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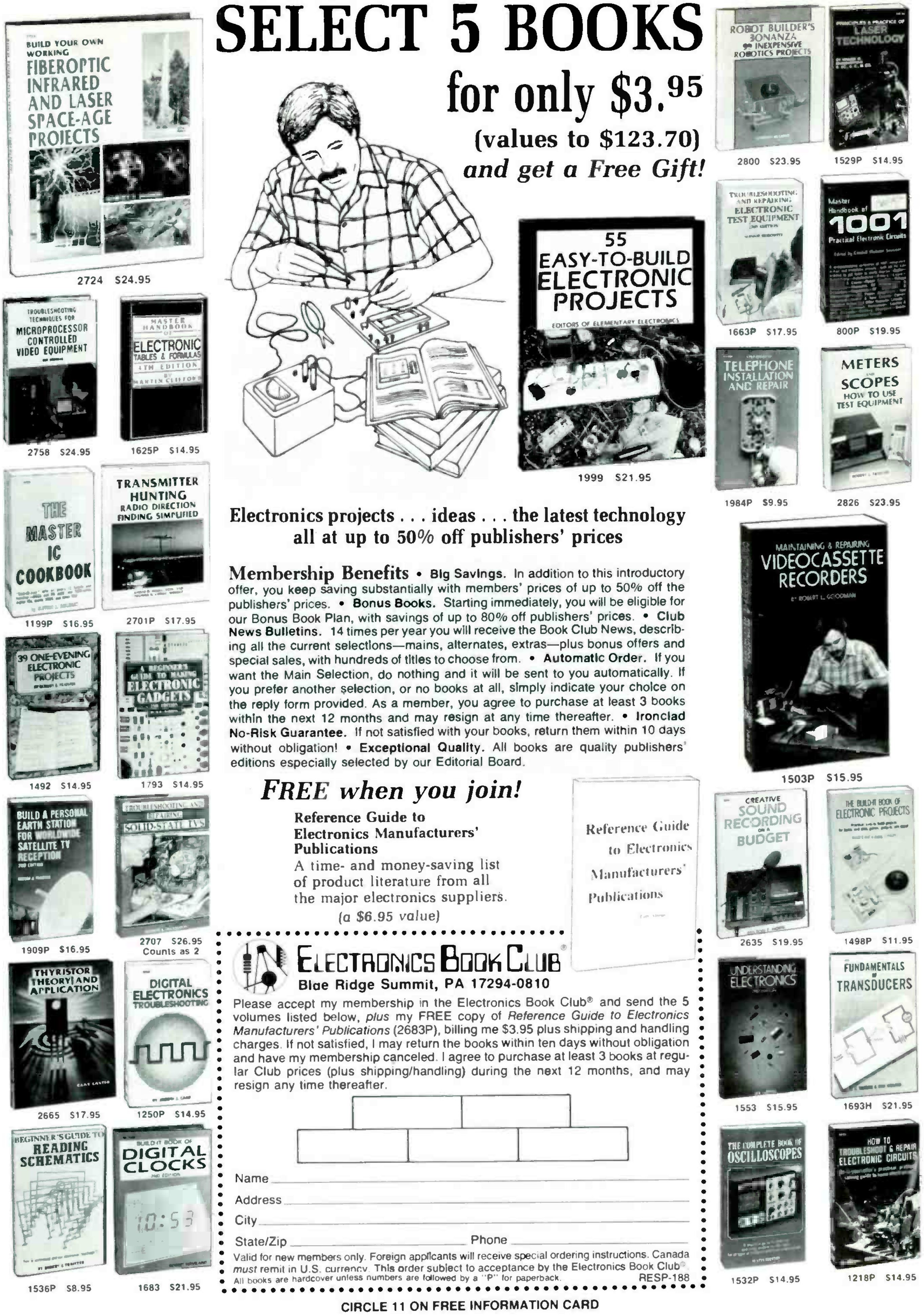
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CIRCLE 11 ON FREE INFORMATION CARD

Hands-on Electronics®
Volume 5, No. 1 January 1988

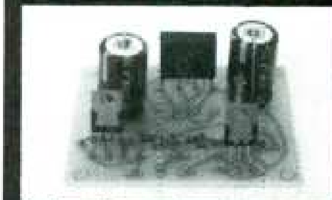
CONSTRUCTION

FEATURES

HANDS-ON REPORTS

SPECIAL COLUMNS

DEPARTMENTS



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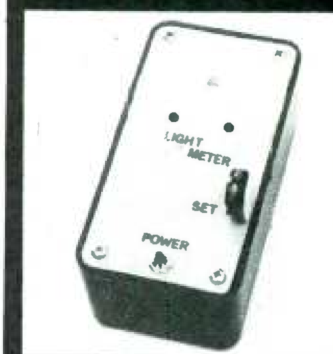

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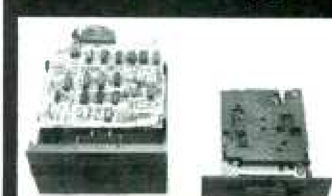

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Hands-on Electronics®

The Magazine for the Electronics Activist!

Wait 'til next issue!

Who is the winning author of the *Hands-on Electronics* IBM Clone Computer Contest?

If you recall, back in April, 1987 we offered to present the author of the best article published in that issue and all issues up to and including the December 1987 issue of *Hands-on Electronics* a computer as a bonus. Now (as I write this editorial, the December, 1987 issue is being distributed to newsstands throughout North America and many other outlets in the western hemisphere, Asia, Europe, Australia, and Africa) you would expect me to announce the winner—*wrong*!

I recorded comments from our readers on the published articles allowing you to become an active participant to the judging of the winning article, and thus the winning author. Those comments were screened for the first 30 days after each issue went on sale, and the December 1987 issue was judged for the same period and the contest closed. When you read this editorial, rest assured that the contest *is* closed (the December issue has been on the newsstands for 30 days) and the winner is being selected.

The announcement of the contest winner will be made in the February issue. That brings to a close the 1987 IBM-Clone Computer Contest. So what do we do for 1988?

I like the contest idea, because the preceding contest brought out the best in many first-time authors. So, I'm going to do it again, beginning with this issue and all 1988 issues of *Hands-on Electronics*. The February issue will give the details. I may change a rule or two including the prize.

To all my readers: I wish for you a very happy, healthy, and prosperous new year.

Julian Martin

Julian S. Martin, KA2GUN
Editor

STAFF

Volume 5, No. 1

January 1988

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C8808	8 pin solder tail, tin	.13	1.15	10.50
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C8828	28 pin solder tail, tin	.32	2.90	27.00
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GOLD INLAY SOLDER TAIL

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C9820	20 pin solder tail, gold	.63	5.90	57.00
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C8124	24 pin wire wrap, tin	.91	8.90	88.00
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C9116	16 pin wire wrap, gold	.85	8.40	83.00
C9118	18 pin wire wrap, gold	.99	9.80	97.00
C9120	20 pin wire wrap, gold	1.19	11.80	117.00
C9122	22 pin wire wrap, gold	1.29	12.80	127.00
C9124	24 pin wire wrap, gold	1.39	13.80	137.00
C9128	28 pin wire wrap, gold	1.69	16.80	167.00
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DIGI-KEY Part No.	1	10	100	1,000
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2N4124	.24	2.27	19.50	178.75
2N4126	.24	2.27	19.50	178.75
2N4401	.23	2.20	18.90	173.25
2N4403	.23	2.20	18.90	173.25
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3 AMP SILICON RECTIFIERS

Part No.	Description	Pkg.	1	10	100	1,000
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1N5402	3 Amp 200PIV	Plastic	.31	2.83	25.20	220.50
1N5404	3 Amp 400PIV	Plastic	.33	2.97	26.40	231.00
1N5406	3 Amp 600PIV	Plastic	.35	3.15	28.00	245.00
1N5407	3 Amp 800PIV	Plastic	.40	3.60	32.00	280.00
1N5408	3 Amp 1000PIV	Plastic	.50	4.50	40.00	350.00

5% Carbon Film Resistors

Available in 1/8, 1/4 & 1/2 Watt

Wattage Rating	1/8W	1/4W	1/2W
Max. Working Voltage	200V	250V	350V
Rated Ambient Temp.		70°C	
Operating Temp. Range		-55°C to +155°C	
Dimension "L"	3.60	6.50	9.50
Dimension "D"	1.50	2.30	3.20
Dimension "d"	0.45	0.60	0.60

5% Carbon Film Resistor Values in Ohms - 1.0 to 4.7M

How To Order: Take any standard resistor value (i.e. 3.2) and add an "E" for 1/8 watt, or a "Q" for 1/4 watt or an "H" for 1/2 watt (i.e. 3.2Q for 3.2Ω 1/4 watt); this is the Digi-Key part number.

Pricing	5	200	1000
1/8 Watt	.25	6.40	25.00
1/4 Watt	.25	3.40	13.00
1/2 Watt	.25	3.50	16.00

1/8 Watt Carbon Film Assortments

RE112 5 each of the 73 standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)

RE217 5 each of the 73 standard values in series 1.1, 1.3, 1.6, 2.0, 2.4, etc. through 910K (365 total pcs.)

1/4 Watt Carbon Film Assortments

RQ125 5 each of the 73 standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)

RQ226 5 each of the 73 standard values in series 1.1, 1.3, 1.6, 2.0, 2.4, etc. through 910K (365 total pcs.)

1/2 Watt Carbon Film Assortments

RH162 5 each of the standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)

RH260 5 each of the standard values in series 1.1, 1.3, 1.6, 2.0, 2.4, etc. through 910K (365 total pcs.)

1% Metal Film Fixed Resistors

Available in 1/4 Watt

Wattage Rating	1/4 Watt
Max. Working Voltage	150V
Rated Ambient Temp.	70°C
Operating Temp. Range	-55°C to +150°C
Dimension "L"	6.6
Dimension "D"	2.3
Dimension "d"	0.6

1% Metal Film Values in Ohms - 10.0 to 1.00M

How To Order: Take any standard resistor value (i.e. 1.69K) and add an "X" (i.e. 1.69KX); this is the Digi-Key part number.

Pricing	5	10	1000
1/4 Watt	.50	3.90	30.00

For large quantities and prices as low as [illegible] call Digi-Key

1/4 Watt Metal Film Assortments

RBX1 5 each of values 10Ω to 97.6Ω (480 total pcs.)

RBX2 5 each of values 100Ω to 976Ω (480 total pcs.)

RBX3 5 each of values 1.00KΩ to 9.76KΩ (480 total pcs.)

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5% Metal Oxide Film Resistors

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It can perform spectrum analysis, digital filtering, signal averaging, speech processing, and telecommunications. Its features include: extensive software support containing source code; PC/R320 upload/download routines; executable files in TURBO PASCAL & TM32010 source code; complete turnkey spectrum analysis software; spectrum analysis via 1024 point FFT; data display for spectrum analyzer or digital scope; window generation source code, comes with Hanning; R320 accepts 8- or 12-bit external data input; optional turnkey 4 channel, 8 bit per channel, 500KHz per channel, 4-channel data acquisition front end.

It's available from Rapid Systems Inc., 433 N 34th Street, Seattle, WA 98103; Tel. 206/547-8311.

24-Pin Color Printer

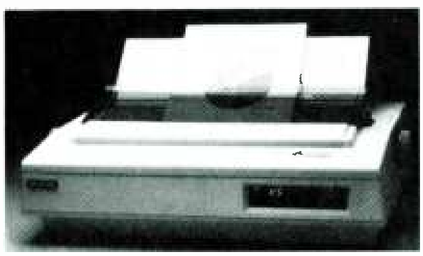
If you're a business or professional printer user, who needs the advantages of color text and graphics, as well as 24-pin letter quality and ease of use, Toshiba may have your printer. They have designed and augmented the front panel of a previous model to incorporate user-friendly features.

An easy-to-use LED display has been added to that the user can select, by simply touching a button, print quality, font, pitch, paper motion, or quiet mode. The printer is designed to allow users to significantly reduce the noise level, when required, in an office environment.

The dip switches for the printer, usually located in the back, have been moved directly behind the front panel for easy access.

The P351C Model 2 will print at 300 cps in draft mode, and 250 cps in the condensed printing mode, faster than the original P351C, while maintaining the 100-cps speed in letter-quality.

Increased software support now is provided with 10 top packages, such as Microsoft Chart, Computer Associates' Supercalc 3A, Redding Groups' Graftalk, Enertronics' Energraphics and a color graphics driver for Lotus 1-2-3.



CIRCLE 66 ON FREE INFORMATION CARD

Purchasers of the P351C Model 2 can receive the Microsoft Chart free by returning a response card packaged with the printer. Suggested retail price of the P351C Model 2, including the new features and all of the standard functions, is $1749, the same as the previous model.

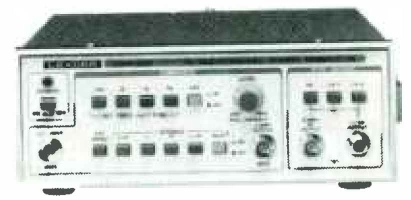
In addition to a bottom-feed provision, especially useful for multipart forms, other standard features are Qume Sprint 11, IBM Graphics Printer and IBM Color Printer emulations; three resident type fonts (prestige elite, courier, and high-speed draft) and the capability to accept a wide variety of type fonts from optional disks or cartridges.

Optional paper handling accessories available include a dual-bin sheetfeeder, unidirectional tractor and bidirectional tractor. The P351C Model 2 is backed by Toshiba's one-year warranty.

For further information contact Toshiba America's Information Systems Division, 2441 Michelle Drive, Tustin, CA 92580, Tel. 800/457-7777.

TV Stereo-Signal Generator

To fill the service needs of stereo television and VCR manufacturers, Leader Instruments has a low cost/high performance MTS Signal Generator, Model



CIRCLE 52 ON FREE INFORMATION CARD

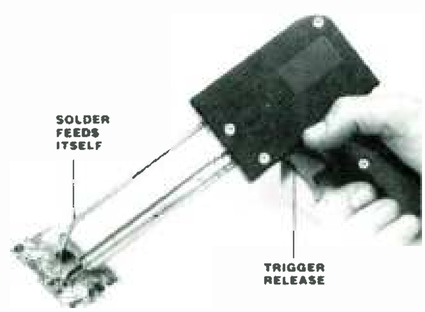
LMS-237. The versatile generator provides the necessary signals for test and alignment of both stereo and SAP (Secondary Audio Program) decoders.

On-screen character displays (L, L, R, and L-R) indicate the selected mode of stereo or mono operation. Composite-stereo and SAP outputs at baseband, SIF (4.5 MHz), VIF (45.75 MHz), Channel 3, and Channel 4 allow the technician to pinpoint the area of malfunction. Four selectable, internal-modulation frequencies (300 Hz, 1 kHz, 3 kHz, 8 kHz) at 14% modulation (-17 dB), as required by the manufacturers, are provided.

For more information on the LMS-238, which retails for $600, contact Leader Instruments Corporation, 380 Oser Avenue, Hauppauge, NY 11788, Tel. 516/231-6900, or 800/654-5104.

Self-Feeding Solder Gun

How would you like a self-feeding, solid-state electric solder gun with replaceable snap-in solder cartridges? Extremely light in weight but rugged in construction, this line of solder guns uses a patented self-feeding system whereby the solder is fed from the solder cartridge to the solder tip.



CIRCLE 63 ON FREE INFORMATION CARD

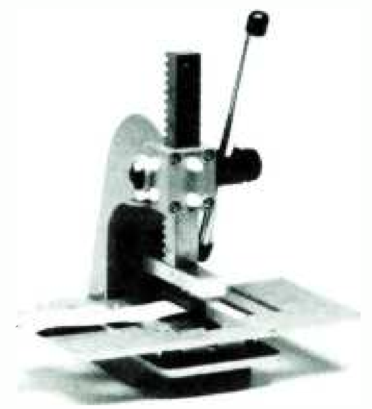
Just squeezing the trigger in the handle of the gun, advances the solder automat-

ically onto the hot tip, thereby allowing the user to flow the solder exactly where needed! That method makes soldering so easy that you can do it with one hand tied behind your back.

The one-handed Soldereaze Solder Gun comes in eight different models from 25 to 150 watt, and features models with an adjustable tip-temperature control, as well as two models with the added feature of a digital temperature read-out. Retail prices range from $21.00 to $66.00. Further details and full-color literature are available from: Soldermatic Corp., 3607 Howard Street, Skokie, IL. 60076; Tel. 312/673-1111

IDC-Assembly Press

The IDC Bench Assembly Press is perfect for short-run production, R&D Centers, MRO's, and service technicians. The IDC Bench Assembly Press is capable of low-volume mass termination of various IDC connectors on flat (ribbon) cable.



CIRCLE 93 ON FREE INFORMATION CARD

Convenient, quick, and easy to use, the ¼-ton manual press has interchangeable base plates (no tools required) and accommodates a broad range of IDC's including female socket transition connectors, card-edge connectors, standard DIP plugs, and D-subs. The interchangeable base plate terminates up to 64-pin IDCs. Cartridge style allows for quick change with virtually no set up.

The IDC Bench Assembly Press has a suggested retail price of $139.95 (base plates and cutters are sold separately) and is available at electronic equipment suppliers nationwide.

For more information on the IDC Bench Assembly Press contact PanaVise Products, Inc., 2850 E. 29th St., Long Beach, CA 90806; Tel. 213/595-7621.

Artificial RF Ground

Don't we all sometimes have problems with not having a good RF ground? Problems like RF "hot spots" that "bite" our lips or fingers when we transmit; RF feedback that cause our rigs to quit working on certain bands; excessive RF coupling to AC lines that causes everything to quit working; our neighbors screaming about TVI and RFI; our computers computing gibberish; or we simply can't talk across town because of extreme ground losses or radiation pattern distortion.

Let the new MFJ-931 create an artificial RF ground with a random length of wire thrown along the floor. It's very effective at placing your rig at or near actual-earth ground potential even if your rig is on a second or higher floor.

That's not all—the MFJ-931 can also electrically place a far-away ground directly at your rig, no matter how far away it is. It tunes out the reactance of the wire that connects your existing ground to your rig.

CIRCLE 84 ON FREE INFORMATION CARD

The MFJ-931 connects between the ground connection of your transmitter or antenna tunner and a random length of wire thrown along the floor. Two knobs on the MFJ-931 are adjusted for maximum RF-ground current using its built-in RF ammeter. That resonates the random wire, converts it into a tuned counterpoise, and presents an effective low impedance near ground potential to your rig, thus creating an artificial RF ground.

To electrically place a far-away ground directly at your radio equipment, simply connect the MFJ-931 between your rig and connecting ground wire and adjust its two knobs for maximum RF current using its RF ammeter. That tunes out the reactance of the connecting wire, reduces the electrical ground lead length to virtually zero, and electrically places your far-away ground directly at your rig.

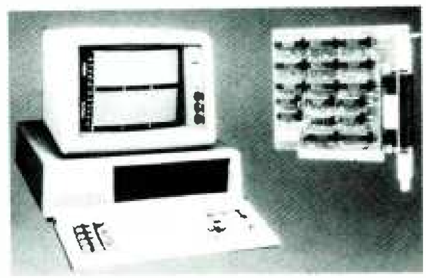
The MFJ-931 covers 1.8 to 30 MHz and has a built-in RF ammeter for indicating RF-ground current. It's ruggedly built in an all aluminum cabinet with a brushed-aluminum front panel.

The MFJ-931 retails for $79.95 it comes with a one-year unconditional guarantee and if ordered directly from MFJ Enterprises, Inc. it can be returned within 30 days for a full refund (less shipping and handling) if not satisfied.

For additional information contact MFJ Enterprises, Inc. at P.O. Box 494, Mississippi State, MS 39762; Tel. 800/647-1800 or 601/323-5869.

Digital I/O Board

MetraByte's PIO-24 is a high-current, parallel I/O card which allows 24 TTL/DTL compatible digital I/O lines to be monitored or controlled by a Personal Computer. The 24 I/O lines are divided into three 8-Bit ports. Each port may be configured as either input or output. What's more, port C may also be divided into two 4-bit ports that may be set as inputs or outputs independently.



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Typical applications for the PIO-24 include contact-closure monitoring, digital I/O control, interface to PB-16A, and similar Solid-State I/O module racks, plotter interfaces, and a wide variety of other digital-interface tasks.

Programming the PIO-24 is extremely simple. The board uses four addresses in the PC's I/O address space. Those addresses represent one control word which simply tells the board which ports are to be inputs, and which will be outputs. The remaining three ports directly write to or read from the three 8-bit I/O ports.

Power from the PC-bus is brought out through the PIO-24 connector, allowing external circuitry to be developed without the need for external power supplies. The PIO-24 allows full access to the PC's interrupt-control lines, which allows the board to be used in a wide variety of high-speed I/O interface applications.

The PIO-24 sells for $165.00. For further information contact MetraByte, 440 Myles Standish Blvd., Taunton, MA 02780.

"Junior spoke his first words today! 'Woofer' and Tweeter'!"

80386 Personal Computer

Designated as the MP 386 Series, these industry-standard personal computers are multifaceted enough to be used as high-performance personal workstations, as the hub of a departmental local area network, or as the main component in a multi-user Xenix or Unix installation.

The MP 386 is based on Intel's 80386 microprocessor that operates at 16MHz/0wait. Standard features include 32KB of cache memory, expandable to 64KB, sockets for 80287 or 80387 numeric coprocessor, 10 slots for expansion and custom configuring, and 5 half-height, mass-storage devices, providing user flexibility. Also, the MP 386 runs virtually every MS-DOS compatible program, as well as supporting most Xenix-based software programs.

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The MP 386 is available in multiple-system configurations including one floppy disk drive, one floppy disk drive/40MB, one floppy disk drive/70MB, and one floppy disk drive/120MB. Each configuration is available separately or bundled with one of the following display monitors: EGA, auto-tracking Diamond Scan, or monochrome.

Extensive software and hardware enhancements also available with the MP 386, such as 5-¼" 1.2MB or 360KB, and 3-½" 720KB floppy disk drives; 40MB, 70MB, and 120MB fixed disk drives; 4MB expansion memory board; Intelligent Multi-Port Board (8-channels); and floor stand.

The MP 386 comes with a one-year warranty backed by a national network of service centers and regional Mitsubishi repair depots. Established pricing for the 40MB configuration is $5,995.00.

For additional information on any of the Mitsubishi brand-name personal computers, contact Mitsubishi Electronics America, Inc., 991 Knox Street, Torrance, CA 90502; Tel. 213/515-3993.

Emergency Radio Systems

Midland Model 77-911C includes an ultra-compact 40-channel Ready Rescue

CIRCLE 70 ON FREE INFORMATION CARD

II transceiver with ⅜" high LED channel readout, emergency button for instant channel 9, electronic channel tuning with up/down switches, LED bar lights for "S" and "RF" readings, computer circuitry, and volume and squelch controls.

The package also includes a unique slide-on battery pack for emergency back-up power or portable use, a cigarette-lighter adapter for mobile use, a telescoping magnetic antenna, and a vinyl carrying case. Suggest retail price is $129.95.

Model 77-915C offers a 4-watt mobile transceiver with instant access to emergency channel 9 or highway assistance channel 19, ANL, TX, and RX indicators, and modern slide control knobs for volume and squelch. A pre-tuned telescopic antenna with magnetic mount, cigarette lighter power cord, and vinyl carrying case complete the package. Suggested retail price is $79.95.

For more information about Midland's new emergency radio systems, contact Midland International, Consumer Products Division, 1690 N. Topping, Kansas City, MO 64120.

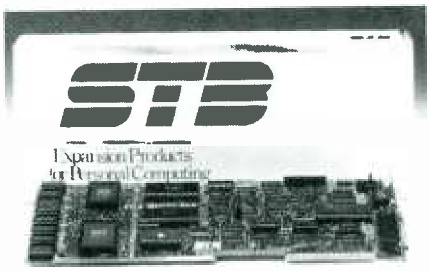
VGA Upgrade Chip

This unit is an inexpensive ROM BIOS replacement that gives users a convenient upgrade to the new IBM 640×480, 2- and 16-color VGA video standard with the EGA Multi Res adapter.

When installed on the EGA Multi Res video adapter, the BIOS chip provides support for VGA 640-by-480, 2 and 16 color modes on multifrequency monitors. Because VGA compatibility is maintained through hardware support at the BIOS level, no preboot software or unique drivers are required.

By adding VGA capabilities to existing features, the BIOS upgrade protects the investment of EGA Multi Res users. Current EGA Multi Res adapters can be enhanced with the upgrade, and new shipments will include the new ROM BIOS as a standard feature.

In addition to VGA support, the EGA Multi RES provides a variety of high-resolution 16 color modes on a large selection



CIRCLE 72 ON FREE INFORMATION CARD

of monitors. The adapter displays EGA software in 640-by-350 on multifrequency, EGA and 25Khz monitors.

The board also produces a superior 832-by-350 resolution on EGA monitors. On multifrequency monitors, the adapter generates higher resolutions of 640-by-480 and 752-by-410, in addition to the new VGA modes. The EGA Multi Res is fully compatible with the IBM PC, XT, AT and equivalent systems.

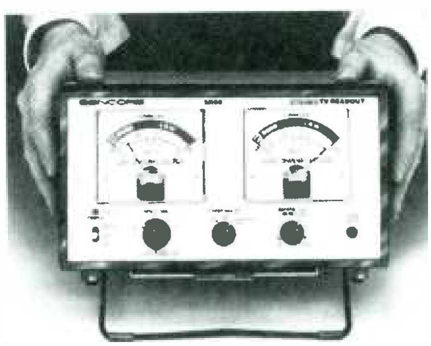
The BIOS upgrade for the EGA Multi Res is available for only $25.00 from STB. Customers wanting to order the chip should write to STB Systems, Inc., ATT: Customer Support, 1651 North Glenville, Suite 210, Richardson, Texas 75081. Or customers can call STB's Customer Support at 214/234-8750.

The EGA Multi Res adapter, which now includes the new BIOS, sells competitively for $399.00 (US suggested resale). The adapter is available through STB dealers and distributors.

For more information about the EGA Multi Res contact STB at 1651 North Glenville, Suite 210, Richardson, Texas 75081; Tel. 214/234-8750.

Stereo-TV Readout

The SR68 Stereo-TV Readout allows the service technician to measure the output of audio amplifiers, either at the line or speaker outputs. The SR68 incorporates dummy loads that provide up to 100-watts-per channel of power dissipation to catch even elusive problems that may show only when components are stressed at their full potential. The SR68 Stereo-TV Readout provides dual meters to visually monitor the outputs, and measure the



CIRCLE 78 ON FREE INFORMATION CARD

audio levels directly in either dB or Watts.

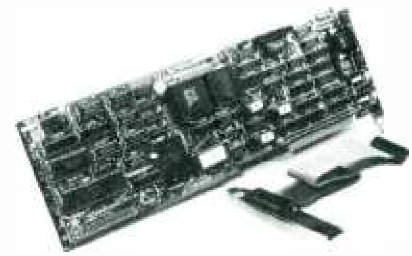
Sencore's SR68 allows technicians to automatically measure audio separation of stereo circuits to as low as -40dB, without having to refer to calculations, by simply turning one knob. The unit gives the user the convenience of a portable by operating 50 hours on one charge, and utilizes an auto-off feature to help conserve batteries for long life.

The SR68 sells for $595, and is supplied with a PA235 power adapter. Optional accessories include a BY234 lead-acid battery for portable operation ($59.95), and a PC253 protective cover/lead storage ($49.95). Contact Sencore Inc., 3200 Sencore Dr., Sioux Falls, SD 57107; Tel. 800/843-3338.

Multisync Color-Graphics Board

The MultiSync Color-Graphics Board Model GB-1, is an ultra high resolution (640x480), 16-color display card (from a palette of 64 colors) for use with an NEC MultiSync Color Monitor or its functional equivalent.

The MultiSync Color-Graphics Board resolution sets a new graphics standard beyond EGA (Enhanced Graphics Adapter) when displayed on an NEC MultiSync Monitor. That resolution matches the IBM Professional Graphics Controller (PGC or PGA-Professional Graphics Adapter) in resolution but at an EGA price. The suggested retail price for the model GB-1 is $549.00.



CIRCLE 89 ON FREE INFORMATION CARD

Compatibility for running software in CGA (Color Graphics Adapter), EGA, MDA (Monochrome Display Adapter) and Hercules modes is made possible through the MultiSync Color-Graphics Board's hardware trapping which is faster than software trapping and supports all functions of true EGA. Users with extensive software libraries won't have to update their software in order to benefit from GB-1's many features.

The Extended text modes enable users to display a full page of text (80 characters by 60 lines) or spreadsheets with up to 132 columns by 44 lines providing a wide range of terminal emulation capabilities.

The MultiSync Color-Graphics Board also provides screen drivers to allow users

(Continued on page 12)

CIRCLE 6 ON FREE INFORMATION CARD

Train for the Fastest Growing Job Skill in America

Only NRI teaches you to service all computers as you build your own fully IBM-compatible microcomputer

NEW! Train with the newest Sanyo 880 Series Computer—it's fully IBM-compatible and runs almost twice as fast as the IBM PC!

With computers firmly established in offices—and more and more new applications being developed for every facet of business—the demand for trained computer service technicians surges forward. The Department of Labor estimates that computer service jobs will actually *double* in the next ten years—a faster growth rate than for any other occupation.

Your NRI total systems training includes all of this: NRI Discovery Lab® to design and modify circuits • Four-function digital multimeter with walk-you-through instruction on audio tape • Digital logic probe for visual examination of computer circuits • Sanyo 880 Series Computer with "intelligent" keyboard and 360K double-density, double-sided disk drive • High resolution monochrome monitor • 8K ROM, 256K RAM • Bundled software including GW BASIC, MS DOS, WordStar, CalcStar • Reference manuals, schematics and bite-sized lessons.

Total systems training

No computer stands alone . . . it's part of a total system. And if you want to learn to service and repair computers, you have to understand computer *systems.* Only NRI includes a powerful computer system as part of your training, centered around the new, fully IBM-compatible Sanyo 880 Series computer.

As part of your training, you'll build this highly rated, 16-bit IBM-compatible computer system. You'll assemble Sanyo's "intelligent" keyboard, install the power supply and disk drive and interface the high-resolution monitor. The 880 Computer has two operating speeds: Standard IBM speed of 4.77 MHz and a remarkable turbo speed of 8 MHz. It's confidence-building, real-world experience that includes training in programming, circuit design and peripheral maintenance.

No experience necessary—NRI builds it in

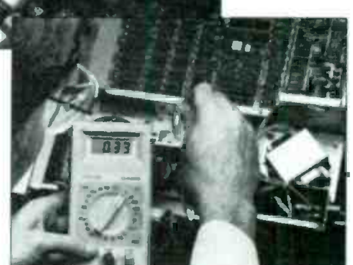
Even if you've never had any previous training in electronics, you can succeed with NRI training. You'll start with the basics, then rapidly build on them to master such concepts as digital logic, microprocessor design, and computer memory. You'll build and test advanced electronic circuits using the exclusive NRI Discovery Lab®, professional digital multimeter, and logic probe. Like your computer, they're all yours to keep as part of your training. You even get some of the most popular software, including WordStar, CalcStar, GW Basic and MS DOS.

Send for 100-page free catalog

Send the post-paid reply card today for NRI's 100-page, full-color catalog, with all the facts about at-home computer training. Read detailed descriptions of each lesson, each experiment you perform. See each piece of hands-on equipment you'll work with and keep. And check out NRI training in other high-tech fields such as Robotics, Data Communications, TV/Audio/Video Servicing, and more.

If the card has been used, write to NRI Schools, 3939 Wisconsin Ave., N.W., Washington, D.C. 20016.

NRI is the only technical school that trains you as you assemble a top-brand microcomputer. After building your own logic probe, you'll assemble the "intelligent" keyboard . . .



. . . then install the computer power supply, checking all the circuits and connections with NRI's Digital Multimeter. From there, you'll move on to install the disk drive and monitor.

NRI SCHOOLS
McGraw-Hill Continuing Education Center
3939 Wisconsin Avenue, NW
Washington, DC 20016
We'll Give You Tomorrow.

NEW PRODUCTS SHOWCASE

(Continued from page 8)

of Lotus 1-2-3, Media Cybernetics' Dr. Halo, and AutoDesk's AUTOCAD to take full advantage of 640×480 resolution mode and Miscrosoft Windows. In addition, NEC has a growing list of software developers who are committed to supporting the GB-1's extended modes.

Incorporated into the MultiSync Color-Graphics Board are several other special features, including: Parallel Printer Port, which supports the I/O port of the LPT1 or LPT2 to open up a slot on the user's PC; a free Printer Spooler utility for higher user productivity, and Hardware Zoom and Viewport, to allow users to zoom in up to eight times closer to magnify screens for detailed viewing or pixel editing. There is a potential 300% speed improvement by using an ET2000 chip set with a micro-engine to assume certain CPU functions, such as memory write/read tasks associated with bit-mapped graphics displays.

For further information contact NEC Home Electronics Inc., 1255 Michael Drive, Wood Dale, IL 60191; Tel. 312/860-9500 ext. 4244.

Portable PC

The T1000 features an 80C88 microprocessor running at 4.77 megahertz, with a single 720-kilobyte 3.5-inch diskette drive.

Measuring 12.2 inches wide by 2.05 inches high by 11 inches deep, the fully portable PC has a built-in handle and rechargeable NiCad battery for up to five hours of cordless computer use.

The unit's 110 VAC power adapter can be used for recharging or line operation. An optional automobile power adapter gives additional power on-the-road.

Equipped with 512KB of random-access memory, the system can be enhanced with an optional 768KB memory card for an additional 128KB user-RAM and 640KB Lotus/Intel/Microsoft expanded memory specification.

Operating with MS-DOS 2.11 in read-only memory, the T1000 is designed for efficient use of a single drive system. Automatic "booting up" from ROM leaves

CIRCLE 81 ON FREE INFORMATION CARD

the diskette drive free for loading application programs.

Full system capabilities are provided by the T1000's six standard ports: parallel printer, RS-232C serial, RGB color video, composite video, external 5.25-inch diskette drive and external numeric keypad.

A real-time clock/calendar and space for Toshiba's optional 300/1200 bits-per-second Hayes-compatible modem are also built in.

Documentation includes a user manual and MS-DOS quick-reference card. A complete MS-DOS 2.11 manual is available, as well as MS-DOS 3.2 on 3.5-inch diskette and manual.

Toshiba's optional 5.25-inch external diskette drive or Floppy Link, a device that connects a desktop PC's drive to the T1000, provides a mode of transferring data to and from 5.25-inch diskettes.

Toshiba's one-year parts and labor warranty, including free enrollment in the "Exceptional Care" replacement program, supports the new T1000. The unit is priced at $1199. For more information contact Toshiba America, Inc., Information Systems Division, 9740 Irvine Blvd., Irvine, CA. 92718; Tel. 800/457-7777.

PC-Based Storage Oscilloscope

Here's a 2-channel 20 MHz digital storage oscilloscope that uses the PC for display and storage—the first technically advanced, full featured PC-based scope for less than $3500. A unique combination of high speed, large memory, programmable gain and 2 simultaneous channels utilizing the power of the PC. Works with IBM PC, XT, AT and compatible computers. Turnkey software allows you to install it and get it running in 2 minutes.

Applications: Electronics, Biomedical, Speech Analysis, Chemical, Automotive, Power, and Data Acquisition. Features include: 2-channel simultaneous acquisition, 20-MHz sampling rate per channel, deep 64K byte buffers per channel, 8 bits of accuracy, switch selectable 1-Megohm or 50-ohm BNC input with warning light, programmable gain from 10 mV/division to 50 V/division, programmable sample rate from 1 Hz to 20 MHz in 1/2/5 sequence, pre- and post-triggering capabilities, digital or analog, internal or external trigger, AC or DC coupling, automatic channel calibration, menu-driven operation, cursor with time/voltage readout, screen dumps to printer, save/retrieve to/from disk, options include: real-time spectrum analysis using FFT 128K-byte buffers per channel

The price of the R2000 is $3495, and it is available from Rapid Systems Inc., 433 N 34th Street, Seattle, WA 98103; Tel. 206/547-8311.

CIRCLE 68 ON FREE INFORMATION CARD

Liquid Electrical Tape

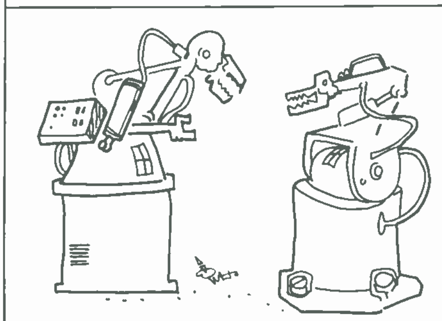
The product is a liquid vinyl, which is applied to wire or terminal junctions to seal out moisture and prevent corrosion. The coating also helps hold wires and terminals together so that vibration does not result in a loose connection.

Starbrite Liquid Electrical Tape is extremely easy to use—apply with the applicator brush/cap and let dry. Unlike conventional electrical tape, the protected connection is neat, clean, and totally waterproof.

CIRCLE 55 ON FREE INFORMATION CARD

Starbrite Liquid Electrical Tape is available in 4 fl. oz. for $4.95 and 32 fl. oz. for $24.95, and it comes in black, red, green, and white. Larger size containers are available for large-scale industrial use.

For further information contact Starbrite, 3650 Hacienda Blvd., Building F., Ft. Lauderdale, FL. 33314; Tel. 800/327-8583 (in Florida 305/587-6280).

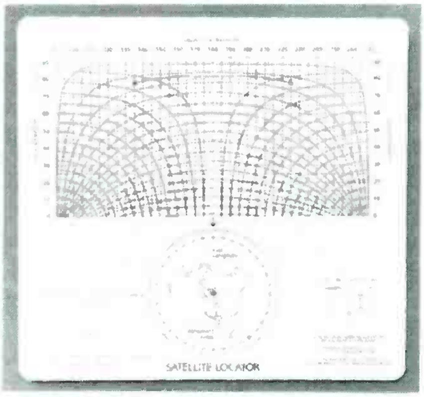


"I just found out... we are industrial workaholics!"

Satellite Locator

A slide rule that gives azimuth/elevation angles to geosynchronous satellites from almost anywhere on Earth is available from WTS Products.

On that one slide rule is included: a visual representation of the full satellite arc, horizon-to-horizon, around the world, even from the southern hemisphere, with local azimuth and elevation angles, U.S. satellite longitude positions, a magnetic declination map of the U.S., a true-to-magnetic azimuth conversion slide rule, and handy formulas for greater precision.



CIRCLE 88 ON FREE INFORMATION CARD

The device allows the quick determination of az/el angles from anywhere on Earth that the satellite arc is visible. A magnetic declination map and a true/magnetic slide rule on the back allows the true azimuth to be converted to local magnetic azimuth. The az/el formulas are also printed on the back to allow more precise angle computation with a portable calculator.

The price is $10 each (shipping included). For more information write to WTS Products, 4308 South Peoria, Suite 681, Tulsa, OK 74105.

Logic Analyzer

The 16-bit Logic Analyzer kit can be used to troubleshoot or verify the proper operation of circuits that contain sequential and/or combination logic. Included with the Analyzer is special software making it fully keyboard-configurable and menu-driven.

The Logic Analyzer has 16 data lines. There is also a clock input and two clock-qualifier inputs. The analyzer is compatible with TTL and 5-volt CMOS logic.

With the accompanying software, the Logic Analyzer enables a computer to show state and timing displays including hex/octal and ASCII equivalents, an address relative to triggering, and other information. That data can then be saved on disk for later examination or comparison. Other operations include a checksum capability with bit selection for easy com-

CIRCLE 91 ON FREE INFORMATION CARD

parison of acquired data, and the ability to search the data for a specific bit pattern.

On-screen help, prompting, status, and error-reporting are available in both the PC- and terminal-modes of operation. A number of positioning commands determine how data captured in the 2K × 16-bit acquisition memory are displayed.

The Logic Analyzer can be configured to capture a specific sequence of pulses, unlike an oscilloscope or logic probe. A single or repeating trigger with selectable time delay can be used to capture a window of pulses. Use the delay mode to acquire data up to 50,000 clocks after trigger, or use the non-delay mode to view events 2,000 pulses before trigger.

The Heathkit IC-1001 Logic Analyzer can be used in circuits with clock speeds of up to 10 MHz. It has a standard RS-232 serial connector for linking up to a computer or terminal and features automatic baud-rate selection between 300 and 19.2K baud. There are also oscilloscope trigger outputs for use with a scope. The IC-1001 has high-impedance inputs for minimum circuit loading while all inputs attach to circuits by convenient spring-loaded clips. The retail price of the Heathkit IC-1001 is $269.00. For further information about the Heathkit IC-1001 Logic Analyzer contact Heath Company, Department 150-935, St. Joseph, MI 49022.

"Herbie traded with me a lot of baseball player cards for your FactCards! His dad says, 'Thanks.'!"

FREE INDEX for 1987 issues
See Page 98 for Free Coupon

LETTER BOX

Crossover Crossing

Thanks for the article on the XMI Crossover Network in the November, 1987 issue of **Hands-on Electronics**. I detected a few glitches. In the circuit diagram, resistor R6 is not connected to pin 1 of U2, but to pin 7 of U3.

In the Parts List, resistor R3 was grouped with the 100K resistors when it is 210K.

In Fig. 8, the Hi and Lo outputs of the right channel are reversed. This is easy to figure out because both low inputs are summed for a common sub-woofer.

Please inform your readers that we usually ship orders within one week.
—Phil Marchand, Pres.,
Marchand Electronics, Inc.
Webster, NY

The Board Was Flipped

The PC board layout for the Economy NiCd Battery Charger in the March, 1987 issue was wrong. I did get the unit to work fine by making a change in the parts layout and another on the solder side of the board. The problem was caused by inversion of the PC negative when the copy was made. The negative should have been flipped over so that Q5 is shown at the top left side of the copy.

Because the negative wasn't flipped, the standby LED (LED2) and low-input LED (LED3) are receiving outputs from opposite opamps. That will cause LED2 to light up at low-input voltages and LED3 to light up when it is in a standby position. By reversing the red and amber LEDs they will operate properly.
—M.C., Far Rockaway, NY

There are detailed directions for using the flipped board, and those are too long to give here. Best bet is to follow the schematic diagram very carefully when using a board made on the "unflipped" side; or reverse the negative and make the board the correct way.

Wants a DCNAP

I enjoyed the article in the October, 1987 issue about ACNAP (the PC Computer AC Network-Analysis Program) very much. Why not follow it up with a few details about using it to analyze DC networks, and how to use the Independent current source, voltage-controlled current sources and Independent voltage source options to represent other components?
—C.H., Sikeston, MO

What you ask is a whole new programming project. We'll ask the author to look into it.

Give Me a K! Give Me a C!

I am referring to Louis E. Frenzel Jr.'s remark in the caption for Fig. 16 on page 81 in the November 1987 issue which reads, "Why anyone would abbreviate cathode with a K is beyond me."

K has been used as cathode designator for many years and is an industry shorthand. Suffice it to say, C could not be used as it is used as the designator for transistor collectors in the industry.

It's remarks such as this that are uncalled for and greatly reduces my opinion of both the author and the magazine. Such a comment should have either been deleted, or, to better service the reader, the author could have offered an explanation for "K" being used.
—J.D., Roseville, CA

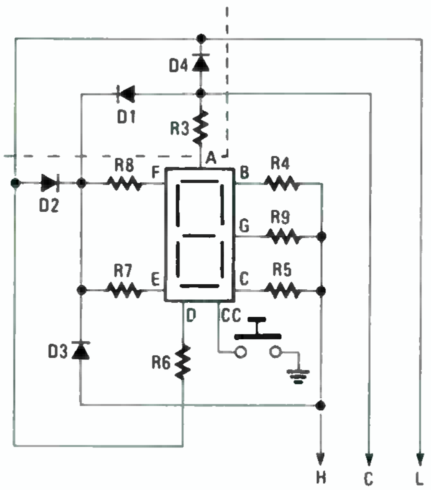
Not all of us, authors and readers, are old enough to have been around when the first cathode-ray tube was made and the designations (possibly in German or French) identified the elements of the tube. The English didn't want to use a C because it would be confused with capacitance, but the Americans used C for collectors and K for relays. So, if you are looking for logic in the use of K or C, don't.

Better Late than Never

Over a year ago, I purchased the May/June 1986 issue of **Hands-on Electronics**. However, the magazine got lost amongst my many hobby magazines, and it was not found until several weeks ago. Last week I built the Super ESP Tester which is a project in that issue.

After I built the project I found that the two middle segments in the letter C were not lighting up properly; the H and L segments lit up properly. My troubleshooting revealed that the voltage for the two middle segments of C have to go through two diodes instead of one. Going through two diodes decreases the voltage substantially. After looking at the sche-

matic diagram I found that changing one diode connection and adding another diode, D4, as shown in the schematic diagram below, will make the middle segments of the C light up properly and the H and L will work as before.
—D.C., Savannah, GA



Thanks for the revised circuit which we are happy to pass on to our readers.

More of Police Radar Detection

I just read the letter printed in the Letter Box (November 1987 issue) from D.T.H., Columbia, MO, on the subject of your Trooper-Proof, Hide-Away, Radar-Detector System. I am in 100% agreement with the writer of the letter. I think the article encourages disregard of our motor vehicle laws. Mr. Pearson's perception that driving within the posted speed limits results in conditions less safe than exceeding the speed limit is a falsehood. The safety hazard is caused by those ignoring the speed limits. Let's put the blame where it belongs. Far too many people already share Mr. Pearson's twisted view.

The promotion of any device that is used primarily to hamper our police forces from effectively maintaining our highway safety standards is an action that places the safety of my family, myself, and the motoring public in jeopardy. Contrary to Mr. Pearson's perspective, speed limits are established to provide an acceptable level of safety on our highways. To ensure highway safety, we should be citing more speeders, not encouraging them to continue breaking the law.

I think your response to the letter on the article is inadequate. The reasons that you give supporting your position for printing the article are poor excuses for having done so.

The real issue here is not legal vs. illegal, which as you have stated, varies from state to state. The real issue is safety, and when you consider such articles, you have the responsibility to make a moral decision as to whether the printing of a particular article is in the best interest of the general public.
—W.C., Mechanicsburg, PA

If I open my mouth, I may let my foot out. (Editor)

He Cast His Ballot

I just got finished browsing through the October 1987 issue, and the editorial prompted me to jot down a few things. You make a good point, if we don't write it's like not voting! Here's a profile of one of your subscribers.

I'm a 34-year old electronics technician. I service X-ray film processors for my dinner, and I spend 2-3 evenings "playing" at my electronics bench per week. I've been faithful since Vol. 2 No. 2. I rejoiced from the start, because it meant there were enough of us out there to merit the bucks needed to put it together. Yes, I'm one of those guys who dumped Popular Electronics when they abandoned

(Continued on page 91)

BOOKSHELF

Sailing With Ham Radio
By Ian Keith and Derek Van Loan

This handbook is intended as a practical guide for the yachtsman who is interested in installing an amateur radio station aboard his boat. The installation process is covered in detail as are the subjects of antennas and on-the-air procedure. The presentation of theory is more general. In the licensing section the text refers to other publications that deal thoroughly with this subject.

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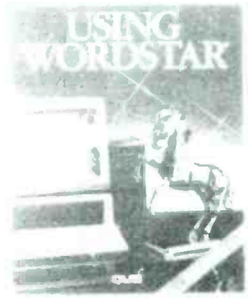
Sailing with Ham Radio covers numerous topics including: deciding between AM and single sideband, license procedure, antenna installation, and on air procedure.

The authors, Ian Keith and Derek Van Loan, are green-water sailors who developed their ideas while operating sailboat-based rigs. The 152-page text sells for $9.95 plus $1.00 for postage and handling. It is available in bookstores or can be ordered direct from Paradise Cay Publications, 1001 Bridgeway #405, Sausalito, CA 94965.

Using WordStar
By Steve Ditlea

Written specifically for MicroPro's new WordStar Professional Release 4, *Using WordStar5* will help both new and experienced users learn and master this version of the program.

WordStar is perhaps the most popular word-processing program of all time. With more than 2-million copies sold, MicroPro claims a base of 4 million "WordStar-literate" users. The latest version of WordStar, Release 4, adds more than 125 new features to the classic program. Incorporating a unique tearout



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Command Reference Chart, this easy-to-follow book has something to offer all WordStar users. *Using WordStar* will help new users learn WordStar basics with step-by-step tutorials, install and format WordStar for their own needs, master WordStar's powerful dot commands, use handy shortcuts to simplify their word-processing tasks.

Users of previous versions of WordStar will find that *Using WordStar* helps them quickly identify Release 4's new commands, learn and master all the new features of Release 4, customize WordStar to their own specifications, develop timesaving shorthand macros, perform sophisticated merge-printing tasks, integrate WordStar with other programs.

The 560-page text is available at better book stores. To order directly from the publisher, write to Que Corporation, 7999 Knue Road, Suite 202; or telephone 1-800-428-5331 and ask for a sales representative. The text sells for $18.95.

Systems Design with Advanced Microprocessors
By John Freer

This important reference provides comprehensive, practical, design specifications for many popular 32-bit microprocessors now being used by design engineers. The Motorola MC8020 and the Inmos T414 Transputer are covered extensively and their differences are emphasized.

Topics covered include new architectures and design features, survey of

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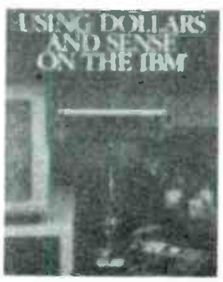
advanced microprocessors (including Intel 80386 chip), Motorola MC68020, Inmos T414 Transputer, 32-bit backplane buses, memory and storage devices, communications interfaces, software options and development systems, design factors, and alternative system architectures.

The author, John Freer, is a principal consultant and technical group manager for networks with Software Sciences Limited, one of the United Kingdom's leading computer systems companies and a part of Thorn-EMI.

Systems Design with Advanced Microprocessors, is 288-pages long and retails for $26.95. Available at major bookstores, college bookstores, or direct from the publisher: Howard W. Sams and Company, 4300 West 62nd Street, Indianapolis, IN 46268.

Using Dollars and Sense on the IBM
By Steve Adams

Unlike previous books, *Using Dollars and Sense on the IBM* is written exclusively for the versions of Dollars and Sense that are designed to run on IBM PCs and compatibles.



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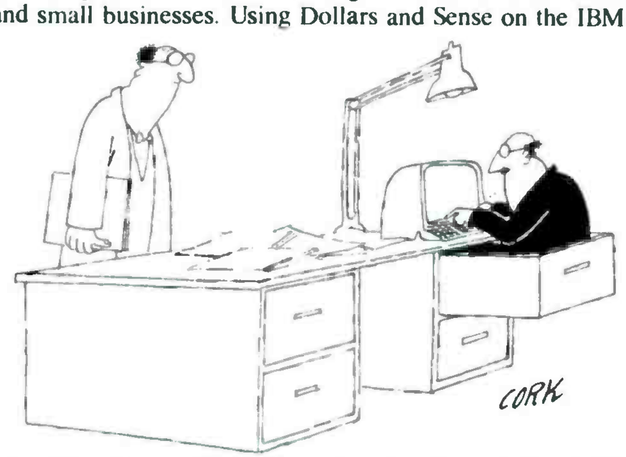
Dollars and Sense is a personal finance software program that computerizes basic accounting functions for individuals and small businesses. Using Dollars and Sense on the IBM



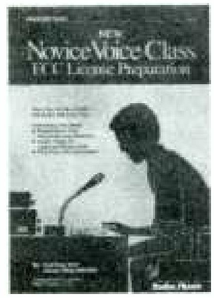
will help readers get the most out of the program, teaching them how to design personal accounting systems, consolidate files for unified reports, design graphs to analyze finances, streamline transaction entries, evaluate "What if?" scenarios, and effectively manage business finances.

The 464-page text is available at better book stores. To order directly from the publisher, write to Que Corporation, 7999 Knue Road, Suite 202; or telephone 1-800-428-5331 and ask for a sales representative. The text sells for a mere $17.95.

New Novice Voice Class Amateur Radio

There is new interest and excitement in Amateur Radio. Recent FCC rules changes have expanded entry-level ham radio privileges. This has sparked the public's interest in becoming Amateur Radio operators. No longer are entry Novice Class operators restricted to just Morse code operation. Now they can communicate with voice transmissions, use FM repeaters, patch ham radios into the telephone system, and link and transmit data using personal computers.

