between 150 to 162 MHz. Since this radio is synthesized, no expensive crystals are needed to store up to ten frequencies without battery backup. All radios come with CTCSS tone and scanning capabilities. A monitor and night/day switch is also standard. This transceiver even has a priority function. The RH250 makes an ideal radio for any police or fire department volunteer because of its low cost and high performance. A UHF version of the same radio called the RU150B covers 450-482 MHz. but the cost is $449.95. To get technician programming instructions, order a service manual from CE with your radio system.

NEW! Bearcat® 50XL-EA

List price $199.95/**CE price $114.95/SPECIAL**
10-Band, 10 Channel • Handheld scanner
Bands: 29.7-54, 136-174, 406-512 MHz.
The Uniden Bearcat 50XL is an economical, hand-held scanner with 10 channels covering ten frequency bands. It features a keyboard lock switch to prevent accidental entry and more. Also order part # **BP50** which is a rechargeable battery pack for $14.95, a plug-in wall charger, part # **AD100** for $14.95, a carrying case part # **VC001** for $14.95 and also order optional cigarette lighter cable part # **PS001** for $14.95.

NEW! Regency® XL156-EA

List price $239.95/**CE price $129.95/SPECIAL**
6-Band, 10 Channel • No-crystal Scanner
Search • Lockout • Priority • AC/DC
Bands: 30-50, 144-174, 440-512 MHz.
Cover your choice of over 15,000 frequencies on 10 channels at the touch of your finger. Display messages. External speaker jack. Telescoping antenna. External antenna jack. AC/DC.

NEW! Regency® R1060-EA

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Bands: 30-50, 144-174, 440-512 MHz.
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List price $649.95/**CE price $349.95/SPECIAL**
Frequency range 10 KHz. to 30 MHz.
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NEW! Regency® HX1200-EA

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9-Band, 16 Channel • Priority • Scan Delay
Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 118-174, 406-512 MHz.
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Bearcat® 210XW-EA

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8-Band, 20 Channel • No-crystal scanner
Automatic Weather • Search/Scan • AC/DC
Frequency range: 30-50, 136-174, 406-512 MHz.
The new Bearcat 210XW is an advanced third generation scanner with great performance at a low CE price.

NEW! Bearcat® 145XL-EA

List price $179.95/**CE price $102.95/SPECIAL**
10 Band, 16 channel • AC/DC • Instant Weather
Frequency range: 29-54, 136-174, 420-512 MHz.
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Test any scanner purchased from **Communications Electronics**™ for 31 days before you decide to keep it. If for any reason you are not completely satisfied, return it in original condition with all parts in 31 days, for a prompt refund (less shipping/handling charges and rebate credits).

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List price $499.95/**CE price $317.95**
12-Band, 40 Channel • No-crystal scanner
Priority control • Search/Scan • AC/DC
Bands: 29-54, 118-174, 406-512, 806-912 MHz.
The Uniden 800XLT receives 40 channels in two banks. Scans 15 channels per second. Size 9¼" x 4½" x 12½."

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RH600B-EA *Regency* 10 ch. 60 Watt VHF trans. $454.95
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MODERN ELECTRONICS NEWS

CD ROM SYSTEMS. CD-ROM systems, which use present-day audio compact-disc technology, can store 600 megabytes. This is enough to put an entire encyclopedia on the 5-in.-diameter optical disc. Microsoft attracted about 1,000 people to its CD-ROM Conference recently, so there's plenty of excitement in the air on it. There are some flies in the ointment, though. Lack of software is one, hampering quick and easy information retrievel.

CRT SHIELDS. Though hazards associated with cathode-ray-tubes in computer monitors and TV sets got a sort of clean bill of health some time ago, the issue is apparently still alive. According to the RAM company (Beverly Hills, CA), researchers in Sweden found that CRT radiation affected fetuses in mice, though a world health organization conference in Geneva recently concluded that office computers did not endanger pregnant women. RAM sells CRT Shields, of course. A new VDT shield using metallized fabric imbedded into a glare filter was recently introduced by Noetic Systems (Los Altos, CA) that is said to be the answer to uncertainty about the effects of a video display tube on unborn babies. In another CRT protection area, Direct Safety Co. (Phoenix, AZ) introduced "Data Shades," non-prescription glasses to reduce glare and sharpen contrast, as well as screening most of the worrisome ultraviolet rays.

SATELLITE TV SCRAMBLING & DESCRAMBLING. Birdview Satellite (Overland Park, KS) has announced an interesting dealer program that provides consumers with Free descramblers (legal ones, we assume). With HBO and CINEMAX now scrambling their satellite transmissions, viewers with backyard dishes cannot receive these signals without leasing a decoder from their local cable TV company. Tandy Corp's CEO, John Roach, charges that the decoders are over-priced, amounting to paying tribute to a local monopoly with an over-priced decoder and inflated fees. He notes that since the cable provider doesn't have any expenses in this case, the satellite dish owner should pay less. More than 100 channels are expected to remain unscrambled, at no cost to dish owners, so there's no cause for alarm, just concern, says Roach.

FIRST SOLID-STATE HUMIDITY SENSOR. Sharp Electronics (Paramus, NJ) announced that it developed the industry's first solid-state electronic humidity sensor for air conditioners, laundry dryers, greenhouses, and so on. The Model ORO5HM1 sensor is said to be a compact module that uses an organic, high-molecular film as the humidity-sensing material. It features a built-in temperature-compensation thermistor. Measuring about one-inch square, the module runs on a single 5-V supply, translating humidity into voltage that can be programmed to perform various control functions. Volume-quantity price is $4.

INVENTORS HALL OF FAME INDUCTEES. Two IEEE Life Fellows were among five inventors inducted into the National Inventors Hall of Fame this year: Harold Edgerton for a 1949 patent on the Stroboscope and Wilson Greatbatch for a 1962 patent on the Medical Cardiac Pacemaker. They join 59 others who were similarly honored. For a free booklet with brief biographies of the inventors, contact the Patent and Trademark Office, 2021 Jefferson Davis Highway, Arlington, VA 22202 (phone 703-557-3428).

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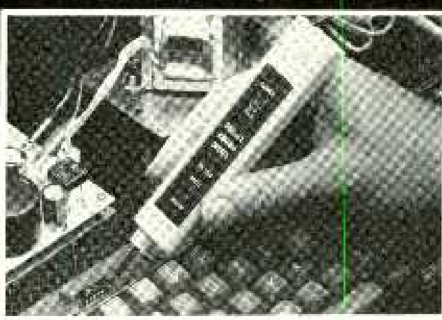

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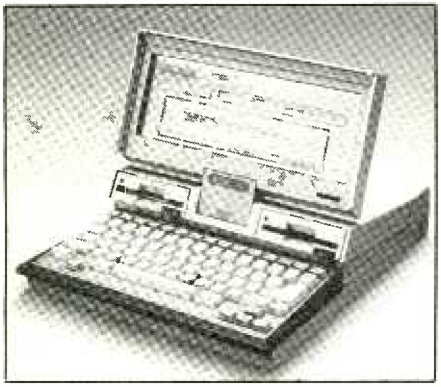
NEW PRODUCTS

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.

IBM's New Laptop Portable Computer

The newest member of IBM's PC line, the PC Convertible, is a full-function laptop with removable 80 × 25-character LCD screen, dual 3.5″ diskette drives and full-size keyboard. Built around a low-power 4.77-MHz CMOS 80C88 microprocessor, the PC-compatible Convertible comes with 64K of CMOS ROM containing power-on self-test of system components, BIOS support and a BASIC interpreter and 256K of user RAM on two 128K RAM cards. User RAM can be supplemented with additional user-installable RAM cards up to a system total of 512K. The removable LCD screen supports 640 × 200 and 320 × 200 graphics.



Standard features include: a 16K RAM display buffer; 8K character-font ROM; printer interface; battery pack and ac adapter; time-of-day clock; 72-pin I/O connector; and speaker. A diskette containing "Applications Selector" and "System-Apps" software is supplied for quick start-up and ease of use.

A number of options are available for the Convertible, including memory cards, printer, serial/parallel adapter, 13″ color display, CRT display adapter, internal modem, printer cable, battery charger and hardware that adapts the Convertible to IBM PC.

The IBM PC Convertible measures 14.72″D × 12.28″W × 2.64″H and weighs 12.2 lbs. $1,995.

CIRCLE 53 ON FREE INFORMATION CARD

High-Resolution DMM

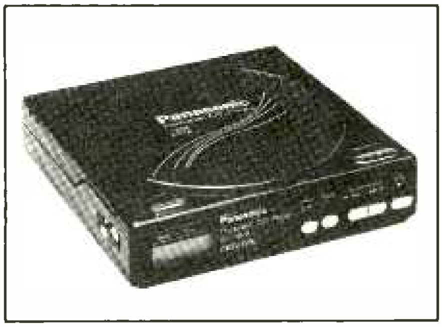
Mercer Electronic's (Div. of Simpson Electric Co.) new Model 9401 hand-held 4½-digit digital multimeter features a large LCD display, DATA HOLD, diode-test and audible continuity functions, a large rotary range/function selector, and recessed testlead inputs.

Measurements can be made from 200 mV to 1000 V full-scale on dc volts; from 200 mV to 750 V on ac volts; from 2 to 200 mA and to 10 A full-scale through a separate testlead input on both ac and dc current; and from 200 to 20M ohms full-scale on resistance. Basic dc accuracy is rated at 0.05%, and voltage/resistance ranges are protected against transients up to 6 kV and 50 μsec. The meter measures 6.69″H × 3.43″W × 1.65″H and weighs only 0.75 lb. $129.

CIRCLE 54 ON FREE INFORMATION CARD

Hand-Held CD PLayer

Panasonic's new Model SL-NP3 portable Compact Disc player is small enough to fit into the palm of a hand, measuring 5″W × 1¼″H × 5″D. It has a specified S/N ratio and dynamic range of 90 dB, and THD rating of less than 0.006% at 1 kHz, 0 dB. The player is built around a miniaturized laser pickup and Accu-Servo System that is said to provide superior tracking error detection.

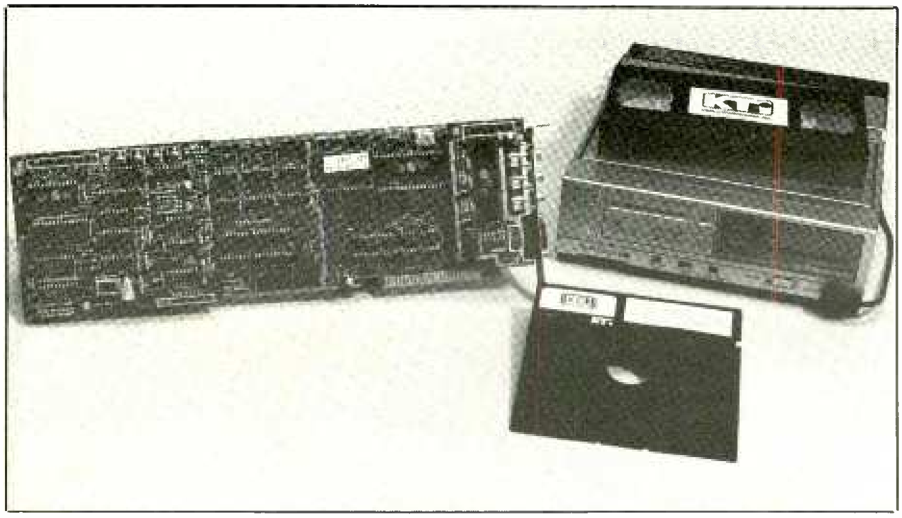


Performance-enhancement features include digital noise canceler, digital phase limiter and drop-out protection circuits; a free floating suspension system that makes the player resistant to physical shock; a spring-loaded mechanism that smooths laser movement on its guide rail. A microprocessor-based attitudinal servo compensates for changes in position during portable operation. Other features include: skip and two-speed search with cueing sound, repeat, defeatable high-cut filter and headphone jack with volume control. An LCD display shows track in play, elapsed track time, remaining time, repeat and battery check. $259.95 with ac adapter and stereo cable.

CIRCLE 55 ON FREE INFORMATION CARD

VCR Storage For Computers

More than 150 megabytes of data from an IBM PC, XT or AT can be stored on one Beta or VHS videocassette with "Background Back Up" from Kirsch Technologies Inc. (201 N.



Riverside Ave., Bldg. A-5, P.O. Box 120, St. Clair, MI 48079; Tel.: 312-329-7166). KTI's Video Memory Manager borad provides the interface between VCR and computer. BBU software, with DOS-like commands, runs in a background mode, allowing full use of the computer while recording memory. All commands use the standard DOS filename format and accept global filename characters, and all can be executed from batch files for unattended operation. A buffer spools multiple Backup commands that can be issued at one time.

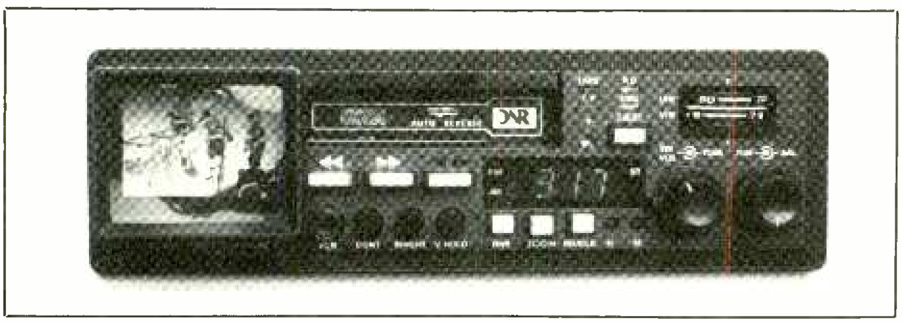
An activity log generated when backing up provides a record of files saved. Backup and restore functions can perform in file-by-file or disk-image mode. A test utility gives tape quality information. A menu-driven setup utility provides control over all important operating parameters. Finally, the system provides full control over all VCR functions from the computer's keyboard.

CIRCLE 56 ON FREE INFORMATION CARD

In-Dash Car Video System

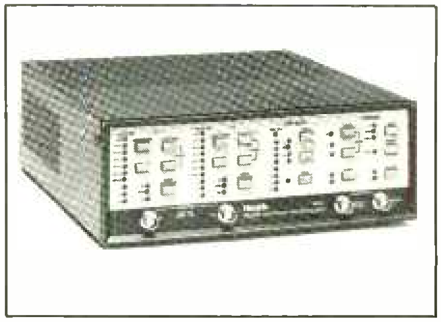
Bould Electronics' (Boulder, CO) American Audio™ "In-Dash Car Video System" offers TV reception in addition to the usual cassette/radio capabilities of the car radio. The Video System features an auto-reverse stereo cassette player, an AM/FM stereo radio with digital numeric frequency/time display, a 50-watt audio amplifier and a 2" black-and-white picture tube. The Video System features both zoom (30% picture enlargement) and connectors for a VCR, as well as a vhf and uhf signal-strength meter, and brightness/contrast/vertical-hold front-panel controls. For in-dash applications, the Video System must be wired so that the TV picture is available only in the ignition key's accessory position, though TV sound can be heard when driving. $299.

CIRCLE 57 ON FREE INFORMATION CARD



Digital Memory Scope

A digital memory scope for IBM PCs and compatible computers and low-frequency bandwidth oscilliscopes is available from the Heath Co. This new device is an interface that turns a computer or 5-MHz scope into a dual-trace 50-MHz, 50-ns risetime digital storage scope. Supplied software gives full control of scope functions from the computer's keyboard. The computer displays two traces on an 8 × 10-division graticule in either Y1, Y2 or dual display mode.



Displays are chopped, except for the highest timebase range, which uses alternate display. Displayed waveforms can be stored on disk for later use as a reference or for waveform manipulation.

A null modem cable is required to use the device with a PC-compatible computer. Use with an oscilloscope requires that the scope have a 5-MHz or greater bandwidth, one 0.5-volt/division sensitivity vertical channel, ability to trigger from a second source and triggered sweep. The digital memory scope is available in kit form as the Model ID-4850 and factory-wired as the Model SD-4850.

CIRCLE 58 ON FREE INFORMATION CARD

Chassis/Enclosures

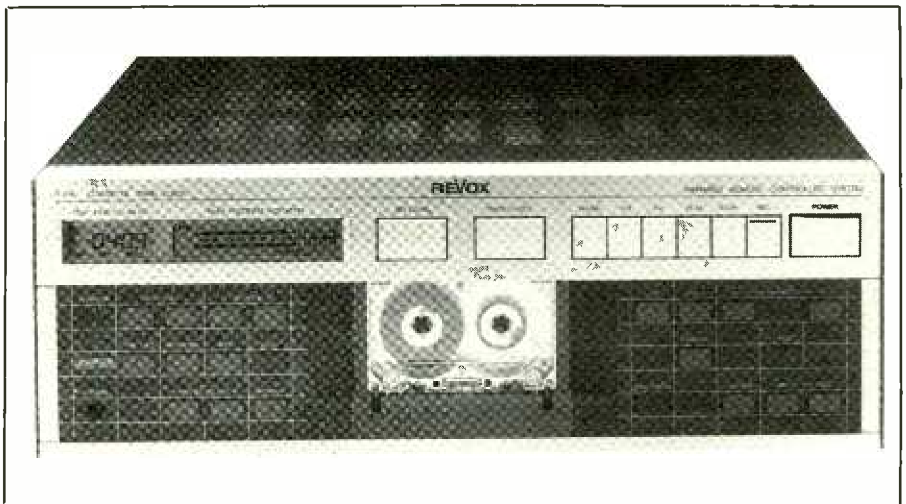
Ten-Tec's new Series B Constructo Enclosures offer all-metal construction and an inner adjustable-height chassis mounted on their two side panels. The chassis and side, front and rear panels are made of $\frac{1}{16}$"-thick sheet aluminum, while the clamshell

(Continued on page 90)

Audio

The Revox B-215—An Elegant Cassette Deck From Swiss Craftsmen

If you still look upon the cassette deck as a "second-best" tape recording device, the magnificantly engineered Revox Model B-215 may well change your mind. Here is a recorder that's ultra-sophisticated in its performance capabilities and convenience features, comparing favorably with open-reel recorders. The Revox B-215 bears the unmistakable stamp of Swiss-based Studer/Revox engineering and innovation. Here is a brief summary of some of its features.



Features

The deck can automatically determine and memorize optimum recording bias settings for six different tape formulations. In order to determine the best possible bias for a given tape, circuits within the B-215 measure tape distortion at three different frequencies. The process takes just 20 seconds. The B-215 can also set optimum recording levels at the touch of a button. A light goes on to indicate that this has been done. You can randomly access recorded selections by pressing a single control. Deck functions can be directed by an optional wireless remote control module ($125) or through a bidirectional port that interfaces with a central controller for operation from a remote location.

A real-time counter lets you access any point on a recorded cassette by entering, in minutes and seconds, the elapsed time desired. Even when a cassette has been partially played (not rewound to its beginning), when it is inserted into the B-215, the deck's unique circuitry calculates the elapsed time from the beginning of the tape by comparing the rotational speed of each wheelhub. Tape location selections can be stored in two programmable address locations and "looping" or repeat-play between the two locations is then made possible.

The Revox B-215 incorporates the well-known Dolby HX Professional system, which continuously monitors program content and varies recording bias for maximum dynamic range. Separate Dolby-B and Dolby-C noise reduction circuits for both record and playback plus separate record and playback tape heads let you monitor recording results accurately while recordings are in progress.

Four-second fade-in and fade-out recording is another feature of the B-215. In addition, the unit's output switches automatically from the source to off-the-tape monitoring whenever the RECORD button is pressed. If the PAUSE control is pressed, the B-215 switches back to the program source so that you can still monitor source material.

The tape transport system of the B-215 is a typical example of Revox's fine precision craftsmanship. The tape drive uses four dc motors: two for direct-drive capstans and two for tape spooling, which is controlled by microprocessors.

The cassette deck carries a $1,400 suggested retail price, which clearly suggests that it's for the audio perfectionist. Dimensions are 17.7″W by 6″H by 13.1″D. Weight is 20 lbs. 3 oz.

Front Panel Layout

Cassettes are mounted at the center of the front panel. Two large touch-pads just above the cassette area are used for automatic level setting and for fade-out/fade-in effects. The automatic set-level feature works by analyzing program material that's about to be recorded. After a short time, it recognizes peaks in the program, and sets recording level accordingly. Major tape transport and record buttons are located at the upper-right of the panel, while LCD real-time counter and peak-program level meters are at the upper-left.

Controls for manually setting record levels, channel balance, headphone volume, tape type, noise-reduction system, automatic bias adjustment and monitoring are located at the lower-left of the panel, together with a stereo headphone jack. Touch buttons needed for the various programming functions and for accessing a point in a tape based upon play time are logically arranged at the lower-right of the panel. The POWER switch is at the upper-right corner of the panel.

Aside from the usual pairs of line input and output jacks, the rear panel contains a multi-pin connector identified as a "Serial Link." The trilingual owner's manual tells us that this connector is used to connect a serial remote-control unit, but no further information is offered. I suspect that this socket is used for incorporating the B-215 into Revox's interactive music system that includes other Revox audio components such as their B-285 receiver and their new B-225 Compact Disc player.

A voltage selector is also found on the rear panel since the Revox B-215 is de-

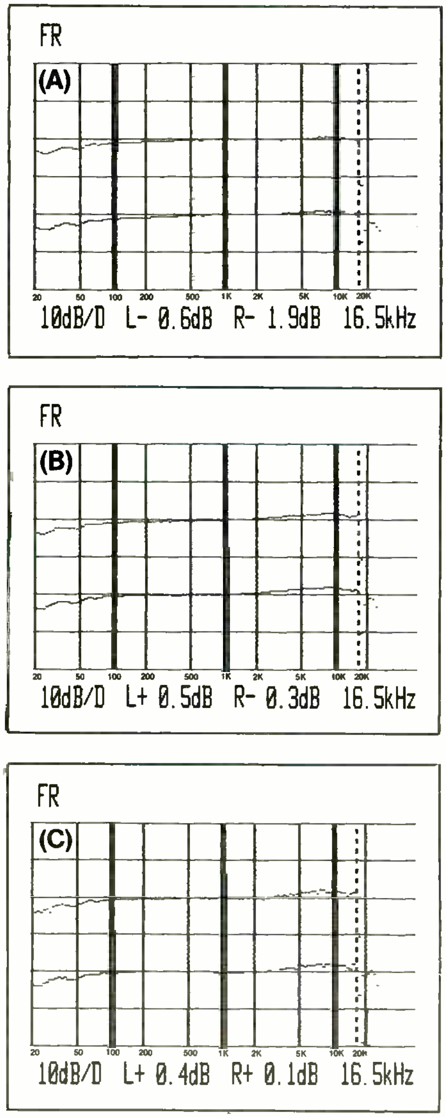


Fig. 1. Record/play response with Type I (A), Type II (B) and Type IV (C) tape, with Dolby B noise-reduction activated.

signed to work at any supply voltage from 100 to 240 Vac, 50 or 60 Hz.

Laboratory Measurements

Since Revox supplies a blank cassette of BASF Type II (chromium-dioxide) formulation tape, we elected to use that manufacturer's tape samples for all three popular tape types. For Type I (ferric-

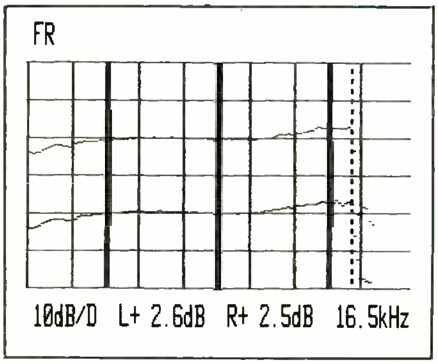


Fig. 2. Record/play frequency response using Type IV tape with Dolby C noise reduction activated.

oxide) tape tests we used BASF Pro Super, while for Type IV (metal-particle) tape tests we used BASF Metal IV cassettes. In fact, just about any high-quality cassette tape will work well with this machine, since it aligns itself optimally not only to the generic type of tape but to the specific batch of tape being used. Before making any of our measurements, we allowed the B-215 to "have a look" at each of our tape samples and to adjust and memorize bias settings for each.

The specification that seems to be of greatest interest to most recording enthusiasts is frequency response (even though professional recording engineers and technicians don't place this specification quite so high on their list of important specs). We measured record/play frequency response for each type of tape three ways: without any Dolby noise reduction, with Dolby B noise reduction (Fig. 1) and with Dolby C noise reduction (Fig. 2). All measurements were made at a −20-dB record level. The 0-dB on the Revox meters corresponds to a magnetization level of 200 nano-Webers per meter (nWb/m).

Without Dolby NR, response for each tape was far better than Revox lists in its traditionally conservative published specifications. The Type I tape sample exhibited response way out to 22 kHz for its −3 dB roll-off point, while Types II and IV tapes had response extending even further, to 24 kHz. With Dolby B or C applied, slight deviations from perfect re-

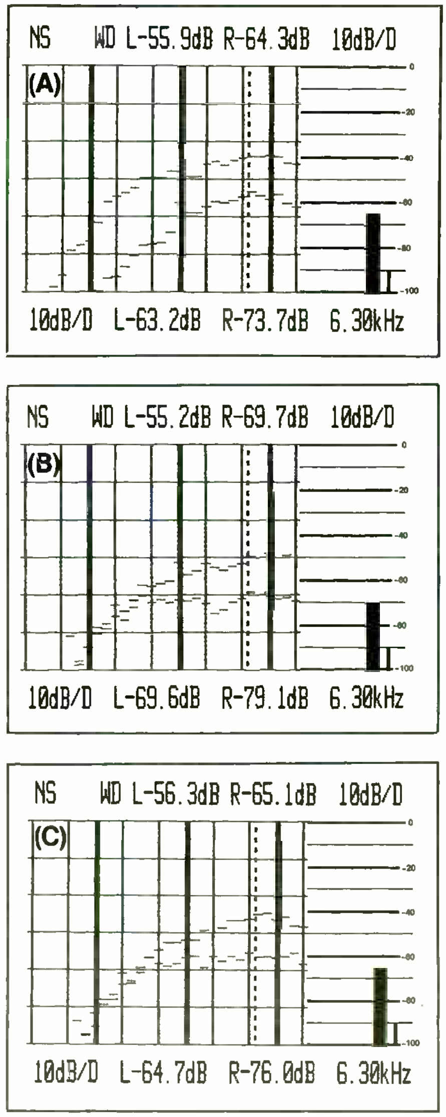


Fig. 3. S/N analysis with and without Dolby B noise reduction using Type I (A), Type II (B) and Type IV (C) tape.

cord/play NR tracking are probably responsible for the somewhat poorer overall record/play response, but in no case did the B-215 fail to meet published specifications even under these measurement conditions.

All of the frequency-response plots extend from 20 Hz to above audibility. The notations below each graph denote the output level at the frequency specified for

PRODUCT EVALUATIONS . . .

Revox's B-125 Cassette Deck continued . . .

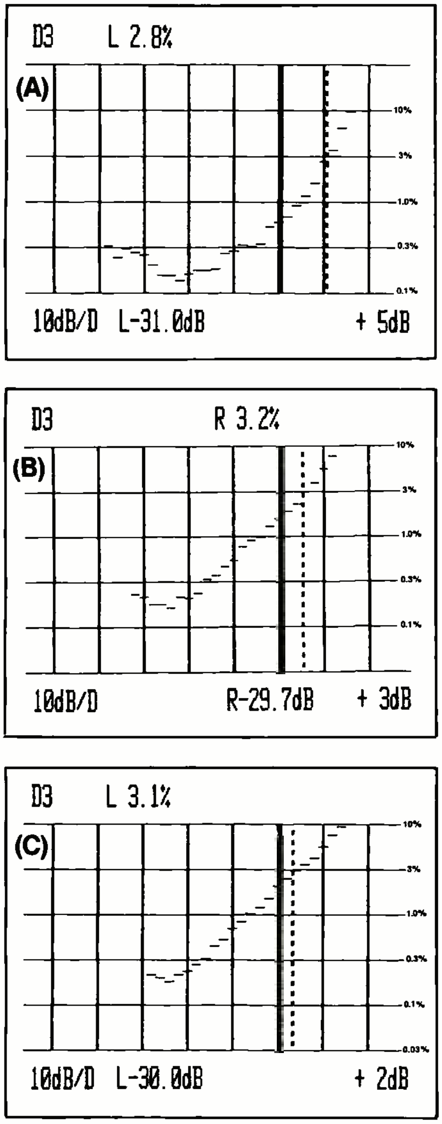


Fig. 4. Third-order distortion versus recording level using Type I (A), Type II (B) and Type IV (C) tape.

the left (L) and right (R) channels; vertical calibration of each graph is 10 dB per division.

Figures 3 and 4 show the results of our signal-to-noise ratio studies. In Figs. 3A, 3B, and 3C, S/N ratios are measured with and without Dolby B. Overall results are shown at the top of each plot, with the "L" results representing the "Dolby Off" condition and the "R" results showing the "Dolby B On" results. Measurements were made with an A-weighting curve and the frequency-versus-noise plots show the actual contribution of noise at third-octave increments in the audio spectrum. (The numbers *below* each graph represent the noise contribution of the particular third-octave increment where the dotted line "cursor" is set; 6.3 kHz in the case of all of these graphs.)

Without Dolby noise reduction, S/N measured 55.9 dB for Type I tape, 55.2 dB for Type II tape and 56.3 dB for Type IV tape. These are good figures, but a function of the tape. With the Dolby-B circuitry turned on, S/N improved to 64.3 dB for Type I tape, 69.7 dB for Type II tape and 65.1 dB for Type IV tape. Thus one gets nearly 10 dB expected improvement. Plots also compared S/N results without Dolby against results obtained with Dolby C. For Type I tape, Dolby C yielded a signal-to-noise ratio of 71.6 dB. For Type II tape the S/N ratio was 75.5 dB, while for Type IV metal tape, the S/N was 72.0 dB. Such dynamic range allows truer reproduction of modern recordings. Furthermore, the Revox machine does it well without using compression.

All of the signal-to-noise ratio figures are referenced to the recording level that produces a third-order harmonic distortion level of 3% during playback of a 1-kHz test tone. To determine that reference level, a plot of third-order distortion-versus-recording level was made for each of the tape samples. The plots of third-order distortion are shown in Figs. 4A, 4B and 4C. Cursors have been set to that recording level (shown in dB at the lower-right of each plot) closest to the 3% distortion point. The "headroom" above 0 dB as indicated on the B-215 meters is, therefore, 5 dB for the Type I sample, 3 dB for the Type II tape and 2 dB for the metal tape. At 0-dB recording level (corresponding to the double vertical line on each graph), third-order distortion measured 0.6% for Type I tape, 1.5% for Type II tape and 2.1% for Type IV tape. This is typical of the best that can be expected of the cassette format today, though it still falls short of good open-reel machines.

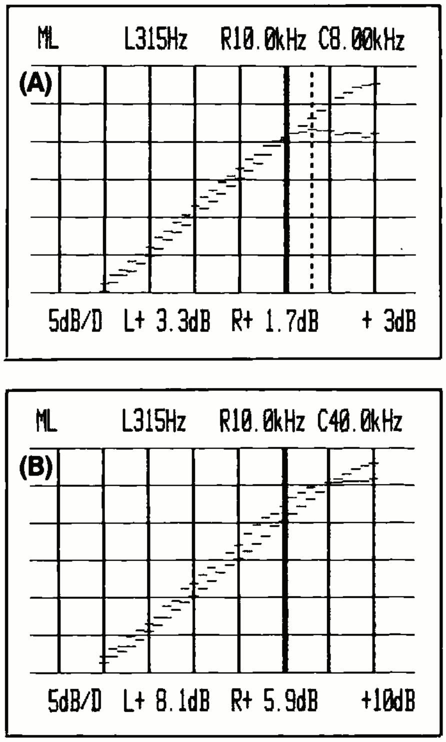


Fig. 5. Maximum output level at 315 Hz and 10 kHz for Type I tape with Dolby B (A) and Dolby C (B).

Based upon these results, you might be wondering what the particular advantage of expensive metal tape formulations might be. The real benefit of Type IV tape becomes apparent when you examine the results of Figs. 5, 6 and 7. Here we have plotted input versus output for each tape type at two frequencies: 315 Hz and 10 kHz. In Figs. 5A, 6A and 7A no Dolby noise reduction was employed, while in Figs. 5B, 6B and 7B, Dolby C was used. Ideally, if the tape/tape recorder system were perfectly linear, the plot would be a straight line over its entire length. The fact is, however, that at high frequencies, cassette tape becomes saturated at much lower recording levels than it does at mid- or low-frequencies. Thus, in Fig. 5A, for example, the output of the 315-Hz signal is +3.3 dB when the input is +3-dB; almost perfect linearity up to that recording level and beyond. The 10-kHz output, however, reaches a peak at the +3 dB

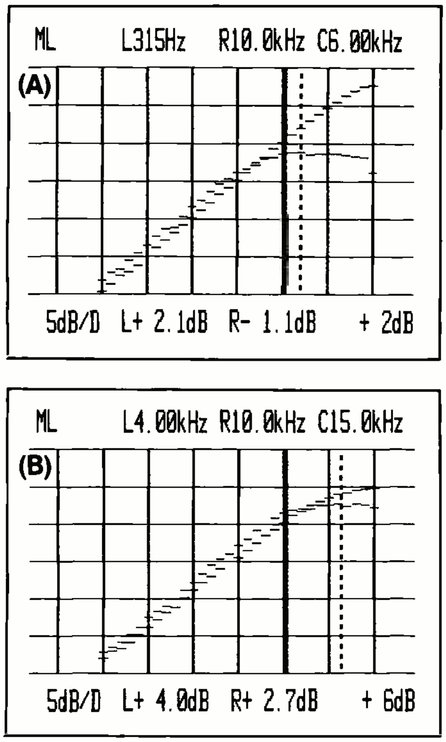


Fig. 6. Maximum output level at 315 Hz and 10 kHz for Type II tape with Dolby B (A) and Dolby C (B).

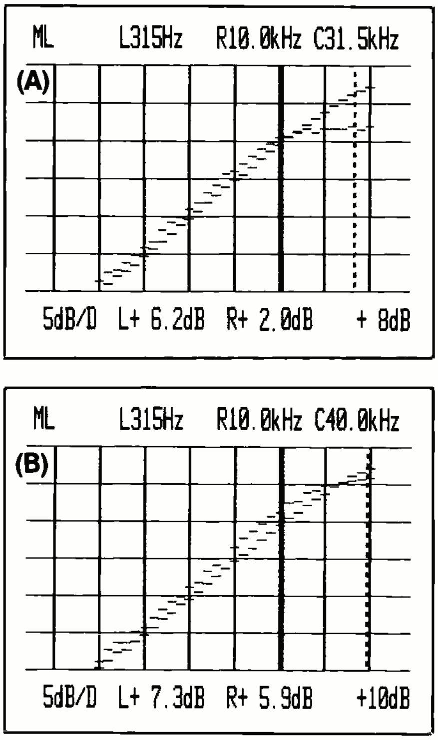


Fig. 7. Maximum output level at 315 Hz and 10 kHz for Type IV tape with Dolby B (A) and Dolby C (B).

