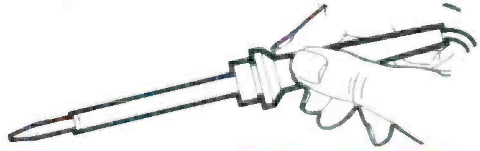
COLLECTORS PREMIER EDITION



From the Publishers of *Radio-Electronics*

Hands-on Electronics

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#1

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Hands-on Electronics Volume 2, No. 1 Summer 1984

FEATURES

CONSTRUCTION PROJECTS

SPECIAL COLUMNS

DEPARTMENTS

#1
SUMMER 1984

Hands-on Electronics

The Magazine for people who build electronic projects

HANDS-ON ELECTRONICS....that's the new name for Special Projects magazine.

The editorial staff decided to change the name of America's only electronics project magazine for a very good reason! The old title just didn't say *electronics*. Plus, we wanted the title to be more explicit—we wanted the new reader, who'd see the cover for the first time on the newsstand, to know that this is the magazine he should reach for! There are countless electronics experimenters and project builders working at their test benches in attics, basements, and nooks about the house who are seeking a magazine just like **Hands-on Electronics**—but who did not realize that the magazine's old title was aimed at them. We are confident that the new title will do the job!

Additionally, our many readers during the past two years have told us of a void in their electronics hobby activities. Many have asked for columns and extended coverage in subject areas like shortwave listening, Amateur Radio, computers for beginners, and many other topics. We have responded to those requests, as we will to others in the future, where we believe that an added service is being provided, and that the basic premise of the magazine—project building—is supplemented by such specialized coverage.

Increasing the number of readers will give the editors of **Hands-on Electronics** the opportunity to receive many more project plans for review and eventual publication. The better our published projects are, the better we can serve you. And, as our supply of articles increases, we would be in a better position to publish **Hands-on Electronics** six times a year—a 50% bonus to our readers.!

Julian S. Martin

Julian S. Martin, KA2GUN
Editor

Hands-on Electronics, (ISSN 0743-2968) published quarterly by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Phone 212-777-6400. Four-issue subscription rate is $10.00 — U.S. funds only. Canada subscribers add $3.00 for postage. All others add $7.00. Mail all subscription orders, address changes, correspondence and Postmaster Notices of undelivered copies (Form 3579) **Hands-on Electronics,** Subscription Dept., P.O. Box 338, Mount Morris, IL 61054. U.S. single-copy price $2.50.

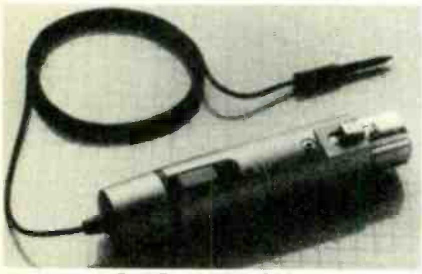
NEW PRODUCTS SHOWCASE

For more details use the free information card found on page 37

Snap-on Microphone Transmitter

A miniature snap-on microphone transmitter, no larger than a disposable cigarette lighter, has been introduced by Audio-Technica.

The Model AT8550 transmitter plugs into any microphone, dynamic or electret, having a professional-type 3-pin connector. It transmits through any FM receiver within a radius of up to 300 feet outdoors or up to 30 feet indoors. Although the transmitter is pre-tuned to a frequency of 100 MHz, it is screwdriver-adjustable to transmit at any frequency between 88 and 108 MHz.



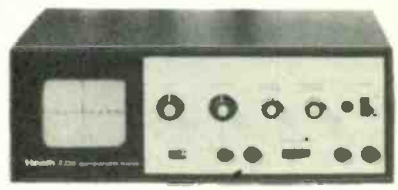
CIRCLE 722 ON FREE INFORMATION CARD

The unit has application in situations where a person must talk while walking about or gesturing, unencumbered by trailing cables. Some applications include schools, churches, outdoor field trips, organization meeting halls, or auctions.

The AT8550 measures .79 inches in diameter by 2.9-inches long and weighs 1.4 ounces. The transmitter is powered by a small mercury cell similar to those used in hearing aids. It features an on-off switch and a quick-disconnect lock release. A flexible 32½-inch antenna trails from the bottom end of the device. The nationally advertised price of the Model AT8550 is $34.95. For more information, write Audio-Technica U. S. Inc., 1221 Commerce Drive, Stow, OH 44224.

Component Tracer

The Heathkit troubleshooting test instrument, the IT-2232 Component Tracer, allows a user to test individual components or entire circuits without the need of circuit power. On a 3-inch CRT, the Tracer displays the electrical characteristics of a component or a circuit under test. Dual displays allow comparisons between good and suspect devices for quick, easy and reliable checks. Two voltage ranges are provided for varying test situations and are current limited to protect the circuit or component under test.



CIRCLE 730 ON FREE INFORMATION CARD

(Continued on page 6)

NEW PRODUCTS

(Continued from page 3)

The IT-2232 Component Tracer features two separate inputs that can be viewed as individual traces or together in a superimposed display. One channel is seen as a solid line, while the second is converted into a unique dotted-line display. In the A/B mode of operation, the superimposed solid- and dotted-line traces allow the user to compare good and suspect units. Any differences in electrical characteristics are clearly identified providing a visual check of the condition of a circuit.

The IT-2232 is a self-contained unit that offers means to service many types of components and circuits, especially digital and microprocessor-based products. It produces triangular signals that are amplified and passed through attenuators. The attenuators provide selectable test voltages of 50 volts peak-to-peak or 5 volts peak-to-peak at the two test jacks. When

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NEW PRODUCTS

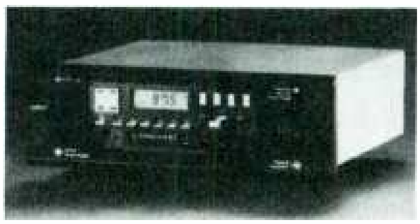
the Tracer is connected to a circuit or component, the triangular voltage waveform is changed by a resulting loading effect. The result is a visual display of the dynamic condition of the component or circuit under test.

The IT-2232 Component Tracer operates on 120/240 VAC at 50/60 Hz at 22 watts. Two sets of color-coded test leads are supplied. The unit measures 4- high × 10- wide × 12½-inch deep and weighs 8.4 pounds.

More information about the IT-2232 Component Tracer, and other quality test instruments, can be found in Heathkit's *free* catalog. Write to Heath Company, Dept. 150-305, Benton Harbor, MI 49022. In Canada, write to Heath Company, 1020 Islington Ave., Dept. 3100, Toronto, Ontario, M8Z 5Z3, Free catalogs are also available at 65 Heathkit Electronic Centers in the U.S. and Canada.

FM Noise Reduction In Car Stereo

Concord's new HPL-520 tuner/amplifier/tape deck with 4-gang FM digital synthesized quartz tuner, features FNR, a new, noise-reduction system that reduces multi-path interference and other FM noise problems inherent in high-sensitivity automotive radios. Audiophiles know that a highly sensitive, wide-band receiver will pick up more FM multi-path interference when the vehicle moves from one type of reception area to another.



CIRCLE 720 ON FREE INFORMATION CARD

Now, without sacrificing maximum FM sensitivity and wide-band reception of strong signals, the operator can greatly reduce FM interference of weak signals by engaging the FNR switch on the Concord HRL-520 receiver.

The Concord HPL-520 also features LCD, liquid-crystal display readouts, Dolby B and C, low-level, front-back fader, 6 AM- and 6 FM-preset stations, autoscan tuning, 2 pairs of line output connectors, matched-phase tape head, metal-tape equalization, DC servo tape drive motor, illuminated switches, and cassette door.

The HPL-520 power output: 25-watts per channel maximum, 12-watts-per-channel high-fidelity rating from 20-20,000 Hz into 4 ohms with less than 0.8% THD. Only 4 ¾-inch deep (fits nearly all cars). Suggested retail price range is $399.00 to $449.00. For additional information, contact Concord Systems Inc., 6025 Yolanda Ave., Tarzana, CA 91356.

Functional Amps

The Mini-Master Series V Models AM251A and AM252A are mixer/power amplifiers at 10-watts and 20-watts output, each in an economical, compact 3½ × 8½-inch package. Each amplifier has two inputs, one fixed high level (music), one microphone, capable of high-Z unbalanced, low-Z unbalanced, or low-Z balanced by adding the TF401 transformer and tone control to adjust the high frequency signals up to 15 dB. Mini-master amplifiers are truly professional and functional in appearance, being desk or rack mountable. They are versatile and easy to operate, with all controls conveniently located on the front panel and all connections made to the rear panel. Due to the compact half-rack width design two

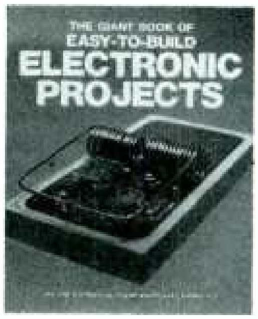
(Continued on page 11)

THE BOOKSHELF

READING ADDS TO YOUR BASIC KNOWLEDGE

The Giant Book of Easy-to-Build Electronic Projects
by the Editors of Elementary Electronics

Here's a text packed with unique and useful electronic devices that you can build in only a few hours time and from readily available, low-cost components!



Detailed illustrations, clear schematics, printed-circuit board templates and easy-to-follow parts lists make construction a snap! The project lineup includes very simple circuits for first-time project builders, as well as exciting, state-of-the-art devices for more experienced hobbyists!

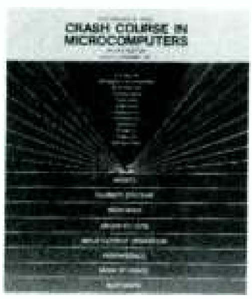
Here's a peek at what you can build from the plans: A smart power supply that automatically keeps tabs on current and voltage levels; backyard weather observatory using a make-it-yourself electronic rain gauge to measure precipitation, and a touch-and-dim light controller in your home that you can build yourself with just two IC's and a handful of low-cost components!

All of the projects contained in the text were acquired and prepared for publication to some degree by the Editor of **Hands-on Electronics**, who was formally the Editor-in-Chief of *Elementary Electronics* magazine.

Tab Books Inc., Blue Ridge Summit, PA 17214. Paperback, 346 pages, $13.50.

Crash Course In Microcomputers
by Louis E. Frenzel, Jr.

The revised Second Edition of *Crash Course in Microcomputers* is one of the most popular books on microcomputers. Because of its unique, highly palatable format and its relevant content, *Crash Course in Microcomputers* can give you a fast, but thorough introduction, to the exciting world of µP's.



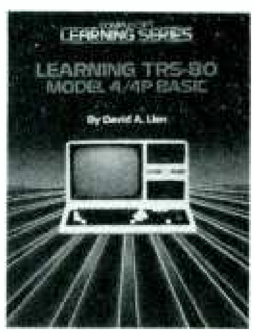
So many microcomputer books tell you more than you really want or need to know. The *Crash Course* tells you what you need to know in an efficient and interesting manner.

In response to reader feedback on the First Edition, as well as recent development and important technological changes, the Second Edition of the text has been extensively revised and updated. All chapters have been edited to reflect the latest technical developments and new-product introductions. Further, several new chapters have been added, expanding the coverage of BASIC programming 16-bit microprocessors, and applications. Unit-14 is a new chapter that picks up where Unit 13 on BASIC programming leaves off. It introduces new statements and commands plus useful programming techniques for those who want to learn to write their own programs.

Howard W. Sams & Co., Inc. 4300 West 62nd Street, Indianapolis, ID 46268. Soft cover with plastic-ring binding, 318 pages, $21.95.

Learning TRS-80 Model 4/4P BASIC
by David A. Lien

There are 50 big reasons why *Learning TRS-80 Model 4/4P BASIC* is the book that you buy right after you acquire the TRS-80 *Model 4*—because there are 50 chapters that teach you how to use the many capabilities of your new computer. Each chapter

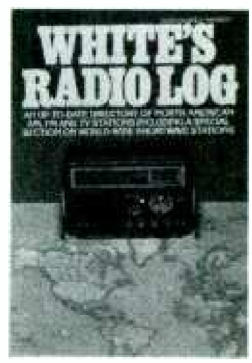


is in a small bite of knowledge so that you won't choke during the learning process. Questions at the end of each chapter permit the reader to review the ground covered. A section is provided with some user BASIC programs, some of which are novel.

CompuSoft Publishing, a Division of CompuSoft, Inc., 535 Broadway, El Cajon, CA 92021. Paperback, 483 pages, $11.95.

Broadcast Listener's Bible

It has been a good many moons since *White's Radio Log* has been published. And, now that it has, pick up your copy soon, for the supply is less than ample. That all inclusive up-to-date directory of North American AM, FM, and TV stations is the oldest publication of its kind. It



started back in 1924 when Charles DeWitt White published his first radio log book. Mr. White had it easy in those days. There were only a few stations on the air—about 700 and all were AM types. In the early issues, White listed stations three times, by call-sign, frequency and location. The practice continues till today with bonuses of FM and

BOOKSHELF

TV stations making the list.

Talking about a bonus, in recent times, worldwide shortwave broadcast-station listings were included. Although not complete—that's near impossible—the shortwave stations listed are those that can be heard in North America. Thus, in one issue, several hobby groups are provided with a reference work that cannot be purchased anywhere else in one volume at so low a price. You can obtain you copy of *White's Radio Log* by writing to Worldwide Publications, Inc., P.O. Box 5206, North Branch, NJ 08876. The price is $4.95 and include 50 cents for postage on orders of one to ten copies. New Jersey residents add sales tax.

The Future of Videotext by Efrem Sigel

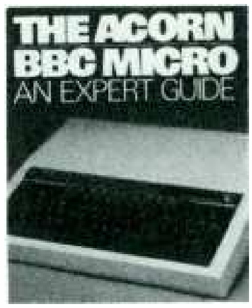
Since 1970, such companies as AT&T, CBS, and Time, Inc. have invested hundreds of millions of dollars on research in video technology. Will videotext—a service in which words, numbers, and pictures appear on a TV screen at the touch of a button—revolutionize communication on a global

scale? Will it become a commercial success? Or will it prove too expensive and difficult to use for all but the most specialized purposes? *The Future of Videotext* addresses those and other issues so that you—the business person or consumer—will know about the possible impact of videotext on daily life. That up-to-the-minute survey examines the enormous potential (and persistent problems) of video technology. It suggests clear and original solutions that could make videotext as popular as the telephone.

Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Paperback, 195 pages, $9.95.

The Acorn BBC Micro—an Expert Guide by Mike James

The amazing Acorn/BBC microcomputer is exploding into American schools and homes—and no wonder! Its special 6502 chip produces a super-speedy memory, a



huge ROM storage capacity, a vivid video display, a music synthesizer...and so much more. But you don't have to be an expert to make the most of that expert design. Now the text gives you an in-depth, yet easy-to-understand, introduction to the computer's advanced hardware and software features. So you can really go nuts with your Acorn!

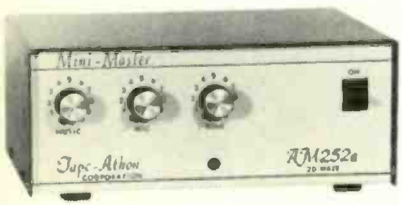
The *Expert Guide* gives you an inside view of how the machine works, including an explanation of its operating system and the types of interfacing you can use with it. By revealing the sophisticated quirks of its graphics- and sound-generating systems, it teaches you how to tap their maximum potential. It introduces you to the two levels of programming language you'll need to run the machine: BBC BASIC and BBC assembly language.

Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632. Paperback, 158 pages, $14.95. ■

NEW PRODUCTS

(Continued from page 7)

Mini-master amplifiers may be mounted side-by-side in only one rack space. Level and tone controls are available with exterior knobs or screwdriver adjustable con-



CIRCLE 728 ON
FREE INFORMATION CARD

trols. Microphone and mute connections are on screw terminals as is the output connector. Music (high level) input uses phono jack. Output impedance is 4 and 8 ohms, 25 and 70 volts, with output overload protection both electronic and thermal. The Model AM251A is priced at $190.00 and the Model AM252A at $215.00. For additional information, write Tape-Athon, 502 S. Isis Ave., P. O. Box 6814, Inglewood, CA 90312-6814.

30-Channel Programmable Scanner

Regency Electronics, Inc. now offers a selection from more than 15,000 frequencies in six bands in a 30-channel programmable scanner. Its American technology incorporates a novel memory-backup system that needs no batteries, yet maintains its programming for up to a week during power outage or storage. The Regency D310 30-Channel Programmable Scanner is available for $249.95 (suggested US resale) at participating Regency Electronics dealers.

CIRCLE 723 ON
FREE INFORMATION CARD

The Regency D310 requires no added crystals, yet covers six bands: low and high VHF (30-50 and 148-174 MHz), UHF (450-470 MHz), UHF "T"(470-512 MHz) and two FM Ham bands (144-148 and 440-450 MHz). Programming its 30 channels is simplified by plain-language prompts that appear on its display to identify the action in process or required next.

A search feature automatically searches through every frequency (stopping every 5 KHz on VHF, every 12.5 KHz on UHF) until it finds one that's active. Scan delay holds the channels open for approximately two seconds at the end of a transmission, to wait for any reply; without scan delay, scanning resumes in about six-tenths of a second.

The D310's design features a slanted keyboard, rotary on-off/volume and squelch controls and a highly-legible fluorescent digital display. Its audio amplifier delivers one watt, and a jack for an external speaker is provided. It includes a telescoping antenna that has been electronically optimized for each band, and an antenna jack is provided for using an optional external antenna.

Dual built-in power supplies permit plug-in AC operation at home or 12-VDC operation in a vehicle (where not prohibited by law). The D310 is UL listed and FCC certified (Part 15, Subpart C). It measures 10⅓ W × 3⅓ H × 7 inches D. For additional information contact Regency Electronics, Inc. 7707 Records St., Indianapolis, IN 46226-9989; (317)545-4281.

Professional Microphone

Crown International's Model 12 SP microphone offers studio quality in recording, sound reinforcement, broadcasting and electronic news gathering for

CIRCLE 725 ON
FREE INFORMATION CARD

the experienced professional. The 12 SP is phantom powered by a supply providing 18 to 48 volts. It features a transformer balanced, low-impedence output available at an integral 3-pin connector; wide, smooth frequency response with high-frequency emphasis for brilliance; low noise and high overload level (150 dB-SPL); a hemispherical pickup pattern; high sensitivity and excellent reach for clear pickup of distant sounds.

In operation, the ruggedly constructed 12 SP can be placed on a surface such as a floor, table, or lectern; used as a handheld microphone; or affixed to a surface near a sound source such as the underside of a raised grand piano lid. Suggested retail price is $245.00. Get all the facts direct from Crown International, 1718 West Mishawaka Road, Elkhart, IN 46517 USA; tel. 219/294-5571.

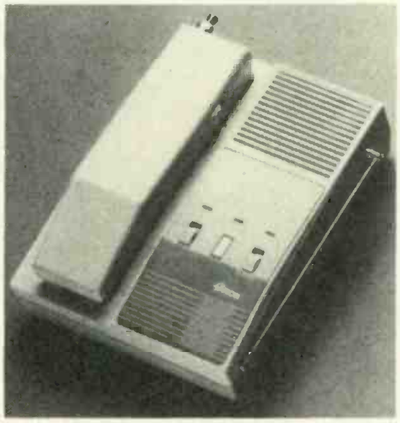
(Continued on page 12)

NEW PRODUCTS

(Continued from page 11)

Cordless Phones

Cordless telephones, Model FCT-246, Model FCT-266, and Model FCT-346 (shown in photo) all feature circuitry that provides security against unauthorized



CIRCLE 736 ON FREE INFORMATION CARD

use, and eliminates interference and false ringing. The three models also feature selectable guardtone frequencies and a handset that operates at the maximum range allowed by the Federal Communications Commission, up to 1500 feet.

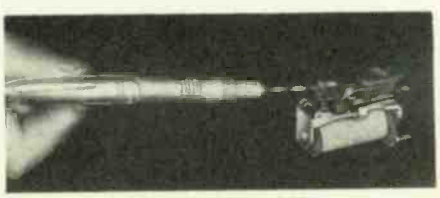
Model FCT-246 features a 3-position sentry switch, touch-button dialing, last-number redial, and paging from the base to the handset. It is priced at $129.95.

Model FCT-266 adds selectable pulse or tone dialing to provide access to long-distance networks, such as MCI, SPRINT, etc. It is priced at $149.95.

Model FCT-346 features continuous monitor digital-security coding to guard against unauthorized use and false ringing, and a range selector for choosing normal or extended range. Pulse or tone dialing allows for access to long-distance networks, and two-way intercom between the cordless handset, and a conventional handset plugged into the base is featured. Write direct to Fanon, 15300 San Fernando Mission Blvd, Mission Hills, CA 91345.

Contact Burnishers

The P-4 and P-6 Contact Burnishers are pocket-pen type burnisher/cleaners for



CIRCLE 731 ON FREE INFORMATION CARD

the communications, telephone, and electronics industries. They are designed for all-type contacts; silver, platinum, gold, palladium, tungsten, molybdenum, and all other precious-metal contacts. The burnishers are light, and the flexibility of the blades can be adjusted by varying their depth in the chuck.

The burnishers are non-residual, leaving no grit or dust on the contact. Their insulated caps permit working on *live* contacts. They have interchangeable blades made of stainless steel, with an abrasive coating of aluminum oxide that insures minimum contact wear.

The burnishers are 5½ inches in length, ⅜-inch in diameter, and are available in two types. The P-6 pen has 12 blades 3.16-inches wide, 1¾ inches long, and .007 inch thick for fine contacts and relays. The P-4 pen also has 12 blades, and is ¼-inch-wide, 1¼-inches long, and .007-inch thick for industrial contacts and relays. Both are priced at $5.70 each--Jonard Industries Corp., Precision Tools Division, 134 Marbledale Road, Tuckahoe, NY 10707.

Multimeter

The B&K Precision Multimeter, Model 2804, is a 3-12-digit auto/manual, hand-held digital multimeter featuring 0.7%-volt DC accuracy; diode test; audible-continuity check, and 10-amp current range. DC-voltage ranges are .200, 2.0, 20, 200, and 1000. VAC voltage ranges are 2, 20, 200 and 750. Input impedance is 10

CIRCLE 732 ON FREE INFORMATION CARD

Megohms. Resistance ranges are 200 Kilohms, 2000 Kilohms and 20 Megohms. DC and AC current ranges are 200 mA and 10A.

The diode test measures the forward voltage drop of a semiconductor junction at 0.6 mA, continuity checks are done through audible tones. Model 2804 is priced at $60.00, includes two AA batteries, and an instruction manual. Contact B&K-Precision Dynascan Corporation, 6460 West Cortland Street, Chicago, IL 60635. ■

ON DX'ING

JENSEN

Reference Books That Make Hobbying Easier

BASED ON OUR MAIL, YOU READERS have a case of *wherejas*!

But it's nothing to worry about; it's perfectly natural. In fact, it's one of the reasons I'm here every issue, to try to give you a hand with some of your questions about DX listening, most of which begin with the *wherejas*.

Taking more pains with my pronunciation, it should come out as "where do you," as in, "Where do you get this or that bit of information."

There are lots of questions. And you find the answers in reference sources that you may want to add to your hobby library.

For the shortwave listener, one all-around, useful, information source is the *World Radio TV Handbook*. It is a volume so basic that SWL's refer to it as the *listener's bible*. WRTH, as it is known to many SWL's, is published annually, and its 38th edition was published this year.

It is a 600-page comprehensive listing, country-by-country, of stations, frequencies, times, languages, leading personalities and addresses. There also is data on international medium and long wave stations, plus FM and TV information. WRTH also has special feature articles, perhaps the most useful of which deal with reviews of shortwave radio receivers.

There are a number of sources for the current WRTH. One that we've found to be reliable is Gilfer Associates Inc., P.O. Box 239, Park Ridge, NJ 07656. It sells for $17.50, plus $1.50 shipping and handling.

QSLs—cards and letters of verifiction sent by many shortwave stations in response to listener's reports of reception—are fun to collect. They are tangible evidence of one's loggings. But, to send a report to a station, you have to know the address. Sure, often they're announced by stations seeking listener mail. But many times you miss the address, or the station doesn't announce it. What then? One source of station addresses for shortwave broadcasters is the WRTH.

Another source is the *QSL Address Book*, which also gives some handy tips on how to get those verification replies. The book contains data on more than 950 stations from 180-plus countries. It also is available from Gilfer Associates for $6.95, plus $1.50 shipping and handling.

The radio scene is rapidly changing. Schedules and frequencies change with the season and, in fact, often even more frequently. Thus, a good list of stations, frequencies, and schedules is a must for SWLs. So, here we go with a few nifties!

Radio Database International, P.O. Box 300, Penn's Park, PA 18943, has an attractive graphic presentation that shows at a glance such useful bits of information about shortwave stations as frequency, languages used, schedule times, transmitter powers, target areas, etc.

On the market now is a *RDI Tropical Bands Edition*, which covers the lower shortwave frequencies up to about 5,600 kHz. It is available postpaid for $3.95.