The *New Novice Voice Class* instructional package from Master Publishing contains everything needed to learn about, prepare for, and pass the new Novice Voice Class examination and obtain a Novice Class Amateur Radio operator's license. With the use of two

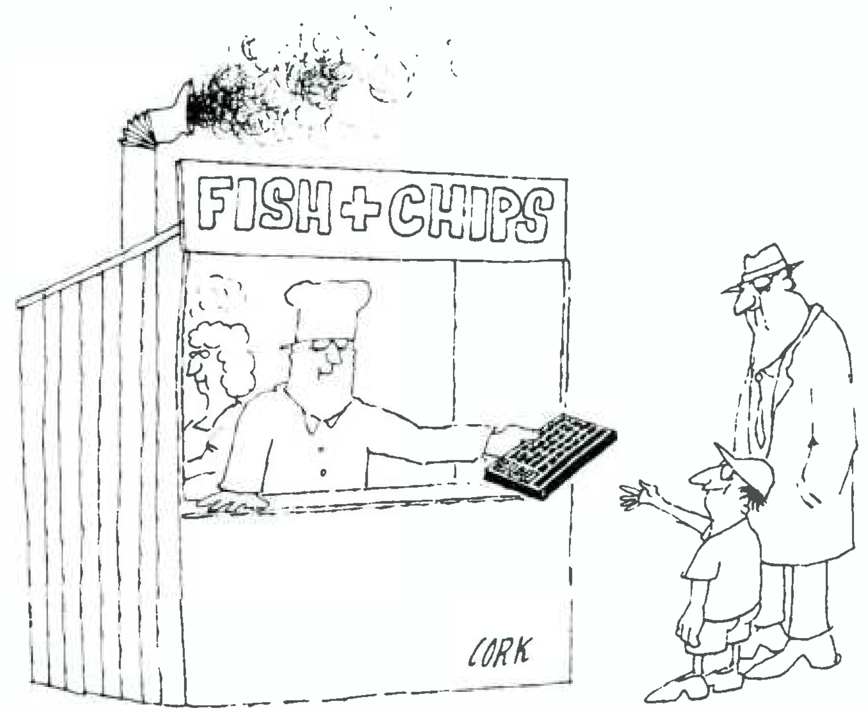


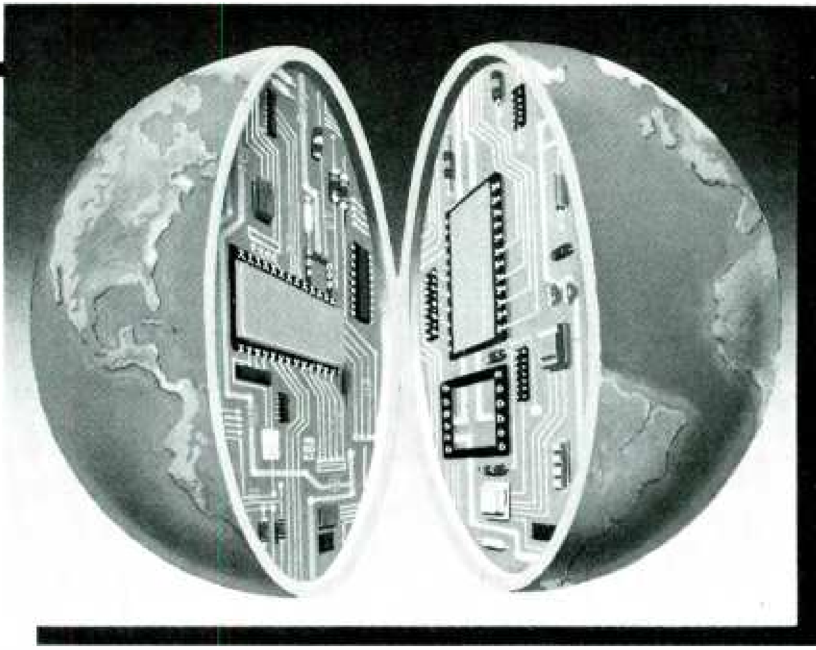
CIRCLE 87 ON FREE INFORMATION CARD

audio cassette tapes and a 112-page book, the instructional package provides all the material to learn and pass both the code and theory elements of the Novice Class examination.

The two sided, 44-minute cassette tapes use a fun method to teach the student how to receive and send five-words-per-minute CW (Morse code). The book contains a 302 question pool from which the examiners select 30 questions for the theory examination. Each question contains multiple choice answers, the correct answer and an explanation as to why the selected answer is correct. Charts, diagrams, and equations, illustrate the subject matter to make the learning process easy. The 112-page book, two audio cassette tapes, and the FCC license application Form 610 are all assembled in a durable vinyl binder. Also included are directions for the examiners under the new volunteer examination system.

(Continued on page 22)





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BOOKSHELF

(Continued from page 18)

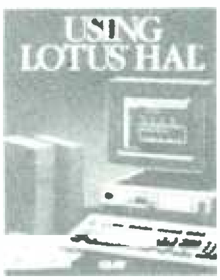
Valuable exam clues and "insider" study tips are provided by the co-authors, two well-known ham radio operators with over 55 years of amateur radio experience. Fred Maia, W5YI, and Gordon West, WB6NOA, both respected Extra Class Amateurs in their own right, use their insight and experience to help prospective hams learn how to qualify and communicate as a licensed Novice Amateur Radio operator.

In easy-to-understand language and easy-to-follow instructions, the self-teaching package assists prospective applicants to pass the examinations. Now they may enjoy the FCC changes that provide the new Novice enhancement privileges.

Published by Master Publishing, the New Novice Voice Class is available in Radio Shack stores across North America for $19.95.

Using Lotus HAL By David Gobel

1-2-3 users have finally found relief from cumbersome command sequences. Working within 1-2-3, Lotus HAL allows simple English-language requests to replace the normal multistep 1-2-3 commands.



CIRCLE 94 ON FREE INFORMATION CARD

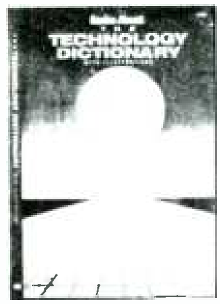
Using 1-2-3, which has sold more than one million copies, is Que's most popular book. Many of *Using 1-2-3*'s readers will want *Using Lotus HAL* to help them master 1-2-3's new companion program. With three different sections corresponding to varying user skill levels, *Using Lotus HAL* teaches 1-2-3 users how to streamline their spreadsheet tasks with Lotus HAL.

Readers will learn easier methods of spreadsheet and graph creation, ways to tailor Lotus HAL vocabularies, undocumented and underdocumented features of Lotus HAL, and additional features (such as 1-2-3 shortcuts, expanded reporting techniques, new auditing features, and easy-to-create macros).

This 500-page Que book, *Using Lotus HAL*, is available for $19.95 in most college bookstores and computer stores. To order directly from Que, call 1-800-428-5331 and ask for a sales representative.

The Technology Dictionary

Almost everyone is touched by electronics these days in some phase of their life. As a result, they must understand or speak the language of the constantly changing high-technology electronic age. A shortcut and real aid to bridge the gap and keep up with technology is a new book from Master Publishing, *The Technology Dictionary*.



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The 176-page book provides a handy reference for layman, technician, professional, hobbyists, engineer and those needing clear, concise definitions of the latest technology jargon, acronyms, and the high-tech terms used in the design, manufacturing, marketing, and maintenance of all types of electronic equipment. Over 2500 current electronic terms and abbreviations are listed with over 150 of them with illustrations.

A handy reference section, located at the front of the book, lists industry abbreviations, acronyms, and special symbols. Definitions in an easily accessible format provide the reader with an up-to-date guide to keep abreast of the leading-edge technologies.

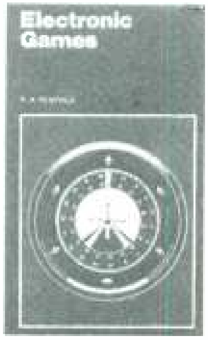
Designed for anyone in business, education, or at home who needs to keep in touch with the language used to communicate in the high-tech industries of electronics, computers, telecommunications, instrumentation, video and consumer electronics.

Published by Master Publishing, *The Technology Dictionary* is available in Radio Shack store across North America for $5.95.

Electronic Games
By R.A. Penfold

One of the most recent and popular applications of micro-chip technology has been the advent of the numerous electronic toys and games now available in many consumer outlets. Some of these games are simple, others are much more complex, most however are rather expensive.

In *Electronic Games* the author has designed and developed a number of interesting electronic game projects using modern integrated circuits which can easily and inexpensively be constructed by the enthusiast.



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The text is divided into two sections, the first deals with simple games and also gives complete stripboard layouts to facilitate construction. The second section deals with more-complex circuits, so making the book ideal for both beginner and the more experienced constructor alike.

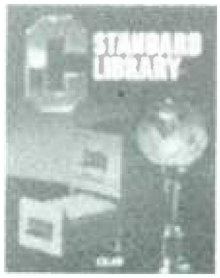
Selling for $5.00, the book contains 90-pages and is available from Electronics Technology Today, P.O. Box 240, Massapequa, NY 11752. Include $1.00 for postage and handling.

C Standard Library
By Jack Purdum

C programmers will be able to enhance their knowledge, skill, and use of the library functions in the proposed ANSI standard and SYSV with Que's *C Standard Library*.

This text helps programmers understand each of the library functions in the proposed American National Standards Institute (ANSI) X3J11 standard for the C programming language. It also covers additional functions from AT&T's UNIX System V (SYSV) standard library.

Using the *C Standard Library*, programmers will learn what each function does and how to use the function in their programs, see how each function



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is used in a sample program, avoid errors that are often made when using C standard library functions, and understand the ANSI enhancements to the C language that effect the new library (e.g. prototyping).

Arranged by function use, Chapters 4 through 9 cover converter, string processing, math, input/output, utility, and time functions. To help programmers find a function easily, each chapter presents functions in alphabetical order. A special function index lists all the functions according to name and task. A companion disk, sold separately, is available for $39.95.

To order directly from Que, telephone 1-800/428-5331 and ask for a sales representative. *C Standard Library* retails for $21.95. Better book stores and computer outlets.

Practical Electronics Calculations and Formulas
By F.A. Wilson

This book has been written not for the family bookshelf but as a workshop manual for the electronics enthusiast. Its aim is to bridge the gap between complicated technical theory, which sometimes seems to have little relevance to practical work and cut-and-try methods which may bring success in design, but leave the experimenter unfulfilled.

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There is, therefore, a strong practical bias, tedious and higher mathematics have been avoided where possible and many tables have been included,

(Continued on page 88)

SCOPING OUT THE SCOPE MARKET: HOW TO SELECT AN OSCILLOSCOPE

Oscilloscopes today have so many features it's hard to decide what's right for you. Here's a little help for the money minded.

By Dave Herrington

THE BOOMING ELECTRONICS INDUSTRY HAS INUNDATED SOCIETY with new and enhanced products over the last decade. Most of those products are based on sophisticated, complex circuitry, of both digital and analog type. When something goes wrong, equally sophisticated equipment is required to test and troubleshoot the device in question.

Fortunately for those in the electronics service industry, one of the basic tools of the trade has kept up with market demand. Recent advances in oscilloscope technology and design make available higher performance at lower retail cost. For example, a 50-MHz scope that ten years ago would have cost over $1,800 is now available for under $1,000. During that same period, many other operating costs have doubled. To keep costs down, denser IC's with more functions are used, reducing the circuit-board components count, while simplifying manufacturing. Fewer extended connections also mean increased instrument reliability.

But, do you really need a 50-MHz scope? In today's world, the answer is probably yes. Along with a higher bandwidth, additional features may be required as well. A scope with the right features for the job decreases the amount of time spent on service calls by improving detection and accuracy, while reducing errors. To achieve increased productivity, a number of factors should be considered when purchasing an oscilloscope.

Bandwidth, Risetime, and Sensitivity

Bandwidth, risetime, and sensitivity are the fundamental specifications for an oscilloscope, because they determine what can and cannot be displayed on the screen. If those measurement factors are inadequate, certain glitches may escape detection, and aberrations may appear that are generated by the scope rather than by the equipment being tested. As a general rule, time-measurement accuracy is related to scope rise-time through a rise-time ratio (see Fig. 1).

Bandwidth, defined as the frequency a scope can handle with less than a 3-dB amplitude loss, is perhaps the prime measurement of oscilloscope performance. Oscilloscope amplifiers properly designed to minimize overshoot and ring have a simple relationship between step-response rise time

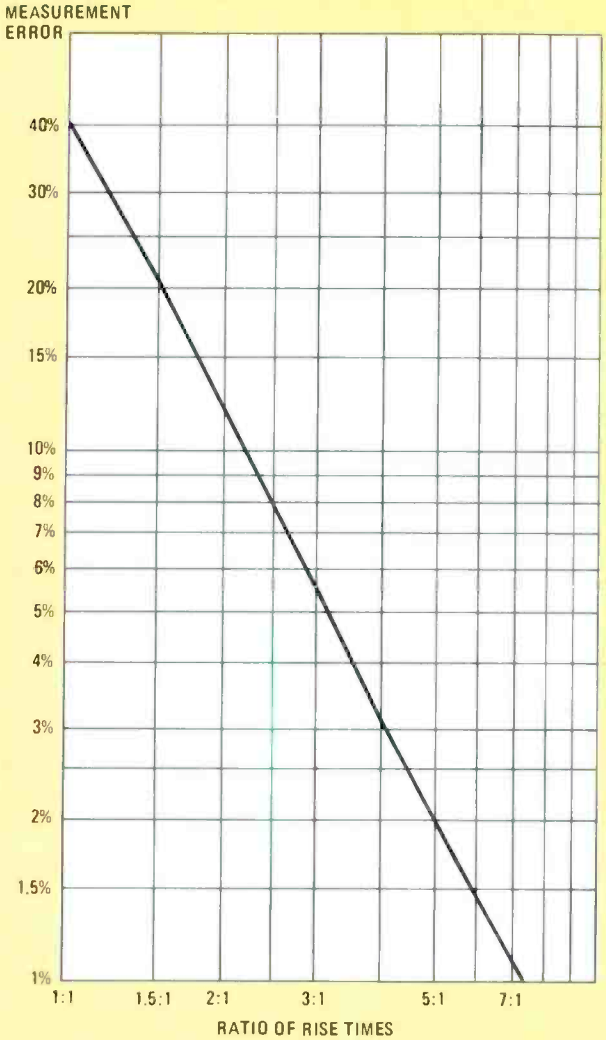


Fig. 1—Time-measurement accuracy is related to scope rise time through a risetime ratio. That can be described by the line graph shown here. It sets the golden limit.

and bandwidth. The rise time is 350 nanoseconds divided by the bandwidth in MHz. Therefore, a 50-MHz scope will have a risetime of approximately seven nanoseconds.

When a signal is applied to an oscilloscope, the displayed risetime is approximately the square root of the sum of the square of the scope risetime, and the source risetime. If the scope risetime is the same as the source, the display will be 40 percent in error. An oscilloscope risetime of one third of the source risetime will show a five percent risetime measurement error.

Higher bandwidth is almost a necessity in the current service market, where even the simplest digital circuits require a minimal bandwidth of 20 MHz. Television and communications applications also require high bandwidth.

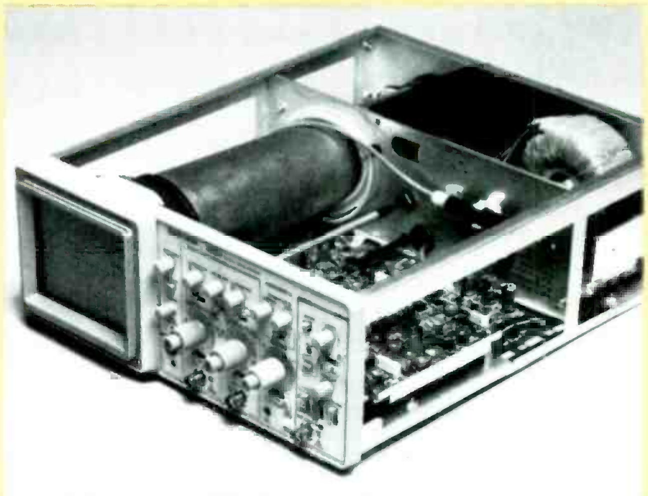
Considerations for determining bandwidth include edge speed and maximum clock speed. If edge speed is critical, as is the case when testing for timing violations, the scope should be at least twice as fast as the fastest edge that the logic can generate. If not, the service technician will be measuring his scope rather than the device under test. In terms of maximum clock speed, a bandwidth approximately 10-times greater than the maximum clock frequency is required to preserve fidelity.

The final measurement consideration is sensitivity, or the amount of signal amplitude (volts/divisions) the scope can display. Detecting low-level signals, power-supply ripple, and noise on both digital and analog waveforms can be problematic when vertical deflection falls below 5mV to 5 volts per division. High sensitivity can be used to look at low-level transducer signals such as magnetic pickups, or to look at voltage drops in ground runs or sense resistors.

Triggering Considerations

The triggering capabilities of an oscilloscope determine the stability of the signal display. While the normal trigger setting is adequate for many measurements, there are times, such as with television applications, when other methods are necessary. It is important to select a scope that provides alternatives such as peak-to-peak automatic, single shot (or sweep), and television line- and field-triggering modes.

Normal mode is applicable for selectively triggering on a specific wave-form feature, such as the examination of a pulse's falling transition. Peak-to-peak auto is helpful in initial scope setup and for probing unknown signals. That feature enables the scope to interrogate the wave form, establishing the highest and lowest voltage levels of an incoming signal. The trigger level is then automatically set between those two points. That eliminates manual trigger setting, saving a considerable amount of time.



Denser IC's add more functions, while reducing circuit-board count. The decrease in the number of connectors simplifies manufacturing and increases instrument reliability.

When signals occur randomly or at a low repetition rate, single shot is the best choice of triggering mode. That mode triggers a single display sweep when the signal occurs. It is particularly helpful in CRT screen photographics.

While they may cost a little more, TV field- and line-triggering modes are often necessary for triggering complex video signals. However, as more and more products incorporate raster scan displays (e.g, video terminals, video games and personal computers), those modes become increasingly necessary for general use. Service technicians whose scopes lack that feature will be at an increasing disadvantage.

Selective-trigger coupling enables the service technician to filter out both high- and low-frequency noise in order to home in on complex waveforms. With selective-trigger coupling, noise either above or below 30 KHz can be minimized, enabling the technician to clearly view the waveform in question.

Basic Oscilloscope Terms

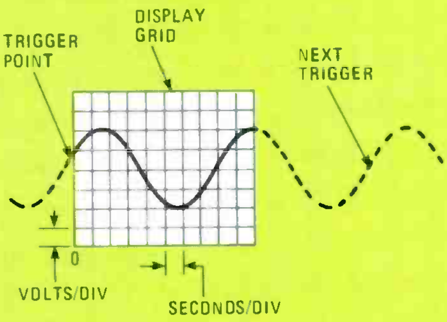
Bandwidth—The highest frequency signal a scope can display with no more than 3-dB amplitude loss compared to mid-band amplitude. For example, a 50-MHz, scope displays sinewaves from low frequency to nearly 50-MHz without changing their actual amplitude. Signals near 50-MHz are displayed at slightly less than actual amplitude due to the onset of frequency bandwidth limits. The maximum decrease is 3 dB (0.707 × voltage) at the 50-MHz bandwidth.

Risetime—A scope's response time for an instantaneous signal change. A scope with a 7-nanosecond rise time, for example, shows an instantaneous voltage step as lasting about 7 nanoseconds. For a scope to closely follow a signal change, such as a pulse edge, the change must take three or more times longer than the scope's risetime. Scope risetime is related to bandwidth by T_{rise} = 0.35/bandwidth.

Vertical Sensitivity—Amplitude scaling a scope gives to an input signal for a calibrated screen display. For example, a 1-volt/division vertical sensitivity setting causes a 1-volt signal change to span one vertical division on the screen's grid lines.

A 5-mV/division setting causes a 5-mV (5/1000 volts) to span one screen division or 20 mV to span four divisions.

Channel and Dual Channel—The signal input of a scope is a channel. A single-



channel scope or display mode uses one signal probe on one channel to display one signal on-screen. A dual-channel scope has two signal inputs (two probes) for displaying two different signals at the same time. For example, a circuit's input and output signals can be viewed simultaneously with a dual-channel scope.

Triggering Mode—Scope triggering determines where the signal display starts relative to the signal. For example, in Normal mode, the trigger level can be set for zero volts. That causes the signal display to start at the screen's left edge when the input signal crosses zero volts. In peak-to-peak automatic mode (P-P AUTO), the scope automatically generates triggers based on the input signal's peak-to-peak amplitude.

HF, LF Reject—Filters that can be selected to reduce noise on the signal going to the scope's triggering circuit. Noise, such as low-frequency (LF) hum from a light fixture or high-frequency (HF) interference from a motor, can cause triggering jitter, making waveforms jump around on the scope display. HF of LF reject filters reduce the triggering noise to produce stable displays.

Time Base and Dual Time Base—A timing circuit that determines the length of signal displayed across the screen and it's time scaling. A 2-millisecond/division setting displays 20 milliseconds (0.02 seconds) of signal (e.g. one cycle of a 50-Hz sine wave) on a display grid of 10 horizontal divisions. All scopes have at least one time base. Some dual-channel scopes have two time bases, allowing different time scaling on each channel.

Horizontal Alternate Magnification—A time scale multiplier that expands alternate traces of the input signal. One trace of the input signal is displayed at the time base setting and the alternate trace is horizontally expanded by 5, 10, or 50 times, allowing detailed displays of signal rise times for example. That is similar to a dual time-base capability, but without the expense or complications of actually having two time bases. ■

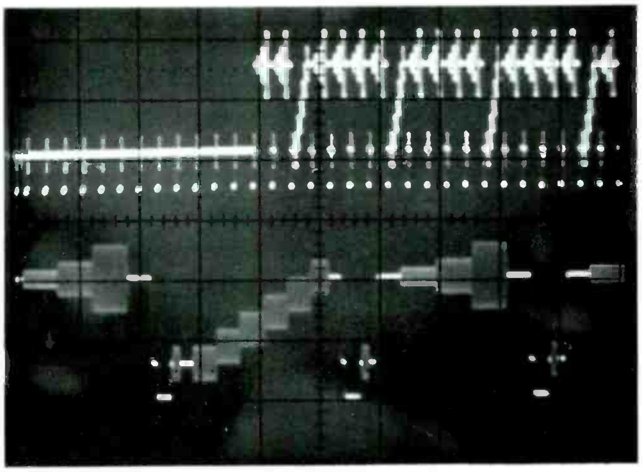
Additional Features

While measurement and triggering considerations are critical in scope selection, a number of other features can make life easier for the service technician.

Alternate horizontal magnification, for example, enables the user to scroll the waveform in search of anomalies. That feature can also be used to alternate between two display speeds, first viewing the magnified wave, and then the entire wave form to establish the location of an anomaly.

Dual input channels make comparisons and level adjustments easier by displaying signal input and output stages simultaneously. Those channels also can be used together in add mode for differential measurements.

Finally, intensity modulation uses an external signal to control brightness of the display, which can be useful when displaying time markers for synchronization. The entire wave form, or a portion of it, can be highlighted with that feature. A front-panel control for intensity modulation guarantees easy implementation of the feature.



The ability to synchronously trigger on a TV frame or a scan line is an important scope feature in a world that is becoming increasingly video (and video repair) oriented.

Ruggedness, Reliability, and Safety

Even with the improved price/performance figures, a new oscilloscope can represent a substantial investment. Therefore, be sure that the instrument is reliable and, particularly if it is portable, rugged.

Environmental factors affecting scopes include shock, vibrations, temperature extremes, and humidity extremes. Any one of those factors can damage an oscilloscope, making it nonfunctional or even unsafe.

Ruggedness and reliability can be determined by looking at several factors. A key consideration is the manufacturer's reputation. Has the company been around for a number of years? Does it have a good reputation for quality products? Does it provide good support and service? Positive answers to those questions speak well for the life of the oscilloscope.

Next, look at the warranty for the scope under consideration. The length of that warranty is a good indication of what you can expect in terms of performance. The longer the warranty, the more likely it is that the scope will perform well and withstand the rigors of the work environment.

You might also check to see if the scope has been designed to military specifications, which impose stringent standards on equipment. If its rugged enough to gain military approval, chances are the scope will stand up well to daily wear and tear in an industrial or shop environment.

Finally, check to see if the scope meets UL safety stan-

(Continued on page 94)

Reconstruct an historic artifact and listen to modern radio on a legend from the past!

BUILD A FOXHOLE RADIO

By TJ Byers

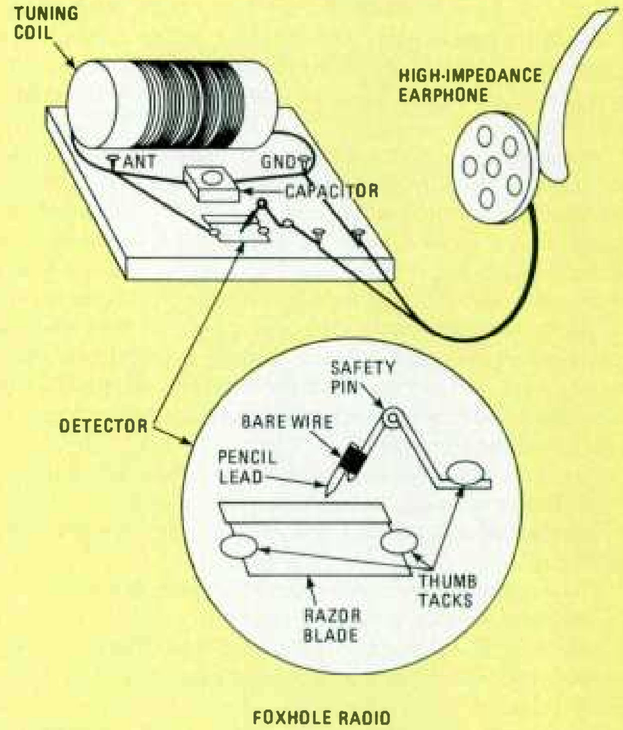


Fig. 1—The construction for this rustic looking (if not rusty looking) device is straightforward. If the tacks shown here don't work well, you can use large-headed nails.

SPENDING THE NIGHT ENTRENCHED CLOSE TO ENEMY LINES during World War II with only a rifle for companionship is not anyone's idea of having a good time. To help pass the long hours in that God-forsaken environment, many soldiers would listen to armed forces and local radio stations on a crude device that came to be known as the foxhole radio. Although humble, the legendary foxhole radio is one of the most fascinating anecdotes in radio history.

About the Foxhole Radio

The foxhole radio is a shining example of Yankee ingenuity at its finest. The foxhole radio was built exclusively from parts readily available to the foot soldier at the time. The unlikely bill of materials included a toilet-paper roll, razor blade, safety pin, nails, tuning capacitor, and a pair of headphones. Despite its unlikely medley of junk, it did work—and work well enough to help keep the sanity of many a GI intact.

Procuring the parts during war time, however, was another matter. Two of the seven components necessary for construction, the tuning capacitor and headphones, were not readily available to all servicemen. Only personnel working in a communications function, such as tank operators and navigators, had access to these precious items, and lore has it that it was not uncommon for a GI to barter a week's worth of cigarette rations to an obliging tank driver for a single set of headphones.

Building a Foxhole Radio

Duplicating the foxhole radio is as much a journey in history as it is a construction project. Its legendary origin notwithstanding, the foxhole radio features a list of parts as nostalgic as the era it came from. In fact, many of the parts have fallen into obscurity, and may be unfamiliar to some readers.

The entire radio is assembled on a simple wood base; an 8-inch length of 1 × 6 soft pine will do nicely. Soft pine is recommended because it is readily available as shelving material in any lumber store, and easy to work with. Pound four nails into the base as indicated in Fig. 1.

Construction begins with the assembly of the tuned circuit. The tuned circuit consists of a coil of wire and a variable capacitor. Those two components form a resonant circuit that allows the listener to select different radio stations by adjusting the variable capacitor.

The coil is made by winding a length of copper wire on the cardboard tube of a toilet paper roll (after the roll is exhausted). Because suitable wire was scarce at the front, the original coils were made from wire salvaged from one of the headphone's earpieces.

Our replica of the foxhole radio coil uses 26-gauge enameled copper wire available from Radio Shack and similar retail outlets. If you are into the foxhole spirit of building the radio from what can be begged, borrowed, or stolen, you will be happy to know the copper wire may be scrounged from an old bell transformer.

Begin the coil by punching two holes in each end of the cardboard tube about an inch from the ends. Now carefully wrap 120 turns of the wire around the tube beginning at one end and progressing to the other, keeping the windings in an orderly, spiral pattern. Use the end holes to prevent the wire from unraveling.

Mount the coil to the wooden base with thumb tacks, as illustrated in Fig. 1. Remove the insulation from the ends of the copper wire (about 2 inches back), and wrap the bared wire around its respective nail post. Fasten the tuning capacitor to the wooden base and run two wires from the capacitor to the coil nails so that the capacitor is wired in parallel with the coil. (Scavenger's note: The tuning capacitor may be found in old six-transistor radios.)

Talking Blades

The detector is made from a discarded razor blade and a length of pencil lead. The original design called for a single-edged razor blade for the detector. The last time I saw a single-edged razor, however, our president's last name read Kennedy.

Fortunately, suitable single-edged blades are still available from a friendly grocery clerk. The disposable blades are found in commercial box cutters used for opening cardboard cases. When asking for a blade, tell the clerk you prefer a used one; it will make him happier and the blade wear will give your radio an edge on performance to boot.

Gilette Blue Blades were also very popular with foxhole radios advocates, and are still sold by many stores. As I recall, there was always a debate between single-edge and Blue-Blade users as to which blade made the better detector. I preferred the single edge.

The razor blade fastens to the wooden base using thumb tacks. Before securing the blade in place, attach a short wire to the blade and connect the wire to the antenna side of the coil.

The detecting element is a piece of graphite extracted from an ordinary wooden pencil. A length of pencil lead about 1 inch long is sufficient. The pencil lead attaches to the pointed end of an open safety pin. Here is where things get interesting.

The pencil lead must make electrical contact with the safety pin while remaining mechanically rigid. In the old days, they would take a piece of bare wire and wrap several turns of it around the safety pin/graphite assembly as tightly as possible. That is both a time consuming and frustrating task that generally requires more than one attempt before success. Small notches in the pencil lead make the job somewhat easier, but at the risk of snapping the rod. A modern-day trick is to use a cyanoacrylate glue like Krazy Glue to secure the graphite to the pin before using the bare wire to make the electrical contact. Bend the head of the safety pin and attach it to the wooden base with a thumb tack as indicated.

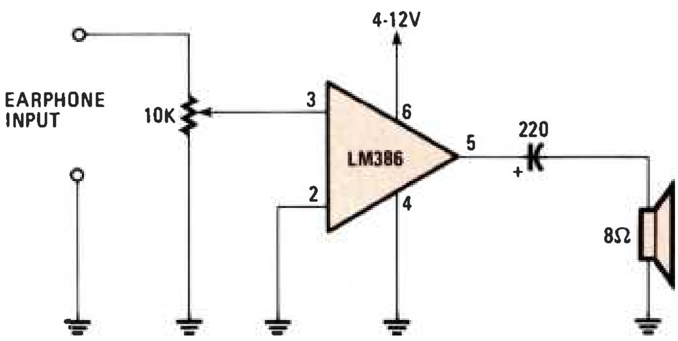


Fig. 2—If no high-impedance headset can be found, you can use this op-amp to act as a high-impedance buffer. It will drive low impedance speakers (8 ohms typically.)

Walkman it's Not

The last step is to connect a pair of high-impedance headphones between the safety pin and coil ground lines. It is imperative that the headphones have an impedance of 2000 ohms or higher. Walkman headsets—with their low 8-ohm impedance—will not work.

But coming across a pair of high-impedance headphones may not be easy. Like the single-edge razor, they have gone the way of all good things. If your Grandmother's attic still has the remnants of a crystal set or other vintage radio receiver, it is a good bet the headphones that came with the receiver will work. Another good source of high-impedance headphones are ham fests and flea markets. Some old timers still have a pair of those beauties stashed away in some long-forgotten box, and are willing to part with them.

For those of us not fortunate enough to procure this scarce item, we have included a single IC amplifier (Fig. 2) that allows you to listen to your foxhole radio through a speaker or 8-ohm headset. Placing the amplifier inside a plastic box apart from the foxhole radio itself maintains the authenticity of the original foxhole design.

Using the Radio

Now comes the fun part: A journey back into time as we listen to the world through a vintage receiver. Because the foxhole radio has no power of its own to boost the signal, the output volume is at the mercy of the received signal strength—which is dependent on the antenna signal. Simply put, the longer the antenna wire, the more signal you are going to receive, and the louder the station will be. Fifty feet or so of annealed copper wire makes an ideal outdoor antenna for foxhole reception.

Another requirement is a good ground. The best source of ground in modern houses are the plate screws found on all electrical outlets and switches. Avoid the traditional practice of using cold water pipes as a ground; plastic pipe has all but eliminated that once-potential ground source. And never—BUT NEVER—use a gas pipe for ground.

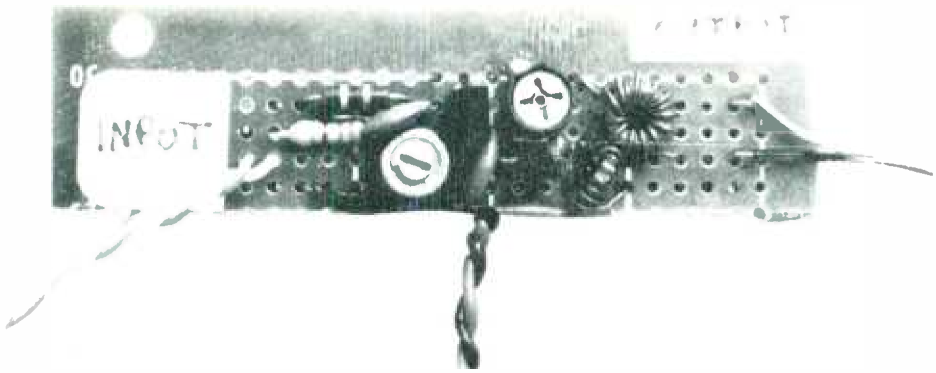
Once the antenna and ground are connected to their respective nail posts, you are set to tune in the world—or at least a local station. Begin by moving the graphite point across the face of the razor blade until a faint sound is heard, then tune the capacitor for maximum volume.

You will find that certain spots on the blade are more sensitive than others. The most sensitive areas are generally near rusty areas or flaws on the metal's surface. The increase in sensitivity at these locations is believed to be caused by imperfections in the metal crystal which enhance rectification. Reception is also better at night when ionospheric skip allows powerful clear-channel stations to come through from around the world.

Well, that's the story behind the foxhole radio. I hope you get as much pleasure from it as did our boys overseas. ■

PARTS LIST FOR THE FOXHOLE RADIO

#26 AWG magnetic copper wire, Safety pin, Pencil lead, Razor blade, 2000-ohm headphones, a toilet-paper roll, 6 × 8 × – in. clear-pine board, thumb tacks, 4 4-penny nails 365-pF variable capacitor; available from Custom Components, Box 153, Malverne, NY 11565. Include $5.00 for each capacitor plus $2.00 shipping and handling per order.



Pump out harmonics up to 240 MHz with one teeny-weeny transistor

ONE TRANSISTOR VHF SIGNAL GENERATOR

By Dan Becker

☐MANY EXPERIMENTERS HAVE AT LEAST ONE TTL-COMPATIBLE signal generator on their test bench. However, many such generators are limited to squarewaves, and often those are limited to 10 MHz (megaHertz) or less. Thus, the following cerebral logic came about! Sometimes a high-frequency sinewave source is needed. It would therefore be convenient to use a solid-state logic signal source and convert its output into a sinewave at an RF frequency of our choosing.

A simple circuit design is desirable, especially if we are interested in VHF-band frequencies, which are beyond the reach of inexpensive signal generators. One method of producing sinewave signals at VHF frequencies is to add a frequency-multiplier circuit to the output of a TTL logic gate or signal source.

The frequency multiplier described here uses only one transistor. By using a high-Q, tuned circuit in the collector lead, it converts a squarewave input into a sinewave output. What's more, the output is isolated from the direct current of the logic source. The input of the multiplier circuit can be driven by a signal generator or any of the popular TTL logic gates, buffers, or Schmitt triggers. Input frequencies between a few megaHertz and 50 megaHertz may be used. By adjusting the value of a trimmer capacitor, you can tune the output to a frequency of your choice. The output frequency can be anywhere in the VHF band, as long as the input frequency (a squarewave) is a sub-harmonic of the desired output.

Is the logic (cerebral or TTL) magic? No! It's common sense that has been used since the first vacuum tube was born. Here, the logic is applied to a simple solid-state circuit that we call the *1-Q VHF Signal Generator*.

Getting Nitty with the Gritty TTL

The schematic diagram of the frequency-multiplier circuit is shown in Fig. 1. The circuit is powered by a 5-volt DC regulated supply. However, a supply voltage as high as 18 volts may be used. A higher supply voltage will increase the voltage of the output signal.

Transistor Q1 operates as a high-speed switch: it can be almost any small-signal transistor having a gain bandwidth

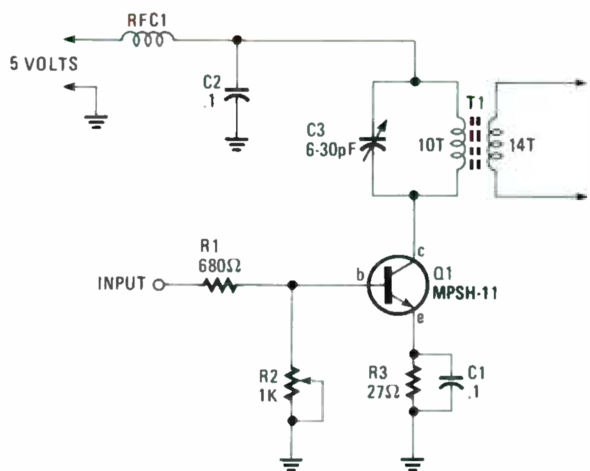


Fig. 1—Schematic diagram of the 1-Q VHF Signal Generator circuit looks too simple to work. Actually, it's too simple to fail.

product (f_t) of 650 MHz. With a logic low (less than 0.8 volt) on the input end of resistor R1, transistor Q1 draws little or no current. With a logic high on the input (about 3.5 volts or more) transistor Q1 is biased on. Because the collector current of Q1 flows in sharp pulses, it contains a large number of harmonically-related, radio-frequency currents. The primary winding of transformer T1 in parallel with trimmer capacitor C3 make up a parallel, resonant tank circuit. The tank is tuned to a high frequency—a harmonic of the input frequency. By inserting this high-Q, tuned circuit in series with the collector current, all of the harmonics except the desired one are attenuated (filtered out, if you wish). The output signal voltage is available from the secondary winding of transformer T1. The secondary may be connected to a 50-ohm, or higher, load impedance.

Resistors R1, R3, and potentiometer R2 determine the magnitude (strength) of the collector current pulses that result from the squarewave input signal. In addition, resistor R1 limits the base current; the signal source cannot be overloaded. That characteristic allows you to drive the input from a low-power Schottky IC, or its equivalent. Capacitor C1 operates as a short circuit to RF currents, giving Q1 maximum gain for AC signals. RFC1 prevents RF signals from reaching the power supply bus. Capacitor C2 also provides a short-circuit to ground for RF signals so that the total load for the amplified currents through Q1 consists of the tank, C3 and T1, and the internal resistance of Q1. Since the resistance within Q1 is a fraction of an ohm and the impedances at the RF frequency for C1 and C2 are almost zero, the only load seen by the transistor is the tank circuit. Understand that and you are on your way to becoming an RF-circuit *maven*.

Table 1 gives the output voltage verses the input and output frequency obtained with the test circuit shown in Fig. 2. Two input frequencies are specified in Table 1 to indicate that the maximum effective output frequency depends on the input frequency. The columns marked "Frequency (MHz)" show the frequency to which the output tank, T1-C3, is tuned. It is evident from the columns marked "Output (millivolts)" that the output signal voltage decreases as the tank is tuned to higher and higher frequencies. Two different input frequencies were used in the test, 10 MHz and 30 MHz. Higher input frequencies give higher output voltages. However, any frequency within the range of TTL IC's can be applied to the input of the 1-Q VHF Signal Generator.

TABLE 1 — 1-Q VHF SIGNAL GENERATOR'S FREQUENCY PERFORMANCE CHARACTERISTICS

10-MHz Input Signal		30-MHz Input Signal	
Frequency (MHz)	**Output (mV)**	**Frequency (MHz)**	**Output (mV)**
40	45	60	190
50	40	90	130
60	45	120	60
70	45	150	50
80	35	180	35
90	30	210	30
100	20	240	15
110	15		
120	8		

PARTS LIST FOR 1-Q VHF SIGNAL GENERATOR

C1, C2—.1µF, ceramic disc capacitor
C3—6-30-pF, miniature, PC-mount, trimmer capacitor
Q1—MPSH-11, NPN transistor (or equivalent with f_t >650 MHz)
R1—680-ohm, ¼-watt, 5% resistor
R2—1000-ohm, miniature, PC-mount potentiometer
R3—27-ohm, ¼-watt, 5% resistor
RFC1—Make from FT-23-43 ferrite toroid core; 14-turn winding evenly spaced (see text)
T1—Make from T-25-0 iron-powder toroid core; 10-turn primary winding #24 magnet wire; 5-turn secondary winding #28 magnet wire (see text for complete instructions)
Perfboard (see photo), hook-up wire, solder, etc.

Toroids available from Amidon Associates, Inc., 12033 Otsego St., North Hollywood, CA 91607.

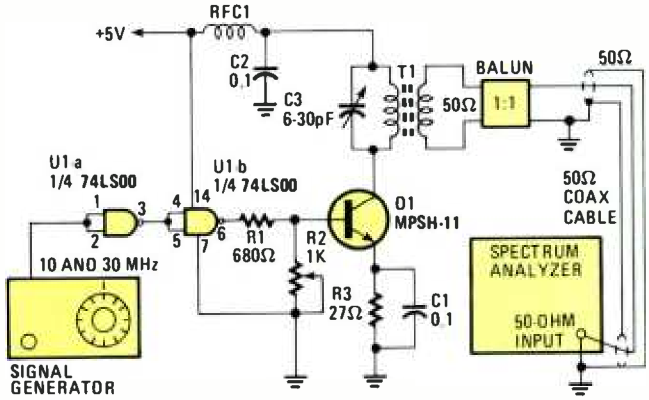


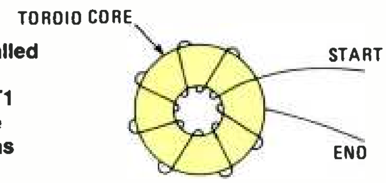
Fig. 2—Test setup for the 1-Q VHF Signal Generator. Not everyone is expected to own a spectrum analyzer; however, a shortwave receiver with an S-meter and a digital scanner can be used to detect the unit's output signals.

Construction

The first step in building the 1-Q VHF Signal Generator is to wind RF transformer T1. This procedure requires the following components: one T-25-0 iron powder toroid core, one 8-inch length of #24 magnet wire for the primary winding, and one 5-inch length of #28 magnet wire for the secondary winding.

Hold the toroid core between the thumb and index finger of your left hand (for right-handed persons). Hold the wire for the primary winding in your right hand. Push about two inches of wire up through the hole in the core and bend this lead over and down, then hold it under your left thumb. Next, take the other end of the wire and thread it through the core from top to bottom. Repeat that process, making each turn snug. Complete a total of ten turns on the toroid form that are evenly spaced. Cut the leads of the primary winding so both are about ¾-inch long. Figure 3 illustrates how a toroid looks with ten turns of wire.

Fig. 3—An example of several turns of wire installed on a toroid core. The two windings of transformer T1 and one winding of choke RFC1 are evenly spaced as seen in the diagram.



Next, take the wire for the secondary winding and install five turns onto the core. As you wind the turns, distribute them evenly over the primary layer. Leave 2-inch leads on the finished winding to identify them as the secondary. Next, dip the two leads, from the primary winding, into a jar of magnet wire stripper to remove the enamel insulation. After about 30 seconds remove and wipe clean the primary leads. Repeat that process for the secondary. Finally, tin the ends of all four leads with solder. If you do not have chemical wire stripper, scrape ¼-inch of enamel from each end of the four leads with a knife, then tin with solder.

In a manner similar to that above, make an RF choke (RFC1) by winding 14 turns of #28 magnet wire into an FT-23-43 toroid core. Strip and trim the two resulting leads.

This circuit is easily assembled onto a small piece of perfboard. Before mounting the components, drill one or

(Continued on page 87)

HAMFESTS
ELECTRONIC TOYLAND

Where can you get those much-needed parts or unload some old junk? A sojourn to a hamfest may fill both your needs

By Larry Lisle

IF YOUR HOBBY IS PUSHING ELECTRONS, YOU'LL BE LIKE A KID IN a candy store the first time you see a hamfest. Originally hamfests were flea markets and get-togethers for ham-radio operators—hence the name. In recent years though they've expanded to include something for everyone to whom the smell of melting solder is sweet.

Whether your interest is computers, antique radio, audio, construction, or of course amateur radio, you'll find bargains in used equipment and parts galore on somebody's tailgate or card table at a hamfest.

What Are They Like

Hamfests come in a variety of sizes, from the giant three-day bash at Dayton, Ohio, every April, to the Saturday and Sunday forty-acre jobs near the big cities. And also to the small community hamfests held on Sunday mornings in many cities and towns throughout the country. Most hamfests still take place in the warm-weather months, but indoor winter fests are growing in popularity. Knowing when and where a hamfest will be in your area is the first step. Check the amateur radio magazines or ask your friendly neighborhood ham—maybe you can go together.

Much of the fun at a hamfest is just wandering the aisles and seeing what there is to see. At the larger fests you'll find dealers displaying the latest in ham radio gear, and you'll be amazed at what they're packing into tiny packages these days. You'll also see "hamfest dealers" who sell at a different hamfest each weekend. They probably don't make much money, but they have fun. Most of the sellers though will be people just like you who are selling one piece of equipment to buy something newer or better or are just cleaning out the basement or garage. You'll find gizmos and gadgets that you never knew existed! If it's electronic, sooner or later you'll find it at a hamfest.

If you're looking for something in particular such as an old radio for the den, a piece of test gear or a computer you might want to get there early. The best deals go fast! Haggling over prices is part of the fun. Try offering ten or twenty percent less than the asking price and see what happens. You'll probably wind up splitting the difference and paying what the seller really wanted in the first place. It's always buyer beware with used things of course but most people at a hamfest will tell you if something's wrong with what they're selling—if you ask.

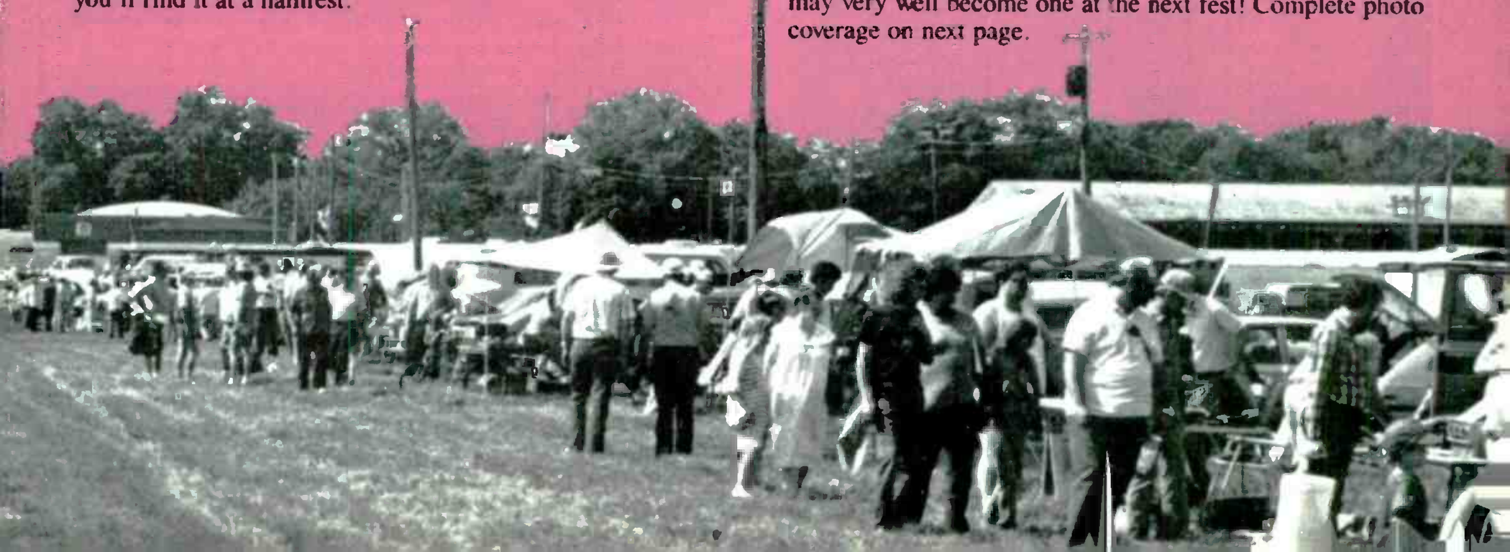
If you're interested in electronic parts, you'll find them by the bushel basket at a hamfest, usually at super-low prices. Obsolete radio tubes which might be impossible to find anywhere else often range in price from "free" to a dollar or so. You'll find wire in all types and sizes, variable capacitors, transformers, speakers—you name it. Stock up for all those winter projects.

Books on electronics and back issues of magazines are usually found in plentiful supply too. You can learn a lot of theory from the books and find hundreds of ways to apply the information from the magazines.

It's easy to become hooked on hamfests. You'll meet a lot of nice people and have a great time. Don't be afraid to strike up a conversation. You'll find many people with the same interests you have.

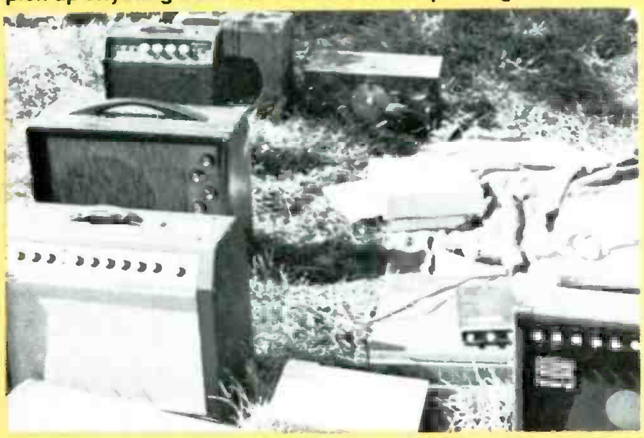
Before you leave, why not pick up some literature on ham radio if you're not a ham already. It's a great hobby and there have been some exciting changes recently, making it more attractive to the newcomer than ever. You can even take your test at a hamfest.

If you're into electronics already, hamfests are a great way to meet other people with the same interest and get those parts you so desperately need, and if your not a ham yet you may very well become one at the next fest! Complete photo coverage on next page.

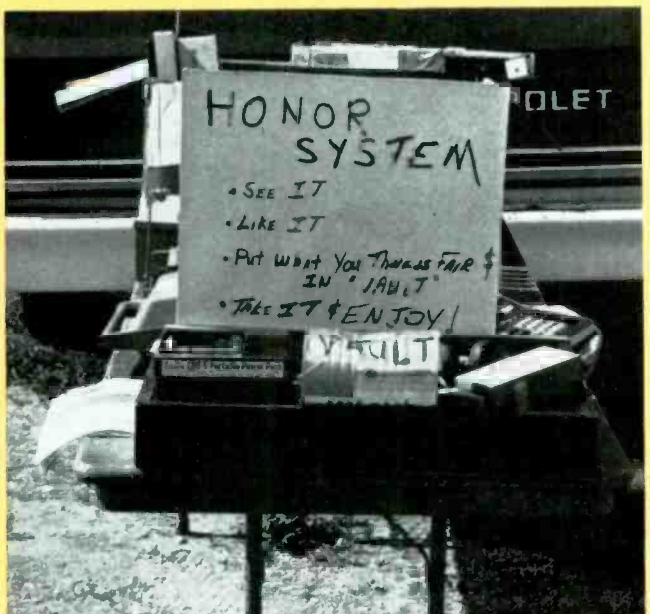


HAMFEST......