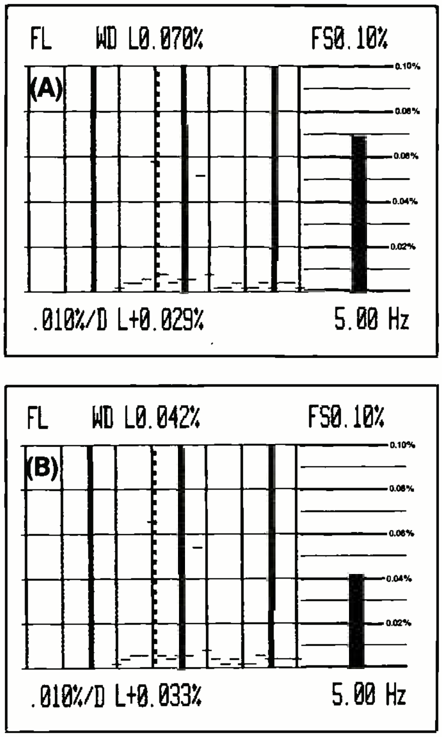


Fig. 8. Wow-and-flutter analysis using DIN peak (A) and wrms weighting (B).

recording level, at which point its output is only + 1.7 dB. Any increase in recording input beyond that point will not result in an increased output during playback. In fact, much greater increases in input actually result in lower and lower output during playback, as the curve begins to droop downward.

In each of the graphs of Figs. 5, 6 and 7, the dotted-line cursor has been set to the maximum output level (MOL) obtainable at 10 kHz for the given tape. This is sometimes referred to as the high-frequency MOL. Now consider the results obtained with metal tape (Type IV), as shown in Figs. 7A and 7B. Without Dolby, the MOL at 10 kHz for this tape is an impressive + 8 dB and the output ascends linearly to above the 0 dB point, right along with the lower-frequency 315-Hz signal. With Dolby C turned on, the linearity improves still further, so that the high-frequency MOL reaches an even higher + 10 dB! This is great for critical recordings that have much high-frequency content program material.

You would expect the wow-and-flutter of such a superb machine to be extremely low, and it was. Both peak-weighted and average or WRMS weighted analyses of wow-and-flutter were made for our sample deck, and results are displayed in the graphs of Figs. 8A and 8B. Using the WRMS method commonly employed by most cassette-deck makers, the wow-and-flutter was a remarkably low 0.042%. Even when measured using the so-called DIN (peak-weighted) method, the 0.07% reading was still well below Revox's published spec of 0.1%.

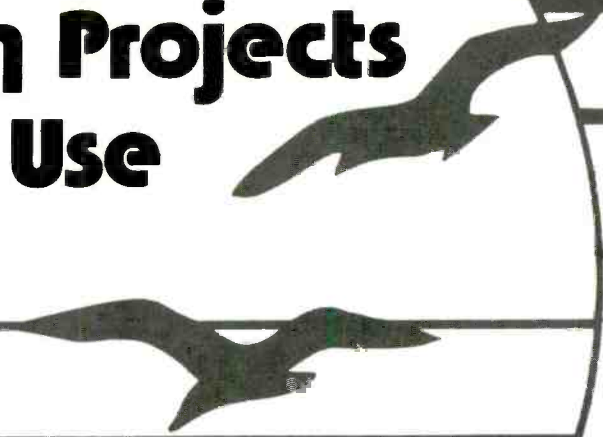
Perhaps one of the most amazing test results obtained for this deck was the accuracy of its azimuth alignment. Despite the fact that separate record and playback heads are employed, when we recorded our special azimuth test frequencies on the left and right channels of a sample tape and played them back, the maximum azimuth error at 15.8 kHz (the highest of the four test frequencies used) was an insignificant 3 degrees! That doesn't mean a misalignment of the head by 3 degrees. It means that the difference in phase angle between the 15.8 kHz recorded on one channel compared with the same frequency recorded on the other was a mere 3 degrees. Translated to actual head azimuth error, the result would be too small to calculate with any degree of accuracy. In short, the Revox B-215 exhibited perfect azimuth alignment between its record and playback head sections so that high-frequencies won't be lost. This is the best alignment I've ever seen!

Channel separation was a respectable 45.8 dB at 1 kHz and was around 25 dB at 10 kHz, which is more than needed for

(Continued on page 100)

MODERN ELECTRONICS

Construction Projects For Summer Use

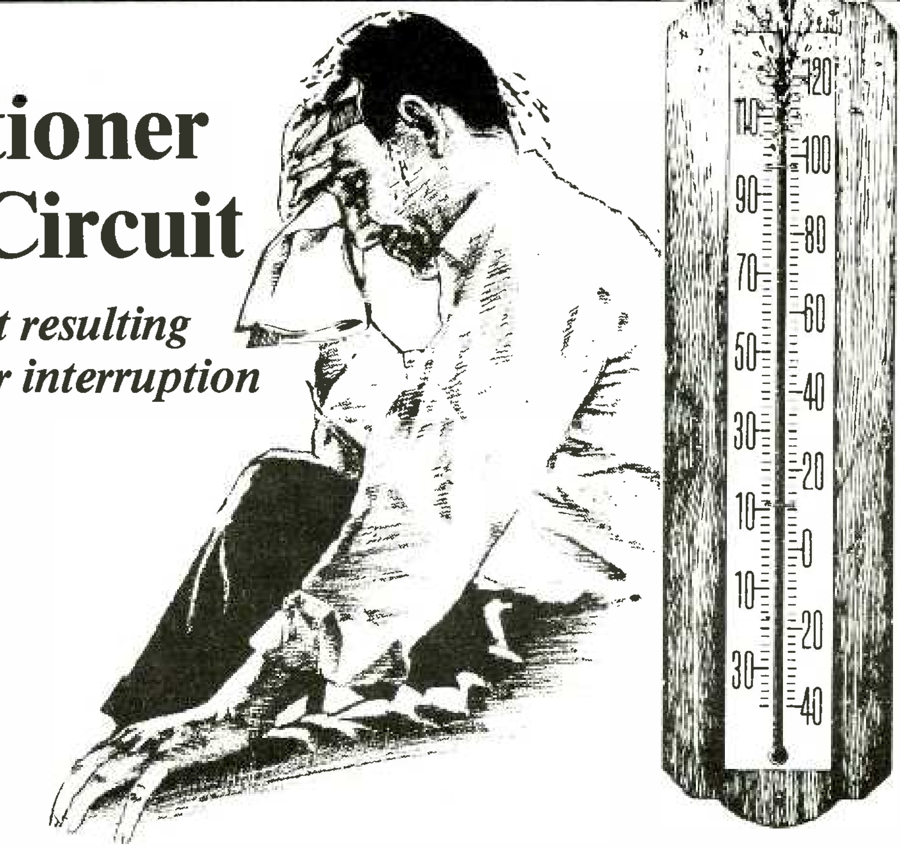


AIR-CONDITIONER PROTECTION CIRCUIT . . . . . Page 20

LAWN SPRINKLER CONTROLLER . . . . Page 26

BICYCLE SAFETY FLASHER . . . . Page 29

Air-Conditioner Protection Circuit



Prevents motor burnout resulting from momentary power interruption

By Dan Becker

Many home and industrial air conditioners—and some refrigerators—are not equipped to safely handle momentary interruptions in line voltage. Such an interruption can burn out an expensive compressor.

This damage is caused by excessive start-up pressure in the condenser coil restraining the electric compressor motor. The latter never gains the momentum necessary to shift into the lower current running phase. Under these conditions, the compressor motor does not pull enough current to activate a circuit breaker, but the motor does, unfortunately, draw enough current to cause it to rapidly overheat and burn out.

The circuit described here will protect any appliance requiring a line voltage post-interrupt delay. If you live in an area where power interruptions are frequent, this protection device can extend and electrical appliance's service life.

About The Circuit

The air conditioner protection circuit, shown schematically in Fig. 1, is designed around two key elements. Triac *Q2* allows the ac line voltage to be switched on or off. The 555 timer, used for *IC2* is the other key element. The circuit is designed to monitor the ac line for interruptions. Should the power fail, a preset, adjustable, delay will begin when power is restored. In addition, the circuit monitors the length of time the power is off. If the off time exceeds a preset maximum, power is switched on to the air conditioner plugged into socket *SO1* immediately when available.

The timing circuit is powered by a transformer-input regulated 9-volt negative dc supply. In addition, the supply regulator protects *Q2* from excessive gate current. Because the triac is switched on at low-level points in the voltage cycle, no detectable rfi (radio-frequency interference) is generated. With power being fed to the circuit, *IC2* operates as a monostable multivibrator.

When the circuit is initially powered up, *Q1* provides a path through which *C3* charges. Gate current of *Q1* is limited to a safe value by *R3*. In addition, *C3* cannot discharge through the gate, since discharge current is in the reverse-bias direction.

When an interruption in line voltage occurs, power to *IC2* is lost. However, *C3* remains charged, due to the high-impedance discharge path established by *R2* and *R9*. Because *R9* is variable, the time for *C3* to discharge can be controlled from a few minutes up to 30 minutes. If *C3* is still charged when line voltage is restored to the circuit, a negative trigger pulse from *C4* and *R4* trigger a pulse from the timer. This causes the output at pin 3 to go high, effectively connecting pin 3 to the neutral leg of the power line, for a period of time determined by the time constant of *C6, R7* and *R8*.

While pin 3 of *IC2* is high, *Q2*'s gate voltage is equal to that at main terminal one (MT1). Thus, *Q1* does not switch on. When a monostable pulse ends, pin 3 returns to its low state of −8 volts with respect to the neutral leg and *Q2* switches on. Resistor *R10* sets *Q2*'s gate current, which must be high enough to ensure complete and rapid turn-on or the triac could overheat.

Closing *S1* provides a delay override, enabling you to defeat the delay and immediately restore power to an air conditioner. Switch *S2* provides a reset that enables you to initiate a new delay cycle.

Construction

Because the circuit operates from the ac power line, it is imperative that you

PARTS LIST

Semiconductors
IC1—7908 8-volt regulator
IC2—555 timer
Q1—MPF102 or similar JFET
Q2—400-volt (see text for current rating) stud-mount triac.
RECT1—Low-voltage, low-current pc-mount bridge-rectifier assembly

Capacitors
C1—470-μF, 16-volt axial-lead electrolytic
C2—10-μF, 16-volt radial-lead electrolytic
C3—220-μF, 16-volt radial-lead electrolytic
C4—1-μF, 50-volt radial-lead electrolytic
C5—0.01-μF ceramic disk
C6—1000-μF, 16-volt radial-lead electrolytic

Resistors (5% tolerance)
R1—6.2 ohms, ½ watt
R2,R7—100,000 ohms, ¼ watt
R3,R4—10,000 ohms, ¼ watt
R5,R6—51 ohms, ¼ watt
R10—50 to 220 ohms, 2 watts (depends on triac used)
R8,R9—2-megohm chassis-mount potiometer or pc-mount trimmer potentiometer (see text)

Miscellaneous
F1—0.5-ampere fuse
I1—Panel-mount neon lamp with built-in limiting resistor
P1—3-prong ac plug
SO1—3-contact chassis-mount ac receptacle
S1,S2—Normally-open, momentary-action spst pushbutton switch
T1—12-volt, 200-mA pc-mount transformer (Radio Shack Cat. No. 273-1385 or similar)
Suitable enclosure; heat sink for triac; terminal strip with three insulated lugs; pc clips for fuse; knobs for potentiometers (2); heavy-duty 3-conductor ac line cord; heavy-duty stranded hookup wire; machine hardware; solder; etc.

Note: An etched and drilled pc board is available for $11.50 ppd from: Dan Becker, 101 Highland Dr., Chapel Hill, NC 27514. NC residents please add sales tax.

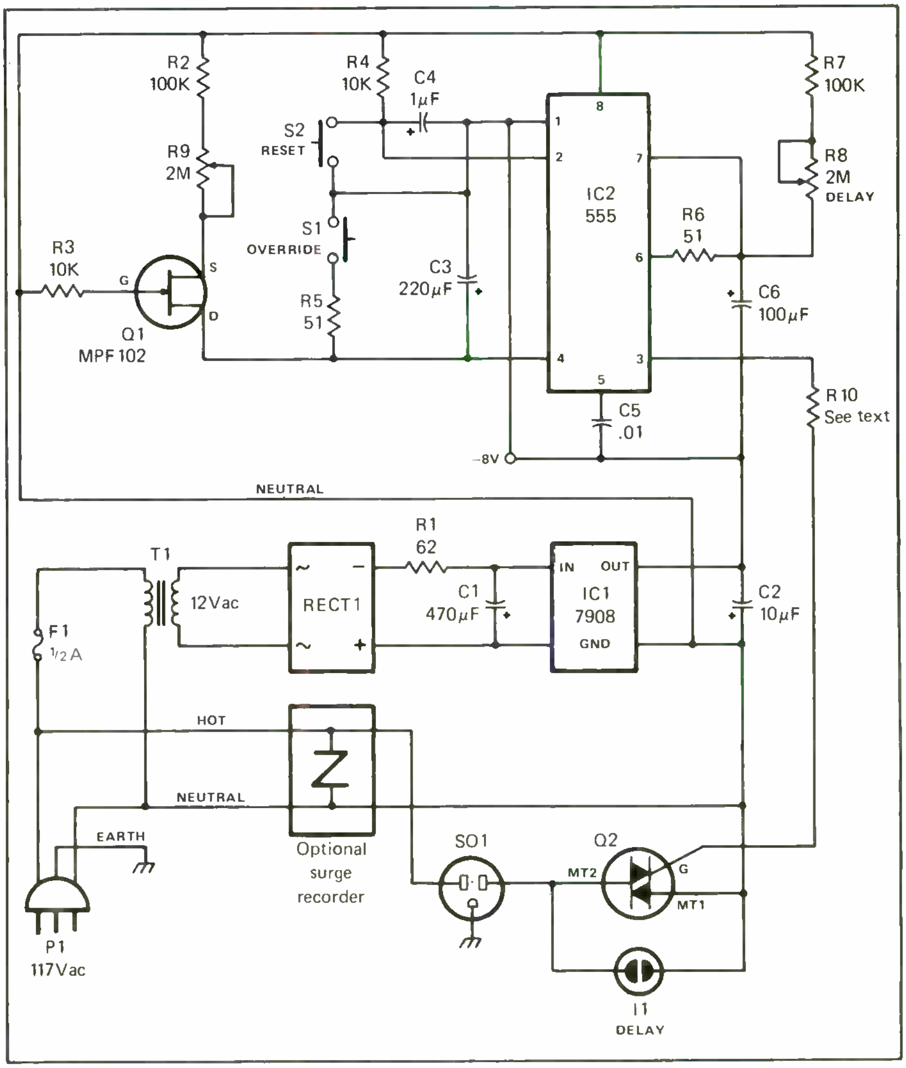


Fig. 1. Overall schematic diagram of the project.

observe standard electrical codes. This means using heavy duty three-prong power cord plug and socket. If the enclosure in which you plan to house the project is metal, it must be connected to the earth ground lead (center prong) of both the incoming and outgoing power cord. Secure each cord to the enclosure chassis with a cable lamp. Then connect both ground leads to the chassis with a crimp-on ring tongue.

Because a window air conditioner requires 12 to 20 amperes of current, a 30 ampere stud-mounted triac should be used for *Q2*. Because the triac must dissipate considerable heat, it must be mounted to a 30-to-50-watt heat sink. Also, if the triac does not have an electrically isolated stud, you must use appropriate hardware to insulate the heat sink from the chassis.

Connect the neutral lead from the incoming power cord to an insulated post of a terminal strip mounted to the enclosure, to which you also connect MT1 of the triac before soldering. In addition, connect the neutral lead to the primary of transformer *T1*. The neutral lead from the power cord that feeds the air conditioner connects to a second insulated post of the terminal strip, along with MT2 of the triac. Connect together the "hot" lead from both the incoming and outgoing power cords, using one of the remain-

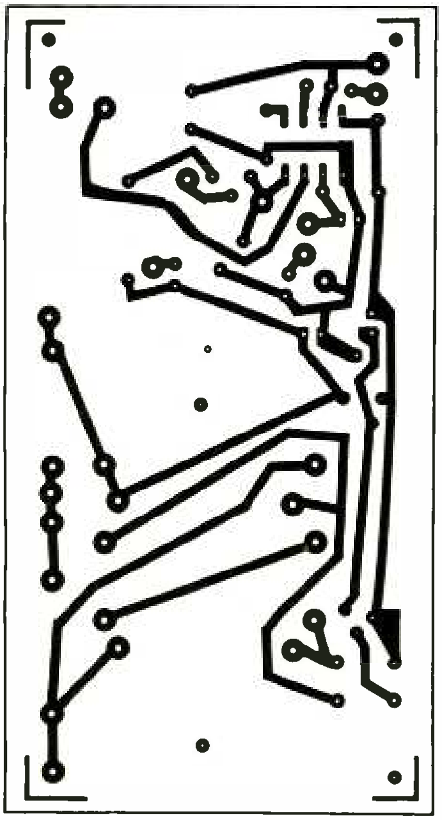


Fig. 2. Etching-and-drilling guide.

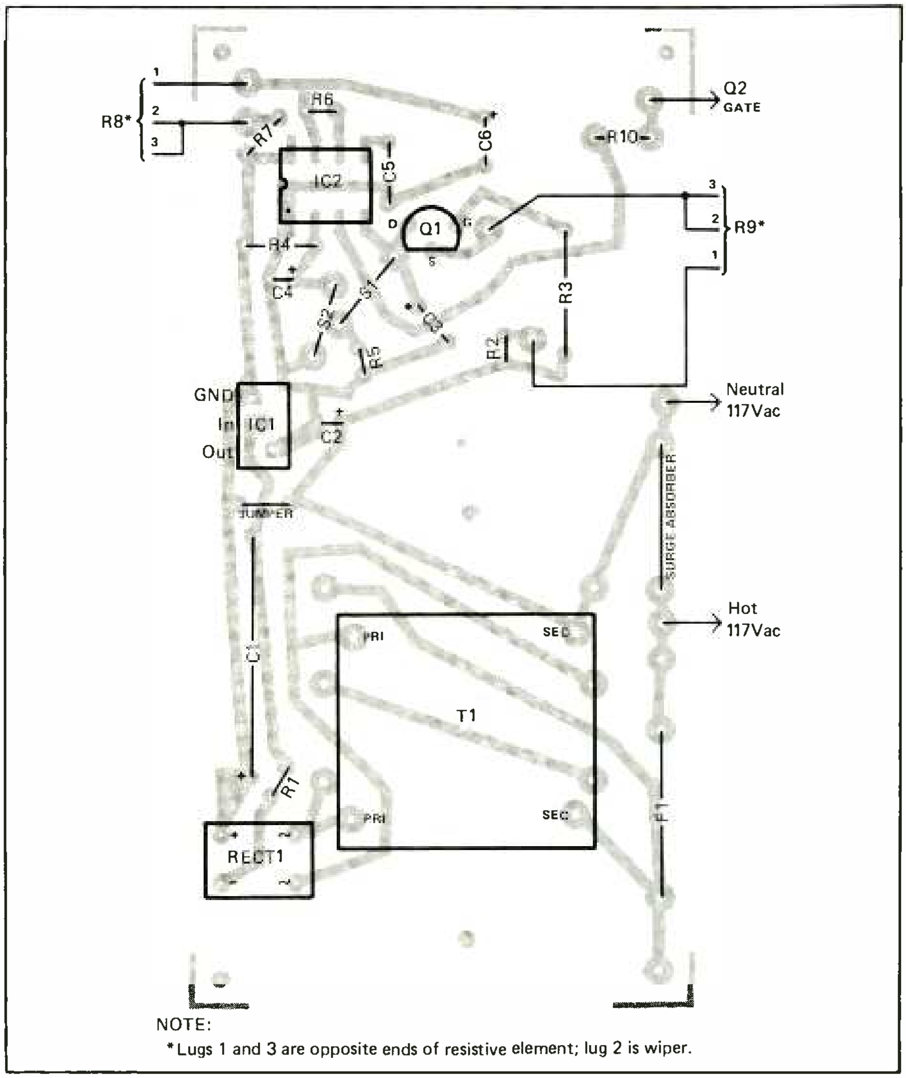


Fig. 3. Components-placement diagram.

ing insulated terminal-strip posts. Then run a heavy-duty stranded hookup wire from this connection to the fuse in series with the primary of the transformer.

Assembly of the timing circuit is best done on a printed-circuit board. You can fabricate your own pc board with the aid of the actual-size etching-and-drilling guide shown in Fig. 2. Alternatively, you can purchase a ready-to-wire pc board from the source given in the Parts List. Wire the board as shown in Fig. 3. Note that the potentiometers can be pc-mount trimmers or chassis-mount units. If the latter are used, connect a short length of hook-up wire between the wiper and left lugs (viewing the pots from the rear with the lugs pointing down). Run a pair of wires from the pc board to each control.

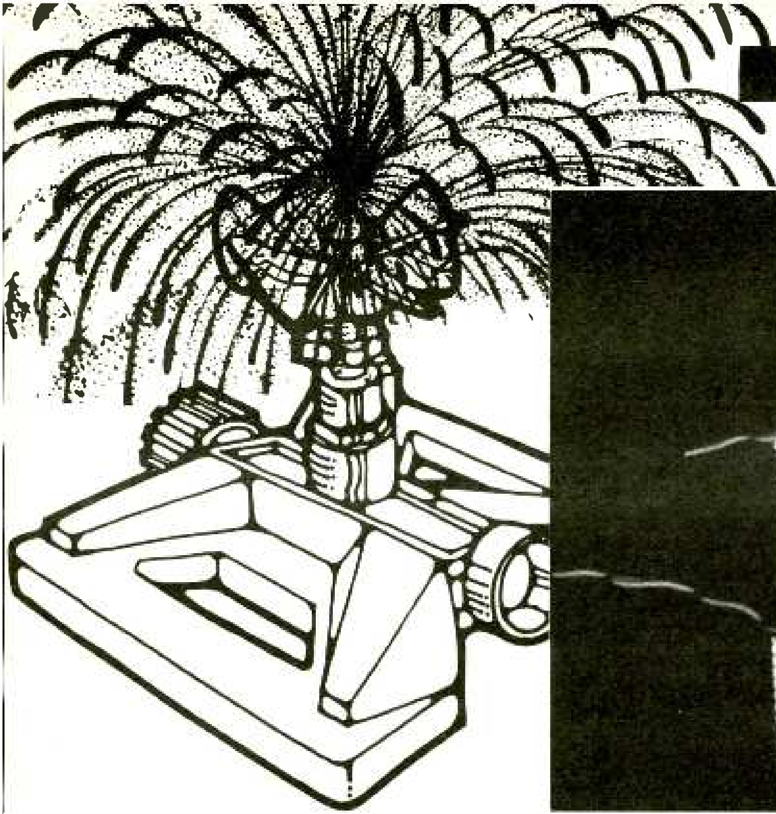
Checkout and Adjustment

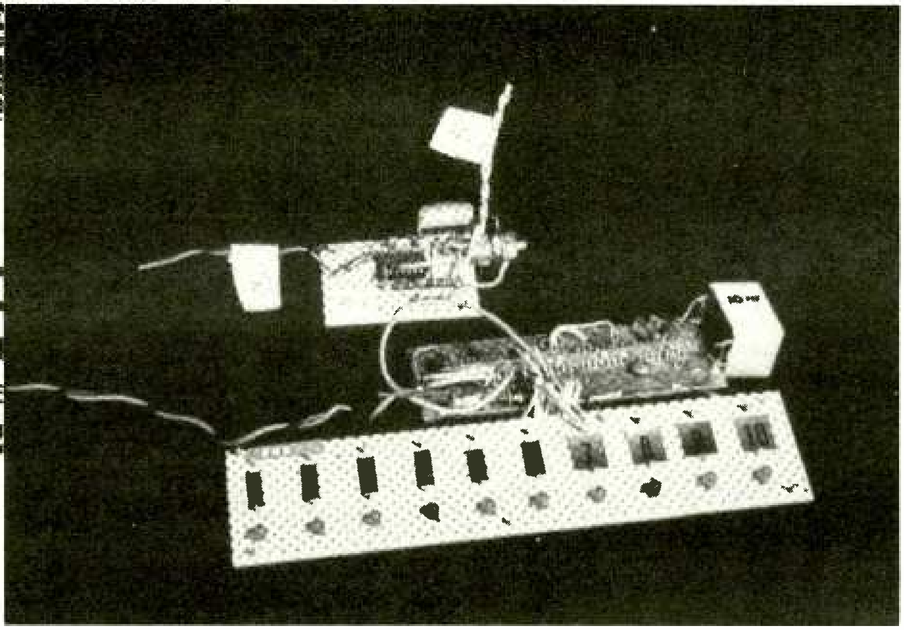
Set *R8* and *R9* to their fully counterclockwise (minimum-resistance positions). Plug a lamp, with its switch in the "on" position, into *SO1* and the project's plug into a 117-volt ac outlet. The lamp should immediately turn on.

Momentarily interrupt power to the project by pulling its plug from the ac outlet and then immediately replacing it. Neon DELAY indicator *I1* should light; after a 2-minute delay, it should extinguish. Repeat this test, but this time press the OVERRIDE button before the delay cycle times out.

Potentiometer *R8* controls the duration of the delay between the time power is restored to your home and to your air conditioner. Potentiometer *R9* sets the maximum time—during the power outage—that can elapse before a delay will no longer be provided. This is practical, because after several minutes, there is no need to delay starting your air conditioner. In other words, after a set time, an automatic override takes effect. The time delay can be preset for just a few minutes up to a maximum of about 30 minutes.

You are now ready to connect the protection circuit to your air conditioner. Make certain that the maximum current capacity of the triac exceeds the current rating of the air conditioner. ME





Lawn Sprinkler Controller

Solid-state solenoid sequencer allows you to tailor lawn sprinkler head outputs to watering needs and solves low-water-pressure problems.

By Imre Gorgenyi

There's nothing like an automatic lawn sprinkler controller that allows you to tailor your sprinkler heads' watering automatically to the turf's requirements. The automatic controller described here does this efficiently, economically and safely.

The Automatic Sprinkler System described here is designed for residential watering needs. It's built around electrically activated solenoid valves and solid-state circuitry that's coupled to an inexpensive 24-hour electromechanical timer. Optical coupling between the ac line voltage that operates the solenoids and the low-voltage driver circuitry satisfies the need for electrical safety.

A sequencing technique takes care of the low-pressure problem common to residential water delivery. So instead of watering a large lawn and/or garden in a single pass, solenoid valves water different areas at different times within a programmed time "window." Moreover, the solid-state system allows you to automatically give an extra-dry lawn section additional watering. The project can handle up to 10 sequence steps.

About the Circuit

Keeping the sequencer portion of the system simple was made possible by eliminating all fancy switching and other expense frills, like dials and indicator lights, as shown in the basic Automatic Sprinkler Sequencer circuit in Fig. 1. An ordinary 24-hour timer with setting pins (not shown) turns on and off the + 15-volt line of the Sequencer's timer circuit. When power is applied to the circuit, timer *IC1* begins 1-minute-on/1-minute-off cycling. Timing is governed by the RC time constant of *R4* and *C4*.

Output pulses at pin 3 of *IC1* are coupled through *C5* into divider *IC2*, which divides by 10 the number of pulses delivered to its pin 14 input. Therefore, only one of every 10 pulses generated by *IC1* are passed on to *IC3*.

Up to 10 solenoid driver circuits can be sequenced by *IC3*, another divide-by-10 chip. Each solenoid driver

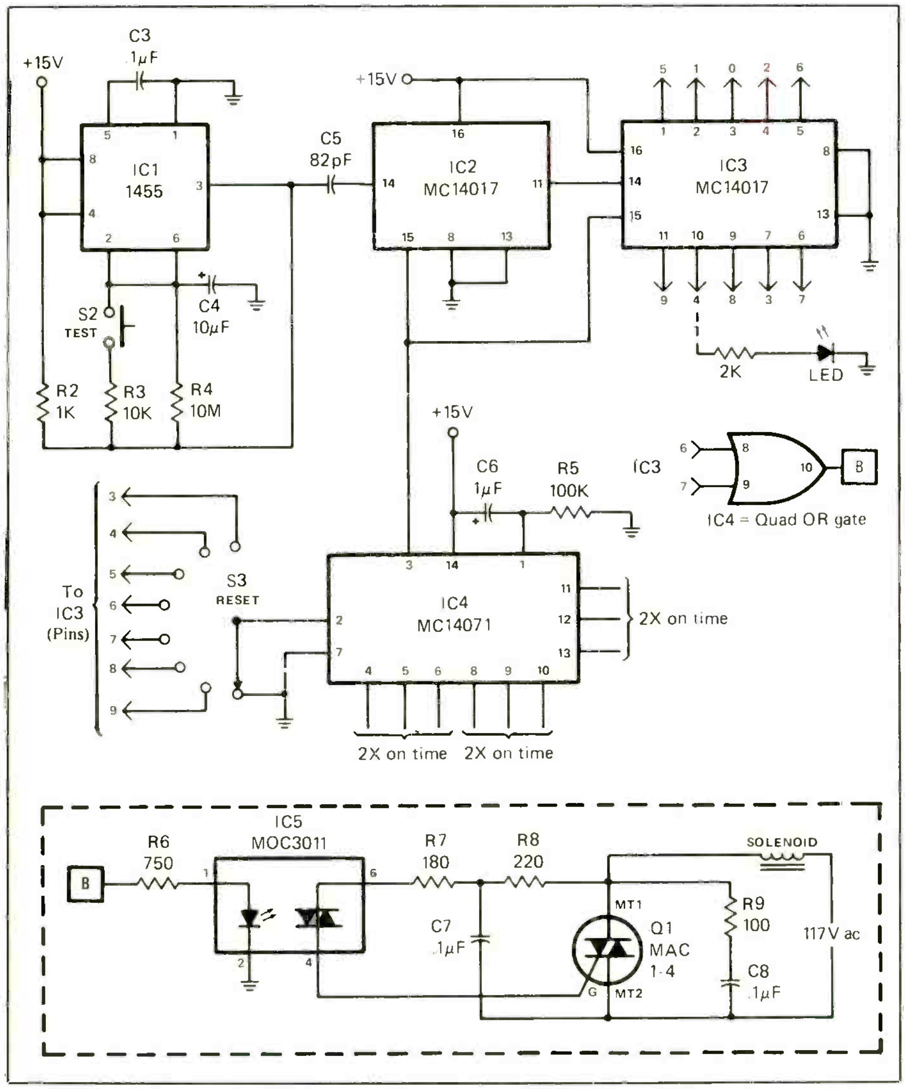


Fig. 1. Schematic diagram of Lawn Sprinkler Controller, minus power supply. Components shown inside dashed-line box are located remotely from main circuit.

circuit consists of an optoisolator/triac arrangement, shown as *IC4* and *Q1* in Fig. 1. Note that the only moving part of this system is the solenoid valve shown in series with *Q1* and the 117-volt ac line.

Normally, you would use a separate circuit arrangement like that shown in the dashed-line box for each solenoid valve to be controlled. However, if you wish, up to four solenoid valves in parallel can be driven by the triac specified for *Q1* so that more of a lawn can be watered with each timing cycle.

Automatic reset for the system is taken care of by *IC4*. When the system is first turned on, the sequence always starts at the first sprinkler head. Contained inside *IC4* are three more OR gates tha can be used to double the on-time simply by inserting a gate between *IC9* and point B, as shown in the detail drawing just below *IC3* in Fig. 1. TEST switch *S2* can be pressed to speed up the sequence to about 2 to 3 seconds so that overall operation of the circuit can be verified.

Operating safety is provided by using an optical device to isolate the Sequencer circuit from the driver circuit. In an actual installation, the low-voltage Sequencer/power supply cir-

PARTS LIST

Semiconductors
D1—1N4744 or similar 15-volt zener diode
IC1—MC1455 timer (Motorola)
IC2,IC3—MC14017 counter (Motorola)
IC4—MC14071 OR gate (Motorola)
IC5—MO3011 optoisolator (Motorola)*
Q1—MAC-1-4 (Motorola)*
RECT1—MDA-920-2 bridge rectifier (Motorola)

Capacitors
C1,C2—100-μF, 25-volt electrolytic
C3,C7*,C8*—0.1-μF, 200-volt disc
C4—10-μF, 25-volt electrolytic
C5—82-pF, 50-volt disc
C6—1-μF, 25-volt electrolytic

Resistors (½-watt, 10% tolerance)
R1—150 ohms
R2—1000 ohms
R3—10,000 ohms
R4—10 megohms
R5—100,000 ohms
R6—750 ohms*
R7—180 ohms*
R8—220 ohms*
R9—100 ohms*

Miscellaneous
S1—Dpdt toggle or slide switch
S2—Spst normally-open pushbutton switch
S3—Single-pole 8-position, nonshorting rotary switch (optional)
T1—18-volt power transformer (Triad No. F-90X or similar)
24-hour ac timer with time-setting pins; solenoid valve*; perforated or printed-circuit board; suitable enclosure for timer circuit; watertight box for solenoid/driver circuits (see text)*; 2 standard line cords with plugs; 3-conductor ac cord with plug*; sockets for ICs; panel-mount light-emitting diodes and 2000-ohm resistors (optional—see text); multiple-contact screw-type terminal strip (see text); silicon adhesive; lettering kit; clear acrylic spray; spacers; machine hardware; hookup wire; solder; etc.

***Note:** you need one set of all these items for each solenoid valve you want the system to control.

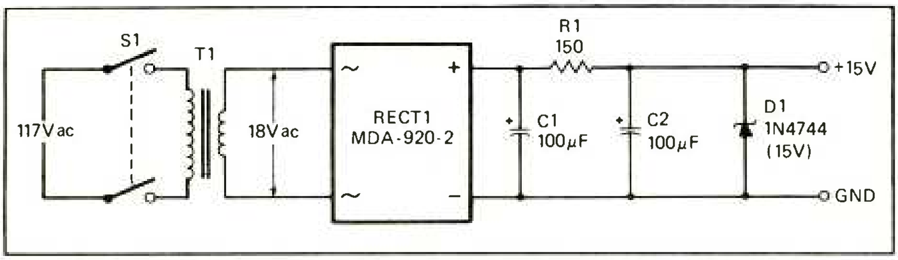


Fig. 2. Power for the Sprinkler Controller is obtained from the ac line.

cuit would be located inside your house, garage or other area protected from the elements where ac power is available. The valve solenoid driver circuits would be housed inside a watertight enclosure and located near the sprinkler heads. The driver circuits then connect to the Sequencer via a low-voltage line instead of a 117-volt ac line. Ac power for the sprinkler heads is then delivered to the solenoids via parallel wiring from the ac line to the triac circuits.

The programmable timer provides a time "window" in which the sequencer will turn on the water lines connected into the system, each for about 10 minutes. If the window's time is set for a long enough period, the Sequencer will automatically repeat the cycle. This way, the same part of your lawn/garden can be watered for two or three 10-minute periods within a couple of hours.

If you require double the watering time (20 minutes) for a certain area, simply wire an OR gate between two outputs of *IC3* and the solenoid driver circuit at point B for two consecutive 10-minute cycles. Three gates wired into the circuit permit three double time and four single time sequences. If necessary, you can set the timer to repeat the cycle by making the window period longer.