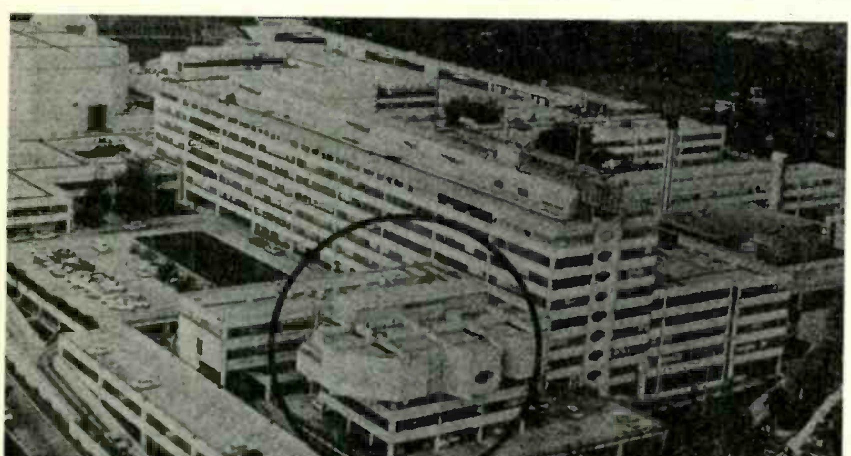
Scheduled for release during the summer was a new Radio Database International volume covering the remainder of the shortwave spectrum, above 5,700 kHz. As a bonus, it was to contain the receiver reviews of Larry Magne, well-known to readers of the WRTH and to listeners to *Radio Canada International*'s Shortwave Listeners Digest program. The new RDI volume, as of this writing, was scheduled to sell for $9.95, plus $1.85 postage and handling.

Interested only in English language SW programs? Dan Ferguson, P.O. Box 8452, South Charleston WV 25303, issues a computer-compiled *Guide to English Shortwave Broadcasts* six times a year, for $3 per issue, or $15 for a yearly subscription.

For general background information, there are a number of data sources. One I can recommend as a quick, easily understood overview of the hobby and SW is the *Electra Shortwave Booklet*. It has the advantage of being in summary form (just eight pages), and it is *free*! Write to Electra Shortwave Booklet, 300 East County Line Road, Cumberland, IN 46229.

A fuller explanation on many aspects of

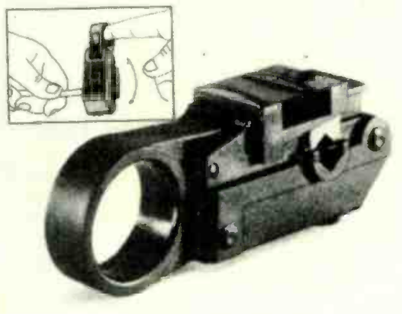
(Continued on page 97)



BOB ZANOTTI's voice is widely known to shortwave listeners around the world. You can hear Bob on the *Swiss Shortwave Merry-Go-Round DX* program on the second and fourth Saturdays of the month on *Swiss Radio International*.

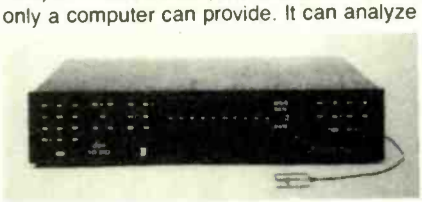
NEW PRODUCT

COAX STRIPPER, No. *70374,* has a holding-ring design that allows the user to strip coax cable with minimum effort. With one's finger in the holding ring, one simply inserts the wire and rotates the tool. It is designed to strip cleanly all of the five most popular sizes of coax cable; RG-6, RG-8, RG-9, RG-174, and RG-182. The stripping blades can be adjusted easily for different cutting depths to meet the user's specifications, and the tool can be set to perform both two- and three-level strips. A 2-bladed replacement blade cassette for the stripper is available. The No. *70374* is priced at $45.90 — **Vaco Products Company,** 1510 Skokie Blvd., Northbrook, IL 60062.



CIRCLE 733 ON FREE INFORMATION CARD

EQUALIZER/ANALYZER, the model *dbx 10/20,* enables automatic equalization to be achieved individually for left and right channels, or in combination, with the accuracy that only a computer can provide. It can analyze as many as 10 locations within a room and then automatically adjust equalization for flat response. The proper equalization setting within a room can be accomplished in seconds, automatically and accurately.

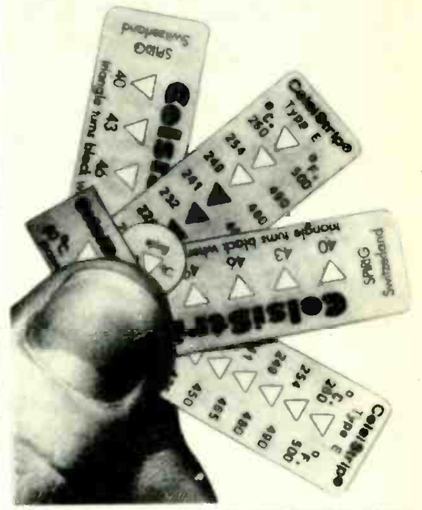


CIRCLE 734 ON FREE INFORMATION CARD

Digitally controlled, the model *dbx 10/20,* with its calibrated microphone and built-in pink-noise generator, can automatically "voice" a room and store as well as recall the equalization settings. Its real-time analyzer function, which also serves as a sound-level meter, provides information on the music energy in each frequency band. A display of 275 LED's shows the functioning of the real-time analyzer by providing an instantaneous read-out of musical content in each frequency band. It can also display any equalization curve stored in memory.

The model *dbx 10/20* has a suggested retail price of $1200.00.—**dbx Incorporated,** 71 Chapel Street, Newton, MA 02195.

TEMPERATURE INDICATORS offer precise, positive, visual proof that a specific temperature has been exceeded, particularly in inaccessible, hazardous areas. When applied to any piece of equipment, the one-shot, irreversible indicators record and document operating temperatures: The sensitive white triangle turns irreversibly black when the surface temperature reaches the particular triangle's temperature level.



CIRCLE 735 ON FREE INFORMATION CARD

They are available in three configurations: *CelsiStrip,* 5 or 8 multiple-sequenced temperature increments, printed in C° and F°; *CelsiDot* labels, single temperature dots in 40 different temperature levels, printed in C° and F°; and *CelsiPoint* labels, single temperature dots in 40 various temperature levels from 40°C to 260°C (105°F to 500°F).

The labels are self-adhesive and adhere to any dry surface. They measure 0.3 mm thick.

The temperature indicators are available in booklets, each with identical rated labels, and can cost less than 10 cents each in large quantities.—**Solder Absorbing Technology,** a Spirig Company, South End Bridge Circle, Agawam, MA 01001.

POWER SUPPLY, model *PS-101,* is triple-regulated and is designed for the hobbyist, student, and lab technician. It features three completely independent supplies. Those power supplies can be either positive or negative; they can be stacked in series so that a 5-volt and two 15-volt supplies can total 35-volts DC, or any combination of the three, resulting in a fully adjustable 0- to 35-volt DC power supply.

CIRCLE 737 ON FREE INFORMATION CARD

The model *PS-101* has a suggested retail price of $119.00.—**E.W. Engineering, Inc.,** PO Box 624, Old Lyme, CT 06371. ■

LETTERS

After Footprint

I am learning much about satellite communications, but every so often I run up against a technical term I don't know about, and no one can tell me for sure what it is. I know what footprint (please, no jokes) is, but what is boresight point?
E. N., Salina, KA

Who jokes about these things? The strength of a downlink signal can be measured on the surface of the earth (that's where the big dishes are) and plotted. Such a diagram is called a footprint. Ideally, that footprint would be a series of concentric circles had the transponder been beamed straight down on a perfectly spherical surface. However, the satellite's antenna is shaped so that most of the power radiated will fall on a selected land area (that's where the big dishes are) on the North American continent. The center of that footprint pattern is where the power received from the satellite is maximum, and that is called the boresight point. In the ideal case described above, the boresight point would be in the center of those circles. The footprint is positioned over a maximum population area (that's where the big dishes are) to serve the largest possible audience (that's where the most money is).

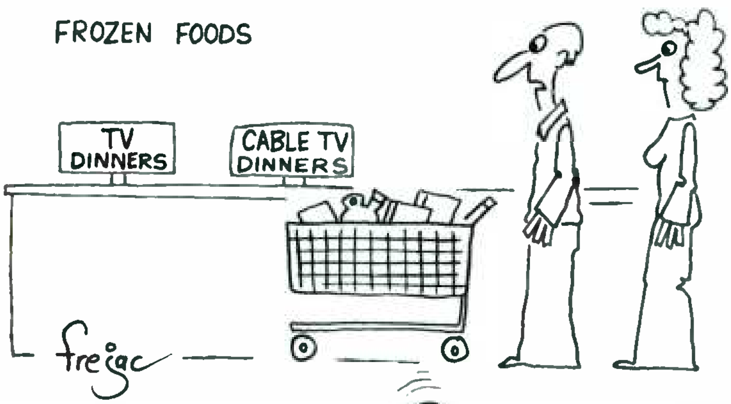
Hearing Saved

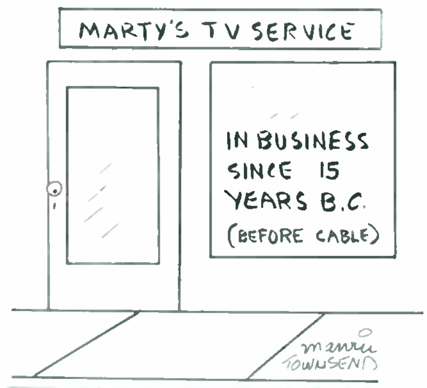
My kids are rock fans, and always have the music blasting. Threats, pleas, all were to no avail until I built the Sound Pressure Monitor described in your last issue. I explained it to them, showed them the "Danger" chart, and took the unit into their room the next time they had the music up. It made an impression, because now it was an objective, mechanical object telling them to turn the sound down—Not just good ol' Dad! It worked, too. Now I'd like to know how

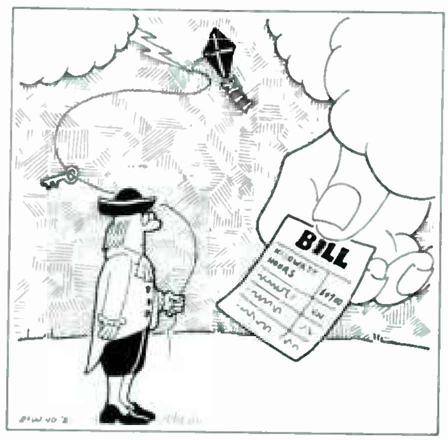
(Continued on page 20)

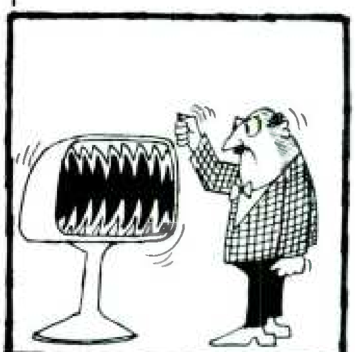
Some Silent Chuckles

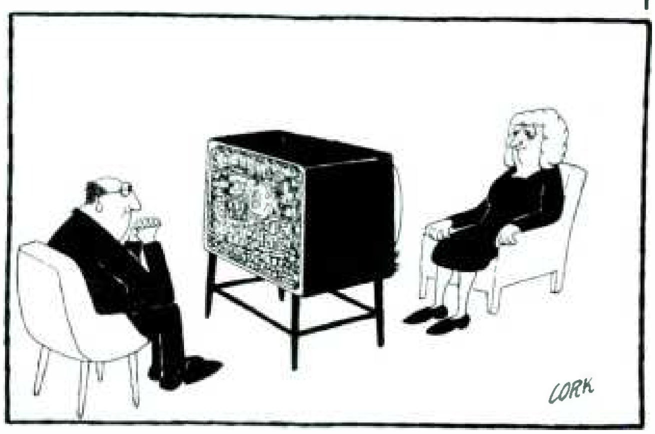
by Cork, Frejac, Redding, Isler & Townsend











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LETTERS

(Continued from page 15)

to fudge the unit to give a "danger" warning, even when the music is moderate, so I can get them to turn it down even more, even if it's really in a safe level. Can we do that?
F. R., Pompano Beach, FL

The best way to fudge the unit is with calibration potentiometer R6. Play with that for awhile, and tell us if it helps. Glad the Sound Pressure Monitor is bringing some peace and quiet to your home!

Look Up to the Heavens

How do I go about measuring the polar angle as I install my satellite anenna?
K.S., Mitchel, SD

There are all sorts of gadgets you could make, but the best method is to sight along the polar axis of your antenna to the North Star on a clear night. That should put you 99-44/100% on target. In essence, what you are doing is making the antenna polar axis parallel to the earth's rotational (polar) axis. From that point on, adjustment is a snap.

Great Caesar's Ghost

I've been having a lot of fun with the "Caeser's Clock" project that I built as described in your last issue. In fact, there have been so many laughs as a result, that I felt I ought to share them with you.

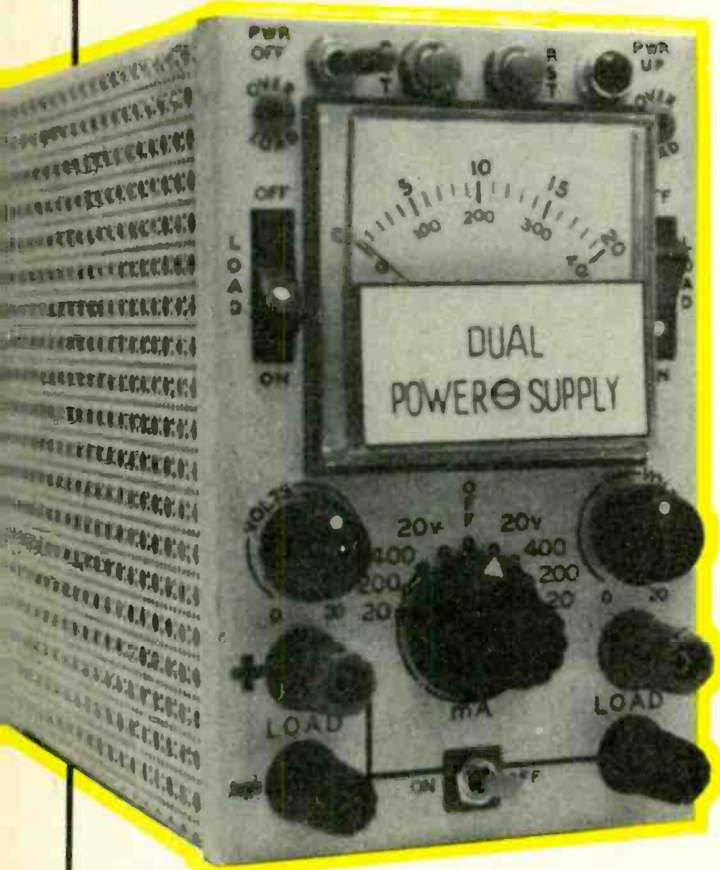
People look at the unit, and ask what it is, and I explain, with as straight a face as I can muster, that it's an antique, found in the ruins of Pompei, and that it gives the time in Roman numerals, just the way that Caeser read the time. The reaction of people is really funny. It doesn't occur to them, at first, that the ancient Romans didn't have electricity, or digital fluorescent readouts. They puzzle over the time for a moment or two, and it isn't usually until much later that the light dawns and they realize that they've been had! I originally built the project because like you, I thought it would be an interesting novelty. I never realized how much fun I'd be having with it.
J. S., Pierre, SD

Now that's funny! It just shows how gullible some people can be, and we're glad that you've found another source of interest and amusement with the project. We'll make sure that the author hears about it, too.

Human Radio Receiver

I've been hearing radio signals in my head, and a friend told me that it could

(Continued on page 99)



DUAL POWER SUPPLY

By John T. Bailey

Here is a design procedure for constructing a bench-top power supply which is adjustable down to zero volts without loss of regulation and that has a snap-action, current-overload protection circuit!

MY VENERABLE HOMEBREW VARIABLE POWER SUPPLY WAS typical of those in common use during the past ten years. It used the popular LM723 voltage regulator with an external pass transistor for higher-output current. The circuit was conventional, as recommended by the manufacturers of the LM723. However, for my applications, it has two characteristics that I wanted to improve. First, the output-voltage lower limit was about 2 volts; and, second, the over-current *shutdown circuit* was *soft*. That is, as the over-current, trip-set point was approached, the regulation began to suffer. So, what is an experimenter to do? As I did—come up with a design that overcomes those two deficiencies. I called my project the Dual Power Supply. The title may not be original, but the circuit application sure is!

I have chosen a 0- to 20-volt, 400-mA, maximum-design objective to illustrate the design procedure I used. Also, I have furnished the essential calculations to permit design of other output ratings to suit output specifications of different values.

Zero Output

Quite a few circuits for adjusting the output of a regulated power supply down to zero volts are to be found in current technical literature. Some circuits are simple, some quite complex. The simple ones that I tried did permit reduction down to zero-volts output but, surprisingly with some, regulation fell off badly as zero was approached. Then, in Hewlett-Packard's *DC Power Supply Handbook, 1970* I found the answer in principle, but without component values. Basically, H-P's circuit uses a floating reference voltage, referenced to the positive-output terminal rather than to ground. Figure 1 is a block diagram of the circuit. The output voltage is determined by:

(Eq. 1) $$E_O = V_{ref} \times (R2 \div R1).$$

When R2 is 10,000 ohms,

$$E_O = 6 \times (10{,}000 \div 3000)$$
$$E_O = 20\text{-volts DC}.$$

When R2 is 0-ohms,

$$E_O = 6 \times (0 \div 3000) = 0 \text{ volts}.$$

Potentiometer R2 has a linear taper; thus, the output will be a linear function of the rotation of R2. However, an audio taper for R2 provides a much better adjustment of output voltages near zero. Remember, that your eye is on the voltmeter scale when adjustments are made, and that no front-

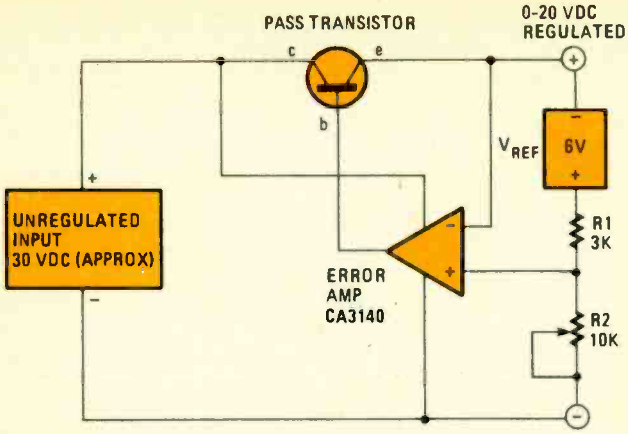


FIG. 1—SIMPLIFIED BLOCK DIAGRAM for one section of the Dual Power Supply. Not shown is the current-sensing resistor and circuitry that eliminates current-overload.

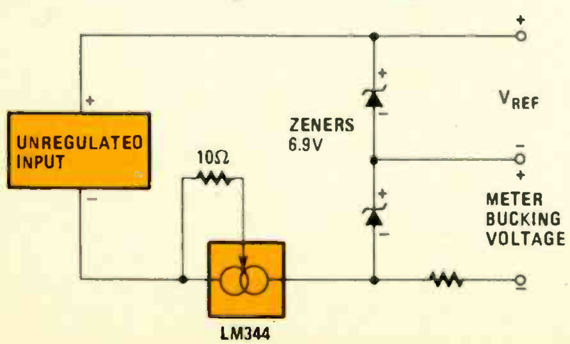
TABLE 1—VOLTAGE CHECK POINTS

Load Conditions (Trip set point = 400 mA)			
No Load	About to Trip	Tripped	
Volts DC to Common from:			Fig. 3
29.9	27.0	29.4	A
18.53	18.27	18.53	B
4.40	4.02	4.37	C
4.06	4.00	4.06	D
−.0157	−.0455	−.0512	E
mA through R10			
14.3	41.4	46.5	

panel scale for the regulated output control is required.

Note that a zero-ohms, terminal resistance of R2 (Fig. 1) is required, theoretically, in order to obtain zero-volt output. I found that different makes of potentiometers varied considerably in their minimum resistances; some were as large as 100 ohms. I used a Mallory U18 Midgetrol 10,000-ohm, #1 taper (audio) potentiometer, which had a 4-ohm minimum resistance. Compensation for that small, minimum-resistance value is possible and shall be explained later.

FIG. 2—VOLTAGE-REFERENCE Zener diodes are fired by a constant current source, practically eliminating voltage variance due to line-voltage and load outrages.



In case you want a different maximum output voltage, merely use different values of reference voltage and/or R1 as necessary to satisfy Equation 1. If R2's maximum resistance is a little greater than 10,000-ohms, it can be shunted to reduce it to 10,000-ohms, or you may prefer to leave it unshunted and get a little more than a 20-volts, maximum output. If R2 is less than 10,000-ohms, change R1 to an appropriate lower value to satisfy Equation 1. Of course, a substantial change in the output will require a change in the value of the unregulated input voltage.

For the 20-volt maximum output voltage, I used a no-load, 30-volt unregulated input. That gave me a satisfactory input-output differential to take care of line voltage changes and voltage drops in current-sensing resistors not shown in Fig. 1. A nominal 20-volt AC, secondary-winding in the power transformer (actually 21 volts under no load) produced an input of just under 30-volts DC after bridge rectification.

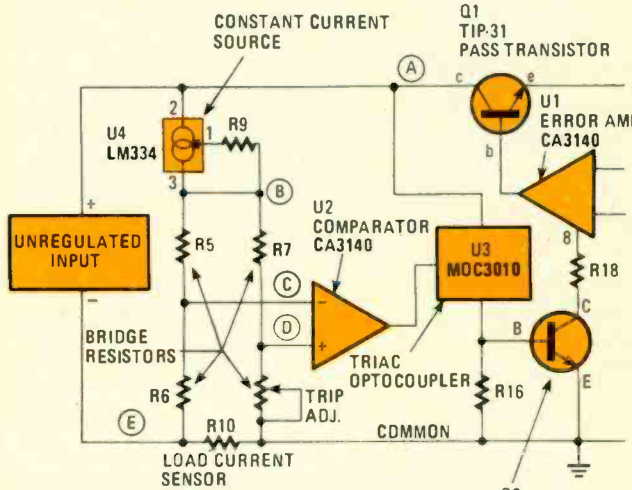


FIG. 3—A BRIDGE NETWORK detects excessive-current across R10 and controls the voltage comparator U2.

It is interesting to note here that the CA3140 op amp used in this circuit (Fig. 1) takes its supply voltage from the unregulated input and that its maximum supply rating is 44-volts DC. That's plenty of latitude! Hence, if the input voltage is increased to more than, say, 40-volts DC to get more than a 20-volt DC output, a resistance divider should be used to maintain the CA3140 op amp DC supply within its maximum rating. Also, if that is done, a pass transistor of a higher wattage rating will be required. The heat dissipation of the pass transistor is greatest at zero output voltage and is equal to the voltage at the collector multiplied by the maximum load current.

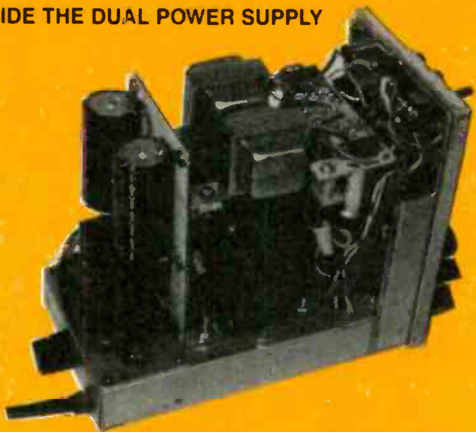
Reference Voltage

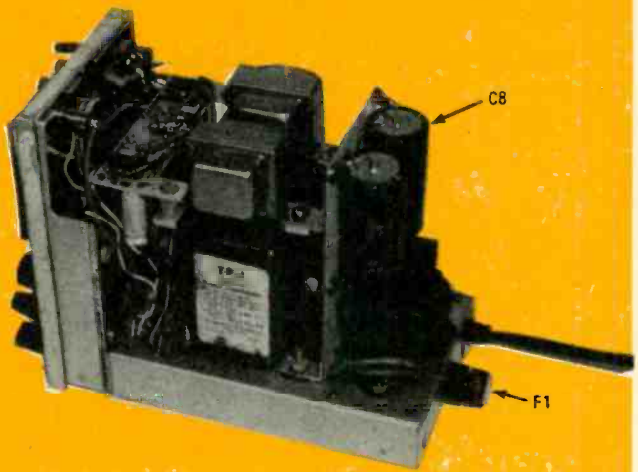
As with all other circuits using reference voltages, the quality of the reference is a major factor in determining overall performance of a regulated supply; regulation will be degraded if the reference is not steady. I used Zener diodes under constant-current bias for my reference voltage as shown in Fig. 2. The LM334 is the constant-current source, set to 6.8 mA by the 10-ohm resistor. The formula for constant current using the LM334 is:

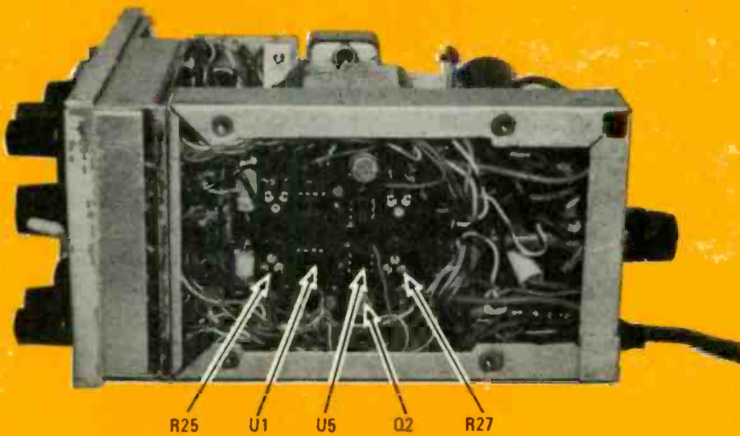
$$I = 67.7 \div R$$
$$I = 67.7 \div 10 = 6.8$$

where I is given in milliAmperes.