Of course ham radio abounds at these gatherings. You can pick up anything from SWR meters to complete rigs.



You never know what will turn up. Amid a display of audio gear, the author spotted a fifty year old Hallicrafters Sky Challenger receiver in the back row. Quit a find!

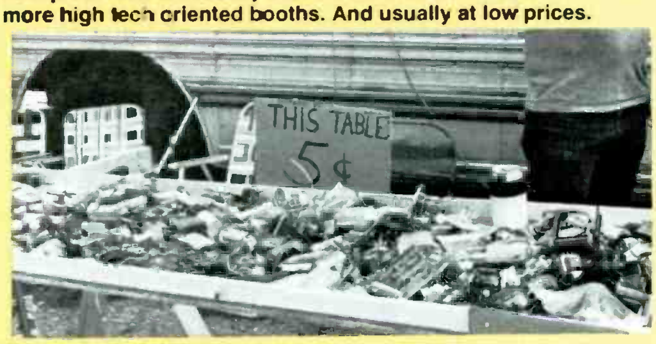


No hard sell at this display. We all know how much a thing is worth without having to haggle, so why bother? Just think, this guy got to see more of the show than his fellow dealers hassle-free (perhaps he spent more than he earned).

The electronic toyland. This is a typical booth at a Sunday morning hamfest. There were ten long aisles of booths chock full of electronic goodies at bargain prices.

Hardware hackers can find more than enough to keep themselves busy for a long time. Where else could you buy a data terminal for $30? The video assembly alone is worth it.

Antique radios are readily available at hamfests even at more high tech oriented booths. And usually at low prices.



Need some small parts? You'll never find them cheaper than at a hamfest. This is a scavenger's paradise, and having fun is what it's all about; profits are secondary. ■

By Herb Friedman

BUILD AN SMT DARKROOM SPOTMETER

This lightmeter makes super-quality photographic prints, and introduces the builder to surface-mounting assembly construction!

IF YOU'RE INTO DOING YOUR OWN DARKROOM WORK, AND YOU'RE tired of spending a whole evening just to make one or two top-quality prints, then it's time you started using a darkroom lightmeter. But just any old lightmeter won't do. What you want is a lightmeter specifically designed for darkroom use—actually a *spotmeter* that can read the negative density from an area not much larger than the eye of a newt. You know what a newt is. It's the chief ingredient in a witch's brew that includes a bat's wing, the force of a thunderstorm, and the rage of an ocean. When used in place of conventional developer, it creates the greatest photographic prints ever seen in this world, or any other.

If you can't get the witch's brew at your favorite photo shop, then substitute the *SMT Spotmeter*. It is shown schematically in Fig. 1. Simply decide what area of white light projected by the enlarger on the easel represents pure black in the print. Place the meter's sensor (light-dependent resistor), LDR1, under the light, adjust the enlarger's lens diaphragm until both LED's glow, and then hit the enlarger's timer control. When the enlarger turns off, develop the print by straight time and temperature. If the print doesn't turn out to be *great* on the first try, at the very least it will be *good*. In fact, by using the SMT Spotmeter, in less than a single evening you can print a whole 36-exposure role from Aunt Minnie's camera—and that includes cropping every negative to size. How's that for precision? Do it often enough and Aunt Minnie will probably include you in her will—she might even leave you enough bucks to buy a Hasselblad.

The SMT Spotmeter works on the principle that, except for esoteric prints, most prints look good, even great, if there is, at the very least, a tiny spot of jet black (*d-max*) somewhere in the print. What the SMT Spotmeter does is to determine the correct exposure for *d-max* (the black spot).

Make a Test Print

Here's how a typical printing session would go. First you take your "standard" negative from its fireproof vault, or wherever you keep it for safety, and using a predetermined knowledge of how it should print, you make a truly great print using a fixed exposure time. The time can be 10, 15, or 20 seconds; it doesn't make any difference as long as that time becomes your standard exposure time for the rest of the evening. Let's assume that you elect 10 seconds.

Leaving all enlarger settings as they are, you slide the SMT Spotmeter *magic eye*, LDR1, under the area of light that represents maximum black density (*d-max*) in the print and adjust SET CONTROL R1 until both LED's turn on. It's a very precise adjustment that's accurate to about 1/8 of an *f-stop*: if R1 is even just a touch off, the mark only one LED will light. That's it! The meter is calibrated for the evening. Simply insert any negative in the enlarger and rack the enlarger for any size print or cropping, focus *on the easel*, and then stick the SMT Spotmeter magic *eye* under the area that you want to be jet black in the print (do not change the focus). Adjust the lens' diaphragm until both LED's light and the system is calibrated. Use your predetermined standard exposure time and you'll get a great print.

Color Too

Although the meter is intended for B&W (black and white) printing, it can be used for color. After you have determined the correct filter pack for a particular color negative, slide

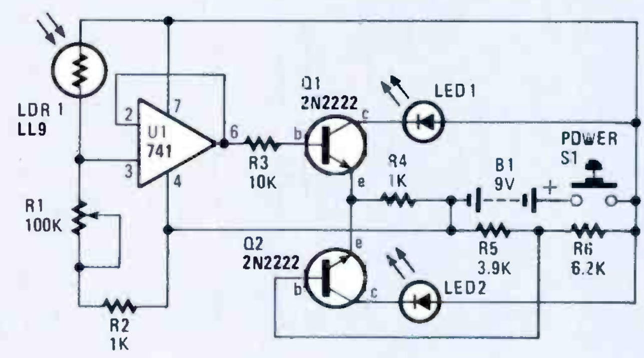


Fig. 1—Other than LDR1, no part is really critical and substitutions can be made. The spectral characteristics of the specified LDR1 specifically matches enlarger lamps, and also compensates for the cabinet's height. Make no substitution for LDR1.

a diffuser under the lens and position the spotmeter's sensor in the approximate center of the easel. Adjust R1 until both LEDs light. Now you can rack and refocus the enlarger to make small, medium, or large color prints. To determine the correct exposure, simply slide the diffuser into position, position the spotmeter on the easel, and adjust the len's diaphragm until the two LEDs light. Remember, the exposure time must be the same as when you "calibrated" the meter to the first color print. Your color exposure should be on-the-mark regardless how you change the enlargers's magnification.

SMT Assembly

To make it simple to build, the project uses SMT assembly. SMT means *S*urface-*M*ount *T*echnolgy, presently being touted in many magazines as the greatest invention since *hot fudge*. All SMT means is that the components are mounted directly on the surface of printed-circuit foils. Since the components are on the same side of the board as the foils, no holes are needed in the board for component leads to pass through. Also, many SMT components are no larger the head of a pin; others could be lined up a dozen at a time on your thumbnail and still leave room for a splash of tomato sauce.

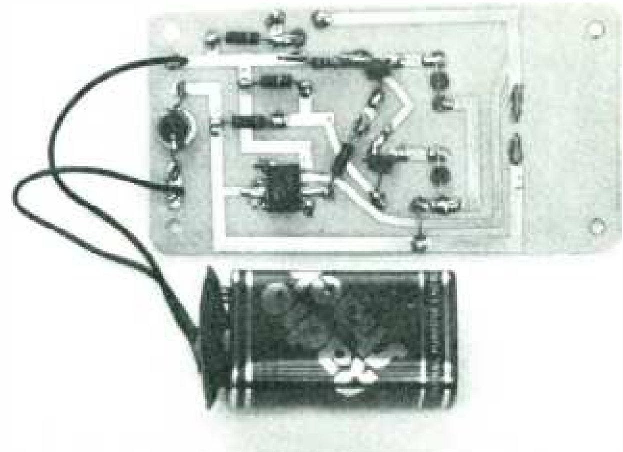
So what's so great about SMT? It's cheap and compact—at least on the manufacturing level. It allows very fast and inexpensive assembly using pick-and-place machines and wave soldering. It allows gigantic circuits to be shoehorned

The small black speck at the tip of the tweezers is a surface-mounting resistor. As shown, you can convert a conventional 1/4-watt resistor into a surface-mounting type like the SMT by shaping the axial leads downward.

into itty-bitty spaces, such as inside the lens of a 35-mm camera, and it allows circuits to be assembled on flexible printed-circuit material. Unfortunately, none of those advantages are needed for the SMT Spotmeter, nor is it likely that you could physically handle SMT components with conventional shop tools—regardless what anyone says.

Look at the photo which compares a standard 1/4-watt carbon resistor with an SMT resistor. Where is the SMT device? It's that tiny black dot at the tip of the tweezers. Got any idea how difficult it would be to hold the SMT resistor in position while you're hand-soldering it to the a foil? Got any idea what the odds are that the two closely-spaced foils to be spanned by the SMT resistor will be shorted if you make the PC board by hand?

But just because it doesn't pay to use SMT devices, doesn't mean you shouldn't use the technique, because it's great—particularly for small projects like the SMT Spotmeter. Except for LDR1, and R1—which must be on top of the PC board so it can be adjusted—every component is surface mounted. To make surface-mounting components from conventional parts, all you have to do is form the components' leads so that they can be applied directly to the foil. But first, keep in mind that the foils must be pre-tinned, because you're going to use reflow soldering.



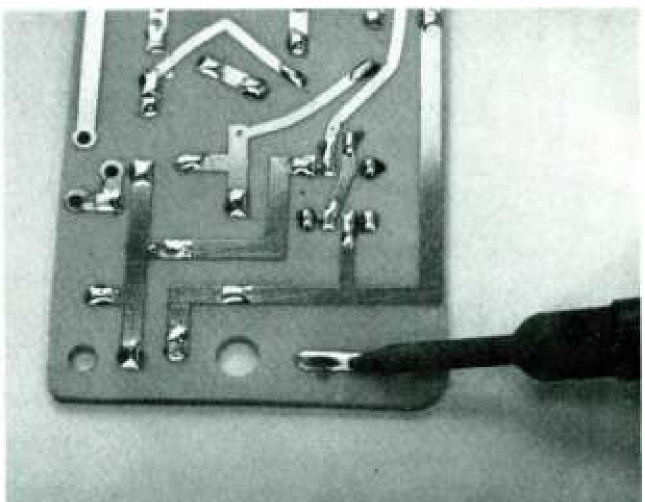
Although the SMT Spotmeter uses conventional parts, the lightmeter is built using surface-mounting assembly. Except for R1 all components are installed directly on the foils.

Reflow soldering is one of those fancy technical terms that sounds like more than it is. All it means is that both the printed-circuit foils and the components will have the solder pre-applied. Their joint will be heated just enough by a soldering iron so the solder on both reflow and merge. The connection is secure when the iron is withdrawn and the solder cools—and no "extra" solder has to be applied to the joint. The connection is made only by reflowed solder. (Yes, you've been doing that for years, but you didn't know it was such a big deal.)

While you could spend a few dollars and also wait a few weeks for delivery of printed-circuit foil-tinning solution, there is a faster way to tin the foils, shown in Fig. 2. Simply apply a small amount of solder to those parts of the foils to which a component will eventually be soldered.

How It Works

Transistors Q1 and Q2 form a voltage comparator (see Fig. 1). LED2 lights when the voltage applied to Q1's base is *less* than the voltage at Q2's base. LED1 lights when the voltage at Q1's base is *higher* than the voltage at Q2's base.



Before mounting anything, use a drop of solder and a very small soldering iron to tin the foils wherever you think a component will be soldered. Don't bother to completely tin the foils; that wastes time and may damage the foil.

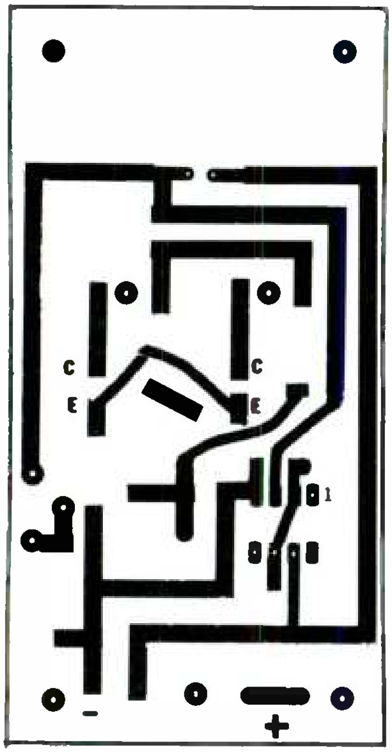


Fig. 2—Copper foil pattern for the SMT Spotmeter (a specialized lightmeter) project is shown here same size. Layout is not critical, so you may want to make your own rather than photo copy authors' version.

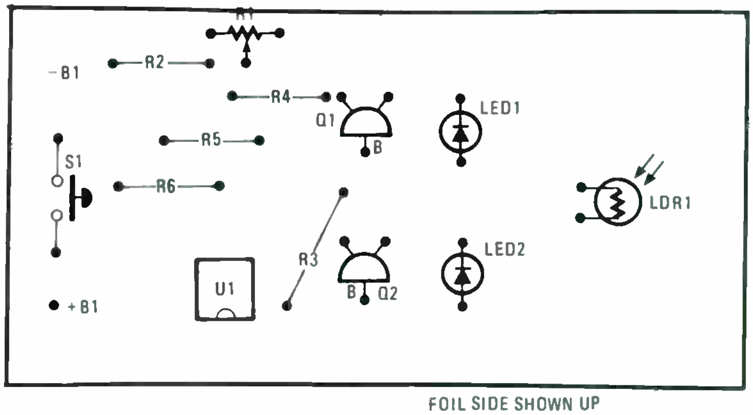


Fig 3—Parts-location diagram for the SMT Spotmeter takes some of the dog work out of determining where each part is placed. Use the diagram as a guide and reference to check out the completely wired unit.

Operational-amplifier U1 is connected as a unity-gain amplifier; it serves only to provide a very high-input impedance so that the junction of LDR1 and R1 doesn't get loaded by a low impedance, which would make LDR1's indication invalid.

When LDR1 is placed under the brightest area of a "standard" negative, R1 is adjusted so that the voltage at the LDR1/R1 junction, which is exactly the same at U1's output (after R3), is equal to the voltage on Q2's base. Since U1's output is applied to Q1's base, and since the voltage on the bases of Q1 and Q2 are equal, both LED's light. If the light falling on LDR1 changes—even insignificantly—the LDR's resistance will also change, thereby changing the voltage at the LDR1/R1 junction, and only one of the two LED's will light.

Construction

Except for LDR1 and the cabinet, nothing is critical. LDR1 is specifically selected for response to the color temperature of an enlarger's lamp, and also for its resistance when exposed to typical enlarging-light levels. All bets are off if you substitute any other LDR.

Normally, a cabinet has nothing to do with anything. However, in this project, the LDR is compensated for the distance that it is raised off the easel by the cabinet. Hence, build the project in the Radio Shack cabinet specified in the Parts List. Again, if you substitute for the cabinet don't expect the SMT Spotmeter to work properly, if at all.

The cabinet is normally supplied with a metal cover. Discard the cover because the printed-circuit board becomes the cabinet's cover. Make the printed-circuit board, using the supplied template as a guide. Then drill the holes for the LED's, S1, LDR1's leads, and the four corner-mounting screws. Do not drill any other holes. Using a file, round the corners of the PC board so that it fits into the cabinet.

Next, convert conventional transistors (Q1 and Q2), op-amp U1, and the two LED's into surface-mounting components. The photos show how it's done. First, the transistor's leads have been fanned out at right angles to the body. The E and C leads are on one side, the B lead on the other. The PC-board is specifically designed for the EBC lead arrangement, which is standard for the 2N2222. If your transistor has an ECB lead arrangement, look for other transistors—because the lead "crossover" when installing the transistor will probably result in a short circuit.

Another photo shows how to n e a standard half-mini DIP op-amp into the SMT type. Bend the IC's leads

PARTS LIST FOR SMT SPOTMETER

SEMICONDUCTORS

LDR1—Light-dependent resistor, type LL9
LED1, LED2—Miniature red LED
Q1, Q2—2N2222, or equivalent, see text
U1—741 op-amp

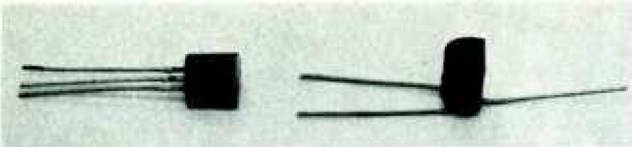
RESISTORS

(All resistors 1/4-watt, 5% unless otherwise specified.)
R1—100,000-ohm, trimmer potentiometer (Radio Shack 271-220, or equivalent)
R2, R4—1000-ohm
R3—10,000-ohm
R5—3900-ohm
R6—6200-ohm

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery
S1—N.O., miniature, momentary-contact switch
Printed circuit materials, Experimenter Box (Radio Shack 270-231 or equivalent), battery terminals, battery clip, wire, solder, PC-board materials, etc.

Note: The LL9 light-dependent resistor is available from Custom Components, Box 153, Malverne, NY 11565. Price is $5 each, plus $2 for shipping, handling, and insurance per total order. NY residents must add appropriate sales tax.



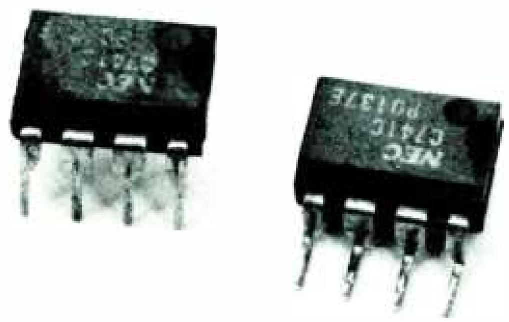
The conventional 2N2222 transistor on the left is made into a surface-mounting device by bending the leads out at right angle to the body, like the one shown on the right.

out at right angles, away from the body, with needle-nose pliers.

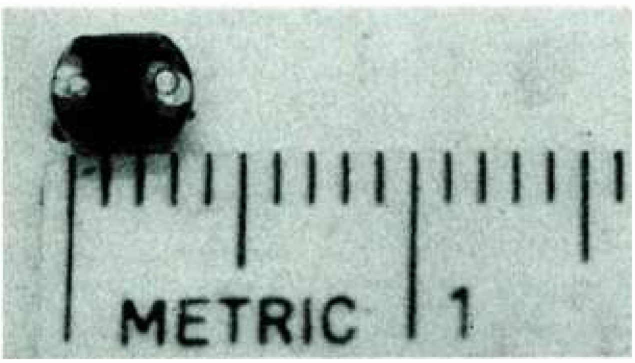
The LED's are a little trickier. Their leads can't take much stress. Use needle-nose pliers to form the leads into strain-relief loops. That way, you can center the LED's in their holes by simply bending a loop (or two) with the needle-nose pliers.

To wire S1, carefully bend its contacts out at right angles so they are parallel to the PC board. Then tack-solder #22 or #24 solid wire to the appropriate foils and run the wires up to S1's terminals, wrap the wires once, and then solder.

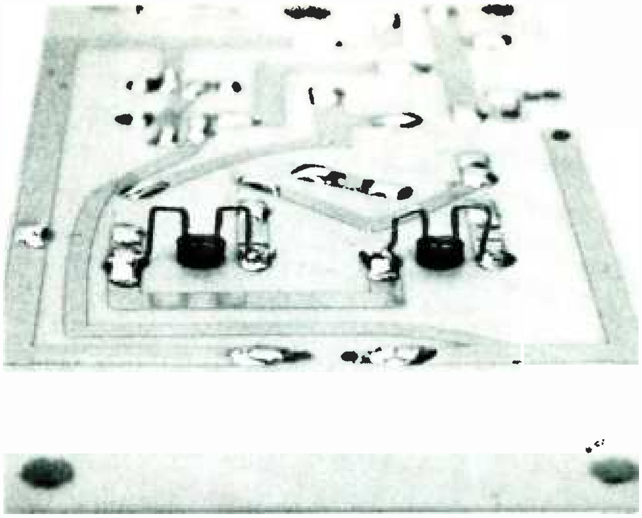
Potentiometer R1 must be mounted on top of the board, because it is calibrated each time that you use the meter. Similarly, LDR1 is mounted on top of the board. Do it that way because the LDR is fragile until soldered. (Bend its



Making the conventional IC on the left into the surface-mounting type shown in the right is only a bit more difficult, because you must fold all eight terminals outward, so the IC can sit flat on the printed-circuit foils. Make certain you make the folds just below the bottom of the IC so the leads can drop right on to the pre-soldered foils.



The LDR (light-dependent resistor) is only 4-mm wide and is very fragile until soldered in place, so handle it very gently and don't force its leads apart. Use two pair of pliers to form the leads so they slip into their holes. The LDR's active area is only 2-mm square, so you should have no trouble positioning it under an area of maximum illumination.



The miniature LED's are very fragile; so, using needle-nose pliers, pre-form their leads into small loops before you insert the LED's into the board. The loops will "give" a little if you have to press the ends of the leads against the pre-soldered foils when affixing to the PC board.

leads too far and the LDR will snap in half.) Drill the holes for the LDR's wires with a #50, #59, or #60 bit. Then install a "viewing easel," a strip of white adhesive label, across the top of the meter. From the underside of the board, push a pin or a thin solid wire through the LDR wire's holes and through the paper. Now flip the board over and insert the LDR from the top until it is about $^1/_{16}$-inch off the board. The distance isn't critical as long as the LDR is off the board—but don't go over $^1/_8$ inch. Solder the LDR's leads to their foils and trim the excess lead length.

Finally, tack-solder (SMT style) the battery clip's wires to their respective foils. Position the wires so that they face toward the center of the board. The wires are very fine and if they come off the end of the board, the sharp bend in the wires that is formed when the cabinet is installed can cause the wires to break at the solder connection.

Checkout

In a lighted room, connect the battery and install the PC board on the cabinet, but don't install the mounting screws until you're certain that the project works. Set R1 to its mid-position. Press S1. One LED should light. Cover the LDR with your finger; the other LED should turn on and the first one should go out. If the SMT Spotmeter doesn't work that way, you have made a wiring error or used an incorrect part.

Use your left thumb to operate S1 and lightly cover the LDR with the index finger of the same hand. Using your right hand, rotate R1 through its range. At some point both LED's will light, thereby indicating that the project is working A-OK. The meter is ready to work for you.

The active part of the LDR is less than 2-mm square, so it can be positioned over what would otherwise be an impossibly small area to measure. Just make certain that the entire sensitive area of the LDR is under the bright light that represents jet black in the print. If any part of the LDR is "shadowed" by less than maximum illumination, its reading will be in error as far as making the correct lens adjustment is concerned. ■

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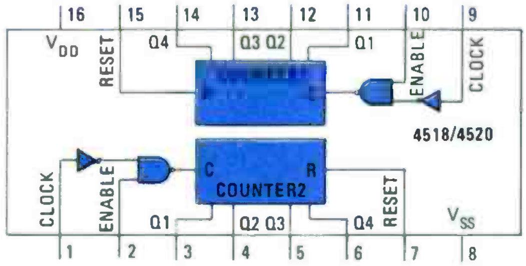
58 Hands-on Electronics FactCard — 45181 • 4520 • Dual Synchronous Up Counter



CLOCK	ENABLE	RESET	ACTION
↑	1	0	INCREMENT COUNTER
0	↓	0	INCREMENT COUNTER
↓	X	0	NO CHANGE
X	↑	0	NO CHANGE
↑	0	0	NO CHANGE
1	↓	0	NO CHANGE
X	X	1	Q1 THRU Q4 = 0

X = DON'T CARE

FEATURES

- Wide supply voltage range — 3.0V to 15V
- High noise immunity — 0.45 V_{DD} (typ.)
- Low power TTL compatibility — fan out of 2 driving 74L or 1 driving 74LS
- 6 MHz counting rate (typ.) at V_{DD} = 10V

ABSOLUTE MAXIMUM RATINGS

V_{DD} Supply Voltage	−0.5V to +18V
V_{IN} Input Voltage	−0.5V to V_{DD} +0.5V
T_S Storage Temperature Range	−65°C to +150°C
P_D Package Dissipation	500 mW
T_L Lead Temperature (Soldering, 10 seconds)	260°C

RECOMMENDED OPERATING CONDITIONS

V_{DD} Supply Voltage	3V to 15V
V_{IN} Input Voltage	0V to V_{DD}
T_A Operating Temperature Range	
CD4518BM, CD4520BM	−55°C to +125°C
CD4518BC, CD4520BC	−40°C to +85°C

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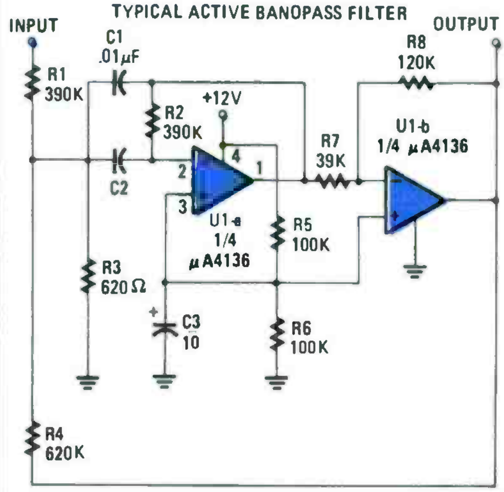
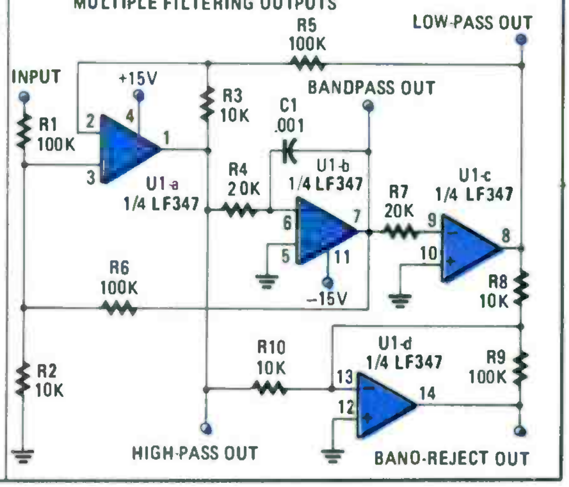
59 Hands-on Electronics FactCard — Op-Amp Circuits

TYPICAL ACTIVE BANDPASS FILTER



STATE VARIABLE FILTER WITH MULTIPLE FILTERING OUTPUTS



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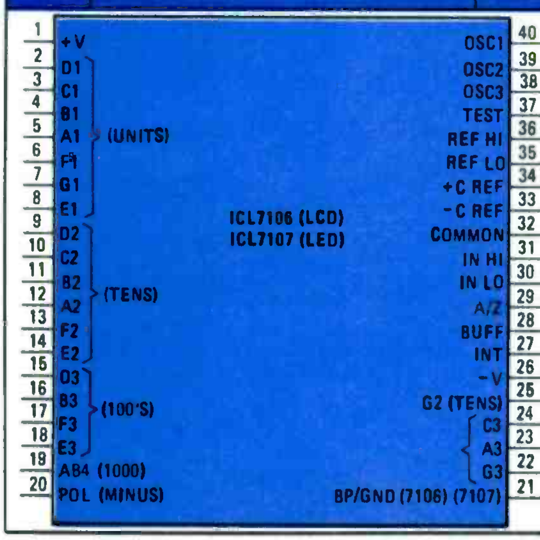
60 Hands-on Electronics FactCard — ICL7106 • ICL7107 • 3½-Digit A/D Converter



FEATURES

- Guaranteed zero reading for 0 volts input on all scales.
- True polarity at zero for precise null detection.
- 1 pA typical input current.
- True differential input and reference.
- Direct display drive—no external components required.
- Low noise—less than 15µV p-p.
- On-chip clock and reference.
- Low power dissipation—typically less than 10mW.
- No additional active circuits required.
- Evaluation Kit available.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	
ICL7106, V+ to V−	15V
ICL7107, V+ to GND	+6V
ICL7107, V− to GND	−9V
Analog Input Voltage (either input) (Note 1)	V+ to V−
Reference Input Voltage (either input)	V+ to V−
Clock Input	
ICL7106	TEST to V+
ICL7107	GND to V+
Power Dissipation (Note 2)	
Ceramic Packaging	1000mW
Plastic Package	800mW
Operating Temperature	0°C to + 70°C
Storage Temperature	−65°C to + 160°C
Lead Temperature (Soldering, 60 sec)	300°C

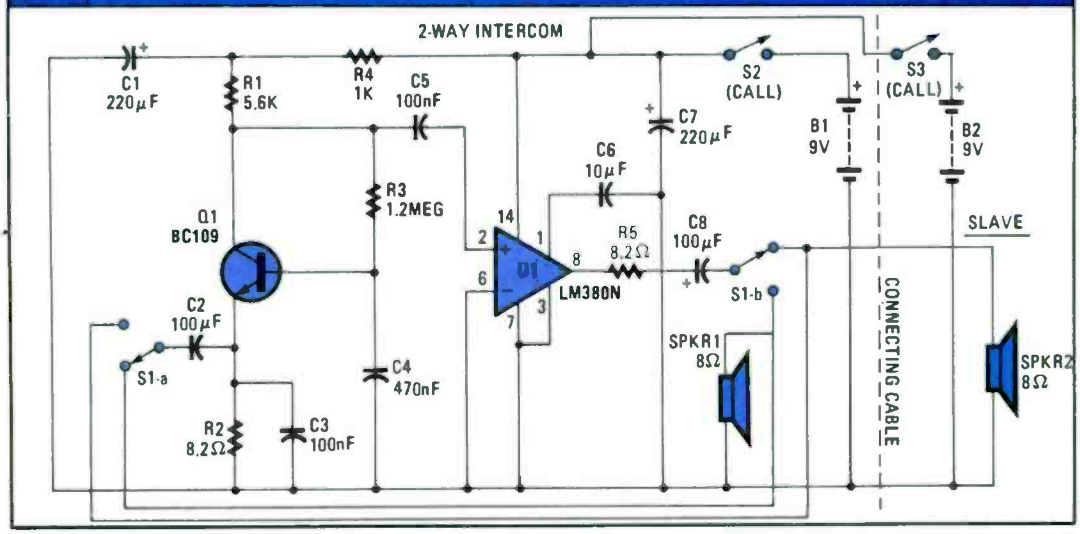
58 Hands-on Electronics FactCard — 45181 • Dual Synchronous / 4520 • Up Counter

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMITS at 25°C (Typ.)	UNITS
Quiescent Device Current, I_{DD} Max.	—	0,5	5	0.04	µA
	—	0,10	10	0.04	
	—	0,15	15	0.04	
	—	0,20	20	0.08	
Output Low (Sink) Current I_{OL} Min.	0.4	0,5	5	1	mA
	0.5	0,10	10	2.6	
	1.5	0,15	15	6.8	
Output High (Source) Current, I_{OH} Min.	4.6	0,5	5	−1	
	2.5	0,5	5	−3.2	
	9.5	0,10	10	−2.6	
	13.5	0,15	15	−6.8	
Input Current I_{IN} Max.	—	0,18	18	$\pm 10^{-5}$	µA

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMITS at 25°C (Typ.)	UNITS
Output Voltage: Low-Level, V_{OL} Max.	—	0,5	5	0	V
	—	0,10	10	0	
	—	0,15	15	0	
Output Voltage: High-Level, V_{OH} Min.	—	0,5	5	5	
	—	0,10	10	10	
	—	0,15	15	15	
Input Low Voltage, V_{IL} Max.	0.5,4.5	—	5	—	V
	1,9	—	10	—	
	1.5,13.5	—	15	—	
Input High Voltage, V_{IH} Min.	0.5,4.5	—	5	—	
	1,9	—	10	—	
	1.5,13.5	—	15	—	

59 Hands-on Electronics FactCard — Op-Amp Circuits



60 Hands-on Electronics FactCard — ICL7106 • 3½-Digit A/D / ICL7107 • Converter

ELECTRICAL CHARACTERISTICS

Characteristics	Conditions	Typ	Units
Zero Input Reading	V_{IN} = 0.0V Full Scale = 200.0mV	±000.0	Digital Reading
Ratiometric Reading	V_{IN} = V_{REF} V_{REF} = 100mV	999/1000	Digital Reading
Rollover Error	−V_{IN} = +V_{IN} = 200.0mV	±.2	Counts
Linearity (Max. deviation from best straight line fit)	Full Scale = 200mV or 2.000V	±.2	Counts
CMRR	V_{CM} = ±1V, V_{IN} = 0V Full Scale = 200.0mV	50	µV/V
Noise (Pk-Pk	V_{IN} = 0V Full Scale = 200.0mV	15	µV
Leakage Current Input	V_{IN} = 0V	1	pA

Characteristics	Conditions	Typ	Units
Scale Factor Temperature Coefficient	V_{IN} = 199.0mV 0°C<T_A<70°C (Ext. Ref. 0 ppm/°C)	1	ppm/°C
V+ Supply Current	V_{IN} = 0	0.8	mA
V− Supply Current (7107 only)		0.6	mA
Analog Common Voltage	25kΩ between Common & Pos. Supply	2.8	V
Temp. Coeff. of Analog Common	25kΩ between Common & Pos. Supply	80	ppm/°C
7106 ONLY Pk-Pk Segment Drive Voltage Pk-Pk Backplane Drive Voltage	V+ to V− = 9V	5	V

HANDS-ON REPORT

COMPUTER AGE MEMO-ME VOICE RECORDER

Electronic memory stores your voice at the touch of a button—and in hi-fi no less!

☐IT WAS A STARLESS, MOONLESS NIGHT. The only light came from the faint glow of a streetlight. Slowly, an intruder tiptoed through the backyards to an obviously empty home. A quick flip of the wrist and a crowbar cracked open a rear window—waking the *Hound of Hell*. The largest, meanest, most ferocious junkyard dog this side of Hades let out a growl that made even the *Devil's Disciples* tremble, and the intruder took the fastest way out: headfirst through the windowpane.

The only thing reported incorrectly about the story is that there was no dog, only a digital voice recorder called a *Memo-me*. Although originally intended as a *messaging* device, this digital voice recorder can double as an effective intruder alarm.

The operating switches are concealed behind the access panel to the battery compartment. The black rectangle on the bottom of the cabinet is a jack for an optional wall-plug AC adapter.

Electronic Memory

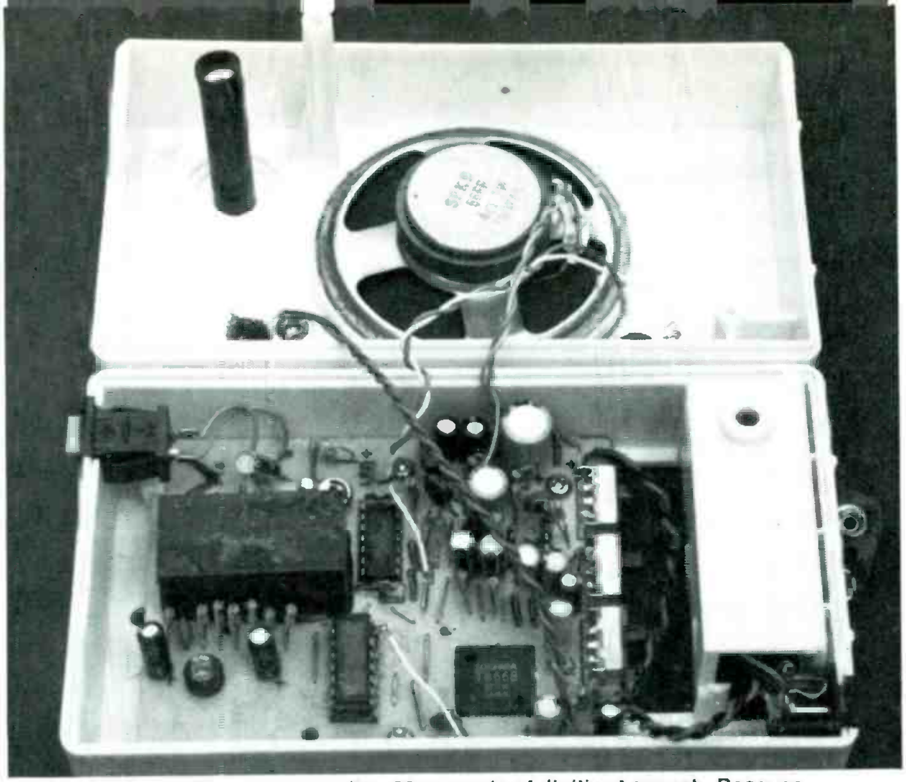
The Memo-me, which is housed in a 5.6 × 3.2 × 2.3-inch plastic cabinet and powered a 9-volt battery, is a digital voice recorder that is triggered into the playback mode by changes in ambient light conditions. Essentially, it is a shadowing of the light that causes the device to play back its recorded message.

The recording media is similar to the voice *messaging* system used in telephones, personal computers, and even digital recordings. Speech spoken into a built-in microphone is digitally sampled at an internal-clock rate, and the volume and frequency variations of the microphone's signal are converted to digital bits that are stored in a 512-Kilobit RAM. For high-fidelity reproduction, the sampling is done at a relatively-high frequency, producing so many bits of information that the 512K RAM can provide only 16-seconds of recording time. For those willing to sacrifice some sound quality, the sampling can be done at half the hi-fi rate, thereby providing 32 seconds (*long play*) of memory. For playback, the Memo-me simply reverses the process, recreating the original signal from the stored data. The sound of your voice will amaze you!

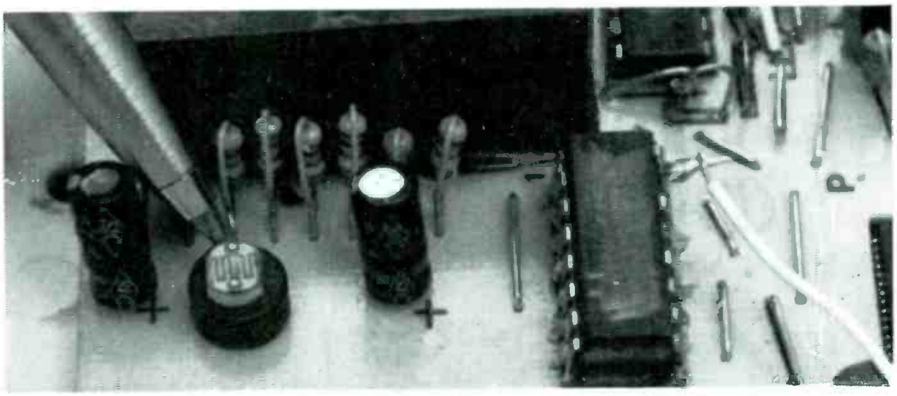
Simplicity of it!

Unlike most digital storage devices, that almost require a degree in engineering just to turn it on, the Memo-me is simple enough to be used by the smallest of children, because it is always set for automatic playback. If you want to leave a message for the family you simply record the message and place the device on a table. Anyone entering the room will au-

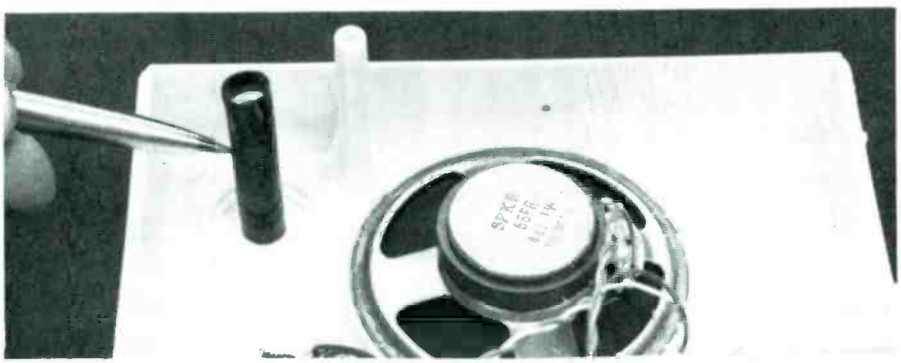
Just press the button on the top of the cabinet to record. The large circle on the upper left front of the cabinet is the sensitive area for the light-switch. The small dark spot at the lower right of the cabinet is an LED that lights only when the device is recording or playing a message. Circle Number 73 on the Free Information Card for more info.



A lot of hardware goes into recording 32 seconds of digitized speech. Because experimenters copy an electronic device, identification has been removed from some ICs, while other components are sealed in an unmarked "black box."



The pointer identifies the miniature photoresistor embedded within the unit; the only playback control for the device. A change in ambient light falling on the photoresistor—not the intensity of the light—starts the playback.



The pointer locates the non-reflecting, cylindrical shield that keeps stray light that might leak into the cabinet from falling on the photoresistor. The cylinder fits over the photoresistor when the cabinet is assembled

tomatically cause the *memo-me* to play the message—unless the table is in a coal bin, it is midnight, and the person entering is really a black cat.

Except for the record button, the control switches are located behind the battery panel. The on-off POWER switch does what its name implies. Immediately adjacent to it, is the VOL level switch—having two settings: loud and louder—and the fidelity SEC switch, which provides hi-fi sound (16 seconds) or long-play sound (32 seconds) quality. The small black rectangle on the bottom-right of the cabinet is the jack for an optional AC adapter.

To record a message you press the switch on top of the cabinet and speak into the slot in the cabinet labeled MIC. Regardless how long you speak—even for just a few seconds—the Memo-me plays back your message the instant the switch is released, because the built-in microprocessor doesn't play to the end of the unused memory. Instead, it instantly jumps to the start of the message.

Learn a Language

Because the playback is essentially instantaneous, and because its *fi* is *hi*, the memo-me is an almost ideal device for learning how to speak a foreign language, because you can record a word, sentence, or phrase and instantly hear the playback. There's no rewinding of a tape or cassette, no waiting for the tape to cue; nothing. The instant you release the recording switch the memo-me play backs your last comment.

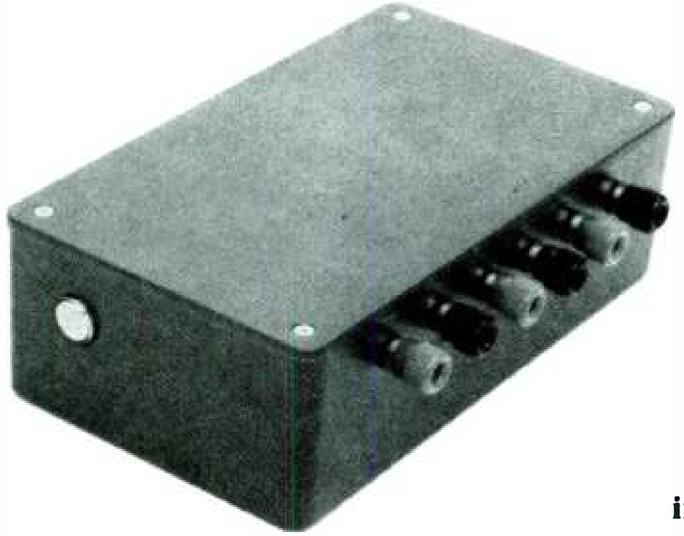
The circuit for the photoresistor functions as an off-on switch rather than as a variable resistance device of some kind. In other words, any change to the light falling on the photoresistor will cause the Memo-me to switch on; the device doesn't wait for a particular light value before replaying the message.

To be sure that the photoresistor responds only to light that falls directly on the cabinet's target area, the light is literally piped to the photoresistor by a black cylinder. Light or shadowing that leaks into the cabinet cannot enter the cylinder and get to the photoresistor.

One Problem

As a digital voice recorder the Memo-me is really spectacular. It's only problem is the lack of a panel-mounted, on-off switch so that messages can be replayed when desired. It can become a bit of a pain to have the thing go off every time someone passes by; and getting at the concealed power switch isn't all that convenient if it's to be done several times a day. An interesting project for the user would be to install his or her own front panel operating switch. (You don't want to make it a power switch, because that would cause the message to be lost whenever the device was powered down.)

The Memo-me Digital Voice Recorder is priced at \$69.00 US dollars. An optional plug-in adapter is \$9.00 US. The device is available directly from Computer Age Ltd., PO Box 730, Ontario, Canada L0G 1N0. ■



NO RFI NIGHT-LITE CONTROLLER

If you want to automate your porch, driveway, or outdoor lights, without RF interference, this project is your best bet!

By Albert F. Gordon

☐THAT BUZZING NOISE COMING FROM YOUR AM RADIO, ham transceiver, or CB speaker could be an unwanted product of solid state on-at-dusk, off-at-dawn light controllers. Though cheap and popular, those 4-layer semiconductor devices trigger an assortment of RFI/EMI problems covering a broad frequency spectrum. This project helps reduce the din so that your radio or TV reception doesn't resemble nightly reruns of "The Texas Chainsaw Massacre." Furthermore, this noiseless, $25 power-controller project has some special features.

Unlike the commercial variety, this "homebrew" design allows for trimming the triggering light intensity to suit your taste (via R3, see Fig. 1) along with the option for powering multiple devices, up to about 175 watts. All you have to do is build it and wire it to your lights or other AC line-powered device. Both are almost no sooner said than done. The parts are available from your local Radio Shack outlet or Jameco emporium, the wiring is non-critical (read "rat's nest is OK"), and the hookup is as simple as A-B-C. Plus, the circuit theory is even more simple.

Enlightening Design

The resistances of R3, R4, and LDR1 (a cadmium sulphide photocell that changes resistance in any inversely proportional manner to light intensity), form a light-sensitive voltage divider, which fires a Schmitt trigger, comprised of Q1 and Q2, which trigger relay driver Q3.

Within the Schmitt trigger, R7 provides uniformity of operation over wide temperature swings. A lot of negative feedback is provided through that resistor because, electrically, the silicon temperature in Palm Springs bears little resemblance to that in Watertown, New York. Something to unify those extremes must be done, and negative feedback is the "something."

In addition, negative feedback keeps the Schmitt-trigger input impedance large relative to the resistance of LDR1 so that the voltage at the input of the trigger doesn't drastically change when it switches states.

Schmitt Operation

There are two states to the Schmitt trigger. At any time, either Q1 or Q2 is conducting. When Q1 conducts, the base

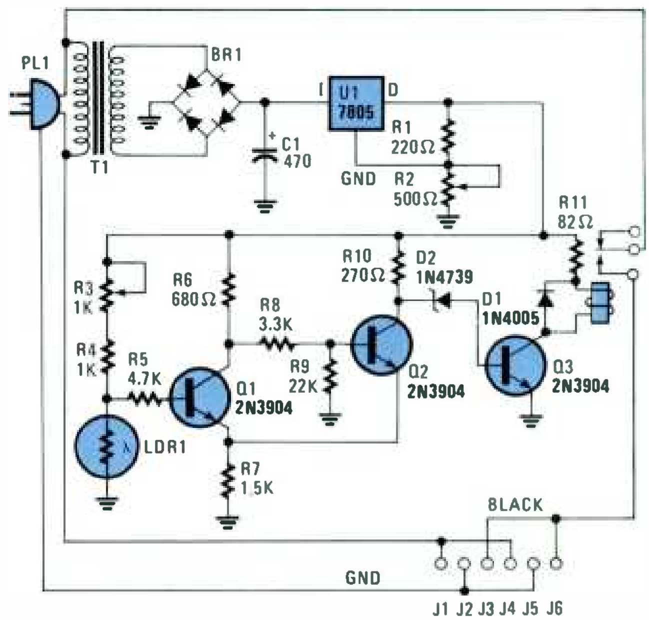


Fig. 1—This is the schematic diagram for the power controller. All parts are readily available.

voltage of Q2 is sufficiently low to cause it to cut off. Thus, the collector of Q2 is high enough to break down the Zener potential of D2, and Q3 conducts, activating the relay.

The other operational state is realized with Q1 cut off. When that happens, the voltage at the base of Q2 is determined by a voltage divider formed from R6, R8, and R9. Since there is no collector current in Q1 (it's cutoff), the voltage drop across R6 is very low. Thus, the voltage at the base of Q2 is relatively large, designed to turn Q2 on. With Q2 on, the collector voltage of Q2 is too low for Zener D2 to conduct, and Q3 is off. That means relay K1 is not activated. So, in the Schmitt trigger, there are two normally stable states: With Q1 on (and saturated), and Q2 off; with Q1 off and Q2 on (and saturated).

Hysterics

Why use a Schmitt trigger instead of a simple transistor switch? By way of explanation, a Schmitt trigger has "hysteresis." What would happen in this project, using a simple transistor switch instead of a Schmitt trigger, if it were getting close to the nightfall switching threshold on an overcast day, and the sun went behind a small cloud? If it weren't for hysteresis (an operational characteristic of the Schmitt trigger), the relay might activate when the sun went behind the cloud, and deactivate when the sun came out from behind the cloud again, only to activate again when the sun went down.

Now, imagine many very tiny clouds with very many clear-sky areas next to them that alternately hide the sun from and then expose the sun to LDR1. As the wind blows, those small cloudy and non-cloudy regions by the sun, the resistance of LDR1 swings high and low and high and low. A transistor switch, without hysteresis, would repeatedly switch on and off rapidly.

In order to keep K1 from activating, deactivating, and reactivating, a special circuit that allows for small LDR1 resistance variances (and hence, small trigger-input voltage changes) must be used so that, as dusk approaches, Q1 will not conduct until a certain very-large resistance of LDR1 is reached when resistance is going up, and Q2 won't conduct until a somewhat lower resistance of LDR1 is approached from the opposite way—LDR1 resistance going down. The amount of voltage between those high and low trigger points of LDR1 is called the amount of hysteresis which, for this project, results from the voltage divider (R6, R8, and R9) and is designed to be about 2.5 volts. That means that a false-triggering avoidance band of 2.5 volts smooths the operation of K1 so that on-off-on-off "chatter" is avoided (see Figure 2).

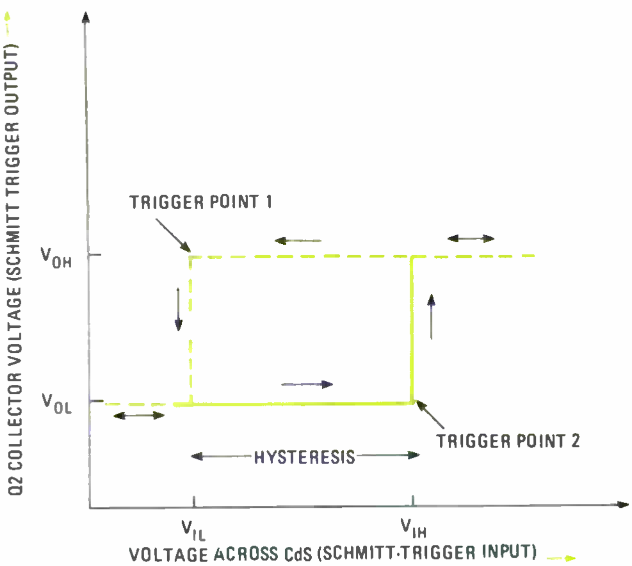


Fig. 2—This is called a "hysteresis loop." Note that the voltage across the CdS (the trigger point) is different depending on whether the controller is switching on or switching off (represented by the arrows).

Construction

Construction—almost nothing to it. In fact, perfboard construction was used in the author's units. Two subassemblies were built (one for the power supply and one for the trigger/controller) on Dick Smith H5310 boards and placed into a Radio Shack 270-224 enclosure, although the Radio Shack perfboards are acceptable. LDR1 was epoxied into place such that the back of the photocell was flush with the inside of the enclosure, and the front was protruding to the outside on the side of the box, which will be facing North so that only ambient sunlight will reach it.

Wire the #12 safety ground wire between the green wire from the input power cord and the binding posts that are designated "safety ground" at the power output of the unit (you may wish to use AC sockets instead of binding posts for appliance control). Run the black wire from the power cord to the relay contacts of K1. With Silicone sealant, insulate and waterproof the binding posts that will be exposed to the outside.