You can calculate the timer window so that the last cycle isn't allowed to time out. This lets you program in a short last cycle. Thus, the system can be tailored to your specific needs without switching just by choosing an appropriate timer setting.

You can wire the OR gates directly into the circuit. Alternatively, you can use a switching arrangement that lets you "program" what you want the system to do at any time you desire. Also, optional RESET switch *S3* provides a simple means to restart the cycle if only a few outputs are used. For example, setting *S3* to position 7 allows the circuit to reset after turning on the first six solenoid valves (counting starts at 0), without having to go through the last four cycles. If you are using all 10 outputs, *S3* isn't needed.

If cost isn't an object, LEDs and current-limiting resistors (shown phantomed in Fig. 1) can be added to tell you which solenoid valve(s) are on at any given time.

Power for the timing circuit comes from the ac line, via the simple power supply shown in Fig. 2.

Construction

There's nothing critical about circuit layout. Therefore, you can use any construction technique you prefer for assembling the circuit. You can design and fabricate a printed-circuit board, or use perforated board soldering hardware, or Wire Wrap the project. Whichever way you go, it's a good idea to use sockets for all ICs.

Be careful when wiring the Sequencer/power-supply circuit to observe proper polarity of the electrolytic capacitors and zener diode and the orientations of the ICs as you install them in their sockets. Wire the circuit exactly as shown in Figs. 1 and 2.

Machine a metal or plastic box by drilling mounting holes for the Sequencer/power-supply assembly, entry of the cables from the programmable timer and driver/solenoid-valve assemblies, the ac line cords and any switches and LEDs you decide to use. You can drill a separate hole for each control line going to the separate driver assemblies, or you can cut a long slot in one side of the box in which to mount a screw-type barrier block or terminal strip with enough contacts to accommodate the number of cables you plan to run to the driver assemblies.

If you're using a metal box, deburr all holes and insert a rubber grommet into each that will be used for cables. Pass the free end of one of the ac line cords through the appropriate grommet and tie a knot about 5″ from this end inside the box. Prepare the line cord conductors and connect and solder them into the circuit as shown in Fig. 2. Pass the free end of the second line cord through another grommet and repeat the above procedure. This time, connect and solder the conductors between the power supply's +15-volt output and the +15-volt bus in the Sequencer circuit. This is the *only* conductor that should bridge these two points. Cut off and discard the plug from this line cord.

Pass the cables that go to the driver/solenoid subassemblies (their lengths will depend on how far away the various driver/solenoid-valve circuits will be from the Sequencer circuit's location) through the remaining holes and tie a knot in each about 5″ from the free end inside the box. If you've decided to use a barrier block or terminal strip instead, connect and solder wires from its lugs to the appropriate points in the Sequencer circuit.

Connect and solder into the circuit any switches and/or LEDs you've decided to use. Then mount the Sequencer/power-supply assembly inside the box with the aid of spacers and machine hardware. Finish up assembling the Sequencer section by mounting the switches and LEDs in their respective holes. Before you

(Continued on page 95)

A Bicycle Safety Flasher

An attention-getting flasher/turn-signal indicator that motorists can see a long way off

By TJ Byers

Bicycling is a pleasant and rewarding form of physical exercise, enjoyed by millions of people around the world. Unfortunately, sharing the road with cars and other motor vehicles exposes cyclists to traffic accidents simply because motor vehicles operators often fail to see them at night until it is too late.

Safety reflectors and standard lights have limited effectiveness. A more effective solution is to equip your bicycle with an attention-getting light of its own, which is where the Bicycle Safety Flasher project described in this article comes in.

Using an eye-catching scanning technique, the device creates a moving display similar to many road-hazard lights. The moving lights instantly get the attention of any motorist. And adding to the project's safety features is a convenient switch that lets you signal when you want to make a turn.

How it Works

Shown in Fig. 1 is the schematic diagram of the basic Bicycle Safety Flasher. The circuit uses CMOS digital ICs. Type-D flip-flop *IC1* is operated as a free-running astable multivibrator. The complementary outputs of this IC are cross-coupled to the SET (S) and RESET (R) inputs through *R1* and *R2* to set up a feedback loop that toggles the flip-flop from one state to the other to generate a square-wave output signal. An RC timing circuit made up of *C1, C2, R1* and *R2* determines the output frequency of the multivibrator.

Programmable counter/divider *IC2*'s 10 outputs go high one at a time in sequence with the pulse count delivered to its CLOCK input from *IC1*. Each time *IC1* outputs a pulse, it increments the count of *IC2* by one. The RESET input of *IC2* allows an output pulse to reset the counter at the end of a predetermined count. The Bicycle Safety Flasher, for example, counts up to only five before output 6 resets the circuit and forces the count to start over again.

Four transistors that sequentially light four incandescent light bulbs are driven by the outputs of *IC2* in a manner commonly referred to as a "lamp chaser" because of its characteristic "moving-bulb" motion. To eliminate the jerkiness associated with so many lamp-chaser circuits, *IC2*'s outputs are ORed together so that two lamps are always lit at the same time.

Output 1 at pin 2 of *IC2* is connected to *D2* and *D3* that drive *Q3* and *Q4*, respectively. The diodes are arranged in a logic-OR configuration so that when pin 2 is high, both *Q3* and

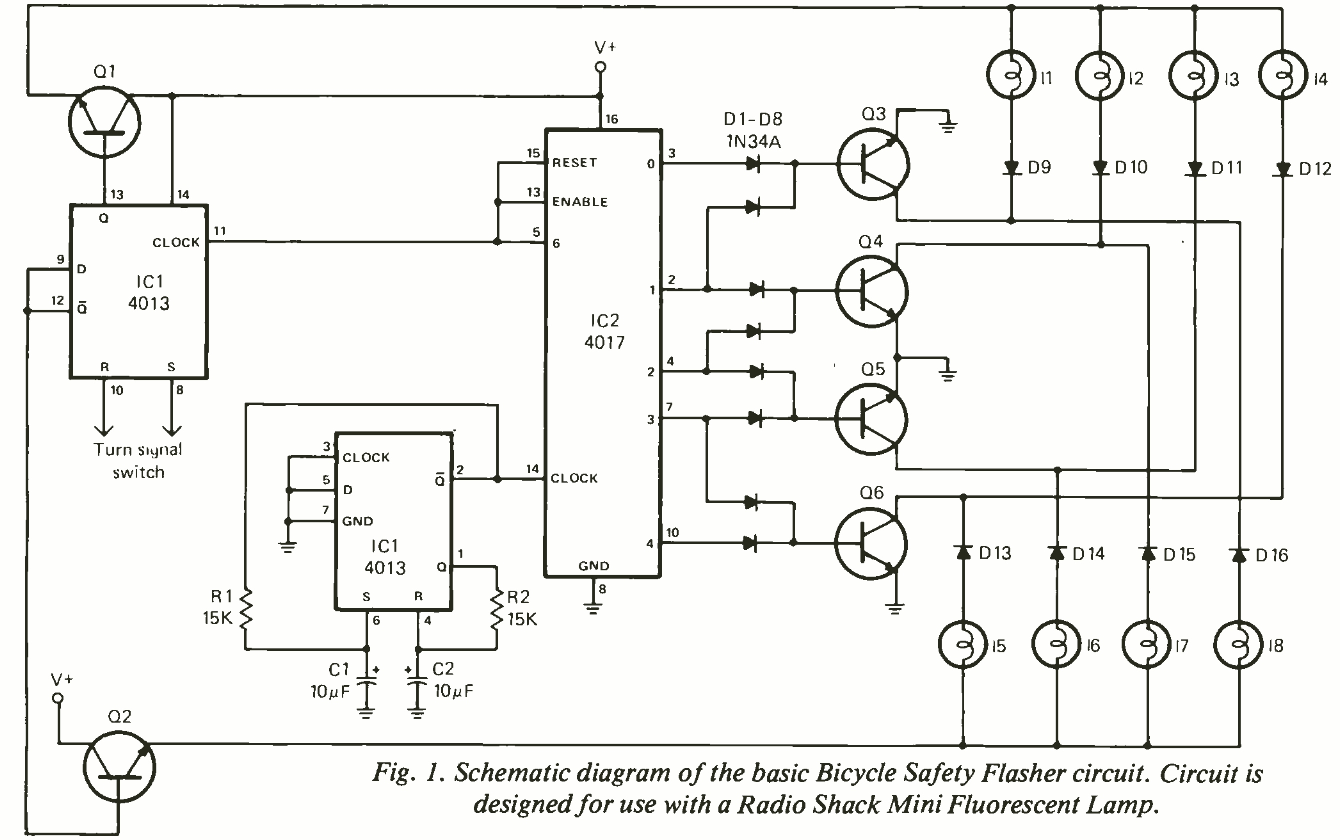


Fig. 1. Schematic diagram of the basic Bicycle Safety Flasher circuit. Circuit is designed for use with a Radio Shack Mini Fluorescent Lamp.

PARTS LIST

Semiconductors

D1 thru D16—1N34A or similar small-signal germanium diode (do not substitute; see text)

LED1—Blinking light-emitting diode (Radio Shack Cat. No. 272-1139 or similar)

IC1—CD4013 dual type-D flip-flop

IC2—CD4017 decade counter/divider

Q1 thru Q6—2N3904 transistor

Capacitors

C1,C2—10-µF, 16-volt tantalum

Resistors

R1 thru R4—15,000 ohm, ¼-watt

Miscellaneous

S1—Spring-return, center-off dpdt switch

Printed-circuit board; Radio Shack Cat. No. 61-2734 Mini Fluorescent Lamp (or suitable plastic chassis box; see text); plastic box for turnsignal switch; electrician's U-clamps (2); four-conductor cable; machine hardware; solder; etc.

Note: The following are available from Danoconths, Inc., P.O. Box 261, Westland, MI 48185: Complete kit of parts, No. RW-127K (does not include plastic cases), for $30; etched and drilled pc board, No. RW-127, for $14.

Q4 are conducting and lighting *I1* and *I2*, respectively.

When the pulse input to CLOCK pin 3 of *IC2* advances the count to 2, the logic at *Q3* is no longer true, causing *I1* to go off. However, *Q4* still has a valid logic input from output 2 via *D4*, keeping *I2* lit. The advance in the pulse count also makes the logic to *Q5* true, in turn lighting *I3*. Hence, as *I1* goes off, *I3* lights and *I2* remains on. Likewise, another clock input forces *I2* to go off and *I4* to light, with no change in the status of *I3*.

The lamps are arranged so that the on/off cycles produce a sweep effect that is more brilliant because of the combined light from two lamps. It also provides a smoother transfer of motion from one station to the next. The lamps are divided into two rows, each powered from two different sources, controlled by *Q1* and *Q2*.

The power transistors are, in turn, controlled by a second flip-flop in *IC1*. When one transistor is on, the other is off, and vice-versa so that only one row of lights is activated at a time. Also note that the CLOCK input of this flip-flop is connected to the RESET pin of *IC2*. Hence, every time the counter is reset, *Q1* and *Q2* alternate states, such that when one is conducting the other is off.

Wiring the lamps so that one row chases in one direction and the other row chases in the opposite direction creates a flashing motion that sweeps back and forth to provide an instant attention-getting display.

It is a simple matter to add to the basic Bicycle Safety Flasher a sequential turn-signal feature. This is done by forcing the second flip-flop in *IC1* to keep either *Q1* or *Q2* conduct-

the fourth law of robotics
A robot shall make learning fun for man and thereby improve the quality of life for mankind.

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ing continuously while holding the other in cutoff, the selected position depending on which turn you want the lights to indicate.

Turn-signal indicator operation is as follows. If SET pin 8 of *IC1* is forced high, only *Q2* can conduct. The CLOCK input is effectively locked out and only *I5* can light. Similarly, forcing pin 10 to high locks out *Q2* and allows *Q1* to remain conducting.

In Fig. 2 is shown the switching arrangement for the turn-signal indicator feature. Flipping spring-return dpdt center-off switch *S1* to either of its "on" positions selects the appropriate turn indication. Letting go the toggle of the switch causes it to automatically return to its center-off position, restoring basic flasher operation.

Note in Fig. 2 that light-emitting diode *LED1* serves as an indicator that tells you when the turn-signal circuit has been selected. The LED flashes whenever *S1* is set to either of its "on" positions and is off when the switch is in its center-off position.

Power for the circuit is provided by a 4.5-volt dc source, with the positive side going to the V+ points in the circuit and the negative side going to circuit ground. There should be an spst slide or toggle switch in series with the + lead and the circuit so that power can be switched on and off. For the Fig. 2 circuit, *S1* is *in addition* to any on/off power switch used.

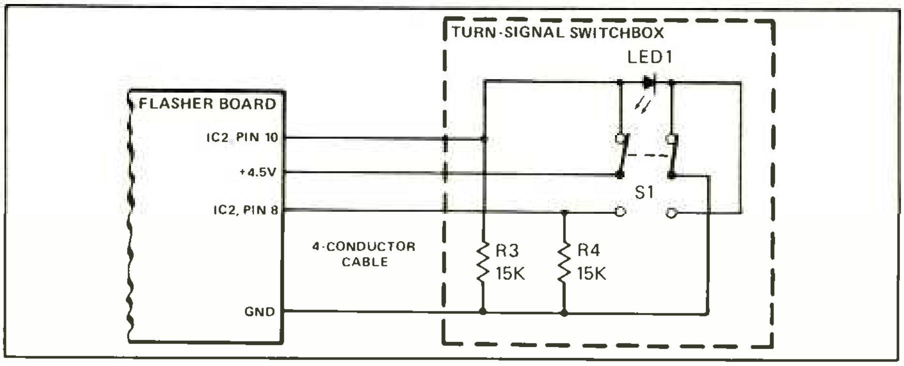


Fig. 2. The turn-signal switch with flashing light-emitting diode circuit.

Construction

A modified Radio Shack Mini Flourescent Lamp (see Parts List) was used for the Bicycle Safety Flasher shown in the lead photo. However, you can build the circuit into any case sized to accommodate a long, narrow printed-circuit board and three 1.5-volt C or D cells and a slide or toggle spst switch.

In Fig. 3 is shown the actual-size etching-and-drilling guide for the pc board. You can fabricate your own or purchase one ready for wiring from the source given in the Parts List. When you are ready to wire the board, begin with the diodes, making sure they are installed in the proper orientation per the component-placement diagram in Fig. 3. (Note that the Parts List calls for small-signal *germanium* diodes. Because the Flasher's power supply delivers less than 5 volts dc, it is important that you *do not substitute* silicon diodes here.)

Before installation, the base and emitter leads of *Q3* through *Q6* must be transposed to allow them to plug into the pc board's holes. (Leave the leads of *Q1* and *Q2* as they are.) To do this, hold the transistor with its flat facing toward you and the leads pointing down. Use longnose pliers to carefully bend the center (base) lead straight back flush with the botom of the case, and at the lip of the case, bend it straight down.

Similarly, bend the right-hand (collector) lead forward and slightly to the left so that it is flat against the bottom of the case and in line with—but not touching—the base lead, and then bend it straight down at the lip of the case. Bend these leads only once; otherwise, you may break off the leads, destroying the transistors.

When all four transistors are prepared, install them in their respective locations on the board, with the flats facing toward the lamp area. Then install *Q1* and *Q2*.

Space limitations on the circuit board require that the thin parts that normally go into the holes in the board of pins 6, 9, 11 and 12 of *IC2* be trimmed away. Before you cut, however, double-check the pin numbers! Then make sure you properly install both ICs in their respective locations. Do *not* use sockets. There is no room for them inside the project.

Install the resistors and capacitors, properly polarizing the latter. Clip the leads of all lamps to about 1" long, strip away about ¼" of insulation from each and install them on the board. Use one of the clipped lamp leads to jumper between pin 2 of *IC1* and pin 14 of *IC2*.

Arrange *I1* and *I5* side by side with one pointing toward the top and the other toward the bottom of the board; use plastic cement to secure them together. Repeat with the *I2/I6, I3/I7* and *I4/I8* pairs. Make sure that if *I1* is pointing up and is on the left, *I2, I3* and *I4* are oriented and positioned the same way.

Now refer to Fig. 4 and wire *S1* as shown. Install the resistors directly on the lugs of the switch, and do not forget the jumper wire. The drawing shows *LED1* mounted on *S1* only to give wiring information. Actually, *LED1* connects to the switch via short wires after the two are installed inside a plastic box, with the LED mounted in its own separate hole.

As you can see from the etching-and-drilling guide in Fig. 3, the Bicycle Safety Flasher was designed to fit inside the Radio Shack Mini Flourescent Lamp's case. Of course, if you wish, you can install it inside a dif-

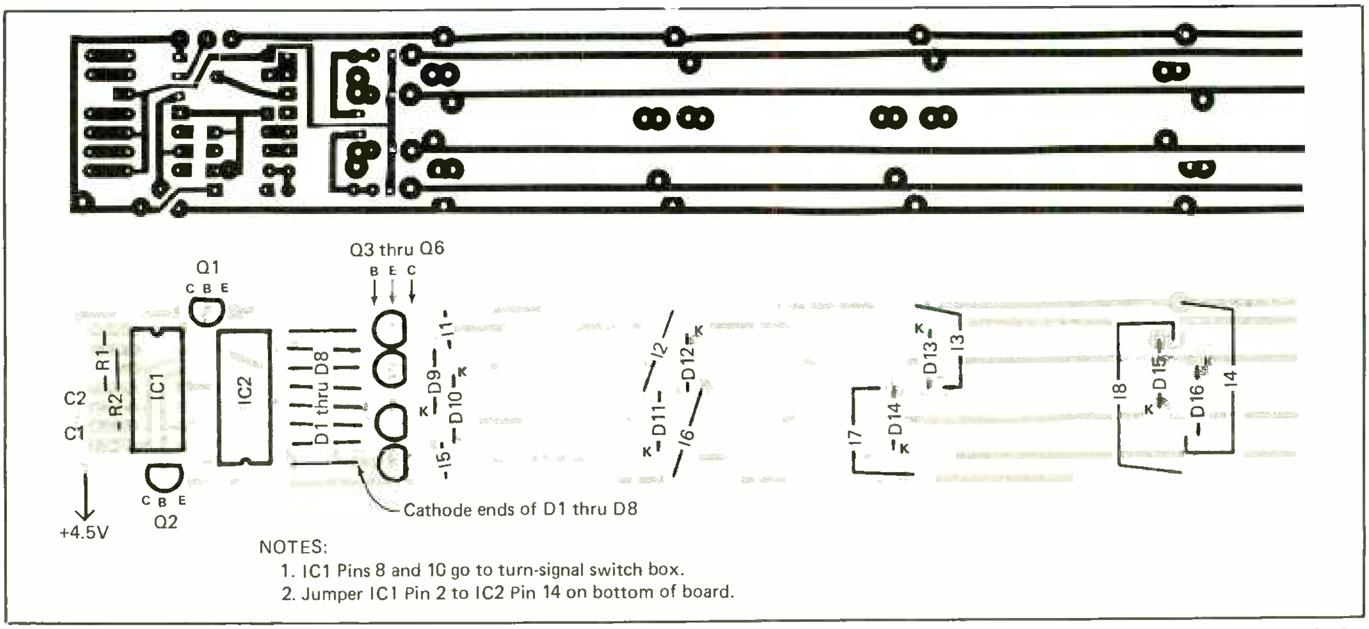


Fig. 3. Actual-size etching-and-drilling guide (upper) and components-placement/orientation diagram (lower). Note that to save real estate on the pc board, unused pins of IC2 are trimmed away before mounting the IC.

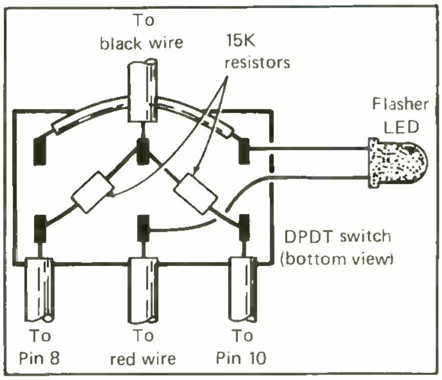


Fig. 4. Wiring details for turn-signal switch/LED arrangement. The LED actually mounts in a panel and is connected to the switch lugs via hookup wire. It is shown here connected directly to the lugs only for the purpose of showing proper polarity.

ferent case, as described above, but the Radio Shack lamp is ideal for this application.

Before you can install the circuit inside the lamp, you must modify the latter as follows. First, unscrew the end rings and slip off the black end-pieces. Break down the lamp into four parts: clear lens, flashlight assembly, battery case and fluorescent tube. Remove the fluorescent tube and its electronic circuit board, including the yellow wire. Unsolder the black and red leads going to the board. Save the fluorescent tube and circuit board for some other low-voltage use.

Now use a hacksaw to cut away the black plastic lamp socket that separates the tube from the circuit board. Do *not* remove the opposite end barrier or its metal contact; they are needed for the battery holder. Finally, remove the metal reflector.

Solder the red and black wires coming from the lamp's battery supply to the indicated points on the flasher board (Fig. 3). Also solder two wires of a 4-conductor cable to pins 8 and 10 of *IC2* and the remaining two wires to the +4.5V and GND pads on the pc board. This cable goes to the turn-signal switch.

Drill a hole in the lamp case, tie a knot in the 4-conductor cable about 3″ from the end connected to the circuit board, and route the free end through the hole. Determine how long this cable must be from the lamp to the turn-indicator switch box and clip it to the length needed.

Mount *S1* and *LED1* in a plastic box large enough to accommodate them. Then mount an electrician's U-clamp on the cases of the lamp and the switch box. Make sure the screws do not touch the battery cells. Route the free end of the 4-conductor cable through a hole in the switch box. After preparing the end of the cable for soldering, tie a knot about 3″ from this end and wire the conductors, resistors and LED to the switch as shown in Fig. 4. Finally, install the battery in and reassemble the lamp.

Flip the lamp's power switch to the fluorescent position and observe the bulbs in the project; they should flash in the "chaser" format described above. Leave the power switch as is and flip the turns-signal switch to one "on" position and note that the lamps flash sequentially to indicate a turn in one direction. Then flip the switch to its alternate "on" position and note that the lamps sequentially flash in the other direction.

If you do not obtain the proper indications, set the power switch to "off" and check component installation, wiring and particularly solder-

(Continued on page 100)

Free BASIC Programs by Radio

How you can capture computer programs that are broadcast internationally and in the U.S.

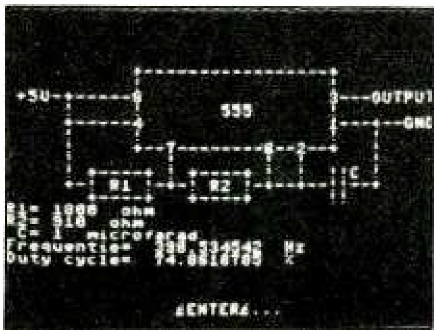
By John Richards

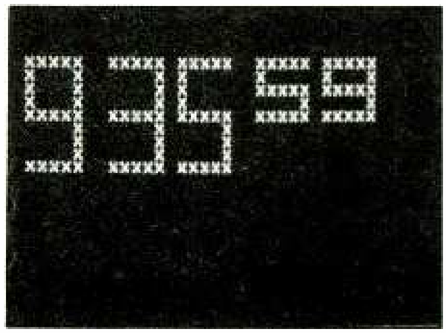
From the earliest days of the home computer, enthusiasts have swapped program tapes and disks, or just printouts of a program's listing.

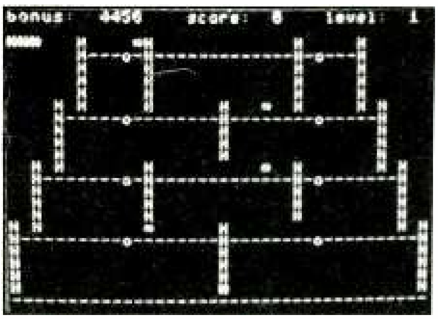
Unfortunately, this kind of program exchange usually limits one to software exchange with friends, user groups, pen pals, and those who utilize the same BBS (Bulletin Board System). A more efficient way to distribute free software is to broadcast programs on an AM or FM radio station. Here, the potential users number in the millions.

While at first glance radio broadcasts might not appear to be an ideal distribution medium for software because of noise interference (QRM and QRN), in actual fact it has proved to be an efficient way to distribute programs written in BASIC because errors caused by noise are easily recognized and corrected. For example, if a statement lists out after reception as "GOSIB 470" you know it should really be "GOSUB 470," just as "PR*)T 510" should be "PRINT 510." On the other hand, it's difficult to accurately broadcast binary encoded programs via a conventional radio broadcast because a single error—just one bit—can cause the program to crash, and there's no way for a user to know where or when the error occurred during reception.

There are presently two ways by which BASIC programs are broadcast to hobbyists: NOS-BASICODE-2 and Sofcast. Although both systems are as different as Apple and IBM computers, both provide a way for the hobbyist to distribute and access public-domain software via his radio.







These photos were made directly from a Commodore 64 computer when running BASICODE programs submitted by hobbyists. As you can see, the free hobbyist-written software competes in quality with some of the programs you might buy.

Photo 1 is a 555 timer program that not only draws the circuit, but also calculates the nearest values for a specified frequency—converting the actual frequency to the value obtained using practical parts values.

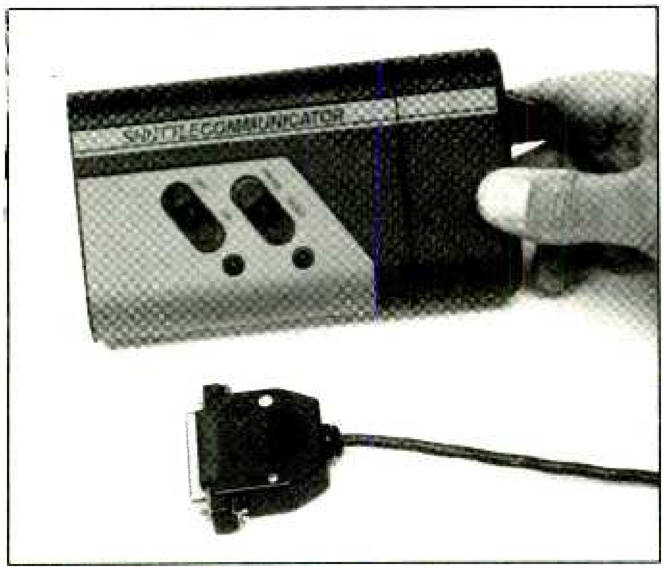
Photo 2 is a numeric clock display whose step and accuracy can be programmed by the user.

Photo 3 is a frozen moment in an "escape" type game.

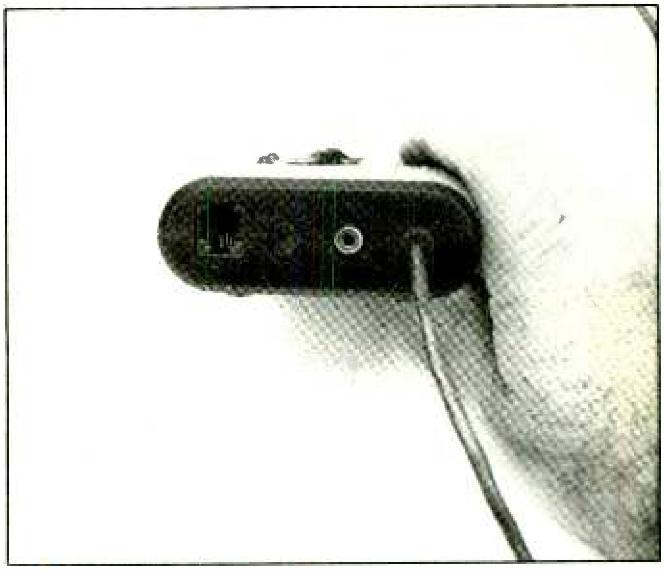
BASICODE

NOS-BASICODE-2, which is known simply as BASICODE, is a combination hardware and software translation system—actually a "standard of exchange"—that permits software to be directly exchanged between nearly 20 different kinds of what is normally mutually exclusive computers. It was originally designed to permit a single radio broadcast of a BASIC program to service all commonly used "home" computers.

BASICODE originated back in 1978 when the Dutch domestic broadcasting service, known as *Nederlands Omrep Stichting* or NOS, broadcast



The Shuttle Communicator is the device that interfaces a computer to a Sofcast broadcast. It converts digital data from a radio or a phone to RS-232 serial for the computer.



A modular phone jack and a phono connector serve as the Shuttle Communicator's signal inputs. A cassette recorder can also feed a prerecorded tape.

BASIC computer programs as part of its Hobbiscoop (in English: Hobbyscope) radio program, a program that covers the latest developments in science and electronics.

The user would record the received BASIC program on a cassette recorder and then LOAD the program from the cassette player into the computer. The first computer broadcasts were dedicated programs written exclusively for the "home" computers then available. Since the programs were for a specific computer, each program had to be broadcast in a specific version that employed the proprietary tape formats for each kind of computer. If the program was intended for four particular kinds of computers, it had to be broadcast that same number of times.

Multiple versions of a program were necessary because manufacturers had gone out of their way to ensure that their version of BASIC as well as the electrical characteristics of the recording (the tape format) were mutually exclusive with every other computer, for in this way the manufacturer locked the user into his particular line of hardware and software.

While the broadcasts were enthusiastically received by computer hobbyists, listeners who did not own personal computers objected to the excessive time used to broadcast "burps and beeps." One must keep in mind that some early "home" computers —and their present versions—employed very low equivalent baud rates for tape storage—300 to 500 baud being a not uncommon value—and a single transmission for but one program could easily take up to 8 minutes. Therefore, you can see why broadcasting computer programs could be annoying to listeners who weren't interested in computers. It was the need to reduce the time necessary to transmit such programs that got the Hobbiscoop people to looking for a way to use a single data broadcast for all computers.

What they came up with was NOS-BASICODE (later refined to NOS-BASICODE-2), a computer transmission system that resolves the problems of both incompatible BASIC statements and operators, and incompatible tape formats. The system, known by the short form "BASICODE," has proved so successful that hobbyists throughout Europe, Britain and even the U.S. contribute programs for broadcast. (The programs are heard throughout Europe and Britain through the Dutch home service, worldwide through the Dutch shortwave service, and locally through some U.S. stations.) In particular, in Great Britain BASICODE broadcasts are used by the BBC as part of its efforts to spread computer literacy throughout the British Isles.

BASICODE works on the simple premise that to be truly "universal" a BASIC program must be transmitted in a single cassette tape format, employ common BASIC statements and operators, and must encode and decode BASIC statements that are not truly common. In BASICODE it is done through a special "translation program" that automatically converts the broadcast tape format (hardware) to the one required by the host computer, and which also automatically converts the BASIC statements and operators to those recognized by the computer. (The translation software is supplied on cassette and is available from the Hobbiscoop people—we'll tell you how to get it later.)

Table 1

The most recent BASICODE translation tape is intended for the most commonly used home computers in Europe.

Apple II
BBC-microcomputer (Models A & B)
Color Genie EG-2000
Commodore VIC-20
Commodore 64
CBM-3008, 3016 and 3032 (with new ROMs)
CBM-4016 and 4032
CBM-8032 and 8096
CP/M System Computers
Exidy Sourcerer
Microprofessor-II
New Brain
Philips P-2000
Sharp MZ-80A, MZ-80B, MZ-80K
Sinclair ZX-81 (Load routine only)
Sinclair Spectrum
Radio Shack TRS-80 Models I and III

To utilize a program that was broadcast in BASICODE, the user simply records the received program from an AM or FM station using a conventional tape recorder. Then he converts the recording into the format needed by his own computer by first loading the translator into the computer, which in turn translates the "universal" BASICODE program into the specific format needed by the host computer. The program that ends up in the host computer's RAM contains the specific BASIC statements and operators used by the host's version of BASIC; and it can be listed, run, or saved to tape or disk as a conventional BASIC program.

The tape containing the translation program actually contains individual translation for about 20 different computers as well as an assortment of BASIC games and educational and scientific/engineering programs. (New translation programs are added to the cassette as needed to keep up with recently introduced models.) Table 1 lists the computers included on the most recent BASICODE cassette. Hobbiscoop will provide translation software for some earlier computers, such as those listed in Table 2.

Table 2

Translation programs for these "older" computers are available on special request.

Acorn Atom
Commodore Pet 2001
DAI
NASCOM/Gemini
OSI Challenger
SWTP-6800

In some instances, such as with the Commodore 64, all that's needed is the translation software because it directly converts the BASICODE program; the user simply loads the translation program and then the BASICODE program. In other instances, such as with the Radio Shack Model I computer, a small recorder-to-computer interface must be assembled. A very small number of computers, generally used outside the U.S., require a somewhat complex hardware and/or software interface.

Although we speak of the translator converting BASICODE to conventional BASIC for the host computer, it also works the other way around. It will SAVE a host computer's BASIC program on tape in the BASICODE format. As far as anyone is concerned, the SAVE'd tape could have originated as a radio broadcast. Hence it can be exchanged with other hobbyists having different computers or sent to Hobbiscoop for possible broadcast throughout Europe and the rest of the world via shortwave radio.

How It Works

Those of you who have experimented with conventional conversion software for BASIC have probably experienced the frustration of a program crash because some statements just won't convert and are wondering how BASICODE pulls it off.

Tables 3 and 4 show how BASICODE works its magic. Firstly, there is the "standard set" of BASICODE statements and operators shown in Table 3: these are the only ones which are recognized by all computers through the translation software and they are the only ones to be used in a program specifically written in BASICODE. (They are almost identical to the so-called "universal" BASIC—the version of BASIC originally used when teletypewriters were used for mainframe terminals.) In addition to this standardized list of statements and operators, the translation program contains exclusive GOSUB routines that reconcile what is normally exclusive variations in BASIC.

As shown in Table 4, these GOSUB routines occupy all lines below 1000. The user's program actually uses lines 1010 through 19999. Lines 2000 through 24999 are reserved for subroutines needed for the program but which are not allowed in BASICODE, and lines 30000 through 32767 are reserved for REM statements.

The real action takes place below line 1000 in the subroutine, which translate the functions that cannot be accommodated by BASICODE. As an example, for a particular computer

Table 3

To ensure that various computers can run a BASIC program, the direct statements and operators are limited to the ones usually considered "universal" or "timeshare" BASIC, as shown.

ABS	INPUT	RESTORE
AND	INT	RETURN
ASC	LEFT$	RIGHT$
ATN	LEN	RUN
CHR$	LET	SGN
COS	LOG	SIN
DATA	MID$	SQR
DIM	NEXT	STEP
END	NOT	STOP
EXP	ON	TAB
FOR	OR	TAN
GOSUB	PRINT	THEN
GOTO	READ	TO
IF	REM	VAL
+	^	<>
-	=	<=
*	<	>=
/	>	

Table 4

A BASICODE program uses this line numbering sequence. The nonstandard BASIC statements for each version of BASIC are resolved by BASICODE GOSUB routines below line 1000.

0-999	Standard routines that are different for each computer and are, therefore, contained in the translator.
1000	Compulsory start of main program. Reserves memory space for strings (in those computers that need it).
1010-19999	The main program.
20000-24999	Subroutines that contain statements that are not allowed in BASICODE.
25000-29999	DATA statements.
30000-32767	REM statements; background details.

the "Clear Screen" command might be CLS, CLR or anything else. The BASICODE translator has a subroutine at line 100 (GOSUB 100) that clears the screen. Instead of writing a CLS or CLR statement into a BASICODE program, the programmer uses GOSUB 100 to clear the screen.