INSIDE THE DUAL POWER SUPPLY







THREE VIEWS of the author's Dual Power Supply are shown here. A quick inspection will reveal the dual nature of the project by the duplication of identical parts almost as mirror images in many instances. Author compacted the parts within, and on, a small chassis to reduce bench-top space. The two small transformers were connected to provide transformer T2 shown in Fig. 4. That proves the power of the junkbox! You may want to package the Dual Power Supply in a larger cabinet, or install it under your workbench as a built-in supply where there's plenty of space.

Constant current operation improves the Zener diodes' stability and minimizes the adverse effect of varying input voltages applied due to change in line voltage. The function of the meter-bucking Zener diode will be explained later. Note that the reference voltage indicated in Fig. 2 is 6.9 volts, whereas it is shown as 6 volts in Fig. 1. That is due to my 10,000-ohm potentiometer having only a 9,000-ohm maximum resistance, which compensation was provided by increasing the reference voltage to 6.9 volts DC.

Over-Current Shutdown

The conventional *shutdown* circuit for protection against excessive-output current, or accidental load short circuits, uses a shutdown transistor, which removes the base current to the pass transistor when the voltage across a current-sensing resistor turns the shutdown transistor *on*. That scheme works, but it doesn't provide snap-action turn-on of the transistor. Hence, as the load current approaches the base turn-on voltage of the shutdown transistor, regulation of the power supply begins to fall off. What I desired was a snap-action shutdown circuit that would maintain regulation right up to the over-current set point, and would hold the supply voltage off until the overload is removed. Also, I wanted both the output voltage and current to drop to zero on shutdown.

By using a comparator driving a Triac optocoupler, my shutdown objectives are easily achieved. Figure 3 shows the basic shutdown circuit.

A resistive-bridge arrangement, with an adjustable circuit in one arm, feeds a differential voltage to the comparator, which trips when the voltage drop across the current-sensing resistor reaches the trip value. The comparator output pulses the optocoupler's internal LED on momentarily, the optocoupler's Triac turns on, and, via a switching transistor, takes the error amplifier's shutdown pin to a low state. That action removes any base current to the pass transistor so that the supply's output voltage and current both fall to zero, and stay there until the overload is corrected and the reset button is activated.

Table 1 shows the voltages measured in the snap-action over-current circuitry of Fig. 3 under three conditions: (1) No load, (2) full load just before tripping, and (3) after tripping. Just before tripping, the bridge arm voltage to the comparator's inverting input (C in Fig. 3) is slightly larger than voltage D applied to the comparator's non-inverting input. When the trip-value current of 400 mA is exceeded, the comparator output goes high to about 25 volts. That voltage, via R15 (refer to Figs. 3 and 4), causes the internal LED of U3 to illuminate the Triac in U3, which then turns on, permitting about 32 mA to flow from the unregulated input point through the shunted trip indicators, D13, R14, the saturated Triac, and R16. The drop across R16 turns Q2 on via R17, thus grounding R18. Hence, pin 8 of U1 is taken low via R18 and base drive to Q1 is removed. That action reduces the output voltage and current to zero. Of course, with the load current reduced to zero the voltage drop across R10 drops to a low value, and the comparator inputs return to their normal values. The current through the Triac, however, remains latched on until the fault is corrected and RST (reset) switch S2 is depressed. Listed at the bottom of Table 1 are the currents flowing through R10 as calculated from the drops measured across it.

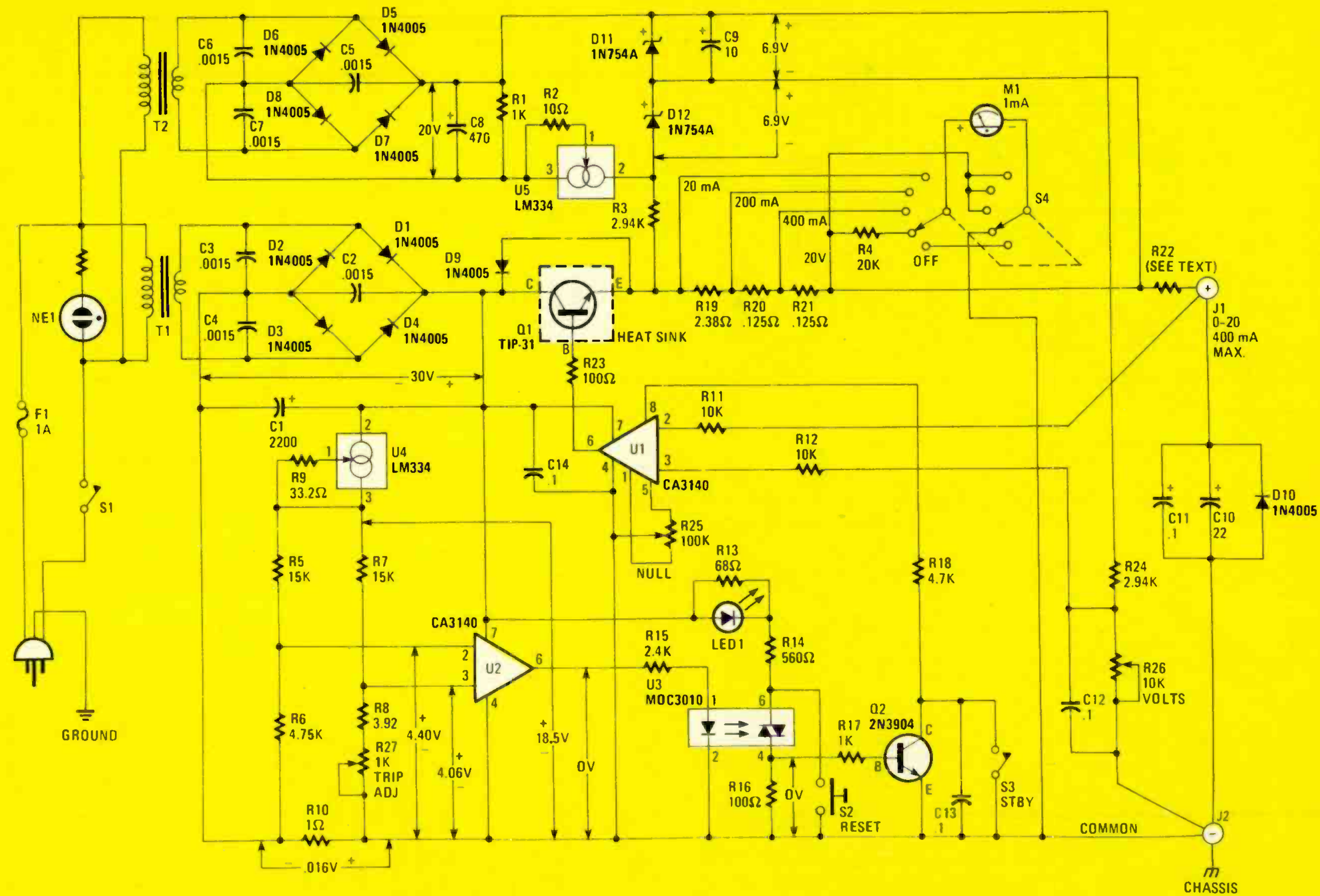


FIG. 4—HERE IS ONE-HALF of the Dual Power Supply. Since both halves are identical, build two from this drawing and package them in one cabinet. In fact, if you wish, you could build a *quad* power supply—it's all up to you. For each power supply you build, use an electrically-isolated chassis ground return so that the supplies can be connected in series using a common tie-point as ground for a dual regulated power supply.

With no external load, the current through R10 (Figs. 3 and 4) is about 14.3 mA. That current represents the currents drawn by U1, U2, and the circuit's resistive dividers. With a 400-mA external load, the current through R10 increases to 414-mA. Under trip conditions, the no-load internal current is increased by the Triac (U3) latched current to a total of 46.5 mA. The measured resistance of my R10 was 1.1 ohms.

Full Schematic Diagram

Figure 4 shows the actual schematic diagram used in my prototype providing an output of 0 to 20 volts at 400 mA maximum. Critical component values are shown as measured; circuit voltages are indicated at points on the schematic diagram, and in the Tables, where they will be of help in duplicating this prototype, or in designing another power supply of a different rating. Measurements were made using a 3½-digit DMM.

Load Regulation

It is possible to get the output voltage to actually rise with an increase in load current, or to obtain perfect regulation at any selected output voltage. That characteristic can be achieved by inserting a small resistance in the path to the positive output terminal, as represented by R22 in Fig. 4. When the load current increases, the voltage drop across R22 increases linearly. That voltage drop is of the proper polarity to add to the reference voltage, so the effective reference voltage increases with increases in load current. Reference to Eq. 1 reveals that there will be an increase in output voltage, which counteracts the normal decrease in output voltage under increased-load current conditions. The required resistance value of R22 is very small and must be determined by trial. Just a few inches of small-gauge magnet wire is all that is needed. The gauge of the wire must be able to carry the current that passes through it without heating up.

Using magnet-wire-wound current shunts, a 1-mA meter and a double-pole, five-throw (DP5T) rotary switch S4, output voltages and three current ranges can be monitored. The current ranges chosen were 20, 200, and 400 mA. With a 30-volt unregulated input to Q1, a 400-mA maximum output can be handled by a heat-sinked TIP-31 transistor with a reasonable safety factor. Also, 400 is a multiple of 20, the maximum output voltage, thus simplifying the meter dial markings.

With no external load there will be an internal current apparent on the 20-mA range. This *error* current will not be noticed on the 200- or 400-mA ranges. It is due to regulatory action of the error amplifier, U1, which must allow Q1 to pass just enough current to make the voltage-drop across R24 equal to the Zener voltage of D11. When that equality is achieved the output voltage is zero because the Zener voltage and the drop across resistor R24 are in series, are equal, and are of opposite polarity. The *error* current is, of course, the Zener voltage divided by the value of resistor R24 in ohms, or about 2.3 mA, and is a constant regardless of the setting of R2. It is bucked out by an equal opposite current produced by the lower Zener diode and series resistor shown in Fig. 2.

A standby LOAD switch, S3, is connected across Q2. The function of S2 is to provide manual shutdown of the supply's voltage and current output. That action is more convenient in some applications than turning off the supply's power switch. Capacitor C13, across S3, was found necessary to prevent triggering of U3, the optocoupler, when S3 is opened after being closed to shut down the supply manually.

The 10-µF capacitor, C9, across the reference Zener diode, D11, minimizes Zener noise.

The protective diodes are included in the Dual Power Supply. Capacitor C10 across the output protects the power supply against reverse voltages, which might be applied by an active load. Diode D9 across pass transistor Q1 is included for the same reason.

Performance

Specific figures for load and line regulation will not be offered because my instruments for determining such figures do not have sufficient resolution to be meaningful. In other words, the power supply's regulation is so good that I can't measure it. Tables 2 and 3 present performance data as well as I could measure them with a 3½-digit DMM. Whereas those

TABLE 2
REGULATION VS. LOAD

Line = 115 Volts	
Load (mA)	
0	400
Output Volts (DC)	
18.48	18.48
11.13	11.13
4.80	4.80
1.181	1.181
.1670	.1670
.0945	.0945

TABLE 3
REGULATION VS. LINE

Load = 400 mA		
Line Volts (AC)		
103.5	115.0	126.5
Output Volts (DC)		
17.56	17.56	17.56

tables show perfect regulation, it should be noted that the normal resolution of a 3½-digit DMM creates that illusion. A 4½ DMM, or better, is required to measure more precisely. Nevertheless, excellent load and line regulation is obvious.

Ripple on the output voltage at full load was so small that, on my scope's 10-mV/cm range, it was barely perceptible and what could be seen may have been caused by hum pickup on the test leads.

Construction

Mechanical layout is not critical. Neither is the wiring critical, except that it is important that connections from R11 and R26 go right to the output terminals as shown in Fig. 4. Those are the voltage-sensing leads and have to be connected as shown, to monitor the voltage as close as possible to the external load for good regulation.

The meter I used, from my junkbox, had a plastic cover, which created a minor problem. It tended to acquire a static charge, so that the pointer wouldn't always return to zero when it should. Passing a finger across the cover, or tapping it, to overcome jewel friction would create a sizeable and unpredictable offset. That annoying condition was eliminated by brushing on a thin coat of Sta-Puf, a laundry liquid for

PARTS LIST FOR DUAL POWER SUPPLY

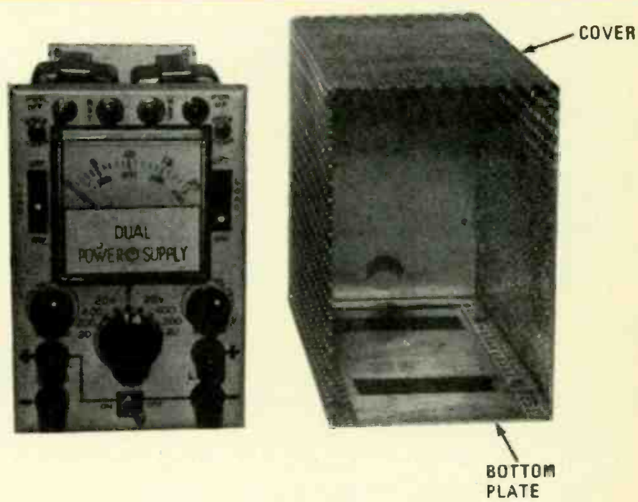
SEMICONDUCTORS
D1-D10—1N4005 600-PIV, 1-A rectifier diode (Radio Shack 276-1104 or equivalent)
D11, D12—1N754A 6.8-volt, 400-mW Zener diode
LED1—Light-emitting diode, T-1, red miniature
Q1—TIP-31 NPN transistor (Radio Shack 276-2017 or equivalent)
Q2—2N3904 NPN transistor (Radio Shack 276-1603 or equivalent)
U1, U2—CA3140 bi-FET op amp, RCA (Jameco Electronics)
U3—MOC3010 Triac output, 250-volts, 100-mA optocoupler (Radio Shack 276-134 or equivalent)
U4, U5—LM334 current-source integrated circuit (Radio Shack 276-1734 or equivalent)

RESISTORS
R1—1000-ohm, 1-watt, 10% fixed
R2—10-ohm, ⅛-watt, 1%, film
R3, R24—2,940-ohm, 1%, film
R4—20,000-ohms, 1%, film
R5, R7—15,000-ohm, 1%, film
R6—4750-ohm, 1%, film
R8—3,920-ohm, 1%, film
R9—33.2-ohm, 1%, film
R10—1-ohm, 1-watt, 5%, wire-wound
R11, R12—10,000, ⅛-watt, 10%
R13—68-ohm, ⅛-watt, 10%
R14—560-ohm, 2-watt, 10%
R15—2,400-ohm, ⅛-watt, 10%
R16, R23—100-ohm, ⅛-watt, 10%
R17—1000-ohm, ⅛-watt, 10%
R18—4700-ohm, ⅛-watt, 10%
R19—2.38-ohm (made from #40-gauge magnet-wire wound on 1000-ohm, ¼-watt resistor form
R20, R21—125-ohm (made from #28-gauge magnet-wire wound on 1000-ohm, ¼-watt resistor form
R22—(See text)
R25—100,000-ohm, ⅛-watt, miniature trimmer potentiometer (Radio Shack 217-338 or equivalent)
R26—10,000-ohm,audio-taper miniature potentiometer (Mallory U18 Midgetrol, #1-taper)
R27—1000-ohm, ⅛-watt, miniature, trimmer potentiometer (Radio Shack 217-333 or equivalent)

CAPACITORS C1—2200-µF, 50-WVDC, electrolytic
C2-C7—.0015-pF, 1000-WVDC, ceramic-disc
C8—470-µF, 35-WVDC, electrolytic
C9—10-µF, 16-WVDC, tantalum
C10—22-µF, 35-WVDC, electrolytic
C11-C14—1-µF, 50-WVDC, Mylar

SWITCHES S1—SPST, 3A, 125-VAC, miniature, toggle
S2—SPST, normally-open, momentary-pushbutton
S3—SPST switch, toggle
S4—2-position, 6-throw, non-shorting, rotary (use only 5 positions)

ADDITIONAL PARTS AND MATERIALS
F1—1-A, type-3AG fuse
J1, J2—Multi-way binding post, one red, one black
M1—DC panel meter, 1-mA, 2¼-in. square
NE1—Indicator part of type-3AG fuse holder
T1—Power transformer; 117-VAC pri.; 20-VAC, 1.2-A sec. (Signal #PC40-600 or equivalent)
T2—Power transformer; 117-VAC pri.; 6-VAC, .15-A sec. (Signal #241-3-16 or equivalent)
Heat sink, two 8-pin IC sockets, one 6-pin IC socket, knobs, line cord, chassis, case, hardware, rubber feet, decals, etc.



A HOME-BUILT front panel, cover and bottom plate was made to fit a standard chassis that the author had available. Metal screen used to make cover provides ample ventilation for project.

fabric softening and static cling control, on the inside of the cover. The coating is still working after six months.

A suitable heat sink is required for Q1, the series-pass transistor. In my prototype I used a flat piece of 3/32-inch thick aluminum that was 3½-inch square, which was mechanically and thermally connected to the chassis. The TO-220 tab of Q1 is internally connected to the transistor collector element, so a mounting screw through the tab hole must be electrically isolated from the heat sink. I used two extruded fiber washers to accomplish that purpose. In addition, a piece of mica ⅝-inch by ⅞-inch with thermal grease on each side was used between Q1 and its heat sink. Figure 5 shows the mounting arrangement. That electrical isolation isn't required if, instead, the heat sink is isolated from the chassis by means of insulating standoffs.

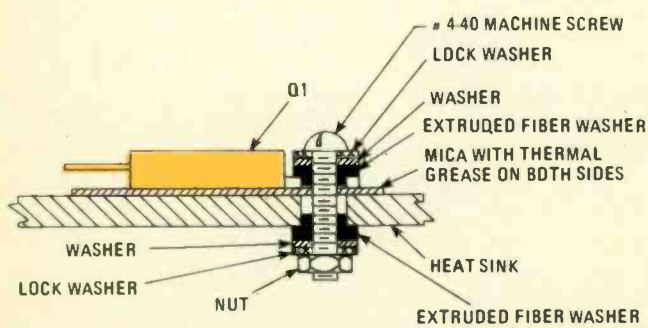


FIG. 5—PASS TRANSISTOR Q1 requires a suitable heat sink, due to the amount of heat it dissipates. The author mounted Q1 on the metal chassis thereby requiring electrical isolation.

Adjustments

There are only two adjustments to be made before operation. The first one is to null the error amplifier, U1. With a digital voltmeter across the Dual Power Supply's output ter-

(Continued on page 92)

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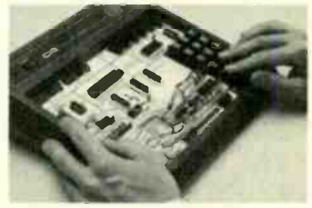

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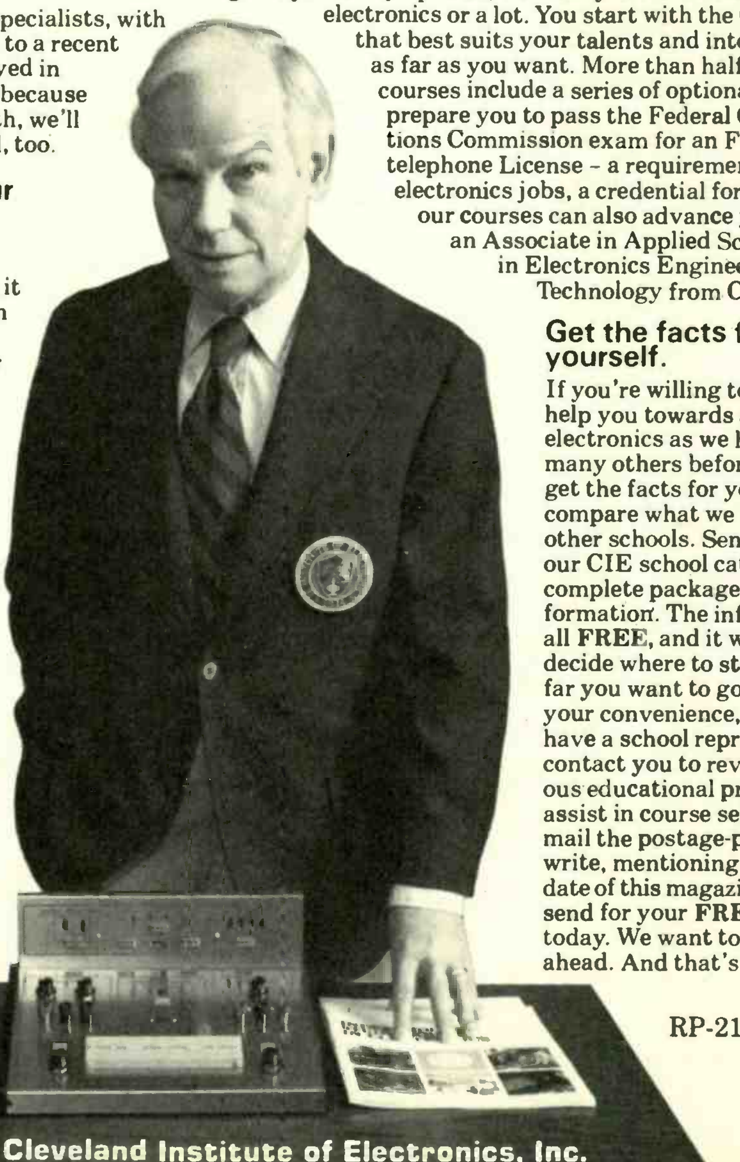

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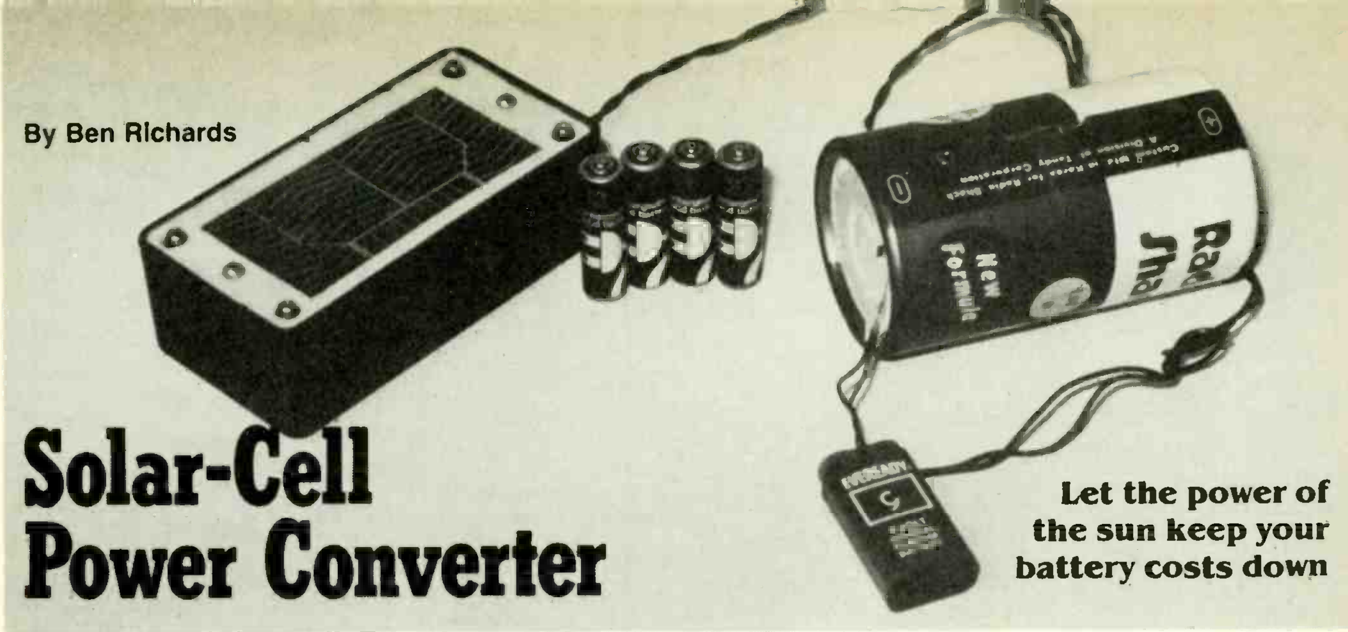


By Ben Richards

Solar-Cell Power Converter

Let the power of the sun keep your battery costs down

SOLAR CELLS PRODUCE VERY LOW VOLTAGE OUTPUTS AT fairly high current when energized by the light of the sun or other similar light. A series of enough interconnecting small solar cells to operate a 9-volt transistor radio can be expensive. It costs less to use a single, relatively large cell, and raise the voltage with a DC-to-DC converter capable of running at the low voltage that the single solar cell supplies. Such a Solar-Cell Power Converter could be very welcome in case of emergencies or natural disasters, where all you may have are dead dry batteries, or discharged Ni-Cd's with no 60-Hertz line power to recharge them.

How It Works

Figure 1 is the schematic diagram of the Solar-Cell Power Converter. Initially, one transistor begins to conduct a little more than the other when power from solar cell D1 is applied, and that results in a regenerative increase of current in one transistor, and a decrease in current in the other one. Very shortly, one transistor is at current saturation (full-on), and the other, at zero conduction (full-off). That condition persists until the transformer saturates and creates regenerative turn-on of the previously conducting (on) transistor. That rapid current-switching repeats cyclically at a high rate. The build up and collapse of current in the primary winding (browm and orange leads) of T1 induces a stepped-up AC voltage across the output winding (gray and white leads).