Calibration

To calibrate the unit, set the trigger-threshold trimmer potentiometer (R3) to about midposition and adjust R2, using an accurate voltmeter, so that the voltage at terminal 3 of U1 is 10.0 volts. Close the box and weatherproof it using Silicone

(Continued on page 87)

PARTS LIST FOR THE LIGHT CONTROLLER

SEMICONDUCTORS

BR1—1.4-amp bridge rectifier assembly
D1—1N4005 1-A, 600-PIV Silicon Rectifier diode
D2—1N4739, 9.1-volt Zener diode
LDR1—Cadmium sulphide photocell
Q1–Q3—2N3904 Silicon transistor
U1—7805 5-volt voltage-regulator integrated circuit

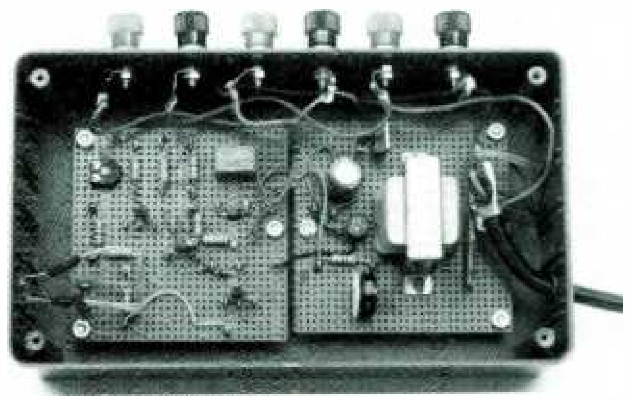
RESISTORS

(All fixed resistors are ½-watt units, unless otherwise noted.)
R1—220-ohm
R2—500-ohm, potentiometer
R3—1000-ohm, potentiometer
R4—1000-ohm
R5—4700-ohm
R6—680-ohm
R7—1500-ohm
R8—3300-ohm
R9—22,000-ohm
R10—270-ohm
R11—82-ohm

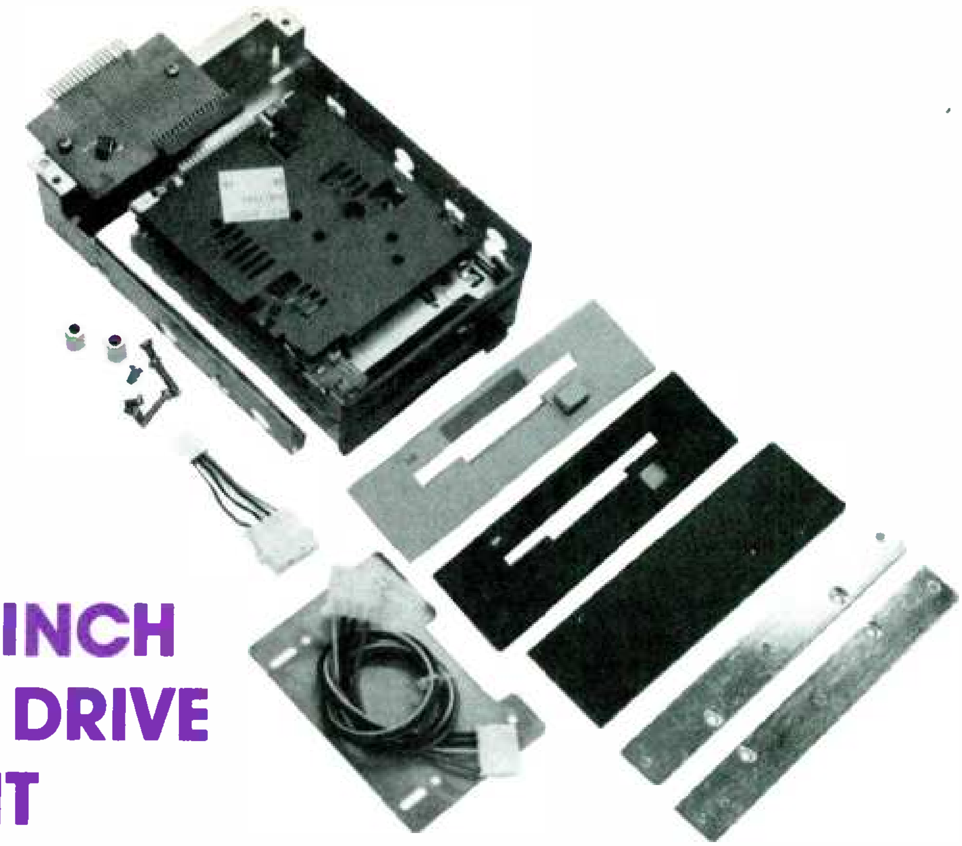
ADDITIONAL PARTS AND MATERIALS

C1—470-muF, 35-WVDC electrolytic capacitor
J1–J6—Insulated binding posts
K1—5-volt, 2-amp relay
T1—12.6-volt power transformer

Line cord, tie strip, enclosure, grommets, Silicone sealant, spacers screws, lockwashers, nuts, etc.



The boards are separated into the power-supply unit and the trigger circuit itself. You needn't separate the project that way, but it may make for clearer troubleshooting.



TOSHIBA 3.5-INCH FLOPPY-DISK DRIVE UNIVERSAL KIT

All you need is a 3.5-inch disk retrofit kit and a screwdriver to upgrade your PC/XT computer to handle 3.5-inch disks.

☐WHEN IT COMES TO PERSONAL COMPUTING, the future is always now, particularly when it comes to disk-storage systems. It seems like only yesterday—and it was—that personal computers switched from the 8-inch to the 5¼-inch disk. Now that almost everyone is using the 5¼-inch disk (here we go again), we find that much of the new gear being introduced uses the 3.5-inch disk, and suddenly, your IBM-type personal computer might no longer be compatible with all others.

Actually there are at least two good reasons why manufacturers are switching to the 3.5-inch disk:

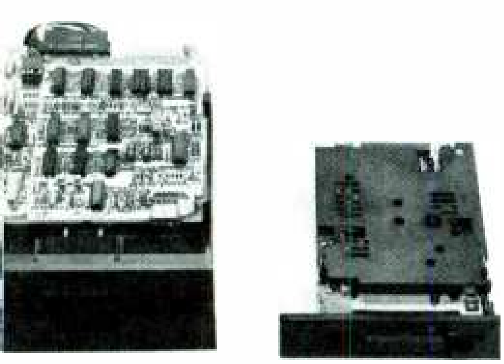
- It can store twice the data of a conventional 5¼-inch disk;
- The mechanism is smaller and lighter, so it lends itself very well to the new breed of battery-powered portable computers.

If your company, school, or whatever is leaning toward the new portables, there's no way that you'll be able to conveniently use the office disks at home, and vice versa. Either you'll be spending a lot of time and money transferring data by modem, or someone will have to tie up two very expensive computers so that data can be copied between the two disk sizes.

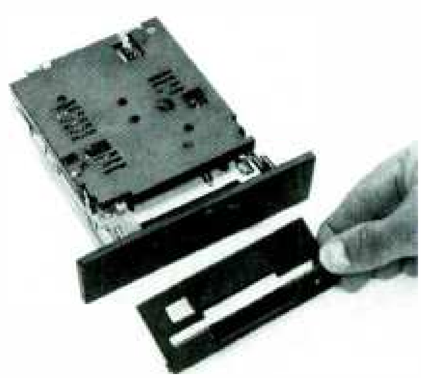
A better way to exchange data between 5¼ and 3.5-inch disks is to simply upgrade or retrofit your present IBM PC/XT/AT-type computer with a 3.5-inch disk drive. Even if you're a novice at the technical nitty-gritty of personal computing, it shouldn't be much of a chore. All you really need to do the job is a Toshiba 3.5-inch upgrade kit, a screwdriver, and some common sense (because the supplied instructions leave much to be desired).

The photographs show how the upgrade is done; but before we get into it, a few words about what you can expect. First, a 3.5-inch upgrade will provide 360K or 720K of storage depending on the particular computer and the version of DOS being used. If your PC/XT is what is called an *original* model, meaning that it can handle a maximum of 512K RAM, a 3.5-inch drive can handle 360K with DOS 3.1 and lower, 720K with DOS 3.2 or higher if special software known as a *device driver* is used (more on the driver later).

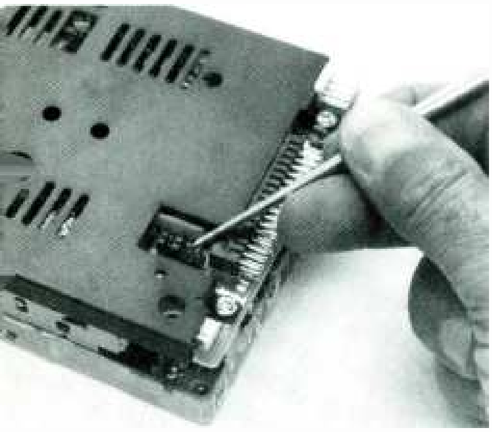
If your computer is the current PC/XT, meaning that it can address 640K of memory, the 3.5-inch drive will store 360K if the DOS is 3.1 or lower; 720K if the DOS is 3.2 or higher—and no special driver is required. The PC/AT provides the same



Just how much space does a 3.5-inch drive save? The one that comes in the Toshiba upgrade kit is shown on the right, while the one on the left is a full-size IBM-compatible model.



The first step is to substitute the required disk-drive front panel for the one that's supplied with the drive. The supplied panel, shown held in the hand, simply snaps off the drive. The black (PC/XT) or gray (AT) panel is simply snapped on the drive. The only difference between them is that the replacement panel is wider, so it fills the computer's entire half-height opening.



After the replacement front panel is installed, check the programming jumpers indicated by the pointer. The drive should come with the jumpers in the PC/XT location: at RDY and DS2. Ours were wrong and had to be reset—use long nose pliers for the job. If you have an AT-compatible computer the jumpers should be at the DC and DS2 locations.

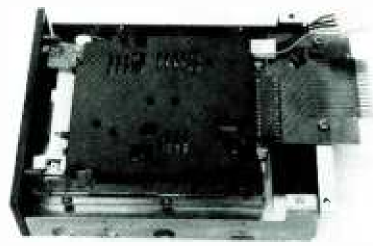
storage as the current PC/XT, and if the DOS is 3.2 or higher the 3.5-inch disk can be formatted for either 360K or 720K, but the computer must be set up through the advanced diagnostic procedures.

If your DOS is 3.1 or lower and you don't want to purchase a newer version in order to get the 720K storage, you can obtain a special 3.5-inch configuration program that will give you 720K storage. It's priced at $30 postpaid (from Microsense, 5580 La Jolla Blvd., Suite 313, La Jolla, CA 92037). Normally, we would recommend that you change to the latest version of DOS; however, we do know that that can cause some problems with a hard disk (which might result in destruction of the hard disk's data), and it can also entangle you in improper MODE, FORMAT, and COMMAND.COM commands on your present program disks. So if you want the greater storage capacity and don't want the hassle of converting to a new operating system, we suggest the 3.5-inch device-driver software.

A Complete Kit

The Toshiba *3.5-inch Floppy-Disk Drive Universal Kit*, which sells in the range of $135–$150, actually consists of two boxes of hardware that are taped together. One box contains only the 3.5-inch disk drive, which you may be able to purchase "barefoot"—meaning no hardware, no instructions, no nothing. The second box contains an assortment of mounting hardware and electrical adapters for which very little in the way of instructions are provided. For example, just the *main* mounting components are a lot of hardware, yet there is virtually no information on what adapters were meant for which computers.

The adapter kit contains half-height (black and gray) disk-drive replacement panels for PC/XT and AT-type computers; a half-height cover plate, mounting rails, and spacers; two sets of power-supply adapters (for IBM-clone and compatible computers); a main mounting frame that includes a special adapter that converts a 3.5-inch drive's header-type connections to the (more-or-less) standard edge-type connector used by IBM, and oodles of screws and washers.



Install the disk drive in the U-bracket. If you place the filler-bushings on the left—as you look at the front—thereby forcing the drive against the right side of the bracket, you'll find that drive ends up almost centered in its opening when the assembly is installed in the computer.

Disk Drive Limits

One important point that you must keep in mind is that the total number of floppy drives that your computer can handle is determined by the kind of drives already installed, the physical space they occupy, and the type of disk-controller card already installed in the computer. For example, original IBM PC's had two full-size disk drives. If you want to upgrade to a 3.5-inch drive, it must physically replace the B: drive.

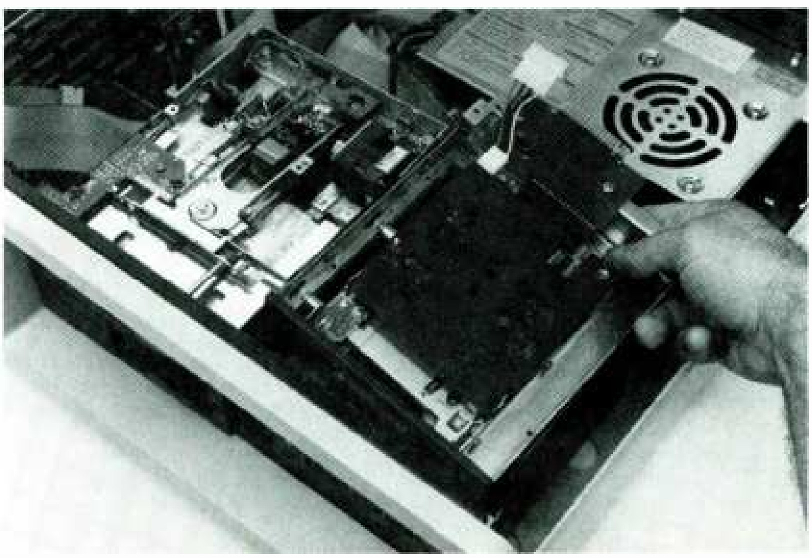
Alternately, you could replace the existing B: drive with a half-height B: drive, leaving room for the half-height 3.5-inch drive—which can be connected to the *rear connector* of an IBM disk controller, so that it functions as drive C: or D:. (The *giant* connector on the back of an IBM-type disk-controller card provides for two extra floppy drives. That's why the motherboard's DIP switches can be programmed for 0, 1, 2, 3, or 4 floppies.)

Many IBM-compatible computers have a multi-function, disk-controller card that can accommodate only two floppies; it doesn't have the rear connector for two additional drives. Hence, the 3.5-inch drive must physically substitute for drive B:. You must disconnect the power and signal cables from the existing B: drive and use them for the 3.5-inch drive.

Even if your computer uses half-height drives and there is physical space for two more half-heights, you still must use the drive B: disk-controller cables for the 3.5-inch drive. The only exception when you have the physical space for extra half-heights is if you have an IBM disk controller—which would allow you to route the 3.5-inch drive's signal cable out the back to the giant connector—or if you're using a *CompatiCard* disk controller, which has internal connections for four floppy-disk drives.

To give you a better idea of how far you can go in upgrading your computer, the photographs show a 3.5-inch, disk-drive installed in a PC/XT clone that was pre-

(Continued on page 93)

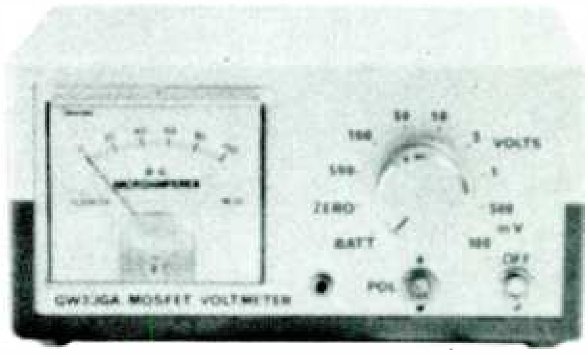


Simply slide the 3.5-inch assembly in by hand. It should drop right into place. If any pressure whatsoever is needed to get it into position, you're doing something wrong; something that could damage the hard-disk. Secure the assembly in place with two screws, and pull the assembly upwards as far as possible before tightening the mounting screws. If the assembly seems to bend toward the left, cut a 1-inch shim from one of the leftover disk-drive mounting rails and mount it under the rear left corner of the U-bracket. It's easier to do!

BUILD THE MOSFET VOLTMETER

Here's a sure-fire circuit that will measure volts without scrimping on the readout or interrupting the test circuit's operation!

By John Thornton Lawrence



ONE OF THE MAJOR CAUSES OF ERROR WHEN MAKING ELECtrical measurements on communications, audio, and other electronic equipment is the loading effect on the circuit caused by the measuring instrument. Voltage measurements suffer from the loading effects of the voltmeter's internal resistance, current measurements from the voltage drop across the ammeter, and oscilloscope measurements from capacitive effects introduced by the scope leads and/or probe. Those are the major causes of inaccurate measurements aside from the simple goof of mis-reading the instrument's indication.

For instance, when you measure the voltage in a DC circuit, the internal resistance of the voltmeter will load the circuit and cause the voltage to fall to some extent. The error between the actual voltage and the measured voltage increases as the loading effect of the instrument increases.

To give a practical example, take a simple potential-divider circuit consisting of two 100,000-ohm resistors connected in series across a 12-volt supply as shown in Fig. 1. We know instinctively that the voltage at the center point will be 6 volts. The mathematics are ultrasimple. When R1 equals R2:

$$V_2 = V_1 \times R2/(R1 + R2)$$

$$= 12 \times 100K/200K = 6 \text{ volts}$$

Now, see what happens when you make an actual measurement using different voltmeters set to their 10-volt DC scale. A 20K voltmeter means that the instrument shows 20,000-ohms of resistance per volt to the external circuit, so that on the 10-VDC scale, the instrument places 200,000 ohms across the circuit. Refer to the table below for values and comparisons.

It seems as if that since the beginning of time the Simpson 260 multimeter with its 20,000-ohms-per-volt meter movement has been the only professional meter to carry. In fact, it still is a workhorse along with similar models offered by Fluke and others. The entire radio, television, and consumer-electronics servicing industries would grind to a halt without those portable, multipurpose instruments. As a result, most service manuals offered by original-equipment manufacturers quote the voltage in various parts of the circuit when measured using such a meter; that has worked well.

However, for experimental purposes (even on the home workbench) there is much to be said for knowing the voltage that is actually present. In fact, some circuits cannot operate and provide a voltage to measure under an external load of a 20,000-ohm-per-volt meter; and that is where the MOSFET Voltmeter comes into its own.

The instrument to be described has an input resistance of 11 Megohms on all voltage ranges and will cause negligible loading when making measurements on virtually all elec-

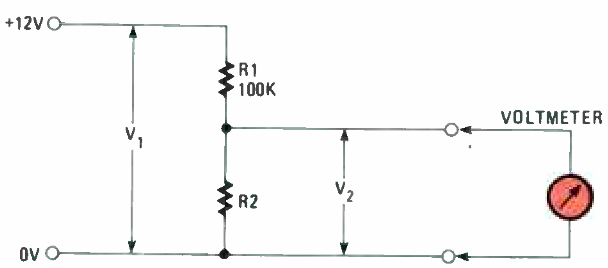


Fig. 1—A voltage divider network works fine until you attempt to measure the center-tap voltage with an ordinary voltmeter with a low internal resistance.

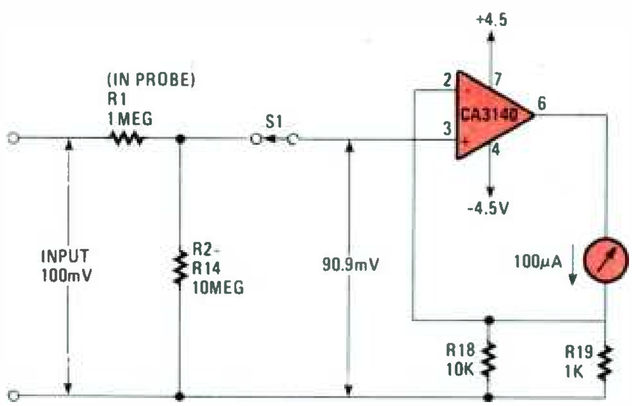
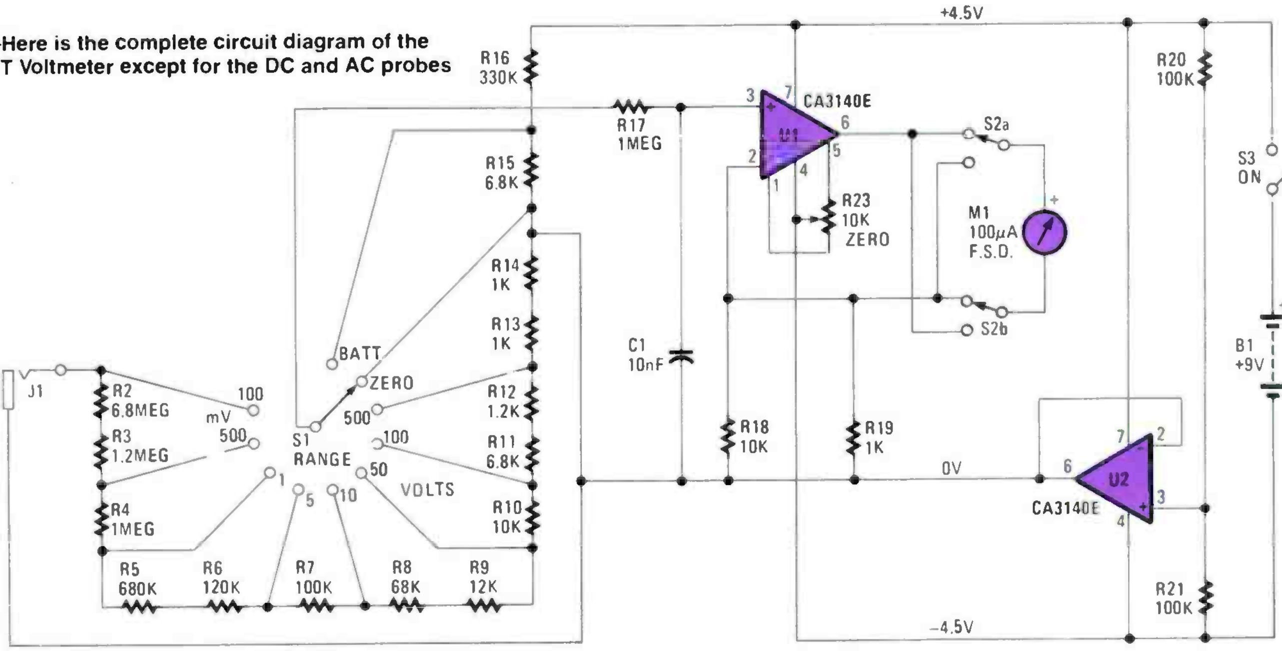


Fig. 2—A simplified circuit of the MOSFET Voltmeter which is fixed at the 100-millivolt range. Although the op-amp, U1, sees only 90.9 millivolts at the + input, 100 μA is required to flow though the meter to obtain the 90.9 millivolts to balance the op-amp inputs.

Our thanks to *Practical Wireless* for permission to reprint this article from their December 1986 issue.

Fig. 3—Here is the complete circuit diagram of the MOSFET Voltmeter except for the DC and AC probes



tronic circuits in common use both in consumer electronics and on the job. The voltmeter covers from 100 millivolts to 500 volts (full scale) in eight ranges arranged in a 5:1 sequence. Positive and negative voltages are catered to by means of a reversal switch. The voltmeter draws 5.5 mA and is powered by a 9-volt transistor-radio battery. An AC-voltage probe is provided for measurements in the radio frequency range.

Circuit Description

The heart of the voltmeter is the CA3140 integrated-circuit chip, U1. It is an op-amp which has a gate-protected MOSFET device in the input stage, giving it an input impedance of 1.5T ohms (1,500,000 Megohms). The output of the device has a bipolar transistor to provide adequate current-sourcing capability. One might think of it as a super high-impedance version of the well known 741 op-amp.

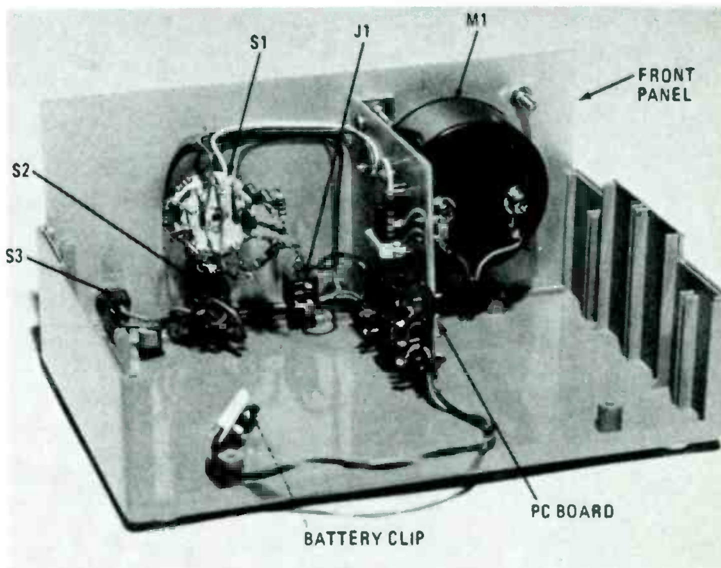
In the simplified circuit shown in Fig. 2, the 100-μA meter is connected in a feedback circuit where the incoming voltage to pin 3 causes U1 to drive current through the meter and R18 and R19 until the voltage drop across those resistors equals the incoming voltage.

Because the DC probe has a series, 1,000,000-ohm resistor, R1, built into it, the actual voltage across R2–R14 is less than the input voltage. For example, on the 100-millivolt range, an input voltage of 100 millivolts causes a voltage of 90.9 millivolts to appear at pin 3 of U1 due to the voltage-divider action of R1 and the range-switch resistors R2–R14. The value of R18 and R19 are chosen so that with 100 μA flowing through the meter, the voltage appearing at pin 2 of U1 is also 90.9 millivolts, thus the meter is indicating full-scale deflection of "100" for a 100-millivolt input.

In the full circuit, as shown in Fig. 3, the input voltage is always applied across R1–R14. Range switch S1 selects the appropriate tapping point for the range in use. A ZERO check position and BATT voltage check are included. Resistor R17 and C1 form a low-pass filter to prevent AC voltages and hum pick-up from overloading U1. Switch S2 is the meter-reversing switch which allows the measurement of negative voltage without the inconvenience of having to cross over the test leads. Resistor R23 is the zero adjustment control which corrects any current off-set existing in U1. Integrated circuit U2, also a CA3140, has the mundane job of center-tapping the single 9-volt power supply and providing equal positive and negative supply voltages to U1.

TABLE 1—VOLTAGE LOADING COMPARISONS

Type of Voltmeter	Actual Reading (VDC)
Ideal instrument (Infinite Resistance)	6.00
1K/V voltmeter (10,000-ohms)	1.00
20K/V voltmeter (200,000-ohms)	4.80
MOSFET Voltmeter (11,000,000-ohms)	5.97



The author constructed his MOSFET Voltmeter in a fancy plastic case with aluminum front and rear panels. You could do the same thing and give the project a pro look. An idea: Bolt an old transformer in the unused volume of the case to give the unit a feeling of *heftability*.

PARTS LIST FOR MOSFET VOLTMETER

SEMICONDUCTORS
D1—BAT85 silicon Schottky barrier diode or equivalent
U1, U2—CA3140 op-amp

RESISTORS
(All resistors are ½-watt, 1% units except where otherwise noted)
R1, R4, R17—1-Megohm
R2—6.8-Megohm, 1/2-watt, 5%
R3—1.2-Megohm, 1/2-watt, 5%
R5—680,000-ohm
R6—120,000-ohm
R7, R20, R21—100,000-ohm
R8—68,000-ohm
R9—12,000-ohm
R10, R18—10,000-ohm
R11, R15,—6,800-ohm
R12—1200-ohm
R13, R14, R19—1000-ohm
R22—4.7-Megohm, 1/2-watt, 5%
R23—10,000-ohm, miniature, trimmer potentiometer

ADDITIONAL PARTS AND MATERIALS
B1—Transistor-radio battery, 9-volt
C1—10-µF, 160-WVDC, polyester, 20% capacitor
C2—1-nF, lead-through capacitor
J1—Miniature jack, phone, phono, or any suitable type
M1—100-µA DC meter, 2–3 inches
P1, P2—Miniature plug to mate with J1
S1—10PST rotary, non-shorting with knob (12-position will do)
S2—DPDT, center-off miniature toggle switch
S3—SPST switch, either toggle or slide type
Miniature insulated alligator clips (2), miniature (thin and flexible) coaxial cable (cut to desired length), surplus pen cases, transistor-radio battery clip, printed-circuit board materials, hardware, solder, wire, etc.

DC-Voltage Probe

The DC-voltage probe must always be used when measuring DC as it is part of the input resistive network, the input resistance is then 11 Megohms on all ranges. As the 1-Megohm resistor, R1, is built into the tip of the probe, that allows DC voltage measurements to be made in the presence of AC signals with very little capacitive loading—just a few picofarads, on the circuit under test.

AC Voltage Probe

The AC voltage probe is intended for measuring voltages up to 10-volts *rms* (28-volts peak-to-peak) in the frequency range 50 Hz to about 200 MHz, covering the audio, video, and radio frequencies, and part of the VHF spectrum. Voltages greater than 10-volts *rms* cannot be accommodated because of the reverse voltage rating of D1, the BAT85 silicon Schottky barrier diode. The frequency response of the prototype probe is shown in Fig. 4. The diode has a reasonably level response ±1dB (±10%) up to about 100 MHz, a rising response to 150 MHz, and falling away at 200 MHz. As with all simple diode rectifier circuits there is some non-linearity at very low-signal levels due to the curvature of the diode characteristic and this non-linearity is shown in Fig. 5. For AC voltages above 1-volt *rms* it can, for all practical purposes, be ignored.

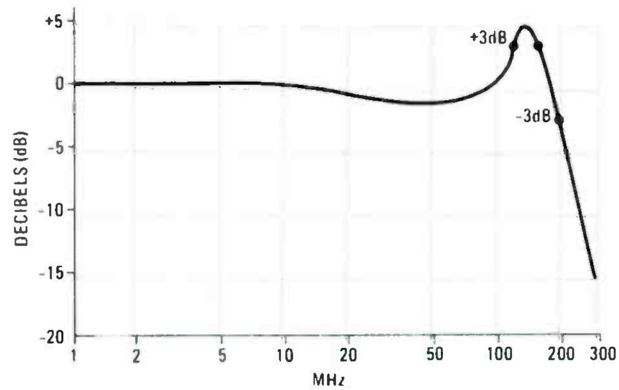


Fig. 4—The frequency response graph for the AC diode probe. The useful frequency range is from 50 Hz to 200 MHz.

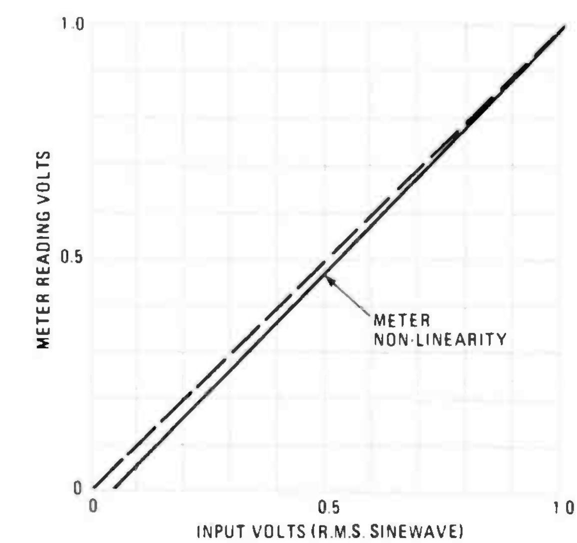
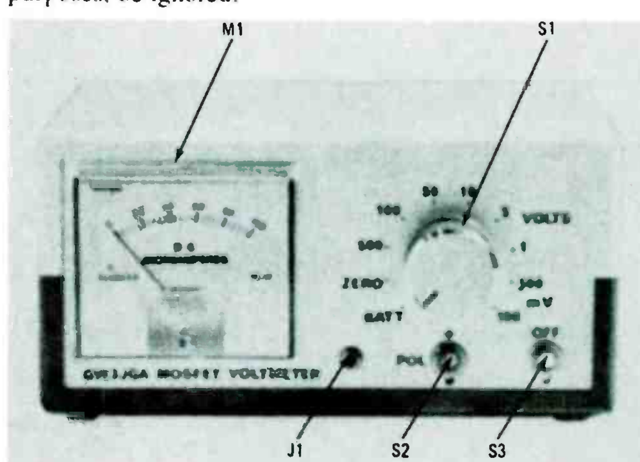


Fig. 5—For voltages below 1-volt *rms* there is a slight voltage non-linearity that is indicated by the graph. If exact voltages below 1 volt must be known accurately, interpolate the meter reading to the true reading by using a vertical straight edge on the graph.



The front panel for the MOSFET Voltmeter is simple and self-explanatory so that most users do not need a manual or instructions. Keep in mind that the POL switch S2 must be in the + position when measuring AC voltages.

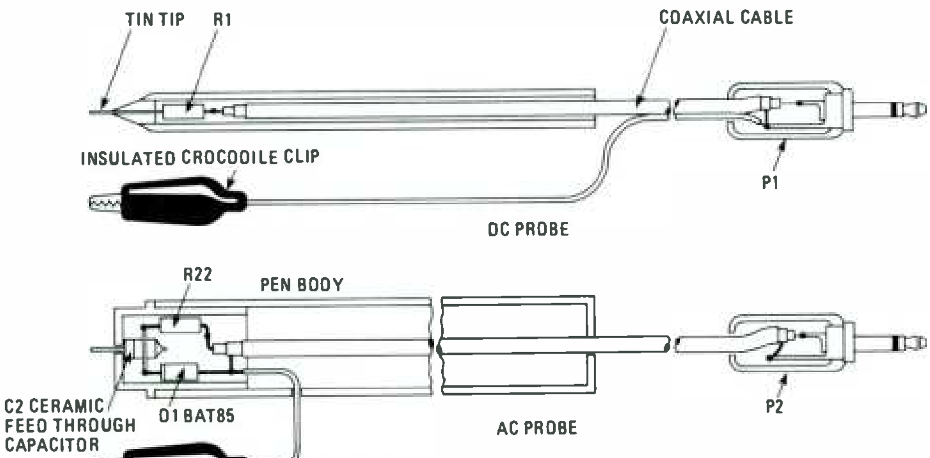


Fig. 7—The probes assembly diagrams indicate the course of action an experimenter should take to made his very own. Cable lengths should be between 3 and 4 feet.

Construction

The MOSFET Voltmeter is housed in a classy plastic case with aluminium front and rear panels. The meter and controls are mounted on the front panel (see Fig. 6) with small right-angle brackets secured under the meter-fixing nuts. The DC probe houses R1, and the AC probe D1, C2 and R22. The resistors R2 to R16 are mounted directly on the range switch, S1, and all the remaining components including U1 and U2 are mounted on the PC board, as shown in Fig. 7. The panel may be lettered using press-on lettering.

Of course, the plastic case you use is optional. In fact, the case can be aluminum throughout. That is up to you. There are many stylish cabinets available from several suppliers. Pick the one that suits you best and rearrange the layout to fit the internal volume. Nevertheless, you will find that the internal placement of parts will conform somewhat better to the author's original.

Both probes are made using discarded pen cases; almost any type will suit the DC probe where the resistor is mounted right at the end with the axial lead-out wire forming the tip. The AC probe requires a case with an internal diameter of just under 3/8-inch. Artist-type and brush-type pens often will fill the purpose. Just don't get the ink all over your hands. The top is removed and drilled to suit the center pin of the lead-through capacitor C2.

The printed-circuit template is given in Fig. 8 and the parts-location information for the board is given in Fig. 9. Consider making the board from the template, because it would be easy enough to make several at the same time. Your friends may want to build the MOSFET Voltmeter.

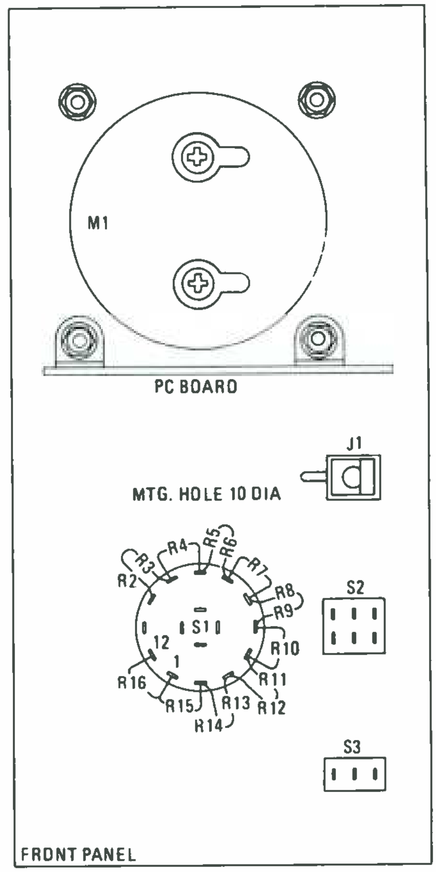


Fig. 6—This illustration serves to suggest a layout similar to that used by the author. Size of the case or cabinet that holds the MOSFET Voltmeter is not critical.

Initially, the MOSFET Voltmeter will require zero adjusting. That is done by rotating the range switch to the zero position and, with the supply on, adjusting R23 for zero reading on the meter.

With the DC probe connected, the MOSFET Voltmeter can be used in the same way as a conventional multirange, DC voltmeter.

With the AC probe connected and the POL switch set to positive (+), voltages up to 10-volts *rms* can be measured in audio, video equipment, and in low-power transmitters. However, do not attempt to measure AC signals greater than 10-volts *rms* and avoid transients greater than 30-volts peak-to-peak or damage to D1 may result. In the BATT check position the meter reads 10-volts full scale. ■

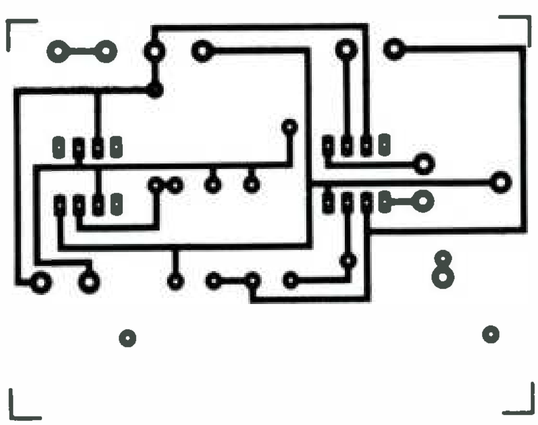


Fig. 8—The full-size, printed-circuit board can be copied or used as a pattern for placing the parts on a perfboard.

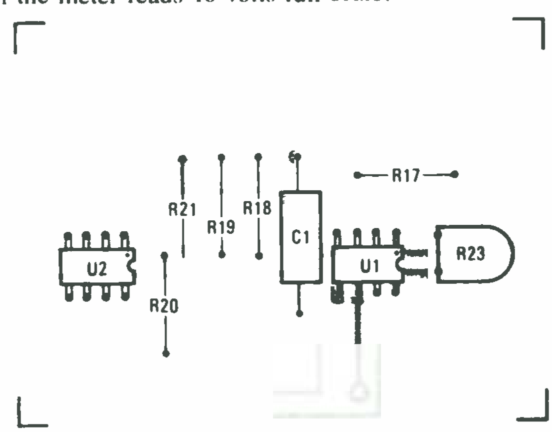
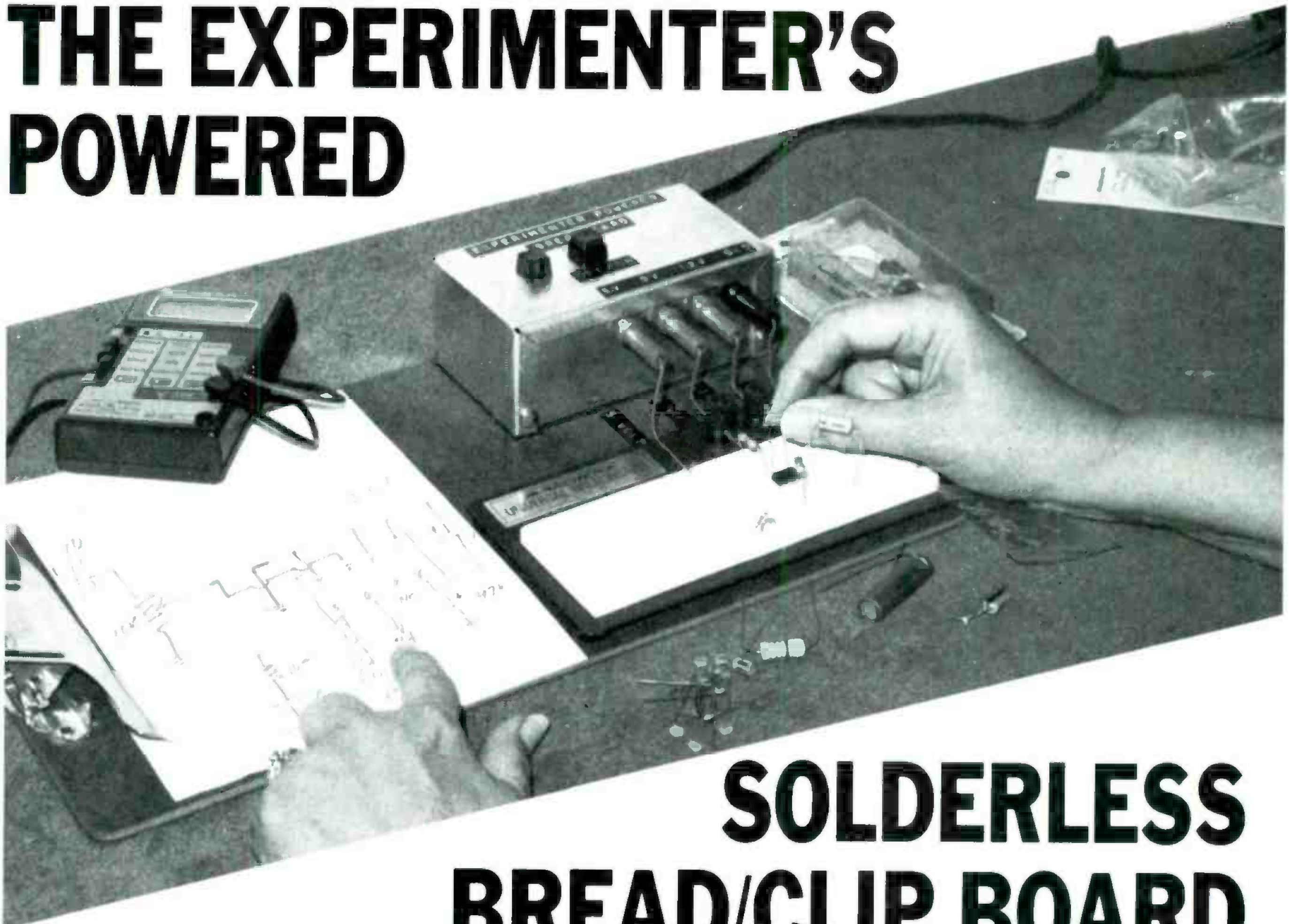


Fig. 9—The parts-location diagram for the printed-circuit board. Should you go your own way, remember that the positioning of parts is not critical to the operation of the voltmeter.

THE EXPERIMENTER'S POWERED SOLDERLESS BREAD/CLIP BOARD



Put the schematic diagram, circuit notes, power supply, solderless breadboard, and parts on one clip board. That's *practicality* at its best!

By: Homer L. Davidson

☐EXPERIMENTING OR BUILDING SIMPLE ELECTRONIC CIRcuits may take up to several hours of your valuable time and you still may not get it just right. The project may not work; at best, its performance may be poor and the finished device may look terrible. Sometimes the so-called solder-and-try method is for the birds, so to speak. Weak or dead batteries do not help the situation. What is the solution? We offer a solderless-breadboard project that is powered with three different voltage-regulating sources with a clip to hold that *roll-your-own* schematic diagram.

The solderless breadboard and power supply are fastened to a regular-size clipboard found at most school-supply outlets. The Masonite clip board is ideal to hold a schematic or wiring diagram from **Hands-on Electronics** in place. Three different voltages sources 5, 9 and 12 VDC will power most projects. There is no need to connect batteries because the various voltage sources are connected directly to the solderless breadboard.

The Power-Supply Circuit

There are power supplies—then there are power supplies. Of course, the power supply for this project is very simple and uses fullwave rectification with a step-down line transformer, T1 (Fig. 1). For convenience, a push on/off AC power switch S1 was used to turn the unit on, with a 120-volt AC neon pilot-light indicator assembly, NE1, which includes a built-in current-limiting resistor. The step-down transformer may be a 12 or 12.6-volt type with current capacity from 450 mA to 1 A. Since most projects draw considerably less current than .5 A, the 450 mA rated transformer T1 was considered suitable for the project.

The output from 12.6-volt secondary winding of T1 is rectified by a bridge fullwave rectifier module, BR1. Although, the module was wired in the project, four silicon diodes may be used, provided that they are rated at 1 A or better. Observe the diodes' polarity when connecting them into the circuit; they will pop if they're installed backwards. The positive terminal of the bridge rectifier is the longest terminal and usually is marked at the top of the plastic casing.

The 12- and 9-volt DC sources are taken from the positive terminal of the bridge rectifier. Input filter capacitor C1 provides ample DC filtering for the 12-volt regulator IC U1. The 9-volt DC source is taken from pin 2 of U1, through voltage-dropping resistor R1, and dropped across Zener diode

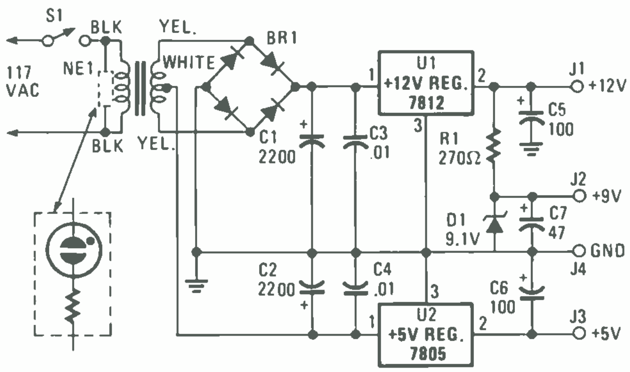


Fig. 1—The power-supply circuitry supplies 12, 9, and 5-volt DC regulated—that is ideal for almost all IC and solid-state experiments. U1 and U2 regulate the 12- and 5-volt DC sources with a 9.1-volt Zener diode regulating the 9-volt DC source.

D3, which is a standard 1-A, 9.1-volt device with C7 provides regulation for the 9-volt source.

The 5-volt DC source is taken from the center tap of power-transformer T1. Again, input filtering of C2 provides adequate filter action to U2, the 5-volt IC regulator (Fig. 2). The 5-volt output is taken from pin 2 of U2 with decoupling capacitor C6 connected across the output. Both IC regulators have marked input, output and ground terminals. They feature thermal-overload protection, and stable, fixed output-voltage protection. The metal lug on the IC body bolts directly to the metal chassis, providing an excellent heat sink.

Preparing the Subchassis

Cut a piece of perfboard 4-½ × 2¼ inches from a larger piece. The transformer is mounted at one end. Drill two ⅛-inch mounting holes for the power transformer. All other parts will fit right into the perfboard holes as they are mounted. The small ½-inch transformer bolts will keep the wiring off the bottom metal chassis. The mounting bolts of U1 and U2 provide adequate support at the opposite end. The regulator chips and banana-jack holes are drilled into the metal chassis after the sub-chassis is wired up.

Wiring the Perfboard

First, mount the power transformer with the secondary leads (12.6 VDC) inside and the black AC wires outside upon the perfboard. Use ½-inch, 4-40 roundhead machine screws and nuts. That length will protrude through the chassis to keep the perfboard up from the metal case to prevent shorting-out of the underside wiring. Next, mount the two IC voltage regulators in their respective holes. Mark each terminal underneath where the terminals go through the perfboard for correct hookup. The IC's should be ⅛-inch above the perfboard when mounted. Of course, the regulators are not bolted into position until the perfboard is completely wired and soldered.

The bridge rectifier, BR1, is the first component to be soldered into the circuit. All other components are mounted as they are wired in the circuit. Remember, the longest terminal of the bridge rectifier is the positive terminal. Mark that terminal (+) upon the bottom side of the perfboard with a felt-tip pen. Diagonally opposite the positive terminal is the negative terminal (–). The other two rectifier terminals (the AC terminals) connect to the secondary leads (yellow) of the transformer (T1). Coil the long yellow leads in a circle, around a pen or pencil, to take up the slack. Wrap the transformer bare wire leads around the rectifier AC terminals before cutting off the excess rectifier leads.

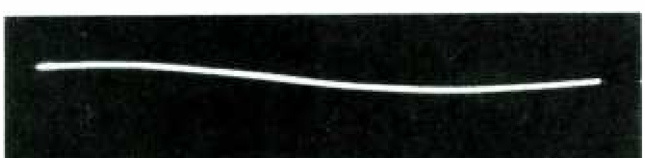
Use the full-length lead of C1 to connect to the input terminal of U1. Place a ground lug to one transformer bolt for the common-ground connection. From that lug, run a piece of bare #22 wire down the opposite side (away from U1 and U2) for a common ground for the other components.

After all components are wired into the circuit, run a tie wire to each voltage source. Leave the leads about 4 inches long to connect to their respective output jacks, J1-J4. Solder a bare piece of #22 hookup wire from common-ground lug for the black banana jack. You should have three voltage wires and a common bare ground wire coming from the perfboard. Mark each voltage upon the top side of the perfboard where the voltage wires are connected. Double check all wiring before proceeding to the metal chassis.

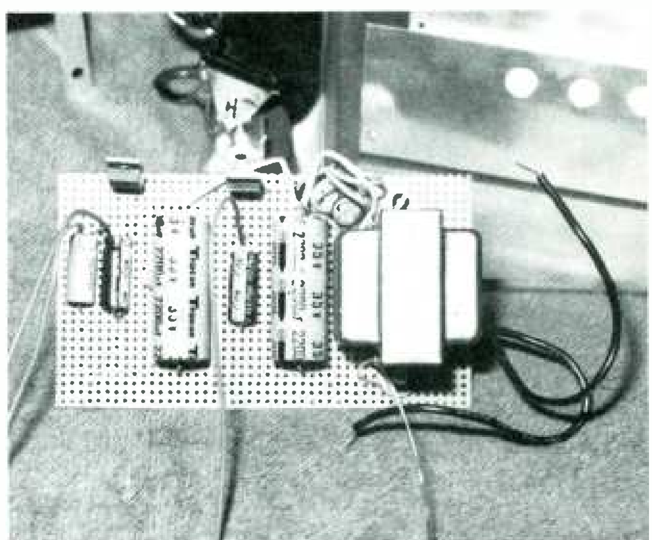
Check the resistance output of each DC power source before mounting the perfboard. Measure the resistance from voltage source to common ground wire with the ohmmeter. If a DMM is used, the numbers will increase until the electrolytic capacitor is charged. When the number stops, you should have resistance-to-ground readings that agree with those in Table 1. Double check the measurement by reversing the test leads. If the resistance measurements are above those shown it indicates that there's no leakage or shorts in the power-supply output circuits.

TABLE 1—PRE-POWER RESISTANCE CHECK

12 VDC	9 VDC	5 VDC
Resistance to ground (ohms)		
Above 6K	Above 5K	Above 6.5K



Here is a photo taken from an oscilloscope of the ripple on the 9-volt power source indicating good voltage regulation with variation less than a small fraction of a percent.

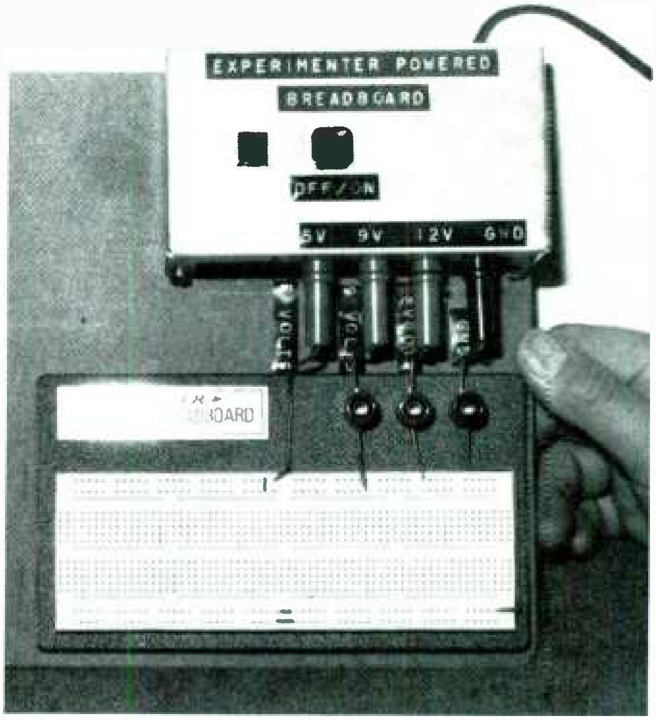


First, mount the power transformer, T1, and the IC voltage regulator components, U1 and U2. Then mount all other parts following the schematic diagram very carefully.