When the BASICODE tape is loaded by the translation software the translator does the necessary conversion, storing the correct clear-screen command in the computer's memory. Similarly, if the programmer wanted to activate an attention-getting "BEEP" he would use the command GOSUB 250. If the programmer wanted to tighten the variables space and report on how much space is available without destroying the variables, he would use GOSUB 275. (The BASICODE handbook that's supplied with the translation tape lists all the GOSUB subroutines.)

If you wanted to get into using BASICODE radio broadcasts, or just want to be able to swap program tapes with other computer enthusiasts, you can purchase the BASICODE handbook and translation tape direct from BASICODE, Administratie Algemeen Secretariaat, NOS, P.O. Box 10, 1200 JB Hilversum, The Netherlands. The price for the U.S. and Canada is 37 Dutch Guilders and *must* be in the form of an International Money Order (IMO).

Sofcasting

Sofcasting is a system whereby a computer program intended for a specific popular computer, such as an Apple, IBM PC or Radio Shack, is broadcast directly to disk storage at a very high baud rate: 1200, 2400 or 4800 baud. (To some degree the transmission baud rate depends on whether the station is AM or FM.)

The software broadcast is a feature of a radio program on personal computing that is broadcast in the U.S. by local AM and FM stations. The software itself actually originates at the radio studio as a tape recording of what is essentially a modem's output. It's the same as if you fed an ASCII file through a modem, but recorded the modem's output instead of sending into a telephone line.

Unlike BASICODE, the computer

How About a Public Digital Radio Service?

Back in December 1983, Donald L. Stoner, Engineering Veep at Microperipheral Corp., the Redmond, WA company that "sofcasts" computer programs on FM subcarriers, proposed a "Computer Hobbyist Radio Service" to the FCC. Two years later, on December 6, 1985, the FCC assigned Petition for Rulemaking #RM-5241 to Stoner's proposal, now called a "Public Digital Radio Service" (PDRS). Comments from the public and industry on the proposal were received until January 6, 1986 by the FCC.

A Radio LAN. Stoner proposed using the 6-meter band, 52-54 MHz, which is virtually unused by amateur radio operators, he said. If this two-way data communication scheme is adopted, computerists will be using the radio modems in a radio "local-area network" (LAN) setup to provide originate/receive capabilities for personal computers. Unlike a typical cable-connected LAN, however, Stoner envisions a packet radio network that connects via radio waves, with each computer user being a "node." In this way, he sees local networks interconnected nationally with a packet radio network.

The proposal also harkens back to one made for CB Radio many years ago, which was never adopted: each user would have a unique digital address code that automatically "announces" its identity as a user signs onto the network.

Each user's radio modem will interface to his computer via a common RS-232 serial port. The proposed modem would contain a receiver, a transmitter, a serial interface, and a vertically polarized antenna. A maximum effective power radiated (ERP) output of 1 watt has been suggested.

The radio modem employs carrier-sense multiple access, with a collision avoidance circuit that determines if it can transmit at any given moment, depending on whether or not another modem's carrier signal is sensed. Due to capture effect of the FM system, each node captures only the strongest signals. Should farther communications be required, appropriate nodes are said to be able to repeat the communication, with its specific address, until it reaches its destination.

Conclusion. This is an exciting proposal that can bring low-cost computer communication by radio to anyone with the proper receiving/transmitting equipment. It has the making of a new data communication service that would be cheap and effective. Among the flies in the ointment, however, is that it falls within a band allocated by the ITU to amateur radio. Recalling what happened with the 220-MHz ham band, which was little used, radio amateurs could well lobby against some spectrum space being taken away from them. Furthermore, the FCC has yet to make a decision concerning this proposal, and chances are that it will be a long time coming if the past is prelude in the decision-making process.

program's off-the-air signal isn't recorded from the radio directly on a cassette tape. Intead, the received signal is fed from the receiver to a battery-powered device called a "Shuttle Communicator," whose electrical circuit is essentially a "DEM"—the *demodulator* section of a "MODEM" (which stands for *MO*dulator-*DEM*odulator).

Normally, the Shuttle Communicator's output is RS-232 serial and is fed to the computer's serial port, but the device actually has several inputs and outputs.

There are really two or three inputs, depending on the particular model: One is intended for the output of an AM or FM receiver; possibly an optional cable TV input (for Sofcasts transmitted by cable TV); and a standard telephone modular input because the device can download data from a host computer.

There are also two outputs. One is conventional RS-232 serial that connects to the computer's RS-232 serial port; the other is a phono-type audio output that can also double as an audio input to the Shuttle Communicator. The audio connection allows the received audio signal (before conversion to RS-232 serial) to be recorded on tape or permits a previously recorded audio signal to be fed into the Shuttle Communicator for conversion to an RS-232 serial output.

The Shuttle Communicator is supplied with disk software that is specifically intended for the particular computer you're using: for example, IBM-compatible, Apple, TRS-80, etc. The software runs under BASIC and is the means the Shuttle Communicator's output saves it to disk.

It works this way. The supplied software initializes the computer and displays a message to the effect that the user should "press ENTER" on hearing a tone from the receiver. During the radio program the moderator announces that they will broadcast a program, and that a warning tone will precede the program. When the listener hears the tone he presses the computer's ENTER or CR key, which opens a buffer that inputs data from the Shuttle Communicator. When the program transmission is completed, a second tone warns that the buffer should be closed by again pressing the ENTER or CR key. Then the user saves the buffer to disk.

Alternatively, the user can tape record the Shuttle Communicator's special audio output. At a later time, the tape can be played back through the communicator, which will feed the

(Continued on page 100)

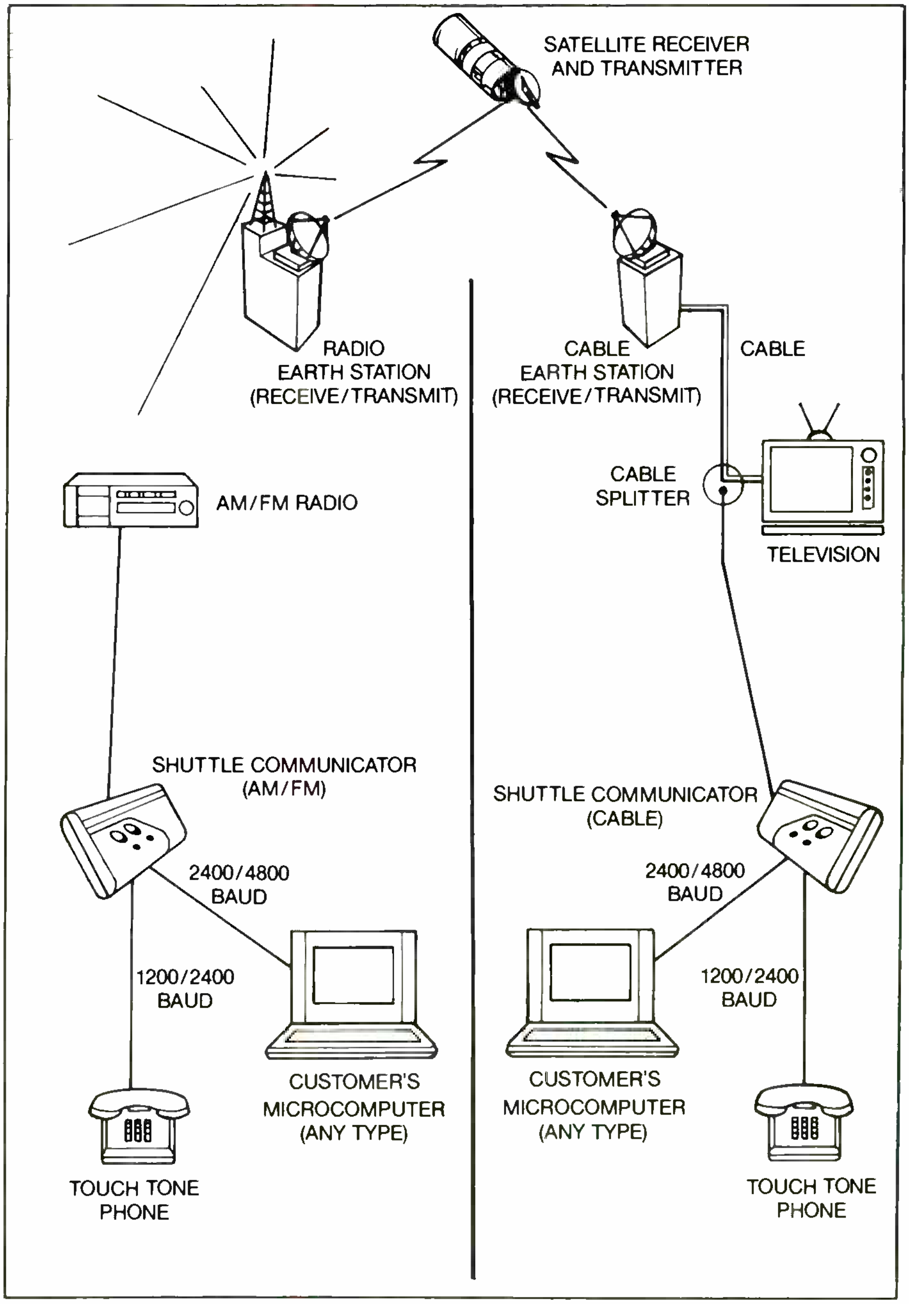


Fig. 1. In national distribution, a Sofcast program originates from a satellite end enters local communication circuits via AM and FM radio, cable TV and possibly the switched telephone network. An inexpensive "Shuttle Communicator" interfaces the user's computer to the signal—regardless how it originates locally.

Those Tuner Specs— And What They Mean

Examining manufacturers' tuners or the tuner sections of receivers

By Len Feldman

If you have been shopping for an FM or an AM/FM tuner of late, you've probably been confronted with brochures that include tables of performance specifications. These published specifications, if presented by a serious manufacturer of audio components, can tell you just about everything you will want to know about the tuner you are considering purchasing.

Unlike amplifiers, speakers and other components in an audio system, for which published specifications don't always correlate with actual sonic quality, a tuner's "specs" pretty well define that tuner's capabilities. This also applies to the tuner section of an all-in-one receiver, if that's what you have in mind to buy. Understanding the specs—and differentiating between a "good" spec and a not-so-good spec—can help you select the tuner that's just right for your listening location and for your budget. So let's examine them and see just what they tell us.

Sensitivity— Not All That Important

In the early days of FM and FM stereo, when most tuners used vacuum tubes, sensitivity was considered to be among the most important things you needed to know about a tuner. Sensitivity, as it was defined then (and as the term "usable sensitivity" is still used today) means the least amount of signal that must be applied to the antenna terminals of a tuner in order to deliver an audio signal whose loudest moments are 30 decibels louder then the sum of any residual background noise (static) plus distortion. A −30-dB level of noise plus distortion is the same as saying that the noise plus distortion constitutes about 3% of the total sound you hear. By modern standards, that's a lot of noise—or a lot of distortion—or a lot of both.

In fact, the term "usable sensitivity" should more properly be called "least unsable sensitivity," as it represents the amount of signal needed to deliver barly usable listening quality. These days, there is very little difference in usable sensitivity between well-made tuners that use solid-state devices in their circuitry. Generally, the figures quoted for this spec will range from around 10 to 12 dBf.

The term dBf is a power term, and it is also relative to an arbitrary "0 dBf" reference, which corresponds to one-trillionth of a watt of power applied at the antenna terminals of the set. Some manufacturers still quote sensitivity in microvolts (millionths of a volt), but this can be misleading. The same number of microvolts applied to an antenna terminal that has an impedance of 75 ohms (the type that accepts a coaxial cable connector) will develop only half as much power when connected to 300-ohm antenna terminals (the type that accepts the bare leads of flat-wire twin-lead cables).

Two microvolts across a 300-ohm antenna input is equivalent to around 11 dBf, while 2 microvolts connected across a 75-ohm antenna input is equivalent to about 17 dBf. If you are comparing sensitivity of two tuners and the numbers are given in microvolts (often abbreviated μV), make certain that the numbers are referenced to the same type of antenna impedance. In any event, don't be too concerned about usable sensitivity figures; in all but the farthest fringe areas at great distances from the station's transmitter, a modern tuner will have a sufficiently low usable sensitivity number.

50-dB Quieting Sensitivity

A much more important specification (and one that will vary widely from product to product) is called the 50-dB quieting sensitivity. This spec tells you how much signal strength (again, either in dBf or microvolts) the tuner will need for it to suppress background noise by a factor of 50 dB, compared with the desired program level peaks. In high-fidelity terms, a signal-to-noise ratio of 50 dB is regarded as the minimum needed to fully enjoy the audio program material. Clearly, the lower the 50-dB quieting sensitivity spec number, the better the tuner being judged.

You will notice, however, that

separate numbers are quoted for mono and stereo operation of the tuner. Any tuner, regardless of how well designed, will require considerably more signal strength to deliver a 50-dB signal-to-noise ratio when receiving a stereo signal than it will to deliver the same quieting level for a signal broadcast monophonically. This substantial difference is a function of the stereo broadcasting system used in the United States (and in most other countries of the world) and not of the tuner design.

Still, some tuners exhibit less of a difference between their mono and stereo 50-dB quieting sensitivities than others. Typically, the monophonic 50-dB quieting sensitivity of tuners (or tuner sections of receivers) may range from a high (poorest) of 30 dBf to a low (best) of only 12 to 15 dBf. A 50-dB stereo quieting may range from a high of 45 to 50 dBf to a superb low of only 20 to 25 dBf.

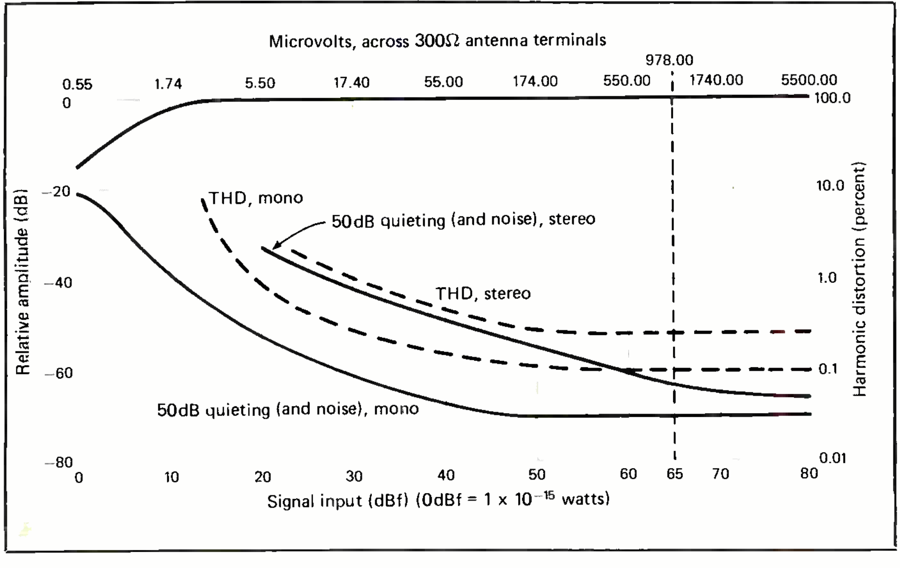
Harmonic Distortion

Unlike the "usable-sensitivity" specification that includes both noise and distortion, the 50-dB quieting specification involves only residual noise. Therefore, a separate figure for harmonic distortion is needed in order to fully specify the performance of a tuner. Although certainly not the only form of distortion that a tuner can develop, it is by far the most common and familiar one. Harmonic distortion is simply the amount of percentage of unwanted mutliples of a desired audio tone that are generated by the electronic product itself. Thus, if the broadcaster is sending out a pure 1000-Hz tone, but your tuner delivers small amounts of 2000 Hz, 3000 Hz, 4000 Hz, etc., those small amounts, taken together, are the harmonic distortion content of the reproduced signal. Total harmonic distortion (often abbreviated THD) is quoted in percent, and the lower the percentage the better.

As is true of most specifications having to do with an FM tuner, THD is usually a bit better when receiving a monophonic signal, compared to THD observed when listening to stereo. Thus, a reputable manufacturer will quote this important specification for both mono and stereo operation of the product. It is also a general rule that distortion of nearly any electronic audio product will be lower at mid-frequencies than it will be at the low (bass) and hight (treble) frequency extremes of the audio spectrum. For this reason, manufacturers who want to make a full disclosure concerning the performance of their products will list distortion figures at three audio frequencies: 100 Hz, 1000 Hz and 6 kHz, both for mono and stereo operation.

Expect THD figures in a modern tuner to be well under 1%, and in the case of really top-grade tuners, you may find some products boast distortion figures of well under 0.1%, even when operating in stereo.

Fig. 1. This is a graphic depiction of the mono and stereo quieting and distortion characteristics of a typical FM tuner.



Signal-To-Noise Ratio

As incoming signal strength increases (either because you are close to the transmitter or you are using a good outdoor antenna), background noise or static continues to diminish, until finally, the noise levels off at some fixed value. This ultimate noise level is referred to as the signal-to-noise ratio or S/N figure for the tuner. It is usually measured at a signal strength of 65 dBf (which corresponds to around 1000 microvolts across a 300-ohm antenna input), and the higher the number the better. Almost any decent tuner will deliver a S/N of at least 70 dB in mono; 60 dB or better in stereo. Top-performing tuners have achieved S/N ratios as high as 85 to 90 dB in mono and above 80 dB in stereo.

All of the specifications discussed thus far are often depicted by a single diagram or graph, containing several curves to represent noise levels and distortion levels as a function of signal strength. An example of such a graph, showing how the various specifications can be derived from it, is shown in Fig. 1.

Selectivity

The Federal Communications Commission (FCC) assigns frequencies to FM and AM radio stations so that a station in one city will not occupy the

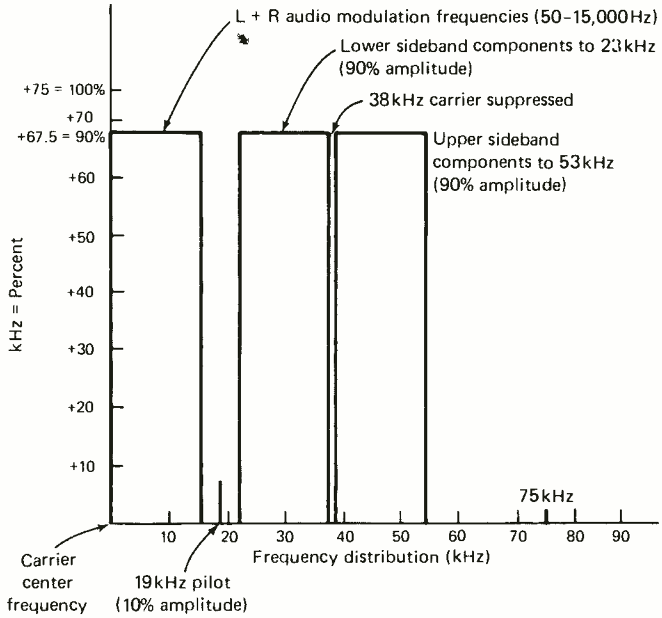
FM Stereo—How It Works

The system used to transmit and receive two stereophonic channels using a single FM station is one that has been uniformly adopted throughout the world. Approved by our own FCC back in 1961, after several years of testing of five competing systems, the so-called Zenith/G.E. system has withstood the test of time; so much so that it formed the basis for the more recently approved stereo TV system that is now beginning to spread across the U.S.

While our standard FM stereo transmission system has its disadvantages (reception in stereo is always noisier than in mono, especially in weak-signal areas), its biggest advantage is its efficient utilization of spectrum space on the FM radio band. Channel width and separation between FM channels remains the same, whether a station is broadcasting in mono or stereo.

FM means frequency modulation, and for a station broadcasting a mono signal, the frequency that's modulated, or altered in proportion to the audio program to be broadcast, is the main or carrier frequency of the station. For example, if a station's assigned frequency is 98.1 MHz, the transmitter will produce that frequency and that frequency only, so long as there's no music or speech being broadcast. When program material is heard, the frequency of the transmitter will alternate above and below that center frequency. The louder the sounds to be transmitted, the greater the deviation from that nominal center frequency—up to a maximum of ±75 kHz. In other words, during loudest moments of music or speech, the center frequency may alternate from 98.175 to 98.025 MHz.

When stereo is to be broadcast, a second subcarrier, having a frequency of 38 kHz, is itself *amplitude* modulated (AM) by the difference between the left and right channels signals (L − R), while the sum of the two stereo signals (L + R) is used to modulate the main or radio-frequency carrier. This subcarrier has often been described as a carrier riding "piggy back" on the main car-



Components that make up the composite signal in a stereo FM broadcast.

same frequency as another station in a nearby city. In fact, within a given metropolitan area, stations are seldom ever assigned adjacent channel frequencies. Adjacent channels in the U.S. FM band are 200 kHz apart, alternate channels, 400 kHz .

Still, with tuners becoming increasingly sensitive and capable of picking up more and more stations at greater distances, it is sometimes possible for a tuner to pick up signals from distant cities that are only one channel width away from a desired local station. Under such conditions, the one station may interfere with the other. Selectivity describes the ability of a tuner to tune to the desired station frequency while rejecting signals coming in at nearby frequencies on the dial. Selectivity is quoted in dB, and the higher the number the better. In most cases, manufacturers will quote alternate-channel selectivity (though the listing may only be labeled "selectivity"). Typical numbers range from 50 or 60 dB (poorest) to as high as 100 dB.

High selectivity numbers may be a mixed blessing. Designing a tuner with high selectivity often means designing it to have a very narrow bandwidth, particularly in its intermediate frequency (i-f) section. But in order for a tuner to deliver lowest possible distortion, its i-f section must have a wide bandwidth. As a result, tuners exhibiting extremely high selectivity may also have somewhat higher distortion levels.

For this reason, some tuners are designed with variable i-f bandwidth. In this case, a switch allows you to alter bandwidth to suit listening conditions. If you are in a crowded signal area, where the station you want to listen to is being interfered with by another nearby (in frequency) station, you select the "narrow" i-f mode, while if you are in an area where there are only a few stations rier. In truth, however, the 38-kHz subcarrier is actually never transmitted. When a carrier (or subcarrier) is amplitude modulated, two sidebands are created; one above the center frequency, the other below it. The frequency of the sidebands depends upon the frequency of the audio signal that is modulating the carrier. If we wanted to modulate the subcarrier by a 5 kHz audio tone, sidebands at 43 kHz (38 kHz + 5 kHz) and at 33 kHz (38 kHz − 5 kHz) would be generated on either side of the subcarrier. In the case of stereo FM transmission, the subcarrier itself is actually suppressed or attenuated, and only the relevant sidebands are transmitted along with the L + R main-carrier modulation.

The diagram here shows the makeup of the composite stereo FM signal. Notice that the upper and lower sidebands of the subcarrier are part of this composite signal, but the subcarrier itself, which would have been located at 38 kHz, is not present.

Notice, too, the presence of a low-amplitude modulating signal at 19 kHz. This is known as the "pilot" signal. It is necessary because in order to recover the L − R audio signals at the receiving end, it is necessary to reconstitute or reconstruct the missing 38-kHz signal that was suppressed at the transmitting end. The 19-kHz pilot signal, at half the frequency of the 38-kHz subcarrier, is used to recreate that subcarrier and to add it to its sidebands in proper phase for subsequent detection or demodulation of the required L − R audio information. The 19-kHz pilot signal is also often used to trigger the familiar stereo pilot indicator light on most FM tuners and receivers to show that a stereo signal is being received.

Suppression of the subcarrier itself and the consequent need for a pilot signal and the reconstitution of a 38-kHz signal at the receiver may seem like a needless pair of steps, but it is this carrier suppression that makes the system so efficient in terms of bandwidth and modulation levels. Though it is difficult to visualize this, here is a case where 1 + 1 equals 1. The main carrier can be modulated to its maximum and the subcarrier can still modulate the main carrier to its maximum all at the same time without exceeding overall maximum modulation limits. The reason for this is a phenomenon known as interleaving. When the L + R audio signals pushes the modulation levels up to maximum, the L − R signal is at a minimum in its alternation cycle, while when the L − R signal from the subcarrier modulation pushes the main carrier to its maximum, the L + R signal at the main carrier is at its minimum.

The first function of a stereo FM receiver is to recover the independent L + R and L − R signals as audio signals. The L + R signal is, in effect, the mono equivalent of the stereo program. It is this signal that is heard by owners of mono FM sets (or by owners of stereo sets who have them switched to the mono mode). By definition, L + R contains the total program being transmitted so mono listeners don't get "half a program" as they might if this technique were not employed.

But what about stereo listeners? They want to hear a left signal from the left speaker and a right signal coming from the right loudspeaker. A bit of simple algebraic addition and subtraction takes care of their needs. If you electrically add the L + R signal to the L − R signal, watch what happens: (L + R) + (L − R) = (L + R + L − R) = L + L = 2L!

Presto! We have recovered a pure "1-only" signal. You can disregard the coefficient of "2." It simply means that you have a louder "L" than you started out with. The independent "R" signal is recovered in a similar fashion: (L + R) − (L − R) = (L + R − L + R) = 2R!

It is this clever system, known as "matrixing," which makes stereo FM compatible for mono listeners while providing stereo listeners with all of the wide channel separation necessary for a good stereo presentation.

spread out across the FM band, you can use the "wide" i-f setting for lowest possible distortion and best possible stereo separation.

Stereo Separation

For stereo sounds to be effective, the program material intended for the left speaker should be well isolated from that intended for the right speaker. Stereo separation, measured in dB, describes this quality in a stereo FM tuner. While stereo stations are required, by FCC rules, to maintain a stereo separation figure of at least 30 dB over the entire broadcast audio spectrum (from 30 to 15,000 Hz), many tuners can provide much better separation than that, especially at mid-frequencies. Measurement standards require that full disclosure of stereo separation include a listing of separation at three key frequencies: 100 Hz, 1 kHz and 10 kHz. Generally, don't expect the separation figures at 100 Hz and 10 kHz to be as good as that obtained at 1 kHz. Often, a manufacturer or a product tester will publish a graph, such as the one pictured in Fig. 2, which shows the overall frequency response of the tuner (upper curve), as well as its separation characteristics, as a function of frequency. From such a graph, you can determine the available stereo separation of the tuner at any specified audio frequency.

Capture Radio

Capture radio is somewhat similar to selectivity, discussed earlier. Capture radio describes the ability of a tuner to zero in on (or "capture") the stronger of two signals that are operating at the very same frequency. Normally, you would never have two stations in the same area operating at the same frequency, but as cited

(Continued on page 52)

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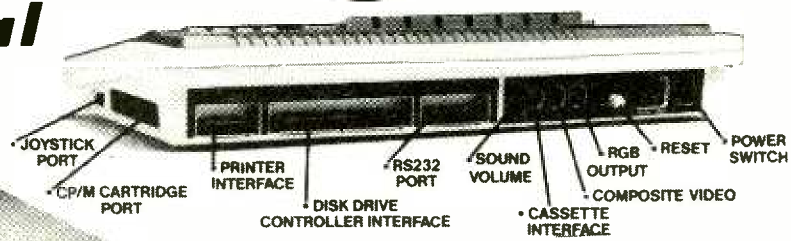

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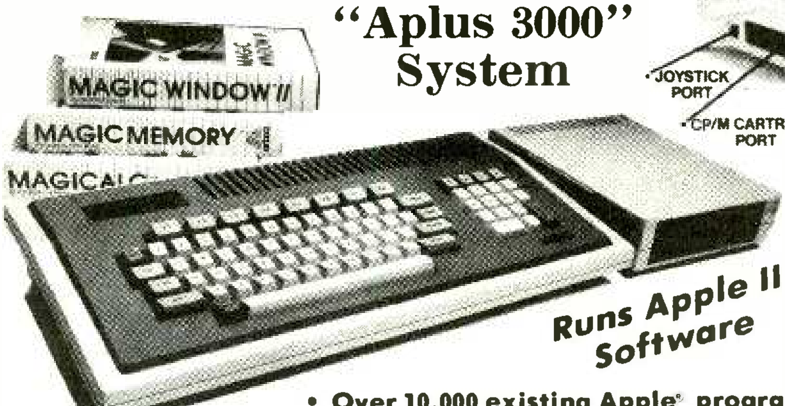

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Composite Video	Yes	Yes	Yes
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Numeric Keypad	Included	Extra Cost	Included
Video Cable	Included	Extra Cost	Extra Cost
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Strong Signals & Weak Signals

Most owners of FM tuners and receivers seem mainly concerned about the sensitivity of the models they buy. Often, a prospective purchaser of an FM tuner may choose one tuner over another because it offered a usable sensitivity of 1.9 microvolts as opposed to 2.0 microvolts. The fact is that tuner sensitivity is seldom a problem these days. Most modern tuners are more than sensitive enough to receive the signals you want—especially if they are fitted with a decent directional outdoor antenna.

What should be of greater concern to the prospective owner of an FM radio or tuner is its ability to handle extremely *strong* signals. This is especially true in metropolitan areas where the receiver is fairly close to the transmitter site. It is not uncommon under such circumstances for the voltage appearing at the antenna terminals of an FM tuner to reach levels of 1.0 or even 2.0 volts or more. Under such conditions, a tuner having a poorly designed front-end, or r-f section, may well be overloaded.

The result can be a variety of distortions, commonly referred to as cross-modulation, intermodulation distortion, or just plain overload distortion. These forms of distortion arise, basically, from the first r-f stage's inability to handle the strong incoming signals in a linear fashion. Nonlinearity in the r-f amplifier stage of an FM tuner is very similar to nonlinearity in an amplification stage of an audio amplifier. Only in this case, the distortion products produced are frequency-related to the incoming r-f carrier signal. They may be harmonics of that signal or they may be spurious "beat" frequencies caused by interaction of the FM set's local oscillator with the incoming frequency or between the desired incoming frequency and other incoming signals that are near enough on the dial to cause problems.

Earliest solid-state FM tuners and receivers employed bipolar transistors as r-f stages in their front ends. Such transistors performed poorly because of their limited dynamic range and also because of their extreme nonlinearity and susceptibility to overload. In fact, owners of early solid-state FM tuners were often disappointed at their performance. They found them inferior to the vacuum-tube-equipped FM tuners that had been discarded in favor of transistorized equipment.

The low-noise triode vacuum tube was an ideal active device for the r-f amplifier stages of an FM tuner. Extremely linear over its entire operating range, the triode was used for many years in a variety of configurations for tuner r-f stages. Bipolar transistors, on the other hand, behaved very differently from triodes. It was only after field-effect transistors (FETs) were perfected to handle the high frequencies of FM that the situation improved. FETs are the closest thing to a triode in the semiconductor category. They are negatively biased, just like triodes, exhibit a high input impedance and minimize cross-modulation effects.

More recent perfection of dual-gate MOSFETS (metal-oxide silicon field-effect transistors) has resulted in r-f front ends that are equal or superior to the best triode circuits of yesteryear. High-power versions of MOSFETs are also now found in amplifier output stages for much the same reasons that their lower-power, small-signal equivalents are used in r-f circuitry—because of their extremely linear operation and ability to handle wide swings of signal voltage without overload.

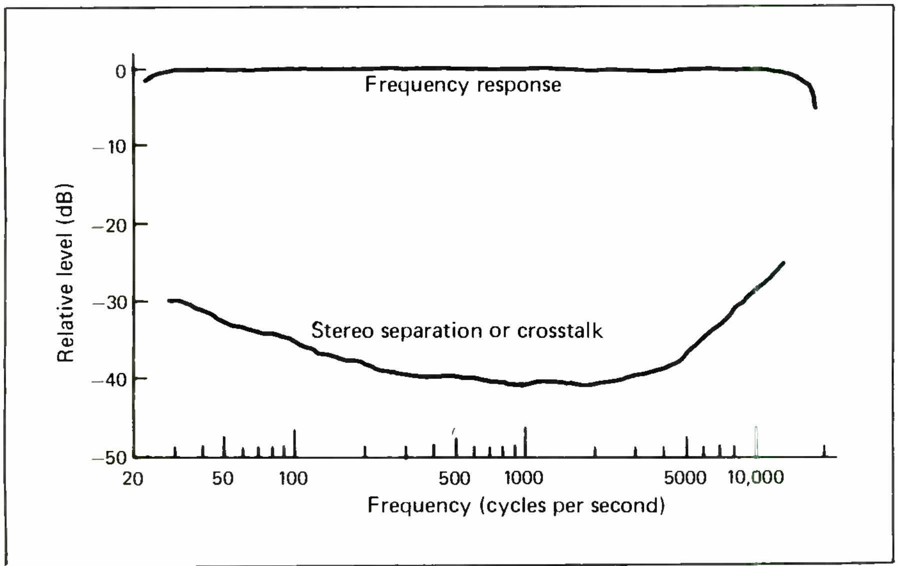


Fig. 2. Divergence between upper and lower curves tells you the amount of stereo separation provided in an FM tuner at any audio frequency.

earlier, increasing sensitivity of modern tuners makes such a condition possible at times. For example, a listener in Philadelphia might well receive usable signals from New York as well as from Washington, and those latter two cities are far enough apart to have been assigned stations at the same frequency.

A much more important reason for having a tuner with a good capture ratio has to do with a phenomenon known as "multipath" interference. FM signals travel in a "line-of-sight" path, but they are radiated in all directions. If some radio energy reaches your antenna directly from the transmitter while parts of the signal reach your antenna having first been reflected from or "bounced off" a nearby steel structure, mountainside, or other terrain, you will be a multipath interference victim.

If you stop to think about it, that condition is exactly the same as having two different signals at the same frequency arriving at your tuner's input. A good capture ratio will help to reject the weaker (reflected) of the two, while accepting or locking onto the stronger, directly received signal. Capture ratio is quoted in dB and, in this case, the lower the figure the better. In a superb tuner, capture ratios of as low as 1.0 dB or even a bit lower are now uncommon, while a capture ratio of 2 to 2.5 dB is considered acceptable under most conditions.

Rejecting Unwanted Signals

There are several secondary FM tuner specifications that are usually listed on the "spec sheet" of a tuner product. Most of these describe the ability of the tuner to reject various signals that shouldn't be received by the tuner but which, to varying degrees, sometimes manage to find their way through the tuner's complex circuitry. Included in this category are such specifications as "i-f rejection," "image rejection," "AM rejection" or suppression, and a catch-all called "spurious signal rejection," the last taking care of all other unwanted signals.

AM Suppression is, perhaps, the easiest of these specifications to understand. A frequency-modulation tuner should be impervious to amplitude modulation, and the AM suppression specification, quoted in dB, tells just how immune the tuner is to that unwanted form of modulation. Figures of 50 dB or better are acceptable, with some sets providing as much as 60 dB of AM rejection.

As for the remaining "rejection" specifications, space does not permit a detailed explanation of each one. Suffice it to say that each of these remaining specifications should have as high a number (in dB) as possible. Acceptable levels for all of these remaining specifications are above 60 dB and many manufacturers claim and deliver rejection figures as high as 100 dB or more for some or all of the listed rejection specifications.