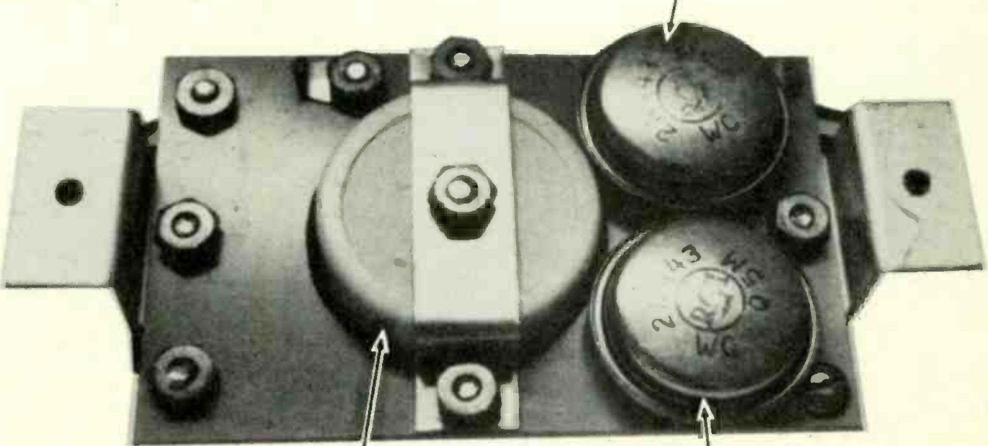
A full-wave doubler rectifier, D2 and D3, is used to produce the required DC voltage output. A Zener diode, D4, is used to set the upper limit on the output voltage when the load current is minimal, but D4 is not intended to keep the output voltage constant. The radio-frequency choke, RFC1 and the .01 µF capacitor, C1, hold down RF noise generated by the switching circuit to an acceptable level.

You may be wondering about the use of power-transistors, Q1 and Q2, of a much higher power rating than would appear necessary. The reason is that the transistors have an extremely low voltage drop at the current levels encountered in changing the roughly 1/2-volt output of the single solar cell to high-frequency AC. Much smaller transistors could handle the current easily, but at two to three times the voltage drop. Since we're starting with a very low DC input voltage, a large voltage drop would result in a circuit whose efficiency was too low to be practical.

Construction

The mechanical layout of the Solar-Cell Power Converter is

A SMALL AMOUNT OF sheet-metal work is required to develop a chassis to mount the power-switching transistors Q1 and Q2, transformer, T1 and the other parts that make up the Solar-Cell Power Supply. The solar-cell assembly mounts on the end brackets.



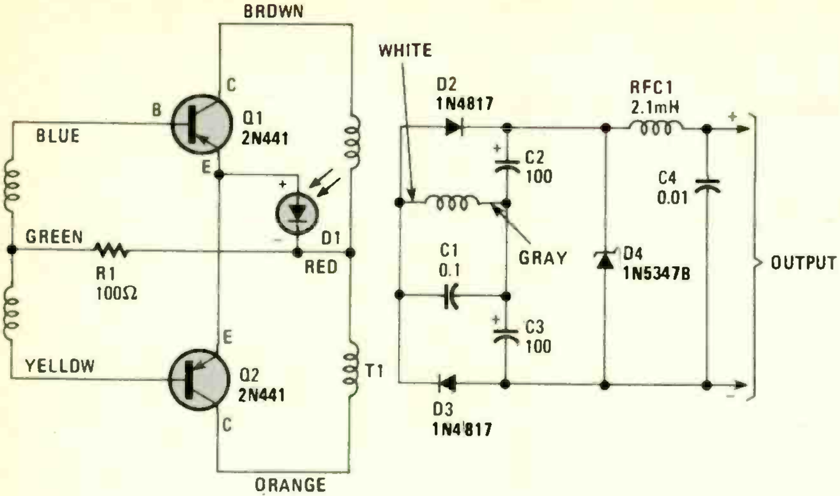


FIG. 1—THE POWER to drive this circuit is obtained from solar cell D1 that produces .45-volt DC at 333 mA in bright sunlight. That's 150 milliwatts of power—is more than enough to drive a transistor radio if its output was 9-volts DC. The five coil elements (other than RFC1) are wound on the same coil form to make up transformer T1. The circuit is designed to obtain minimum switching losses and maximum current reversals in the collector circuits of Q1 and Q2. The remainder of the circuit is a fullwave, voltage-doubler rectifier with filtering and Zener diode regulation.

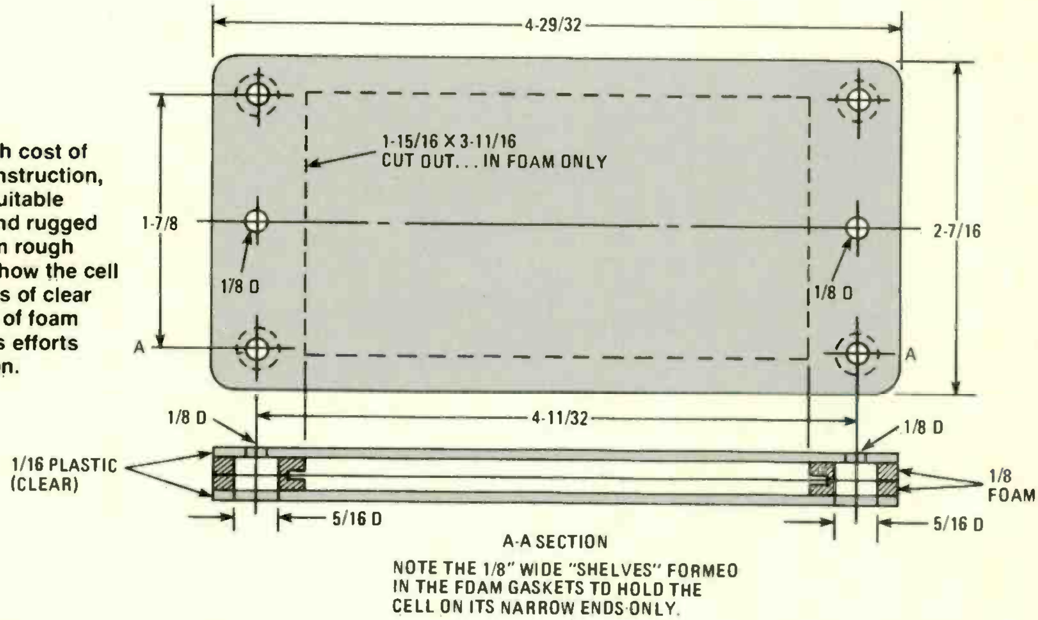


FIG. 2—CONSIDERING the high cost of solar cells and their fragile construction, it is wise to mount them in a suitable holder that is gentle to them and rugged enough to offer protection from rough handling. The diagram shows how the cell is mounted between two pieces of clear plastic and suspended by bits of foam material. Duplicate the author's efforts for suitable solar cell protection.

PARTS LIST FOR SOLAR-CELL POWER CONVERTER

SEMICONDUCTORS

D1—2- × 4-inch (5- × 10-cm) solar cell (Radio Shack 276-126 or equivalent)
D2, D3—1N4817 rectifying diode
D4—1N5347B, 10-volt Zener diode
Q1, Q2—2N441, 2N442 or 2N443 germanium, PNP power transistors

ADDITIONAL PARTS AND MATERIALS

R1—100-ohm, ¼-watt, 5% resistor
C1—0.1 µF, 100-WVDC, tubular capacitor
C2, C3—100 µF, 6-WVDC, electrolytic capacitor
C4—0.01 µF, 50-WVDC, ceramic-disc capacitor
RFC1—2.1-mH, radio-frequency choke
T1—EC-0201-IP saturable transformer (available from Milwaukee Electromagnetics, P.O. Box 07476, Milwaukee, WI 53207, for $6.95 postpaid)
4 × 2⅛ × ⅝-inch plastic box (Radio Shack 270-231 or equivalent), plastic sheets, foam sheet, scrap aluminum, wire, solder, hardware, cement, etc.

not critical, but some specific dimensions are suggested for those who wish to duplicate the original project.

Begin by preparing the plastic-sheet chassis according to Fig. 3. A chassis punch or hand-grinding tool with a fluted cutting bit can be used to form the large-diameter hole through which the inverter transformer, T1, is mounted with the aid of the aluminum mounting strip. Attach the transistors, Q1 and Q2, the end-mounting brackets, the transformer, and the corner-mounted soldering lugs as shown in the photograph. Make sure that the power-transistor cases do not touch each other or the screws which fasten the four, corner, solder lugs to the plastic chassis. Be sure to provide heat-sink thermal connection to the base and emitter terminals of the transistor when applying the soldering-iron heat.

Solder fine, insulated, stranded-wire leads to the solar cell, D1, very carefully using a small, low-wattage, soldering iron. The full surface ohmic connection on the back of the solar cell is the positive terminal and the comb-like electrode on the opposite surface is the negative terminal. If in doubt, check the solar cell's output polarity with a voltmeter.

The plastic and foam sheets which make up the solar-cell assembly should be formed as shown in Fig. 2. As shown in the drawing, the solar cell is mounted between a set of plastic and foam sheets so that it is supported only on the narrow

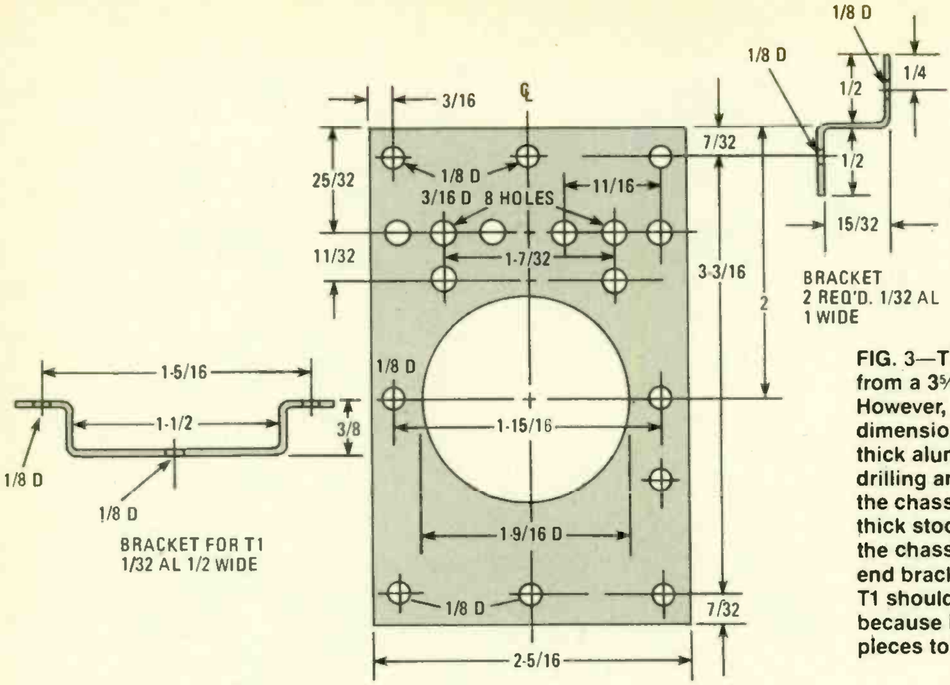
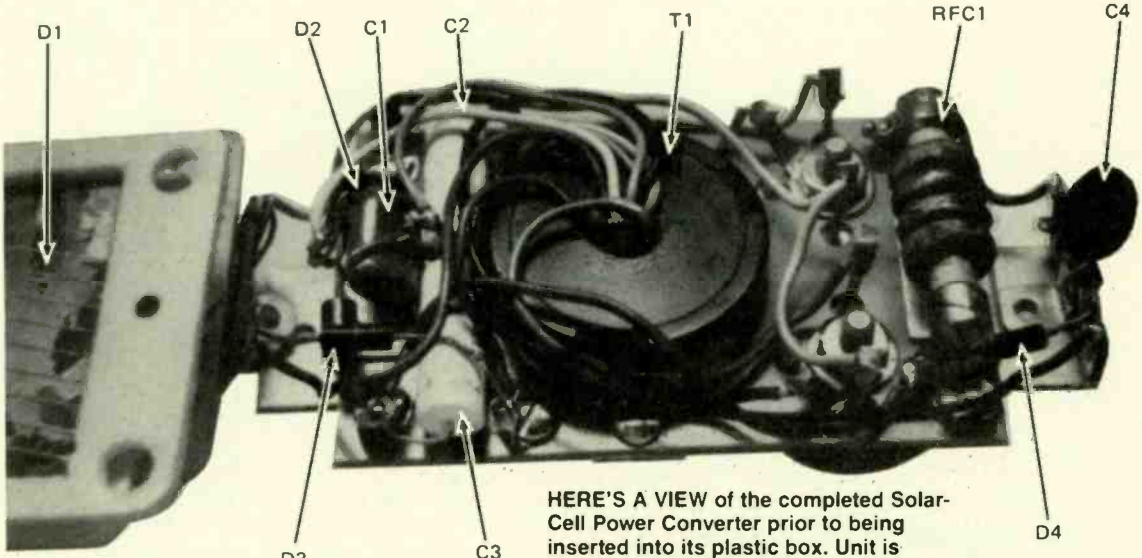


FIG. 3—THE ALUMINUM CHASSIS is made from a 3⅝-in. by 2 5/16-in. sheet. However, it is wise to scratch the overall dimensions on a scrap sheet of 1/32-in. thick aluminum, and do all the necessary drilling and hole punching before trimming the chassis down to size. Or, should 1/16-in.-thick stock, or better, be used to make the chassis, that is not necessary. The end brackets and the bracket for transformer T1 should be of 1/32-in. aluminum stock because it will be easier to bend the cut pieces to the shapes required.



HERE'S A VIEW of the completed Solar-Cell Power Converter prior to being inserted into its plastic box. Unit is extremely compact; however, that is not a design necessity. RF choke RFC1 reduces the high-frequency hash generated by switching circuit.

ends by a ⅛-inch shelf cut into the foam gaskets. The plastic used was an acrylic such as used for glazing windows and can be cut using a scribe-and-break technique. The foam gaskets were made from a tray used to package food; they can be cut to shape with a razor blade. Be careful not to crack the solar cell during assembly. By the way, neither wiring dress nor parts layout are critical. The wired chassis and solar cell assembly are joined with the end brackets shown in Fig. 3. The combined chassis-solar cell assembly is fastened to the plastic case with four mounting screws.

Testing and Use

Probably the easiest thing to do is hook up the output leads to the load and walk out into the sunshine to enjoy solar-powered music. If you want to test the converter first, just connect a voltmeter across the output leads. Expect 9 to 11 volts under light load and moderate illumination.

A small amount of RF noise between stations (if you're powering a receiver) is normal and shrinks to virtually nothing when the radio's AVC takes over.

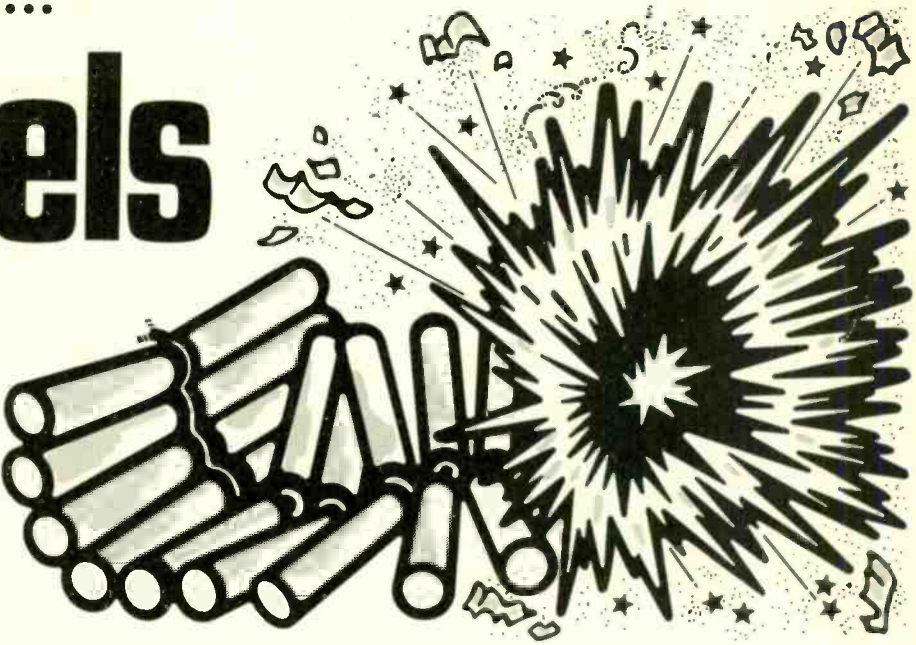
If the converter doesn't work, check the polarity of the solar cell output. If it's OK, check the wiring for an incorrect, broken, or shorted connection. By the way, you can bench-test the converter alone by disconnecting one lead of the solar cell and applying 0.6-volts DC from a variable power supply.

Intended use of the Solar-Cell Power Converter is to power small AM transistor radios. Our tests indicate that you'll get satisfactory operation under sunlight conditions ranging from overcast to full noonday sun. The Solar-Cell Power Converter is not intended for FM receivers, because they are sensitive to small supply-voltage changes such as might occur when fast-moving clouds pass by. It is not advisable to leave the circuit wiring exposed indefinitely to the elements, so you should seal the circuit thoroughly. ■

Understanding and Using....

Decibels

By Marvin D. Lamb



We are sure that you have seen many equipment specifications—from dynamic range of amplifiers to the output level of signal generators—given in dB's. While you may know that a dB is a decibel, do you really understand how to use the unit properly?

IN ELECTRONICS, POWER, VOLTAGE, OR OTHER LEVELS ARE often specified in decibels (dB). But because those levels aren't *always* given in decibels, conversions to and from that unit are often necessary. While you may have a calculator handy for such occasions, there are some easily learned "rules of thumb" that will enable you to conduct the conversions in your head. We'll talk not only about those conversion rules in this article—we'll also discuss some basic facts about the decibel. So after reading this, you should be more familiar with dB's, and should even be able to mentally compute dB levels.

What Is a dB?

The decibel is the standard unit for expressing relative power levels. For example, the gain of a system—the ratio of the system's output power (P2) to its input power (P1)—can be expressed in dB's:

$$n \text{ dB} = 10 \log_{10}\left(\frac{P2}{P1}\right)$$

Some of you are, perhaps, unfamiliar with the term "$\log_{10}$" that appeared in the preceding equation. It stands for the common logarithm, or the logarithm to the base 10. (When using common logarithms, the subscript "10' is often omitted, as we will do in the remainder of the article.)

The logarithm is the inverse operation of raising a 10 to a power. For example, the expression "n = log x" means: n equals the power that 10 has to be raised to so that it equals x. In other words, $10^n = x$ For example: $\log 10 = 1$ since $10^1 = 10$. In a like manner, $\log 15 = 1.176$ since $10^1 \times 10^{.176} = 15$.

Power ratios are not the only thing that decibels can be used to express—voltage and current ratios can also be expressed in decibels. In that case, $n \text{ dB} = 20 \log V_2/V_1$ or $n \text{ dB} = 20 \log I_2/I_1$. In the strictest sense, the decibel can be used to express voltage and current ratios only when the voltages or currents are measured at places having matching impedance. We'll talk more about that later.

You may wonder why the logarithm of ratios would be a useful way to measure different quantities. Its usefulness stems from the fact that power and audio levels are related on a logarithmic basis. That is, if the power increases by a factor of 4, that doesn't mean that the audio level (voltage) will increase by a factor of 4. Instead it increases as the square root of the power increase.

That can be shown as follows: Presume you have a 4-ohm resistor dissipating 4 watts. Using the formula $P = IE = E^2/R$, you can determine that the voltage across the resistor $= \sqrt{PR} = \sqrt{16} = 4$ volts. If the same resistor dissipates 16 watts, then $E = \sqrt{PR} = \sqrt{64} = 8$ volts. So while the power increases by a factor of 4 (from 4 watts to 16 watts) the voltage across the resistor increased by $\sqrt{4} = 2$—the square root of the power increase (from 4 volts to 8 volts).

The unit originally used to express power ratios was the "bel," which was defined: n bels = log (P2/P1). (The term "bel" was derived from the last name of Alexander Graham Bell, an early investigator of sound levels.) Even before the days of amplifiers and low RF levels, it was felt that the bel was too large a unit for practical measurements, so the decibel (1/10 bel) was adopted as the international standard unit where n dB = 10 log (P2/P1).

Because the decibel measures the ratio of two power levels, a reference power level (P1) must be specified. For example,

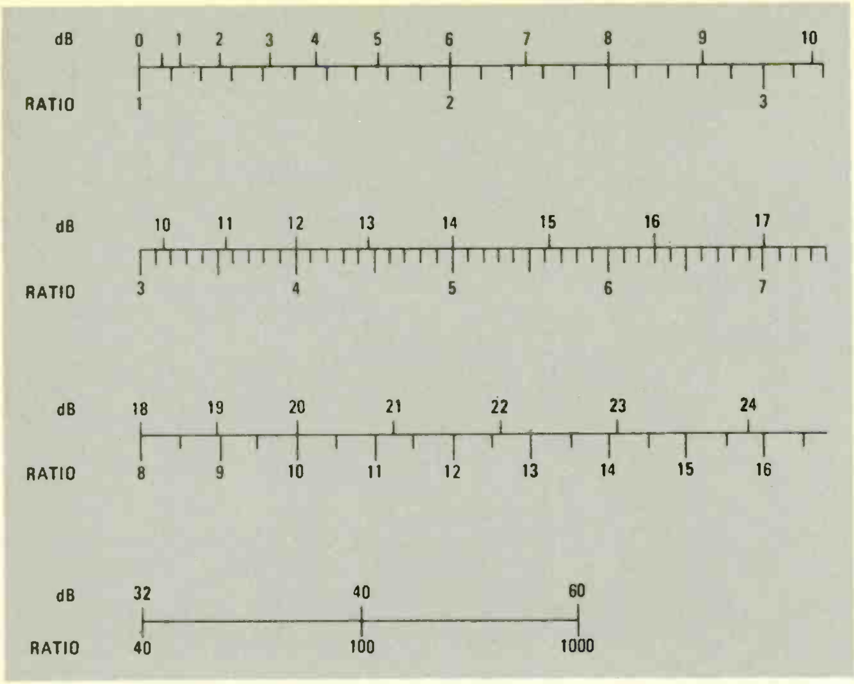


FIG. 1—THIS CHART CAN BE USED as a memory aid or simply to obtain ball-park figures. Note that the ratios shown are for voltage measurements. If you need to determining dB levels corresponding to power measurements, square the ratios shown. (For example, a power ratio of 4 corresponds to a voltage ratio of $\sqrt{2}$ = 6 dB.)

while you could say that the *gain* of an amplifier is 6 dB, you could *not* say that the amplifier's maximum *output* is 22 dB.

There are, however, several *derived* decibel units that can be used. When making power measurements, for example, the unit dBm is often used, where dBm is a power level referenced to 1 milliwatt. Several other decibel abbreviations are often used. Their abbreviations will consist of the letters dB plus additional letters to specify the reference level. Table 1 lists some of those units.

The decibel is used effectively in measurements covering a wide range of levels. The frequency response of amplifiers and filters, for example, is usually expressed as a graph of voltage in decibels as a function of the frequency in Hertz. Most analog AC voltmeters with dB scales are calibrated in dBmV (decibels referred to 1 millivolt across some particular impedance).

TABLE 1—DERIVED DECIBEL UNITS

dBF	Decibels above 1 femtowatt (10^{-15}), or 0.223 μV
dBj	Relative RF signal levels. 0 dBj = 1000 μV
dBk	Decibels referred to 1 kilowatt
dBm	Decibels referred to 1 milliwatt
dBmV	Decibels above 1 millivolt
dBμV	Decibels above 1 microvolt
dBRAP	Decibels above reference acoustical power (10^{-16} watt)
dBv	Decibels relative to 1 volt
dBW	Decibels referred to 1 watt

dB's and Voltage Measurements

If we want to use decibels to relate to the voltage levels of the system, we have to look at another factor: The circuit impedance becomes important when determining dB reference levels. (That's because $P = E^2/R$, or $P = I^2R$ and, therefore, for a given power, the voltage depends on the impedance.)

For example, how would we determine what 0 dBm means for audio measurements? We know that the characteristic impedance for audio transmission lines is 600 ohms. We can also determine what voltage level corresponds to 600 ohms dissipating 1 milliwatt. Recalling that $E = \sqrt{PR}$, we have $E = \sqrt{(.001\ W)(600\ \Omega)} = \sqrt{.6} = 0.7746$ volts.

The characteristic impedance of RF generators, attenuators, etc. in the U.S. is 50 ohms (75 ohms in Europe). Thus, 0 dBm for RF measurements is 1 milliwatt into 50 ohms, and the reference voltage is 0.2236 volts.

Decibels and Voltage Ratios

In the following examples, we'll look at how to work with dB ratios, and how the dB ratios correspond to voltage ratios. Using voltage ratios yield answers twice as big as those we'd get using power ratios. Remember, n dB = 10 log (P2/P1) for power levels, while n dB = 20 log (V2/V1).