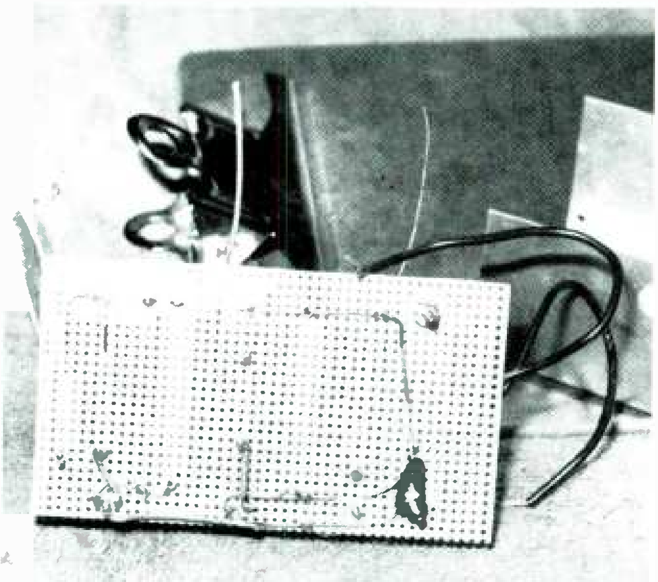
PARTS LIST
FOR EXPERIMENTER'S POWERED SOLDERLESS BREAD/CLIP BOARD

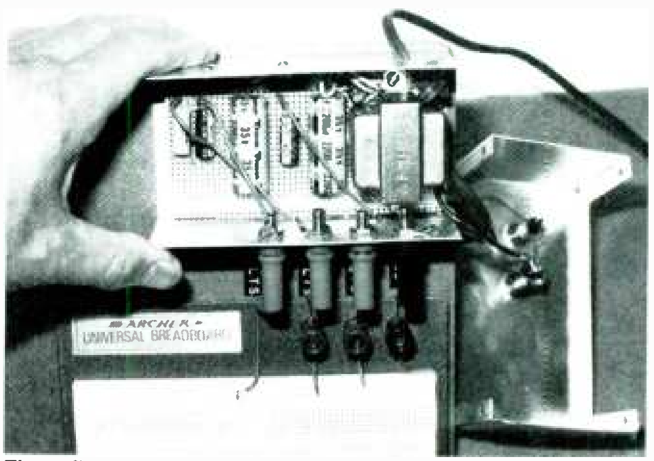
BR1—Bridge rectifier or 4, 1-A, 50-PIV diode rectifiers (Radio Shack 276-1151 or equivalent)
C1, C2—2200-µF, 35-WVDC, electrolytic capacitor
C3, C4—.01-µF, 100-WVDC, ceramic-disk capacitor
C5, C6—100-µF, 16-WVDC, electrolytic capacitor
C7—47-µF, 16-WVDC, electrolytic capacitor
D1—9.1-Volt, 1-A Zener diode
NE1—Neon pilot-light assembly with built-in current-limiting resistor, 117-VAC
J1–J3—Insulated banana jack, red
J4—Insulated banana jack, black
R1—270-ohm, ½-watt, resistor
S1—SPST, pushbutton switch
T1—Step-down power transformer; 117-VAC primary; 12.6-VAC, 450-mA, center-tapped secondary (Radio Shack 273-1365)
U1—7812 12-Volt regulator IC
U2—7805 5-Volt regulator IC

Solderless breadboard (see photo); 6-ft., 3-wire, AC power cord with molded AC plug; 4 banana plugs (3 red, 1 black) to mate with J1–J4; aluminum chassis box 5-¼ × 3 × 2⅛ (Radio Shack 270-238), perfboard, 4-40 hardware, #22 solid hookup wire, solder, clipboard, decals or press type, etc.



This view shows the voltage sources tied to their respective jacks. Take resistance measurement to ground to find shorts.


Notice the common-ground terminal lug under the transformer mounting nut. Run a bare, solid, #22 wire down one side of the perfboard. It will provide a ground for the other components.


The voltage sources are connected to the solderless breadboard-labeled voltage connections. Notice two shorting bars at the two bottom rows connect to make both rows the common ground.

Preparing the Metal Chassis

Prepare the bottom part of the metal box by drilling four 5/16-inch holes in the side panel for mounting the voltage jacks J1-J4. Temporarily place the perfboard chassis inside the metal chassis and level with the two transformer bolts. Mark the holes inside the case to mount the IC regulators. Remove the perfboard chassis and drill the two ⅛-inch holes for the regulator ICs. Drill two ⅛-inch mounting holes in the bottom of the chassis to fasten it to the Masonite clipboard.

Before mounting the perfboard chassis, bolt the bottom metal case to the clip board. Place the metal chassis upon the Masonite and mark the mounting holes. Countersink the bolt heads into the bottom side of the Masonite clipboard. Use two short flathead or bindinghead bolts so that they will be mounted flush with the Masonite. Cut off any excess of the bolts inside the cabinet so that they will not short against the soldered connections.

Place a dab of silicone grease behind each regulator before mounting. Now, bolt the two voltage regulators (U1 and U2) to the metal case. The metal chassis serves as heatsink for U1 and U2. Mount the four banana jacks in their respective holes. Make sure that the jacks are in the center of each hole. Check each jack for possible shorting to the metal chassis with the ohmmeter. Those jacks must be insulated from the metal chassis. Solder the respective voltage sources from the perfboard to the lugs upon the banana jacks. Make sure that the +5-VDC jack is to the far left, and the ground jack to the right. Use #22 solid hookup wire for all wiring connections.

(Continued on page 92)

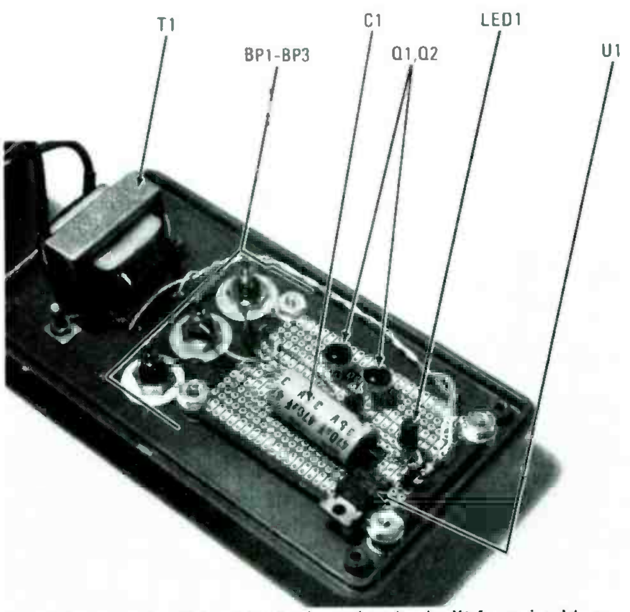
TEST

By Michael A. Covington

☐JUST HOW ACCURATE IS THE TACHOMETER THAT YOU'VE been using to tune your car? Chances are, you have no idea. Tune-ups performed with an inaccurate tachometer can cost you money in wasted gasoline and poor performance.

A tachometer gauges engine speed by measuring the frequency of the square wave that appears across the breaker points. To test it, we need a precise frequency source. The *Tachometer Tester* circuit shown in Fig. 1 generates a 12-volt square-wave signal from the 60-Hz line, whose frequency is very-accurately regulated. At that frequency, the Tachometer Tester mimics the signal from an engine—firing at a rate of 3600 times per minute, which corresponds to a speed of 7200/N RPM, where N is the number of cylinders.

The circuit can also test dwell meters. The dwell angle is the fraction of time that the points are closed, ranging from 0-degrees (open all the time) to 360°/N (closed all the time). The effective dwell angles (corresponding to points that are closed 49% of the time) for the Tester are shown in Table 1, which vary slightly with supply voltage. Now, dwell meters may be old hat to the new computerized cars, but enough of the oldies are still on the road and serviceable. If you work on a computerized ignition, exact rpm measurements mean the difference between 26 miles per gallon and 17, or less.



The Tachometer Tester is designed to be built from junkbox parts, so component values are not critical. Any general-purpose silicon transistors can be used, provided that they can handle the current requirement (which may be 50 mA or more).

TABLE 1—TACHOMETER CALIBRATOR READINGS

Cylinders	RPM	Dwell
4	1800	44.0° ±0.5°
6	1200	29.0° ±0.5°
8	900	21.7° ±0.5°

How It Works

As shown in Fig. 1, the incoming AC voltage is stepped down by the transformer and converted to DC (rectified) by D1, filtered by C1, and regulated by U1 (a 7812, 12-volt regulator) and LED1. Meanwhile, the unrectified AC signal is applied to the base of transistor Q1, causing it to conduct on the positive half-cycle. (Diode D2 conducts on the negative half-cycle to avoid applying too large a reverse voltage to the transistor.) The duty cycle is 49%, not 50%, since Q1 doesn't conduct until the positive voltage reaches 0.6V.

Q1 acts as a switch in series with R2, so that the base of Q2 is shorted to ground half the time, and receives the full supply voltage the rest of the time. Q2, in turn, switches on and off

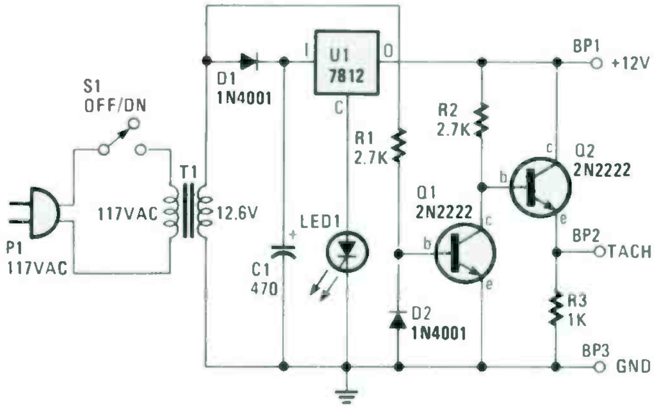
PARTS LIST FOR THE TACHOMETER TESTER

- **BP1–BP3—Binding posts**
- **C1—470-µF, 25- to 35-WVDC electrolytic capacitor**
- **D1, D2—1N4001 (or equivalent) 50-PIV, 1-A silicon rectifier diode**
- **LED1—Jumbo red light-emitting diode**
- **Q1, Q2—2N2222 (or similar) general-purpose NPN silicon transistor**
- **R1, R2—2700-ohm, ¼-watt resistor**
- **R3—1000-ohm, ½-watt resistor**
- **S1—SPST switch (see text)**
- **T1—117-volt primary, 12.6-volt secondary, 100 to 300-mA step-down transformer (Radio Shack 273-1385 or equivalent)**
- **U1—7812 12-volt, 1-A regulator, integrated circuit**
- **Printed-circuit or perfboard materials, enclosure, two-wire AC line cord, IC socket, solder, hardware, etc.**

YOUR TACHOMETER

Test your tachometer before using it to calibrate your car!

Fig. 1—Schematic diagram of the Tachometer Tester. Tachometer connects to BP2 and BP3 terminals; the +12v terminal (BP1) provides a separate power connection for those tachometers that require it.



the voltage applied to the tachometer across BP2 and BP3 (TACH and GND terminals). A +12V terminal (BP1) is provided for tachometers that require a separate power connection, and is capable of delivering about 13.6 volts, which is similar to the voltage level provided by the electrical system of a car with the alternator running.

LED1 (a red, light-emitting diode) plays a special role. In series with the ground lead of U1, a 12-volt regulator, the LED provides a constant voltage drop, which raise the regulated output voltage by 1.6 volts. (A green LED would give a 2.1-volt rise.)

Construction

The Tachometer Tester is designed to be built from "junk-box" parts; component values are non-critical. Any general-purpose silicon transistors can be used as long as they can handle the current that the tachometer draws (which may be 50 mA or more). Switch S1 is optional; you may choose, as I did, to turn the tester off by unplugging it. If you wish, you can mount the LED on the front panel as a power-on indicator, but it will glow rather dimly.

An alternative is to build the tester temporarily on a breadboard. If you do that, you can leave out D1, C1, U1, and LED1 provided a source of 12- to 15-volts DC is available. Just apply power to the +12V line and apply 10- to 20-volts AC to the top of resistor R1.

A word of caution when working an engine in motion: moving parts like fan belts and the fan itself plus the high-voltage ignition system can hurt you. So, be cautious! ■

A dwell/tachometer is shown here connected across BP2 and BP3 (TACH and GND terminals) of the Tachometer Tester. A +12V terminal (shown as BP1 in Fig. 1) is provided for tachometers that require a separate power connection. BP1 can deliver about 13.6 volts (mimicking the voltage level provided by the electrical system of a car with the alternator running).

By Jack Cunkelman

UNIVERSAL POWER SUPPLY

Ever wished for a power supply, printed-circuit layout whose output could be tailored by plugging in the right components?—Well, here it is!

IF YOUR PROJECTS FOLLOW THE SAME ROUTE AS MINE, THE power supply is the last item to be considered. After all, if I've built one supply I've built a dozen; it's hardly a challenge any more. So I set out to build up a module that would take all the drudgery out of the process—the *Universal Power-Supply module*.

Three criteria were applied to the module's design; for one, it had to use state-of-the-art components; two, it had to be simple. (That meant that linear three-terminal regulators would be used.) They are so easy to understand and apply that it makes no sense to build power-supply regulators from discrete components these days.

The third criteria was that parts from my junkbox could be used in the project. (Those priceless bargains that have been procured over the years could now be used). So let's run through some of the considerations in building up a power supply using the Universal Power-Supply Module.

Choosing the Transformer

There are three types of transformer/rectifier combinations possible (as shown in Fig. 1) with the module: A full-wave bridge rectifier coupled with a center-tapped transformer; a full-wave rectifier in conjunction with a center-tapped transformer, and finally a bridge rectifier with non-center-tapped transformer.

With the aid of Table 1, you should be able to tell what voltage that transformer in your junkbox will supply with different rectifier combinations. Table 1 can also assist you in making the correct transformer purchase. All the values in the Table are based on capacitor-input filtering. Be aware that transformer secondary voltage ratings vary widely, depending on how the voltage measurements are taken.

Transformer output-voltage is higher with no load than under full-load conditions. Typically, transformers with a higher output-current ratings sags less under load than do those with lower output ratings. In addition, the size of the wire used to make the transformer has a lot to do with loading effects. And the current supplied by the transformer depends on the type of rectifier circuit used.

For a full-wave bridge rectifier (Fig. 1C), the transformer's output RMS-current rating should be divided by 1.8; it should be divided by 1.2 when a full-wave, center-tapped rectifier (Fig. 1B) is used. For example, a full-wave rectifier and a center-tapped transformer rated at 1A RMS, can deliver 1/1.2 or 830 milliamperes.

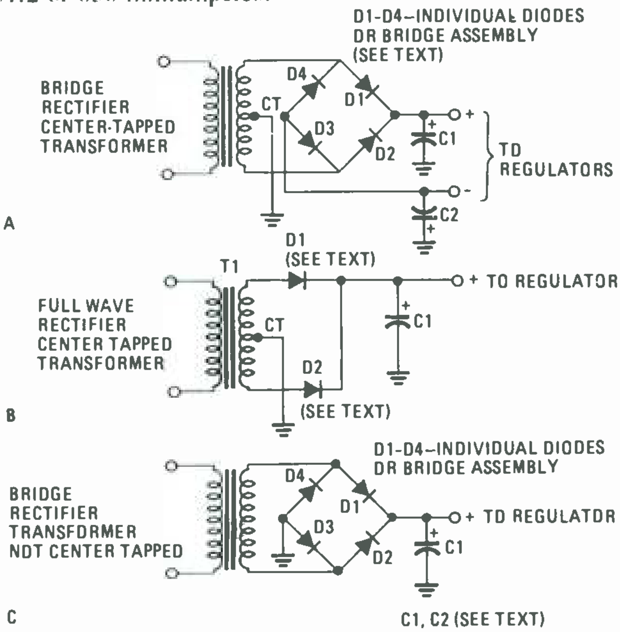
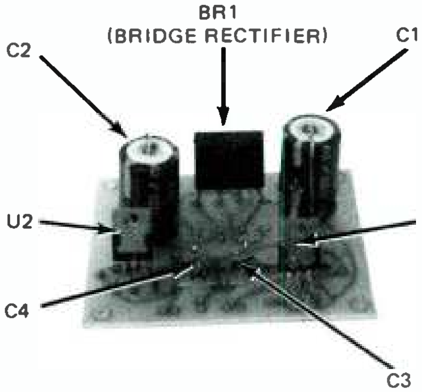
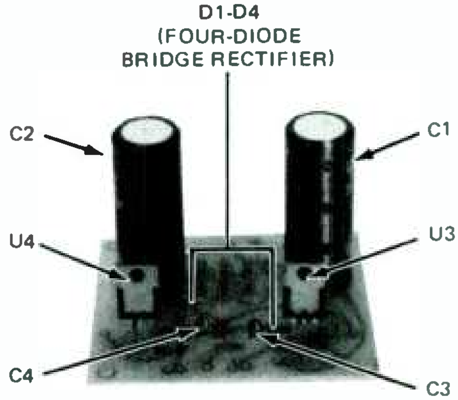


Fig. 1—There are three transformer/rectifier combinations possible with the module: full-wave bridge rectifier, or full-wave rectifier in conjunction with a center-tapped transformer, and a bridge rectifier with non-center-tapped transformer.



The Universal Power-Supply printed-circuit board is small enough so that it can be mounted in an unused corner of the chassis on your next project or a completed project



The circuit board is designed to use either individual diodes (in a straight row) or an epoxy-packaged bridge rectifier. The diode-voltage rating should be at least three to four times that of the transformer's rated secondary-voltage, and the current rating should be twice the maximum load current drawn.

The Rectifiers

The circuit board is designed to use either individual diodes or an epoxy-packaged bridge rectifier. The bridge assembly should have all the input and output leads in a straight row with the AC input on the middle two leads. The diode voltage rating should be at least three to four times that of the transformer's rated secondary-voltage. And the current rating of the diodes should be twice the maximum load current that is to be drawn.

It is always safest to *round up* (go for the higher rating) when choosing diode or bridge current and voltage ratings. For example, if the power supply is to provide 15 volts at .800 A, the diodes should at least have a 2-ampere rating.

Filter Capacitors

The job of the filter capacitor is to smooth out any ripple in the rectified AC voltage. The amount of residual AC ripple is determined by the value of filter capacitance. The larger the filter-capacitance value, the lower the ripple. Assuming a 10-percent ripple value (pretty normal) calculate the value of the filter capacitor needed by:

$$C = I/V_F$$

where C is the filter capacitance in microfarads (μF), I is the output current in amperes (A), V is the ripple voltage in volts (V), and F equals 120.

For an 18-volt supply delivering 500 milliamperes of current, the value of the filter capacitor is:

$$C = .5/1.8 \times 120 = 2315\ (\mu F).$$

That value being non-standard, the next greater standard value should be used.

TABLE 1—V_{OUT} FOR SELECTED TRANSFORMER RATINGS

Transformer Voltage (RMS) Rating	Bridge CT Xformer Input Filter Capacitor	Full-Wave CT Xformer Input Filter Capacitor	Bridge No CT Input Filter Capacitor
6	+/− 4	4	8
8	+/− 5	5	10
10	+/− 6	6	13
12	+/− 8	8	16
15	+/− 10	10	20
18	+/− 12	12	24
20	+/− 13	13	26
24	+/− 16	16	32
28	+/− 18	18	37
30	+/− 20	20	40
36	+/− 24	24	48
40	+/− 26	26	53

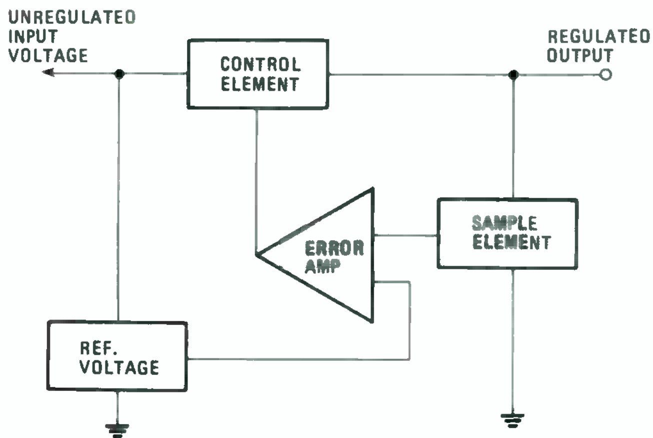


Fig. 2—Shown here is a block diagram of a typical linear regulator (also called a three-terminal, integrated voltage regulator)—the device that gives us a nice steady DC source.

The other consideration in choosing the correct capacitor is its voltage rating. The working voltage of the capacitor has to be greater than that of the peak output-voltage of the rectifier. In the case of our 18-volt supply, the peak output voltage is 1.414 × 18 or 25.5 volts, so a capacitor rated at 26- or 30-volts should prove adequate.

The Regulators

We've finally arrived at the output regulators—the devices that give us a nice, steady, DC source. Figure 2 is the block diagram of a typical linear regulator, also referred to as a three-terminal integrated, voltage regulator (which come with various output levels). The unregulated input voltage is fed to the control element and a voltage reference circuit.

The reference voltage developed is consistent for all input-voltage conditions. The output voltage is sampled and fed into one input of the error amplifier. The other input to the error amplifier is fed the reference voltage. If the error amplifier senses a difference between the reference voltage and sample voltage, it acts upon the control element to correct the error. (By dropping a greater portion of the input). The control element can be thought of as a variable resistor whose resistance or loss is controlled by the error amplifier.

The unregulated input voltage must always be higher than the regulator's output voltage. That voltage is called the input output differential. The minimum for the more commonly available regulators is about 3 volts and the maximum is about 35 volts. It's important to remember that the difference between the regulator's input and output voltages must be

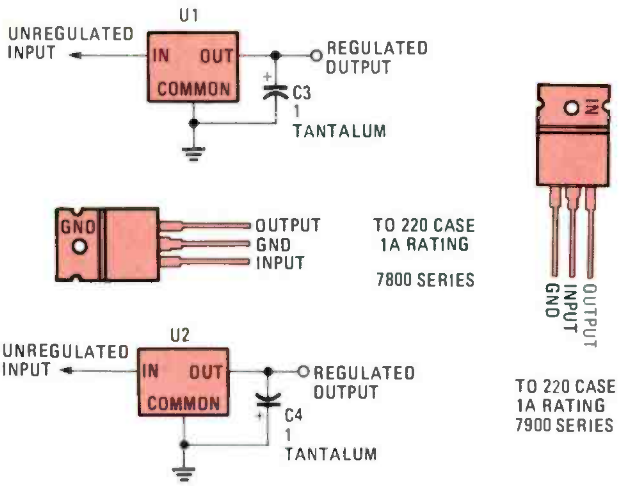


Fig. 3—Both positive and negative fixed-voltage regulator circuits—based on the 7800/340 (pos.) and 7900/320 (neg.) series of voltage regulators, all of which have fixed output voltages—are shown here. Those three-terminal regulators, housed in TO-220 cases, are popular and readily available.

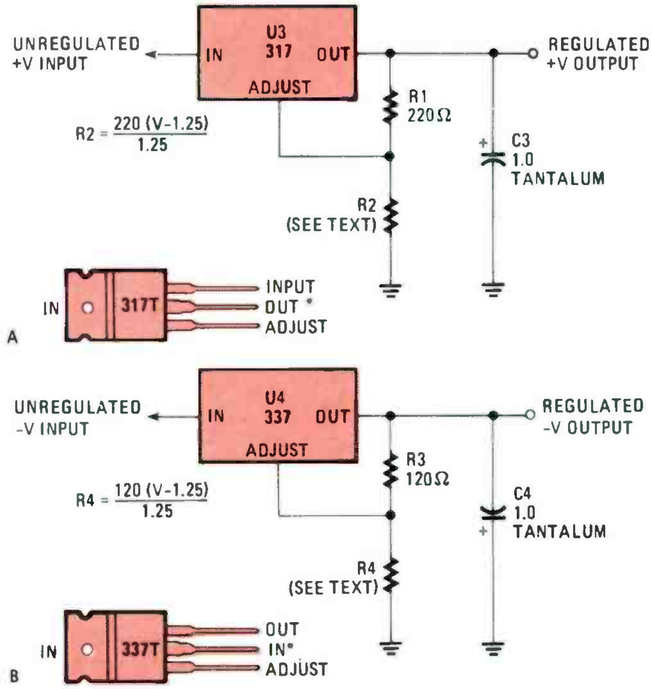


Fig. 4—A adjustable-output supply can be built using the 317/337 series of voltage regulators. The 317T (A) is used for positive voltages, while the 337T regulator (B) is used for negative voltages. Either way, the unregulated input must be 3 volts (minimum) higher than the output of the regulator

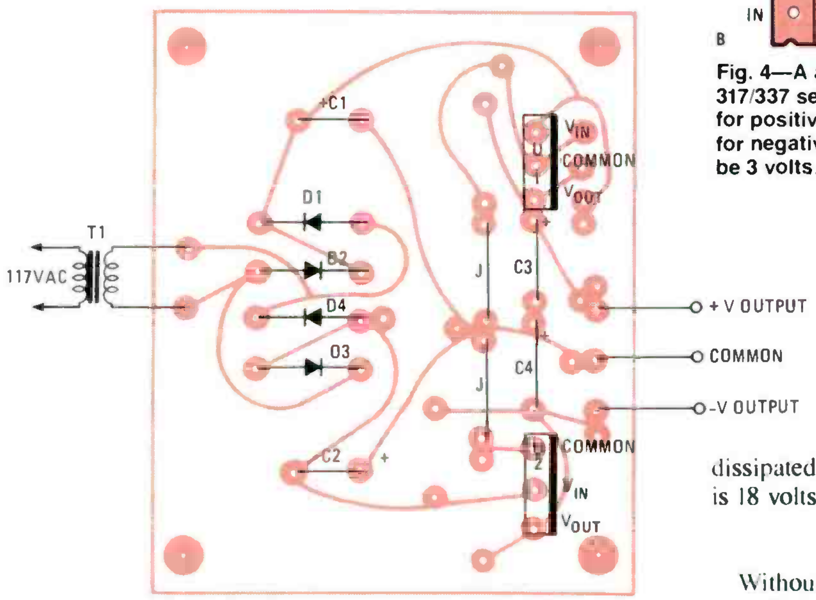


Fig. 6— Shown here is a parts-placement diagram for the circuit board in Fig. 5. The components and jumpers needed depend on the configuration chosen, so that not all of the parts are used in all cases. For instance, you could use a variable regulator (U3) for the positive voltage regulator and a fixed regulator (U2) for the negative voltage.

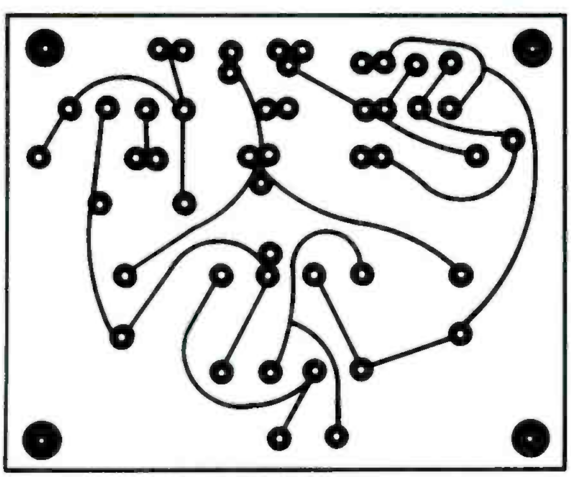


Fig. 5—A template of the Universal Power-Supply's printed-circuit board, which can accommodate all of the various power supplies that we've discussed, is shown here full-scale. It's small enough that, upon completion, it can be mounted in an unused corner of the chassis on your next project.

dissipated by the regulator. The input voltage to the regulator is 18 volts, and its power dissipation (in this instance) is:

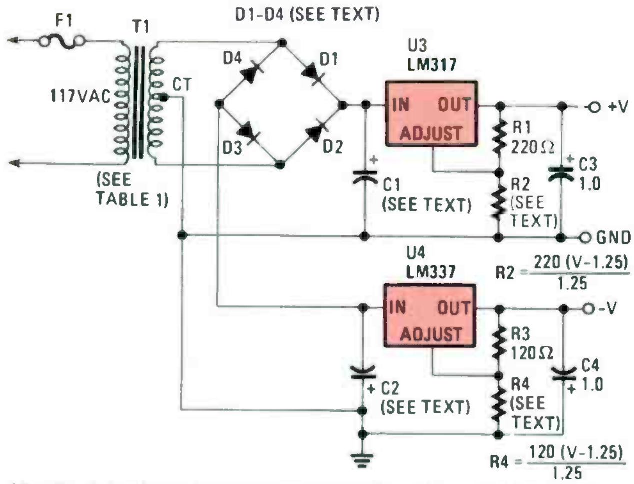
$$P_d = (18 - 12) \times .100 = 0.6 \text{ (W)}.$$

Without a heatsink, a three-terminal regulator in a TO-220 case dissipates about 2 watts, and has several built-in protection devices. For one, there's a thermal or excessive-heating protection circuit, so that if internal temperature exceeds 150°C, the regulator turns off.

Another protection device is a current limiter. If the output of the regulator is accidentally shorted, the amount of current the regulator can output is limited to about 200 milliamperes. In addition, the regulators have a feature called *safe-area protection*, which limits the output of the regulator when the input voltage is excessively high, ensuring that the built-in pass transistor (control element) operates within the allowable voltage and current ranges.

Figure 3 shows both positive and negative fixed voltage regulators and their pin configurations. They are a very popular series of regulator and should be readily available. The small capacitor placed across the regulator output to ground improves the regulator's ability to react to quick changes in load current and to prevent oscillations. The value of the capacitor should be between 1 and 5 µF, preferablly a Tantalum unit.

The printed-circuit board layout was designed to accom-



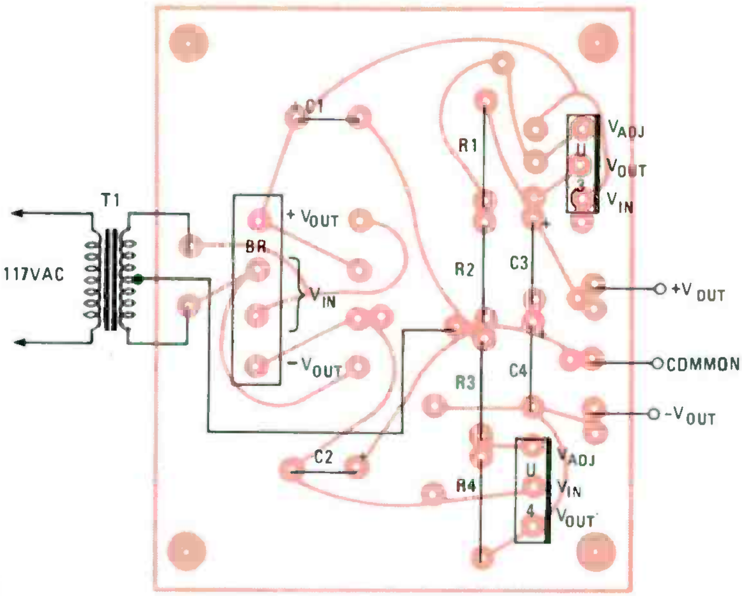
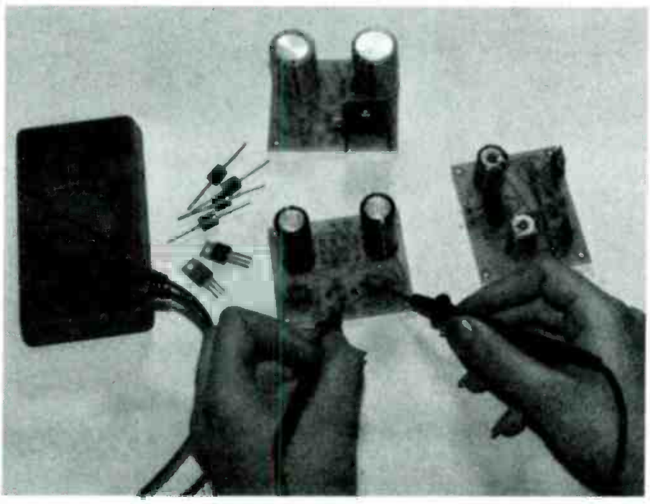


Fig. 7—A typical bipolar power supply using a bridge rectifier, center-tapped transformer, and variable regulators is shown in A and its parts-placement diagram is shown in B.



Once completed, check the output of the power supply for the proper voltage and current outputs. Measure the voltage across the output filter, referenced to ground. And make sure that it can deliver the required current by loading the supply with a resistor about equal to the load impedance. Drop-off in the output voltage should be small (if at all).

modate three-terminal regulators in TO 220 cases. The pinouts are for the 7800/340 series of positive-voltage regulators and 7900/320 series of negative-voltage regulators, all of which have fixed output voltages.

Variable Voltage Regulators

If the output voltage needed falls between one of the fixed values available, the 317 or 337 (positive and negative, respectively) series of variable-output voltage regulators can be used, allowing you to customize the output level. Shown in Fig. 4A is a schematic diagram using the 317T positive-adjustable regulator, along with the formula for calculating its output voltage. Resistor R1 is fixed at 220-ohms and resistor R2 is varied to achieve the desired output voltage.

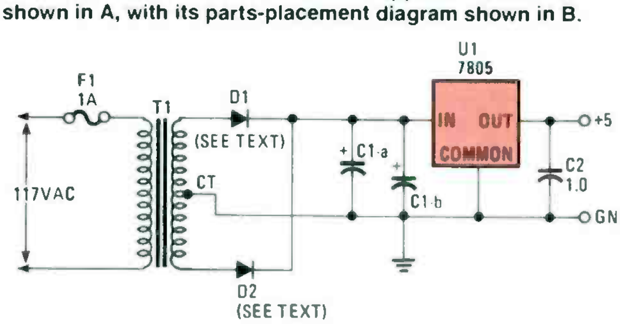
The schematic diagram in Fig. 4B is a regulator circuit built around the 337T negative regulator. The operation is the same except resistor R1 is fixed at 120 ohms. For both circuits, the unregulated input voltage must be 3 volts (minimum) higher than the output voltage for the regulators.

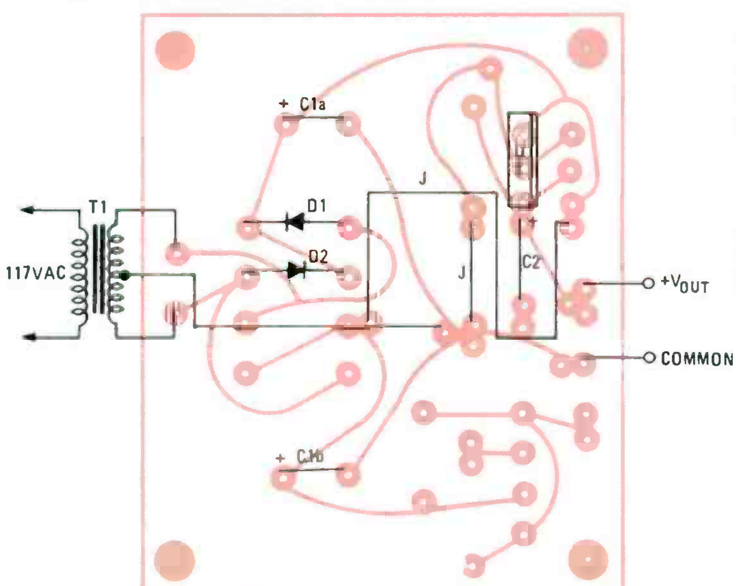
Universal Power-Supply Circuit Board

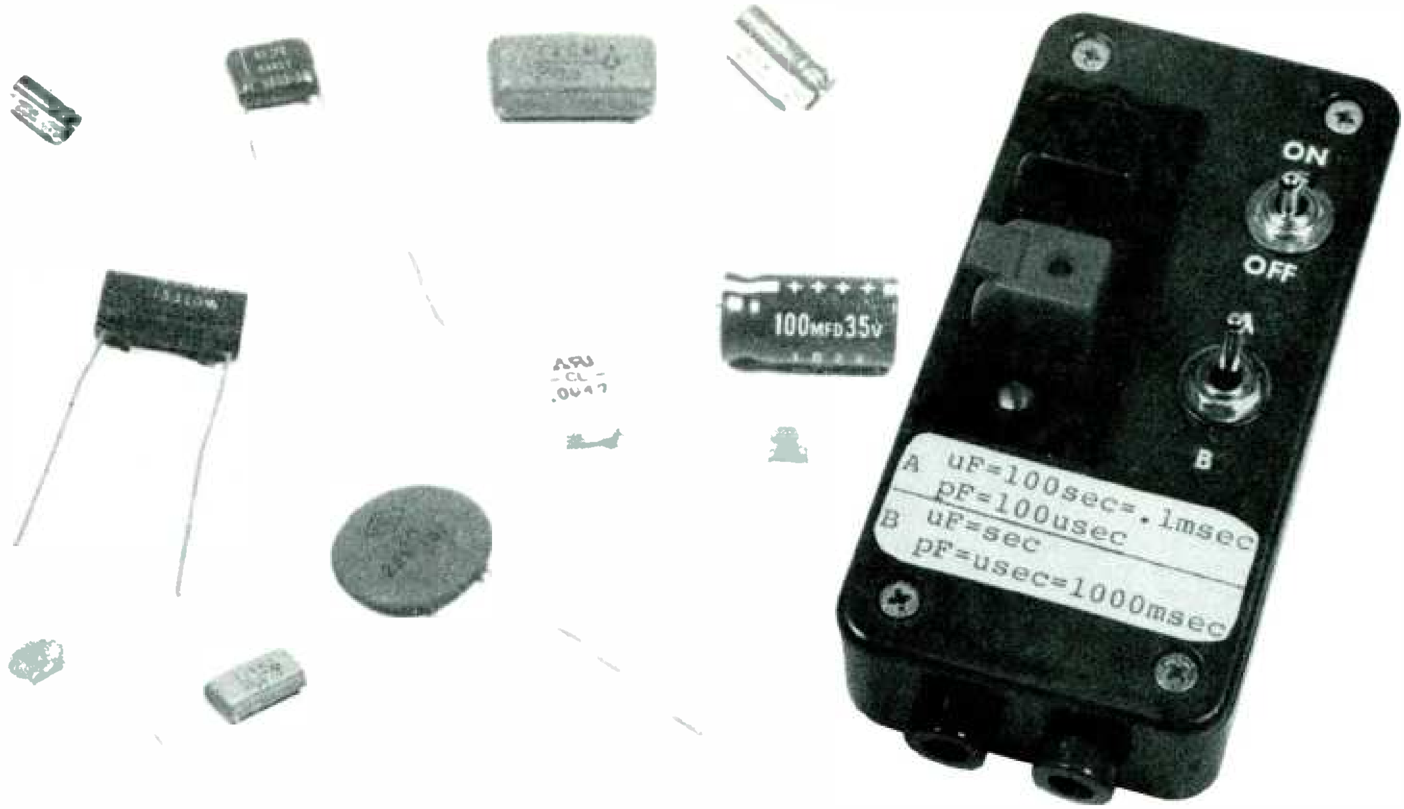
The full-size template of a printed-circuit board that can accommodate all of the various power supplies that we've discussed is shown in Fig. 5. It's small enough so that it can be mounted in an unused corner of the chassis on your next project, or a previous one.

(Continued on page 95)

Fig. 8—A single-polarity, fixed output-voltage supply, which uses a full-wave circuit and a center-tapped transformer is shown in A, with its parts-placement diagram shown in B.







HOW MANY MICROFARADS?

Look at a capacitor and it may tell you is capacitance value. If not, build our Capacitor Checker and measure it yourself!

By Jan Axelson

T WAS SOME BARGAIN YOU PICKED UP AT THE FLEA MARKET—A bag of new, assorted capacitors for only $3.95. That's about 6 cents per capacitor, but good buys occasionally come with problems. Some of the capacitors are unmarked, and others have a mysterious code that gives you no indication of the part's capacitive rating. Figuring out the value of an unlabeled or obscurely labeled capacitor can be a challenge. A typical capacitor pulled from the junk drawer might be stamped with any of a number of "standard" codes. Those codes can tell you the component's capacitance, tolerance, working voltage, operating temperatures, and more—but only if you can decipher them. Don't despair! Here are two ways to make identification and sorting easier. The first is a guide to understanding capacitor labeling codes; the second, a simple project to help you measure the values of mysterious capacitors. We call it the *Capacitor Checker*.

Capacitor Values

Electronics hobbyists know that capacitors are circuit components that store electrical charge. That ability to store a charge is called *capacitance*, and it's measured in units called Farads. But since one Farad is a *lot* of capacitance, the values of most capacitors are given in microfarads (one millionth of a Farad, abbreviated µF) or picofarads (one millionth of a microfarad, or pF).

Capacitors can be made of any of a number of different materials. Some of the most popular capacitor types are named after the materials that are used to manufacture them; such as aluminum and tantalum electrolytic, plastic film, ceramic disc, and mica. Each of those types is suitable in specific applications and follows its own set or sets of conventions for labeling. That is why the labels on capacitors can be so difficult to understand—you have to ascertain which marking system is being used before you can decode what the label says.

Electrolytic Capacitors

Can-type electrolytic capacitors are one type that are usually clearly marked. Their large size and cylindrical shape leaves plenty of room for labeling, so the capacitance and working voltage (WVDC) can be legibly stamped along the side of the device. (Working voltage is the highest voltage recommended for continuous operation.) Most electrolytic capacitors are polarized—a + or − next to one of the axial leads tells you which end is which. If the tolerance isn't given, you can assume it's quite large—many aluminum electrolytic capacitors vary from −10% to +50% of the labeled value. Electrolytic capacitors that are packed in aluminum cans with tabs for mounting directly to the chassis have the can as the common negative terminal. One or more terminal in the base of the unit are for the capacitor elements packed within the can.

Tantalum-electrolytic capacitors are labeled much the same way, with one number indicating the value, another giving the working voltage, and a + or other mark near the positive lead to indicate polarity. The units of capacitance may be left off to save space, but tantalum capacitor values are almost always given in microfarads. Figure 1 shows some examples of labeling on electrolytic capacitors commonly used by experimenters.

Once in a while you'll see capacitors that are color-coded. Capacitor color codes are similar to the familiar code used for resistors: black is 0; brown, 1; red, 2; etc. In one system used on tantalum capacitors, the top two bands give the first and second significant figures of the capacitance value, and the bottom band gives the number of zeros to add. A dot on top gives the tolerance and a dot on the + (positive) side tells the working voltage.

You may find other conventions used—to numerous and complex to describe here. With color codes you're not sure of, your best bet is to verify the values by measuring. We'll say more on how to do that later.

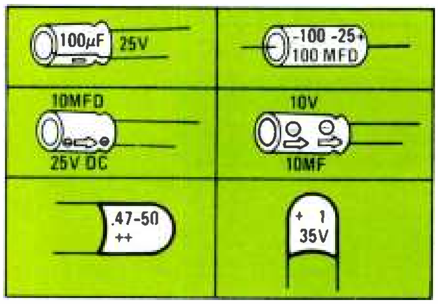


Fig. 1—Aluminum and tantalum electrolytics are labeled for capacitance, DC working voltage, and polarity. In most cases the part is large enough for straight-forward identification.

Plastic-Film Capacitors

Mylar, polystyrene, polyester, and polypropylene materials are used to make plastic-film capacitors. Often those capacitors are labeled with a four-figure code that compactly tells both capacitance and tolerance. Figure 2 shows that code. Here's how it works: The first two numbers give the significant figures of the capacitance value, the third number is the multiplier (the number of zeros at the end) and a letter tells the tolerance. So a capacitor labeled 105M is 1,000,000 picofarads (10 with five 0's), or 1 microfarad, ±20%. Just remember that the value in the code is always expressed in picofarads.

Sometimes you'll see just a number stamped on a capacitor, perhaps .0047 or 470. The number indicates the capacitor's value, but the value may be in microfarads or in picofarads. Here you have to guess from the physical size and type of the capacitor in which the units of the value is given. A good rule of thumb is that values greater than 1 are probably in picofarads and values less than or equal to 1 are in microfarads. Of course, a capacitor in a computer power supply stamped 20,000 is 20,000 microfarads—they do come that big!

Ceramic Disc Capacitors

Probably the capacitor type most used by experiments is the ceramic disc capacitor. Those capacitors may use the four-figure code explained above, or they may give the value directly; and because they're often used in sensitive tuning circuits, those capacitors may also be rated and labeled for

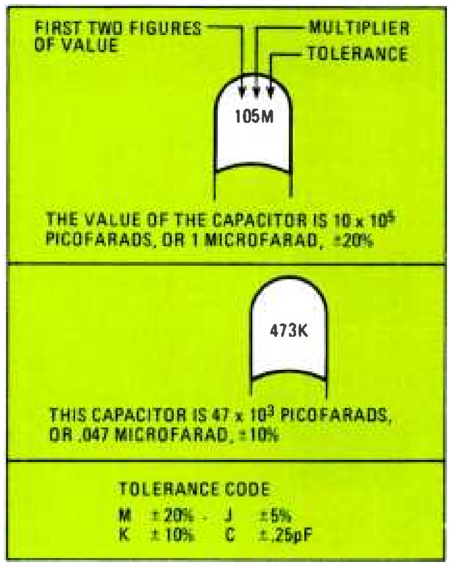


Fig. 2—In this code, two digits and a multiplier give the value of the part in pF, and a letter tells the tolerance.

temperature characteristics. Figure 3 shows the EIA (Electronic Industries Association) three-figure code for temperature characteristics. That code tells you how much the capacitance will change over a specified temperature range. For instance, according to that code, a capacitor labeled Z5P may vary ±10% over a temperature range from +10 to +85° C.

Ceramic capacitors with very close tolerances and predictable responses use a different code. In that code the letter N or P tell how many parts per million the capacitance changes for each 1° C change in temperature.

MINIMUM TEMPERATURE	MAXIMUM TEMPERATURE	MAXIMUM CHANGE IN CAPACITANCE OVER TEMPERATURE RANGE
X -55° C	2 +45° C	A ±1.0%
Y -30° C	4 +65° C	B ±1.5%
Z +10° C	5 +85° C	C ±2.2%
	6 +105° C	D ±3.3%
	7 +125° C	E ±4.7%
		F ±7.5%
		P ±10%
		R ±15%
		S ±22%
		T -33%, +22%
		U -56%, +22%
		V -82%, +22%

Fig. 3—The EIA temperature coefficient code for Class 2 ceramic disc capacitors is given above.

What does this mean in practical terms? A capacitor labeled N750 will drop in value by .075% for each 1° C rise in temperature. For a 500-picofarad capacitor that means a change of just .4-pF per degree. For rock-solid performance, a capacitor rated NPO (negative-positive-zero) is virtually unaffected by changes in temperature.

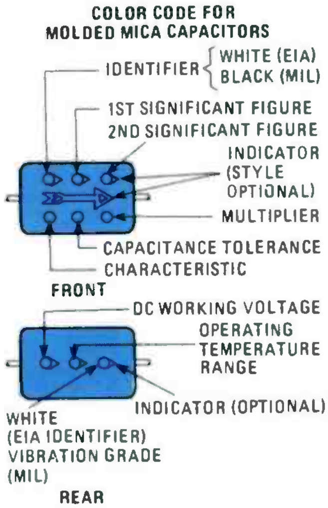
Unless your application is critical, you don't need to worry about those temperature characteristics at all. But it is nice to know what they mean for those times when it is important.

Mica Capacitors

Capacitors of molded mica may use the EIA or MIL (military standard) color codes. In those codes a series of colored

21 Hands-on Electronics FactCard

Capacitor Codes



CAPACITOR CHARACTERISTIC CODE

Color	Temperature Coefficient (ppm/°C)	Capacitance Drift
Black	±1000	±5% +1 pF
Brown	±500	±3% +1 pF
Red	±200	±0.5%
Orange	±100	±0.3%
Yellow	−20 to +100	±0.1% +0.1 pF
Green	0 to +70	±0.05% +0.1 pF

EIA TEMPERATURE CHARACTERISTIC CODE
FOR DISC CERAMIC CAPACITORS

Minimum Temperature		Maximum Temperature		Max. Cap. Change Over Temp. Range	
X	−55°C	2	+45°C	A	±1.0%
Y	−30°C	4	+65°C	B	±1.5%
Z	+10°C	5	+85°C	C	±2.2%
		6	+105°C	D	±3.3%
		7	+125°C	E	±4.7%
				F	±7.5%
				P	±10%
				R	±15%
				S	±22%
				T	−33%, +22%
				U	−56%, +22%
				V	−82%, +22%

21 Hands-on Electronics FactCard

Capacitor Codes

Color Code for Molded Mica Capacitors

Color	Capacitance: 1st and 2nd Significant Figures	Capacitance: Multiplier	[illegible]	[illegible]	Operating Temperature Range	[illegible]
Black	0	1	±20% (EIA)		−55° to +70°C (MIL)	10-55 Hz
Brown	1	10	±1%	100 (EIA)		
Red	2	100	±2%		−55° to +85°C	
Orange	3	1000		300		
Yellow	4	10,000 (EIA)			−55° to +125°C	10-2000 Hz
Green	5		±5%	500		
Blue	6				−55° to +150°C (MIL)	
Purple (violet)	7					
Gray	8					
White	9					
Gold		0.1	±½% (EIA)	1000 (EIA)		
Silver		0.01 (EIA)	±10%			

Fig. 4—This illustration is a replica of a December 1986 FactCard. It provides the decoding information on the EIA and Military capacitor codes commonly used.

dots divulge the capacitor's value, tolerance, temperature characteristics, and voltage ratings. Those codes as well as the EIA's temperature and tolerance code for ceramic-disc capacitors are nicely summed up on the FactCard in the December 1986 issue of **Hands-on Electronics**. Just in case you didn't save that FactCard, it is duplicated in Fig. 4.

Measuring Capacitance

If you still find yourself with a capacitor that is not marked; marked with a code you cannot decipher; or the marking is unreadable, all is not lost—you can measure the capacitor's value. Capacitance meters are readily available that give quick and reliable readings. If you don't have a capacitance meter, you can use either an oscilloscope or frequency counter to measure capacitance with the simple circuit shown in Fig. 5.

Here's how the circuit works. Integrated circuit U1 is a 555 timer connected in astable, or free-running, mode. The

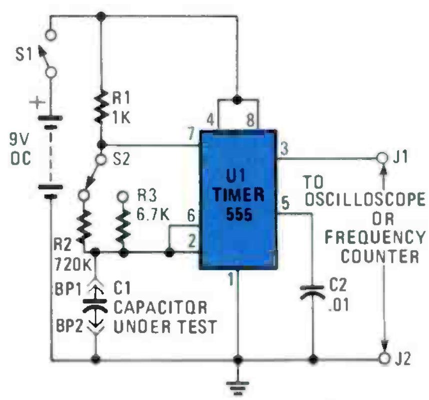


Fig. 5—**Measure the period of the output frequency of the 555 timer and you can easily calculate the capacitance of C1.**

timer's output at pin 3 is a rectangular wave whose frequency is set by R1, R2 or R3, and C1. So, if you know the output frequency and the values of the resistors, you can calculate the value of C1.

The equation for the circuit (with R2 selected) is:

$$C1 = 1.44T/(R1+R2)$$

where C1 is in µF (microfarads) and T is in µS (microseconds).

That the timer's output period (1/frequency), or the time it takes for one complete cycle. Plugging in the values for R1 and R2 (with a little mathematical rounding off) gives:

$$C1 = T/1{,}000{,}000 = T \times 10^{-6}$$

or

$$C1 = T'$$

where T' is in seconds.

The resistor values are chosen to make the math as simple as possible—the period of the output in seconds equals the capacitance of C1 in microfarads. And, by doing a little algebra (dividing each side by 1,000,000), you learn that the output period expressed in microseconds equals the capacitance of C1 in picofarads. Just remember the equation:

$$1\ \mu F = 1\ pF \times 10^{6}$$

So a 200-µS period means that C1 is 200 pF, a 1-second period means that C1 is 1 µF, and so on. Fig. 6 shows the output waveform caused by a 200-pF capacitor.