Practical Buying Tips

While understanding FM tuner specifications will certainly help you to pick the tuner that's right for you, it is a good idea to audition the tuner of your choice under "real-world" conditions that exist in your listening location. Remember, too, that to derive the best possible performance that your tuner is able to deliver, you should equip it with a good, directional outdoor antenna. The so-called antenna often packed with tuners and receivers (consisting of nothing more than a T-shaped piece of wire) should be looked upon as only a temporary expedient—suitable for making certain that your tuner is operating with any sort of signal.

If circumstances prevent your using a good outdoor FM antenna, use a signal "splitter" to tie into your existing outdoor TV antenna.

If you can't use a TV antenna, at the very least get yourself one of those inexpensive but fairly effective indoor "rabbit-ears" antennas, whose rods can be lengthened, shortened and rotated for best signal reception. Even the very costliest tuners will sound noisy and will not deliver acceptable reception unless hooked up to a proper antenna. Conversely—and this is a point worth thinking about—a low-cost tuner with just average specifications, hooked up to a multi-element, properly oriented directional antenna may well outperform the most expensive tuner that uses a bit of wire thrown behind it as an "antenna." ME

Designing Active Filters

Part 1

A short-cut method for practical design of first-through-third-order active filters

By R. Fleischman

Active filters are among the most important circuits used in modern electronics. They're used in every type of equipment where signal bandwidth must be kept within specified limits to assure proper operation. In this article, we'll explore how to design active filters, using a number of examples to show you how to quickly design circuits to suit virtually any need.

Covered in the first installment of this two-part article are general filter basics and how to design first-order active filters, selecting component values based on those of a time-saving reference circuit. So if you'd like to experiment with active filters but don't know where to start, dig in. While this article won't tell you everything you need to know about designing active filters, it should point the way.

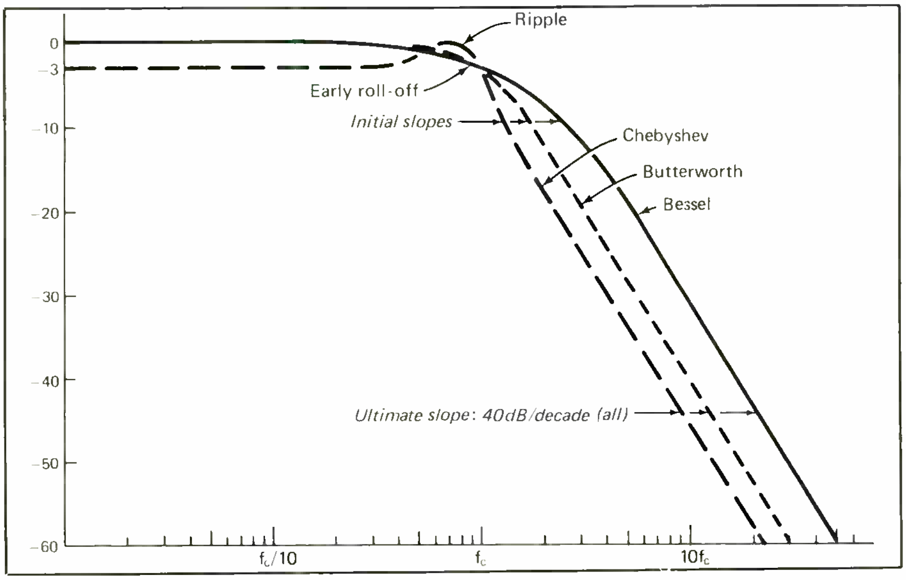


Fig. 1. Amplitude-vs.-frequency plots of the three basic types of filters.

The Basics

Passive filters can be made up of resistive-capacitive (RC) resistive-inductive (RL) and resistive-inductive-capacitive (RLC) elements. Designed in this passive manner, such filters suffer from insertion loss. To obviate this, you can combine any passive filter network with an amplifier to obtain an active filter. The active filter gives you a number of advantages. These include: better control over the response shape; signal gain instead of insertion loss; and elimination of the need for inductors, allowing you to build smaller, more cost-effective filters than is possible with passive designs.

The easiest and most economical way to design gain into an active filter is with an operational-amplifier integrated circuit, rather than a discrete-component amplifier. This being the case, our discussion will focus on IC op-amp active filters.

Whether passive or active, filters are commonly referred to by their "order," which refers to the degree of rolloff they exhibit beyond the design cutoff frequency. A first-order filter has a rolloff slope of 6 decibels per octave (dB/octave), or 20 dB/decade beyond cutoff. Similarly, a second-order filter has a slope of 12 dB/octave or 40 dB/decade, while a third-order filter's slope is 18 dB/octave or 60 dB/decade.

These figures hold true for the response of each type of filter network for a decade or so beyond cutoff. Any second-order low-pass filter network with a 1-kHz cutoff frequency will eventually reach a slope of 40 dB/decade by the time the frequency reaches 10 kHz or so. The slope the filter eventually gets to, long after cutoff, is called the *ultimate slope.* But its slope just beyond cutoff—say at about 1.5 to 2 kHz in our example—might be either more or less than that, depending on what type of filter is being used.

Filters are also classified according to the shapes of their response curves and their phase shift. Response shape refers to the degree of flatness throughout the passband and the degree of rolloff slope just beyond the cutoff frequency. Phase shift is the amount by which the phase angle of the signal as it passes through the filter changes with a change in frequency.

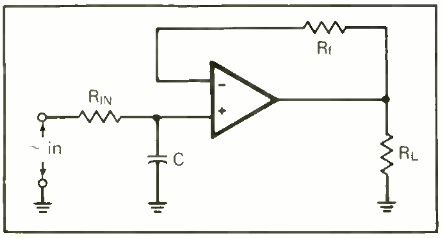


Fig. 2. A first-order, low-pass, unity-gain active filter.

Bear in mind that every filter type represents compromises. To obtain the benefits of a given type of filter, you must put up with its disadvantages. Let's review the advantages and disadvantages of the three basic filter types:

- *Bessel* (also known as a "minimum-phase") filter—least amount of phase shift; early rolloff and slow rolloff near cutoff.
- *Butterworth* filter—flattest passband; only moderately good rolloff.
- *Chebychev* filter—steepest rolloff slope near cutoff; exhibits passband ripple and the worst phase-shift characteristic of the three filter types.

In Fig. 1 are plots that graphically show comparisons of the amplitude responses of the second-order versions of the three basic filter types. Using the Butterworth filter as the standard for comparison, you can see that the Chebychev filter has the steepest slope and the Bessel filter has the most gradual slope in the region just beyond cutoff. Despite the differences in initial slope, all three filters eventually reach the same ultimate slope, with the rolloffs straightening out into parallel lines that drop forever after at a 40-dB/decade rate. Again, compared to the Butterworth filter, the Chebychev filter suffers from a peak (usually called "ripple") in its passband, while the Bessel filter actually begins to roll off prematurely, resulting in a slight response depression some distance into the passband.

The main advantage of the Bessel filter can't be seen in Fig. 1, because it doesn't show up in an amplitude-versus-frequency plot. Exhibiting the least phase shift and best transient response, it's the only filter that doesn't "ring" appreciably when subjected to pulse or square-wave inputs.

First-Order Filters

Simplest in design, the active first-order filter uses an RC network at the input of the op amp, plus a feedback resistor from the op amp's output back to its input. Shown in Fig. 2, this circuit's RC input network is followed by a unity-gain op-amp buffer. (See the "Unity Gain" box for more details.)

It's easy to calculate the cutoff frequency of the first-order active filter, using the formula $F_c = 1/(6.28 \times R_{in} \times C_{in})$. If you already know the filter's cutoff frequency and wish to know the value of either network component, you can rearrange the formula so that $R_{in} = 1/(6.28 \times F_cC_{in})$ or $C_{in} = 1/(6.28F_cR_{in})$. In all cases R_{in} is the input resistance, C_{in} is input network capacitance, and F_c is the cutoff frequency. Unless you're using a wire for the feedback link, the values of feedback resistor R_f and input-network resistor R_{in} should be about the same.

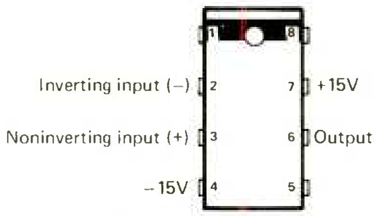
Unity Gain

Over the flat part of a filter's response curve, the unity-gain circuit delivers an output voltage (V_{out}) equal to the input signal voltage (V_{in}). Therefore, with $V_{in}/V_{out} = 1$, gain is said to be unity. Another way of stating this is that the filter does nothing to change the amplitude of the signal over the range of frequencies it passes.

An op amp can be forced into unity gain simply by connecting a wire directly from its output back to its inverting (−) input. However, if the output offset voltage must be minimized, a resistor should be used in place of the wire. The resistor's value should be the same as that of the input resistor to the noninverting (+) input. The wire feedback link causes only a few millivolts output offset, though, which is usually not a problem, except in critical applications.

Construction Hints

By far the best way to build an active filter to check out its operation after designing it on paper is to assemble it on a solderless breadboarding socket. Such a breadboard facilitates quick assembly and makes circuit revisions easy to perform. It has standard 0.1" IC hole spacing to fit dual in-line package (DIP) op-amp ICs. A solderless breadboarding socket only 4" long will easily accommodate first- and second-order filters. For third-order filters, however, you're better off using a 6" long socket.



Pinouts for 741 and LM318 op amps.

For convenience in laying out the circuit, it's a good idea to use single op-amp ICs, rather than dual or quad devices. This tends to spread things out a bit, but it also permits the circuit to be laid out to physically resemble the schematic diagram for easier wiring and troubleshooting.

For the sake of economy, use inexpensive 741 op amps when maximum cutoff frequency is 8 kHz and output signal swing is no more than 10 volts peak. If these limits are exceeded, the 741's maximum slew rate of 0.5 volt per microsecond causes waveform distortion. The LM-318's 80-microvolt per microsecond slew rate makes this much the superior device. Of course, there are a wide variety of other IC op amps you can use in your active-filter circuits, ranging from the very economical to quite expensive.

The 741 and the LM318 have the same pinout (see drawing) and, therefore, can be used interchangeably, depending on the level of performance required.

Let's do some design calculations. Assume you want the value of R_{in} and R_f to be 10,000 ohms and F_c to be 1 kHz. Using this information, calculate input-network capacitance: C_{in} = 1/(6.28 × 1000 × 10,000) = 0.0159 microfarad. The data for and result of this calculation are worth remembering. Even though you won't always want a 1-kHz cutoff frequency, you can use these values (F_c = 1 kHz, R_{in} = 10,000 ohms and C_{in} = 0.016 μF) as a "reference" that can save a lot of work in the future when designing almost any filter.

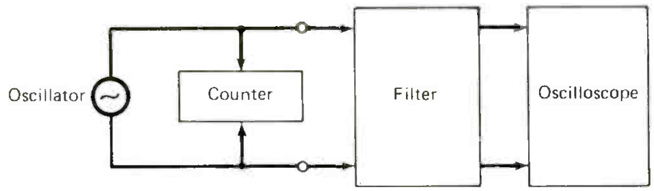
To see how this works, let's try another example. This time, let F_c = 500 Hz and R_{in} = 10,000 ohms. With this data, C_{in} becomes approximately 0.032 μF. Since 10,000 ohms is a practical value for R_{in} and unity gain is often desired, you need only scale the value of C_{in} as needed.

Notice that by halving the cutoff frequency you've doubled the value of C_{in}. This suggests that you could have gotten the same answer more easily simply by scaling C_{in} in the same scale-down ratio for F_c. This ratio works out to (1000/500) = 2. You now simply multiply the ratio by the value of C_{in} at 1 kHz to obtain the result: 2 × 0.016 μF = 0.032 μF. This tells you that F_c is always inversely proportional to C_{in} (and R_{in}). Once you know this, your design work is considerably reduced.

Before moving on, let's use one more example. This time, let's say you want to use a 0.02-μF capacitor you have on hand in a filter whose cutoff frequency is to be 1 kHz. Again, the easy approach is to begin with the reference filter. Since F_c is to be 1 kHz, you must keep the RC product constant. Because you're increasing C_{in} from 0.016 to 0.02 μF, R_{in} must decrease such that R_{in} = 10,000(0.016/0.02) = 8000 ohms. If you should now want to change F_c to 2 kHz, you simply rescale to obtain the value: R_{in} = 8000(1000/2000) = 4000 ohms. That's all there is to it!

There are many combinations of R_{in} and C_{in} values that will work for a given F_c. Scaling gives you an easy way to find the most convenient combination for your needs.

Plotting a Filter's Response



Test setup for plotting the response of a newly designed active filter.

Once you've designed and built a filter, you can "proof" its performance by plotting its response curve. For this, you need the test setup shown in the drawing and four-cycle semilog graph paper. Make sure your test setup is as shown. Then set the generator to some convenient input level (2 volts is good) and keep it there for all subsequent measurements.

On a sheet of paper, write down the type and order of the filter you've designed and the legend "V_{ref}." Just under this, write down the headings for four columns, labeling them F, V_{out}, V_{out}/V_{ref} and dB.

Start your test by sweeping the generator's frequency control until you find the highest amplitude in the filter's response, as indicated on the oscilloscope's screen. (For a Butterworth or Bessel filter, this occurs at some frequency well into the filter's passband; for a Chebychev filter, it will be the top of the "bump" in the curve.) When you locate the highest point in the response curve, write it down next to the V_{ref} on your sheet.

Beginning well into the passband, take a series of amplitude measurements, stepping in frequency toward F_c. Continue on into the stopband rolloff. Each time you change frequency, measure the generator's output voltage and, if necessary, adjust the generator's output amplitude control to maintain the same input voltage to the filter at all times. If you fail to do this, all your measurements will be meaningless. Make a note of each change in frequency in the column headed "F," and then fill in the "V_{out}" and "V_{out}/V_{ref}" columns.

Try to choose generator frequencies that can be accurately located on the graph paper. The reason for this is that it's almost impossible to "eyeball" nonstandard frequencies on semilog paper.

Take enough readings to assure that the graph paper will be densely filled with plotted points, particularly near cutoff. You need fewer points at the frequency extremes. Beyond cutoff, keep working until the output voltage from the filter becomes too low to measure accurately.

When all measurements have been entered on your chart, you're ready to convert them to decibel (dB) values with the formula: Gain in dB = 20 log(V_{out}/V_{in}). Enter the results in the "dB" column of your chart.

Label the *Y* axis of your graph paper so that 0 dB is one major division down from the top. Then label the *X* axis appropriately for the frequency range covered in your test. Transfer the information contained in your chart onto your graph paper in the form of dots at the appropriate *X* and *Y* coordinates. Then connect the plotted dots with a smooth-flowing line.

You now have a plot of the frequency-versus-amplitude characteristics for your particular filter. It's a good idea to make a plot for every filter you design and build.

Coming Next Month

Up to this point, we've been discussing first-order active filters. Next month, in the conclusion of this article, we'll zero in on second- and third-order filters and finish up with recommendations for obtaining further information. **ME**

A Discrete-Component High-Frequency Op Amp

Gives good performance at frequencies to 4 MHz and beyond

By Duane M. Perkins

Operational amplifiers have become extremely popular in low-cost integrated-circuit form. However, even with enormous incentives for designers and experimenters to use IC op amps, there are times when an op-amp circuit made with discrete components is the only way to implement a practical circuit. A typical example of this is when one needs an op-amp circuit to operate in the megahertz range. Most IC op amps cannot deliver the required performance if the frequency goes much beyond about 1.5 MHz.

In this article, we'll explore the design of a simple discrete-component op amp you can build and its advantages and limitations. You'll find this circuit useful when operation to 4 MHz and beyond is needed.

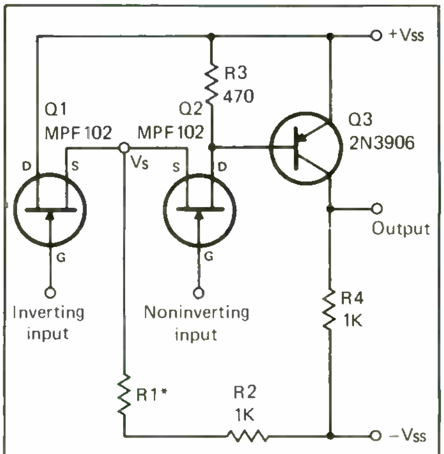
The Basic Circuit

If you've ever examined the schematic diagram of the internal circuit of a typical IC op amp, you'll probably think the circuit of the discrete-component version shown in Fig. 1 is much too simple to be practical. However, the performance of this circuit is adequate for a wide variety of high-frequency applications. The circuit's open-loop dc gain is greater than 35 dB, with rolloff beginning at about 350 kHz at a 20-dB per decade rate.

Gain at 3.5 MHz is typically about 15 dB, as shown in Fig. 2. Compare this with a high-performance LF353N IC op amp that has a specified gain-bandwidth product of 4 MHz. Gain of the LF353N at 3.5 MHz would be slightly greater than 1 dB, which is much less than adequate for most applications.

Of course, a discrete-component op amp has limitations not found in IC op amps. For example it's designed for a specific tightly regulated supply voltage. Open-loop dc gain doesn't approach that of most IC op amps. Also, careful adjustment of a trimmer control is required for minimum offset voltage. So this type of op amp should be considered only if these limitations aren't serious handicaps and the frequency limitation of the available ICs make them inadequate for a given need.

Aside from these limitations, the Fig. 1 circuit functions as a typical op amp that has the V+, V−, inverting (−) input, noninverting (+) input, and output terminals required of an op amp. Note that there's no ground connection when the circuit is used with a split power supply. The standard op-amp symbol shown in Fig. 3



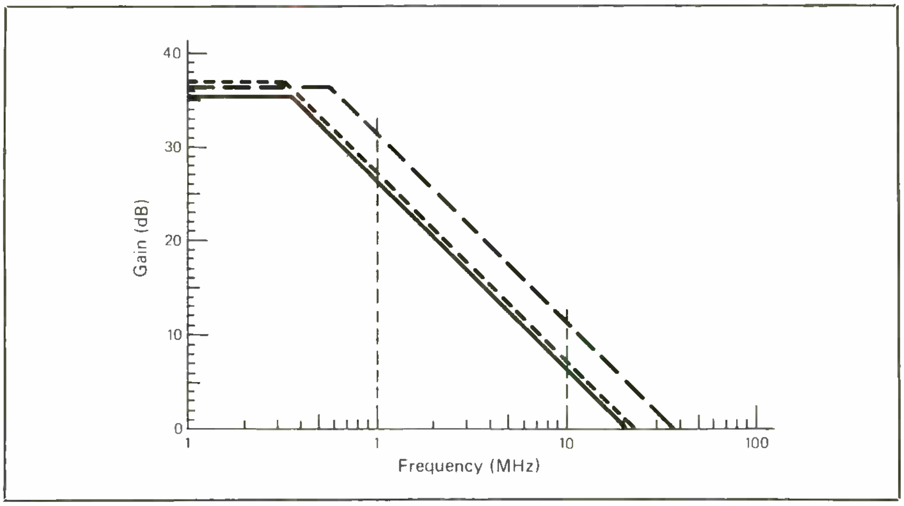
$R1 > (V_{SS} + V_S)/0.0026$

$R1 < [(V_{SS} - V_S/0.0026] - 1000$

Where Vs results in ID2 = 1.3 mA

Fig. 1. A basic discrete-component operational amplifier you can build.

Fig. 2. Typical gain/frequency curves.



applies as much for the discrete-component as it does for the IC op amp.

During the design stage, the values of *R1* and *R2* are selected and adjusted so that *Q2* draws just enough base current from *Q3* to set the output voltage at the midpoint between the voltages at the supply terminals when both inputs are at the same level. This level is at ground potential when a split supply is used.

Since the base voltage of *Q3* remains essentially fixed, any change in current through *Q2* changes *Q3*'s base current by an equal amount. This will be amplified by a factor equal to the beta (β) of *Q3*. the output voltage will change by an amount equal to the change in *Q3*'s collector current multiplied by the value of *R4*.

Transistors *Q1* and *Q2* are mutually coupled through resistors *R1* and *R2*. If one output is held fixed and a signal is applied to the other, the currents through *Q1* and *Q2* will vary in opposite directions, tending to hold source terminal voltage V_S constant. Because coupling depends on a change in source voltage, V_S must vary to some extent, but at a much lower amplitude than the input signal.

Assuming that the transconductances (Gm) of *Q1* and *Q2* are equal, the amplitude of the input must be more than twice that of V_S for the source-to-gate voltage of the input transistor to exceed that of the transistor with a fixed gate voltage. Accordingly, negative feedback resulting from the signal at V_S must be less than 50 percent. Signal currents through *Q1* and *Q2* will be approximately equal, and the signal current through *R4* will be in-phase with the signal current through *Q2*. The input voltage will be greatly amplified.

If the same signal is applied to both inputs, the signal currents through *Q1* and *Q2* will be in-phase, and V_S will follow the input signal. The resulting negative feedback will be much greater (nearly 100 percent), and the signal current through *Q2* will be much less. The input signal will be

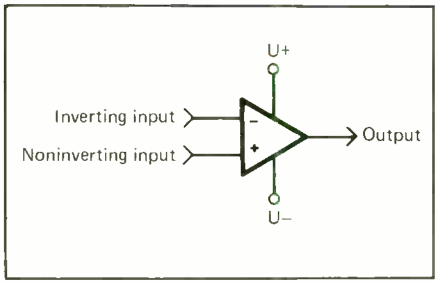
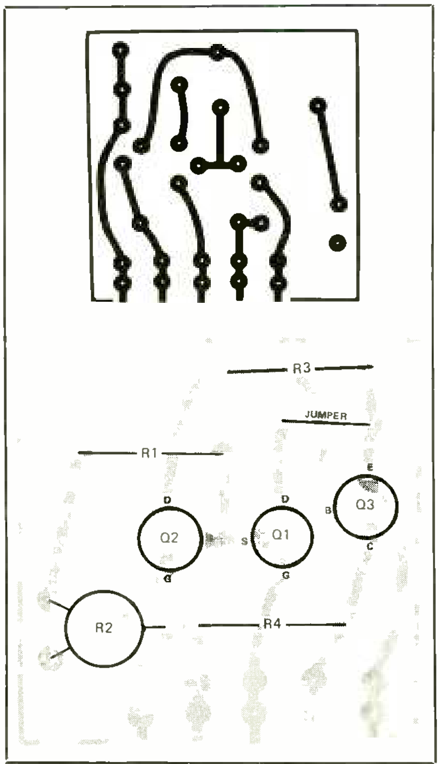


Fig. 3. The standard op amp symbol.

amplified, but to a much lesser degree than it would if one input were held constant.

The Fig. 1 circuit is essentially a differential amplifier. That is, it amplifies a differential signal much more than it does a common input signal. This effect is called common-mode rejection. The ratio of the differential open-loop gain divided by the common-mode gain is called the common-mode rejection ratio (or CMRR). Although it is not nearly as great as the typical figure for an IC op amp, it's quite effective, measuring

Fig. 4. Actual-size etching-and-drilling and components-placement guides.



about 24 dB when V_{SS} is $\pm$ 12 volts. As V_{SS} is reduced, the resistance of *R1* or/and *R2* must also be reduced, resulting in less coupling between *Q1* and *Q2* and a smaller CMRR.

Construction Considerations

The op amp can be built as part of the circuit in which it is to be used. Alternatively, it can be built as a separate module that can be plugged into a solderless breadboard, or it can be connected into a circuit using Wire Wrap or printed-circuit board construction. If the last, you can use the actual-size etching-and-drilling guide shown in Fig. 4 to fabricate your own pc board. If several op-amp circuits are needed, several pc boards can be etched on a large copper-clad blank and be cut apart as needed. Wire the board(s) according to the instructions given in the components-placement diagram, also shown in Fig. 4.

Because of the high open-loop gain, keep in mind that oscillation may occur in the op-amp circuit if there is little negative feedback and even a small amount of positive feedback to the noninverting input through stray capacitance. The pc layout shown in Fig. 4 minimizes this possibility by isolating the noniverting input from the output.

The MPF-102 or similar field-effect transistors used for *Q1* and *Q2* in the op-amp circuit must be closely matched. This selection is facilitated by the circuit shown in Fig. 5. This circuit can be quickly assembled on a solderless breadboard.

When using the Fig. 5 circuit, adjust the 10,000-ohm potentiometer for a 1.3-volt drop across the 1000-ohm drain resistor. This gives a 1.3-mA drain current. Measure the voltage at the source terminal, which is the source-to-gate voltage required for proper op amp operation. The two selected FETs must pass approximately the same current with equal source-to-gate voltages. This current must be about 1.3 mA to cause about a 0.6-volt drop across *R3*.

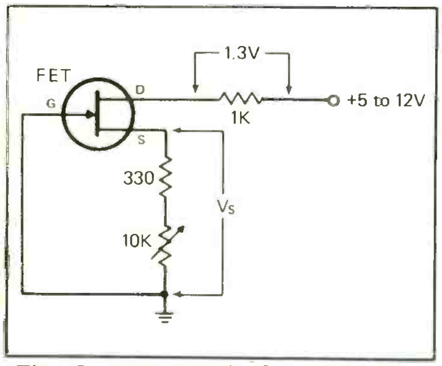


Fig. 5. Test circuit for comparing FETs to obtain a matched pair.

Current through *R1* and *R2* will be about 2.6 mA. This must produce a drop that exceeds the negative supply voltage by the amount of the source-to-gate voltage required for a current of 2.6 mA. Accordingly, the sum of the resistances of *R1* and *R2* is determined principally by the supply voltage. For a ± 12-volt supply, 5200 ohms will be about right for typical FETs, setting the source-to-gate potential at 1.5 volts.

The value of *R2* should be 1000 ohms to permit adjustment over a range of ± 1.3 volts. If *R1*'s value is 4700 ohms, for a drain current of 1.3 mA, V_S must be well within the range of 0.22 to 2.82 volts. As a general rule, calculate *R1*'s value as half the difference between the voltages at the supply terminals divided by 2.6 mA. Select the standard value of resistance nearest to the calculated value but scale it upward or downward, depending on how much additional resistance is needed when taking into consideration that *R2* adds up to 1000 ohms to the overall resistance.

Once *R2* has been properly adjusted for a given supply voltage, further adjustment shouldn't be necessary, provided the supply voltage remains unchanged. To set *R2*, connect the op amp to a split supply and ground both inputs. Adjust *R2* to obtain an output voltage near ground potential. A slow drift will be observed as the transistors

(Continued on page 94)

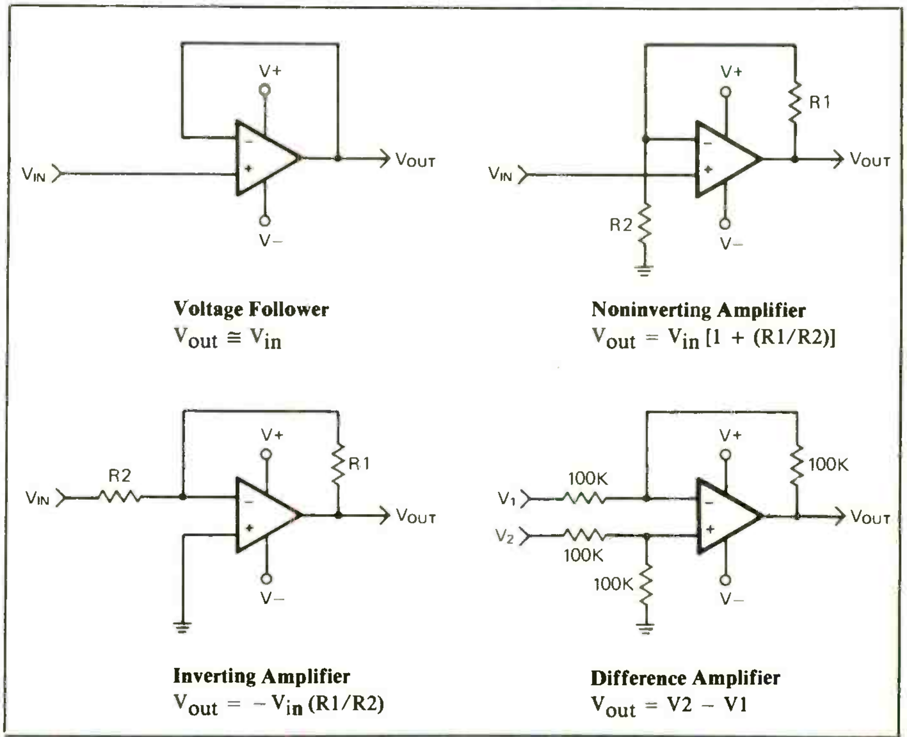
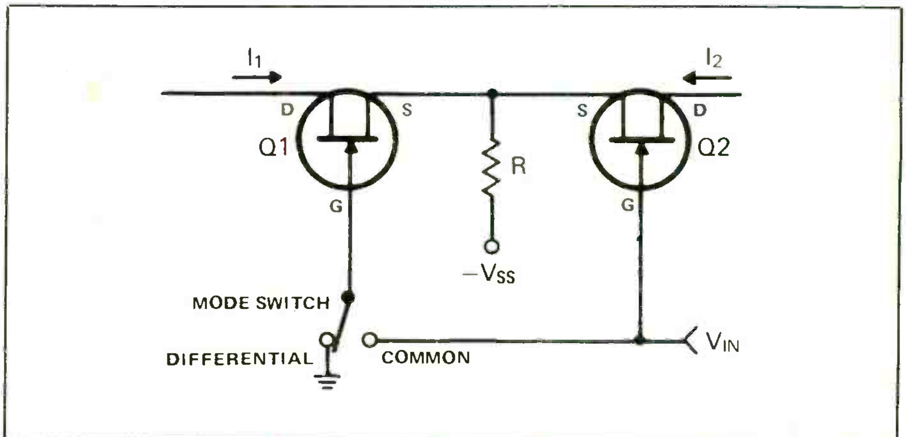


Fig. 6. Examples of op-amp linear amplifiers.



MATHEMATICAL ANALYSIS

Differential Mode

$\Delta I1 = -Gm\,\Delta V_S$

$\Delta I2 = Gm\,(\Delta V_{in} - \Delta V_s)$

$\Delta V_s = R(\Delta I1 + \Delta I2)$

$\Delta V_s = GmR(\Delta Vin - 2\Delta V_s)$

$\Delta V_s(1 + 2GmR) = GmR\Delta V_{in}$

$\Delta V_s = \Delta V_{in}[GmR/(1 + 2GmR)]$

Common Mode

$\Delta I1 = Gm\,(\Delta V_{in} - \Delta V_s)$

$\Delta I2 = Gm(\Delta V_{in} - \Delta V_s)$

$\Delta V_s = R(\Delta I1 + \Delta I2)$

$\Delta V_s = 2GmR(\Delta V_{in} - \Delta V_s)$

$\Delta V_s(1 + 2GmR) = 2GmR\,V_{in}$

$\Delta V_s = \Delta V_{in}\,[2GmR(1 + 2GmR)]$

Common-Mode Rejection Ratio

$$CMRR = \frac{\Delta Vin - \Delta Vs\,(differential)}{\Delta Vin - \Delta Vs\,(common)}$$

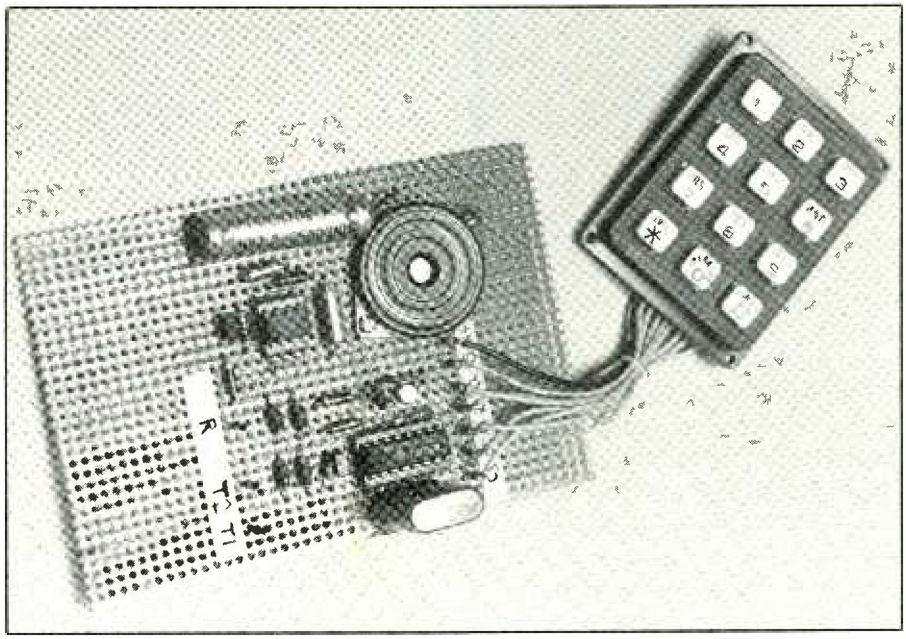
$$CMRR = \frac{1 - [(GmR)/(1 + 2GmR)]}{1 - [(2GmR)/(1 + 2GmR)]}$$

Add a Speakerphone to Your Telephone

(Conclusion)

Adds an Electronic Ringer and Touch Tone Dialer to the Speakerphone or any other telephone

By Anthony J. Caristi



Last month in Part 1 of this article, we told you how to add hands-free talk/listen capability to an existing telephone instrument with the Speakerphone accessory. In this concluding installment, we describe how to add a Touch Tone dialer/electronic ringer to give your Speakerphone stand-alone communications capability.

Though the dialer/ringer has been designed specifically for use with the Speakerphone, it can also be used to supplement an existing telephone instrument to provide Touch Tone dialing and electronic ringing independent of the instrument's built-in facilities.

Used alone, the accessory provides true Touch Tones for originating calls from any telephone line and a pleasant telephone bell ringing sound to announce incoming calls. Add it to the Speakerphone, and you have a complete state-of-the-art telephone that can be used anywhere you can run a pair of telephone line wires.

This dialer/ringer can be used with most telephone services, too, including MCI, Sprint and others. It gets its power directly from the telephone line, so there's never any need to change batteries or provide an ac power supply. It's also easy to build and low in cost.

About the Circuit

As shown in Fig. 1, the accessory consists of independent Touch Tone dialer and electronic ringer sections. Each section is complete by itself, and is built around its own separate integrated circuit.

A Texas Instruments TCM5087N, identified as *IC1*, is at the heart of the Touch Tone dialer circuit. Power for this specialized IC is taken from the telephone line by diode bridge *D1* through *D4*. Zener diode *D5* regulates the bridge output so that no more than 13 volts reaches *IC1*.

When the dialer circuit is connected to the telephone line, current through *D5* places the line in the "off-hook" condition. This signals the telephone company's central office equipment to put a dialtone on the line.

Contained within *IC1* are an oscillator, two independent divider sections and logic circuitry that controls the division ratios of the dividers according to the buttons pressed on the keypad. Oscillator frequency is determined by external crystal *XTAL*. The crystal-controlled oscillator operates at the 3.579-MHz TV color-burst frequency, obtained by a commonly available, inexpensive crystal.