Ratios are most often used when comparing input and output voltages. For example, if we wanted to determine the gain in decibels of an amplifier having an input of 10 millivolts and an output of 1.0 volt, we would write:

$$\begin{aligned} n\ dB &= 20 \log\left(\frac{1.0\ V}{10\ mV}\right) \\ &= 20 \log (100) \\ &= 20 \times 2 = 40\ dBV \end{aligned}$$

When measuring attenuation ratios, we have a more interesting computation. For example, presume we want to determine the attenuation in decibels of a device with 1.0-volt input and 20-millivolt output. Using our method developed so far, we would proceed as follows:

$$\begin{aligned} n\ dB &= 20 \log\left(\frac{.02}{1}\right) \\ &= 20 \log (.02) \\ &= 20\,(-2.3010) = -40.602\ dB \end{aligned}$$

(Incorrect)

Unfortunately, that is *not* the correct answer. The problem arises because of the *negative characteristic* of the log of a number less than 1. So in the case above, we must write the log with a negative characteristic as a positive number. That's done by adding 10 to the negative log and then subtracting 10. The net effect is zero change to the number but puts it into a form that we can handle. We'll do that for the previous problem as follows:

TABLE 2—EASILY REMEMBERED FACTORS		
dB	**Voltage ratio**	**Power ratio**
3	$\sqrt{2}$	2
6	2	4
10	$\sqrt{10}$	10
12	4	16
14	5	25
20	10	100
40	100	10,000
60	1000	1,000,000

$$\begin{aligned} n\ \text{dB} &= 20\,(8.3010 - 10) \\ &= 166.02 - 200 = -34\ \text{dB} \end{aligned}$$

which is the correct answer.

A less cumbersome method of achieving the same result is to arrange the division so that a number greater than 1 always results. Just don't forget to add a minus sign if the circuit is an attenuator. For the previous example:

$$\begin{aligned} n\ \text{dB} &= 20 \log \left(\frac{1}{20 \times 10^{-3}}\right) \\ &= 20 \log (50) \\ &= 20 \times 1.669 = 34\ \text{dB} \end{aligned}$$

The Factor Method

Now we'll discuss a method that will let you find the answer to the above problems in your head—although you first have to memorize what we'll call combination factors. The factors or ratios are listed in Table 2. With those ratios or factors memorized, you should be able to derive almost all the rest—without referring to any tables! If you don't want to memorize anything, you can always keep Table 2 handy. But we're sure that after you've used the table for a while, you'll find that you've memorized it! Note that the ratios given are for voltage measurements—use the square of the ratio for power measurements.

Some of the ratios are exact, and a few are very close approximations. But all will put your quick answer well within 0.1 dB—which should be sufficient for answers "off the top of your head."

TABLE 3—dB VERSES VOLTAGE RATIO					
dB	**Voltage ratio (factor)**				
½	$\frac{3\sqrt{2}}{4}$	= 1.06	11	$\frac{5\sqrt{2}}{2}$	= 3.53
1	$\frac{\sqrt{5}}{2}$	= 1.12	12	4	
2	$\frac{2\sqrt{5}}{5}$	= 1.26	13	$2\sqrt{5}$	= 4.47
3	$\sqrt{2}$	= 1.414	14	5	
4	$\frac{\sqrt{10}}{2}$	= 1.58	15	$4\sqrt{2}$	= 5.66
5	$\frac{5\sqrt{2}}{4}$	= 1.77	16	$2\sqrt{10}$	= 6.32
6	2		17	$5\sqrt{2}$	= 7.07
7	$\sqrt{5}$	= 2.236	18	8	
8	2.5		19	9	
9	$2\sqrt{2}$	= 2.83	20	10	
10	$\sqrt{10}$	= 3.16	21	$5\sqrt{5}$	= 11.18

Let's look at a problem and use the factor method to solve it. What is the attenuation in decibels of a system with an attenuation factor of 50?

We can find the answer by taking a few simple steps. We know that $50 = 10 \times 5$. We remember (or look at Table 2, to find) that a ratio of 10 corresponds to 20 dB, and a ratio of 5 corresponds to 14 dB. Adding the two figures gives us 34 dB—the same answer we came up with previously. The rule here is that when voltage ratios (the factors) are multiplied, their corresponding decibel values are added together.

Let's look at another problem and another rule for using the factor method: Using the factor method, determine the voltage ratio for a gain of 7 dB.

We have two approaches: First, we know that 7 dB = 10 dB − 3 dB (both of those factors are listed in the table). The rule to remember is that when we subtract units of decibels, we divide the factors, and vice-versa. Thus, our solution is:

$$\frac{\text{Factor for 10 dB}}{\text{Factor for 3 dB}} = \frac{\sqrt{10}}{\sqrt{2}} = \sqrt{5}$$

Our second approach: We know that 7 dB is one-half of 14 dB. Thus, the factor for 7 dB is the square-root of the factor corresponding to 14 dB. The rule here is that when a decibel value is multiplied by a number, the corresponding factor is raised to that number (in this case, ½). That's best shown by another example: as 3 dB increases to 12 dB, the corresponding factor should increase by a power of 4. Indeed, if you look at the table, you can see that the factors increase from $\sqrt{2}$ to 4, which is $(\sqrt{2})^4$. Another example: For a decrease from 60 dB to 20 dB, the factor decreases from 1000 to $(1000)^{1/3}$; which is equal to 10.

Let's go through a couple more examples. What is the difference between an amplifier with a 7 dB gain and one with a 6 dB gain? With the factors of 6 dB and 7 dB known (from the table and the previous example), 1 dB can be computed as their difference. So we have: 7 dB − 6 dB = $\sqrt{5}/2$.

What factor corresponds to 4 dB? Well, 4 dB can be thought of as 14 dB − 10 dB = $5/\sqrt{10} = \sqrt{10}/2$. It can also be thought of as 10 dB − 6 dB = $\sqrt{10}/2$.

In a similar fashion, all the dB ratios (or factors) from 1 dB to 20 dB can be figured by memorizing just a few. After 20 dB, the ratios repeat, but are multiplied by a factor of 10. For example, the factor for 24 dB is ten times the factor for 4 dB, or $10 \times \sqrt{10}/2$. The factor for 40 dB is therefore ten times that for 20 dB, or $10 \times 10 = 100$.

A good exercise is to list all the factors for decibel values from 1 to 20 using Table 2 and the rules we have discussed. Compare your results to the factors listed in Table 3.

Whole-number Factors

Certain dB ratios provide whole-number factors. The factors are easy to remember (especially if you use them frequently) and can greatly help you to determine dB/voltage levels. The most common ones are given in Table 4.

The Sixth Root of Two

Another convenient memory device to determine the dB ratios uses the sixth root of 2. (That's for voltage measurements—use the third root of 2 for power measurements.) We merely establish $2^{1/6}$ as being equal to 1 dB. That ⅙ power of

(Continued on jump page 92)

ON COMPUTERS

FRIEDMAN

If it *ain't* broke, fix it anyway!

ONE OF THE MOST FRUSTRATING ASpects of personal computing for the beginner is the so-called *RS-232 standard*. Most of the world accepts the term *standard* to represent something universally understood, whether it's a manufacturing standard, a performance standard, a size standard, a musical standard... whatever. The standard *foot* is twelve standard inches anywhere in this world, the musical tone *middle A* is 440-Hz unless specified otherwise; a compact cassette tape is mechanically the same in Hong Kong as it is in Switzerland, and a *DIN* connector is a *DIN* connector everywhere on Earth.

But an RS-232 I/O (input/output) is a standard that depends on who built the equipment. Back in the dim (not to be confused with DIN) days of the past, when every manufacturer had his own unique protocols—*control signals*—for serial transmission of data, communications closely resembled the legendary language gap in the *Tower of Babble* story. About the most one could expect is that a computer could communicate with other equipment from the same manufacturer. It was unlikely that two devices of different manufacture could communicate with each other, because both the signals and the connectors were different for each device.

Realizing that the world is neither flat nor prepared to forego modern communications because there was no communications standard, the EIA—the Electronic Industries Association—eventually came up with the *RS-232 standard*.

Introducing RS-232

The RS-232 standard is jam-packed with goodies, because it's supposed to be a universal standard capable of accommodating all foreseeable communications needs. It would take a book-length feature to cover everything about RS-232. To keep it all within this column, we'll limit ourselves to RS-232 as it affects personal computers and ancillary hardware such as printers and modems.

To start off, there is the connector. It is almost universally accepted that RS-232 I/O (input/output) will use the DB-25 connector, meaning a D-type connector having 25 terminals. Unfortunately, *universally* doesn't mean *always*—at least not in the dictionary used by computer manufacturers.

For example, the IBM PCjr uses what is called a *Berg* connector for the RS-232 I/O; the user must purchase a special *Berg-to-DB* adapter cable if he or she is going to connect to a standard RS-232 connector. As a matter of fact, the only place where the IBM PCjr uses a DB-25 connector is for the printer parallel-output, which should be a Centronics-type connector. So what do you think you have to purchase in order to use a parallel

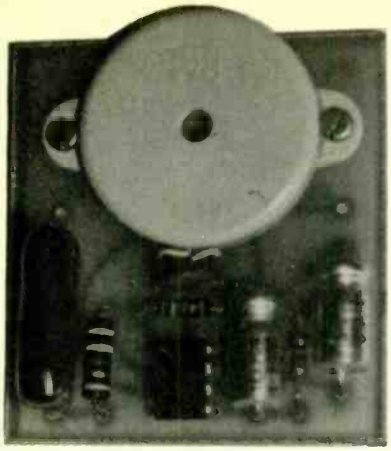
(Continued on page 95)

TABLE 1—RS-232 CIRCUIT SUMMARY

Pin	Name	EIA	DTE/DCE	Function
1	CG	AA	—	Chassis Ground
2	TD	BA	▶	Transmit Data
3	RD	BB	◀	Receive Data
4	RTS	CA	▶	Request To Send
5	CTS	CB	◀	Clear To Send
6	DSR	CC	◀	Data Set Ready
7	SG	AB	—	Signal Ground
8	DCD	CF	◀	Data Carrier Detect
9*			◀	Positive Test Voltage
10*			◀	Negative Test Voltage
11				(usually not used)
12+	SDCD	SCF	◀	Secondary Data Carrier Detect
13+	SCTS	SCB	◀	Secondary Clear To Send
14+	STD	SBA	▶	Secondary Transmit Data
15#	TC	DB	◀	Transmit Clock
16+	SRD	SBB	◀	Secondary Receive Data
17#	RC	DD	◀	Receive Clock
18				(usually not used)
19+	SRTS	SCA	▶	Secondary Request To Send
20	DTR	CD	▶	Data Terminal Ready
21*	SQ	CG	◀	Signal Quality
22	RI	CE	◀	Ring Indicator
23*		CH	▶	Data Rate Selector
		CI	◀	Data Rate Selector
24*	XTC	DA	▶	External Transmit Clock
25*			▶	Busy

The character following the pin number means:
*—Rarely used.
+—Used only if secondary channel is implemented.
#—Used only on synchronous interfaces.

The direction of the arrow indicates which end (DTE or DCE) originates each signal, except for the ground lines (—). For example, circuit 2 (TD) is originated by the DTE and received by DCE.



TONE-RINGER

Eliminate that spine-chilling, ear-grating Ma Bell ringer by replacing it with our pleasing two-tone warble caller!

By Gary Kloesz*

☐EVER WISH YOU HAD A TELEPHONE RINGER IN YOUR BACK yard, or one that sounded different than your neighbors? Here is an electronic ringer project that is centered around a Motorola MC34012 telephone, tone-ringer, integrated circuit. The MC34012 chip, along with a piezo-electric sound transducer, produces a pleasing two-tone warble (some say it's a *turkey* call) whose frequency may be adjusted to suit anyone's listening taste.

Circuit Description

The MC34012 tone-ringer chip (Fig. 1) derives it's power by rectifying the AC ringing signal. That signal is normally at 20 Hz and measures between 70 and 130-volts *rms*. It uses that *stolen* power for the tone generator and to drive the piezo-electric transducer.

The sound that is produced is a warble that varies between two frequencies, $f_0/4$ ($f_0 \div 4$) and $f_0/5$. The clock, or fundamental, frequency, f_0, is generated by a relaxation oscillator. That oscillator has R2 and C2 as its frequency setting components providing a selectable range of 1 kHz to 10 kHz. Selecting different values for R2 and/or C2 changes the clock frequency, which in turn varies the warble frequencies.

The MC34012 chip comes in three different warble rates at which the warble frequencies ($f_0/4$, $f_0/5$) are varied. These warble rates are $f_0/320$, $f_0/640$, or $f_0/160$ and the different chips are designated as MC34012-1, -2, and -3, respectively. For example: with a 4.0-kHz oscillator frequency, the MC34012-1 produces 800-Hz and 1000-Hz tones with a 12.5-Hz warble rate. The MC34012-2 generates 1600-Hz and 2000-Hz tones with a similar 12.5-Hz warble frequency from a 8.0 kHz oscillator frequency. MC34012-3 will produce 400-Hz and 500-Hz tones with a 12.5-warble rate from a 2.0-kHz oscillator frequency.

The Tone-Ringer output circuit can source or sink 20 mA with a voltage swing of 20-volt peak-to-peak. A volume control may be installed by adding a potentiometer in series with the piezoelectric sound transducer, PZ1.

The input-signal, detection circuit activates the Tone-Ringer output when the AC-line voltage exceeds the pro-

*Consumer Strategic Marketing, Motorola, Inc., Semiconductor Productions Sector, Phoenix, Arizona

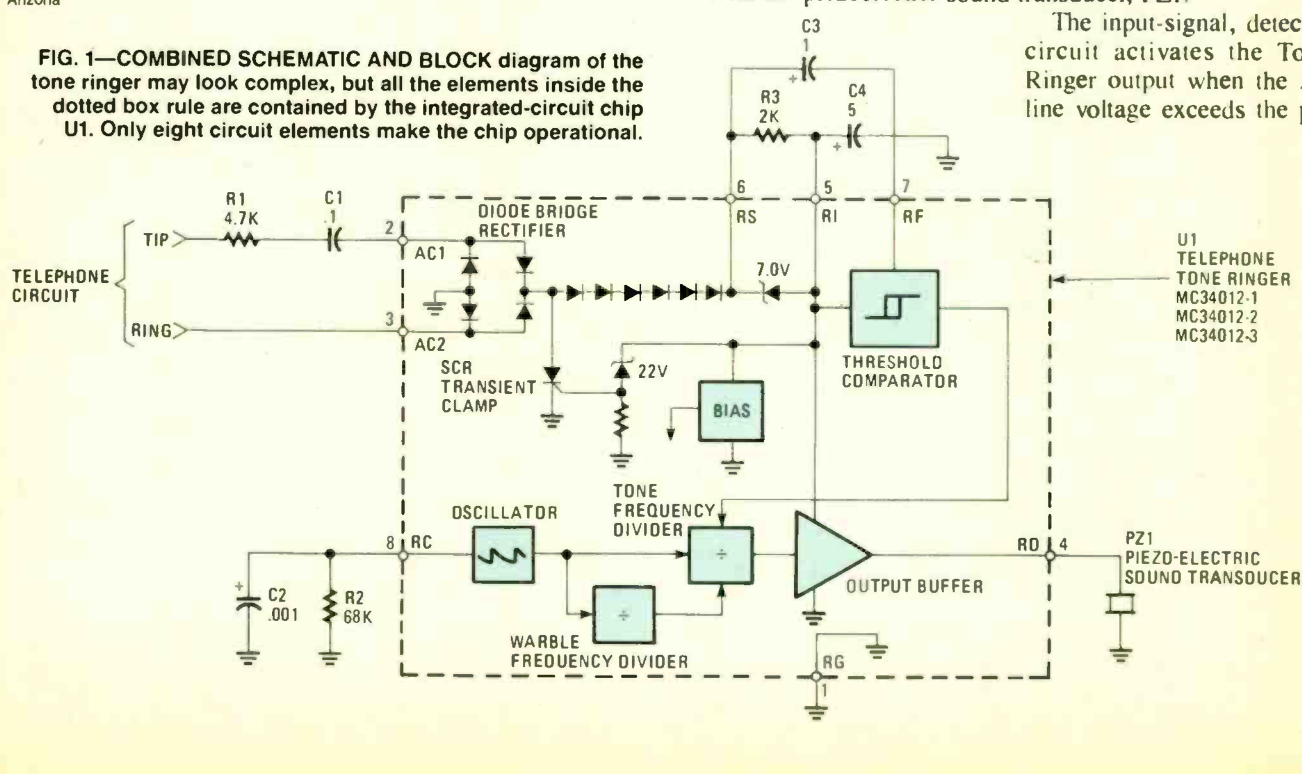
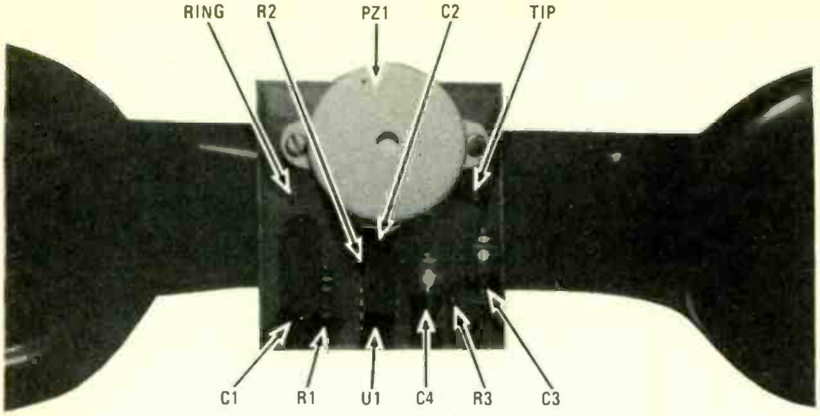


FIG. 1—COMBINED SCHEMATIC AND BLOCK diagram of the tone ringer may look complex, but all the elements inside the dotted box rule are contained by the integrated-circuit chip U1. Only eight circuit elements make the chip operational.



THE COMPLETED Tone-Ringer is smaller than the mouthpiece of a telephone handset. Connect the telephone line to the ring and tip terminals, and the project is ready for its first call. Install the Tone-Ringer inside your telephone, provided that you own it and there is ample space to house it.

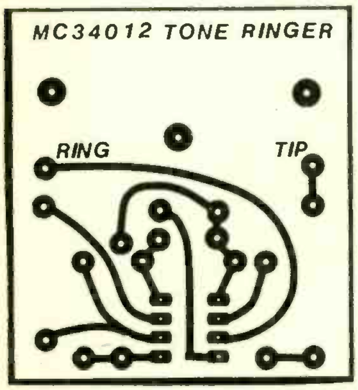


FIG. 2—PRINTED-CIRCUIT board layout is shown here same size. Should you plan to make one, then make ten or more for almost the same price and time. Your friends are sure to want a few.

grammed threshold level. The threshold is set to keep the ringer from sounding during dial pulse transients.

The MC34012 chip also contains transient protection to protect it from high-voltage spikes that can occur on telephone lines, and incorporates a bridge rectifier (polarity guard) on the input which allows the chip's tip and ring connections be reversed.

Ringer equivalence is a measurement that compares the electronic ringer's AC load impedance to a standard 500-series Bell telephone. The standard is 7000-ohms at 20 to 30 Hz. The Tone-Ringer's AC impedance, using input values of 4,700 ohms and 1 μF, is greater than 10,000 ohms. That results in a ringer equivalence of approximately 0.7A, and should be reported to the telephone company.

PARTS LIST FOR TONE-RINGER

SEMICONDUCTOR
PZ1—Toko PB-2720 sound transducer (Radio Shack 273-064, or equivalent)
U1—MC34012 tone-ringer, integrated circuit

RESISTORS
(All resistors are ½-watt. Refer to text for value ranges)
R1—4700-ohm
R2-68,000-ohm
R3—2000-ohm

CAPACITORS
(Refer to text for value ranges)
C1—1.0-μF, 200-WVDC, non-polarized
C2—0.001-μF
C3—1.0-μF, 10-WVDC, electrolytic
C4—5.0-μF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
Printed-circuit material, telephone cable, required plugs and jacks to tie into your phone line, plastic housing to contain project, wire, solder, hardware, etc.

Parts Value Ranges

Listed below are circuit-function descriptions of the external components connected to the MC34012 chip and the normal ranges they may fall into:

R1—Line input resistor—controls the Tone-Ringer input impedance. It also influences the ringing threshold voltage and limits excessive currents due to line transients. Range: 2000-10,000 ohms;

C1—Line input capacitor—couples the line's AC-ringing signal to the Tone-Ringer's MC34012 chip and determines the ringer-input impedance at low frequencies (5 Hz)—range: 0.4—2.0 μF (use 200-WVDC, non-polarized type);

R2—Oscillator resistor—range: 50,000-300,000 ohms;

C2—Oscillator capacitor—range: 400-2000 pF;

R3—Input-current, sense resistor—controls the ringing threshold voltage. Increasing R3 decreases the ring-start voltage. Range: 800-2000 ohms;

C3—Ringing threshold capacitor—filters the rectified supply voltage across R3 at the input of the ringing threshold comparator. It also provides dialer transient rejection. Range: 0.5-5.0 μF; and,

C4—Ringer supply capacitor—filters the rectified supply voltage for the tone generating circuits. It also provides an AC path for the 10-volt *rms* ringer signature impedance. Range: 1.0 to 1 μF.

Construction

The Tone-Ringer may be constructed on a perfboard or

(Continued on page 97)

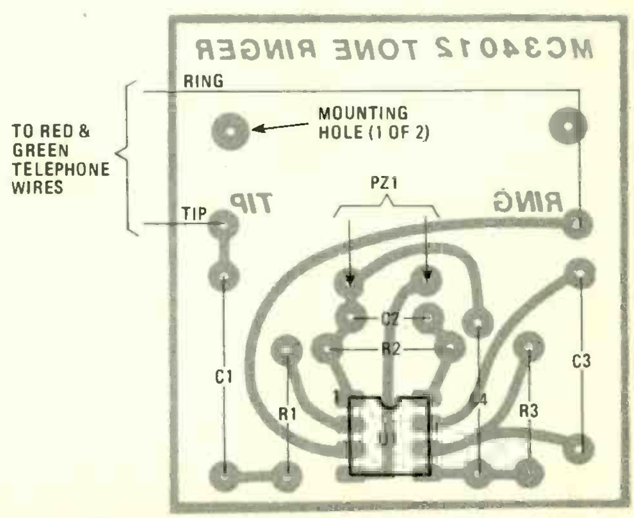


FIG. 3—X-RAY VIEW of printed-circuit board showing circuit parts location and external circuit connection.

SAXON ON SCANNERS

Welcome to the wide-world of Scanners

IT WAS INEVITABLE, THE INTERFACING of a scanner and a personal computer.

But Electra did it. Well, it was Electra (in 1968) who invented the scanner in the first place, so it was probably their destiny to come up with that absolutely fascinating marriage of those two devices. The Electra Company (300 East County Line Rd., Cumberland, IN 46229) calls that tantalizing innovation the Bearcat CompuScan 2100; they supply the scanner and the software—you provide the personal computer of your choice.

What does the CompuScan do? For starters, it's a 200-channel scanner that covers ten bands, including the 70-cm., 2-, 6- and 10-meter Amateur Radio bands, the VHF zero band, and the low/high/UHF and UHF-T public-safety bands. The channels you program into the CompuScan can be individually-custom tailored to your specific monitoring desires, such as assigning them levels of priority to permit you to bring the calls you want in the order of importance. You can also select special instructions for each programmed channel and the CompuScan will switch to a certain antenna, or turn on a tape recorder, per your commands for individual channels.

The monitor screen brings up a full tally on each channel you've programmed into the scanner, including its lockout or priority status, what that frequency is used for (and who is using it), and the number of transmissions monitored on that channel. You may even wish to program in the operating codes used by various agencies on certain channels!

A search feature permits you to have the CompuScan sort through large band segments to seek out new stations and active frequencies—and when it discovers a frequency you like, it programs that frequency into the computer's memory for more intensive study while in the scan mode.

Electra has prepared software to be used by virtually all of the popular personal computers, and (of course) you can use any antenna of your preference with the CompuScan. We saw it operating with a Commodore 64, and the software was on a single floppy disk. It was simple to hook up, easy to program and operate, and it performed like a champion. If you have a personal computer, here's a new dimension to add to it's usefulness. Those units are now on the market at dealers who carry the Bearcat scanner line. The name of the Bearcat dealer nearest you can be obtained by calling 1-800-SCANNER (It's a free phone call).

THE BEARCAT CompuScan 2100 comes with custom software on a *floppy*, custom interface cable, AC adaptor, plus a special telescoping whip antenna with 20-foot coaxial cable and mating BNC connectors.
CIRCLE 720 ON FREE INFORMATION CARD

TELEPHONES in vehicles operate in the 152 and 454 MHz bands. The recent commercial growth of on-the-road phones increases your scanning pleasure.

Eavesdropper Special

Do I have to tell you that wiretapping is illegal? They had to make it so because so many folks are fascinated by what other folks are saying *in private*. By a rather odd twist of fate, it seems that cordless telephones aren't covered by the privacy laws. What with cordless telephones so popular, you're probably within listening range of anywhere from 1 to a dozen such units; they're usually advertised as having a 700-foot range, but most can be heard for considerably farther than that: all it takes is a scanner and a good outside antenna! It's unbelievable what people say over those things. In fact, a Kansas police department was monitoring someone's cordless telephone frequency and they overheard the guy making a drug deal. They busted him, based upon his cordless phone chatter!

Older cordless telephones had the handsets operating in the 49-MHz region of the spectrum (within the frequency capabilities of all scanners) and the base (or pedestal) units operating between about 1600 and 1800 kHz. Just recently, the FCC announced new frequencies which go into effect in October (1984), and that means that your scanner will be able to monitor both sides of cordless-telephone conversations!