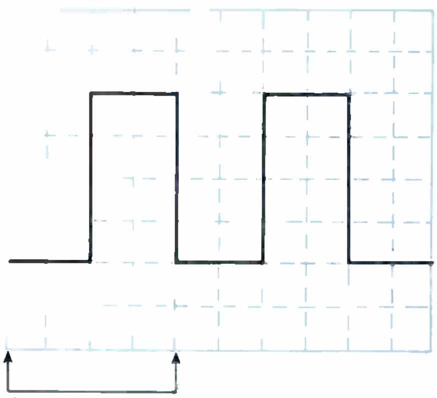


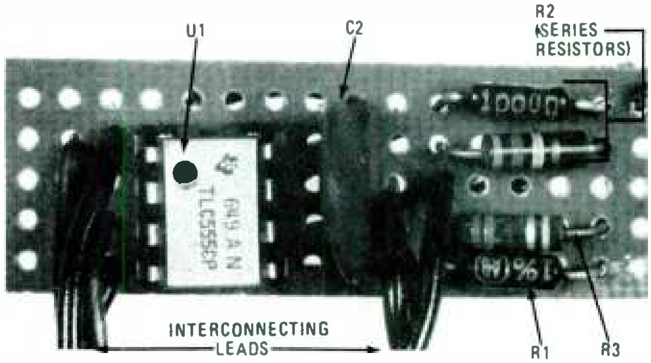
Fig. 6—The period of the waveform on the 'scope face is 200 microseconds, so the value of the capacitor is 200 picofarads.

Limits

With R2 selected by setting S2 to A, the circuit works well for values from about 100 pF on up, but a 100-µF capacitor causes an output with a tediously long 100-second period, not to mention that large leakage currents in the capacitor under test can frequently keep the timer from oscillating at all!

You can speed things up by selecting R3 with switch S1. That makes the timer oscillate 100 times faster. A 100-muF capacitor now causes an output with a 1-second, rather than 100-second, period. Also, leakage currents in the capacitor under test have less effect when used with the smaller resistor in the circuit.

The tradeoff is that the faster circuit doesn't do as good of a job measuring smaller values—it's best reserved for measurements of .001 microfarads or larger. (That keeps the output of the timer below 100 kHz.) Table 1 sums up the



Most of the small parts are mounted on the perfboard chassis. Switches and interconnecting hardware are mounted on an experimenter-type plastic case.

conversion constants for the circuit using both R2 and R3.

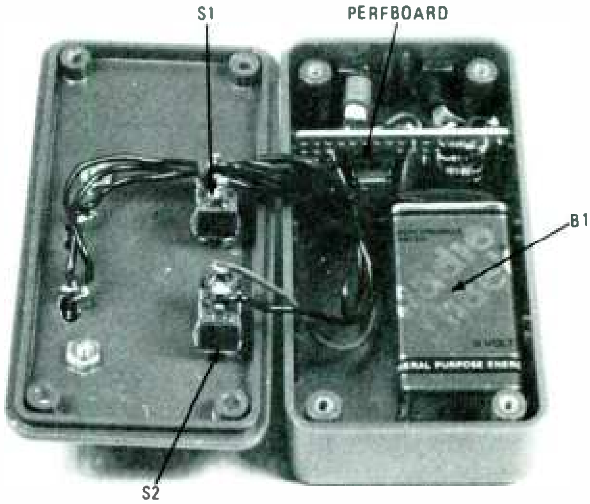
How accurate is the measurement method? Variation in the resistor values is one source of error, but if your resistors are within 10 percent of the recommended values, the total error they cause will be 11 percent or less. Resistors with 5% precision are within a reasonable price range—you can cut the error down to below 6 percent. Precision resistors are not called for, because of the rounding-off of values in the mathematics will negate the cost effectiveness of those more expensive resistors. If you enjoy working for perfection, go ahead.

Leakage current in the capacitor under test and stray capacitance will also affect the accuracy of your readings. But all in all, the circuit does a good job of "ballpark" measurements (±20% or so), and that's close enough for many purposes. Should you own a few precision capacitors, you could test the accuracy of the circuit at different ranges of capacitance.

Circuit Construction

You can breadboard the circuit for the Capacitor Checker in a few minutes to make a quick measurement, but you'll probably find the circuit so handy you'll want to make a permanent test fixture.

To do that you can easily wire the circuit on a piece of



Here is a view of the finished assembly of the Capacitor Checker just before it is buttoned up. A small, compact case requires some extra effort in the unit's construction.

perfboard using wire-wrap or point-to-point soldering; or you could use a printed-circuit board of your own design.

For U1 you can use either the bipolar 555 timer or the CMOS low-power version (TLC555 or ICM7555). A socket for the chip is optional, but recommended.

Notice that the values of R2 and R3 aren't standard resistor values. When you put the circuit together, aim for resistances that are within 10% of the recommended values by using either a single resistor or a series combination. For instance, two 360,000-ohm resistors in series will give you the 720,000 ohms for R2, and a single 6,800-ohm resistor is fine for R3.

Capacitor C2 is a bypass capacitor; its exact value isn't at all critical.

Spring-action pushbutton terminals, BP1 and BP2 (see photograph and Parts List) make a good test jig for the capacitor under test. The test leads to the oscilloscope, J1 and J2, or frequency counter plug into banana jacks or other connectors of your choice.

To build the Capacitor Tester, cut a small piece of perfboard to fit the plastic enclosure you will be using. Insert the IC socket, capacitor C2 and the resistors on the board. Layout isn't critical. An accompanying photograph shows one possible arrangement of parts. Using the schematic diagram in Fig. 5 as a guide, wire the on-board connections between the components and the IC.

Next, cut eight 4-inch pieces of insulated hookup wire. Strip 1/4-in. of insulation from the ends of each wire. Then solder a wire to each lug on switch S2, to each of the pushbutton terminals and banana jacks, and to one of the lugs on switch S1. Solder the positive battery wire to the remaining lug on S1.

Now prepare the enclosure. Drill holes for the switches, pushbutton terminals, and banana jacks. Be sure to plan ahead when positioning the holes—leave enough room for the battery and circuit board when the switches are inserted and the top is fastened down. Insert and fasten the switches, terminals, and jacks on the case and cover of the enclosure.

Refer to the schematic diagram in Fig. 5, solder the free ends of the 8 wires to the appropriate points on the circuit board. If your pushbutton terminals are color-coded, connect the black terminal to ground. Otherwise, you'll need to label the terminals + and – as a guide for inserting polarized capacitors. Solder the negative battery wire to ground on the circuit board.

Double check your wiring. Then, observing proper orientation, insert the IC in its socket. Snap the battery into its connector and insert the battery and circuit board into the case. Scraps of foam will hold the battery in place and keep it from touching the circuit board.

Clamp a test capacitor into the pushbutton terminals, plug your oscilloscope or frequency counter probes into the jacks, and turn on the circuit.

Checkout and Use

To measure capacitance with the Capacitor Checker and a frequency counter, see if your counter gives a direct readout of the period. If not, you'll have to calculate the period from the frequency. (Refer to the equations discussed previously.) Take note of the units (seconds, mS or μS) of the period as well as its value, and calculate the capacitance from the chart in Table 1.

TABLE 1—CAPACITOR TESTER SETTING AND UNITS

Timing Resistor	Units (T)	Multiplier	C1
R2 (A on S2) (720,000 ohms)	seconds	×1	µF
	mS	×1000	pF
	MS	×1	pF
R3 (B on S2)	seconds	×100	µF
	mS	×.1	µF
	MS	×100	pF

To measure capacitance with the Capacitor Checker and an oscilloscope, set the volts/division switch to 2 volts, adjust the trigger for a stable display, and select a time base so that the screen shows one or two complete cycles of the waveform. Fig. 6 shows an example.

To find the period, multiply the time base by the number of screen divisions in one cycle. For instance, in Fig. 6:

$$50\ \mu\text{S/division} \times 4\ \text{divisions} = 200\ \mu\text{S}.$$

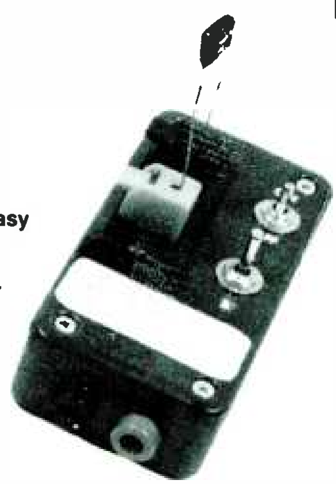
From Table 1, with the value of R2 selected, the capacitance is 200 picofarads.

Final Tips

When testing polarized capacitors be sure to observe proper polarity when inserting them into the pushbutton terminals (BP1 and BP2) of the Capacitor Checker. Keep in mind that the capacitor under test will charge to 6 volts (2/3 of the supply voltage). That is no problem for most, but not all, capacitors—if in doubt, check the working voltage.

As finishing touches on the Capacitor Checker, use rub-on transfers to label the switches and glue an abbreviated "key" (gleaned from Table 1) on the case for interpreting the readings. That is seen clearly in the photograph of the completted unit with the cover ton. You may want to copy Table 1 and paste it on the bottom of the case. The two positions of switch S2 are marked A (selects 720,000 ohms) and B (selects 6,700 ohms).

Now get back to the test bench with the Capacitor Checker and attack those unknown capacitors. You have only bucks to save. ■



The Capacitor Checker is easy to operate. It connects directly to an oscilloscope or frequency counter through two banana jacks on its case. Follow the directions in the text.

E-Z MATH

FLIPPING FORMULAS

By Louis E. Frenzel, Jr.

You can't design an interesting circuit without math, but how can you avoid useless theorems? Read only what you need to know in this new electronics math series!

MATH. YUK! ALMOST EVERYBODY HATES IT. EVEN people who have a knack for it avoid it. And those who struggled with math in school really dread it. But regardless of which category you are in, if you're an electronics enthusiast, you are probably running into math problems all of the time. Electronics is a highly technical subject that lends itself to mathematical analysis. You've got to know a little math to understand electronics. You've got to know a lot of math to do electronic design. You can get by in electronics without a lot of math, but it greatly limits you. You will understand more and be able to do more if you have basic-math competency.

Actually, math isn't all that hard. Most of what you need to know you learned in high school. You have probably forgotten it, but with a little refresher, you should be able to recall the most important facts. That's the main problem most people have. They learn a subject but never apply it. It's either use it, or lose it. Most people lose it, but it's also pretty easy to get it back.

The purpose of this and future articles in this series is to get back to basics and review the math that can be helpful to you in electronics. We will review all the basic procedures, give you some practice, and teach you some new tricks that will make it all faster and easier.

If you've had trouble with some particular aspect of electronic math, drop me a line, and I will try to work it into a future article. In the meantime, let's start our review with how to transpose formulas.

Formulas and Equations

A formula is a mathematical expression showing the relationship between two or more different variables. A variable is just some physical characteristic that changes under certain conditions. Variables are usually represented by letters of the alphabet.

An example of a simple formula is:

$$D = R \times T$$

where D is the distance travelled in miles, R is the rate of speed in miles per hour (mph), and T is time in hours. All of those are variables because if one changes, at least one of the others changes too.

If a car is going 45 mph and it does so for 1.5 hours, the distance travelled is:

$$D = R \times T = 45 \times 1.5 = 67.5 \text{ miles}$$

You'll also hear formulas called equations. An equation is a mathematical expression that sets one variable equal to some combination of other variables.

A really great example of an electronics formula is Ohm's law which forms the whole basis for electrical and electronic action. Ohm's law is simply an expression of the relationship between the current, voltage, and resistance in a circuit. A simple example is given in Fig. 1. Current, of course, is electron flow which is measured in amperes. It is usually

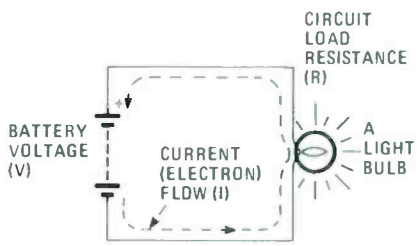


Fig. 1—Ohm's law for the above circuit can be stated as follows: The current I supplied by a battery with voltage V, through a bulb with resistance R, is equal to V/R.

represented by the letter I. Voltage is the electrical pressure that makes current flow. Voltage is expressed or measured in volts and is usually represented by the letters V or E. Then, there's resistance which is the opposition to current flow in ohms represented by the letter R.

Simply stated, Ohm's law says: Current is directly proportional to the voltage and inversely proportional to the resistance.

What does that really mean? Well, all it says is if you increase the voltage, the current will increase by a proportional amount. If you double the voltage, the current will go up by two. Decreasing the voltage, of course, decreases the current. If you cut the voltage to one-fourth, then the current is quartered also.

Changing the resistance also affects the current. But here it is an inverse or opposite relationship. Increasing the resistance gives more opposition to electron flow so current decreases. Also, dropping the resistance lowers the opposition so the current goes up.

A formula lets us state the whole phenomena very succinctly:

$$I = V/R$$

All we're really doing here is dividing one number by another. Any division problem can be expressed as a fraction, that is, one number divided by another.

$$\text{fraction} = \text{numerator}/\text{denominator}$$

You will also see it written like this:

$$\text{fraction} = \text{numerator} \div \text{denominator}$$

Suppose we apply 6 volts to a light bulb with a resistance of 3 ohms. The current is super easy to compute:

$$I = V/R = 6/3 = 2 \text{ amperes}$$

Now let's double the voltage to 12 volts. The new current is:

$$I = V/R = 12/3 = 4 \text{ amperes}$$

It doubled since we doubled the voltage. Looking at the basic formula, you can see that.

Any division problem has three elements: a dividend, a divisor, and a quotient shown like this:

$$\text{quotient} = \text{dividend} \div \text{divisor or dividend/divisor}$$

In the Ohm's-law formula, we divide the dividend (the voltage), by the divisor (the resistance), to get the quotient (the current). The dividend over the divisor forms a fraction. The voltage (dividend) is above the line so it is the numerator. The resistance (divisor) is below the line so it is the denominator. Obviously, by making the dividend greater, the quotient will be greater. The number being divided (the dividend) is larger so the outcome has to be larger.

Now, what if we return the voltage to 6 volts, but increase the resistance to 6 ohms? The new current is:

$$I = V/R = 6/6 = 1 \text{ ampere}$$

Doubling the resistance halved the current. That's because we increased the divisor or denominator. Doesn't it make sense that if we divide the dividend by a large value, the result will be smaller? It's sort of like cutting a pie into larger pieces. We get fewer of them.

Keep these basic relationships in mind when you deal with electronic formulas because they will help you determine how different variables change with variations in some of the other variables.

Formula Transposition

There are many times when you know the actual numerical values of two or more variables and you wish to calculate the remaining variable. But unfortunately, the formula is set up to calculate a variable we already know. Let's use Ohm's law again as an example. Suppose we know that the current is 3 amperes and the resistance is 10 ohms. What we don't know is the voltage. If we plug those values into our basic Ohm's law formula, we get:

$$I = V/R$$

$$3 = V/10$$

What do you do with something like this? The answer is, you transpose the formula to solve for V, *then* plug your values in to make the final calculation. The trick is in the actual transposition.

Transposition means changing the variables around and regrouping them so that the one you are trying to solve for is isolated on the left-hand side of the equals sign and all the remaining variables are on the right-hand side of the equals sign. The way you do that is to use some of those basic techniques you learned in algebra.

Our job is to change:

$$I = V/R$$

into a revised formula with V on the left and I and R on the right. The easiest way to do this is to first just rewrite the formula as:

$$V/R = I$$

You haven't really changed anything as the two are still equal. You just swapped sides.

Next, try to get rid of any fractions. We usually do this by eliminating the denominator to get rid of the R. We do this by multiplying both sides of the formula or equation by R like this:

$$R(V/R) = I(R)$$

The two R's on the left cancel one another leaving V. We would rewrite that as:

$$V(R/R) = I \times R$$

Remember, R/R = 1. Anything divided by itself is 1. So one times V is just V. So our new formula is:

$$V = I \times R$$

That formula says that the voltage equals the current multiplied by the resistance. Just as a reminder, we don't usually use the multiplication sign (×). Instead, we write the variables directly next to one another to show multiplication like this:

$$V = IR$$

But you can also use parenthesis to show multiplication like this:

$$V = I(R)$$

Don't forget, it also doesn't matter what order you write the factors in.

$$V = IR = RI$$

The question you are probably asking is: how did you know to multiply both sides of the equation by R? After all, that's the basic transformational trick that solved our problem. The key to deciding what to do is to look for operations that will cause one number to cancel another. Using an opposite or reverse operation does that. For example, the opposite of division is multiplication and vice versa. And the opposite of addition is subtraction and vice versa.

In our formula, V is divided by R. So to get rid of R we multiply V by R. The two R's cancel because R divided by R is just 1. And one times V is just V.

Of course, you can't arbitrarily just multiply one side of the equation by R. You have to multiply both sides to keep the two sides equal. That goes for any operation you decide to use.

Now, let's try it one more time. Assume we know I and V but not R. Starting with our equation:

$$I = V/R$$

we need to convert it so that R is on the left and V and I are on the right. The easiest way to do this is to

$$V = IR$$

Then, we rearrange it:

$$IR = V$$

Then, since we want to get rid of R in order to isolate I, we can divide both sides by R:

$$IR/R = V/R$$

$$I = V/R$$

Easy, huh?

We could have also started with our original equation:

$$I = V/R$$

First, we try to get rid of any fraction so we multiply both sides by R:

$$IR = V/R \times R$$

$$IR = V$$

Then, to isolate R, you divide both sides by I:

$$IR/I = V/I$$

$$R = V/I$$

Actually, you could just memorize those three versions of Ohm's law and eliminate all this work. But, knowing transposition techniques you can derive anything yourself from one basic formula. Then you only have to remember one formula.

More Transposition Tricks

Now let's take some more complex formulas. A good one is the power formula:

$$P = I^2R$$

Here I is squared, that is, multiplied by itself, as the exponent of 2 indicates. Now, how do we solve for R? Like with Ohm's law, the simplest approach is just to divide both sides by I^2:

$$P/I^2 = I^2R/I^2$$

The I^2's cancel leaving:

$$P/I^2 = R$$

Then swapping sides we get:

$$R = P/I^2$$

But what if we want to solve for I? We start with:

$$P = I^2R$$

Then we isolate I^2 by dividing both sides by R:

$$P/R = I^2R/R$$

The R's on the right cancel leaving:

$$P/R = I^2$$

We are close, but we have I^2 instead of I. Again we look for a reverse or opposite operation. The reverse of squaring a number is taking its square root. Taking the square root of a number squared is just the number:

$$\sqrt{X^2} = X$$

Conversely, squaring the square root of a number is just the number.

$$(\sqrt{X})^2 = X$$

So taking the square root of both sides produces:

$$\sqrt{P/R} = \sqrt{I^2}$$

That reduces the I^2 to I.

$$\sqrt{P/R} = I$$

Then, reversing sides, we get:

$$I = \sqrt{P/R}$$

Practice Problem 1

It's time for you to try some of these yourself. Here is another power formula:

$$P = V^2/R$$

Solve this equation for V and R using the techniques described earlier. Check your answers on page 69.

Additon and Subtraction

Another transposition technique can be illustrated using the well-known formula for two resistors in parallel. See Figure 2.

$$R_T = R_1R_2/(R_1 + R_2)$$

The total resistance R_T is the product of the resistors divided by their sum.

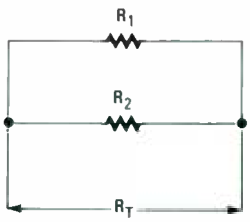


Fig. 2—Although the equation for resistors in parallel looks troublesome, it is easy to transform into equations that will give you value of R_1, R_2 or R_T.

As an example, if a 20 ohm and a 30 ohm resistor are connected in parallel, what is the total resistance?

$$R_T = 20(30)/20 + 30$$

$$R_T = 600/50 = 12 \text{ ohms}$$

But let's suppose you had a 20 ohm resistor (R_1) and you wanted a total resistance (R_T) of 12 ohms. What value of resistance (R_2) would you put in parallel with R_1 to get 12 ohms? Of course, you already know the answer because we just solved the problem. But what if you don't know? That calls for a transposition to solve the basic formula for R_2.

The first thing is to get rid of fractions. In this case, it means getting rid of $(R_1 + R_2)$. The way to do that is to treat $(R_1 + R_2)$ as one term (a single variable). Then, multiply both sides of the equation by it to cancel it from the right-hand side.

$$R_T(R_1+R_2) = R_1R_2(R_1+R_2)/(R_1+R_2)$$

The (R_1+R_2) terms on the right cancel out leaving:

$$R_T(R_1+R_2) = R_1R_2$$

Next, expand the left-hand side by multiplying each term inside the parenthesis by R_T.

$$R_TR_1 + R_TR_2 = R_1R_2$$

Next, we need to get all the terms with R_2 in them on one side. One way to do that is to subtract R_TR_2 from both sides of the equation.

$$R_TR_1 + R_TR_2 - R_TR_2 = R_1R_2 - R_TR_2$$

The $+R_TR_2$ term cancels the $-R_TR_2$ term on the left leaving:

$$R_TR_1 = R_1R_2 - R_TR_2$$

Here we are performing a reverse operation. R_TR_2 is added to R_TR_1 so if we subtract it, we eliminate it. Adding and subtracting the same thing causes them to cancel. Of course, we have to subtract the same from both sides of the equation to keep it equal.

We still have the job of isolating R_2. The next step is to factor R_2 out of both terms on the right-hand side of the equation. Factoring means dividing all terms by a common factor, then multiplying the by that same factor. Doing that to the left side gives us:

$$R_2(R_1R_2/R_2 - R_TR_2/R_2)$$

The R_2's cancel. That leaves:

$$R_2(R_1 - R_T)$$

Note that we both divided all terms and multiplied them by R_2. So we really didn't change the numerical value, only the physical arrangement of terms. Since we didn't change the value of the right-hand side of the equation, we didn't have to do anything to the left-hand side of the equation.

Now we have:

$$R_TR_1 = R_2(R_1 - R_T)$$

We're almost there now. To get R_2 by itself, all we need to do is divide both sides by $(R_1 - R_T)$.

$$R_TR_1/(R_1 - R_T) = R_2(R_1 - R_T)/(R_1 - R_T)$$

The $(R_1 - R_T)$ terms on the right cancel leaving:

$$R_TR_1/(R_1 - R_T) = R_2$$

Then, swapping sides:

$$R_2 = R_TR_1/(R_1 - R_T)$$

We said we had $R_1 = 20$ ohms and we wanted R_T to be 12 ohms. So, R_2 is:

$$R_2 = 12(20)/(20-12) = 240/8 = 30 \text{ ohms}$$

That jibes with our previous calculation.

Practice Problem 2

Here's one for you to try out these techniques on. Refer to Figure 3. The formula for computing the value of a series dropping resistor R_1 is:

$$R_1 = (V_i - V_o)/I$$

where V_i is the input voltage, V_o is the desired output voltage, and I is the load current. Transpose this formula to solve for V_o. Check your answer on page 69.

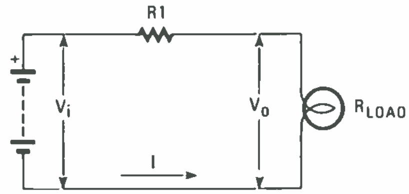


Fig. 3—If you know the voltages V_o and V_i, and the current I through the lamp (and thus the resistor) you can determine the resistance R_1 without knowing R_{load}.

Advanced Applications

The examples given earlier show all the techniques you need to understand and transpose almost any electronic formula. But let's look at some additional, more complex formulas. Consider the formula for inductive reactance X_L.

$$X_L = 2\pi fL$$

First, π or pi is a constant. Its value is 3.1415927. We usually round it off to 3.14 for simplicity. Multiplying it by 2 gives 6.28. So the formula becomes:

$$X_L = 6.28fL$$

where X_L is the reactance in ohms, f is the frequency in cycles per second also called Hertz (Hz), and L is the inductance in henries (H).

So what does this formula tell you? The inductive reactance is the opposition to alternating current flow offered by a coil or inductor. Since f and L are multiplied, it says that X_L is directly proportional to f or L, increasing either or both increases X_L.

Inverse Relations

Transposition is pretty easy using the multiply and divide techniques we used earlier. It is easy to solve for f or L.

$$f = X_L/(6.28L)$$

$$L = X_L/(6.28f)$$

Check it for yourself just to be sure.

Another example is the formula for capacitive reactance, the opposition to AC offered by a capacitor.

$$X_C = 1/(2\pi fC), \text{ or}$$

$$X_C = 1/(6.28fC)$$

X_C is in ohms, f is in Hz and C is in farads (F).

Since 1 is divided by f and C, then X_C has an inverse relationship to f and C. Increasing f, C, or both causes X_L to decrease and vice versa.

Again, transposition is easy using the multiply and divide techniques presented earlier.

$$f = 1/(6.28X_CC)$$

$$C = 1/(6.28fX_C)$$

You can easily verify the transpositions yourself for extra practice.

Combining Equations

There is a special case when a coil and a capacitor are used together. Their reactances will be equal at some specific frequency. This condition is called resonance. A common problem is to determine the frequency f where $X_L = X_C$. We can do this using the procedures you've already learned here. First we assume:

$$X_L = X_C$$

Then, we substitute the formula for each giving:

$$6.28fL = 1/(6.28fC)$$

Our job is to find f.

To start, multiply both sides by 6.28fC to get rid of the fraction.

$$6.28fL(6.28fC) = 1$$

All those terms are just multiplied together, but we can collect them and simplify the expression somewhat. For example, 6.28×6.28 is 39.4384. Also, $f \times f$ is f squared or f^2. Rewriting we get:

$$39.4384f^2LC = 1$$

To isolate f we divide both sides by 39.4384LC:

$$39.4384f^2LC/(39.4384LC) = 1/39.4384LC$$

The terms on the left cancel leaving:

$$f^2 = 1/(39.4384LC)$$

Next, to get f we take the square root of both sides or:

$$\sqrt{f^2} = \sqrt{1/(39.4384LC)}$$

$$f = \sqrt{1/39.4384LC}$$

So we now have a working formula for f. But wait, we can simplify a little more. Taking the square root of a fraction is the same as taking the square root of the numerator and denominator separately.

$$f = \sqrt{1}/\sqrt{39.4384LC}$$

The square root of 1 is just 1, so:

$$f = 1/\sqrt{39.4384LC}$$

The rules of square roots say we can take the square root of factors multiplied together separately. A simple example of this is:

$$\sqrt{XY} = \sqrt{X}\sqrt{Y}$$

Applying that to our formula, we can take the square root of 39.4384 to get 6.28. We also have to take the square root of LC. The result is:

$$f = 1/(6.28\sqrt{LC})$$

And that's our final formula. You probably recognize it as the often-used resonant frequency formula. It's an easy one to remember, but now you can also derive it from the basic reactance formulas if you need to.

Practice Problem 3

A common problem is to know the desired frequency and have a given value of inductance. Given the resonant frequency formula, transpose it to solve for C. Check your answer at bottom of page.

Summary

Transposing formulas is basically pretty easy, as you can see. With a little practice, you can handle almost anything. The procedure is summarized in these simple steps:

1. Reverse the two sides of the equation if necessary to get the variables where you want them.
2. Get rid of any fractions by multiplying or dividing both sides of the equation by an appropriate factor. Eliminate squares or square roots by performing the opposite operation.
3. Add, subtract, multiply, divide, square, square root factor or expand both sides of the equation, or whatever is needed to isolate the desired variable to one side of the equation.
4. Perform any squares or square roots as necessary to reduce the equation so that the desired variable stands alone on one side of the equation.
5. Look for ways to simplify the remaining expression by performing any other operations possible.
6. Plug in the values and calculate the final value.

Practice Problem 4

As a final test of your skill, transpose the equation:

$$Z = \sqrt{R^2+(X_L-X_C)^2}$$

to find X_C.

That is the formula for computing the impedance (Z) of a series LCR circuit as shown in Figure 4. The impedance is the total opposition to current flow offered by the resistor, coil and capacitor. R, X_L and X_C are the resistance, inductive reactance, and capacitive reactance respectively. Solve for X_C. Check your answer.

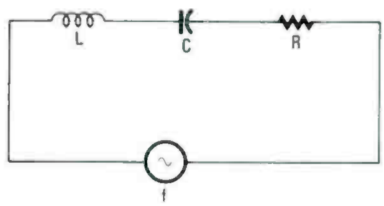


Fig. 4—In a series tank circuit, the frequency of resonance can be found by setting the equations for the impedance of an inductor and a capacitor equal two one another. Two equations can be solved for one variable.

Answers to Practice Problems

1. $P = V^2/R$

a) Solving for V we first swap sides:

$$V^2/R = P$$

Multiply both sides by R to get rid of the fraction.

$$V^2R/R = PR$$

The R's cancel.

$$V^2 = PR$$

Take the square root of both sides:

$$\sqrt{V^2} = \sqrt{PR}$$

(Continued on page 94)

DX-COM

Hear what you've been missing on the shortwave bands

By Larry Lisle, K9KZT

IF YOU HAVEN'T LISTENED TO THE SHORTWAVE-BROADCAST bands, you've missed something! News, documentaries, plays and music from around the world await you at the flick of the on/off switch. With shortwave radio, the world truly is at your fingertips, and your fingers are on the pulse of the world.

So, why not reach out and grab hold of the world, through this simple receiving system—called *DX-Com*—which you can put together in an evening for less than $15. It has good sensitivity, stability, and bandspread. It's so cheap and easy to build and use that you might want to make one even if you have a shortwave radio already.

The system consists of a car radio, backed up by a crystal-controlled converter. That combination allows you to tune three shortwave-broadcast bands with just one crystal. With DX-Com, the stronger shortwave stations, such as the BBC or Radio Canada, came booming through (in my area) like local medium-wave AM stations—using nothing more than a piece of wire strung across the ceiling of the basement for an antenna!

The Main Ingredient

The heart of the system is the car radio. Auto radios have a lot to recommend them for use with converters. That's because the designers never know whether they'll be used in the middle of nowhere, and so they pack in plenty of gain.

On the other hand, they might be used in a large city with dozens of AM stations crowding the dial, so they usually use an intermediate frequency (of around 262 kHz) for lots of selectivity. The receivers are well shielded, have pushbuttons for instant station selection and best of all, they're cheap if you look in the right places. Second-hand stores often stock dozens of old car radios, ranging in price from one to five dollars for the deluxe AM-FM models. Usually the car wears out long before the radio! You can also find auto radios at garage sales, flea markets and, by the ton, at junk yards.

The Converter

Figure 1 shows a schematic diagram of the *autodyne* converter, which is like the ones found in most broadcast receivers. The question might be raised whether such a simple circuit can be effective. The answer is a resounding yes! Below about 10 MHz, atmospheric and man-made noise are the main determiners of receiver sensitivity. As long as the internal noise generated by the converter is less than this (as is the case here) a more sophisticated front-end design isn't warranted.

Image rejection could be improved by adding tuned circuits at the input, but because of the high power used by shortwave-broadcast stations, such a modification is usually unnecessary.

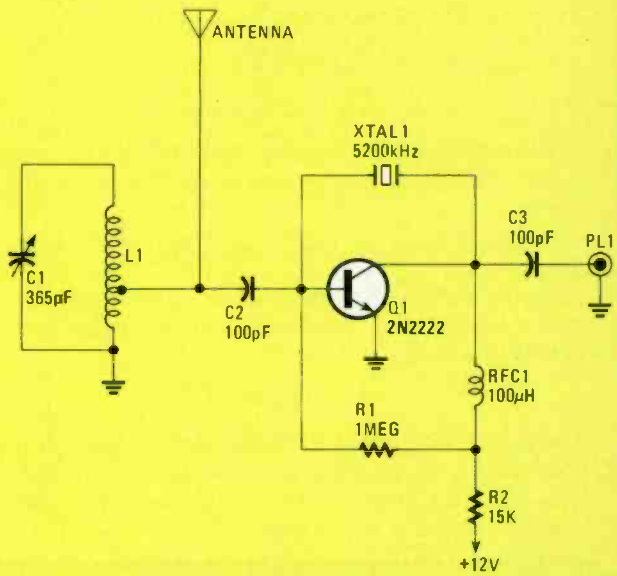
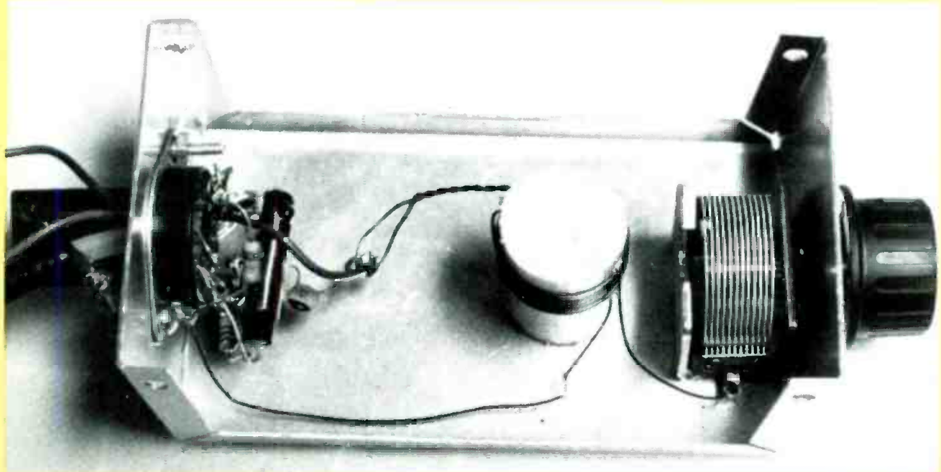


Fig. 1—The main ingredient in the DX-Com circuit is this autodyned, crystal-controlled converter. Transistor Q1 generates a signal at 5200 kHz and mixes it with the shortwave signal tuned. The difference is tuned by the car radio. It's a simple and effective circuit.

In Fig. 1, transistor Q1 performs two functions: First, it generates a signal at the frequency of the crystal; and second, it amplifies the shortwave signal picked up by the antenna,



The DX-Com is about as simple as an electronic project can get; yet the finished product it will give many hours of shortwave listening pleasure. Note that all of the components that go into the makeup of the DX-Com (except a hand-wound coil, L1, and the tuning capacitor, C1) are mounted on an octal tube socket, which also serves as a grommet for the power lead, antenna wire, and shielded output cable.

mixing that signal with the crystal frequency. The output of Q1—the *sum* and *difference* of the two signals—appear across RFC1 (a 100-µH RF choke). The one we want (the difference) is tuned on the car radio dial. If a crystal with a frequency of 5300 kHz is used, the DX-COM would be able to pick up the 49-, 31-, and 25-meter bands, as shown in Table 1. Table 1 also gives the shortwave frequency bandspread, and the radio dial-setting.

Note that the 31- and 25-meter bands are tuned with the second harmonic of the crystal on 10,600 kHz. Since the oscillator frequency is above the signal on the 31-meter band, it tunes *backwards* on the receiver dial, but that presents no problem once you get the hang of it.

TABLE 1—CONVERSION CHART

Shortwave Band (Meters)	Shortwave Band (kHz)	Car radio (kHz)
49	5950-6200	650-900
31	9500-9775	1100-825
25	11,700-11,975	1100-1375

Many other crystal frequencies can be used. For instance, a 3580-kHz, color-burst crystal from an old TV set, puts the three bands between 960 and 1240 kHz on the broadcast dial. That can lead to image problems, but for casual listening and exploring, it might be useful.

The Joining

Looking at the nuts and bolts of the converter, there isn't much to say that isn't shown in the illustrations. The author mounted the entire circuit, except for the coil L1 and tuning capacitor C1, on an octal tube socket (see photos). All parts except the crystal are housed in a metallic enclosure, which helps to shield the circuit from interference. The crystal is then mounted in the octal socket, which protrudes through the enclosure (see photos).

Begin building the DX-Com by mounting the octal socket in a convenient position (see photos) on the enclosure. With socket in position, begin building DX-Com, using Fig. 1 as a guide, by mounting the components to the solder-eyelets of the socket, making the appropriate connection as each component is installed.

Next feed the power lead, antenna wire and shielded output cable through the center (guide) hole in the socket, saving a grommet or connectors. Once the main portion of the circuit is prepared, mount the tuning capacitor (which can be salvaged from an old broadcast receiver) and the coil to the enclosure. The coil is simply nine turns of enameled wire wound on a 1-inch dowel rod (see photos), tapped three turns from the ground end. Hook-up wire can be used if you don't have enameled wire on hand and a toroid or slug-tuned form could be substituted if you want.

Bias for the transistor is provided by R1. If the converter is to be used where extreme temperatures may be encountered, a better bias scheme should be used. As is, the bias is adequate for room-temperature operation. The 15,000-ohm resistor (R2) reduces the current for a better noise figure. If you're using a 6-volt or less power source for the converter, R2 can be omitted.

RFC1 provides an impedance for the signal going to the car radio. A larger choke, say 2.5-µH would be better, but the one shown is readily available and works fairly well. The output cable and Motorola style plug were cut from a Radio Shack extension cable.

Any shielded container can be used for the converter—even an old coffee can! You can make the converter much smaller than shown here, but I've found that many otherwise

(Continued on page 92)

PARTS LIST FOR THE DX-COM

C1—365-pF variable capacitor
C2, C3—100 pF ceramic disc capacitor
L1—See text
Q1—2N2222 (or equivalent) general-purpose NPN silicon transistor
R1—1-Megohm, ½-watt, 5% resistor
R2—15,000 ohm, ½-watt, 5% resistor
RFC1—100-µH, RF choke
XTAL1—5200-kHz crystal
Printed-circuit or perfboard materials, enclosure, FT-243 crystal holder (see supplier below), octal socket (Amphenol 78RS8 or equivalent), chassis box (RS 270-238 or equivalent), Motorola-style antenna plug, shielded wire, hook-up wire, solder, hardware, etc.

Note: The 5200 kHz crystal and FT-243 crystal holder are available from CW Crystals, 570 N. Buffalo St, Marshfield, MO 65706, $2.80.

By Herb Friedman

FRIEDMAN ON COMPUTERS

You can't go home...Even if IBM says that you can.

THE GREAT AMERICAN NOVELIST, Thomas Wolfe, wrote that "You can't go home again." Unfortunately, it appears that the folks at IBM who write the DOS manuals never read Thomas Wolfe, because they don't mention or imply that you can't go home; and that singular omission has been the cause of more tears, troubles, and frustration than anything else when the non-hacker computerist upgrades his IBM-type computer with a hard disk.

In recent columns and articles we have covered various upgradings of an IBM-type computer. For many users, the primary upgrade is the hard disk because it stores many, many files. Unfortunately, there is not only a finite limit to how many disk files can be listed by the directory, but, in addition, the MS/PC-DOS command DIR is non-sorting: Files get listed in just about the order that they were stored. Imagine trying to locate the files you need from a random listing of more than 100 files. Of course, you could probably use one of the *public domain* programs, such as D.COM, to provide an alphabetic listing; but the problem with D.COM is that it does not display the subdirectories, which is what MS/PC-DOS provides for file management.

To get around screen clutter, MS/PC-DOS allows the user to create disk subdirectories, and subdirectories of subdirectories of still more subdirectories. Unfortunately, a subdirectory or a subsubdirectory does not appear on a DIR command unless the *prior* subdirectory has been made the default directory.

For example: Assume that you want to have your word-processing disk files represent similar letters and memos. You might, for example, create a WORD PROCESSING subdirectory, which would hold only your word-processor and its spelling checker. One level down into a NASTY subdirectory would be your nasty letters, while another subdirectory in the word-processing chain, labeled NICE, would contain your nice letters; and yet another subdirectory, COMMEND, might contain the letters in which you commend salespersons, mechanics, etc.

Alternately, you might create other subdirectory chains containing your spreadsheet software and templates, another subdirectory chain with utility programs, etc., etc., *ad nauseum*.

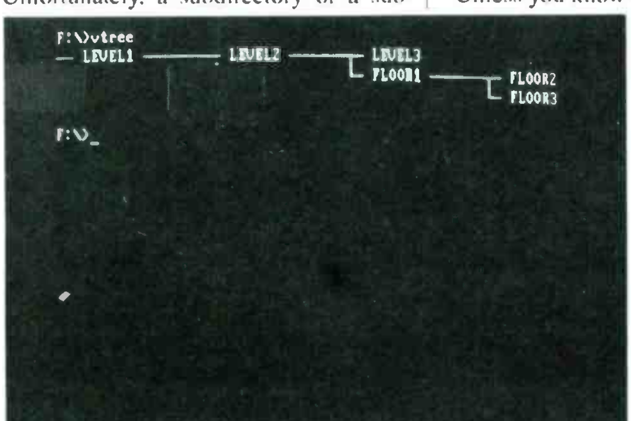
How to create, clear, and delete subdirectories is well-covered in any of the PC/MS-DOS manuals, so we won't cover any of it here. What the manuals usually don't tell you is that you can't move backwards. For example, assume that you have a UTILITY subdirectory, which has its own subdirectory of DISK CHECK software, which in turn, has its own subdirectory for DISK REPAIR utilities. If you go to DISK REPAIR, and then determine that the program you want is in the previous subdirectory for DISK CHECK, you can't back up. Unless you know some cute tricks, you'll get some form of screen display indicating that the directory doesn't exist. That is because MS/PC-DOS makes no provision for "going home" easily. You can only go home the hard way.

Tracking Subdirectories

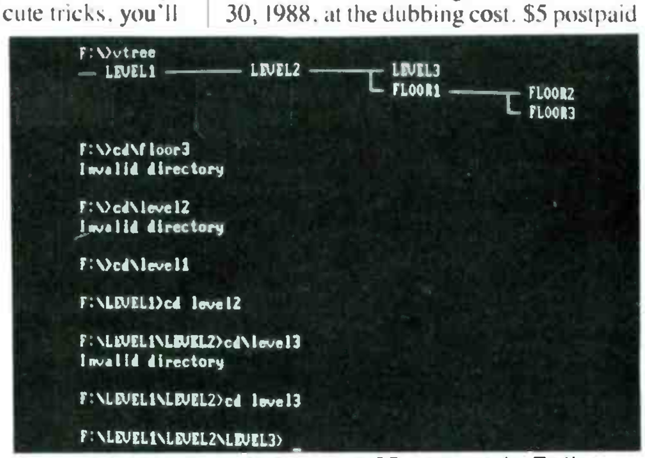
First things first. Since you should actually be trying the things we will be talking about on your computer, you've got to get rid of IBM's "curse"—the uninformative default screen display. If your default is the *root directory* (*root* meaning the *main* directory) of drive A:, your screen will display A. If you go even to the seventh level of a subdirectory chain, the screen will still normally display A, and you will have absolutely no idea as to which subdirectory is the default. So before going any farther, enter the command:

PROMPT PG,

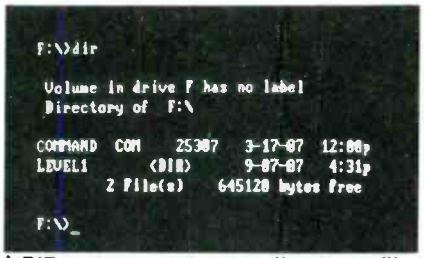
which will result in the prompt always showing the default directory, and the complete path from the root—the main directory—to a default subdirectory. Next, from some BBS (bulletin board), download the program VTREE.COM. Unlike the MS/PC-DOS command TREE (which scrolls an incomprehensible list of subdirectories off the screen), VTREE (see photos) produces what is literally a road map of the subdirectories. (If you can't get VTREE, we have arranged for **Hands-on** readers to get it until March 30, 1988, at the dubbing cost, $5 postpaid



With the command PROMPT PG, your screen prompt always indicates the default directory or subdirectory. VTREE will display the complete subdirectory chain(s) at one time.



Be careful of the backslash in your CD commands. To the computer, it means "move to the root directory," which can prevent an otherwise legitimate subdirectory change.



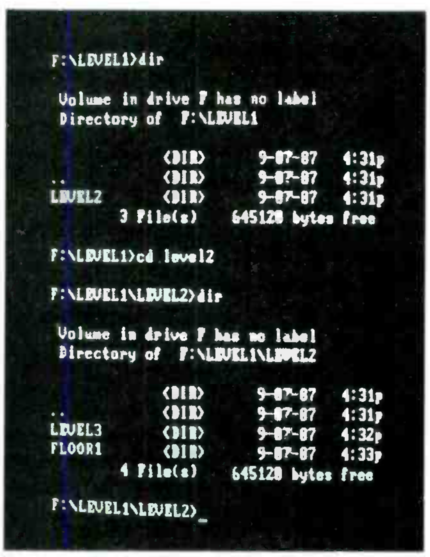
A DIR look-see at the root directory will show only the first subdirectory in a chain of subdirectories. Here it's LEVEL1.

gets you a copy with insured delivery. If you want to supply your own disk (preformatted for MS/PC-DOS 2.0, 2.1, 3.0, 3.1, 3.2, or 3.3), send it along with a reinforced disk mailer, a prepared return label, first-class postage plus insurance, and a check for $1 to Custom Components, Box 153, Malverne, NY 11565. (NY State residents must add the appropriate sales tax.)

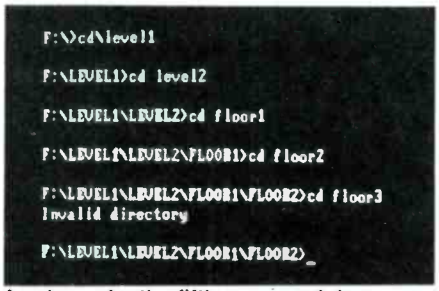
As shown in the photos, the default prompt now shows the default directory, in that instance the root, which is indicated by a backslash; hence, the prompt is F:\. (On my computer, the 3.5-inch drive—the one I used for the illustrations—is drive F:.) Entering the command VTREE shows the complete subdirectory path in a manner that anyone can understand. (Level1, Level2, etc., are the subdirectory names that I have selected to make things easier for you to follow.)

Normally, if you take a straight DIR, as shown in the photos, all you will see is the single subdirectory of LEVEL1. That's because LEVEL2, LEVEL3, FLOOR1, and FLOOR2 are subdirectories of the LEVEL1 subdirectory. (That's why you need VTREE.)

If you issue a CD command to change the default to the LEVEL1 subdirectory you will get the screen display shown in the photos. The single dot (.) at the top represents the subdirectory that you're in; what is now the default subdirectory. The double dot (..) represents the *parent directory*, which in non-IBMese means the directory in front of the one you're in. The double dot (..) is extremely important because it can be used to "go home"—something that normally can't be done in DOS. (I will show you how to use the double-dot shortly.) Notice that now the root directory shows only the LEVEL2 subdirectory. If, as shown in the photos, you change to the LEVEL2 subdirectory, you see that both LEVEL3 and FLOOR1 subdirectories are available.



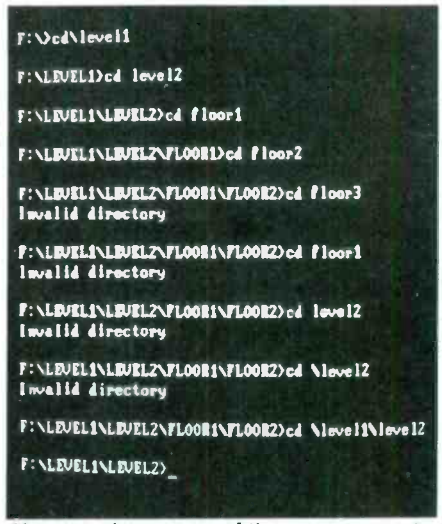
If you make LEVEL1 the default directory, you'll then see the LEVEL2 subdirectory. But you must CD to LEVEL2 in order to see the LEVEL3 and FLOOR1 subdirectories. Compare this miserable method with the VTREE display in the other photos.



As shown by the fifth command down, you can't move back or sidewise from a subdirectory with a simple CD command.

Now, assume that you think the disk file you want is in the FLOOR2 directory, so you move to FLOOR2, and Whoops! It's not there. It must be in the FLOOR3 directory; so you issue the command CD FLOOR3 to move into FLOOR3. But as shown in the photos, you get an "Invalid directory" screen prompt. Wha' Hoppen'?— You know from VTREE that there's a FLOOR3 subdirectory. The answer to "Wha' Hoppen'!" is that MS/PC-DOS normally makes no provision to do anything except move to the next subdirectory, or return to the root and move step by step through the entire subdirectory chain until you get to the needed subdirectory. If you refer to the VTREE display in the photos, you'll see that both FLOOR2 and FLOOR3 are subdirectories of LEVEL2. You cannot change directories sidewise from FLOOR2 to FLOOR3. If you are in either one, DOS (as shown in the photos) doesn't know that the other exists; so DOS returns you to the last "legal" subdirectory, which (as the photos show) is FLOOR2. (Isn't it lovely how the command PROMPT PG produces the entire default path?)

In moving along a subdirectory chain, the backslash (\), which is often used to move from the root (main) directory to a subdirectory, can cause no end of problems, particularly if you haven't set up



Here we show some of the wrong ways to step to a desired subdirectory; and finally, how to do it "the long way 'round" with a full path that first moves back to the root directory.

your computer with the command PROMPT PG. The VTREE display that we're working with and a series of directory changes are shown in the photos. Look at the fifth CD command down; the one to move into LEVEL3. It was not accepted by the computer because there is a backslash in front of the "LEVEL3." The command reads "cd\level3," and it looks as if it should work.

No! Not on your life. Once you are in a subdirectory; the backslash means "go back to the root—the main directory." So the command really means: "Go back to the root directory and then to LEVEL3," and, as you know, that cannot be done because DOS must move through each subdirectory in sequence. The sixth CD command shows the proper way to move down one subdirectory. Notice that the difference between the two commands is that the backslash has been eliminated.

Two Ways To Back Up

There are two ways to move backward through subdirectories. The first is to use the command CD .. (that's correct, CD plus a space followed by two dots). That will back you up to the previous subdirectory or the root directory (if the root is the previous directory). Try it.

The second method to back up is the usual way, and that's to go all the way home to the root directory and then step through each subdirectory (as shown in the photos). You can do it *s-l-o-w-l-y*, one subdirectory at a time, or use a single path command. Count down to the seventh illustration in the photos. Notice that we are attempting to move from subdirectory FLOOR2 to subdirectory LEVEL2, which (as you know from consulting the VTREE display in the photos) can't be

(Continued on page 97)

By Marc Ellis

ELLIS ON ANTIQUE RADIO

Taking A Backward Look

THIS COLUMN BEGAN WITH THE FIRST monthly issue of **Hands-on Electronics Magazine** in November 1986. When I first discussed the project with the Editor of H.O.E., he told me that I was free to take *Ellis On Antique Radio* in whatever direction I wanted—as long as I kept it interesting to the readers. Having written the column for a little over a year now, the January 1988 issue seems to be a good place to take stock of where we've been and where the future might lead.

The first six issues of *Ellis On Antique Radio* were fairly carefully structured. In November and December, we offered a quick run-down on the types of collectibles available to the antique-radio enthusiast. The January issue featured some advice on how to decide what to collect and how to go about finding it. Coverage of specific antique-radio topics began in the February issue with a review of early battery/tube types. The tubes used in the first AC-operated radios were covered in March, 1987. And in April, we wrapped up the tube discussion with a chronological outline of key physical characteristics of the early battery and AC-tubes.

By the time I was ready to put together the May column, quite a bit of reader mail had come in, and I could see that there was a lot of interest in the diagnosis and solving of filter capacitor problems. Accordingly, the May and June issues were devoted to the theory, care, and replacement of filter electrolytics.

July saw the first of our series of restoration articles, featuring the Echophone EC-1—a popular shortwave radio of the early 1940's. And in August, we presented some ideas for putting together a control unit for starting up long-disused radios. The September, October and November issues were devoted to completing the EC-1 restoration, and I used December to catch up on answering the backlog of reader queries.

I'd certainly welcome comments from any reader who'd like to contact me about what we've done so far, and where we might go in the future. I'd like to start another set restoration project and perhaps do some test equipment construction projects. In future columns this year, I plan to again pick up vacuum-tube chronology where I left off and discuss developments of the 1930's and 1940's. However, I'll always be ready to change the direction of the column to answer questions or follow up suggestions from the readers. So don't be shy! Write and let me know what you think.