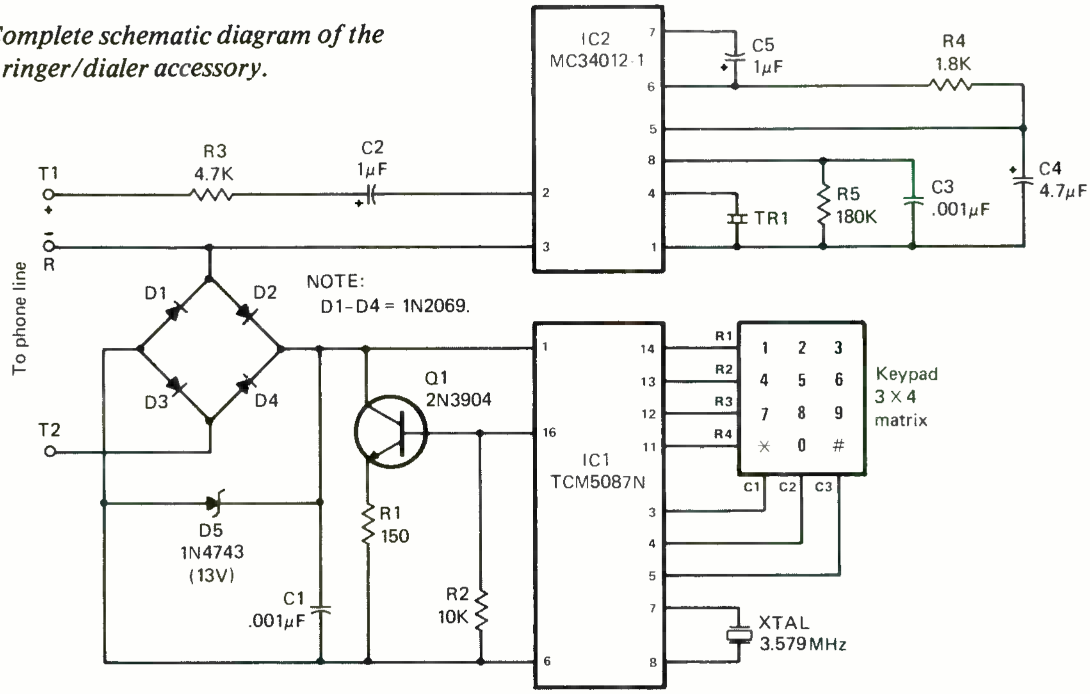
Touch Tone dialing uses one frequency tone from a high band and one from a low band each time a button on the keypad is pressed. Each divider section in *IC1* generates a specific frequency. Low-band frequencies range from 701 to 935 Hz, and high-band frequencies are from 1216 to 1645 Hz.

Pressing a button on the keypad selects the appropriate frequency pair for that button (each of which is assigned its own unique frequency pair). Pressing any given button shorts together one of the four "row" wires (R1 through R4) and one of the "column" wires (C1 through C3). Logic circuitry inside the chip senses the specific row and column wires that are shorted together for any given button and sets each divider to the proper division ratio to produce the required pair of frequencies for the button pressed. The output signal at pin 16 of *IC1* is amplified by *Q1* before delivery to the telephone line.

Electronic ring detector *IC2* is another specialized chip, this one designed to detect and announce (via an external sounder) presence of a ring signal on the telephone line. Except for external timing components and piezoelectric transducer *TR1*, the entire circuit for this section is contained inside *IC2*. This chip processes the 90-volt, 20-Hz ring signal by first rectifying it to a dc voltage, which is then used to power the internal oscillator and divider.

The divider inside *IC2* switches back and forth at a low repetition rate so that the divided oscillator signal becomes two distinct high and low audio frequencies, called the low and high tones. The "warble" tone switching frequency is about 13 Hz. These frequencies produce electronic

Fig. 1. Complete schematic diagram of the ringer/dialer accessory.



PARTS LIST

Semiconductors
D1 thru D4—1N2069 or similar silicon diode
D5—1N4743 or similar 13-volt zener diode
IC1—TXM5087 integrated circuit (Texas Instruments)
IC2—MC34012-1 integrated circuit (Motorola)
Q1—2N3904 transistor
Capacitors
C1,C3—0.001-μF, 25-volt ceramic
C2—1-μF, 250-volt electrolytic or Mylar (see text)
C4—4.7-μF, 25-volt electrolytic
C5—1-μF, 10-volt electrolytic
Resistors (¼-watt, 10% tolerance)
R1—180 ohms
R2—10,000 ohms
R3—4700 ohms
R4—1800 ohms
R5—180,000 ohms
Miscellaneous
TR1—Piezoelectric transducer (Radio Shack Cat. No. 273-069 or similar)
XTAL—3.579-MHz TV color-burst crystal
Industrial Electronic Engineers Inc. Type KS 2585 or similar 3 × 4-matrix telephone keypad (see text); spst switch; printed-circuit board or perforated board and soldering hardware; suitable enclosure (see text); telephone cord with modular plug; machine hardware; hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Etched and drilled pc board for $6.75; TXM5087 IC for $7.50; MC34012-1 IC for $5.50. Add $1.00 S&H. New Jersey residents, please add sales tax.

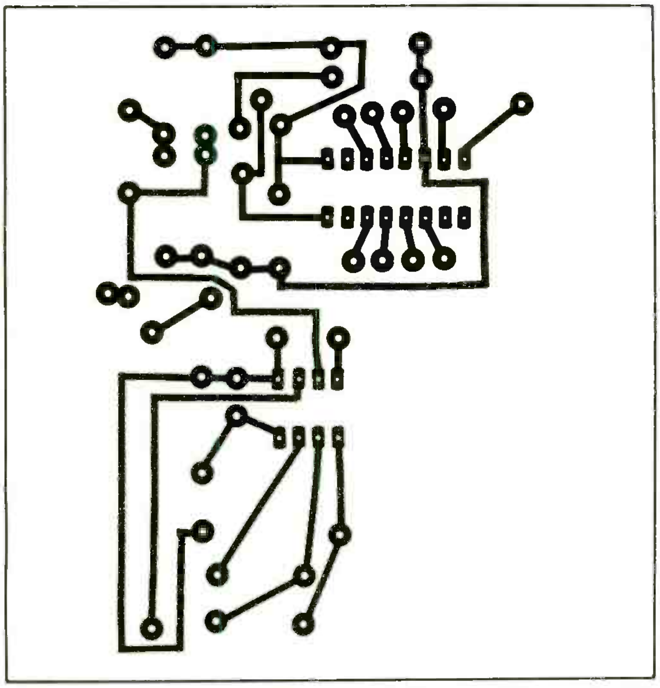


Fig. 2. *Actual-size etching-and-drilling guide to use for fabricating your own printed-circuit board.*

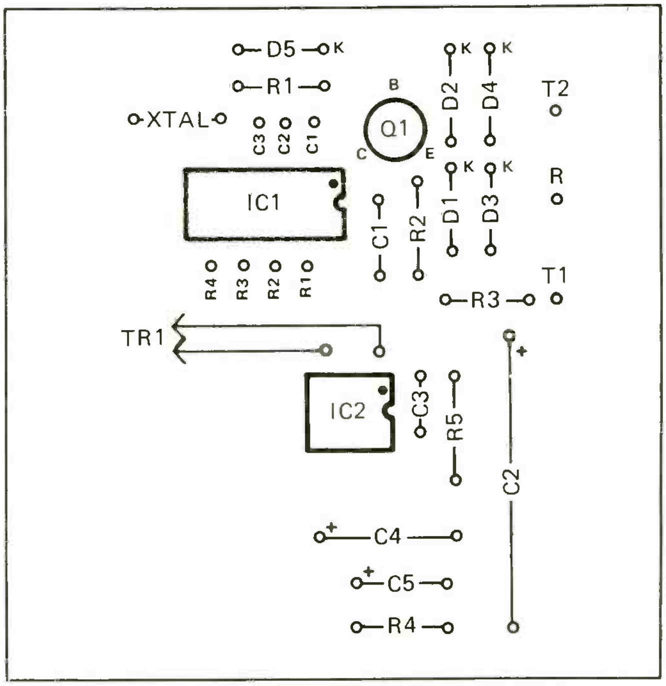


Fig. 3. *Use this diagram as a guide to component placement and orientation when wiring the pc board.*

signals that sound like an old-fashioned telephone bell whose clapper strikes two different-sounding bells.

Construction

This dialer/ringer is very simple in design from a component-count point of view. It can be assembled on a small printed-circuit board or on perforated board with appropriate soldering hardware. If you wish to fabricate your own pc board, you can use the actual-size etching-and-drilling guide shown in Fig. 2. Alternatively, you can purchase a pc board ready for component installation from the source given in the Parts List.

Shown in Fig. 3 is the components-placement-and-orientation diagram. Use this as an installation guide when wiring the pc board and as a guide to perf-board layout. Whichever wiring technique you elect, use sockets for the ICs. As you install each component—and before you solder its leads or pins to the pads on the board—double check each for value, part number and proper orientation. Wire the board exactly as shown, but do *not* install the ICs in their sockets just yet.

Note than *C2* must have at least a 250-volt rating to bear up to the up to 125 volts that can appear on the telephone line. You can use either a polarized electrolytic capacitor or an unpolarized paper or Mylar capacitor. If you use the former, be sure to install it in the polarity shown in Fig. 3.

The keypad is a common 7-wire matrix type that has 12 single-pole, normally-open switchers and no common wire. If your keypad has a common wire, ignore it. The keypad used in this project must short only one row wire to only one column wire for any

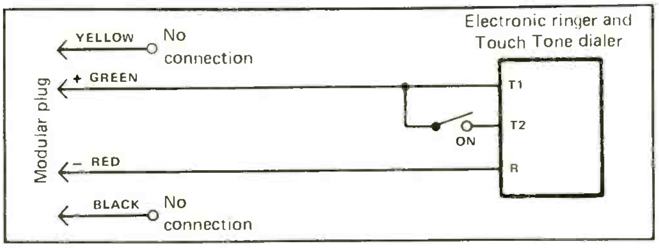
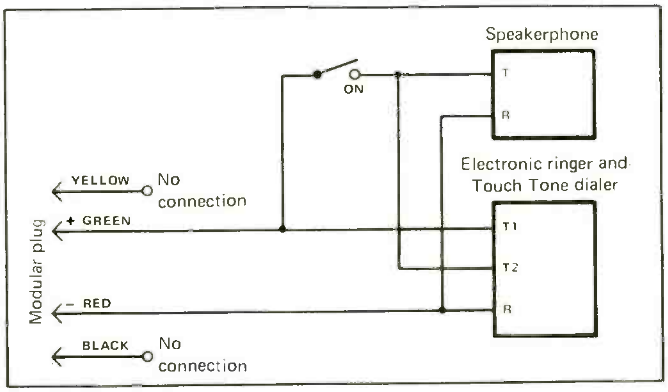


Fig. 4. *The wiring scheme for mating the dialer/ringer accessory to telephone line and Speakerphone project.*

Fig. 5. *The wiring scheme for using the dialer/ringer accessory with an existing telephone instrument.*



given button pressed. Use the keypad specified in the Parts List or salvage one from a low-cost telephone.

If you plan to use the dialer/ringer accessory with the Speakerphone, refer to Fig. 4 to wire it to the existing modular plug and Speakerphone circuit. However, if the accessory is to be used as a separate unit, use the wiring scheme shown in Fig. 5. Note that in Figs. 4 and 5 the electronic ringer circuit is connected across the telephone line at all times and that the Touch Tone dialer is switched on, via the spst POWER switch shown, only when the telephone line is in use.

Be sure to use a modular plug to make the connection to the telephone line. Such a plug makes it easy to connect the dialer/ringer to and disconnect it from the telephone line and is actually an FCC requirement for any telephone accessory. When used with the Speakerphone, the dialer/ringer requires only one modular plug.

You can install the dialer/ringer accessory in the Speakerphone's cabinet if there's room enought for it. A good alternative, and the approach you must use when using the accessory with an existing telephone instrument, is to house it in a small box of its own. If you do the latter, be sure to drill a number of holes in the box near where the *TR1* transducer is mounted to allows the sound to escape.

Checkout and Use

Before you install the ICs in their respective sockets, use a dc voltmeter to check out the dialer/ringer. First plug the project's modular plug into the telephone line and set the POWER switch to ON. (See Figs. 4 and 5 for the location of the POWER switch.) Measure the dc voltage between pins 1 and 6 of *IC1* (positive meter lead to pin 6). You should get a reading of 12 to 14 volts. Then measure the voltage between pins 2 and 3 of *IC2* (common or negative meter lead to pin 3). It should now be essentially zero.

Disconnect the meter leads from the circuit and the modular plug from the telephone line. If you obtain the proper meter readings, install the ICs in their respective sockets. Make sure when you do so that the ICs are properly oriented and that no pins bend under as you push them home.

With both ICs installed, reconnect the project to the telephone line and set the POWER switch to ON. Using a telephone instrument or the Speakerphone connected to the same line, listen to the Touch Tones as you dial a number with the accessory's keypad. When the party being called answers, have him or her call you back so that you can check out operation of the electronic ringer circuit. Note that the POWER switch must be set to OFF *and* you must hang up the telephone's handset to free your line for an incoming call when using the dialer/ringer accessory with the Speakerphone. **ME**

This is Your Computer Speaking

A plug-in board that lets your personal computer verbalize human-sounding speech

By Barry L. Ives

There's an easy way to get your computer to talk to you. All you need is a General Instruments SP0256-AL2 Allophone Processor, a handful of components and a bit of patience. The speech processor chip is available from a variety of sources, including Radio Shack. It's used here in a circuit that plugs into the Commodore 64's User Port to give you access to the 64 speech allophones required to synthesize any English word. Although the construction information in this article is for the C-64, this chip can also be used with most other personal computers.

The speech processor's audio output is fed back into the computer's audio/video port, filtered through the computer's SID sound device and amplified by the usual audio amplifier, TV receiver or monitor. Simple BASIC programming is sufficient for using the project, as only 10 to 12 bytes per second are needed to produce intelligible, if somewhat mechanical-sounding, words, phrases and sentences.

Unlike some other speech-synthesizer chips that convert English spelling directly into vocalized speech, the SP0256-AL2 generates speech sounds called "phonemes." Since some phonemes sound a little different in different words, several variations of these are included in the processor's internal ROM. For practical purposes, a series of allophones, or phoneme variations, is required to make a complete word or phrase. (The 64 allophones programmed into the SP0256-AL2 are listed in the Table.) If you wanted to have the computer vocalize the word "hello," for example, you would program it to link together the allophones HH, EH, LL, AX and OW.

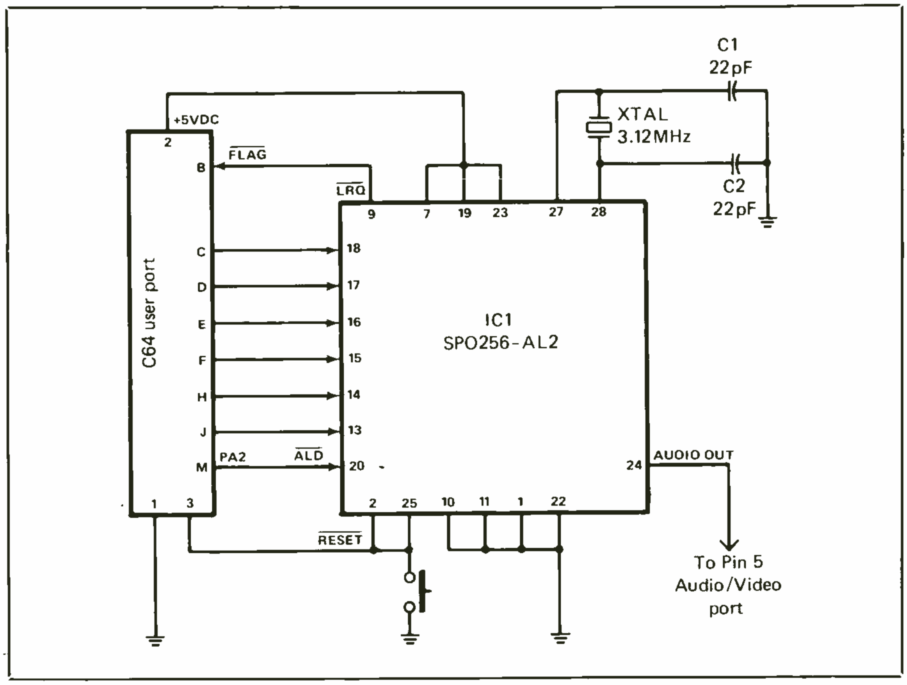


Fig. 1. Schematic diagram of the plug-in speech-processor module.

About the Circuit

As you can see from the schematic diagram shown in Fig. 1, in terms of component count, the circuit for the speech synthesizer is very simple. Though the actual circuitry required for synthesizing speech is very complex, it's all contained within the *IC1*

PARTS LIST

C1,C2—22-pF mica or disc capacitor
IC1—SP0256-AL2 speech synthesizer processor (General Instruments; Radio Shack Cat. No. 276-1784)
P1—12/24-pin edge connector
P2—5-pin DIN plug (Radio Shack Cat. No. 274-003)
S1—Spst normally-open pushbutton switch (optional; see text)
XTAL—3.12-MHz crystal
Misc.—Plug-in board (Radio Shack Cat. No. 276-154); 12/24-pin pc board edge connector; 5-pin DIN plug (Radio Shack Cat. No. 274-003); hookup wire; solder; etc.

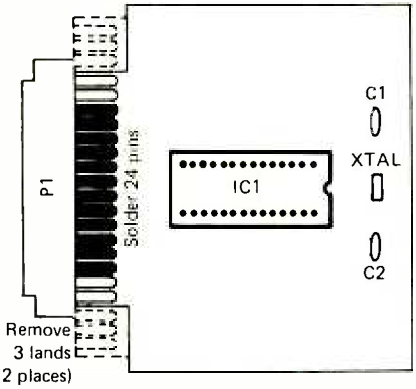


Fig. 2. Assembly details the of speech-processor board with the User Port connector.

processor chip. To complete the circuit, only three external components are needed: capacitors *C1* and *C2* and crystal *XTAL*.

In Fig. 1 is also shown an optional RESET switch *(S1)* in the circuit. Incorporating *S1* into the circuit provides a convenient means for resetting the computer and speech processor without having to turn off the computer.

Power for the circuit comes from the computer itself, via pin 2 of the User Port.

Construction

Because the project contains so few components, construction is simple and straightforward. No printed-circuit board is required, nor is there much in the way of soldering. Also, you don't even have to machine a case in which to house the circuitry.

Use of a 22/44-finger printed-circuit prototyping board greatly simplifies construction. With a hacksaw, modify the board by cutting away the three fingers (lands) at both ends, as shown in Fig. 2. Then solder the 24 pins of the 12/24-pin edge connector to the remaining center fingers on the top and bottom of the board. Make sure that the lettered pins on the connector are on the bottom (copper side) of the board, the numbered pins on the top (blank side) of the board.

Plug the IC socket into the board as shown and solder all pins into place. (Don't install the processor chip until all wiring has been completed.) Make sure the socket is oriented as shown before soldering its pins to the copper pads on the board. Plug in and solder the two capacitors and crystal.

Referring back to Fig. 1, wire together the components. Use 18-gauge or smaller wire for all interconnections. When this is done, install the processor chip into its socket. Don't let any pins bend under or overhang the socket as the IC is pushed home.

Audio output at pin 24 of *IC1* connects to pin 5 of the C-64's audio/video port. If this port is already being used for your video monitor, you may have to make a new cable, because the cables supplied with most monitors don't include the audio input.

Note in Fig. 3 that the pins of the DIN plug that goes to the C-64's audio/video port follow an unusual pattern. When fabricating a cable for this port, use shielded wiring for all conductors to your monitor or audio amplifier. You can use the coaxial cable with phono jacks that came with your computer for this. Simply cut the cable in half and use separate halves for the luminance and chrominance signals. A single 8″ length of stranded hookup wire from pin 24 of *IC1* and pin 5 and a shielded audio cable with a phono plug takes care of the audio connection.

```
10 REM TALKING KEYBOARD
20 REM COPYRIGHT 1985 BY BARRY L. IVES
30 PRINT CHR$(147)CHR$(17)TAB (12)"WAIT A MOMENT"CHR$(17)
40 DIMAL(60,60):W=1:N=1:S=0:REM DATA
50 READD:IF D=77 THEN 75
60 AL(W,N)=D:N=N+1:IF D=99 THEN W=W+1:N=1
70 S=S+D:GOTO 50
75 IF S<>824 THEN PRINT CHR$(17)TAB(12)"ERROR IN DATA":END
80 PA=56576:SI=54272:REM INITIALIZE
90 POKE PA+3,255:POKE PA+1,0:POKE PA+2,4
100 POKE PA,4:POKE PA,0:POKE PA,4:REM PULSE
110 POKE SI+22,180:POKE SI+24,31:POKE SI+23,8:REM SID INITIALIZE
120 PRINT TAB(9)"PRESS ANY LETTER KEY"CHR$(17):POKE 198,0
130 GET A$:IF A$=""THEN 130
135 PRINT A$
140 W=ASC(A$)-43:N=1:IF W<10 OR W>47 THEN 130
150 IF AL(W,N)=99 THEN 130: REM END OF WORD
160 POKE PA+1,AL(W,N):REM ALLOPHONE BYTE
170 WAIT PA+13,16:REM WAIT FOR REQUEST
180 POKE PA,0:POKE PA,4:REM LOAD
190 N=N+1:GOTO 150:REM NEXT ALLOPHONE
191 DATA 42,24,24,16,15,2,99,99,9,60,19,12,21,2,99,99,43,60,53,2,
    99,46,15,15,11
192 DATA 99,13,31,2,99,29,51,00,19,2,99,40,40,58,2,99,40,40,6,35,
    2,99,55,55,12
193 DATA 12,2,41,55,2,99,55,55,7,7,35,12,11,2,99,20,2,13,2,99,11,
    6,11,2,99
194 DATA 8,53,45,15,11,2,99,55,55,7,16,6,1,8,53,45,15,11,2,99,99,
    99,99,99,99
200 DATA 20,2,99,63,19,2,99,55,55,19,2,99,33,19,2,99,19,2,99,7,7,
    40,40,2,99
210 DATA 10,19,2,99,20,1,2,50,2,99,24,6,2,99,10,7,20,2,99,42,7,20,
    2,99
220 DATA 7,7,62,2,99,7,7,16,2,99,7,7,11,2,99,53,2,99,9,19,2,99,42,
    25,31,2,99
230 DATA 59,2,99,7,7,55,55,2,99,13,19,2,99,25,31,2,99,35,19,2,99,
    33,15,1,63,49
240 DATA 31,2,99,7,7,2,41,55,55,2,99,46,6,2,99,43,19,2,99,77
```

Using the Vocalizer

In operation, eight bits are loaded into a latch when the ALD (Address LoaD) line goes low. The lower six bits specify a location in *IC1*'s internal ROM that contains the desired allophone. After the allophone is vocalized, the LRQ (Load ReQuest) line goes low to signal the computer to load another byte. The two most-significant bits must be zero; any other condition will cause a crash, resulting in the computer putting out static and then going into lock-up.

You must initialize the computer to use the speech processor. To do this, POKE Data Direction Register (DDR) 56579 with the value 255 to in-

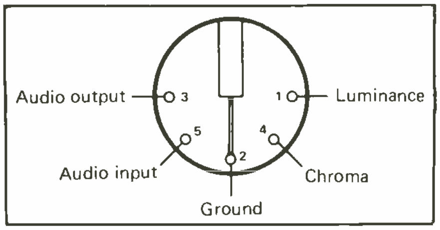


Fig. 3. Pin identifications for 5-pin DIN plug, shown from rear.

dicate on Port B. Then POKE 0 to Port B (56577) to load an initial pause. POKE 56578, 4 initializes the DDR for PA2, the Port A signal line used for ALD, for output. Pulse PA2 by POKEing Port A (56576) with 4, then 0 and then 4 again. This causes the pause allophone to be "spoken" and, when it is finished, to set the interrupt flag (bit 4 of control register 56589).

You must also initialize the C-64's SID sound device to amplify the verbalized audio and to filter out undesirable high-frequency noise generated by the processor chip. POKEing 180 into byte 54294 sets the filter frequency to the 5 kHz specified by the manufacturer. However, I have discovered that a value of 150 to 200 yields clearer-sounding speech. POKE 31 into register 54296 to turn on the low-pass filter and audio amplifier. Set bit 3 of register 54295 with a POKE of 8 to allow the external audio to pass through the filter.

By doing the above, the speech processor is put on-line. Now to make it talk. To do this, POKE Port B (56577) with the decimal value of the first allophone to be spoken (see Table). Then check the interrupt flag at 56589. PEEKing this location will return a 16 if the flag is set, indicating that the processor is ready to load. Reading this register automatically resets the flag to 0.

Pulse ALD by POKEing PA2 (56576) to 0 then back to 4 in two quick steps. The selected allophone will be vocalized and the flag will be set to 1. Load the next allophone by POKEing Port B and waiting for the LRQ before pulsing the ALD, and so on to the last allophone in the series, which should always be a pause to prevent the chip from repeating the last allophone.

The BASIC program shows the initialization procedure and one way in which a series of allophone values can be passed to the speech processor. When this program is RUN, pressing most keys causes the computer to vocalize their letters, numbers or punctuation as well as print them on the screen of the video monitor. This can be very useful for typing practice, since it makes it so that you don't have to look up to see if you've made a typographical error.

More information on allophone usage is included in the data sheet that comes with the speech processor chip. The data sheet also contains information that will help you adapt this project's circuit to a computer other than the Commodore 64.

THE 64 ALLOPHONES AND THEIR ADDRESSES

Value	Allophone	Example	Value	Allophone	Example
00	PA1	(Pause, 10ms)	32	AW	Out
01	PA2	(Pause, 30ms)	33	DD2	Do
02	PA3	(Pause, 50ms)	34	GG3	Wig
03	PA4	(Pause, 100ms)	35	VV	Vest
04	PA5	(Pause, 200ms)	36	GG1	Got
05	OY	Boy	37	SH	Ship
06	AY	Sky	38	ZH	Azure
07	EH	End	39	RR2	Brain
08	KK3	Comb	40	FF	Food
09	PP	Pow	41	KK2	Sky
10	JH	Dodge	42	KK1	Can't
11	NN1	Thin	43	ZZ	Zoo
12	IH	Sit	44	NG	Anchor
13	TT2	To	45	LL	Lake
14	RR1	Rural	46	WW	Wool
15	AX	Succeed	47	XR	Repair
16	MM	Milk	48	WH	Whig
17	TT1	Part	49	YY1	Yes
18	DH1	They	50	CH	Church
19	IY	See	51	ER1	Fir
20	EY	Beige	52	ER2	Fir
21	DD1	Could	53	OW	Beau
22	UW1	To	54	DH2	They
23	AO	Aught	55	SS	Vest
24	AA	Hot	56	NN2	No
25	YY2	Yes	57	HH2	Hoe
26	AE	Hat	58	OR	Store
27	HH1	He	59	AR	Alarm
28	BB1	Business	60	YR	Clear
29	TH	Thin	61	GG2	Guest
30	UH	Book	62	EL	Saddle
31	UW2	Food	63	BB2	Business

Applications

There are perhaps hundreds of uses for the vocal synthesizer. For example, an arcade style game could be made faster-paced by having the computer vocalize the score and other information printed on the screen so that your eyes don't have to leave the object of the game. Educational games are much more fun with vocal feedback. Also, don't overlook the value of vocal feedback for the visually impaired. Other applications include audible clocks, appointment reminders, typing monitors, Morse code readers, and so on. ME

Understanding Feedback

By Forrest M. Mims III

Among those principles that form the underpinnings of modern technology, few share as vital a role as that of feedback. Feedback is simple enough; it occurs when a portion of the output from a system is fed back to the system's input to modify the operation of the system. Yet the capabilities made possible by this simple arrangement are often quite astounding. Indeed, life as we know it would be impossible without feedback.

A Simple Feedback System

Figure 1 illustrates two methods of controlling an electric heater. In the first, the heater is switched on and off by a manually-operated power switch. In the second, the manually-operated on-off switch has been replaced by a thermal switch or thermostat. The contacts of this switch are bridged by a bimetal strip that bends away from one or both contacts when it is heated. The thermal switch is installed so it is heated by the heater. When the switch is warmed to its tripping point, the heater is automatically switched off. When the switch cools, the heater is switched on and the cycle is repeated. The net result is that the heater's on-off cycles maintain the temperature of the surrounding area at a reasonably constant level.

The first method of controlling the heater forms an open-cycle or open-loop control system, since there is no feedback from the heater back to the switch. The heater controlled by the thermal switch is a closed-cycle or closed-loop system. Feedback from the system's output (heat) is fed back to the switch that controls the system's input (electrical power).

The electromechanical feedback control system for an electric heater is representative of many kinds of simple feedback control systems. Another common example is the system that regulates the temperature of a refrigerator or freezer. Some feedback systems are entirely mechanical in operation. Common examples include motor speed-control governors and float-value mechanisms that maintain the liquid in a tank at a constant level.

Electronic Feedback

Feedback plays a key role in many kinds of analog and digital electronic circuits, particularly amplifiers. The capabilities it provides can be much more sophisticated than the simple electromechanical and mechanical systems described above.

There are two principal kinds of feedback, one of which is considerably more difficult to control than the other. An example of the former is the surprising and sometimes startling effects that can occur when part of the output signal from an amplifier is unintentionally fed back into the input of the same amplifier. A real-world case is the ear-piercing howling and shrieking that results when some of the amplified sound emerging from the speaker of a public address system finds its way back to the system's microphone. Even the quiet hissing noise emerging from a speaker when the microphone is not being used is sufficient to effect this result when the gain of the amplifier has been turned up too high or the microphone has been placed close to the speaker.

The screeching of PA system occurs when the feedback signal has the same phase as the input signal. This is called *positive feedback*. Positive feedback increases the gain of an amplifier at the risk of instability that can quickly give rise to undesirable oscillation. When the output signal has a phase opposite that of the input signal, *negative feedback* occurs. Though negative feedback reduces the maximum possible gain of an amplifier, it stabilizes the operation of the amplifier, reduces noise, and lowers the amplifier's

Fig. 1. Open- and closed-cycle control methods.

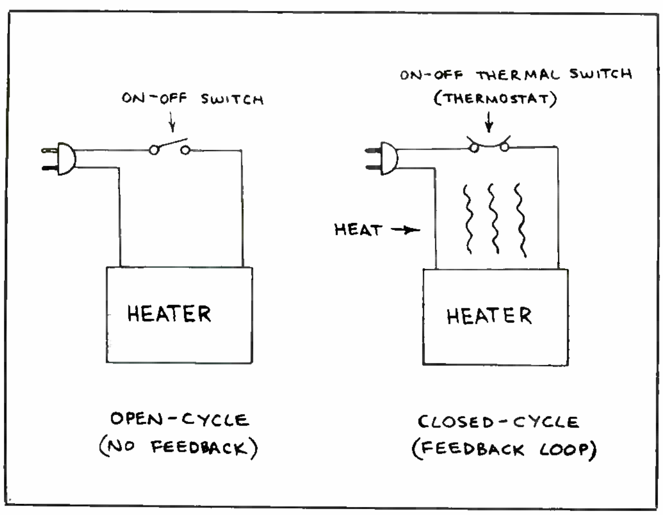
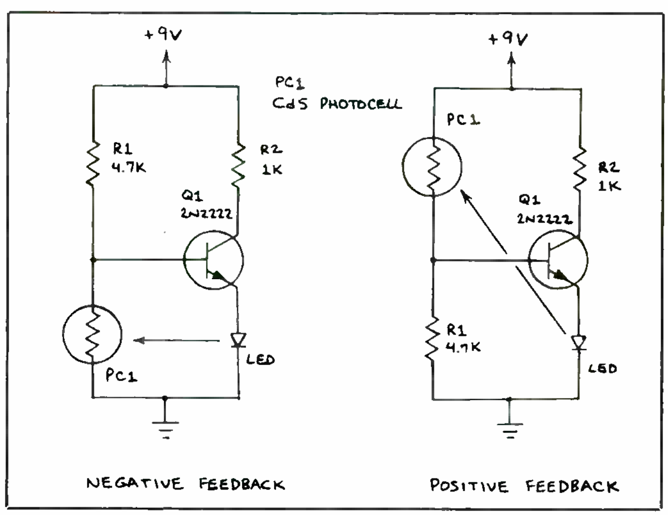


Fig. 2. Electro-optical feedback demonstration circuits.



output impedance. Negative feedback is the variety used most frequently in electronic circuits.

Feedback Pioneers

Since feedback plays such a key role in modern electronics, it seems fitting to mention some of the people who made pioneering contributions to the technology. The positive-feedback or regenerative amplifier was invented in 1912 by Edwin Armstrong, the brilliant inventor who later pioneered FM radio. Shortly before Christmas the following year, Armstrong demonstrated for David Sarnoff a regenerative wireless receiver having unprecedented sensitivity. Sarnoff, who later became president of RCA, proclaimed the new receiver "the most remarkable receiving system in existence." Within ten years, Armstrong had licensed 24 manufacturers to build regenerative receivers, and his royalty income was around $10,000 each month.

Not everyone shared Armstrong's claim of priority for the invention of the regenerative amplifier. Lee DeForest, the eminent inventor of the vacuum tube, claimed he had invented the concept before Armstrong and took the latter to court. The ensuing litigation became bitter, lasted years, and cost both inventors considerable time and expense.

There is also controversy over who first invented negative feedback. According to the public relations division of Bell Laboratories, in 1927 Harold S. Black first invented the negative feedback amplifier, cited as "one of the most important inventions in the history of communications." (*Facts About Bell Laboratories,* 1980, p. 23.) Black, a brilliant engineer who received 62 U.S. patents during his 42 years at Bell Labs, was named to the Inventors Hall of Fame for his invention.

Actually, negative-feedback amplifiers had been built long before Black's invention. According to Macon Fry, who wrote about his controversy for IEEE Spectrum (April 1979, p. 11), "Even if we restrict the term negative-feedback amplifier to its application in electronic amplifiers, we find it considerably older than Black's putative date." He then quoted from a 1920 book by H.J. Van Der Bijl: "Multistage amplifiers frequently have a tendency to sing. One way of preventing this is to feed part of the output energy back to the input in opposite phase." (*The Thermionic Vacuum Tube,* McGraw-Hill, 1920, p. 260.) Macon also observed that "L.A. Hazeltine and C.D. Tuska both patented negative-feedback circuits for stabilizing radio-frequency amplifiers; the former's was capacitative and the latter's inductive. Hazeltine's invention was conceived in 1918 and Tuska's around the same time."

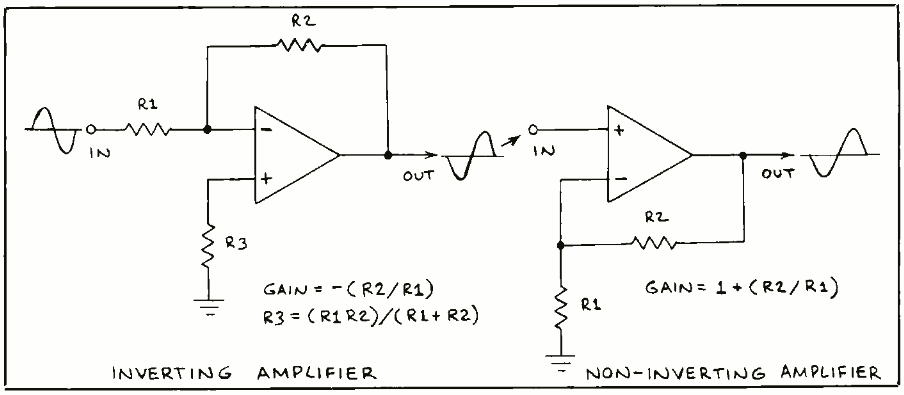


Fig. 3. Negative-feedback operational-amplifier circuits.