The new frequencies are shown in Table

SAXON ON SCANNERS

1. Note that the 49-MHz channels for the older-type cordless telephone handsets have been incorporated into those new allocations so there are presently stations operating on channels 2, 3, 5, 6, and 7 (handset frequencies only).

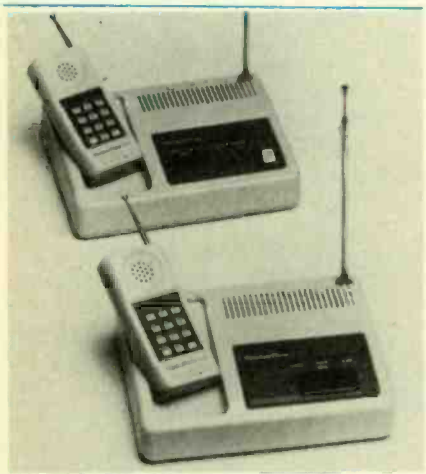
TABLE 1
New Cordless Telephone Channels

Channel No.	Base (Mhz)	Handset (Mhz)
1	46.61	49.67
2	46.63	49.845
3	46.67	49.86
4	46.71	49.77
5	46.73	49.875
6	46.77	49.83
7	46.83	49.89
8	46.87	49.93
9	46.93	49.99
10	46.97	49.97

Because the majority of users of cordless telephones don't seem to realize that they can be easily overheard, they are usually pretty free with their thoughts and words. By the way, the little hands-free FM communicators also operate on those same 49-MHz channels.

High Tone Monitoring

Speaking of monitoring phone calls, when those calls come from car telephones they are probably within the bands 152.51 to 152.81 MHz or 454.375 to 454.65 MHz. As pointed out by reader Randy McGuire of Dallas, TX, it's interesting to check those frequencies out to see which of the 23 channels is active in a given area.



A WHOLE NEW listening area for scanner owners is available. Cordless telephones are easily heard on your scanner. Don't believe the sales data about *up to 200, 500, 700 or more feet* of listening range. With a clear channel in your area, distances up to half-a-mile have been recorded.

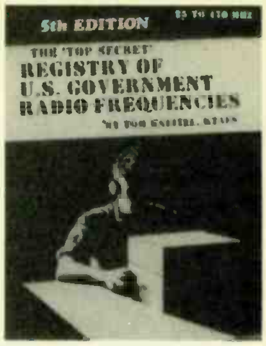
Once you find such a frequency, you're sort of stuck with it. That is to say, your scanner is more or less stuck on it, and he means literally, not in the romantic sense. Most of the base stations associated with such operations transmit a signal even when they are not actually handling a phone call; and more often than not there is a shrill and high-pitched tone superimposed on that carrier. It's like a dial tone, in a sense. In any event, as the man said, once your scanner locks on to such a signal, it just can't find the heart to leave it. That's because scanners are designed to hop to their next programmed frequency *only* when the signal to which they are tuned stops transmitting. Those signals are on continuously, like the NOAA weather stations on 162.55 MHz and other 162-MHz-band frequencies.

If you want to monitor those mobile phone frequencies, start out by entering the band limit in your scanner's search mode and finding out which are active in your area. (Just about every area has at least one or two, with larger metro areas having a dozen or more, and in both bands.) When you find the active frequencies, you'll probably have to endure the annoying high pitched tone between calls placed and simply sit on that one frequency, or else depress the scanner's *monitor* button manually to get it past that frequency so it can continue scanning. If you don't mind doing that, then you will probably find monitoring those stations pretty interesting.

Federal Stuff

Reader Jack Harrington of Los Angeles, CA says that he once read that FCC mobile units communicate on 41.06 MHz, but he's spent a lot of time monitoring that frequency and hasn't heard anything. My own experience is that your best bet would be to try 167.05 MHz on your scanner, because I think it has possibly replaced the 41.06 MHz frequency. At any rate, 167.05 MHz does appear to be active in many areas of the nation and repeaters are located in most (or all) FCC District Offices.

Jack advises that he especially enjoys monitoring the scanner frequencies used by various federal agencies. He has heard plenty of Coast Guard activity on 157.10 MHz, and also Dept. of Agriculture Forestry Service aircraft on 118.95 MHz. He does complain that he's had some difficulty in gathering frequency data on federal agencies, especially some of the more *interesting* ones, because such information doesn't show up in the various police/fire frequency lists available to scanner users. That's true; however, the many scanner owners avidly devoted to monitoring all federal agency frequencies have come to rely upon a really useful



SCANNING the federal frequency bands offers lots of excitement, but only if you know where to listen. This frequency directory tells all! Refer to the text for details.
CIRCLE 727 ON FREE INFORMATION CARD

book which lists about 60,000 frequencies, call signs, locations, and other data on those systems. It covers FBI, FCC, Secret Service, Border Patrol, Alcohol Tobacco and Firearms, Customs Service, federal prisons, Federal Marshals, NASA, FAA, EPA, *bugs* and surveillance frequencies, National Park Service, all military services, and more. That is a large 168 page volume called *The Top Secret Registry of U.S. Government Radio Frequencies*, by Tom Kneitel, K2AES. The recently updated 5th Edition is available at $14.95 (plus $2 postage) from CRB Research, P.O. Box 56-GK, Commack NY 11725. CRB also has a free catalog of all sorts of other fascinating and unique scanner directories, covering things such as railroads, aeronautical, survival, and similar communications.

For scanner buffs who want to expand their horizons into some really exciting areas, the federal stations are surely the way to go. Most people don't realize that more than half of the communications-frequency spectrum between 30 and 512 MHz is reserved for the exclusive use of federal-agency communications! Without sufficient information on what's going on there, your 8-cylinder scanner is only running on 3 cylinders, so to speak.

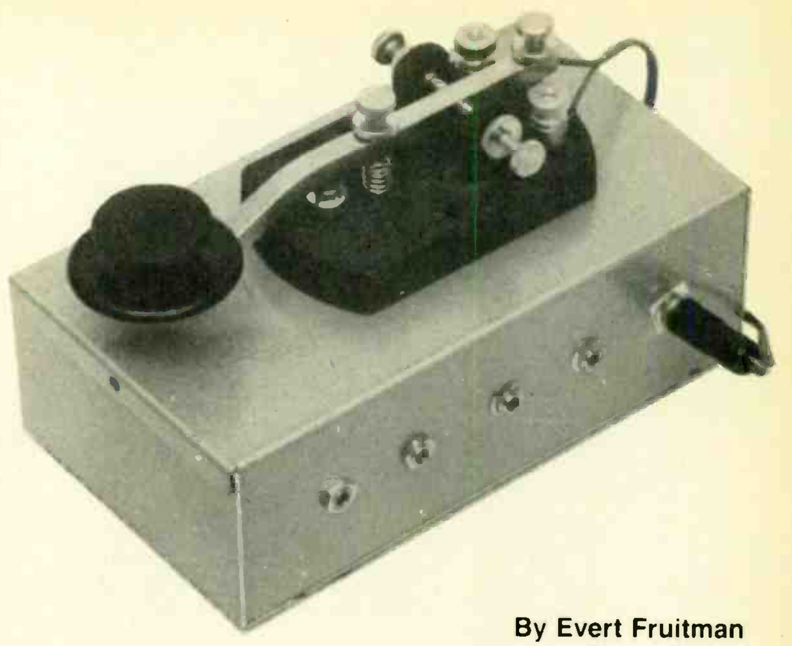
Helping Hands

Many police and fire agencies have come to find that their operations are enhanced by cooperative arrangements with similar agencies in other cities or counties. The way that they communicate with one another is by means of Mutual Aid frequencies, and it's usually worth programming such frequencies into a scanner to see what they have to offer in the way of traffic.

While some agencies don't make use of such communications, and some that do have them established on uncommon channels, there are certain Mutual Aid frequencies which appear to be rather

(Continued on 94)

Quick Code Practice Oscillator



By Evert Fruitman

Morse Code proficiency comes quicker when you pound and hear the key!

THE *HMS TITANIC* WAS ONE OF THE FIRST OCEAN-GOING vessels to use the then newly standardized wireless distress call, **SOS*. Of course the shipboard radio operator sent it by Morse code, because that was many years before two-way voice communication became a practical reality. To this day, ships at sea and the Coast Guard still monitor certain channels on a regular basis for distress traffic. International law still requires a working knowledge of International Morse Code for those radio operators who sail (or motor) across the ocean.

Almost-painless ways to learn the International Morse Code abound. You can make it even more enjoyable by building some of the equipment yourself. That way you can learn some theory as you learn the code. I went down that road myself with a vacuum-tube *c*ode *p*ractice *o*scillator (CPO). In addition to the code, I started learning vacuum-tube theory, transformer theory, and troubleshooting techniques!

Thanks to modern technology, we have a simplified code-practice oscillator that is a fun project and won't overdose us with theory.

The common *clock* oscillator found in computer circuits forms the basis for the Quick Code Practice Oscillator. That basic circuit (Fig. 1) can operate from the low-megahertz frequencies to the subaudible region. (Down there it runs so slowly that you could use a light bulb to tell when the gates turn on and off.) We will pick our circuit values so that it operates in the audible region.

A transistorized oscillator by comparison, would need more parts before it could drive low-impedance earphones or speakers. The inexpensive 7404 hex-inverter integrated circuit (Fig. 2) chosen for this project has enough amplification to handle a wide range of transducers. Some of that amplification connected in a closed (positive) feedback loop produces an oscillation (a tone) in the audible range. Connect that to an earphone and chop the tone up with a telegraph key (via jack J1) for instant code practice. The resistors in the circuit are 2200-2700-ohm values.

Closing the key completes the battery circuit and applies four to five volts to the 7404 chip. See Fig. 1. The battery, B1, is a 4.5-5.0-volt DC unit. Bias for the first two inverter amps (U1-a and U1-b) comes from the two resistors, R1 and R2, connected between their inputs and outputs. The capacitor and rheostat control (R3/C1) close the feedback loop from the input to the properly-phased output. The signal leaving U1-b drives the remaining four inverter amplifiers, U1-c through U1-f; they, in turn, drive the phones or speakers.

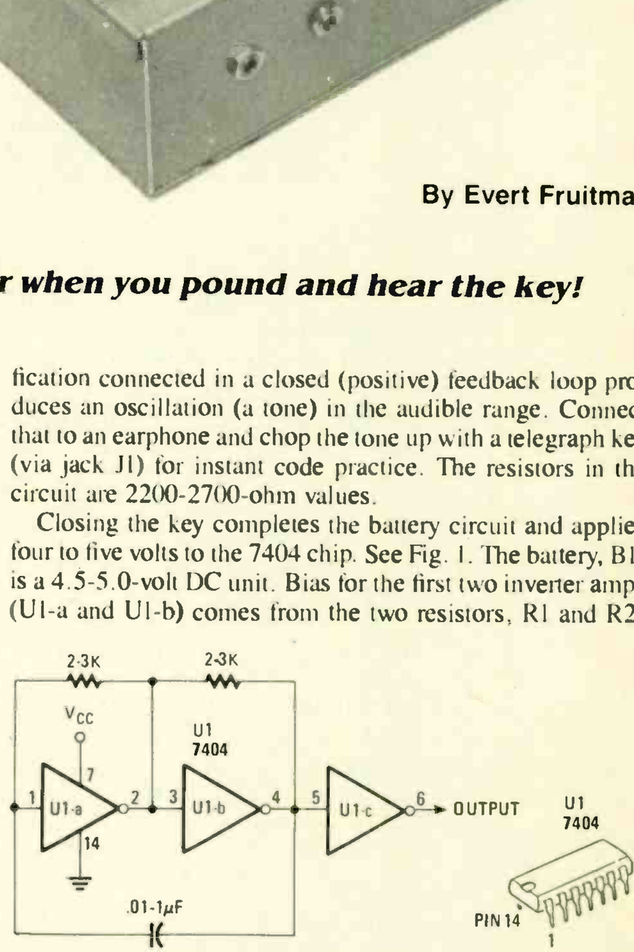
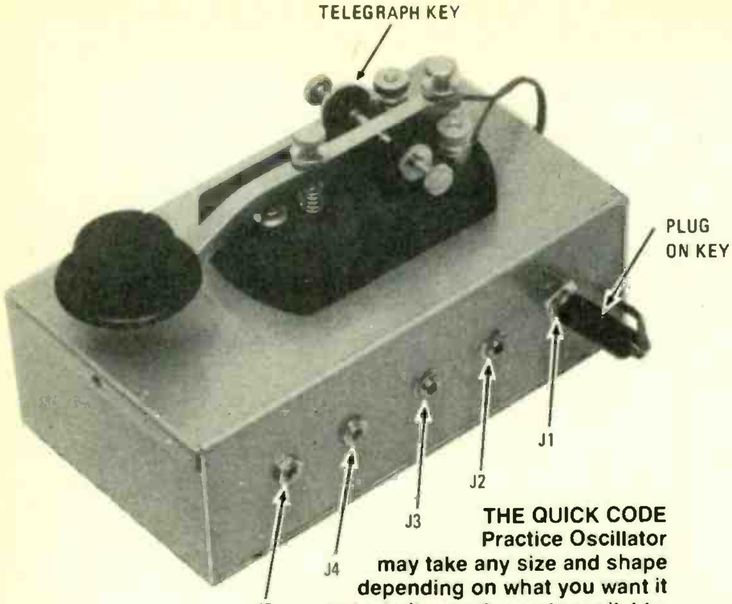


FIG. 1—BASIC SCHEMATIC DIAGRAM of an audio oscillator with buffer that can be used as the tone element of a code practice oscillator. Key may be inserted in V_{CC} line.

The volume control potentiometers, R4-R7, (Fig. 2) may have any value from 1500 ohms to 10,000 ohms. The smaller values work best when speakers, or low impedance phones, are used.

Although the IC manufacturer recommends 5.00-volts ±0.5-volt power sources, and loads no smaller than about 250 ohms, I have had no trouble using three penlight cells for power, and 8-ohm speakers for the loads.

*Actually, the *Titanic* sent both SOS and CQD (Come Quick—Disaster) Morse code calls. The SOS call was approved for international use at a Berlin conference in 1908, and it took a few years for all nations to accept the new standard distress call—SOS.



THE QUICK CODE Practice Oscillator may take any size and shape depending on what you want it to look like, or the parts available.

TABLE 1—INTERNATIONAL MORSE CODE

A ·—	N —·	1. ·————
B —···	O ———	2 ··———
C —·—·	P ·——·	3 ···——
D —··	Q ——·—	4 ····—
E ·	R ·—·	5 ·····
F ··—·	S ···	6 —····
G ——·	T —	7 ——···
H ····	U ··—	8 ———··
I ··	V ···—	9 ————·
J ·———	W ·——	0 —————
K —·—	X —··—	
L ·—··	Y —·——	
M ——	Z ——··	

. (period)	·—·—·—
, (comma)	——··——
? (question mark) (IMI)	··——··
/ (fraction bar)	—··—·
: (colon)	———···
; (semicolon)	—·—·—·
((parenthesis)	—·——·
) (parenthesis)	—·——·—
' (apostrophe) (WG)	·————·
- (hyphen or dash) (DU)	—····—
$ (dollar sign) (VU)	···—··—
" (quotation mark open)	·—··—
" (quotation mark close)	·—··—·
Error sign (8 dots)	········
Separation indicator (BT)	—···—
End of transmission (AR)	·—·—·
Invitation to transmit	—·—
Wait (AS)	·—···
End of work (SK)	···—·—
Starting signal	—·—·—

Construction

Most of the parts mount on the chassis box. The IC socket, bias resistors R1 and R2, and feedback capacitor C1 reside on a small piece of perforated board. Insulate the key jack, J1, from the (metal) chassis. Miniature plugs and jacks make convenient and economical connectors. If I didn't have a chassis box left over from another project, the project most likely would have found itself in a plastic 3- × 5-in. card file box, with 6-32 machine screws serving as binding posts.

Use any form of construction that you find convenient. Use only one volume control if you don't plan on group study. If one or more of the hex inverter amplifiers is not used, leave the input and output pins disconnected. Do wire the second inverter amplifier output (pin 4) to the third inverter amplifier (pin 5); the latter serving as a buffer stage. That gives the oscillator section good isolation from the load. Mount the controls and the jacks on the panel, then wire the circuit board to them. A small piece of perforated board holds the few parts that don't mount on the chassis. The resistor and

(Continued on page 101)

PARTS LIST FOR QUICK CODE PRACTICE OSCILLATOR

B1—4.5-5.0-VDC (See text)
C1—.27-µF, disk capacitor
J1-J5—Two-circuit jacks, phone or miniature type
R1, R2—2200-2700-ohm, ½-watt, 10% resistor
R3-R7—1500-10,000-ohm potentiometer, any taper
U1—7404 TTL hex inverter integrated circuit
Telegraph key, aluminum chassis box, wire, solder, hardware, etc.

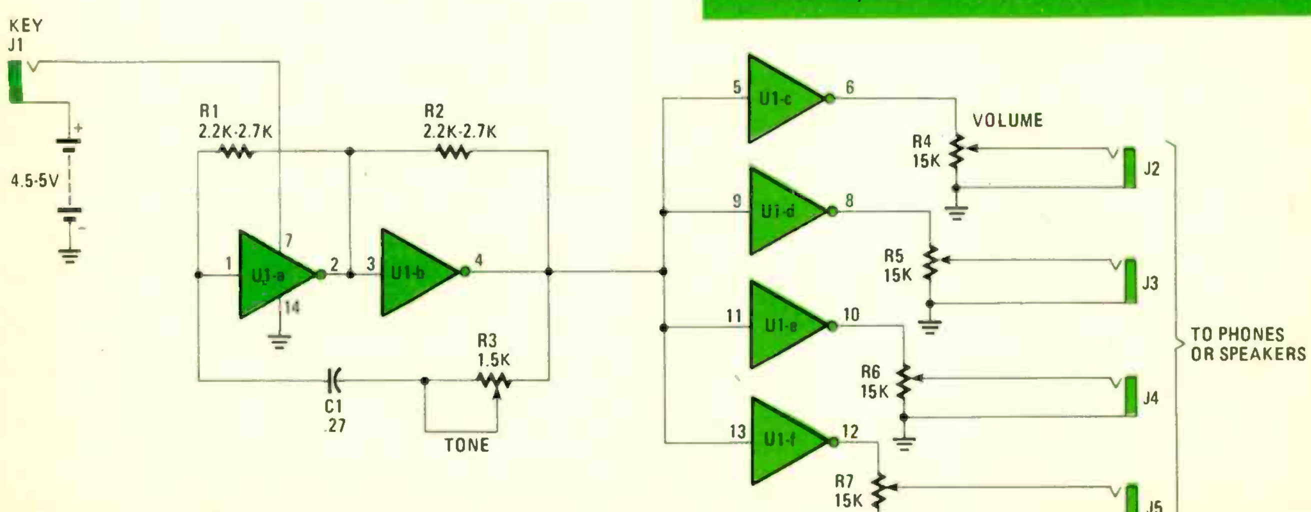


FIG. 2—YOU'LL SPEND MORE TIME drilling holes in the chassis box when assembling the project than soldering the circuit components together.

DO-IT-YOURSELF DISK EMULATION FOR THE RS MODEL 4

By Herb Friedman

Why wait for your disk drive to clinkity-clink while retrieving and storing data from a floppy, when it all can be placed in RAM that is configured to function as a disk and do the job in nanoseconds!

ONE OF THE MAJOR FEATURES OF THE LATEST, HIGH-PERformance, personal computers is something called *disk emulation*, or *RAMdisk*, meaning RAM memory that functions as a disk drive. Disk emulation provides essentially instantaneous data and program access, because there's no mechanical movement involved with searching out the desired data.

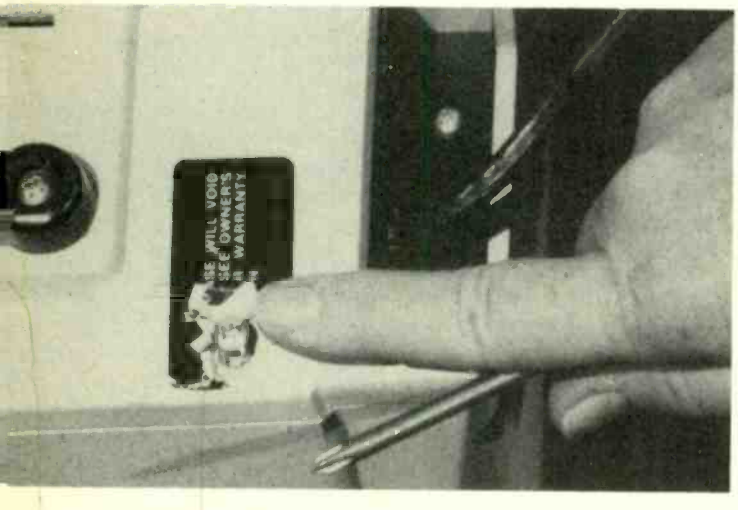
As a general rule, the computer itself doesn't come with the feature. Either it has the capability for RAMdisk, meaning that there are *unpopulated* (meaning *empty*) sockets for the required IC's, or there's an optional plug-in accessory board containing the necessary circuits and sockets. Either way, the cost of components and installation is often well beyond what the budget can stand. If your computer has the inherent capability for RAMdisk (as Radio Shack's Model 4 has) anywhere from 25% to almost 50% of the usual upgrading cost can be saved if you do the upgrade yourself. That usually consists of no more than plugging the right chips into a matching empty socket.

A do-it-yourself upgrade of Radio Shack's Model 4 computer shows just how easy it is, and the kind of savings that can be made. The Model 4 can address 128K of RAM memory in two banks of 64K. It is normally supplied with 64K; the additional 64K is optional. Normally, any part of RAM can be software-configured to function as a disk; but if we start dividing 64K into bits and pieces there isn't room to do much of anything. With 126K of RAM, however, if 64K is used for normal functions, that leaves 64K either for use as RAMdisk, or for use as straight additional RAM...and you can run a lot of in-memory data files in 128K of RAM.

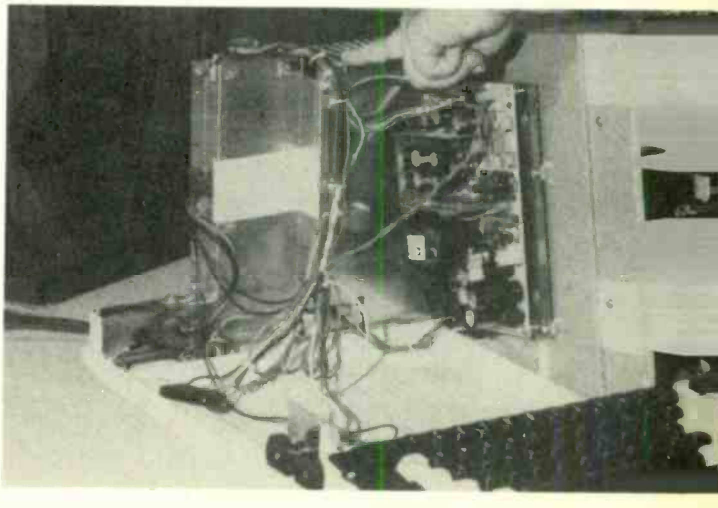
But factory-authorized RAM upgrades don't come cheap! For example, RADIO Shack charges $149 for the 64K RAM upgrade chips, plus an installation charge of $15; total: $164. As you might imagine, $15 represents about 20 minutes work. Since you're not all that skilled when it comes to Model 4 servicing, it would take you about one-half hour. And what would you save? About $75, because you can purchase the complete upgrade package, consisting of only nine IC's, from aftermarket vendors for $89 or less. Of the nine IC's, eight provide the additional 64K of RAM; the ninth is called a *PAL*, a device that handles the bank switching.

Going About It

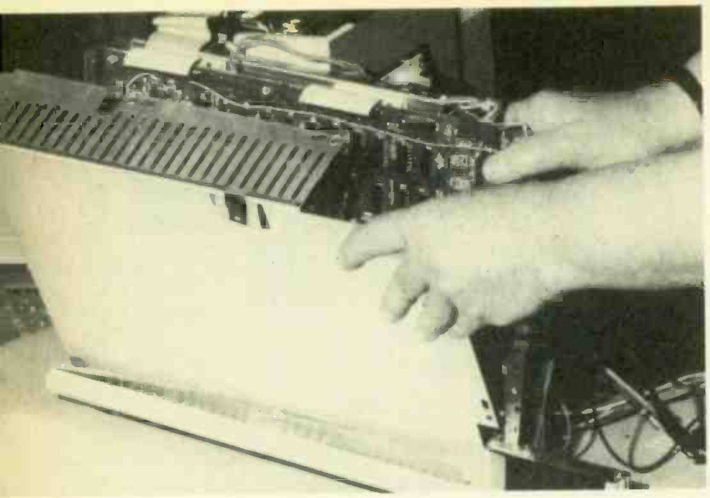
The photographs show how to handle the upgrade of a Model 4 computer. Other computers are physically different,



DON'T DO ANY do-it-yourself retrofits of a computer until the warranty expires. Then you can break the *seal* to get across at one of the screws that secures the cabinet. Fool around before and you may have to pay the piper!



IN RADIO SHACK'S MODEL 4 computer the main chassis containing the RAM IC'S is in the metal box at the rear. Other computers have this portion of the circuitry on the *mother* board, and that board may be completely removable.



VERY CAREFULLY, so you don't disturb any internal plugs and connectors, remove the shield cover from the main chassis. Keep a log of the disassembly procedure so that you can restore your computer to a whole state.

but the general idea is the same. Keep in mind that upgrade kits are supplied with specific instructions for the kind of computer you may own.