Mid-1925 Crosley ad shows Model 50 as bottom-of-the-line in a 3-set series. Middle-size model 51 had two tubes; larger model 52 was a 3-tuber.

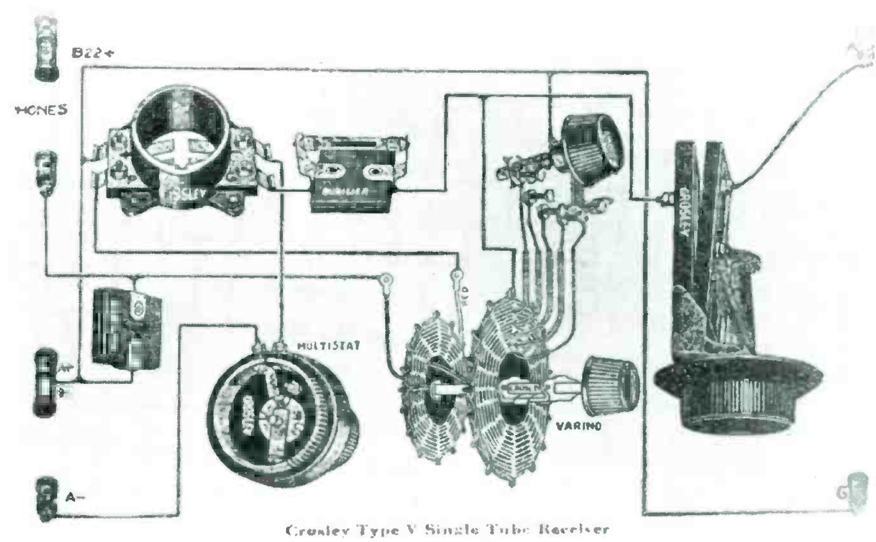
But for now, we'll return to the 1920's and discuss a favorite radio of mine from that era.

A Bit of Personal Nostalgia

One of the earlier radios in my collection is a neatly made one-tuber, the Crosley Model 50. It was a *bottom-of-the-line* radio offered by a company that specialized in inexpensive sets. But its price tag of $14.50 (not including tube or headset) was still fairly hefty for the time (mid 1920's).

The set is a favorite of mine because it's the one that really got me started in the antique-radio hobby. As an electronically-minded kid in the mid 1940's, I'd acquired many early radios. Some were given to me by friends and relatives, and a goodly number were rescued from the trash collector.

Hopelessly outclassed by the technology of the day, radios of the 1920's or early 1930's could be had for the asking. Few of those sets remained with me past my teen years. But the Crosley 50 was an exception. It was small and easy to store, and didn't require an *impossible-to-*



Pictorial diagram of the model 50 (for some reason called "Type V" in the caption) from an early Rider's manual.

achieve array of voltages to make it operate, as did most early battery sets. Just a single dry-cell and a 22.5-volt battery. I felt that some day I might make the set play again—that is if I could ever find a replacement for the burned-out WD-12 tube!

Many years later (the Crosley all but forgotten), I was working as an Associate Editor on the old *Popular Electronics* magazine. (My boss, at that time, was the very same Editor who signed me up to write this column.) One of my jobs was to answer the reader mail, and one reader

Front view of the set. Scale is not apparent from photo, but cabinet is only about 8 ½ inches wide.

had asked for some help locating a replacement tube for for an antique radio. I was able to find a dealer who had a large stock of tubes and, remembering the old Crosley, I also purchased a WD-12 for myself.

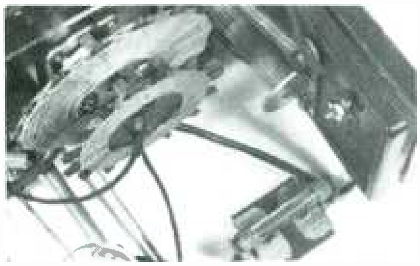
On my next visit home, I dug out and dusted off the set. Eventually, I cleaned and restored it, purchased the necessary batteries, and made it play again. The experience was so much fun that I began to look for other old sets and soon formed the nucleus of the collection I have today.

Looking Inside the Crosley

From the outside, the Crosley 50 looks almost modern in its simplicity and functional design. The parts inside, though, are charmingly archaic. For example, the two RF coils are wound "honeycomb" style on flat forms—each made up of a central disc surrounded by radial struts.

The smaller of the two coils is movable, mounted on a sliding shaft controllable from the front panel. In that way, the distance between it and the larger coil can be varied. The larger coil is tapped at several locations, and these taps can be selected by a panel-mounted switch.

The variable capacitor consists of a couple of foil-lined bakelite plates hinged at one end. The plates can be moved closer together or farther apart by a cam-and-spring arrangement controlled by a knob on the front panel. As was the custom of the day, most of the wiring was done *bus-bar* style. In other words, the wire was



This close-up shows some of the components that make up the set: Honeycomb-wound coils (top left); hinged-plate variable capacitor (top right) with a spring that holds the plates apart and rod-mounted cam that forces them together. Capacitor with clip-mounted grid-leak resistor is at bottom.

formed of heavy-gauge rod-like stock run in straight lines wherever possible, with all corners turned at 90-degree angles.

A heavy-duty wire-wound rheostat (also controlled from the front panel) adjusts the voltage on the WD-12 filament. Finally, inserted in the tube's grid lead, is a flat, square capacitor made up of bakelite foil and mica plates. Clipped to the top of that capacitor is a 3-megohm resistance mounted in a glass tube much like a fuse.

How It Works

The circuit of the "50" is easily explained. The larger, taped coil, series-tuned by the variable capacitor (which is inserted in series with the antenna), is part of the WD-12 tube's grid circuit. The smaller coil (sometimes called the *tickler*) is part of the tube's plate circuit.

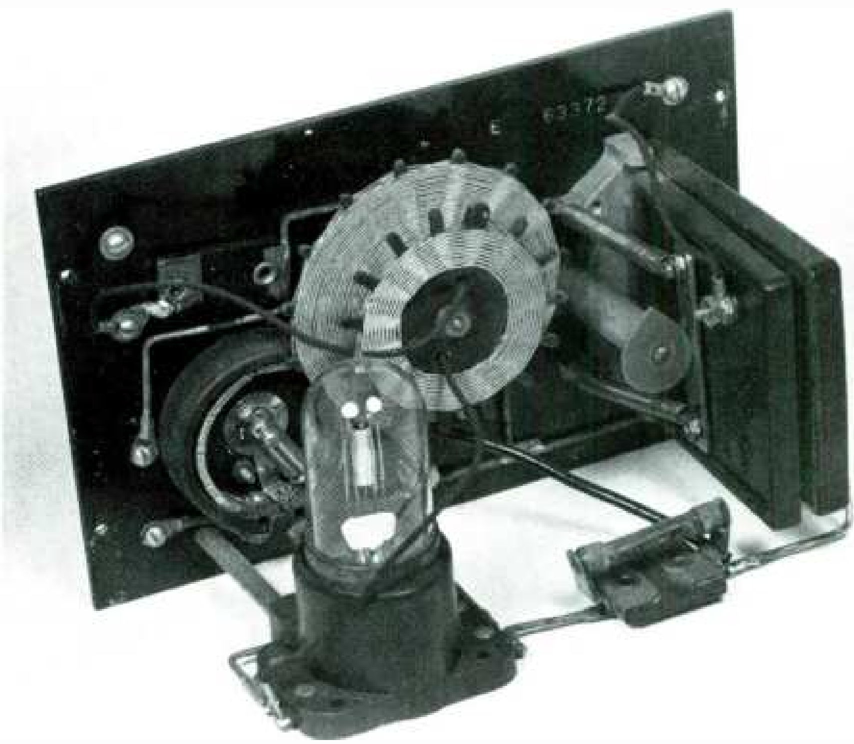
When the coils are placed in proximity to each other, part of the energy in the plate circuit is fed back into the grid, re-amplified and appears at the plate again. Part of the re-amplified energy is fed back to the grid once more, re-amplified again.

Weak signals can be amplified greatly by that regenerative circuit, but if the coils are placed too close together, the set breaks into oscillation—becoming, in effect, a miniature radio transmitter. Maximum amplification is achieved with the two coils just far enough apart so that oscillation does not take place.

The capacitor and 3-megohm resistor wired in series with the grid of the tube form a circuit called a *grid-leak* detector. The circuit rectifies the radio-frequency signal entering from the antenna, separating the audio-frequency component from the RF so that it can be heard by the operator. Another capacitor (connected between two binding posts) acts as a bypass, removing any radio-frequency energy from the output circuit.

Calling it Quits

That about wraps it up for the month, fellow collectors. Next month we'll rig a set of batteries to the old Crosley, fire it up and see what we can hear. In the meantime, be sure to tell me about your ideas for future columns. Write to Marc Ellis, C/O **Hands-on Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■



Rear view of radio removed from cabinet. Note the sturdy construction, and the neat arrangement of its component parts.

By Joseph J. Carr, K4IPV

CARR ON HAM RADIO

Understanding how radio-wave propagation affects amateur-radio activity.

OVER THE PAST SEVERAL MONTHS, we've dealt with various aspects of radio propagation. In our final installment, we'll cover the measures of the radio propagation phenomenon in order to allow you to understand propagation forecasts as they affect amateur-radio activity.

The *Critical Frequency* and *Maximum Usable Frequency* (MUF) are indices that tell us something of the state of ionization and communications ability. Those frequencies increase rapidly after sunrise and international communications usually begin within 30 minutes.

Critical Frequency

The critical frequency, designated F_c, is the highest frequency that can be reflected when a signal strikes the ionosphere as a vertical (90-degrees with respect to the Earth's surface) incident wave. Critical frequency is determined from an *ionogram*, which is a cathode-ray tube (CRT) oscilloscope display of the height of the ionosphere as a function of frequency.

The ionogram is made by firing a pulse vertically at the ionosphere from the transmitting station. F_c is that frequency that is just sufficient to be reflected back to the transmitter site. Values of F_c can be as low as 3 MHz during the nighttime hours, and as high as 10-15 MHz during the daylight.

Virtual Height

Although the ionosphere is described as a layer, it is really a region of the atmosphere. The boundaries for each layer are frequently quoted as definite figures, even though such figures are only approximations, determined somewhat arbitrarily.

Radio waves are refracted in the ionosphere; and those above a certain critical frequency are refracted so much that they return to Earth. Such waves appear to have been reflected from an invisible radio *mirror*. An observer on the Earth's surface could easily assume the existence of such a mirror by noting the return of the reflected signal.

The height of that mirror is called the *virtual height* (see Fig. 1) of the ionosphere, and is determined by measuring the time interval required for an ionosonde pulse (used to measure critical frequency) to return to the transmitting station. A radio signal travels at a velocity of 300,000,000 meters-per-second (which is the speed of light).

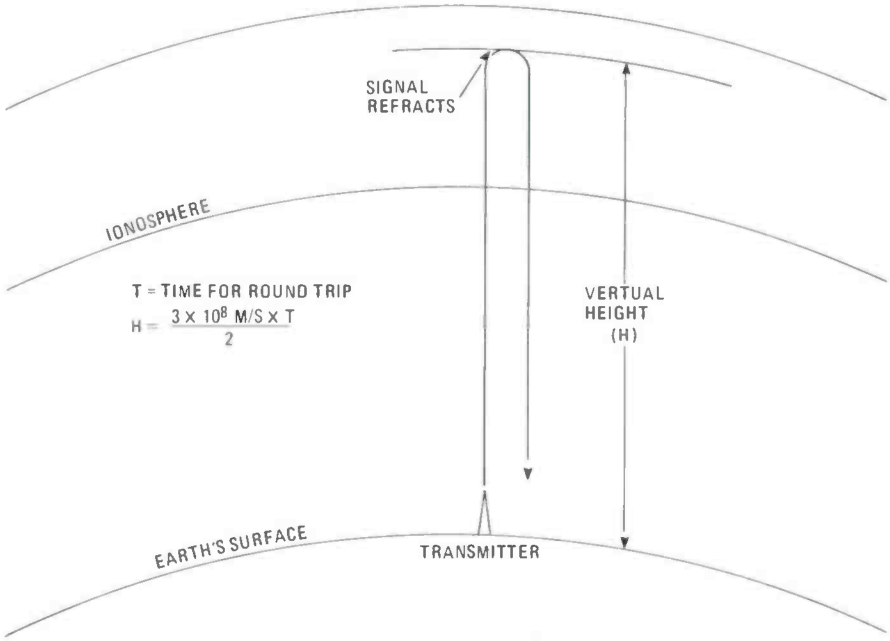


Fig. 1—The height of that mirror is called the *virtual height* of the ionosphere, and is determined by measuring the time interval required for an ionosonde pulse. By observing the time between the transmission of a signal and reception of its echo, we can calculate the virtual height of the ionosphere.

By observing the time between transmitting the pulse and receiving its echo, we can calculate the virtual height of the ionosphere. The distance, thus, calculated must be halved to account for the round trip, as in radar applications.

Maximum Usable Frequency

The Maximum Usable Frequency (MUF) is the highest frequency at which communications can take place via the ionosphere over a given path. The MUF between a fixed transmitter site and two different, widely separated, receivers need not be the same. Generally speaking, the MUF is about three times higher than the critical frequency. Both the MUF and the critical frequency vary geographically, but become higher at latitudes close to the equator.

It is a general rule that communications occur at frequencies just below the MUF. In fact, there is a so-called *Frequency of Optimum Traffic* (FOT) that encompasses about 85-percent of the MUF. Both noise levels and signal strengths are improved at frequencies near the FOT.

Lowest Usable Frequency

At certain low frequencies, ionospheric absorption, atmospheric noise, miscellaneous static and receiver signal-to-noise ratio requirements conspire to reduce radio communications. The lowest frequency that can be used for communications, despite those factors, is the lowest usable frequency (LUF).

Unlike the MUF, the LUF is not totally dependent on atmospheric physics. We can vary the LUF of a system by controlling the signal-to-noise ratio. Although certain factors that contribute to SNR are beyond our control, we can change the effective radiated power (ERP) of the transmitter; a 2-MHz decrease in LUF is available for every 10-dB increase in the ERP of the transmitter.

Using the Ionoshpere

The refraction of high-frequency and some medium-wave radio signals back to Earth via the ionosphere gives rise to intercontinental HF-radio communications. That phenomena becomes possible during daylight hours and, for awhile at least, after sunset when the ionosphere is ionized. Figure 2 shows the mechanism of "skip" communications.

The transmitter is located at point T, while receiving stations are located at sites R1 and R2. Signals 1 and 2 are not refracted sufficiently to be refracted back to Earth, and so are lost in space. Signal 3, however, is refracted enough to return to Earth, so that it is heard at station R1. The *skip distance* for signal 3 is the distance from T to R1.

At points between T and R1, signal 3 is inaudible—except within ground-wave distance of the transmitter site (T). That is the reason why two stations 40-miles apart hear each other only weakly, or not at all, while both stations can communicate with a third station 2000-miles away.

In amateur-radio circles it is common for South American stations to relay between two US stations only a few miles apart. For an example of that problem, listen to the *Inter-American and Halo Missionary Nets* on 21.290-MHz (15-M) daily from about 1700Z to 2100Z (ending time dependent upon traffic).

Multi-hop skip is responsible for the reception of the signal from transmitter T at site R3. The signal *reflects* (not refracts) from the surface at R1, and is retransmitted into the ionosphere where it is again refracted back to Earth.

Figure 3 shows a situation where skip signals are received at different distances depending upon the *angle of radiation* of the transmitting antenna. A high angle of radiation causes a shorter skip zone, while a lower angle of radiation results in a longer skip zone. Communication between any particular locations, on any given frequency, requires adjustment of the antenna-radiation angle. Some shortwave stations have multiple antennas with different radiation angles to ensure that the correct skip distances are available.

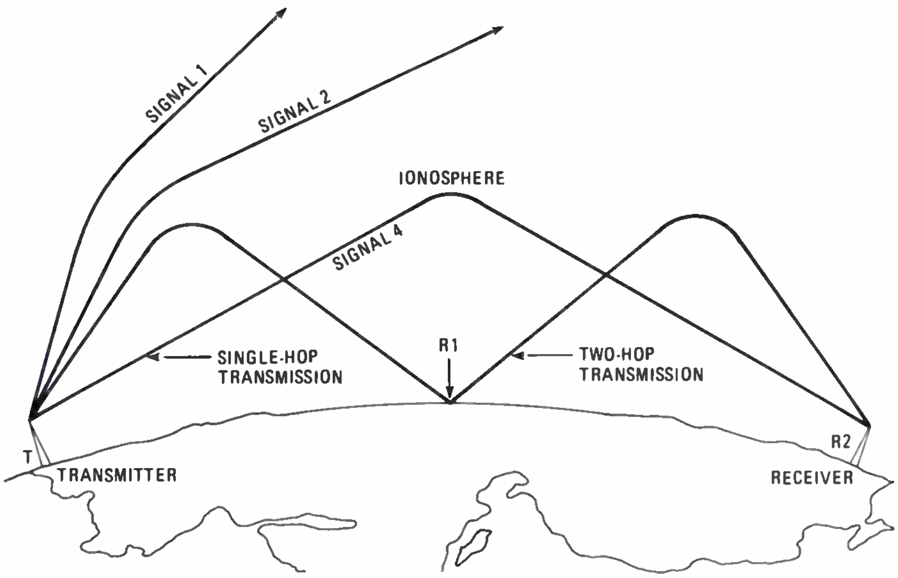


Fig. 2—The refraction of high-frequency and some medium-wave radio signals back to Earth via the ionosphere allows intercontinental radio communications.

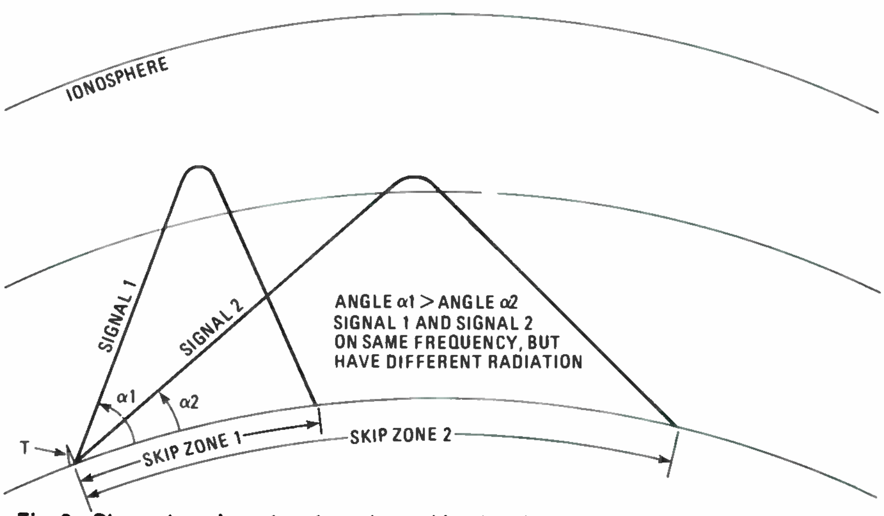


Fig. 3—Shown here is a situation where skip signals are received at different distances depending upon the *angle of radiation* of the transmitting antenna. A high angle of radiation causes a shorter skip zone, while a lower angle of radiation results in a longer skip zone.

Fading

Skip communications is not without problems. One phenomena is *fading*: a variation in signal strength as perceived at the receiver site. That problem can sometimes be overcome by using one of several *diversity-reception* systems. Three forms of diversity techniques are used: frequency diversity, spacial diversity, and polarization diversity.

In the frequency-diversity system (see Fig. 4), the transmitter sends out two or more frequencies simultaneously with the same modulating information. Because

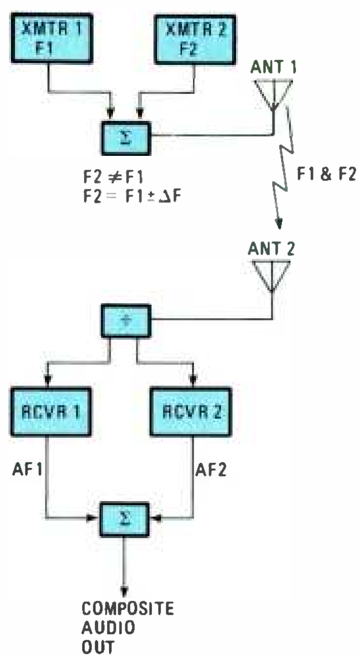


Fig. 4—Fading, a variation in signal strength as perceived at the receiver site, can sometimes be overcome via the use of frequency diversity, spacial diversity, and polarization diversity. In the frequency-diversity system, the transmitter sends out two or more frequencies simultaneously with the same modulating information.

the two frequencies fade differentially, one will always be strong. The spacial diversity system (Fig. 5) assumes that a single transmitter frequency is used. At the receiver site, two or more receive antennas are used, spaced one-half wavelength apart.

The theory is that the signal will fade at

(Continued on page 98)

By Marc Saxon

SAXON ON SCANNERS

Fox—probably the closest-kept secret in scanner-ware.

You may know the products of Fox Marketing as being mainly concerned with detecting highway-radar speed traps. The company, however, also produces an interesting little scanner, which has never been given the publicity it deserves. Why Fox has kept their BMP 10/60 scanner such a well-kept secret remains a mystery. Perhaps, with new owners having taken the helm at Fox within the past few months, the BMP 10/60 will take its rightful place with the other excellent Fox products.

The BMP 10/60 is a small seventy-channel, keyboard-programmable unit, primarily intended for portable and mobile use. Looking more like an overgrown, eight-track tape cartridge (remember those?) than anything else, most of its controls as well as the set's frequency readout and loudspeaker are located on the top of the case.

The channel indicators, squelch, and volume controls are located on the front of the unit. It covers all standard scanner bands between 32 and 512 MHz, including the 144- to 148-MHz ham band.

Lightweight and compact (measuring 6½-inches wide, 1⅝-inches high, and 9-inches deep), it can be powered from 12-VDC or 117 VAC sources, and comes with a telescoping antenna and cigarette lighter plug. Its features include a priority channel, channel lockouts, channel step-through, and LED readout.

Optional accessories include a mobile mounting bracket and a self-contained Porta-Pac, a carrying-case equipped with a shoulder sling, room for ten "C" batteries, and its own antenna. The batteries may be nickel-cadmium types that may be recharged using the AC converter supplied with the unit.

For more information on the the Fox BMP 10/60, contact Fox Marketing, 4518 Taylorsville Road, Dayton, OH 45424; or circle 75 on the Free Information Card.

Suddenly, Last Summer

From the community of Le Mars, IA comes a plea from reader W.S. Billingsgate who wonders if we can tell him why all he hears is a hissing sound now when he tunes to either 153.935 or 154.025 MHz on his scanner.

The Fox BMP 10/60 features an LED readout, channel indicators, squelch and volume controls, a priority channel, and channel lockouts; both 12-VDC or 117-VAC operation, and comes with a telescoping antenna and cigarette lighter plug. For more information, contact Fox Marketing, 4518 Taylorsville Road, Dayton, OH 45424; or circle 75 on the Free Information Card.

He used to hear his local police communications there, and although his scanner does fine on other channels, those two suddenly copped out last summer.

Most readers will probably wonder why that small community (population less than 8,300) is more in need of message security than, say, New York City or Los Angeles. Nevertheless, last summer the Chief of Police installed voice scramblers on the town's equipment.

The system used wasn't the usual type of voice scrambling gear that's normally used by those few major city departments that decide to scramble one or two of their tactical or surveillance channels. Instead, it was very expensive *state-of-the-art* digital equipment like the military forces use for high-level command communications! Looks like the Chief hates scanners and is out to get them!

The salesman that unloaded that fancy junk on the good Chief was probably given a two-week vacation in Tahiti as a bonus for clinching a deal like that one. (Just wait until the over-burdened taxpayers of Le Mars find out what they're paying for that gear!) Nevertheless, the Police Chief vows to use it to secure all of his agency's communications—that includes everything from messages about people locked out of their cars to reports of chickens on the highway.

For scanner owners trying to monitor those important communications, it means hearing only a hissing sound. Some might interpret that sound as the opinion of the Police Chief when he's asked about scanner owners!

How Low Can You Get?

A question that has been asked of us more than once seeks information on whether (as it is rumored) federal agencies have certain frequencies that lie outside the most-popular scanner bands.

Well, 406 to 420 MHz is a band in heavy federal use, although those frequencies aren't always included in scanners. Federal agencies also use the 27-MHz CB channels, plus special frequencies just past the high-frequency end of the CB band. For instance 27.575 and 27.585 MHz, which are used by many federal agencies.

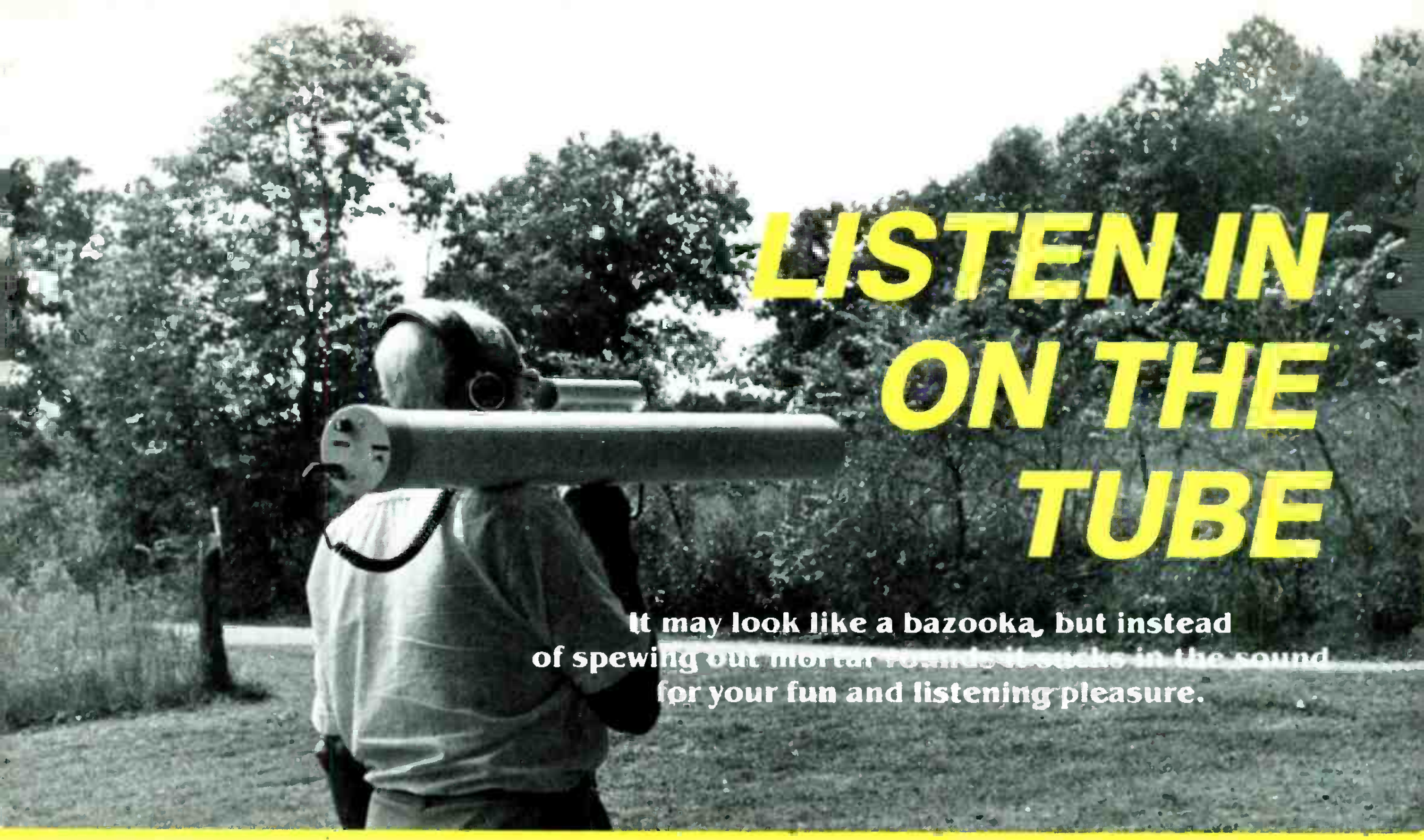
US Coast Guard Reserve stations have also been reported using 27.890 MHz, which lies in the same frequency range. Actually, the frequency range from 27.540 to 27.995 MHz is reserved for federal agency use, although that range is also popularly used by hobbyists who like to *bootleg* there.

Since some of the newer scanners cover those frequencies, it might be worth your while to search through that rather obscure federal band to find out what's doing there. What, with DX conditions improving, those frequencies could offer many opportunities for federal catches, especially on 27.575 and 27.585 MHz. We suggest monitoring in AM mode here.

Business Band Business

We've noticed that several companies are now offering hand-held two-watt transceivers for *business communications*

(Continued on page 98)



LISTEN IN ON THE TUBE

It may look like a bazooka, but instead of spewing out mortar rounds it sucks in the sound for your fun and listening pleasure.

□HAVE YOU EVER WANTED TO EAVESDROP ON THAT SHY AND elusive Yellow-Throated Warbler, or catch what Ms. What's-her-name, from down the street, is saying to Mr. Know-it-all? If the answer is yes, then read on and see how to build your own version of the *Tube*.

What is it

The Tube is a super-sensitive, long-range listening device that's easy to build and a ball to use. Just aim the Tube at the object you want to place under surveillance and sleuth away.

This particular tubular microphone differs in design, from the shotgun and the parabolic mikes that are ofteh seen at various sporting events, by using a single large-diameter tube as the sound-directing and gathering instrument. A special 3-inch microphone is used to take advantage of the enormous sound-gathering capabilities of the large tube, and the detected sound is fed to a three-stage IC amplifier to wiggle your ears with either a stereo or mono pair of headphones.

The Amplifier Circuit

The sensitive mike is no more than a 8-ohm, 3-inch round, replacement speaker connected to a mini output transformer, to better match the input impedance of the first amplifier stage. The high-impedance winding of T1 is coupled to the input of one section of a low-noise, low-power, dual operational amplifier U1, see fig. 1. Resistors R3 and R5 set the gain of the first amp to 21. Output from that amplifier is fed to the input of amplifier "B" which magnifies the signal 15 times. The total gain of stages "A" and "B" is 315.

A .4-watt, audio, IC amplifier, U2, performs double duty by supplying ample drive for today's popular low-impedance headphones, and boosting the gain an additional 50 times. Total AC-voltage gain for the three amps is over 15,000. With the gain set for a comfortable listening level, the circuit's

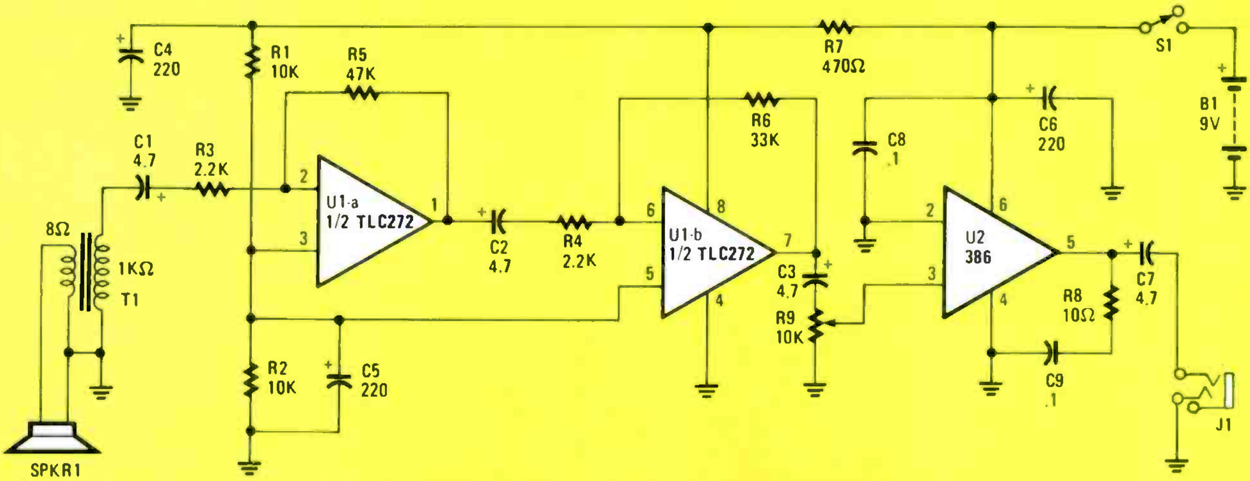
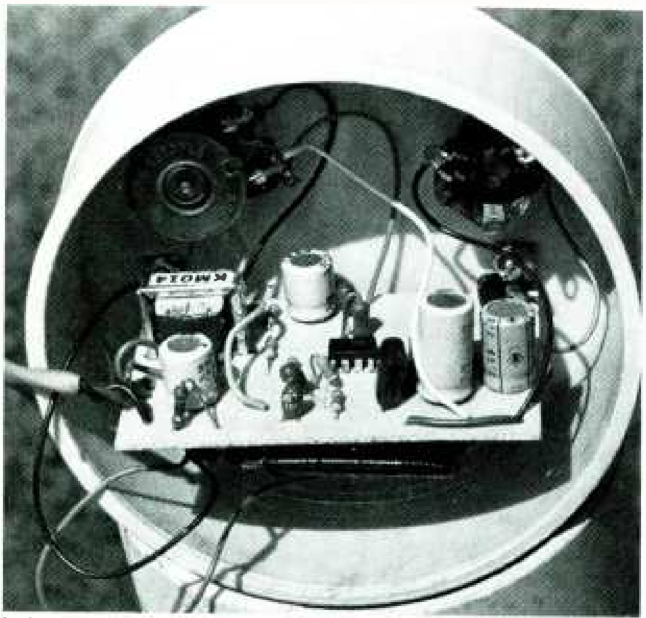
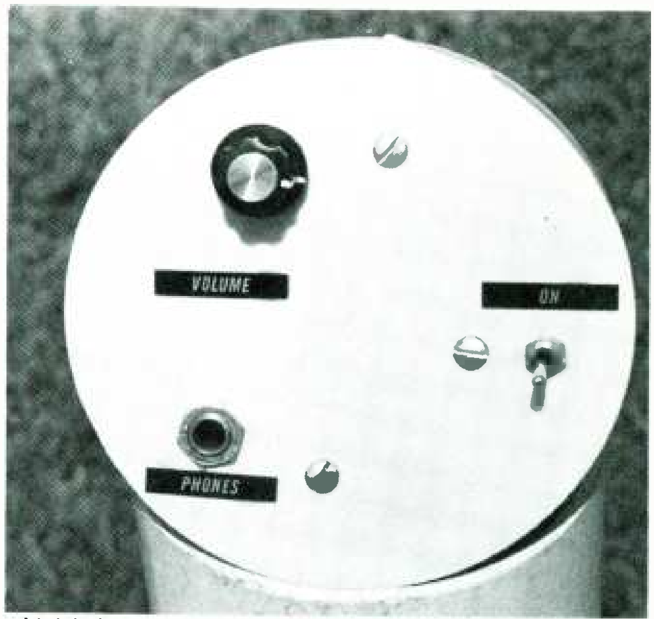


Fig. 1—Notice that the opamps are all AC coupled. That will allow you to skip the use of input-offset resistors.



This interior view should give you some idea of how you can easily place the components in the end of the tube. The circuit board is held to the back panel with right angle brackets and machine screws.



With labels, the project can look well finished. You needn't create your own. Just cut the labels from the faceplate of an old junk stereo out of your collection of parts

average current drain is slightly over 10 mA.

The output jack, J1, is wired to place the two earphones of a stereo headset in series, and will allow most mono phones to work as well. By increasing the impedance of the load (headphones) connected to the output of the driving amplifier, U2, the overall current drain from the battery will be reduced.

Building Your Own Tubes

Start out by gathering up the PVC tubing and cut a 42-inch length of 4-inch pipe, and a 8-inch length of 2-inch pipe.

Cut a 3-½-inch circle from a piece of circuit board, or similar material, and in the center of the circle cut another hole to allow the magnet on the 3-inch speaker to snugly pass through, see Fig. 2. Use contact cement and attach the PC-board circle to the speaker frame.

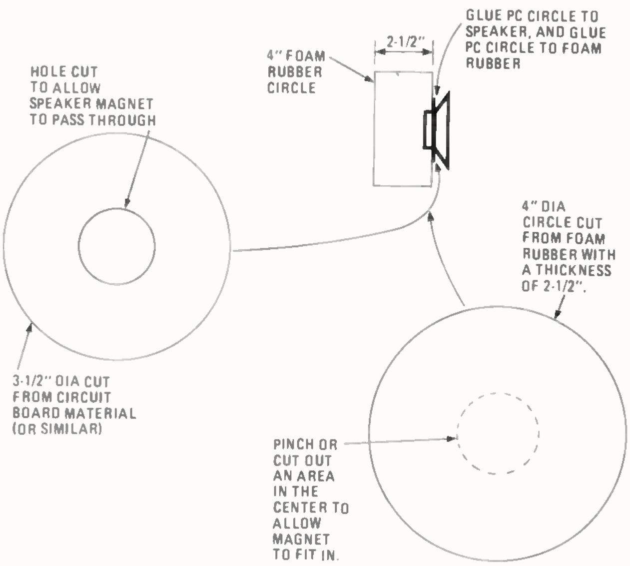


Fig. 2—Proper mounting of the speaker is not critical, but you should try to center it as best as possible. Using PC-board material may be a little expensive for your taste. If so, use a piece of plywood or plexiglas.

PARTS LIST FOR THE TUBE

CAPACITORS

C1,C2,C3,C7—4.7-µF, 25-WVDC electrolytic capacitor
C4,C5,C6—220-µF, 16-WVDC electrolytic capacitor
C8,C9—.1mfd, 100-WVDC electrolytic capacitor

RESISTORS

(All fixed resistors are ¼-watt, 5% units)
R1, R2—10,000-ohm
R3, R4—2200-ohm
R5—47,000-ohm
R6—33,000-ohm
R7—470-ohm
R8—10-ohm
R9—10,000-ohm potentiometer

ADDITIONAL PARTS AND MATERIALS

B1—9-Volt transistor-radio battery
U1—TLC272 dual operational amplifier integrated circuit, Radio Shack #276-1749
U2—386 .4-watt audio amplifier
J1—¼-inch stereo headphone jack
SPKR1—3-inch round 8-ohm speaker
T1—1K to 8-ohms, mini, output transformer
Misc.—42-inch length of 4-inch (dia.) PVC sewer pipe, end cap, 8-inch length of 2-inch (dia.) PVC pipe, 2 ½-inch spacers, PC board or perfboard, foam rubber, solder, etc.

Complete kit of parts for building your own Tube, less only the handle, and including tubing, hardware, circuit board, component parts, pot, switch, jack, speaker, foam rubber, and end cap, all for $39.95 plus $2.50 (UPS) shipping and handling. Circuit board only $7.95 pp. Order from Krystal Kits, P.O. Box 445, Bentonville, AR 72712.

Cut a circle 4-inches in diameter out of a piece of foam rubber that's at least 2-½-inches thick. Pinch or cut out a small area in the center of the foam rubber to allow the speaker's magnet to fit in place. Center the speaker, with an attached collar, in the center of the foam-rubber circle, and make a permanent joint with contact cement.

Connect a 10-inch length of twisted or shielded twin-wire cable to the speaker terminals, and cut a shallow slit down the side of the foam rubber, below, and in line with, the terminals, to let the cable slip in and hide in place.

Both the handle and sight tube are located in the center of the 42-inch tube (see Fig.3), with the handle centered at the bottom and the sight tube centered lengthwise, but off from top center about 20 degrees in either direction. By mounting those two items in the center, lengthwise, the assembly will work equally well for a left-handed or a right-handed person.

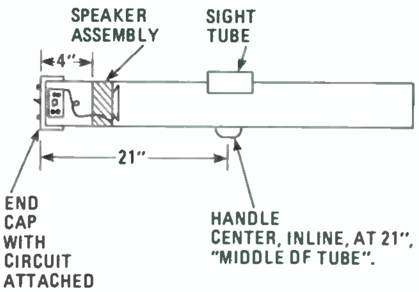
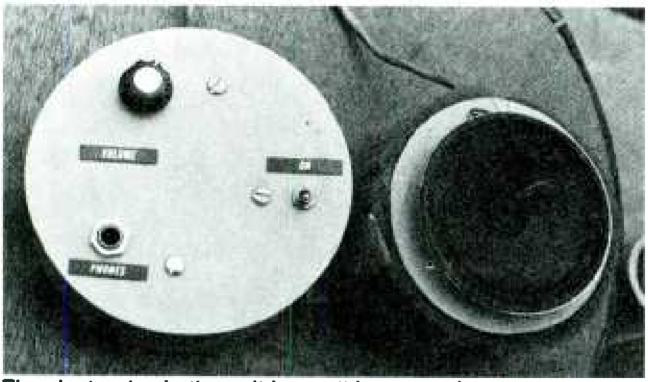
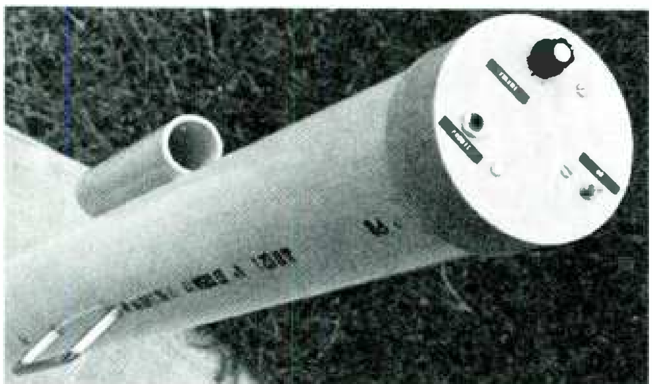


Fig. 3—The completed unit should have a handle and sight for easy aiming. be sure to use sufficient leads on the speaker to allow easy connection with the circuit board.



The electronics in the unit is small in comparison to the overall project size. The electronic unit can be used in a variety of applications, especially if you switch the leads to the speaker and jack. Then speaker will be the output and the jack can be used to amplify any desired input.



Mounting the handle and sight is, of course, optional. The handle is a good idea as it keep sound of the movements of your hand upon the tube at a minimum

The Circuit Board

The electronics can be built on a PC board or perfboard, whichever you choose will work okay. Just keep all leads short, and follow the general layout as shown in Fig. 4.

The circuit board is mounted in the lid with two small metal angle brackets, with the battery and on/off switch on one side, and the pot and phone jack on the other. Since the layout for the lid is certainly noncritical, you can rearrange the components to suit any scheme you desire, but try to keep the interconnecting wiring as short as possible.

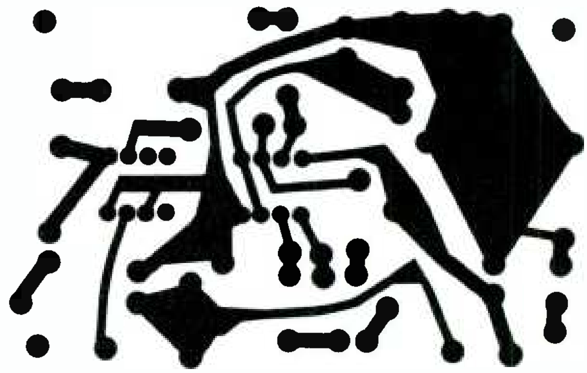


Fig. 4—The circuit board can be constructed using this foil pattern as a guide. Be sure to trim the solder pads as shown so that they do not interfere with other traces.

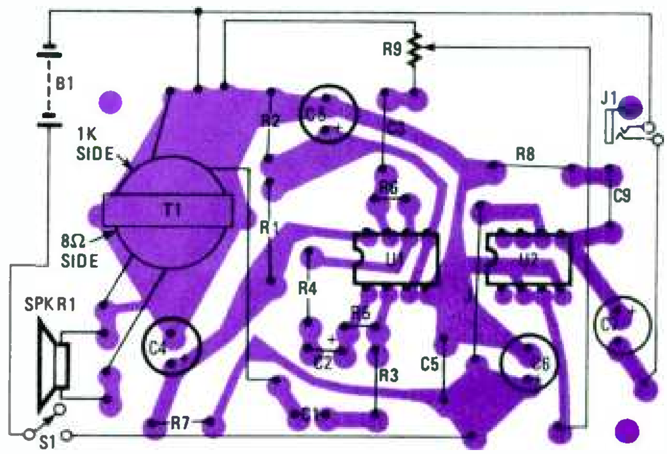


Fig. 5—Please note that the negative battery terminal must be connected to the ground circuit trace and to J1. Be sure that the windings of T1 are connected to they proper pads.

Take the speaker assembly and slide it into one end of the 4-inch tube, leaving a 4-inch space behind the back of the foam rubber, see Fig. 3. When positioning the speaker in place be sure that the speaker's cone is perpendicular to, and in line with the tube opening.

Fire it Up

Give the Tube a workout. Connect a battery to the circuit and slide it in the metal battery clip and slip the end cap assemble on the tube. Turn the gain to its minimum setting and with headphones in place flip the power on. Set the gain to about mid-position and rest the back of the tube on your shoulder, and aim toward whatever you want to listen in on.

The Tube is an ideal instrument to use in locating the noisy little critters that occupy our back yards, parks, and forests. Birds, in particular, are easy to locate and listen to at distances of several hundred feet; and kids at play can be checked on at even greater distances. Like any other new gadget the Tube will need some playing with to obtain the best possible results, and it's possible to get cauliflower ear before you tire from just listening in on the outside world. ■

By Don Jensen

JENSEN ON DX'ING

When is the shortest distance between two points *not* a straight line

YOUR HIGH SCHOOL GEOMETRY TEACHER told you that the shortest distance between Point A and Point B is a straight line. But if Point A is Argentina and Point B is Brazil, the quickest way to get from here to there is shortwave radio.

We tend to think of our Latin American neighbors as being not so far away. Not so. The distances that shortwave signals must travel from the South American nations to our radio receivers are surprisingly long. We're really talking about some rather long-haul DX reception.

An SWL (*shortwave listener*) in New York City, for instance, is closer to Cairo than he is to Buenos Aires; nearer to Athens than to Rio de Janeiro. But because there are international broadcasters in both countries using reasonably powerful shortwave transmitters to beam programs in English to North American audiences, SWL's should be able to add Argentina and Brazil to their "countries heard" totals with little difficulty.

The overseas services of the Argentine National Radio is called, in Spanish, Radio Argentina al Exterior, usually abbreviated, simply, RAE. RAE has an hour-long daily English language program.

It also airs 45-minute programs each day in five other foreign languages; French, German, Italian, Japanese and Arabic. In addition, there are four hours of Spanish programming. The broadcasts consist of news, short program segments focusing on some aspect of Argentina today, and popular Argentine music.

RAE shares its studios and offices with LRA1, the domestic Radio Nacional, in a building at Ayacucho 1556 in metropolitan Buenos Aires. Transmitters are located at General Pacheco, outside the capital city but within Buenos Aires province. Two of the transmitters are decades old and, by today's standards, their 50 kilowatts of power are modest indeed. A newer US-made Harris transmitter of 100 kilowatts puts out a better signal abroad.

Antennas are directed to the eastern half of North America, to Europe, and to the rest of South America, with RAE's English program to North America heard at 0100 and 0400 UTC on 9,690 and 11,710 kHz. English to Europe and Africa is broadcast on 15,345 kHz at 1745 and again at 2100 UTC.

A special QSL card issued by RAE to make an Argentine DX'er's day.

SWL's may send their reception reports to RAE; Casilla de Correo 555; 1000 Buenos Aires, Argentina.

Brazil has many more shortwave stations than Argentina. There are scores of stations broadcasting on the higher frequencies in Portuguese to Brazilian audiences. But one, Radio Nacional in Brasilia—Radiobras—has an external service broadcasting to listeners from North America to the Middle East. And its 250-kilowatt shortwave transmitter also is used for Portuguese broadcasts to the vast Amazon region within Brazil.

The external service has daily programs in English, German, French, Spanish and, of course, Portuguese. An hour-long program to North American listeners is heard at 0200 UTC on 11,745 kHz; English to Europe is transmitted on 15,155 kHz at 1800 UTC.

Listener reports go to Radiobras, Caixa Postal 04/0340; 70323 Brasilia, Brazil.

More Letters

We're always pleased to hear from you with your SW-logging information, comments, and questions. Drop a note to me in care of *Jensen on DX'ing*, **Hands-on Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

This month, we heard from Ramon Fernandez of Caguas, Puerto Rico, who has a long list of questions. For space reasons, though, some will have to wait for a future column. But let's take a look at one of them right now.

"What about QSL cards?" Ramon asks, "How can I get them?"

As we all know, shortwave listening, unlike amateur radio or CB, is one-way communications. So early in the history of radio, broadcasting stations sought a way to get some sort of feedback from listeners about their programming.

Since listeners *listen*, not transmit, the only practical way to hear from the radio audience was for the stations to ask, over the air, that reception reports be mailed in. Shortwave listeners were encouraged to write with their comments on programs and the quality of reception.

In return, the stations promised to reply by mail with a QSL card or letter, acknowledging that the listener's report was correct and useful. SWL's began collect-ing those QSL's from the stations they heard. It became, very often, a competitive thing. How many stations? How many countries could one QSL or verify?

Today, many shortwave listeners still send reception reports to stations and treasure the QSL cards and letters that they usually receive in return.

But because of increased costs, both to the stations (some of which receive in the tens of thousands of listeners' letters each year) and to SWL's—who have to put at least 44 cents worth of postage on every airmail letter they post to an overseas station—QSL'ing has probably declined somewhat over the years.

Still, many find it a fascinating aspect of the SWL'ing hobby. They are willing to pay the increasing postage costs of sending reports. And, thank goodness (I say) for those many shortwave stations that remain willing, for goodwill reasons and despite the increased expense, to continue to respond by mail to listeners' letters.

Being a *dyed-in-the-wool* QSL collector myself, I still get a thrill to find a QSL reply from an overseas SW station in my mailbox, weeks or months after I've mailed out my reception report.

A QSL is, by definition, a statement from a station which says, in effect, yes, your report was correct. So that brings us to the report itself. You should include in your letter to the station, such details that would allow the broadcaster to make that determination. Minimally that includes the frequency on which you heard the station, the date, and the time; plus some details of the programming you heard.

You should also give the station some information about how you liked the programs you heard, or if you didn't care much for them, give your reasons. Listeners' letters, after all, are the only feedback those broadcasters get from their far-flung audiences. Particularly with the international broadcasters' external services, they want you to tune in and tune in again to programming that you enjoy.

Where should you mail your reports? Often the mailing address will be mentioned in the program itself. For the ones who don't announce their addresses, there are two helpful books on the market today.

One of those publications, the *World Radio TV Handbook* (from Billboard Publications Inc., 1515 Broadway, New York, NY 10036) is available through various electronic supply dealers and larger bookstores. The other, the *QSL Address Book* is published by Gilfer Shortwave, PO Box 239, Park Ridge, NJ 07656.

Down the Dial

Here are some of the shortwave broadcasters of the world being heard by North American listeners. All frequencies are given in kiloHertz (kHz) and times are referenced to Universal Time Code/Greenwich Mean Time (UTC/GMT)

Bangladesh—15,525 kHz, *Radio Bangladesh* is a nice bit of South Asian DX for most SWL's. It may be a bit difficult to hear but try for its half hour English program at 1230 UTC.

Costa Rica—5,055 kHz, *TIFC*, the Central American religious broadcaster has gone to 24 hours a day, according to listener reports. Most programs are in Spanish, but you can catch this one in English from 0300 to 0400 UTC.

Cuba—4,765 kHz, *Radio Mayak* is a Russian-language radio service relayed by Radio Havana Cuba transmitters, presumably for Soviets in Cuba. You can find this one on the air at about 1000 UTC.

Iraq—9,515 kHz, *Radio Baghdad* takes no "open sesame" magic to hear. Tune for this one around 0130 to 0230 UTC for its Arabic-language programming. Chimes on the hour and half hour will help to identify it.

New Caledonia—7,170 kHz, *Radio Noumea* is a nice, exotic catch from this little bit of France in the Pacific. It has been noted in North America with fair signals at times, in French, of course.

USA—15,300 kHz, WCSN, the *Christian Science Monitor* SW station in Maine has been noted on this frequency at 2345 UTC with a "Letterbox" program, reading listener mail.

Yemen—9,780 kHz, *Radio Sanaa* is another Middle East station to look for when tuning on the 31-meter band. Its programming also is in Arabic, and airs during the 0300 to 0330 UTC time slot.