A Feedback Demonstrator

The simple circuits in Fig. 2 can provide an effective demonstration of both positive and negative feedback. In both circuits, feedback is effected by placing an output LED near the active surface of a photoresistor that controls the circuit. The feedback mechanism is then the light emitted by the LED.

In the negative-feedback configuration, the photoresistor is connected between the base of *Q1* and ground. Assume the photoresistor is initially dark. Its resistance is, therefore, high and *Q1* is switched on. This allows current to flow through the LED. Light from the LED, however, now strikes the photoresistor, thereby lowering its resistance. This causes the current flow through the transistor to be reduced and the light from the LED to be dimmed. Since *Q1* is operated in a linear mode, it does not switch the LED fully off (in which case the circuit would oscillate and the LED would blink on and off). Instead, the current through the LED is reduced to that point where the current is balanced by the light from the LED. In other words, the circuit functions as a regulator that causes the LED to emit a constant level of light. The light level from the LED can be reduced by moving the LED closer to the photoresistor. It can be increased by moving the LED away from the photoresistor.

In the positive-feedback configuration, the photoresistor is connected between the base of *Q1* and the supply voltage. When the photoresistor is dark, its resistance is high, *Q1* is switched off, and the LED is dark. If a small amount of light is allowed to strike the photoresistor for a moment, *Q1* will begin to turn on, allowing current to flow through the LED. The light level from the LED will increase as the light at the photoresistor is increased. If some of the light from the LED is allowed to strike the photoresistor, more current will flow through the transistor, and the LED will begin to glow much more brightly. Almost immediately, the transistor will be switched full on and the LED will glow at maximum brilliance. The LED can be switched off by preventing its light from striking the photoresistor.

The Operational Amplifier

The operational amplifier is a very-high-gain linear amplifier. It is a differential amplifier having two inputs, inverting and

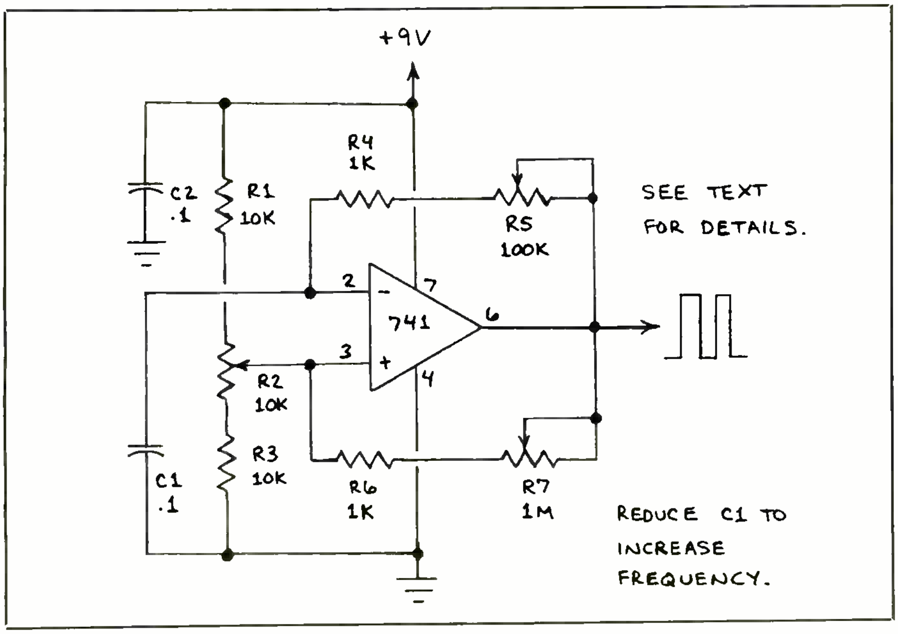


Fig. 4. Positive-feedback op-amp square-wave generator.

noninverting. The polarity or phase of a signal applied to the inverting input is reversed at the output. A signal applied to the noninverting input retains its phase.

The gain of an op amp may be as high as 1,000,000,000, but the output from the amplifier cannot exceed the supply voltage. This means that the output of this op amp, when powered by a 10-volt supply, will be saturated by a signal having an amplitude of only 0.00000001 volt. Since most input signals exceed this amplitude, it is usually necessary to reduce the gain of an op amp to a more practical level. This is ordinarily done by feeding some of the output of the amplifier back to the inverting input. This provides negative feedback that controls the gain and enhances the performance of the amplifier.

Figure 3 shows how negative feedback is used to form both inverting and noninverting op amp circuits. Note how the gain of these amplifiers can be easily changed simply by altering the value of a single resistor. This, of course, is one reason why op amps are so popular.

An op amp can also be operated in a positive-feedback mode. This is the configuration most often used to produce various kinds of oscillators. For stability, negative feedback must also be used. Figure 4 shows a simple op-amp square-wave generator that employs both positive and negative feedback. The frequency of this circuit can be altered by changing the value of *C1*. Increasing *C1*'s value reduces the frequency. Resistors *R5* and *R7* also control the frequency. The duration ("width") of the output pulses is controlled by *R1-R2-R3*. When *R2* is at its center position, the pulses are symmetrical. For more information about this circuit, see *Engineer's Mini-Notebook* (Forrest M. Mims, III, Radio Shack, p. 46).

The Phase-Locked Loop

The most elegant of purely electronic feedback circuits is the phase-locked loop. This remarkable circuit automatically tracks and locks onto a signal, even one whose frequency continually varies. This capability permits the design of highly stable and reliable frequency synthesizers, frequency-modulated communication systems, FSK (frequency-shift-keying) decoders, tone decoders, and frequency-to-voltage converters.

In its simplest form, the phase-locked loop (PLL) consists of a phase comparator, voltage-controlled oscillator (vco), and loop filter arranged as shown in Fig. 5. The vco initially oscillates at a frequency determined by its own RC network. This frequency is applied to one of the two inputs of the phase comparator. An input signal is applied to the second phase comparator input. If the frequencies of the input and vco signals differ, the phase comparator generates an error voltage whose amplitude is directly proportional to the difference.

The loop filter is a low-pass device that smooths the pulsating error voltage to a dc level that is applied to the control input of the vco. This forms the system's feedback loop. The vco responds by adjusting its frequency of oscillation toward that of the input signal. This capture process continues until the vco's frequency matches that of the input. The PLL is then said to be "locked" onto the input signal. When the PLL is locked onto a signal, it automatically tracks any changes in the frequency of the signal, so long as the frequency doesn't stray outside the PLL's capture range (the frequency range over which the PLL can hunt for and "capture" an incoming signal).

Figure 6 shows how a digital divider can be inserted in the feedback loop of a PLL to form a programmable frequency synthesizer much like those used in multichannel citizen's band transceivers. This arrangement will generate an output signal having a frequency that is a preset multiple of the input signal.

Figure 7 shows a tested and working version of the synthesizer in Fig. 6. This circuit is designed around the 4046, a CMOS digital phase-locked loop. In operation, a single NAND gate from a 4011 operates as a 1-kHz crystal-controlled oscillator. The output from the oscillator is fed into the input of the 4046. A 4017 decade counter is connected between the vco and phase comparator of the 4046. The 4017 functions as a programmable divide-by-*n* divider where *n* is 2 to 9.

An eight-position switch permits one of the 4017 counter's outputs to be applied to the chip's reset input. When the selected count is reached, the counter is reset and a new count cycle begins. In a working version of this circuit, all unused CMOS inputs must be grounded.

Servomechanisms

A servomechanism is a mechanical feedback system with an input signal. Any difference or error between the two signals activates a control mechanism that brings the system back into balance. Though servomechanisms are generally viewed as recent inventions, their origin is soundly rooted in living systems. For example, the automatic tracking system formed by the human eye, the brain and various control muscles is the biological counterpart of a servomechanism.

Consider the ability of the human eye to track a bird in rapid flight. The image of the bird focused on the retina gives rise to signals that, when processed by the optic nerve and the brain, permit an observer to perceive the image of the bird. After processing, some of the signal is fed back to the muscles that surround the eye. Now the signal assumes a control function as it directs the muscles to cause the eye to center the image of the bird directly on the fovea, the most sensitive region of the retina. Moreover, simultaneous with the previous action, feedback from the brain constantly corrects the focus of the eye and aperture setting of its iris. Should the bird move beyond a point where it can be comfortably acquired by movement of the eye muscles alone, control signals are diverted to the muscles of the neck so that the entire tracking system can be pointed in the appropriate direction.

As for electromechanical servomechanisms, they are found in computer disk drives, compact disk players, x-y pen plotters, radio-control actuators, aircraft control systems, missile guidance systems, and military gun controllers. Figure 8 shows the design of a simple servomechanism that automatically tracks the position of a manually-operated joystick. In this system, the input is a variable voltage provided by a variable-resistance joystick. The position-sensing transducer is a potentiometer whose rotor is connected to the shaft of the output motor by means of a gear train. Both pots function as voltage dividers that provide a variable voltage to the two inputs of the comparator.

When the voltages at both inputs of the comparator are equal, the output of the comparator is low and the motor is off. When the joystick is moved so the voltage applied to the noninverting input of the comparator exceeds the voltage from the position-sensing transducer, the comparator's output will go high, switching the motor on. The position-sensing transducer will now begin to feed a progressively higher voltage back to the comparator as the motor shaft turns. When the two voltages are again equal, or when the voltage from the position-sensing transducer is slightly higher than that from the joystick, the comparator will again go low, and the motor will switch off. Therefore, the position of the motor shaft has tracked the position of the joystick.

The basic servomechanism in Fig. 8 is not practical, since no mechanism for reversing the direction of the motor has been made. However, it illustrates the operation of most electromechanical servos. Incidentally, practical servos don't always operate as efficiently as might be expected from the foregoing description. For example, a practical servo has the capability of rotating in either of two directions until it reaches a desired null point, at which no error voltage is present. The inertia of the motor, however, might sometimes cause

Fig. 5. Block diagram of a phase-locked loop.

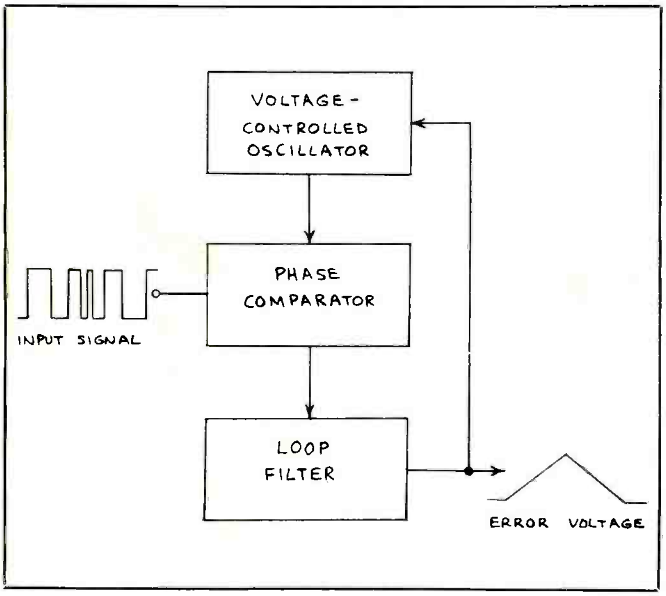
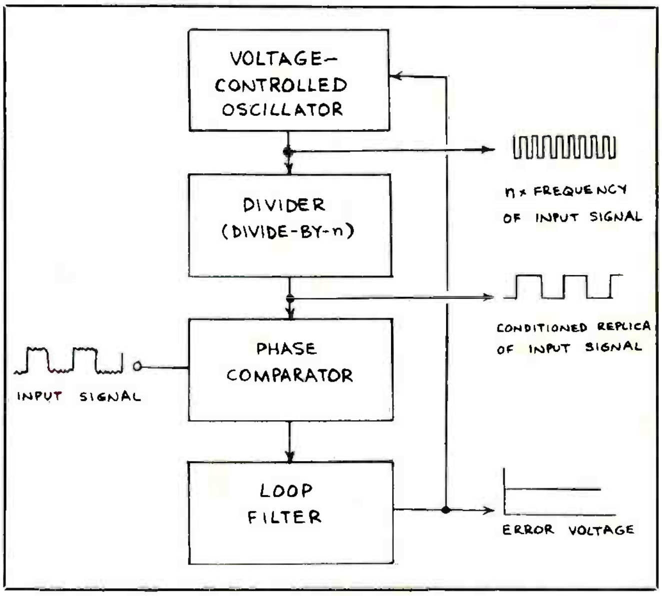


Fig. 6. Phase-locked loop with divider.



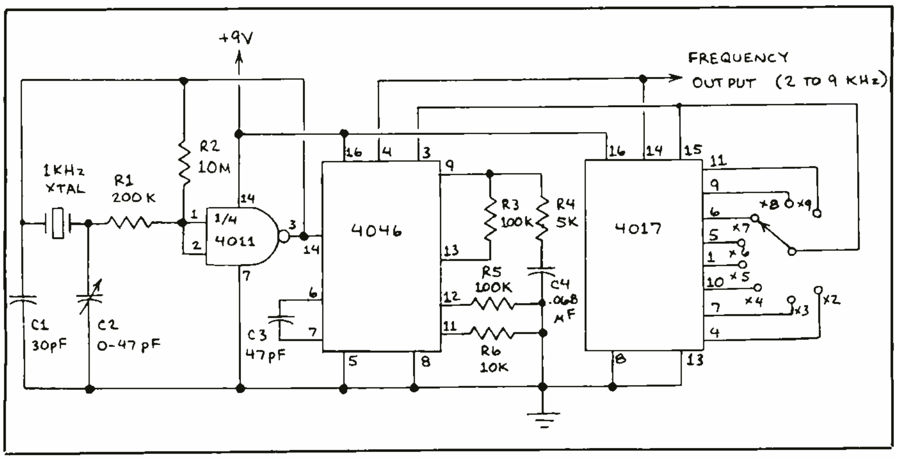


Fig. 7. Phase-locked-loop frequency synthesizer.

the armature to move past the null point after a stop command has been given. The motor will then be backed up to the null point, where it might again overshoot the target. This phenomenon is known as *hunting* or *seeking,* and it can cause a great deal of frustration to the servo designer and user.

In most systems the damping effect of the drive motor's gears will cause progressively less hunting each cycle, thus allowing the motor to eventually stop at the correct position. In very precise systems, however, the motor may never settle down and hunting may evolve into an annoying back-and-forth oscillation. One way to reduce the incidence of hunting is to reduce the precision of the servo by lowering the tolerance of the null region. This will provide more space for the motor to stop, thereby compensating for the system's inertia.

Modern servomechanisms usually incorporate integrated circuits designed specifically for servo applications. The Signetics NE543 servo amplifier, for instance, is designed to accept pulse-duration-modulated pulses. If the duration of the applied pulse exceeds that of an internally generated pulse, the difference between the two pulses is stretched and applied to an output stage. The output signal actuates a motor connected to a position-sensing transducer much like the one in Fig. 8. The resistance of the transducer alters the duration of the pulses generated within the NE543 until it matches that of the input pulses. The motor is then switched off.

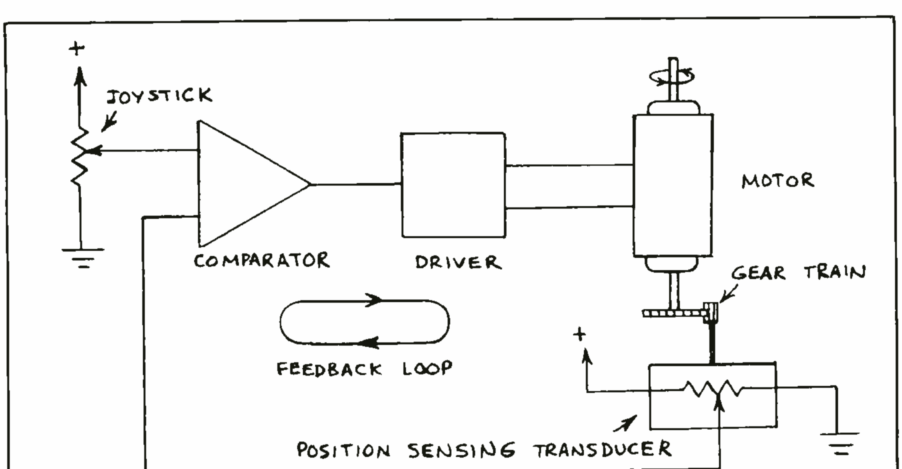
A very fast way to become acquainted with the capabilities of modern servomechanisms is to experiment with a servo designed for radio-control applications. You can buy servos from hobby shops that sell radio-control equipment. Servos are also available from mail-order dealers that advertise in model airplane magazines. One of the major suppliers of miniature servos is Ace R/C, Inc. (Box 511, Higginsville, MO 64037). In addition to a variety of assembled units, Ace R/C's catalog lists a great variety of servo components (motors, gears, pots. etc.) for do-it-yourselfers.

More About Radio Control

Radio control was, coincidentally, the subject of the February 1986 installment of this column. Recently Mr. A.K. Scidmore wrote to express his concern about the unauthorized use of the 72-to-76-MHz frequency band designated exclusively for radio-controlled aircraft. The column described in detail the modification and use of a commercial 26-to-27-MHz system designed and specifically authorized for remote control. I described that system even though it is far more susceptible to interference than those that operate in the less-crowded 72-to-76-MHz band.

However, my column did mention that I had used 72-to-76-MHz R/C equipment to trigger kite and balloon lofted cameras. I turned to 72-to-76-MHz after a rash of false triggering that made reliable 26-to-27-MHz operation impossible. Even though the very brief pulses that are used to trip and airborne camera pose little or no risk to R/C aircraft, Mr. Skidmore's point is well taken. I shall now undertake the design of a 26-to-27-MHz receiver decoder that will, hopefully, ignore virtually all forms of interference. I'll describe this system in a future column. **ME**

Fig. 8. Simple electromechanical servomechanism.



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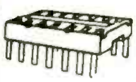

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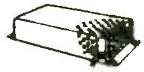

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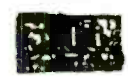

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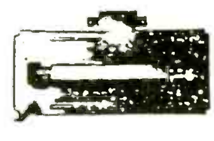

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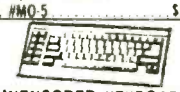

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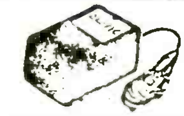

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CIRCLE NO. 138 ON FREE INFORMATION CARD

HARDWARE HACKER

New ideas in piezoelectricity and optics, the ASCII code, doing tech research

By Don Lancaster

Let's start out with several updates on previous topics. I have just found a very good resource for pressure-transducer information. Its called the *Pressure Transducer Handbook* and is published by *SenSym,* the people who took over the old *National Semiconductors* transducer line.

The handbook has lots of hacker-type ap-notes in it. Also included is a handy slide rule that does both pressure and temperature conversions for you. Both are free on a phone or letterhead request.

Turning to shaft encoders, check out the *Optical Encoder Design Guide* from *Motion Systems,* a short but helpful tutorial. *Hewlett-Packard* also has lots of new shaft-encoder products at (for them) extremely reasonable prices. Ready to go encoders are available for $24.

They also have an even cheaper HEDS-7000 panel-mount digital potentiometer that produces 256 pulses per revolution. Unlike an ordinary pot, this one goes round and round continuously. H-P intends this jewel for hand operation and strongly recommends that you do *not* motor drive it. But it should be useful for "limited-motion" encoders such as you might need on a hacker's robotics arm. Cost is as little as $12.

Finally, H-P also has a new integrated circuit that does all the conditioning and encoding of absolute shaft encoders. Contact the company directly for more details.

Don't forget that I have some free shaft-encoder software for you, along with some other freebies that include a laser printing demo pack, an RS-232C handout, and copies of this month's ASCII code tables. I've also just freshly reprinted my *Micro Cookbook,* Volume I, so this once hard-to-get volume is now back in stock.

What is new in piezoelectricity?

Piezoelectricity is the property of certain substances that produce a voltage when they are stressed and, conversely, to stretch when they have voltage applied to them. Two very old examples of piezoelectric components are the quartz crystals used for frequency standards and the Rochelle salt crystals used long ago for phonograph cartridges and microphones.

A few years back, new piezoelectric materials came along involving man-made crystals called PZT and PZBT. These are used in such things as gas pilot ignitors and sonar transducers.

One useful resource on all this is the *Piezo Technology: Data for Designers,* 40-page manual available from *Vernitron.*

But, there's now a brand new piezoelectric ball game. A magic thin-film plastic is now available from *Penwalt* called Kynar PiezoFilm. Many new applications can now be found for this new piezoelectric film.

For instance, you can now build piezoelectric fans that have no moving parts except for their vibrating plastic blades. These can be made small enough to deliver the cooling air exactly where it is needed, reliably and quietly.

The piezo film apparently is not as sensitive as older piezoelectric materials, but its form factor more than makes up for this. The film is also pyroelectric, which means it can also be used for such things as infrared receivers and detectors. One possible application would be a low cost "hot-spot" detector for firemen looking inside walls on a post-fire overhaul.

You can get a tiny free sample by a letterhead request to Penwalt. They also have a $45 evaluation kit that includes full technical data, connectors, and samples of the various film types.

Let us know what you can come up with on this, for there are literally hundreds of possible construction projects that could be worked up with this material.

What is ASCII?

ASCII is short for American Standard Code for Information Interchange. It is *the* standard way that text messages are handled by virtually all personal computers and their peripherals.

Microcomputers speak ASCII. Printers speak ASCII. Modems speak ASCII. Disks store ASCII in their text files. An understanding of what ASCII is and how it is put to use is essential for just about anyone doing anything at all with a microcomputer.

The ASCII code was originally a 7-bit code, meaning that it could represent 128 different symbols associated with the gathering and printing of text. Because most of today's micros handle text in 8-bit bytes, there are really *two* different ASCII codes in use today.

These are called the "ASCII Code" and the "High ASCII Code." The only difference between the two is whether the eighth, or most significant bit (MSB) is a logic 0 or a 1.

Since only the bottom seven bits are needed for ASCII symbols, the use of high

	$-0	$-1	$-2	$-3	$-4	$-5	$-6	$-7	$-8	$-9	$-A	$-B	$-C	$-D	$-E	$-F
$0-	[@] NUL 0	[A] SOH 1	[B] STX 2	[C] ETX 3	[D] EOT 4	[E] ENQ 5	[F] ACK 6	[G] BEL 7	[H] BS 8	[I] HT 9	[J] LF 10	[K] VT 11	[L] FF 12	[M] CR 13	[N] SO 14	[O] SI 15
$1-	[P] DLE 16	[Q] DC1 17	[R] DC2 18	[S] DC3 19	[T] DC4 20	[U] NAK 21	[V] SYN 22	[W] ETB 23	[X] CAN 24	[Y] EM 25	[Z] SUB 26	[[] ESC 27	[\] FS 28	[]] GS 29	[^] RS 30	[_] US 31
$2-	SPC 32	! 33	" 34	# 354	$ 36	% 37	& 38	' 39	(40	) 41	* 42	+ 43	, 44	- 45	. 46	/ 47
$3-	0 48	1 49	2 50	3 51	4 52	5 53	6 54	7 55	8 56	9 57	: 58	; 59	< 60	= 61	> 62	? 63
$4-	@ 64	A 65	B 66	C 67	D 68	E 69	F 70	G 71	H 72	I 73	J 74	K 75	L 76	M 77	N 78	O 79
$5-	P 80	Q 81	R 82	S 83	T 84	U 85	V 86	W 87	X 88	Y 89	Z 90	[91	\ 92	] 93	^ 94	_ 95
$6-	` 96	a 97	b 98	c 99	d 100	e 101	f 102	g 103	h 104	i 105	j 106	k 107	l 108	m 109	n 110	o 111
$7-	p 112	q 113	r 114	s 115	t 116	u 117	v 118	w 119	x 120	y 121	z 122	{ 123	| 124	} 125	~ 126	DEL 127

Table 1. Low ASCII character code ranges from hexadecimal $00 to $7F or decimal 0 to 127.

ASCII or low ASCII depends on the system and the system designer. For instance, low ASCII might be used for normal text, and high ASCII might be used for inverse text on a video screen. Or low ASCII might be used for a "normal" font, while high ASCII might be used for a "bold" font by a printer. Or, you might mix low ASCII text characters with parsed commands, all of which have their MSB set to 1. This is done in BASIC and similar languages.

Some machine-language programs may use low ASCII for all but the last character of a text string. The last character is coded in high ASCII. This is a "free" way to tell when one message ends and the next message begins.

As specific examples, the Apple II+ and IIe screen uses high ASCII for normal text, as does the older DOS 3.3e operating system. The newer ProDos operating system uses low ASCII, as do most modems and most text routines on most other personal computers.

Table 1 shows the low ASCII code, while Table 2 shows the high ASCII code. I have purposely separated these two, since it is much easier to use one or the other separately when "tearing apart" a computer program.

As you can see, there are 128 different symbols available in low or high ASCII. There are 32 values for upper-case letters and certain punctuation; 32 values for lower-case letters and some more obscure punctuation; 32 values for numbers and common punctuation; and, finally, 32 values used for control commands.

A control command is something that never appears in print, but instead causes something to happen at some end of the communicating process. As examples, the BEL command may ring a bell or sound a tone, while the CR command may issue a carriage return, and so on down the list.

Many control commands are standardized and are always used for their intended purpose. Others are rather specialized and can be "liberated" for your custom uses or special applications.

There are several ways to read these tables. The ASCII character is the big center character in each box. The small number immediately below each ASCII character is the *decimal* value of that ASCII character. Decimal values are often used in BASIC and other high-level programming languages, sometimes as a CHR$() command.

Ferinstance, a CHR$(107) represents a lower-case "k" in low ASCII. The same symbol in high ASCII would be a CHR$(235). Note that you can alway get between high and low ASCII in decimal by adding or subtracting 128, the value of the MSB in the 8-bit word.

The table row in which an ASCII character appears gives you the leftmost, or more significant, hex byte for that ASCII character, while the column gives you the rightmost, or less significant hex byte of the code.

Ferinstance, a hexadecimal $47 is an upper-case "G" in low ASCII. The same "G" in high ASCII would be a hexadecimal $C7. Note that you can always get between high and low ASCII in hex by adding or subtracting $80, once again the value of the MSB in the 8-bit word.

The bracketed letter above the ASCII control characters in these tables shows how you would enter such a control character from the Apple keyboard. Thus, to issue an FF formfeed, use a [L] from the keyboard. This [L] means to enter a "control-L", or Press down and hold the CONTROL key. Then press and release the L key. Finally, release CONTROL.

How do you handle things that are *not* in the ASCII code? The official way to do this is with escape sequences. An escape sequence consists of an escape control command, followed by enough characters to convey the task to be done in whatever needed the escaping in the first place. For instance, the Diablo 630 daisywheel printer uses an "[esc]-M" to enter its full fill justification mode.

Another way to handle ASCII exceptions is to put the main code in low ASCII and the exceptions in high ASCII. For instance, a full typesetting font might need a trademark symbol, or a letter with those european dots on top of it that might be coded in high ASCII. Then some convention is used to switch you between the two.

In the Postscript language used in the Laserwriter, a reverse slash, followed by a three-digit octal number will print any of 256 different characters or control commands, but does so only while receiving ordinary printable low ASCII characters.

More information on tearing apart ASCII text files appears in my book *Enhancing your Apple II and IIe,* Volume I (SAMS #21822).

You might like to copy Tables 1 and 2, place them back to back, and laminate them in plastic.

	$-0	$-1	$-2	$-3	$-4	$-5	$-6	$-7	$-8	$-9	$-A	$-B	$-C	$-D	$-E	$-F
$8-	[@] NUL 128	[A] SOH 129	[B] STX 130	[C] ETX 131	[D] EOT 132	[E] ENQ 133	[F] ACK 134	[G] BEL 135	[H] BS 136	[I] HT 137	[J] LF 138	[K] VT 139	[L] FF 140	[M] CR 141	[N] SO 142	[O] SI 143
$9-	[P] DLE 144	[Q] DC1 145	[R] DC2 146	[S] DC3 147	[T] DC4 148	[U] NAK 149	[V] SYN 150	[W] ETB 151	[X] CAN 152	[Y] EM 153	[Z] SUB 154	[[] ESC 155	[\] FS 156	[]] GS 157	[^] RS 158	[_] US 159
$A-	SPC 160	! 161	" 162	# 163	$ 164	% 165	& 166	' 167	(168	) 169	* 170	+ 171	, 172	- 173	. 174	/ 175
$B-	0 176	1 177	2 178	3 179	4 180	5 181	6 182	7 183	8 184	9 185	: 186	; 187	< 188	= 189	> 190	? 191
$C-	@ 192	A 193	B 194	C 195	D 196	E 197	F 198	G 199	H 200	I 201	J 202	K 203	L 204	M 205	N 206	O 207
$D-	P 208	Q 209	R 210	S 211	T 212	U 213	V 214	W 215	X 216	Y 217	Z 218	[219	\ 220	] 221	^ 222	_ 223
$E-	` 224	a 225	b 226	c 227	d 228	e 229	f 230	g 231	h 232	i 233	j 234	k 235	l 236	m 237	n 238	o 239
$F-	p 240	q 241	r 242	s 243	t 244	u 245	v 246	w 247	x 248	y 249	z 250	{ 251	| 252	} 253	~ 254	DEL 255

Table 2. High ASCII character code ranges from hexadecimal $80 to $FF or decimal 128 to 255.

What's new in optics?

A mind-boggling assortment of new and

exciting optics concepts have recently shown up in many different magazines. All have outstanding hacker potential and are crying for your use. Here's a quick rundown:

From the April 86 *Popular Science,* a magic new plastic from *Mobay Chemical* that carries total internal reflection to extremes. Much of the light that goes in the faces comes out the ends. Besides "gee whiz" neon-looking business cards, this stuff should be ideal for "sidelit" dials and panels. More importantly, it should be a very-low-cost solar electric concentrator.

From the March 6, 1986 issue of *Machine Design,* a brand new, simple, and cheap way of creating just about anything at all. You pour a liquid polymer onto a sheet or into a clear tank. Then you shine light at those portions of the polymer you want to harden into a product. Then you wash away the remaining unexposed polymer. Such things as "drilling" blind square holes are now trivally done by a hacker on his kitchen table!

The future of light-hardened polymers is even better. Take a tank of liquid polymer and scan it with three lasers on the X, Y and Z axes. Where they cross, the liquid polymer hardens. And, yes, there is a definite threshold effect where low light levels will do no hardening at all. Software routines can then describe any shape from an artist's sculpture to a precision machinery part. Which means that repair and replacement machinery parts can eventually be "shipped" anywhere in the world over a telephone!

A third optic development came out of the recent *Microsoft* CD Disk conference and is outlined in the March 17, 1986 *Infoworld.* There's a new CD disk operating system called CD-I, where the I means *interactive.* This means that DC disk systems can now handle pictures, animation, and graphics, as well as words, and that you can quickly random access any portion of the disk. It uses the Tandy Color Computer operating system.

Turning to the March 17, 1986 issue of *Electronics,* a Swedish firm named ASEA now has some very interesting fiber-optic sensors. One is a remote reading thermometer. You shine light of one frequency down the fiber, and the frequency of the light coming back is proportional to the sensor temperature. It works remotely from over a quarter of a mile away, with total electrical and safety isolation. A somewhat similar product has a cantilevered mirror at the end that forms a remote accelerometer.

A final look at the April '86 *Scientific American* reveals two fascinating optical areas. One is the optical gyroscope, which has few or no moving parts. The first hacker to develop a $25 optical gyroscope will run away with a very large bag of nickels. The time is ripe for a dramatic drop in the cost of gyroscopes, which would open them up to an incredible array of new applications, even toys.

The same issue has some construction details on creating a magic phase conjugating mirror that automatically removes distortion from optical images. Under certain circumstances, these magic mirrors even exhibit the concept of negative time!

Yes, all of this stuff is for real. And here and now.

NAMES AND NUMBERS

Hewlett-Packard
3155 Porter Oaks Drive
Palo Alto, CA 94304
(415) 857-8000

Motion Systems
7230 Hollister Avenue
Goleta, CA 93117
(805) 968-0782

NTIC
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4929

Penwalt Piezo
Box C
Prussia, PA 19406
(215) 337-6710

SAMS BOOKS
4300 West 62nd Street
Indianpolis, IN 46206
(800) 428-SAMS

SenSym
1255 Reamwood Avenue
Sunnyvale, CA 94089
(408) 744-1500

Vernitron
232 Forbes Road
Bedford, OH 44146
(216) 232-8600

How do you do technical research?

First and foremost, read as many possible trade journals involving your field of interest. So many times, you find useful and profitable information in areas where you least expect to find it.

Secondly, get thoroughly familiar with a large technical library. I'm purposely not going to give you any names or numbers to those optics references above, because I want you to go to any old library and check out a key reference book called *Uhlrichts*

Periodicals Dictionary. This will show you all the trade journals available in all fields and how to get them.

One obscure technical library tip: Practically all of the reference materials will send you *backward* through time, and thus aren't that useful in fast breaking fields. But there is a reference called the *Science Citations Index* that, believe it or not, moves you *forward* through time.

How does it work? Every time a paper is referenced, that newer paper is listed. Just about any field has its early "horses-mouth" source documents. For instance, anything competetent written on active filters *must* reference Sallen and Key. Anything competent written on unfocused solar collectors *must* reference Winston, and so on.

This can start a tree, for as soon as you find a newer author making the reference more than once, you can also chase him *up* through time.

The third way to research is with electronic data bases. Things have gotten far too complicated for any library to keep up, let alone any individual. As an availability example, *NTIS,* among zillions of other published searches, can send you a 208-entry annotated bibliography on laser optical gyroscopes if you order No. PB84-852987CAI. Cost is around $50, which is a real bargin, considering what you get.

How about another contest?

All right, a *Modern Electronics* Hardware Hacker has a problem that you may be able to help solve. I'll award the usual SAMS book to the best ten entries, and an all expense paid tinaja quest for two (FOB Thatcher, AZ) to the best entry.

The problem is to design a robotic cow. Rodeo is a very big sport in many parts of this country. To train cowboys and roping horses for certain events, a robotic cow is needed.