The first step is to remove the cover, that is usually not a problem, though you must be certain that there aren't components attached to the cover. On the Model 4, one of the attaching screws is directly on top of the cover; another is concealed behind the warning-label *seal* that states you void the warranty if you break the seal. Since your computer is probably out of warranty by now, go ahead and lift, or puncture, through the seal.

Lift the cover off gently. *Aha*! The CRT assembly and its circuit board are attached to the cover, and there is a wire bundle from the main circuit board to a connector on the cover. Mark the connector with a grease pencil, so you know which side goes where, and carefully slip the connector free. Do not free the connector until you have made your mark! While the connector is normally polarized by a small internal strip of plastic, on *your* computer the plastic might be missing, or not even provided. Finally, set the cover aside.

Locate the main computer area. To prevent RF radiation, it's generally located within a metal shield. On the Model 4 it's the rectangular metal box at the rear of the main unit. Remove the shield's screws and carefully lift the cover clear. Take note that if any wiring gets disturbed when you remove the cover, because there might be a connector at the end of the wire, and internal computer connectors are notoriously *loose*, easily disturbed.

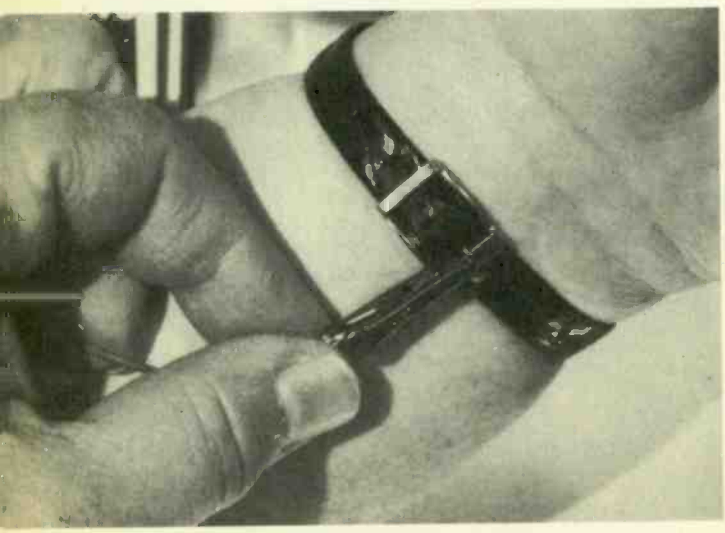
Look at the rear of the main board and you will find eight unpopulated (empty) sockets for memory expansion. Regardless of the type of computer you have, the unpopulated sockets will most likely be immediately adjacent to the main RAM. The RAM IC's in your upgrade kit will go in those sockets. (If your computer takes more than 64K of RAM you will probably have eight sockets for each 64K of RAM.)

Somewhere there will be a jumper plug or plugs that control the RAM addressing. Your upgrade kit will usually be provided with instructions on what jumpers are to be changed, or—as in the case of the Model 4 computer—you will replace a DIP jumper plug with an IC. In the Model 4, a four-position DIP jumper is installed in the lower half of socket U72, which is located near the bottom center of the main board.

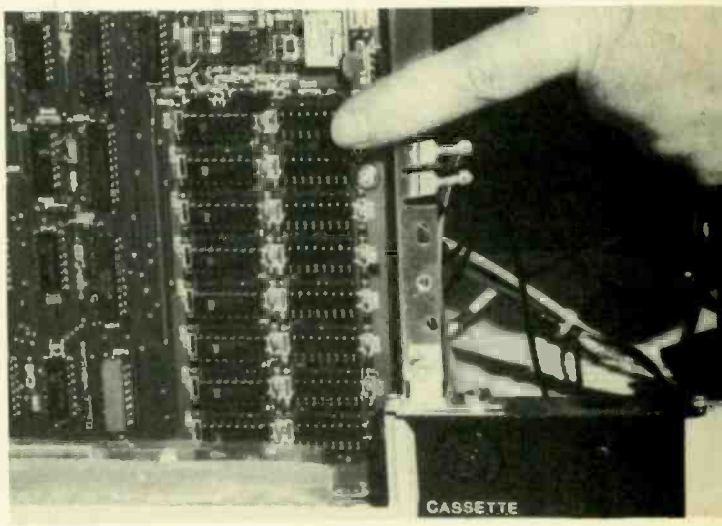
Installing the Chips

The CMOS RAM IC's are extremely sensitive to static electricity, and just one touch is all it takes to zap an IC; so you *must* be grounded before you touch either the IC's in the upgrade kit or anything on the main computer board. A safe ground is made by attaching a small alligator or crocodile clip to a thin insulated wire which is in series with a 1-megohm ¼- or ½-watt resistor. The free end of the assembly is connected to an electrical ground,, such as the cover of an electrical outlet which you know for certain is grounded. As a general rule—but check the outlet, anyway—if the receptacle has only two slots for a *parallel-blade* plug, the receptacle box is probably not grounded. If the outlet is the U-ground type, the box is probably—but not necessarily—grounded (there *are* sloppy electricians). The ground strap assembly construction details are shown in Fig. 1.

If you have U-ground outlets, that 1-Megohm resistor can



BEFORE TOUCHING any IC, either in the computer or in the upgrade kit, attach a ground clip to your watchband's metal part. If you don't usually wear a watch, wear one for this job. The text covers the construction details of this assembly.



THE ROW OF EMPTY SOCKETS accommodates the additional new RAM IC's. Those sockets are located immediately adjacent to the sockets filled with the factory-installed RAM IC's. Check the instruction sheet for different computers.

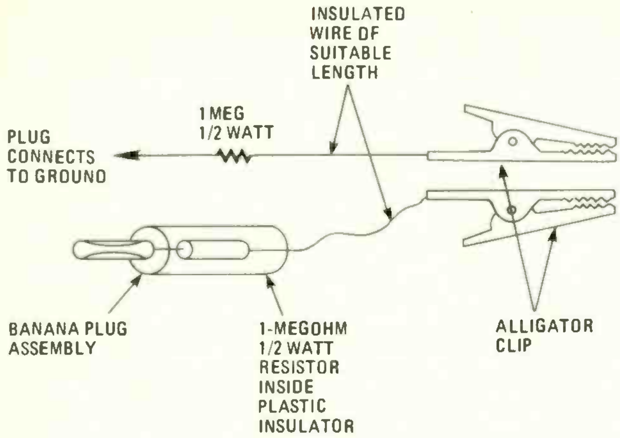
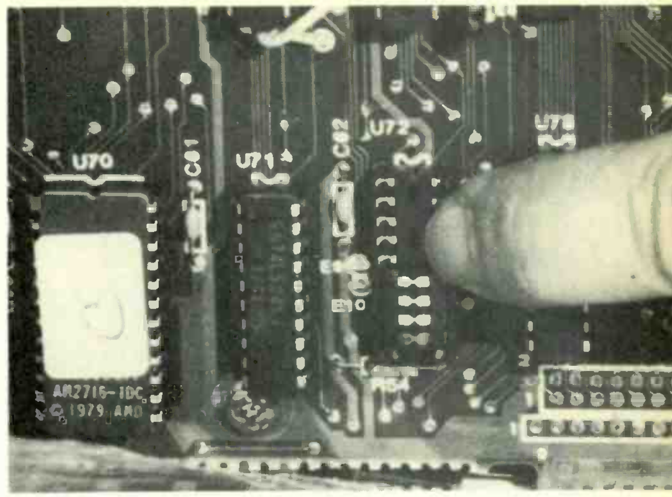


FIG. 1—A GROUNDING STRAP is required to handle CMOS IC's. A banana plug can be inserted into the U-ground terminal of an AC outlet. Should no 3-terminal outlet be available, use a water pipe or other good, metallic ground.



FINGER POINTS to the DIP-jumper plug that occupies part of an IC socket. Mark the DIP's position within the socket (it takes up part of the socket) somewhere on the chassis for future reference, and then substitute the supplied *PAL* chip.

be installed inside a banana plug. If you expand the sleeve of the plug with the blade of a knife, it will plug into the ground connection of a U-ground outlet. (No, it can't plug into a *hot* connection, because the banana plug won't fit into a blade opening.)

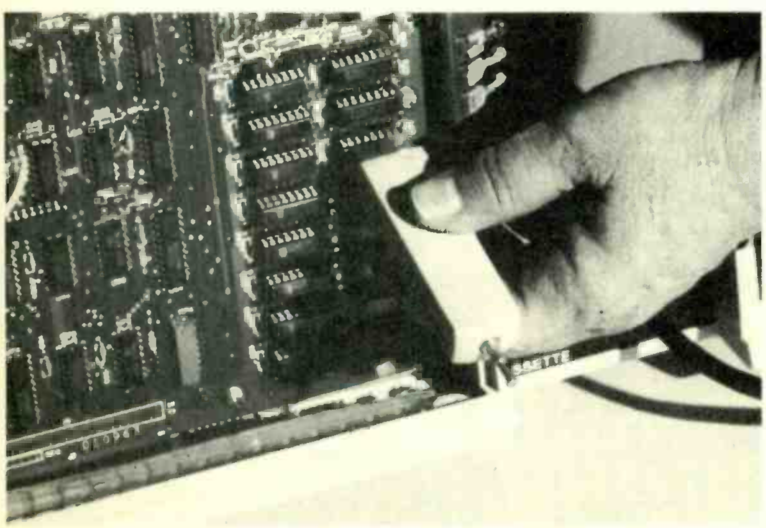
Making certain you have the IC's positioned correctly—usually the notch at one end of the IC's all face the same direction—carefully insert the RAM chips in their sockets. Usually, the IC terminals are flared and are wider than the spacing of the socket's terminals. Don't try to force the IC terminals straight as you insert the chip, because that's a sure way to end up with one or more terminals folded under the chip. Straighten the IC terminals with long-nose pliers, or an IC-terminal tool, before you try to insert the chips. Also, if possible, use an inserting tool when installing the chips; it keeps the terminals in alignment. (But there's no need to buy one if you don't already own one.)

Finally, locate the DIP jumper, which uses only part of the *PAL* socket, and carefully note for future reference where it is located in its socket. Mark its location directly on the chassis, because you might need the information if you ever need to remove the upgrade.

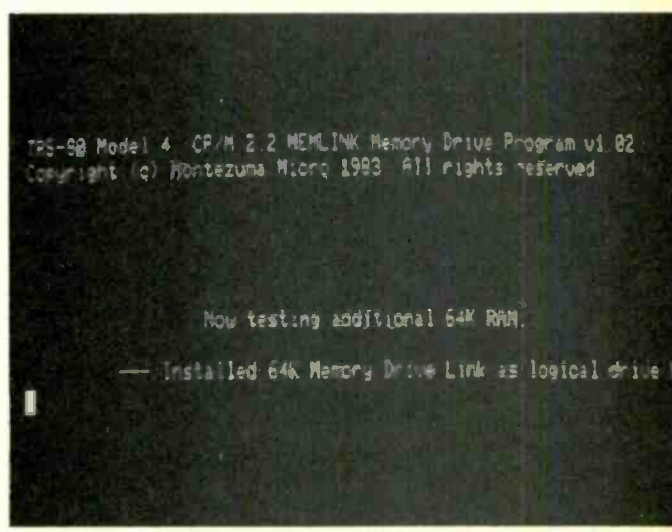
Position the notch on the PAL chip as shown in the supplied instructions and plug it in. That's it; the RAM upgrade is completed.

Checkout

Some means to check the additional RAM is usually provided with the computer's operating system. Often, it's done by taking a check of available memory, or an actual separate test of the additional RAM is run. In the case of the Model 4, which is used with Montezuma Micro CP/M, a separate utility program supplied with CP/M automatically tests the 64K RAM and then partitions the full 128K of memory into 64K user RAM and 64K RAMdisk. Radio Shack's own operating system allows user utilization of the complete 128K of RAM, and permits any amount of RAM to be partitioned as a RAMdisk. ■

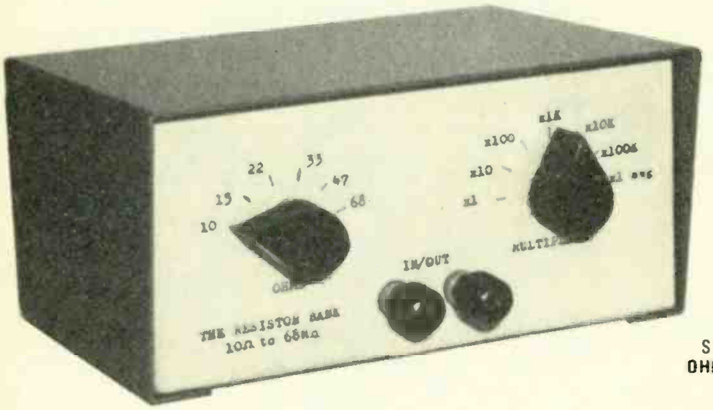


INSTALL the upgrading RAMs very carefully, so that a pin terminal does not fold under the chip. If possible, use an IC inserting tool to be certain that the IC pin terminals are kept in perfect alignment with the socket during insertion.



REASSEMBLE the computer, and then run your test program. The display on the screen from the Montezuma Micro CP/M DOS shows that the user-installed 64K has passed its test and has been configured to function as RAMdisk (drive M:).

RESISTOR BANK



- **Pick the right resistance to complete the transistor bias network**
- **Find the replacement for a burned out, or otherwise illegible, resistor**
- **Select the frequency determining resistor for an R-C oscillator**
- **Determine a pot's paralleling resistance to trim to a selected value**
- **Check your ohmmeter's readings**

By C. B. Ohman

ONE OF THE MORE USEFUL TEST-BENCH INSTRUMENTS FOR the electronics experimenter is a resistance substitution box. The one described in this article—we call it the Resistor Bank—is unique in its convenience and ease of operation. What makes the device so useful? The Resistor Bank is useful in selecting the right resistance to complete a specialized-biasing network. It is useful for finding the right replacement for a burned-out, or otherwise illegible, resistor. It's ideal for selecting the frequency-determining resistor for an R-C oscillator. The Resistor Bank lets you check an ohmmeter for correct ohmic indication throughout the meter's many ranges. See how handy it is to determine the required paralleling resistance to trim another resistor to a desired value. Other opportunities for unusual applications for the device will suggest themselves once you make the unit and have it at the ready on your test bench

Had the Resistor Bank been a commercial unit, the engineering specification sheet would probably read something

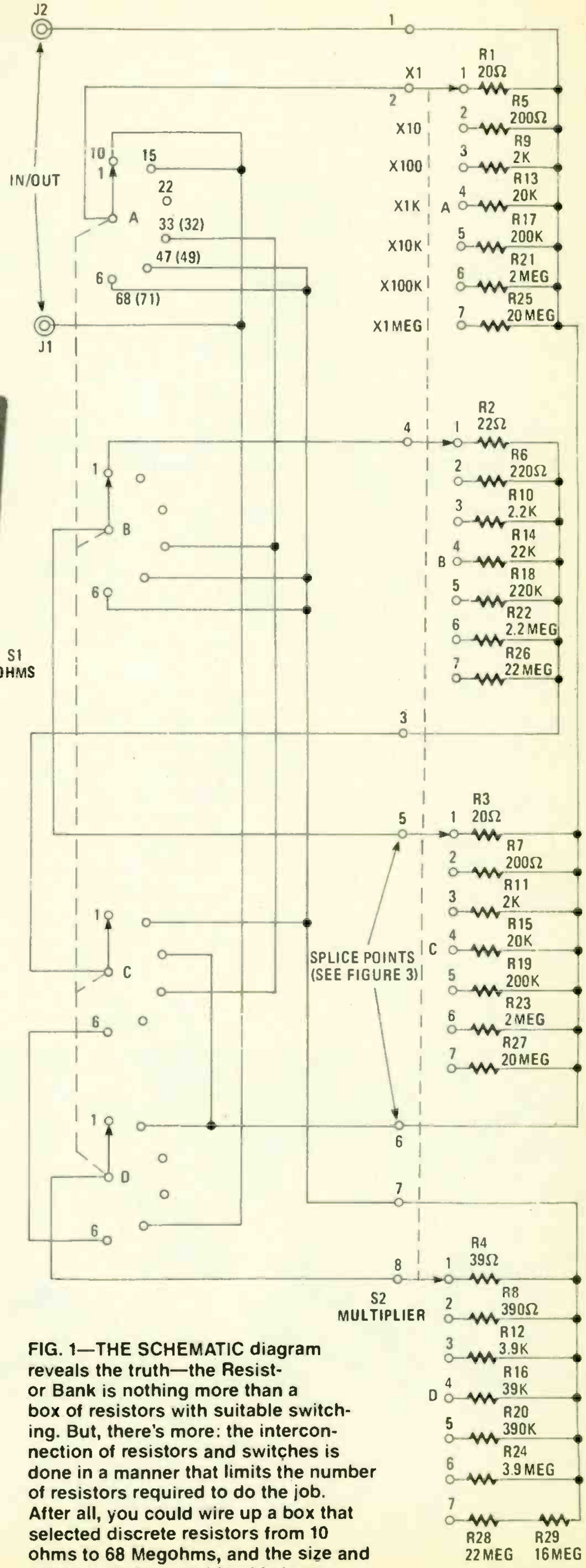
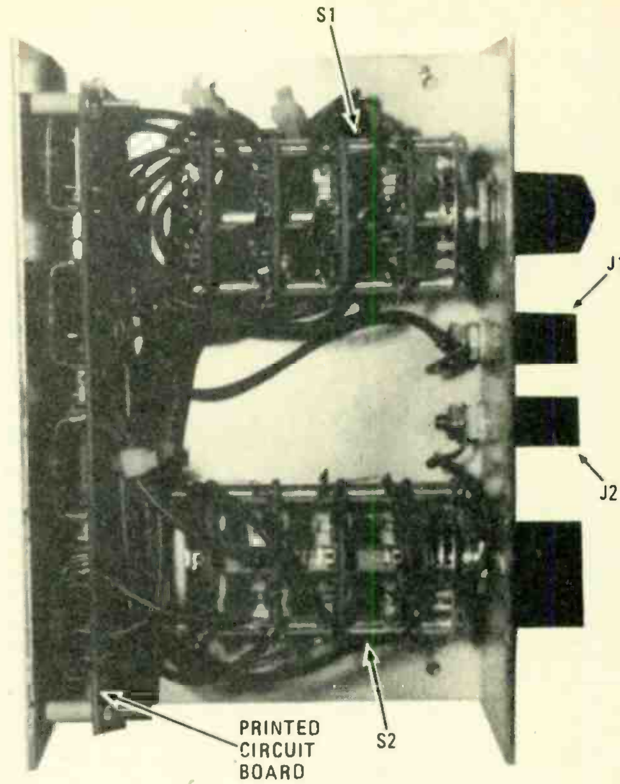


FIG. 1—THE SCHEMATIC diagram reveals the truth—the Resistor Bank is nothing more than a box of resistors with suitable switching. But, there's more: the interconnection of resistors and switches is done in a manner that limits the number of resistors required to do the job. After all, you could wire up a box that selected discrete resistors from 10 ohms to 68 Megohms, and the size and price would be considerably larger.

like this:

Specifications: *Ranges*: 7 decades (10-68 ohms, 100-680 ohms, 1K-6.8K, 10K-68K, 100K-68K, 1 Megohm-6.8 Megohm, 10 Megohms-68 Megohms). *Readings and Accuracy*: 6 selections per decade. ±5% resistors simulate a logarithmic progression (10, 15, 22, 32, 49, 71). Panel markings are to the nearest standard resistor values. *Internal Connections*: Series and/or paralleling to produce 42 outputs from 29 resistors. *Voltage Rating*: 500-volts AC or DC. Basically limited to 1-watt resistor heat dissipation, up to a maximum set by component ratings. Permissible voltage varies from 4.5-volts, as tabulated on instrument instruction plate. *Size*: Optional. Prototype is 6-in wide × 3-in. high × 4-in. deep. *Shipping Weight*: 1.5 pounds, approx.

There are seven groups of resistors, one for each resistance "multiplication" setting group. Refer to Figs. 1 and 2. Each group is made up of four resistors, two of different values and two of the same value. One group has five resistors, where two resistors simulate a single, unavailable resistance value. MULTIPLIER Switch S2 selects the group to be used, then (OHMS) switch S1 connects in series or parallel those resistors in the selected group. The resulting outputs conform to close approximation of the standard logarithmic progression. The 29 resistors provide a total of 42 outputs, from 10 ohms to 68 Megohms. Fig. 2 offers several simplified diagrams that indicate how resistors are selected and connected and the mathematics related to their summation.



HERE IS THE INSIDE VIEW of the author's Resistor Bank. The printed-circuit board is mounted off the rear surface of the chassis box on spacers. Switches were pre-wired before mounting and then soldered to the foil surface of the printed-circuit board which faces front. In truth, how you do it is your business, which in turn depends on the materials you have available and the intended use. You may want to build two units with one wired into your testbench top or panel for availability on all test and repair jobs. The other you can put in your portable test case.

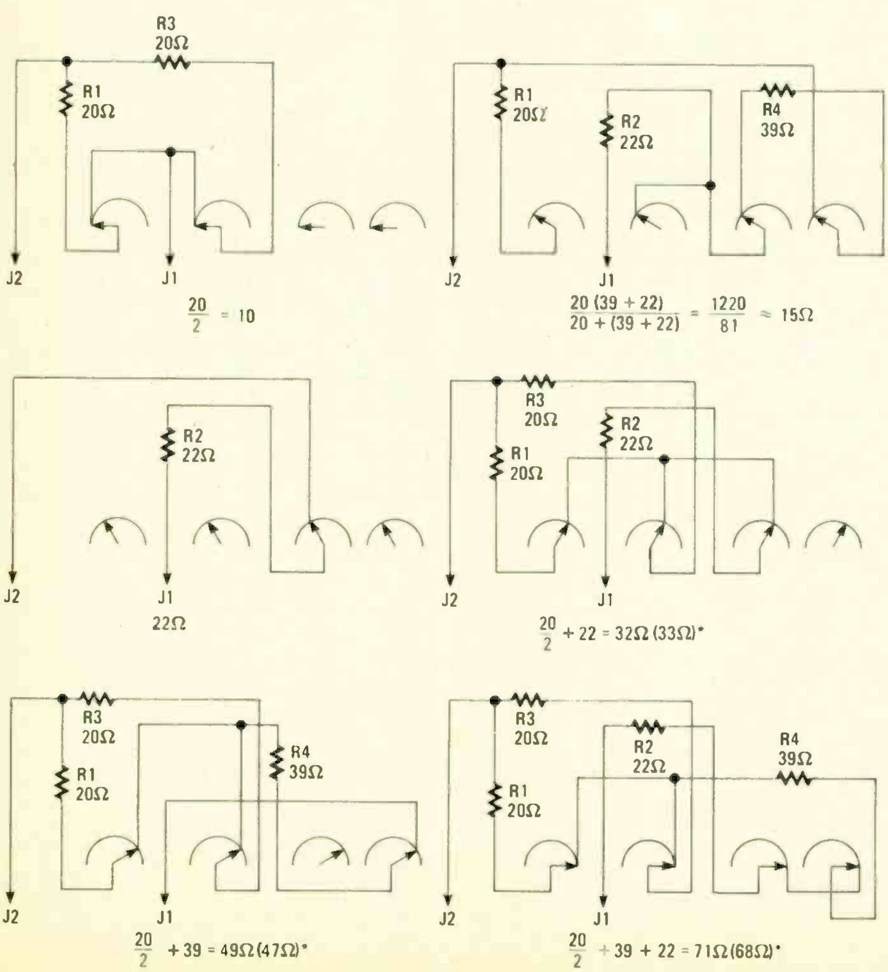


FIG. 2—SIX SIMPLIFIED diagrams illustrate with attending mathematics the techniques used to obtain six discrete resistance values. To obtain 10 ohms, two 20-ohm resistors are placed in parallel; 15 ohms, 20 ohms is paralleled with 22- and 39-ohms in series; 22, only one resistor is used; 33 ohms, approximated with the 10-ohm circuit in series with 22 ohms; 47 ohms, approximated with the 10-ohm circuit in series with 39 ohms; and, 68 ohms, approximated with the 10-ohm circuit in series with 39 and 22 ohms. Hand selecting a 39-ohm resistor that actually measures 37 ohms would bring the 47- and 68-ohm ranges right on the money and introduce a small unnoticeable −.4 percent error in the 15-ohm range compared to a previous +.4 percent error. In either case—peanuts!

Construction

Parts used can be obtained from the junkbox if yours is well stocked. You will probably have to buy all or most of the ±5%, 1-watt resistors. You'll find them at an electronics parts supply house or in a mail-order catalog. Refer to the Parts List for a kit supplier.

A mail-order catalog is a good source for the rotary wafer-type switches, S1 and S2. Either shorting or non-shorting contacts (or a mixture) will do; but, if you are buying the switches, specify shorting-contacts for both switches to avoid presenting an open, or pulsed circuit to the external circuit.

Figure 3 diagrams the actual wiring. The Resistor Bank printed-circuit board can be composed of fiberglass, or the less expensive phenolic material. Resist circles, resist pen and etchant are the only other materials required for the printed-circuit fabrication. Wire used may be small gauge, say 24 AWG, since current-carrying capacity is not a factor; solid conductor is the easiest to handle.

You could generate a printed-circuit board for the Resistor Bank directly from Fig. 3. If you prefer, use perfboard and flea clips to simulate the same layout. Some builders may try to assemble the resistors directly to the switches, which is a *big mistake*. The heat of the soldering iron may damage the switch—that would be costly.