Credits: Richard D'Angelo, PA; Michael Bryant, GA; Arthur Bonnet, IN; Peter Dillon, MD; Cesar Obijo, Dominican Republic; John Cook, PA; David Snyder, NY; Daniel Sampson, WI; North American Shortwave Association, 45 Wildflower Road, Levittown, PA 19057) ■

ABBREVIATIONS

CB	Citizens Band
DX	long distance (over 1000 miles)
DX'er	listener to shortwave broadcasts
DX'ing	listening to shortwave broadcasts
kHz	kiloHertz (1000 Hertz or cycles)
QSL	verification reply from broadcaster
QSL'ing	sending of reception report to station
SW	shortwave
SWB'ers	shortwave broadcasters
SWL('s)	shortwave listener('s)
US	United States
UTC/GMT	Universal Time Code/ Greenwich Mean Time
WCSN	Christian Science Monitor

By Charles D. Rakes

CIRCUIT CIRCUS

Checkout the smorgasbord of circuits offered this month

THIS MONTH'S OFFERING HAS TURNED out to be a dab of this and a dash of that; a real potpourri of parts mixed together to produce several circuits that, hopefully, will solve one or more of your electronic problems, or perhaps become a viable ingredient in a future project. In any case, bring out that old soldering iron and slap one of these circuits together; and who knows, it just may be the solution needed to put you in a high state of electronic Utopia.

The first circuit is a real electronic snitch, which I've dubbed the *Electronic Tattletale*.

The Electronic Tattletale

The Electronic Tattletale (a monitoring circuit) shown in Fig. 1, can help keep Murphy's crew from getting away with his sneaky underhanded trick of turning off a piece of electronic equipment that's in the middle of performing some crucial task. A cadmium-sulfide photocell or light-dependent resistor (LDR) keeps a constant vigil on any pilot or indicator lamp, and sings out when the device's normal operation changes. The circuit can be set to "scream" out when a indicator lamp turns on or off.

Refer to Fig. 1. LDR1 in is placed in one end of an opaque tube with the sensitive area of the cell facing outward. The other end of the tube is sealed. The LDR, in it housing, is then placed over the equipment's indicator lamp. With the indicator lamp illuminated, the LDR1's resistance is very low, allowing much of the 9-12 voltage supply (between 2 and 8-volts, depending on the intensity of the light source) to be fed to the base of Q1, turning it on. Resistor R8 determines the circuit's switching point.

As long as LDR1 is blanketed with light, Q1 and Q2 are biased on, and Q3 is turned off. If S1 is placed in the "A" position, a continuous tone is heard from the Piezo sounder (BZ1). But with S1 in the "B" position, the circuit remains tranquil until an input change occurs. The circuit works best as a silent sentry with

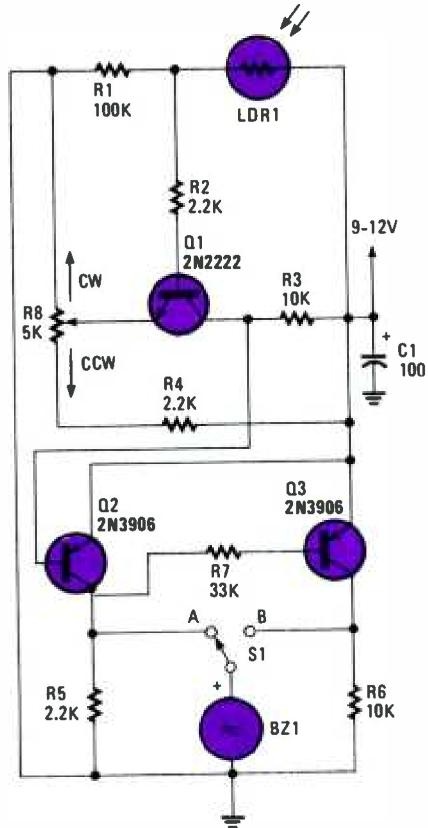


Fig. 1—The Electronic Tattletale circuit uses a photocell, LDR1, to keep a constant vigil on any pilot or indicator lamp, so that when the lamp goes out, the circuit sings out, indicating a deviation from normal operation.

S1 in the "A" position to monitor an indicator that's normally dark and only comes on to give out an alarm, and in the "B" position to indicate a failure of the light source.

Any DC power source of 9 to 12-volts will do just fine in pushing the electrons through the circuit, but a plug-in AC-derived power source would be the economical choice. A two-inch length of metal, fiber, or plastic tubing can be used to house the LDR. A small rubber grommet can be placed at the open end of the tubing to make a snug fit over the monitored lamp. Black electrical tape can then be

PARTS LIST FOR THE ELECTRONIC TATTLETALE

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
BZ1—Piezo buzzer
C1—100µF, 16-WVDC electrolytic capacitor
LDR1—Light-dependent resistor
Q1—2N2222 (or 2N3904) general-purpose silicon NPN transistor
Q2, Q3—2N3906 (or 2N3638) general-purpose silicon NPN transistor
R1—100,000-ohm resistor
R2, R4, R5—2200-ohm resistor
R3, R6—10,000-ohm resistor
R7—33,000-ohm resistor
R8—5000-ohm potentiometer
S1—Single-pole, double-throw (SPDT) toggle or slide switch
Printed-circuit or perfboard materials, opaque light shield, knob, 9-volt battery, battery snap, enclosure, IC sockets, wire, solder, hardware, etc.

wrapped around the opposite end of the tubing to make a light-tight seal.

Select the desired indicator and slip the light *eye* over it, and turn the equipment on to light the indicator. Place S1 in the "B" position, and turn R8 fully counter clockwise (CCW, the direction that produces maximum voltage at wiper) and the sounder should be doing its thing. Turn R8 in a CW direction until the sounder ceases, and go a quarter turn more in the same direction to add a buffer to the setup. The same setup works for a normal unlit indicator with S1 in the "A" position.

The Electronic Cricket

Our next circuit is one that will thrill the kiddies, frustrate the wife, and make you either hero of the day or an occupant of Pluto's house. This unusual and simple circuit, shown in Fig. 2, is known around our house as the *Electronic Cricket*.

The Cricket does nothing more than blurt out a brief sharp chirp ever so often. So what's the big deal you might ask?

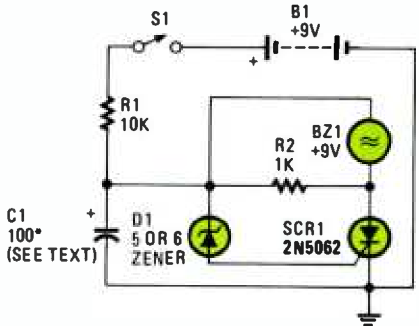


Fig. 2—The Electronic Cricket consists of few parts, and has a power-drain that's so low that it can go on for weeks without a battery change. The time between chirps is set by R1 and C1, and can be adjusted from a chirp every 9 or 10 seconds to one every 45 seconds, by varying the value of C1.

Build a Cricket or two and hide them around the house, then sit back and watch the fun as the little ones and mom try to pinpoint the source of the chirping. Or let junior and his friends play electronic hide and seek with the Cricket. How many times will the bug man be called back to get the job done with a few Crickets working overtime? No, I'm not advocating that you should do such a dastardly deed, but?

The components that make up the Cricket are few indeed, and its hunger for power is very small. So the chirping can go on and on for weeks without a battery change.

Resistor R1 and capacitor C1 set the time interval between chirps, which can be adjusted from a chirp every 9 or 10 seconds to one every 45 seconds. A 500-µF capacitor provides a delay of up to 45 seconds; a 220-µF capacitor gives about 20 seconds, and a 100-muF provides 9 to 10 seconds between chirps.

When power is applied to the circuit, C1 initially acts as a short circuit, and then begins to charge through R1. When the charge across C1 reaches about 5 to 6 volts, the Zener (D1) begins to conduct, supplying a forward-bias current (I_{GT}) to the gate of SCR1. That causes the SCR to fire, placing the energy stored in C1 across the Piezo sounder, BZ1. The current drawn by the sounder and the 1000-ohm resistor discharges C1 and the cycle starts all over again.

The value of R1 can be varied some, and may need to be adjusted for the individual SCR used, but if it is made too large in value the SCR will fail to operate due to insufficient gate current. And if the value of R1 is made too small the circuit will lock up with the SCR remaining on after the first discharge of C1. Experiment and have a good time with the Electronic Cricket circuit.

PARTS LIST FOR THE ELECTRONIC CRICKET

(All resistors are ½-watt, 5% units, unless otherwise noted.)
B1—9-volt transistor-radio battery
C1—100-muF, 16-WVDC electrolytic (see text)
BZ1—9-volt Piezo buzzer
R1—100,000-ohm resistor
R2—1000-ohm resistor
S1—See text
SCR1—2N5062 (or similar) 0.8-A 100-PIV silicon-controlled rectifier
D1—5 or 6-volt Zener diode
Printed-circuit or perfboard materials, enclosure, IC sockets, battery snap, wire, solder, hardware, etc.

PC Trace Checker

The third and final homebrew this month is a handy test circuit, that's designed to make the job of searching for open traces on printed-circuit boards a snap. How many times have you traced a micro-copper strip for a mile on a 2 × 2-inch circuit board and as you looked up at the ohm meter one of the meter's leads slip off track? Enough said, read on.

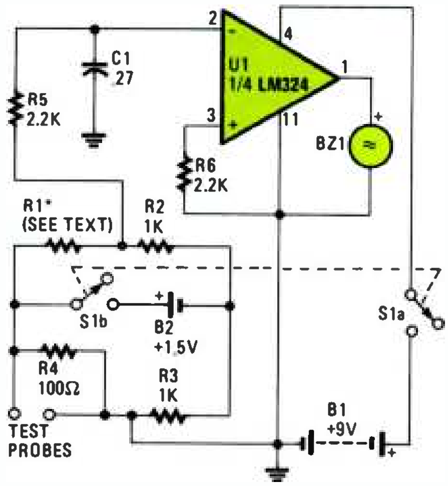


Fig. 3—PC Trace Checker is designed to make the job of searching out open printed-circuit board traces a snap. The circuit is built around a resistance bridge, whose output is amplified many times by an LM324 integrated op-amp (U1), and used to drive the Piezo sounder (BZ1).

The circuit, shown in Fig. 3, is designed around a resistance bridge, with its output amplified many times by an LM324 integrated op-amp, which also drives the Piezo sounder (BZ1). When a 10-ohm resistor is used for R1, the circuit does not acknowledge a resistive path that's over the value of 5-ohms, and with a 5-ohm value for R1, the circuit will only respond to a resistance path of 1-ohm or less. Less than .14 volts is present across the test leads, so no semiconductor devices are damaged while using the Tester.

Not having to look at a meter to know that you are still on track and the fact that circuit won't let you get off on another path, due to a low value coupling resistor (above the 5 or 1 ohm value), that might be hard to notice on a standard VOM, the simple Tester just might be the circuit you have been looking for. As long as the two leads are on a trace, with a resistance value of less than 5 or 1 ohms, the Piezo sounder sings out, but let either lead slip off and the sounder shuts down. It is as simple as that. Build and have fun until next month. ■

PARTS LIST FOR THE PC TRACE CHECKER

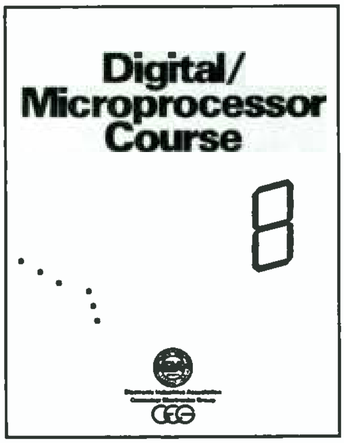
(All resistors are ½-watt, 5% units, unless otherwise noted.)
B1—9-volt transistor-radio battery
B2—1.5-volt AA-cell battery
BZ1—9-volt Piezo buzzer
C1—0.27-muF 100-WVDC ceramic disc capacitor
U1—LM324 quad op-amp, integrated circuit
R1—See text
R2, R3—1000-ohm resistor
R4—100-ohm resistor
R5, R6—2200-ohm resistor
S1—Double-pole, double-throw (DPDT) switch
Printed-circuit or perfboard materials, enclosure, IC sockets, test probes, 9-volt transistor-radio battery, battery holder, battery snaps, wire, solder, hardware, etc.

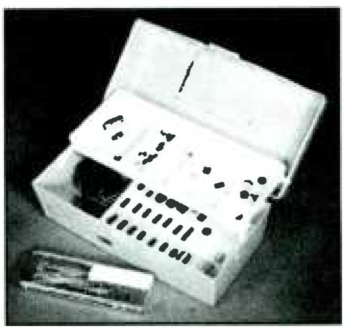
"You've linked up Washington, Chicago, and L.A.? Good! Put them on hold till I get back."

EIA/CEG AUGMENTS DIGITAL AND MICROPROCESSOR COURSE HIGH TECH PARTS KITS NOW AVAILABLE

The members of the Electronic Industries Association Consumer Electronics Group (EIA/CEG) through the Product Services Committee, has marketed the illustrated parts kit for vocational schools, educators and technicians. This is the same material used in the Digital and Microprocessor Course during EIA's summer workshop programs. These workshops are organized by the Consumer Electronics Group and co-sponsored by national service organizations and state departments of vocational education.

Parts and components are contained in a lightweight tool box with individual compartments. It includes a breadboard, power supply, pre-dressed jumpers, resistors, capacitors, and integrated circuits to perform all digital exercises 1 through 25 of the Digital/Microprocessor course book listed in the table of contents. Some parts have been included for the microprocessor section but other components will have to be acquired (as listed in the Introduction to Exercises 26–31).





Individual and classroom size quantities are available at the following cost: quantities 1–9, $69.95 each, quantities 10–19, $67.95 each, and for quantities 20 or more, $64.95 each (cost includes shipping and handling). The kits will also include the Digital and Microprocessor Course book. Additional books are available at the cost of $2.00 per copy.

PLEASE COMPLETE ORDER FORM FOR PARTS KITS AND BOOKS

Send to: EIA/CEG, Department PS, P.O. Box 19100, Washington, D.C. 20036

ORDER FORM

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10–19	________	$67.95 each	________
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Additional Digital/Microprocessor Course Books	________	$2.00 per copy	________
		Total Amount Enclosed	________

Name

Title

Firm

Address

City State Zip

NO RFI NIGHT-LIGHT CONTROLLER

(Continued from page 42)

sealant. Connect the AC devices to be powered (up to a maximum of about 175 watts) to the binding posts. Be certain to use sufficient care in handling, insulation, and installation

Exposed binding posts should be covered in silicone sealant after wires are connected to them. AC sockets can be used in place of the posts for quick plug-in connections.

since those connectors carry AC-line voltage, which can be lethal! Also, if it is used as a light controller, be certain that the assembled unit is placed far enough away from the controlled bulbs so that enough light to cause the CdS voltage to pass through the hysteresis band doesn't feed back to the CdS. That could result in oscillating relay chatter when the unit is switched on at nightfall.

As a replacement for solid state light controllers, this project should go a long way in reducing electromagnetic interference around your household, and the buzzsaw barnacles emanating from your receiving equipment can be sheared. But, if quiet storms still continue to invade your listening or viewing, what are your neighbors using for their light controllers? ■

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B. PAID AND/OR REQUESTED CIRCULATION 1. Sales through dealers and carriers, street vendors and counter sales	35,792	34,437
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E. TOTAL DISTRIBUTION (Sum of C and D)	55,295	53,221
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PS Form 3526, Dec. 1981

WHAT'S TV COMING TO?

Remember the days of viewing one station at a time, without TV freeze frame, and you couldn't watch a video tape while keeping tabs on live TV? What's that; you're still putting up with primitive TV without state-of-the-art advances? There's no reason to, even for the budget minded.

The VC-D800U VCR is a couch potatoes dream. It can display nine channels at once by splitting the screen up into tic-tac-toe like sections containing the picture and channel number of each selected station.

Further, if you want to view two channels at once, or watch a video tape and one channel at the same time, you can. Just think, watching the news and not missing that all important scrimmage, or catching up on the soaps you've taped without missing the local weather report.

This baby even has freeze frame to stop the picture while the audio continues. But for how much? Sony's suggested retail price is $549.95; not bad, huh? ■

A wonder of digital technology, the VC-D800U provides you with 9-channel scan, freeze-frame, picture strobe and more.

I-Q SIGNAL GENERATOR

(Continued from page 30)

more mounting holes into the board to accommodate 2-56 hardware.

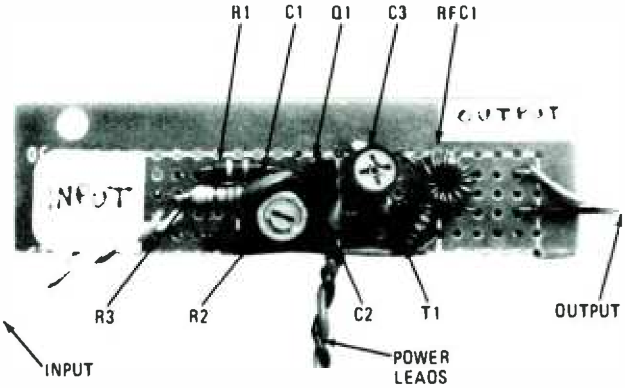
When you install transformer T1 onto the circuit board, keep all four leads as short as possible—especially for circuits that are to operate above 60 MHz. Align the planes passing through the toroids perpendicular to each other to reduce the mutual conductance between them. Following the schematic diagram in Fig. 1, mount the resistors and capacitors flush against the board and minimize the lengths of all leads. Keep the leads of the transistor to about 5/16-inch long. Solder four 3-inch lengths of hookup wire to the circuit, one pair to the input, and one pair to the output terminals. Solder a longer pair of leads to the power supply terminals of the circuit. You might want to put the circuit inside the enclosure of another piece of gear. However, if you intend to use a separate enclsure, decide on the type of input and output cable or cnnectors you want to use. Short lengths of #26 gauge twisted pair, or coaxial cable can be used for input and output leads. Solder them to the input and output terminals of the circuit.

Use an electric drill to prepare the enclosure in the following way: Drill two holes, one in each end, for the input and output leads or connectors. Drill one or more holes in the bottom of the enclosure for mounting the perfboard. Drill a hole for a pair of wires from the 5-volt DC regulated supply. Next, drill a hole in the lid of the enclosure directly above the location of capacitor C3. Make it large enough to pass the shank of a small screw driver used to adjust capacitor C3. Finally, using self-adhesive labels, mark the INPUT, OUTPUT, and C3 ADJUST locations.

Adjustment and Application

Initially, the quiescent emitter current of Q1 should be set to 25 mA. To do this requires a voltmeter. Attach the negative probe of the meter to power supply ground. Attach the positive probe of the meter to the emitter of transistor Q1 and then turn on the power supply. With the input terminal open, the meter should read zero volts. Next, apply a logic high--about 3.5 volts--to the input terminal (resistor R1). If a logic high signal is not available, simply connect the input terminal to the positive 5-volt DC supply. The voltmeter should now indicate a voltage. Adjust potentiometer R2 until the voltmeter reads 0.675 volts DC.

The impedance of the load effects the tuning of capacitor C3. Therefore, adjust capacitor C3 for maximum RF output



The 1-Q Signal Generator is shown here in the perfboard stage prior to insertion into existing test gear or into a plastic probe for testing purposes.

voltage whenever a new or different load is connected. This requires either an RF probe or the S-meter of a receiver connected to the output (secondary) terminals.

Once you become familiar with the simple operation of the 1-Q VHF Signal Generator, you might want to build several of them and set each to a different frequency. In addition, by reducing the number of primary windings on transformer T1, you can experiment with output frequencies higher than those given in Table 1. ■

BOOKSHELF

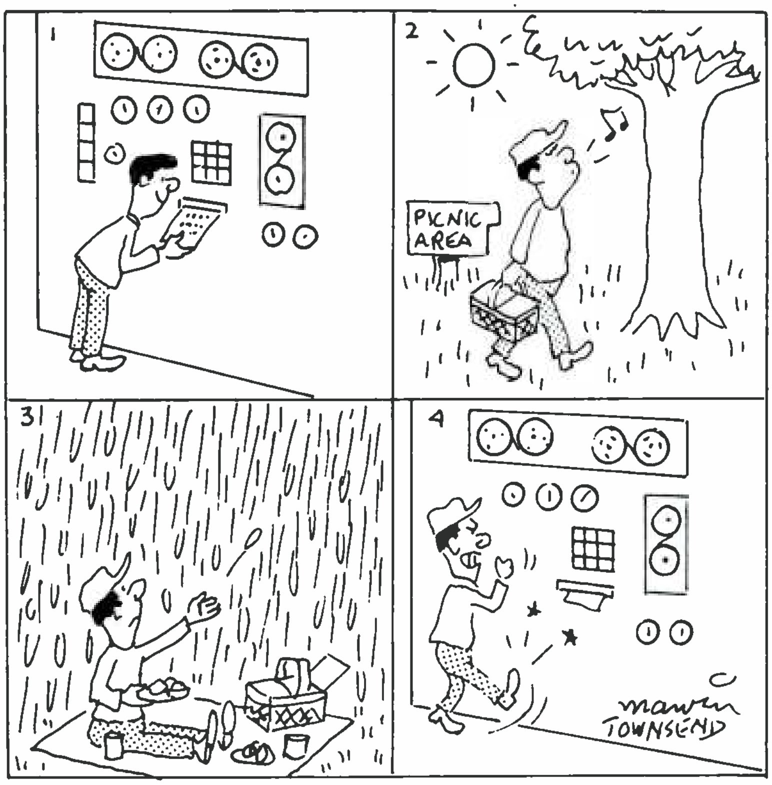
(Continued from page 23)

partly to save calculations and partly because actual figures bring a greater intimacy with the design process.

As a reference book, sections have been written to be as self-contained as possible. The book is divided into six basic sections—Units and Constants, Direct Current Circuits, Passive Components, Altering Current Circuits, Passive Components, Altering Current Circuits, Networks and Theorems, and Measurements.

Practical Electronics Calculations and Formulas is an essential addition to the library of all those interested in electronics, be they amateur or professional. The text contains 249 pages and costs $6.95 plus $1.00 for postage and handling from Electronics Technology Today, P.O. Box 240, Massapequa, NY 11762.

It can happen to the weatherman!



Smart Tips, Tricks, and Traps By Andrew N. Schwartz

The book teaches users tips and tricks for getting the most out of Smart. It also describes strategies for avoiding or working around the "traps" that can interfere with efficient, effective use of the program. The book, written in Que's clear and logical style that makes learning easy, focuses on the Data Base Manager, but gives ample coverage to the other modules.

With *Smart Tips, Tricks, and Traps*, users will be taught the SmartSystem as a whole, including installation and networking; the powerful Data Base Manager and its unmatched reporting capabilities; the Spreadsheet with features not found in any other available spreadsheet; the Word Processor with its sophisticated capabilities for formatting, printing and merging text with graphics; and the unique Project Processing

(Continued on page 91)

LETTER BOX

(Continued from page 15)

opamps and transistors, and tried to convince me that without a computer I would shrivel up and blow away. Well, I own an IBM PC I've pieced together myself, and I spend as much time on it as on my bench, but I still salvage all the goodies from every dead TV I can find. And I still get excited over a new little timer circuit, or one of those jewels in *Circuit Circus* or *Wel's Think Tank* that comes up every month. Keep that stuff coming!

I even go so far as to use dBase III on my PC to keep a running library of all those projects. I also enjoy Jensen's DX'ING. If I could talk the budget, wife, and kids into a good SW receiver, I would enjoy it more. The wife says I have enough doodads to build 100 receivers so why buy one! She has a point...so I'm officially voting for a good SW receiver project. Not the 4-transistor, medium-priced Kenwood. Then follow it up with a good antenna article, not one that leaves you hanging as to what type of wire, or just exactly where and how to ground the thing to the receiver or waterpipe or whatever!

Keep the FactCards coming (it would be nice if they had some sort of order to keep though), and keep up your tutorials on the basics. Almost all of us don't use much of what we learned ten years ago in school, and we need to relearn that stuff over and over. Also, I don't need to tell you people how fast this industry changes. I count on magazines like this one and **Radio-Electronics** to keep me informed. Keep up the good work.

—D.K., Waldorf, MD

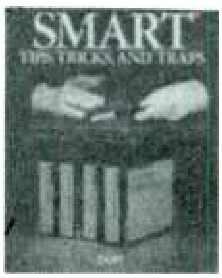
Boy, do we love letters like yours. To help you remember the basics of electronics math we've started a new series on that subject by Louis E. Frenzel, Jr. It'll help dust off those brain cells and maybe even show you a few new tricks. ■

BOOKSHELF

(Continued from page 88)

and Communications modules, Smart's complete facilities for applications development and data transfer.

Written for users who are already fasmiliar, or are becoming familiar, with one or more modules of the Smart Sys-



CIRCLE 94 ON FREE INFORMATION CARD

tem, thifs book, when used as a comlpanion to Using Smart, also helps novices get up to speed.

To order your 480-page copy of *Smart Tips, Tricks, and Traps* directly from Que, call 1-800-428-5331 and ask for a sales representative. It sells for $23.95 and can be obtained at better book stores.

"Evidently. A fly was in the transmitter during your last teleconference with the New York Office!"

DX-COM

(Continued from page 71)

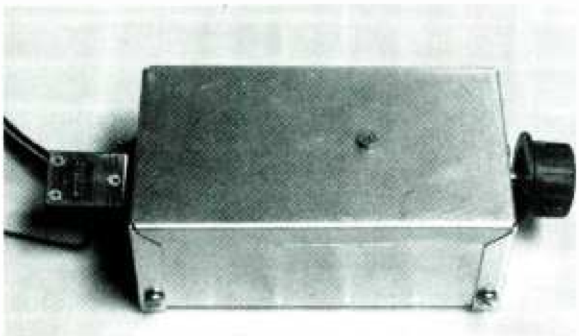
simple projects can be made difficult by trying to make the project more compact.

When the converter is finished and the wiring double checked, it's time to fire up the system. Always be sure an eight- to ten-ohm speaker is connected to the car radio before applying power or you might damage the output transistors(s).

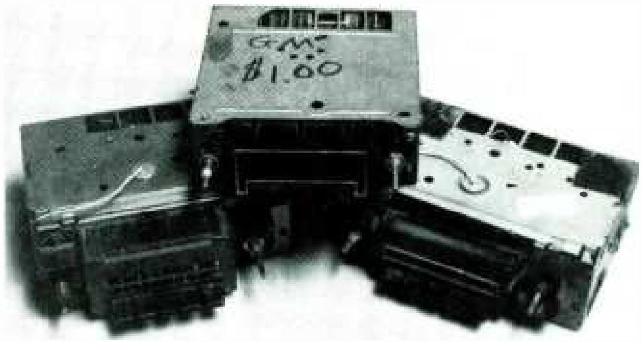
You can use the jacks provided on the rear of the radio for speaker and power connections since there's usually plenty of room. Any power supply delivering between 12 and 13.8 volts can be used. The power source needn't be closely regulated, but be sure it's attached to the radio before plugging it in.

Fire It Up

During the early evening hours many stations can be found on all three shortwave bands so this is a good time for an initial tune-up. Set the dial on the car radio to the correct range and rotate the converter tuning capacitor until stations



The DX-Com converter is shown here buttoned up and ready to go. The tuning knob peaks the circuit to the 49, 31, or 25 meter shortwave broadcast bands.



Old car radios are one of the best electronic bargains around. They're sensitive, selective, shielded and cheap! Pushbutton tuning makes them especially attractive for backing up a shortwave convert, like that n DX-Com.

are heard. The 49 meter band will appear with the capacitor about a third open, the 31 meter band at the half-way point and the 25 meter band about three-fourths open. The system will go dead when the input circuit is tuned to the exact crystal frequency or a harmonic so this can be used as an indicator to find the bands.

It takes a little two-handed tuning to adjust the converter and car radio at first but once you find the bands on the converter you can mark their location on the chassis box with a pencil or drop of paint for future reference. The pushbuttons on the car radio can be set to your favorite stations by pulling them all the way out, then pushing them all the way in.

I think you'll be pleased with the performance of your new receiver—I know I am with mine. They are so inexpensive I built one for my workshop and another for the basement recroom, and they're so convenient to use with the pushbutton tuning that I often use them in preference to my more elaborate receivers. ■

SOLDERLESS BREAD/CLIP BOARD

(Continued from page 51)

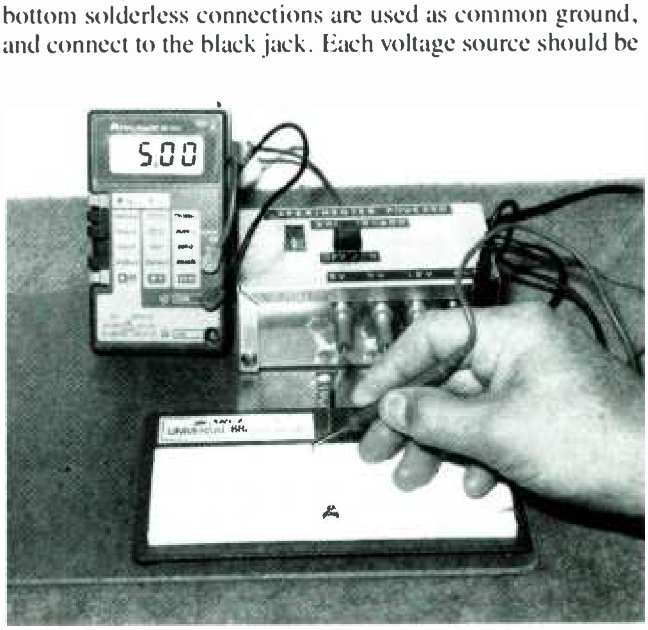
Finishing Up

The push on/off power switch (S1) and pilot light NE1 are mounted on the top cover. Stagger the two parts so they do not touch any wired components on the perfboard. Switch S1 was placed to the outside for easy operation. Drill a ⅛-inch hole for S1 and a ½-inch hole for NE1. Center both holes in the top aluminum cover.

After installing a vinyl grommet for the power cord, tie a knot in the AC cord so that it will not pull out. Leave 6 inches of AC-line cord inside the case for easy hookup. Solder one power lead to one black terminal wire of T1. Tie the other black transformer lead to one side of S1. From that same connection, run a piece of hookup wire to one side of the neon pilot light (NE1). Solder a 4-inch hookup wire to the other side of NE1 to the AC cord and black power transformer wire. Tape up the connection.

The solderless breadboard is cemented to the Masonite clipboard with epoxy. Place epoxy upon the rubber felt and mount the breadboard in the far righthand bottom corner of the clipboard. Leave the cement set up for at least four hours. Place two dabs of silicon rubber cement upon perfboard and metal case opposite the IC's to keep chassis level.

Connect the banana plugs of the test leads to the voltage jacks on the breadboard. The top righthand row of breadboard connections should be connected to the 12-volt source jack. Connect the 9-volt jack to the second row at the top. Both lefthand top rows were connected to the 5-volt jack. The bottom solderless connections are used as common ground, and connect to the black jack. Each voltage source should be



The payoff comes when the project is completed and you get to the serious part of your hobby—creating and testing circuits.

labeled for easy and unmistakable reference. Remember, the rows at the top and bottom are broken in half at the center of the solderless breadboard.

You can fuse each voltage-output source with a ¼-A pigtail fuse for added protection. Solder one end of the pigtail fuse into the male banana jack and plug the other bare end into the respective voltage post. A short or leak within the wired-up project will open the fuse and protect the power supply and project circuits.

You can check the operating voltage right at the various voltage posts. If the voltage measurement is low at the voltage source, you may assume that the project has a leaky component or a misplaced connection. Just remove the male banana plug and insert the test probes in the banana jack and test post of the solderless breadboard to check the current to the wired project upon the breadboard.

The clip/breadboard is now ready to wire up your favorite project. Remember, the row of two top-hole connections at the top and bottom of the breadboard go horizontally, while the solderless connections inside go up and down. Simply plug in the various components to your project and select the correct voltage source. Take a resistance measurement of the selected power source to common ground at the post terminals, before firing up the power supply. Just hang the clip-breadboard upon a nail or hook after designing that new project. It will be there when you need it most. ■

3.5-INCH RETROFIT

(Continued from page 44)

viously equipped with two floppies and a half-height hard disk. The 3.5-inch drive is installed in the remaining space above the hard-disk unit, and it connects as drive D: to the extra internal connections on a CompatiCard controller.

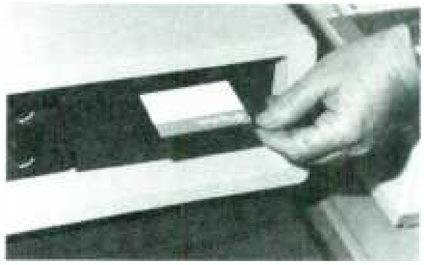
Getting Power

If you're upgrading a PC, you'll find that the power supply has only two disk-drive power connectors. Since you'll be substituting the 3.5-inch drive for the existing B: drive, you simply use drive B:'s power connector. If your PC has already been upgraded with half-height floppies, so that a full-size disk drive location is free for use by a hard-disk or a 3.5-inch drive, you can add a Y-adapter to either power cable to provide the extra power connection. Since half-height drives use half the power of a full-size drive, you won't have to worry about overloading the power supply, even though it might be the early 60-watt type.

If you're upgrading an XT-compatible, it's quite likely that the two floppies are half-heights, leaving front-panel room for the 3.5-incher. If you look under the nest of disk-drive wires, you'll find that there are four disk-drive power connectors, of which two are unused. If your computer also has a hard-disk, it will use one of the remaining power connectors, so at the very least one power connector will be free for the 3.5-inch drive.

Follow Along

The photographs show how the 3.5-inch disk-drive retrofit/upgrade is done. Bear in mind that all that's needed in the way of tools is a philips screwdriver; and just possibly, a flat-blade screwdriver if you have to remove some old equipment. If any situation develops that looks as if a soldering iron or wire cutters will be needed, you're doing something wrong. For more information on the Toshiba 3.5-inch Floppy-Disk Drive Universal bit Circle no. 77 on the Free Information Card or write to Microsense, 5880 La Jolla Blvd., Suite 313, La Jolla, CA 92037. ■



Install the device driver (if needed) as part of your computer's CONFIG.SYS file, then insert a blank (unformatted) 3.5- inch disk into the drive and try to for mat the disk. If all has gone well, the computer should recognize the 3.5-inch disk drive as drive B:. Get the hang of formatting and using the drive at both 360K and 720K storage if that is possible with your particular computer and disk-operating system (DOS).

HOW TO SELECT AN OSCILLOSCOPE

(Continued from page 26)

dards. The requirements of this regulatory body are as stiff as are those of the military. Use of non-UL equipment may impact insurance coverage. In some cases, safety certification of the scope may be required. In any case, it is a precaution well worth taking.

No matter how sturdy it is, there will be times when a scope requires repair. When that happens, time out of service becomes critical. Reputable manufacturers will have a network of service centers for scope repair. Check and see if loaner scopes are available while yours is being repaired.

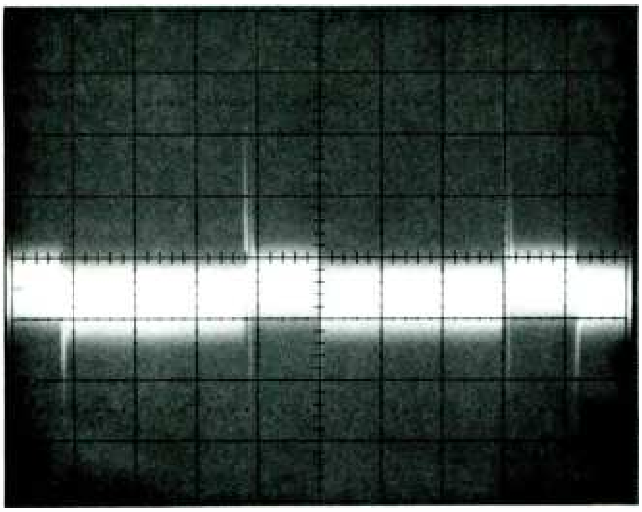
Ease of Use

Of course, the new capabilities provided by modern oscilloscopes require controls. However, enhanced capabilities become a hindrance when the technician must go through complicated operations involving numerous controls. A good scope will minimize the number of controls by using new technologies to internalize many of the functions required for operation.

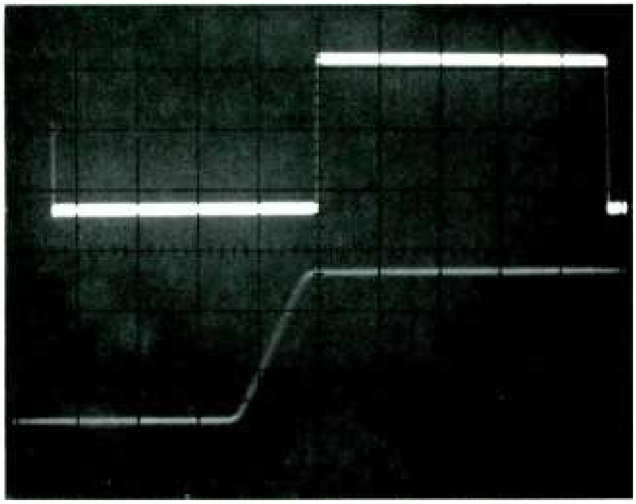
A streamlined front panel is, therefore, a key consideration in the purchase of an oscilloscope. Logically-grouped controls and a tidy layout can make a scope easier to operate. In addition to making on-the-job operations simpler, simplified controls also make training on the equipment an easier task. And, when manual steps are minimized, the chance of inadvertent error is reduced.

Suit the Instrument to the Occasion

Technology has affected the oscilloscope market just as it has affected the society that the service technician serves. A wide range of features and capabilities are available to make testing and troubleshooting of electronic equipment much more efficient and accurate than it has ever been before. By matching capabilities to needs, oscilloscope users achieve positive results both for fun and business. ■



High sensitivity input (500 µV/div) and high-frequency reject triggering provide large, stable displays of low-level signals by cutting out noise.



Alternate horizontal magnification allows zooming in on transition details without the complexity or expense of dual time base or delaying time base features.

ELECTRONICS MATH MADE EASY

(Continued from page 69)

The square root of the square of a number is the number.

$$V = \sqrt{PR}$$

b) Solving now for R we reverse sides:

$$V^2/R = P$$

Divide both sides by R to get rid of the fraction.

$$V^2R/R = PR$$

The R's cancel leaving:

$$V^2 = PR$$

Divide both sides by P:

$$V^2/P = PR/P$$

The P's on the right cancel.

$$V^2P = R$$

Swap sides.

$$R = V^2/P$$

2. $R_l = (V_i - V_o)/I$

To solve for V_o, we start by dividing both sides by I to get rid of the fraction.

$$Ir_l = (V_i - V_o)I/I$$

The I's on the right cancel.

$$IR_l = V_i - V_o$$

Add V_o to both sides of the equation.

$$IR_l + V_o = V_i - V_o + V_o$$

The V_o's on the right cancel.

$$IR_l + V_o = V_i$$

Subtract IR from both sides to isolate V_o.

$$V_o = V_i - IR_l$$

3. $f = 1/6.28\sqrt{LC}$

To begin solving for C, first get rid of the fraction by multiplying both sides of the equation by $6.28\sqrt{LC}$.

$$6.28f\sqrt{LC} = 1(6.28\sqrt{LC})/6.28\sqrt{LC}$$

The terms on the right cancel.

$$6.28f\sqrt{LC} = 1$$

Divide both sides by 6.28f to isolate the term containing C.

$$6.28f\sqrt{LC}/6.28f = 1/6.28f$$

The terms on the left cancel.

$$\sqrt{LC} = 1/6.28f$$

Square both sides to get rid of the radical (square root).

$$(\sqrt{LC})^2 = (1/6.28f)^2$$

Squaring the square root of a number is just the number. So:

$$LC = (1/6.28f)^2$$

Squaring a fraction is the same as squaring the numerator and denominator separately.

$$LC = 1^2/(6.28f)^2$$

Now to solve for C, we divide both sides by L.

$$LC/L = 1/(6.28f)^2L$$

So:

$$C = 1/(6.28f)^2L$$

4. $Z = \sqrt{R^2+(X_L-X_C)^2}$

Take the square of both sides to eliminate the radical.

$$Z^2 = (\sqrt{R^2+(X_L-X_C)^2})^2$$

$$Z^2 = R^2+(X_L-X_C)^2$$

Subtract R^2 from both sides.

$$Z^2-R^2 = R^2+(X_L-X_C)^2-R^2$$

The R2's cancel because $R^2-R^2 = 0$.

$$Z^2-R^2 = (X_L-X_C)^2$$

Now, take the square root of both sides to eliminate the square.

$$\sqrt{Z^2-R^2} = \sqrt{(X_L-X_C)^2}$$

$$\sqrt{Z^2-R^2} = X_L-X_C$$

Subtract X_L from both sides to isolate X_C.

$$\sqrt{Z^2-R^2}-X_L = -X_C$$

We want X_C, not $-X_C$. So we can multiply both sides of the equation by -1.

$$-1(\sqrt{Z^2-R^2}-X_L) = -1(-X_C)$$

$$-\sqrt{Z^2-R^2}+X_L = X_C$$

A minus times a minus is a plus. Now, rearranging the terms on the left gives:

$$X_L-\sqrt{Z^2-R^2} = X_C$$

And finally, swapping sides:

$$X_C = X_L-\sqrt{Z^2-R^2}$$

We hope you've all enjoyed this, the first edition in our electronic math series. Next month's column will be filled with more quick routes through math (no pun intended). In the meantime, please write in and let us know what topics in electronics math you'd like us to cover. ■

UNIVERSAL POWER-SUPPLY MODULE

(Continued from page 57)

Figure 6 shows a parts-placement diagram for the circuit board shown in Fig. 5. The components and jumpers needed depend on the configuration chosen, so not all of the parts are used in all cases. For instance, you could use a variable regulator (U3) for the positive voltage regulator and a fixed regulator (U2) for the negative voltage. If that were the case, U1,U4,R3 and R4 would not be used. The board can be customized for your particular application.

Typical Applications

A bipolar power-supply—with a full-wave bridge (performing rectification), a center-tapped transformer (to step-down the AC line voltage), and variable regulators (for voltage stability)—is shown in Fig. 7A, with its parts-placement diagram shown in Fig. 7B. That arrangement is the most complex and uses all of the parts from the Parts List (except U1 and U2). It would probably be most useful with op-amp projects that require dual-polarity supplies.

A single-polarity, fixed output-voltage supply using a full-wave rectifier and a center-tapped transformer is shown in Fig. 8A, and the parts-placement diagram is shown in Fig. 8B. The fixed-output supply would be ideal (using a 5-volt regulator for U1) for TTL projects.

After it's up and running, carefully test the metal tabs on the regulators to be sure they are not running too hot (brush the tab lightly at first to kind of get an idea of what you are dealing with—don't just grab the tab). The regulators should not be running *ouch*! hot. If they are, bolt one of the readily available TO-220 heatsinks to the tab using some silicone grease. ■

PARTS LIST FOR THE UNIVERSAL POWER-SUPPLY MODULE

SEMICONDUCTORS

D1–D4—Rectifier diode (see text)
U1—78XX or 340T series three-terminal, positive voltage regulator, integrated circuit.
U2—79XXX or 320T series, three-terminal, negative voltage regulator, integrated circuit
U3—317T series, three-terminal, positive adjustable voltage regulator, integrated circuit
U4—377T series, three-terminal, negative adjustable voltage regulator, integrated circuit

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)

R1—220-ohm
R3—120-ohm
R4—See text

ADDITIONAL PARTS AND MATERIALS

C1–C2—See text
C3–C4—1.0–10-µF (see text)
T1—See Table 1
Printed-circuit materials, etching solution, wire, solder, hardware, enclosure, etc.

Note: An etched, plated, and pre-drilled printed-circuit board for the Universal Power-Supply Module is available from Jack Cunkelman, PO Box 397, Milford, OH 45150, priced at $5. per board, plus $1. shipping and handling. Ohio residents please add 5.5% sales tax. Please allow 6 to 8 weeks for delivery

HANDS-ON MARKETPLACE

FOR SALE

GIANT shortwave listener's catalog. Features shortwave receivers, antennas, accessories, radioteletype facsimile equipment and books. Free! **UNIVERSAL SHORTWAVE RADIO,** 1280 Aida Drive, #OH, Reynoldsburg, OH 43068.

PC-XT/AT clone bare PCB, wholesale. **INTEGRITY TECHNOLOGY,** 105 Serra Way, Suite 230, Milpitas, CA 95035.

TEKTRONIX 545A 24MHz scope $125.00. Lowest prices test equipment, parts. Free catalog. **EF ELECTRONICS,** Box 249, Aurora, IL 60507.

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6	7	8	9	10
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CABLE TV converters, descramblers. All major brands. Specializing in Scientific Atlanta, Jerrold, Oak, Zenith, Hamlin. $2.00 for catalog. **K.D. VIDEO,** P.O. Box 29538, Mlps., MN 55429. 1-800-327-3407.

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150WX2 pre-main amplifier, kit or assembled, professional quality, class A circuit, dynamite sound $78 discount if wholesale. Send check, M.O. to **KATLI ENTERPRISE,** P.O. Box 5565, Hacienda Hts., CA 91745. For details send self addressed envelope. Distributor needed.

ADVERTISING INDEX

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FRIEDMAN ON COMPUTERS

(Continued from page 73)

done in a single step. (You could back up with two CD .. commands.) You can't even do it in the eighth illustration by first going through the root directory because LEVEL1 stands between the root and LEVEL2. But now look at the ninth example in the photos. In a single step we move from FLOOR2 to LEVEL2. How was it done?

The move in the ninth step was made possible by entering the complete path to LEVEL2 with the command "CD \level1\level2." DOS interprets that command as: CD (change directory) to \ (which is the root directory), then to LEVEL1, then to LEVEL2. By using a full path that starts out at home—the root directory—the user actually backs up from FLOOR2 to LEVEL2 by going "the long way 'round," with a jump to the root and then stepping through intervening directories in the path.

Although we have restricted ourselves to movement within a single subdirectory structure because of space limitations, you would use exactly the same procedures if you had several subdirectory chains and wanted to move between them. You would first return or jump to the root directory and then step or path to the new subdirectory chain.

If it all seems confusing on the first reading, don't think that you're the only one who's confused. All MS/PC-DOS manuals and "instruction" texts that I have seen make the same error and fail to adequately state that "you can't go home" other than by first returning to the root directory and then stepping directly through a subdirectory chain, or by using a single path command that starts at the root directory. The best way to get a firm grasp on subdirectories is to set up with the command PROMPT PG so that the screen displays the subdirectory depth—how deep your default is buried—and then try creating and moving around various kinds of subdirectory structures. In fact, the PROMPT command should be made part of your AUTOEXEC.BAT file so that it's always active. (VTREE will keep you from getting lost.) ■

SAXON ON SCANNERS

(Continued from page 78)

use. The idea is that the general public can purchase the sets for a relatively small investment, fill out a simple FCC license form, and have hassle-free, cheap, short-range communications. The transceivers are especially appealing to those who want to communicate within factories, warehouses, at construction sites, in large office complexes, etc.

Scanner owners can listen in on all of the action as those units operate on four channels that are set aside just for that type of use. They are 457.525, 457.55, 457.575, and 457.60 MHz. There are no base stations or repeaters involved; it's strictly a portable and mobile unit single-channel type of operation.

A similar type of thing is available for those in medical-related professions. It might be used, for instance, by doctors communicating within hospitals, EMT's talking to one another at a disaster or accident scene, etc. The stations, permitted to run at 5-watts, operate on 458.025, 458.075, 458.125, and 458.175 MHz.

We are always happy to hear from our readers. Send your comments, questions, photos, and whatever to: Marc Saxon, *Saxon on Scanners*, **Hands-on Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. We'll be waiting to hear from you! And, we'll have more for you next issue! ■

CARR ON HAM RADIO

(Continued on page 77)

one antenna, while increasing at the other. A three-antenna system is often used. Three separate, but identical, receivers, often tuned by the same master local oscillator, are connected to the three antennas. Audio mixing, based on the strongest signal, keeps the audio output constant while the RF signal fades.

Polarity diversity reception (see Fig. 6) uses both vertical and horizontal polarization antennas to receive the signal. Like the space diversity system, the outputs of the vertical and horizontal receivers re combined to produce a constant level output.

Another form of fading, called *selective fading*, is derived from the fact that fading is a function of frequency. The carriers, upper and lower sidebands, of an AM signal are slightly different in frequency, and so arrive out-of-phase with each other. Although that type of fading is lessened through the use of single-sideband transmissions, that does not help AM users.

In those systems, some operators use a filtering scheme that eliminates the carrier and one sideband, and then reconstitutes the AM signal with a product detector. SSB receivers with stable local and product detector oscillators, and a sharp IF bandpass filter, can be used to reduce the effects of differential fading of AM signals due to phasing of the LSB, USB and carrier components.

Carefully tune the receiver to only one sideband of the signal, and note when the heterodyne beat-note disappears. The correct point is characterized by the fact that you can then switch among USB, LSB, and CW modes without changing the received signal output.

Back to the Future

In future columns we'll discuss working DX from both the operating and equipment points of view. I recently returned from El-land (Ireland) where an old friend of mine has a six-element, 20-meter beam up 88-feet driven by several hundred watts (kilowatts are illegal there). What I will answer for you is whether or not you need that level of equipment, or will a more modest station suffice (hint: the first DXCC operator I knew used a Heathkit DX-20 into a dipole). ■

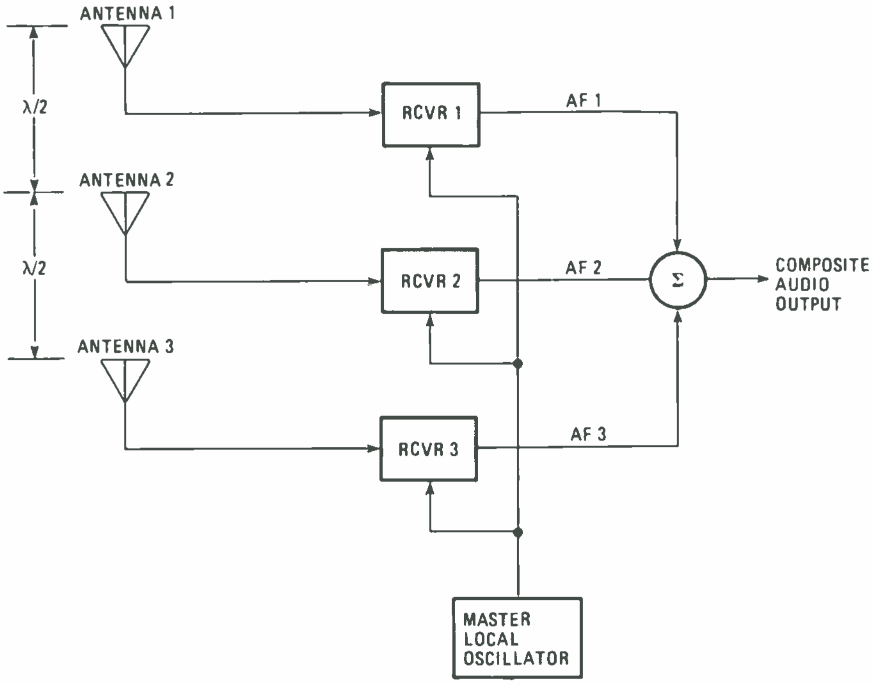

Fig. 5—The spacial diversity system assumes that a single transmitter frequency is used. At the receiver site, two or more receive antennas are used, spaced one-half wavelength apart. The theory is that the signal fades at one antenna, while increasing at the other.

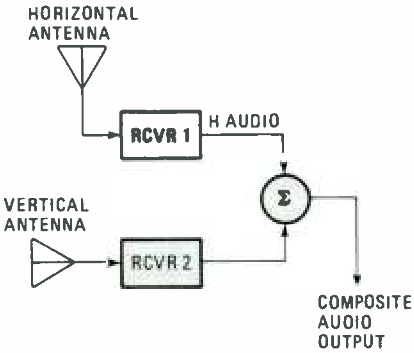

Fig. 6—Polarity-diversity reception uses both vertically and horizontally polarized antennas to collect airborne signals Like the space-diversity system, the outputs of the vertical and horizontal receivers are combined to produce a constant level output.