The pseudocow has to travel along an 80-foot-long linear track and must be able to rapidly change speed and direction, both under programmable and remote operator control. As much as possible, "found" or adapted materials are to be used. The budget is tight, say $250 maximum, not including stock personal computers or standard R/C radio controllers. ME

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:

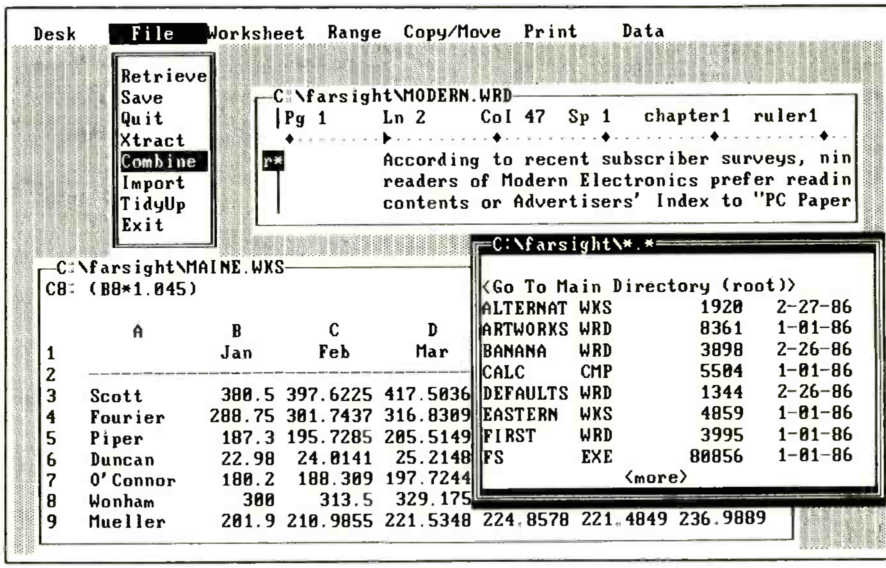
Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

First Impressions: Interface Technologies' "Farsight" Lotus-Clone Spreadsheet; McGraw-Hill Software's "Maxit" RAM Board; Toshiba's Model P321 Printer

By Eric Grevstad

Legends die hard. Last year, the Coca-Cola Company spilled New Coke down its shirtfront while America demanded Coke Classic. Two years ago, Apple tried forcing the toylike IIc on buyers who rallied to the IIe even when hit with a price hike. Today, Lotus Development Corp.'s high-priced upgrade and different file format have to some extent offset the extra features of 1-2-3 Release 2. Release 1A may no longer be the best program in its field, but it's an established institution. It's the WordStar of the late '80s.

Even before Release 2, there were 1A-compatible spreadsheets like Mosiac Software's Twin and Paperback Software's VP-Planner. This month's products, however, are new variations on Lotus' old theme. One is a program that combines 1A-format worksheets with a word processor and windows to cut and paste between them, all for $100. The other is a hardware upgrade aimed at Release 1A software owners. (This month's third product is a high-quality printer, but I couldn't work it into this lead except to say that both old and new Lotus users appreciate good printouts.)



Menu choices are familiar, but Farsight adds word processing and disk directory windows to its Lotus-clone spreadsheet software.

Integrated Economy

Business users accustomed to deluxe software that they don't personally pay for may share my early impressions of Interface Technologies' Farsight: it's slow at some jobs, it takes a few extra keystrokes to use its menus, it's rather fond of beeping and clicking at you through the PC's speaker. As integrated packages go, I prefer Framework II. But Farsight requires only 256K and two floppies, works like Lotus 1A on 1A files, and costs $99.95 (not copy-protected). It's almost worth buying just to salute the manufacturer.

Except for its eye-saving reverse video display, showing black text on a light background (it looks better in monochrome than color), Farsight's desktop resembles Framework's. You can move, size, and switch among multiple windows, each showing a worksheet (.WKS) or word processing (.WRD) file or disk directory. Consistent function-key commands cut, copy, or move text, worksheet cells, or disk files. Changing or creating subdirectories is easy with the software.

Farsight uses moving-bar menus and directories, letting you select items with the arrow keys or by typing initial letters. (Start typing the name of a disk file, and the cursor jumps to it alphabetically; type an unrecognized name, and Farsight opens a new file.) Some choices call option boxes, where the tab key moves through submenues—such as forward or backward and match or ignore case for search and replace functions.

It's a simple, efficient scheme, backed by good context-sensitive help screens. Beginners should adapt readily, and Lotus buffs need learn only F3 (instead of a slash) to call the top-line menu, a few extra Enters amid first-letter typing for menu choices, and Alt before entering some function-key commands.

Lotus users will also have to give up graphics, but otherwise Farsight has the same versatile spreadsheet, makeshift database, and macro ability as Release 1A, with a few extras. (The F5 or search command, besides serving the word processor, replaces GoTo for cells addresses and also finds specific values or labels.) Existing 1A files and macros work perfectly.

If you don't need graphics or giant worksheets, Farsight is a fully acceptable replacement, though it loads files at half Lotus' speed and recalculates one-third slower (9.4 versus 6.3 seconds for the same 200-cell exercise). For big jobs, despite the same theoretical limit (2,048 rows by 256 columns), Farsight falls down. My test tile (the formula 2 + 2 in all 256 columns) produced "Worksheet full" messages after 40 rows to Lotus' 64. Copying eight rows took two minutes instead of 26 seconds. Cursor movement slowed to a crawl.

Farsight's word processor, by contrast, is fast and attractive, lacking a "delete word" command but with automatic reformatting, unlimited mixing of margin or layout rulers, visible page breaks, mail merge, and typestyles from underlined to italic. The Esc key undoes casual deletions, while a more formal cut-and-paste buffer not only handles block operations, but easily puts spreadsheet rows into text. A background queue lets you continue working during printing.

Interface Technologies, proud of its

Modula-2 compiler and window manager, promises add-on graphics, communications and relational database components by midyear; I look forward to them. Farsight isn't spectacular but everything about it, from its Lotus-meets-Framework menus to the overlay system that lets it fit into 256K, works smoothly. If I name a "Bargain of the Year" in the future December column, you read it here first.

Memory to the Max

When it comes to memory, we PC owners are insatiable. We used to be happy with 128K or 256K; nowadays we gnash our teeth that the 8088 can address only a measly megabyte and that we're allowed just five-eighths of it. "It's so unfair," we moan. "Such a waste to have 640K for us and 384K reserved for ROM and video stuff that's usually only a fraction of that size. How are we supposed to load DOS and SideKick and still have room for giant spreadsheets?"

A recent answer is the bank-switching scheme of expanded memory, which is admirably ingenious but technically hilarious—up to eight megabytes sharing a 64K window in upper memory, a RAM Rolodex shuffling 512 slices in and out of four 16K slots. But expanded memory boards are costly and useless for all but the newest programs (such as 1-2-3 Release 2). If you're willing to accept a smaller increase for a small but choice selection of software, $195 will give you another 255K of Release 1A workspace—or, if you like, another 193K for Lotus with space for Borland's SideKick thrown in free.

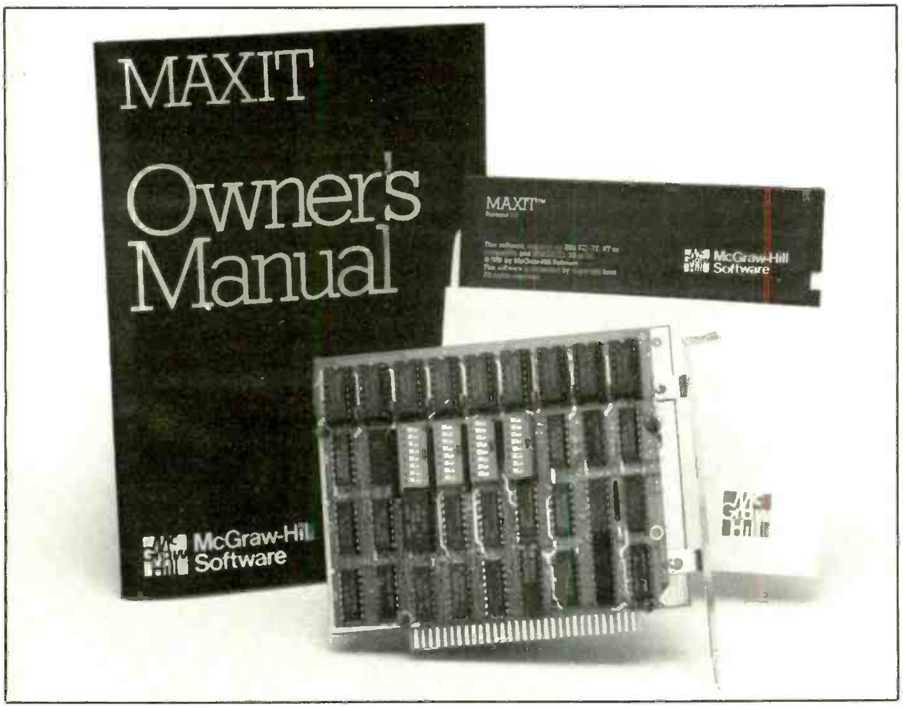
The secret is McGraw-Hill Software's Maxit, a half card with 256K RAM. It can reside below the 640K line to fill smaller systems, but that wastes Maxit's talents and your money; Turner Hall Publishing's half card does that job for $100. Maxit can also do the bank-switching bit, supplying a driver for the Lotus/Microsoft Expanded Memory Specification, but its 256K can't match other EMS boards' two megabytes. Besides, using EMS mode with my Tandy 1200, Framework II reported only 164K added, while Microsoft's EMS RAM disk used all 256K but was grotesquely slow (WordStar loaded a paragraph in 36 seconds).

Maxit's real value lies in the high ground above 640K, which a clever installation program scans for gaps, prompting you to set the board's DIP switches and add two lines to your AUTOEXEC.BAT files. That done, Maxit automatically assigns its three 64K and two 32K segments to vacant addresses at system startup. This fills, for example, the space from 640K to 736K, skipping your video card, filling from 768K to 800K, skipping the hard disk ROM, then reappearing from 832K to 960K. (My old color/graphics adapter used 32K video memory; my STB Chauffeur uses 64K, cutting Maxit to a 224K total. An Enhanced Graphics Adapter would take even more.)

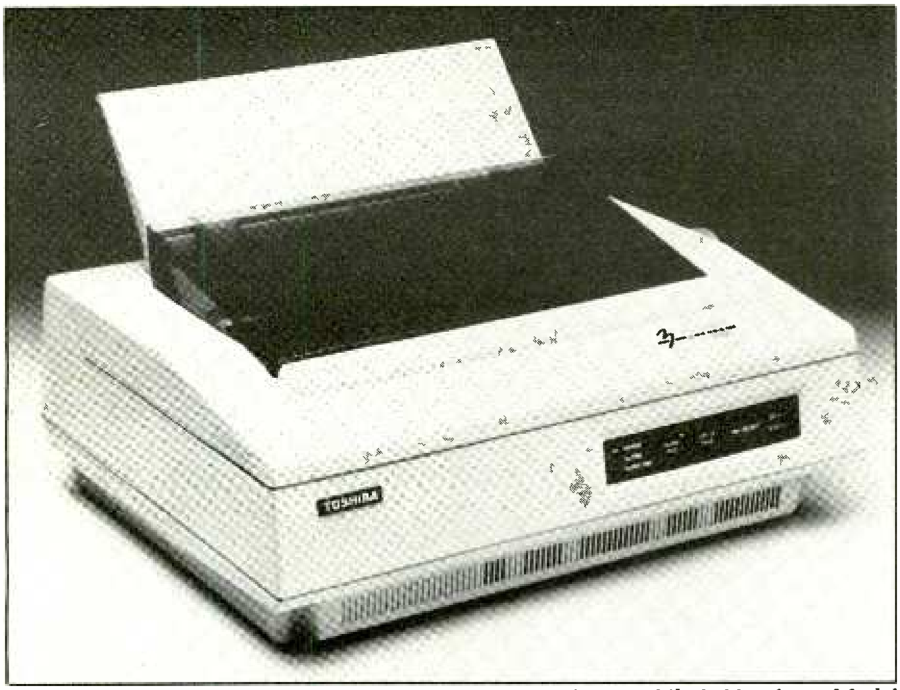
Past its opening logo, Maxit is invisible; CHKDSK reports extra money up to the first gap (e.g. 736K), but your programs ignore it, actually losing 1K to Maxit's software. The exception, however, is Lotus 1A, at whose starting cell Maxit activates its RAM. The result is magic: My worksheet space jumped from 527,004 to 788,243 bytes. No bother, no bank switching, just room for 96 instead of 64 rows of my test file.

Maxit's other magic trick, though the otherwise nicely detailed manual doesn't spell out its limitations, is to slip memory-resident programs up its sleeve. Putting KEY between the two Maxit AUTOEXEC lines, for instance, will slash Superkey above 640K, where it won't subtract from your applications.

The drawback, as McGraw-Hill admitted when I called about my crashing attempts to load both SideKick and Superkey or RoseSoft's ProKey in the overhead compartment, is that such programs won't work when split across noncontiguous areas. They're limited, in most systems, to that first 96K block. Between that and different video cards, it might be nice to see a sticker on the box saying "Your mileage may vary." But there are lots of people who use 1-2-3 and a single pop-up program, who don't want to guy an EMS



Maxit adds 256K to 640K for 1-2-3 and memory-resident programs.



If you like the newest dot-matrix printers' near letter quality, Toshiba's 80-column Model P321 brings 24 pins within your price range.

board and new software, and who'll find Maxit a neat, affordable quick fix.

An Elite Affair

There's nothing I dislike about the Toshiba P321, but some things I like less than others. In my book a $699 printer should offer more than a manual friction feed (a tractor unit costs $99, a sheet feeder $219), and you can get better, if not faster, draft-quality text from Stars and Epsons costing hundreds less. I timed the Toshiba's draft pica and elite at a respectable 91 and 101 characters per second (cps) respectively, but both had a slightly nervous or trembly appearance, though the condensed pitch (86 cps) looked good.

Along with a paper-handling option, I'd spend an extra $49 for IBM Graphics Printer emulation. Without it, the P321 couldn't do graphics screen dumps, and Framework II charts (using the P351 driver) were beautifully crisp but actually too dark to tell shading patterns apart easily. Toshiba's control codes, too, are a little tricky for beginners—for the character spacing value 12, enter decimal 49 50 (ASCII for 1 and 2).

But this is nit-picking. The P321, which replaces the P1340 as Toshiba's thriftiest 24-pin dot-matrix (aren't printer prices falling wonderfully?), is a solid, sturdy device that accepts your word processor's Qume Sprint 11 control codes and produces up to six fonts: draft, NLQ Courier, NLQ Prestige Elite, two more NLQ fonts from a plug-in cartridge, and one downloaded from your PC (the downloading kit sells for an extra $99).

It lacks many new printers' easy front-panel controls for changing fonts, but you'll probably stick to only one. Courier (41 cps) looks like very good, dark draft pica, but I'm in love with the P321's Prestige Elite (47 cps). It matches anything out of a daisy-wheel printer, and separate control codes for font and spacing let you use it for 10-pitch and proportional as well as the usual 12-pitch output.

Some decisions are made on individual instead of overall concerns; you might think Subarus aren't sexy, but buy one for its four-wheel drive, or find an otherwise average house with the bay window you've always wanted. If you're more concerned with letter-quality letters than fast draft runoffs, Prestige Elite will tempt you to the Toshiba P321. **ME**

Draft 10 cpi: Please accept my congratulations on your daughter Mary's engagement to John Doe.

Draft 12 cpi: I know John is a *fine young man*, because he reads Modern Electronics. Mary is very fortunate.

Courier 10 cpi: I usually skip the 'PC Papers' column myself, but otherwise enjoy ME as well.

Prestige Elite 12 cpi: Best wishes to you and to Mrs. Quincy, and keep in touch. See you at the wedding.

Besides the usual underlining, italics, bold, expanded and compressed text, the Model P321 has three built-in fronts from which you can choose.

Names & Addresses

Interface Technologies Corp.
3336 Richmond Ave., Suite 200
Houston, TX 77098
713-523-8422

McGraw-Hill Software
8111 LBJ Freeway, Suite 1350
Dallas, TX
214-437-7422

Toshiba America, Inc.
Information Systems Division
2441 Michelle Dr.
Tustin, CA 92680
714-730-5000

BOOKS

Complete Guide to Compact Disc (CD) Player Troubleshooting and Repair by John D. Lenk. (Prentice-Hall. Hard cover. 258 pages. $29.95.)

With the explosive growth in purchases of CD players during the past year, electronics service personnel must learn how to troubleshoot and repair these sophisticated marvels of audio technology. This book provides what knowledge is needed. It leads off with the basics of CD players and their relationship to stereo systems. From there, it goes on to describe the encoding and decoding processes and explains the theory of operation of a cross-section of player circuits with the help of schematic and block diagrams. This is followed by discussions of user controls and operating procedures and required test equipment and tools.

Detailed drawings help to explain the mechanical sections of typical CD players. Both early and current models of CD players are covered in the troubleshooting section, which describes a systematic approach to localizing problems in the electronic sections.

Tools For Thought by Howard Rheingold. (Simon & Schuster. Hard cover. 335 pages. $17.95.)

Recounted in this book is the roughly one hundred-year history of computing (at least the concept has been around that long). It is basically the story of people like Babbage, Boole, Turing and almost everyone else up to today's geniuses who have been and still are responsible for the significant developments in the evolution of the computer. These stories reveal their genius and eccentricities, but not without due reverence.

The theme of this book is that the computer revolution has not occurred yet, that everything that has happened to this point is just prelude to truly powerful "mind machines" that will make today's most powerful computers' capabilities appear to be insignificant by comparison. The peeks the author gives into the future, mostly through the eyes of the people who are currently engaged in developing new computing machines, are both fascinating and mind bending.

Whether or not you are interested in "history," you will likely find this book to be thoroughly absorbing. It is an imaginatively written documentary.

Troubleshooting & Repairing Your Commodore 64 by Art Margolis. (Tab Books. Soft cover. 351 pages. $14.95.)

If you own a Commodore 64, this book can be an important computer accessory. It provides practical information on putting an ailing C-64 back into operation. Written by a servicing specialist, the book is logically organized to help you to rapidly localize any source of trouble.

Early on, you are told how to recognize and interpret symptoms. You are shown how to disassemble the C-64 and locate all 32 of its IC chips and told what each does. A battery of chapters are then devoted to subsystems inside the C-64, liberally peppered with important servicing tips. Along the way, every circuit is closely examined in full technical detail so that when you are finished reading, you know more than you need to know to service each and how it relates to the system.

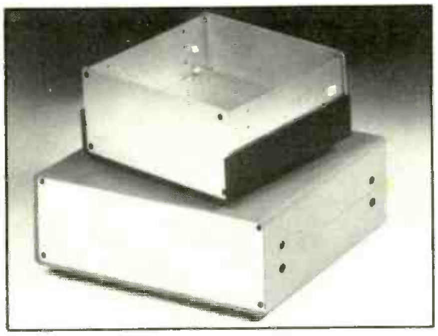
Supporting the well-written text are more than 250 photos, drawings, schematics, block and timing diagrams, and tables—all provided to help you through the servicing procedure. Very handy are the chip-function diagram and the master schematic of the C-64 at the end of the book. The master schematic is rendered in large size and spread out over 24 pages for easy readability.

NEW LITERATURE

Test Equipment Rental Guide. United States Instrument's 368-page 1986/87 Product Guide contains complete information on 4,351 different models of test instruments the company has available for rental. Full descriptions, specifications and comparison charts are given in 14 product categories. Products include analyzers, CAE/CAD equipment, microprocessor development systems, counters, generators, desktop controllers, meters, oscilloscopes, recorders, signal modifiers and telecommunications devices. For a free copy, write to United States Instrument Rentals, 2988 Campus Dr., Dept. ME, San Mateo, CA 94403.

Electronic Products & Kits Catalog. The latest edition of the Heathkit catalog features more than 400 electronics and computer products for the home, car, boat, testbench, and communications shack. The full-color 104-page catalog highlights the Hero 2000 educational robot, a new line of computer-based test instruments and a complete satellite TV receiving system. For a free copy, write to: Heath Co., Dept. 150-775 ME, Benton Harbor, MI 49022.

NEW PRODUCTS . . . *(from page 13)*



tops and bottoms are 20-gauge steel with hemmed front and rear edges.

The bottom cover is provided with punched mounting holes for Ten-Tec's accessory tilt-up bails or large rubber feet. Front and rear panels are finished in eggshell baked enamel; top and bottom clamsheels are finished in contrasting blue or black textured enamel.

Sizes range from 6″W×5″D×2.5″H to 12″W×9″D×5.5″H. The 2.5″H models offer three vertical chassis positions, the 4″H models five positions and the 5.5″H models seven positions, all in 0.75″ increments. Standard enclosures are packaged in knocked-down form and come with all required hardware and adhesive-backed rubber feet.

CIRCLE 59 ON FREE INFORMATION CARD

Electronic Video Switcher

You can switch in and out and route up to five video sources of any type as desired with RCA's Model AC019 electronic video switcher. The switcher features soft-touch switches, high-performance amplifier circuitry with low signal loss, and a switchable r-f amplifier for use in weak-signal areas. Panel LEDs light when each function is selected for at-a-glance system setup. $119.95.

CIRCLE 60 ON FREE INFORMATION CARD

LETTERS . . . (from page 4)

but need the schematic diagram for it to complete the job. Can anyone help me?

Donald C. Poston
RR #1, Box 196
Springfield, NE 68059

Praise & Neighs

•I found the series "All About Telephones and How to Repair Them" by TJ Byers the best source of information on the subject I have ever seen. Well done.

On another matter, a couple of gremlins crept into Fig. 1 of my "Add Stereo Sound to Your TV Receiver" (April 1986): *R3* should be 22k (not the 33k shown) and the line from *L3, R7* and *C9* goes to pin 10 (unmarked) of *IC1*.

Gary McClellan
La Habra, CA

•Some errors showed up in my "Day/Night Safety Beacon" (April 1986). In Fig. 1, *Q1* and *Q2* should be labeled 2N5296, as in the Parts List, and B1 and B2 on *Q3* should be transposed. In the "Winding the Transformer Box," amend the middle of the third paragraph from the end beginning "Label the ends . . ." to read: "Cut through the fold and label the two conductors created with number tags 4 and 5. Use an ohmmeter to identify the unmarked end of the wire labeled 4, and twist together and solder this wire, the wire end labeled 5 and a 4" hookup wire to form the center tap. Tag the remaining unmarked wire with the number 6."

Anthony J. Caristi
Waldwick, NJ

•In "A Wireless TV Audio Mute" (March 1986), Fig. 3 doesn't agree with Fig. 1 in the area around *C1, R1* and *R10*. What must be done to correct this?

Dieter Heckele
Hubertus, WI

Move the lower (+) lead of C1 *one hole down as viewed in Fig. 3, and connect the other side of* S1 *to the vacated hole.—Ed.*

•In the schematic of the "64K Printer Buffer for $50" (March 1986), pins 10 and 11 of *IC22* should be connected together and pin 9 should go to X9. The etching-and-drilling guide is correct.

Jeff Burnett
Springfield, VA

CIRCLE 52 ON FREE INFORMATION CARD

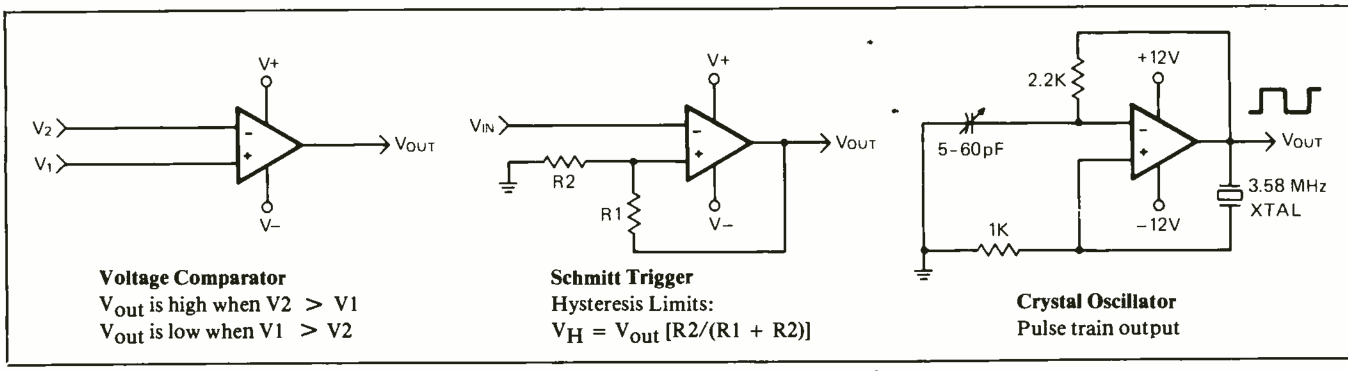


Fig. 7. Using op amps in nonlinear applications.

warm up. When the drift ceases, readjust *R2* to obtain minimum offset from ground.

Use Considerations

Because of its sensitivity to variations in supply voltage, the op amp should always be used with a tightly regulated power supply. However, it's not necessary to use a split supply when a fixed ground reference isn't required. The circuit works better with higher supply voltages; just make sure you don't exceed the transistors' voltage limits.

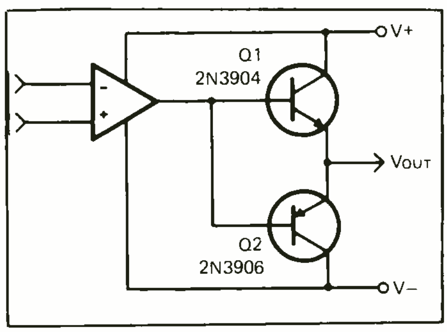


Fig. 8. A class-B output stage.

The high input impedance of FETs (measured above 10 megohms shunted by about 3.5 picofarads) permits a very high current gain at high frequencies, even from a relatively high impedance signal source. Both inputs should have a dc path to ground of not more than 10 megohms. The circuit should be designed with an input resistance equal to the input reactance at the corner frequency, above which the gain drops 20 dB per decade. This can be calculated approximately as: $X_C = 10^{12}/(7\pi f)$. Here, X_C is capacitive reactance, π is 3.14159 and f is frequency in Hz.

In all nonlinear amplifiers, such as voltage comparators and Schmitt triggers, negative feedback isn't necessary. Because the output transistor will be saturated or cut off at all times, drift isn't a problem. Examples of non-linear applications are shown in Fig. 7.

In a linear amplifier circuit, the op amp operates as a class-A amplifier. A class-B output stage, like that shown in Fig. 8, can easily be added to the basic op-amp circuit. Here, *Q1* follows the op amp's output on the positive half, while *Q2* follows the output on the negative half of the cycle. With a split supply, the output can be directly coupled to a low-impedance load, such as a speaker voice coil. Crossover distortion will be severe at low signal levels. The class-B output stage can also be used in nonlinear applications in which crossover distortion isn't a problem.

In Conclusion

There are many applications for the high-frequency op amp described in this article. These include video amplifiers, oscilloscope preamplifiers, broadband r-f amplifiers, high frequency pulse generators, fast response multivibrators and many more circuits in which high-frequency amplification or fast response is required. Due to the circuit's 20-dB per decade rolloff, the op amp is inherently stable at any gain. **ME**

An Automatic Lawn Sprinker *(from page 28)*

assemble the box, wire *IC3*'s gates into the circuit for the operating conditions you desire, as described above.

Label the cable entry holes, switch positions and LEDs with appropriate identifying legends using a dry-transfer lettering kit. Spray two or three *light* coats of clear acrylic over the lettering to protect it. Assemble the box.

You *must* use watertight enclosures for the driver subassemblies. You can make such enclosures from standard chassis boxes simply by sealing all joints and holes with silicone adhesive after the circuit has been installed and tested and the boxes have been assembled.

Wire each driver circuit on a small pc or perforated board exactly as shown inside the dashed-line box in Fig. 1. Make sure you electrically isolate all parts of the circuits from the metal boxes and the low- and ac-voltage sections from each other, and connect the neutral wire of the three-conductor ac cords to the boxes. The cables from the solenoids connect to the appropriate points in the circuits inside the boxes.

Drill three holes in each box, one for the low-voltage lines from the Sequencer, a second for the solenoid's leads, and the last for the three-conductor ac wiring. Line each hole through which a wire is to pass with a rubber grommet and tie a strain-relieving knot in the ac cords and low-voltage cables inside the boxes before connecting and soldering the conductors into place.

Liberally coat the cables, knots and grommets with silicone adhesive, overlapping it onto the inside box walls. Repeat on the outside. Assemble the boxes, using the hardware supplied with them, and liberally coat all seams and screw heads with silicone adhesive. *These must be watertight seals!*

When installing the system, make certain you observe all local electrical wiring codes. Mount the Sequencer/power-supply assembly and programmable timer in a protected location near a pair of ac outlets.

Connect the solenoid valves between the water supply line and individual sprinkler heads. Then wire together the system.

In Closing

Now that you have the Automatic Sprinkler Sequencer installed, turn it on and relax. Instead of having to remember when to water your lawn and garden, dependable solid-state electronics is at work. ME

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PRODUCT EVALUATIONS . . .

(from page 18)

good stereo. Speed accuracy was within 0.249%. What's even more important, however, is the fact that the speed did not vary at all over the four-minute period during which we plotted speed error from a cold power-up start; this despite the fact that we simultaneously varied power-line voltage at least plus and minus 10% above and below the nominal 120 volts.

Summary

Measurements tell only part of the story concerning this superlative cassette recorder. You have to experience working with the B-215 to really appreciate its flawless peformance. The speed with which the deck's microprocessor circuitry analyzes any tape you supply and adjusts parameters to suit is not only awesome, but provides an assurance to the user that he or she will obtain the best possible results from the tape.

Even the speed at which fast winding is accomplished (no more than 75 seconds for a C-90 tape) sets this machine apart from all others. Yet, despite that fast speed, the counter/timer, operating in conjunction with another microprocessor, is able to locate called-for points on a tape with extreme accuracy. Quite frankly, from my own perspective, the performance of this cassette deck seems to be limited only by the quality of the tape that's used with it. That, by the way, is reason enough to use only the very best grades and brands of tape with this instrument.

About the only criticism I could make against the Revox B-215 is the absence of front-panel control lights and use of LCD displays instead of the fluorescent type. Both shortcomings make it difficult to use the machine in a darkened room.

Much as I would like to refrain from resorting to shopworn cliches, the best way to summarize and describe the Revox B-215 on an overall basis is to say that it is, truly, a Rolls Royce among cassette recorders. Its marque evades prestige. Moreover, it's built to last—and to go on meeting or exceeding all of its published specifications after many years of use.

—Len Feldman

CIRCLE 51 ON FREE INFORMATION CARD

Free Basic Programs

(from page 43)

computer's serial port just as if the data originated from a direct broadcast (the computer cannot tell the difference because both the tape and direct broadcast look the same to the computer's serial port).

Though a Sofcast doesn't have the universality of BASICODE because each broadcast is intended for a specific computer, it is more convenient and certainly much faster. Furthermore, several different versions of the same program—or different programs—can be broadcast in a relatively brief time period because of the relatively high baud rates of the Sofcast system.

As for swapping programs, it can be done by simply exchanging disks, or even cassette tapes, made from the Shuttle Communicator. However, it is limited to exchanges between the same kinds of computers because the BASIC of computer A might not be fully compatible with the BASIC of computer B. But because Sofcast programs are not limited to a select group of statements and operators, the program can utilize the complete BASIC for a particular computer.

One great advantage of Sofcasting is that it lends itself nicely to high technology. As shown in Fig. 1, the programs or other data can be easily distributed through a satellite link using the same communication technique that is used to broadcast stock market quotations to pocket data receivers. The Sofcast radio program is uplinked at its city of origin to a *bird* whose signal can be received by either a local radio station or a cable *head*. The radio station broadcasts the date for reception by a home radio equipped with a Shuttle Communicator; or the signal can be fed into a cable TV system for reception by a Shuttle Communicator that is specially designed to receive a Sofcast from both a radio and cable source.

For information on stations in your area that are Sofcasting, write to Microperipheral Corp., 2569 152 Ave. N.E., Redmond, WA 98052. **ME**

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PROJECTS FOR SUMMER

A Bicycle Safety Flasher

(from page 35)

ing. Correct any problem before proceeding to installation.

Installation

After your Bicycle Safety Flasher checks out as operational, mount it and the turn-signal switch on your bicycle via the U-clamps. The lamp/Flasher assembly mounts on the seat post, the turn-signal switchbox on the handlebars.

To use the Bicycle Safety Flasher, slide the Mini Lamp's power switch to the fluorescent lamp position to obtain multi-lamp bar flasher operation. Note also that the lamp's built-in flashlight (which was not defeated in the modification detailed above) will be active when the switch is set to the flashlight position. If you opted for a housing other than the specified Mini Lamp, of course, the power switch will have only a single "on" position and no built-in flashlight.

Have fun . . . and safe cycling! **ME**

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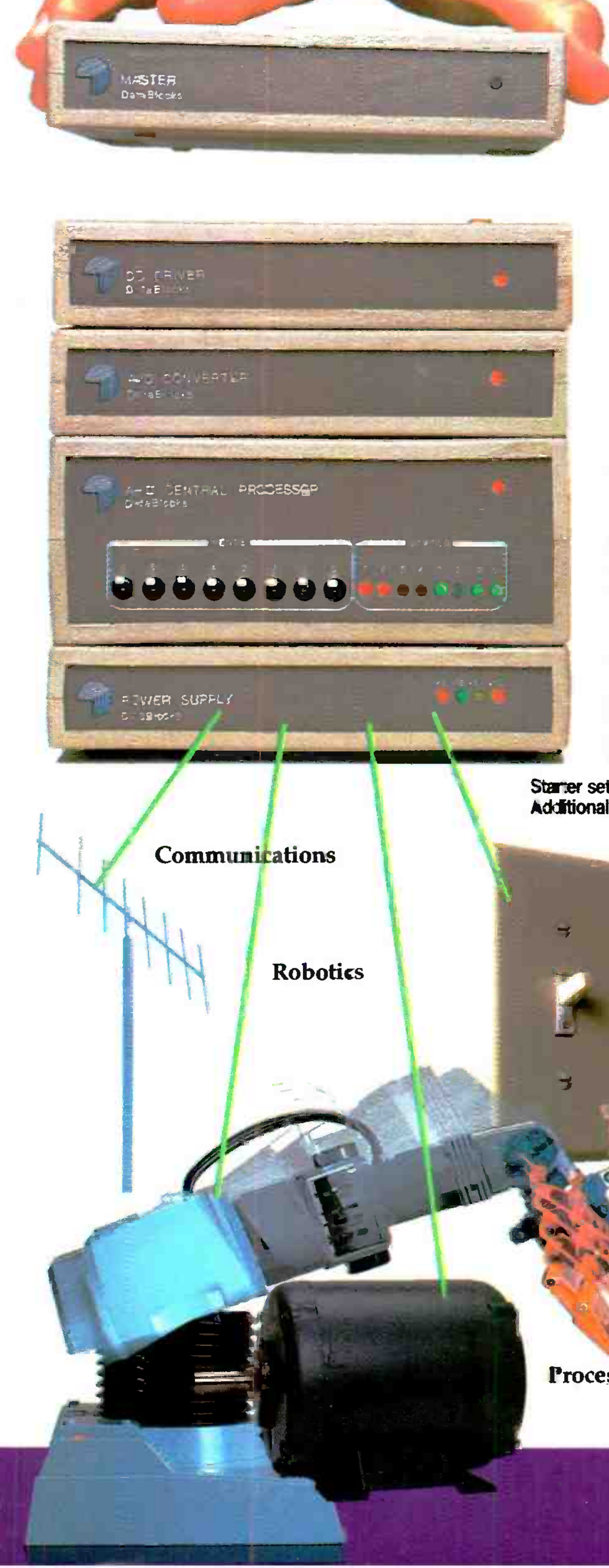

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