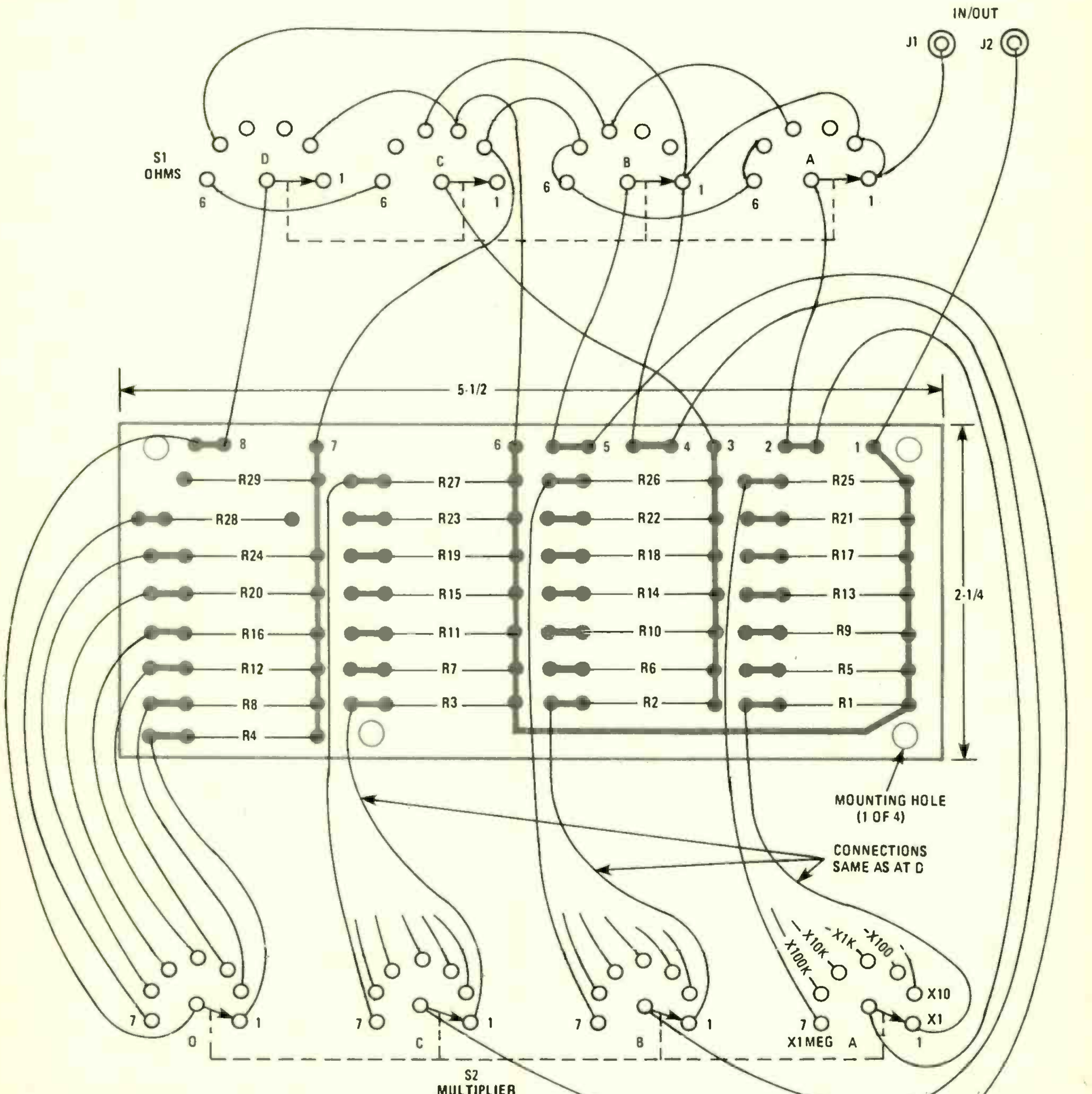
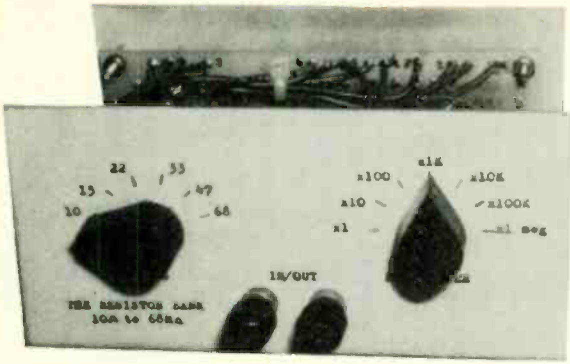
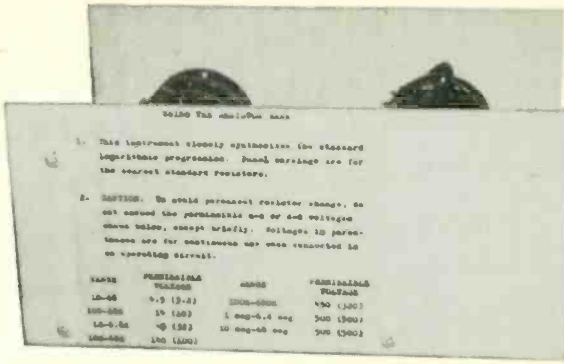


FIG. 3—THE PROJECTS's wiring diagram is shown here with the foil shown right-side up and full size. Switch terminals are shown as viewed from inside the box since that is where you will do the wiring. It would be a good idea to use colored ribbon cable. Wire the switch wafer closest to the printed-circuit board first, and then repeat procedure for each switch section duplicating that effort. Trace the printed-circuit foil pattern from the page to make your board and mount resistors on the non-foil side.





TWO VIEWS of the author's Resistor Bank. The front panel was suitably marked by typing switch settings on paper and cementing the paper to the panel. A typewriter eliminated the need for decals, but you may want to be a bit fancier. The rear panel presents some operating information gleaned from the text.

The packaging of the project is up to you! You may prefer a home made box, a professional-styled cabinet, or no box at all. The author used an LMB-463 aluminum box. Panel treatment is optional. The faceplate on the prototype Resistive Bank shown in the photos was made by typing on paper. The layout was first drawn by hand, then the legends and wording were done on the typewriter. The finished product was cemented to the box's front panel. The faceplate was given several coats of spray from a can of clear lacquer. Rubber feet were added to the unit so that the front panel tilted up to the face of the technician using the instrument.

The use of the Resistor Bank requires only connection into the circuit via binding posts J1 and J2, then setting switches S1 and S2 to the desired resistance. The user selects the significant digits (OHMS), then sets the desired range (MULTIPLIER) from X1 to X1 MEG.

Protection against exceeding allowable resistor wattage (and the consequential danger of permanent resistor change) is assured by staying within the permissible voltages presented in Table 1. Those voltage limits should be included on an instruction plate attached to the rear or top of the Resistor Bank, so as to be a reminder. The same caution applies as for any resistance-substitution box: Do not to exceed the power rating of the internal resistors.

PARTS LIST FOR RESISTIVE BANK

RESISTORS
(All resistors are 5% tolerance, 1-watt, composition fixed types)
R1, R2—20-ohm
R2—22-ohm
R4—39-ohm
R5, R7—200-ohm
R6—220-ohm
R8—390-ohm
R9, R11—2000-ohm
R10—2200-ohm
R12—3900-ohm
R13, R15—20,000-ohm
R14—22,000-ohm
R16—39,000-ohm
R17, R19—200,000-ohm
R18—220,000-ohm
R20—390,000-ohm
R21,R23—2-Megohm
R22—2.2-Megohm
R24—3.9-Megohm
R25, R27—20-Megohm
R26, R28—22-Megohm
R29—16-Megohm

ADDITIONAL PARTS AND MATERIALS
J1, J2—Multi-way, black binding posts (Radio Shack 274-662, or equivalent)
S1, S2—4-pole, 11-position, 4-sections, shorting-contacts, rotary wafer switches (Centralab PA1014, or equivalent)
Printed-circuit materials to manufacture circuit board, two knobs, hardware, aluminum chassis box (see text), rubber feet, wire, solder, etc.

WHERE TO BUY
A kit of working parts (consisting of all resistors, switches, solder-plated, pre-drilled, fiberglass, printed-circuit board, and wire) is available from C. B. Ohman, 3695 Alcott Street, San Diego, CA 92106. Cost: $33.00 plus #3.00 for shipping and handling.California residents add $1.98 sales tax. Allow for 6 to 8 weeks for delivery.

TABLE 1
MAXIMUM VOLTAGE PER RANGE

Resistance Range (Ohms)	Permissible Voltage (VAC/VDC)*
10-68	4.5 (3.2)
100-600	14.0 (10.0)
1000-6.8K	45.0 (32.0)
B 10K-68K	140.0 (100.0)
100K-680K	450.0 (320.0)
1 Meg-6.8 Meg	500.0 (500.0)
10 Meg-68 Meg	500.0 (500.0)

Evaluation

The accuracy of the resistance value selected is independent of the number of resistors involved, or their interconnection. The overall accuracy of the instrument is therefore ±5%, the same as that of the individual resistors used. That accuracy is for the actual 10-15-22-32-49-71 progression, not for the 10-15-22-33-47-68 panel markings.

The listings in Table 2 shows actual selected resistance for the Resistor Bank as measured with a digital multimeter whose accuracy is ±0.2% of reading on the resistance set-

(Continued on page 90)

Want to know what your RS-232 connectors are doing? Then, buld this test circuit, today!

☐IF YOU'RE INTO ANYTHING MORE THAN JUST PLUGGING together matching computer and communications equipment, one of the handiest gadgets to have around your shop, school or electronics club is an RS-232 Breakout Box. The device quickly lets you interchange the wiring, or determine the status, of just a few or all of the 25 connections used to interface devices with RS-232 I/O (input/output). When you can't seem to connect the gadgets to the gizmos, it's more than likely that the Breakout Box will help you pinpoint what's causing the problem in minutes, rather than hours.

Why do we need to interchange connections when RS-232 is a *standard*? Because it's a standard in name *only*! Considering how often we waste hours before we discover a manufacturer has decided that one, maybe two, connections will be *off-the-standard*, imagine how bad things would be if there were no standard at all.

Before we go any farther, maybe we should clarify the difference between RS-232 and RS-232C, RS-232C being the designation usually associated with peripherals intended for use with personal computers. RS-232 is an EIA standard for interfacing data equipment. Within the RS-232 standard there is RS-232B and RS-232C. In the simplest of terms, RS-232B has a negative ground with the signal lines normally held positive. RS-232C has a positive ground with the signal lines normally held negative. For personal computers only the RS-232C positive ground interface is used. Often, advertisers, authors, and technicians *shorten* RS-232C to RS-232. While technically incorrect, we all know what we are talking about, so that the terms RS-232 and RS-232C are used interchangeably in personal computer chit-chat.

A breakout box that will open all 25 RS-232 connections doesn't come cheap. In actual fact, more often than not only 10 or fewer connections are used, and two of them are ground while another is not generally used. So tops, all we need worry about are seven active circuits, which can be easily handled by an RS-232 Breakout Box built mostly from junk-box parts, such as shown in the photographs and Fig. 1.

In the RS-232 Breakout Box shown in Fig. 1, switch S1 reverses the connection of the RS-232 signal lines, which are 2 and 3. That is needed because RS-232-2 is used when providing a signal to a printer, while RS-232-3 is the signal feed to a modem. If your computer's RS-232 output doesn't

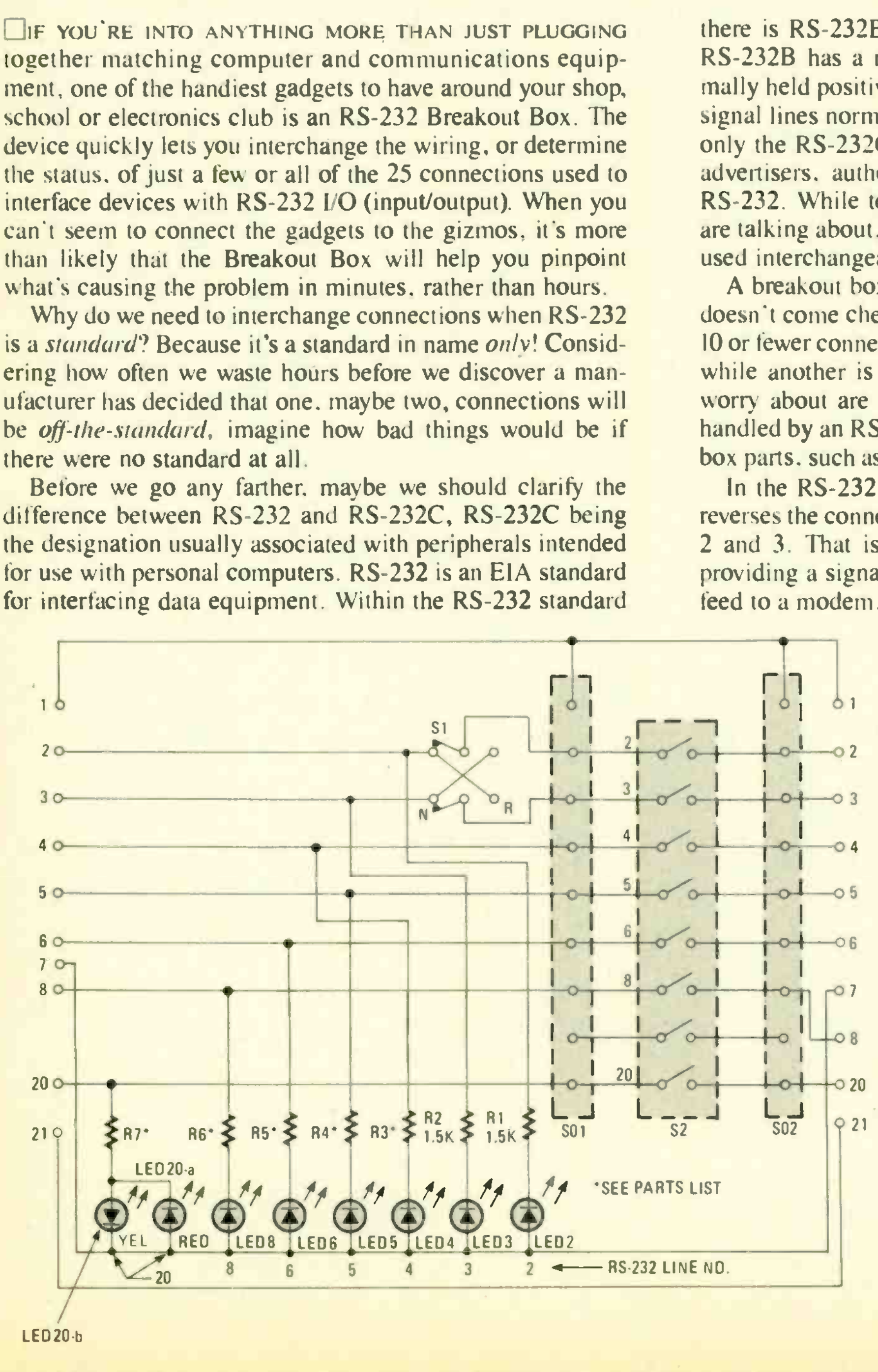


FIG. 1—COMPLETE schematic diagram of the Breakout Box makes its principle of operation easy to understand. You'll need a little RS-232 background provided by the text. The light emitting diodes are numbered to correspond to the signal lines in the cable. Whether they are on, or off, or flickering, will indicate to you the status of the RS-232 signals in the cable.

BREAKOUT BOX

By Herb Friedman

drive the printer and flipping switch S2 to the reverse (*r*) position causes the printer to work, you know you need a *reversing* cable between the computer and the printer. Switch S2 is an 8-section DIP switch that opens and closes the commonly used RS-232 connections. Jumper wires connected from matching sockets SO1 and SO2 can be used to bridge or interchange the connections when individual S2 sections are open.

More Examples

For example, the usual serial printer handshake connection is terminal 20. Some computer serial inputs, however, handshake on terminal 4. If your computer isn't correct, you can open switch S2's sections 4 and 20 and then connect a wire jumper from pin 20, SO1 socket, to pin 4, SO2 socket. (Or vice versa, depending on which side of the device you consider to be the input.) Pin 1 on SO1 and SO2 are *ground*, and aren't generally used unless you need a grounding wire for tests or experiments.

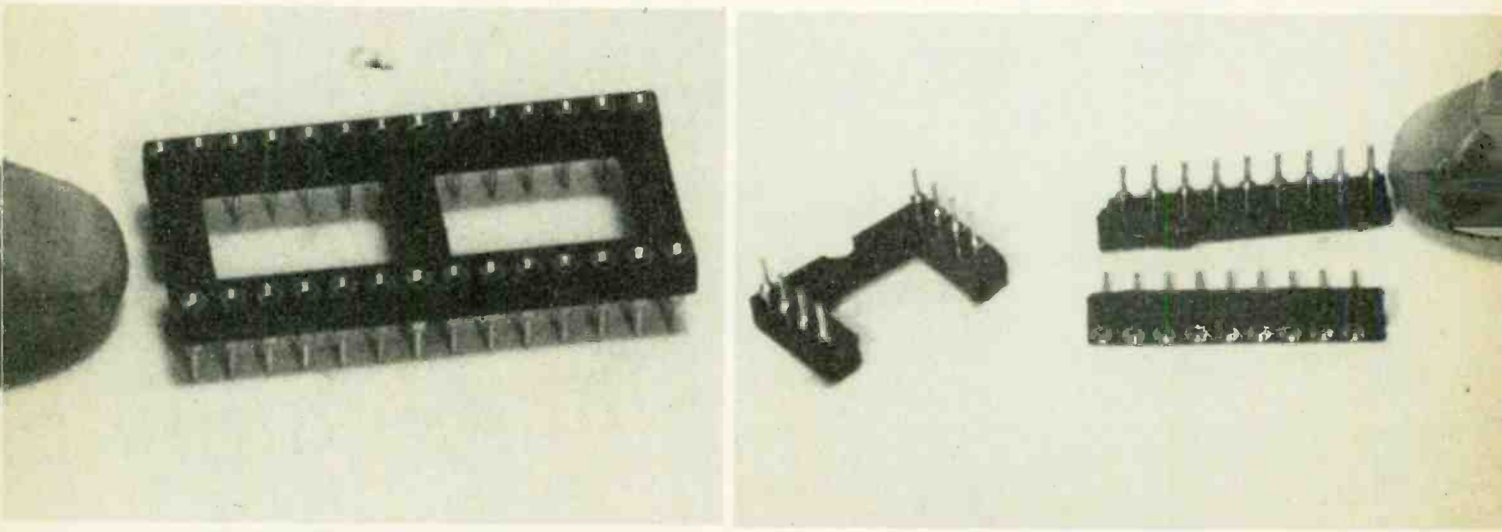
For proper printer operation from the particular printer you're using, the computer must have RS-232 terminals 6 and 8 shorted together independent of a short across printer terminals 6 and 8. No problem: simply open DIP sections 6 and 8, and connect a jumper across SO1 sockets pins 6 and 8 and SO2 sockets pins 6 and 8. If everything works correctly, you just make up a permanent connecting cable that corresponds to the connections of the RS-232 Breakout Box.

Light Tips

Each of the commonly used RS-232 connections has a light-emitting diode (LED) status indicator. LED1 through LED7 are red. LED8 is yellow or green, or anything else easily distinguished from red. Any light-emitting diode that is *on* indicates a normal *high* on the circuit. If the LED is not *on*, the circuit is *low*. If the LED flickers, it's an indication that there is data being transmitted on the circuit. For example, when feeding a modem, the status 3 light-emitting diode (LED3) will flicker when keys are pressed. (Note: in Fig. 1 the practice of numbering LED's consecutively has been discontinued in favor of having the LED's symbol designation coincide with the RS-232 signal line. Thus, line 20 is common to LED20 with a LED panel marking of "20" on the box.) Similarly, LED2 will flicker when the modem passes data to the computer. Actually, when using a full-duplex modem, LED3 will flicker followed almost immediately by a flicker from the LED2 as the modem receives the echo of the keyboard entry from the host computer.

The exception to the on-off rule is for status 20 on the RS-232 line. Here two light-emitting diodes are used—LED20-a (red) and LED20-b (yellow or green). While the most common use of the line 20 handshake is *high* for send, *low* for stop, some computers use a reverse handshake. (Early Heath/Zenith HB computers used the reversed handshake.) If you don't know that the handshake is reversed from what's considered normal you can spend hours searching for trouble that doesn't exist. If the handshake is reversed, the yellow light (LED20-b) will normally be *on* and the red LED will be *off*. Keep in mind that the RS-232 status 20 LED's monitor the handshake on the signal line, not the polarity required by the particular device. If, for example, your printer is sending a positive *standby* handshake (indicated by the red light (LED20-a) and the computer requires a negative handshake, nothing is going to work. The RS-232 Breakout Box will only tell you the status of the connections—not if they are correct for the particular equipment you are using.

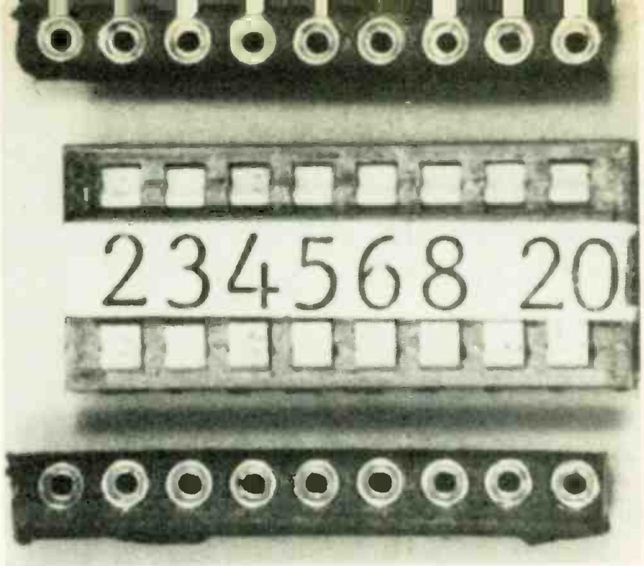
As shown in Fig. 1, three connections pass through the



IF YOU CAN'T locate IC-socket strip material, SO1 and SO2 can be cut from a standard IC socket—the open-type (left) with formed individual socket terminals. The socket strips look like this (right) when you cut your own. Each is 9-pins long, though you can change the number of pin-terminals should you modify the RS-232 Breakout Box.

PARTS LIST FOR BREAKOUT BOX

RESISTORS
(All resistors are 1/4-watt, composition types)
R1, R2—1500-ohm
R3-R7—270- to 560-ohm (see text)
LIGHT-EMITTING DIODES
LED2-LED6, LED8, LED20-a—Red light-emitting diode (see text)
LED20-b—Yellow or green light-emitting diode (see text)
ADDITIONAL PARTS AND MATERIALS
S1—DPDT, center-off, miniature, printed-circuit switch (see text)
S2—8-section, on-off, DIP switch
SO1, SO2—9-terminal, IC-socket strip (see text)
2 DB-25 connectors (see text), printed-circuit materials, solder, ribbon-cable (see text), decals, etc.



RENUMBER THE DIP SWITCH of each section to correspond to the signal line it controls. The spacing between the switches corresponds to a 10-pitch typewriter, so you can type the signal line numbers on a strip of adhesive label. The switch section between circuits 8 and 20 isn't used.

RS-232 Breakout Box. They are: RS-232-1, the equipment ground; RS-232-7, the electrical ground, or common; and RS-232-21, which is the ring detector for an auto-answer modem. If you're into *modemry* (a term just created) you might want to add an LED status indicator for connection RS-232-21. Use the same LED and resistor values you use for RS-232 lines 2 and 3.

Construction

The RS-232 Breakout Box shown in the photos is built on a printed-circuit board that serves as the cover for a Radio Shack plastic cabinet approximately 5- × 2⅝- × 1⅝-inches. A full-size template for the printed-circuit board is shown in Fig. 2. Depending on the particular cabinet you get, you might have to round off the board's corners to fit the cabinet. Since some of the printed-circuit foils pass very close to the holes for the mounting screws, you might prevent some later problems if you drill the four mounting holes before you apply the resist patterns.

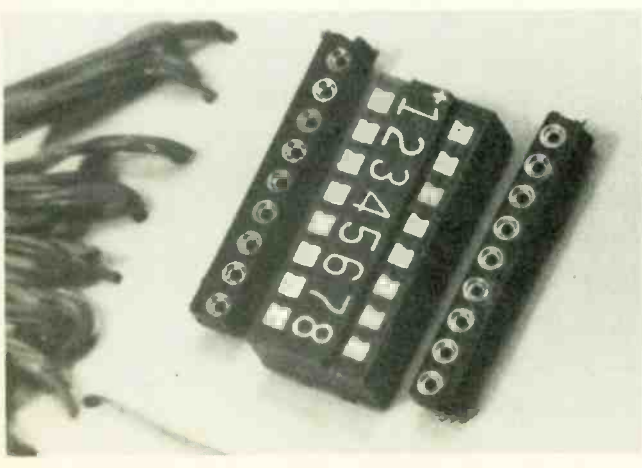
All component holes except those for S1's terminals are made with a No.60 drill bit; a No. 53 bit is suggested for S1's terminals. Switch S1 is DPDT with a center-off position that allows both the RS-232-2 and -3 signal lines to be opened simultaneously (and easily) for testing. If you have no need for the function, or want to cut costs to rock-bottom, use whatever DPDT switch you have.

The socket strips needed for SO1 and SO2 are available from some mail-order houses, but you probably won't be able to make up the minimum-cost order. You can do the next best thing by cutting them from a 20 or 48 terminal IC socket. That's the way we made the socket strips for the unit shown. You can cut through the socket strips using a hand "mototool" with a saw blade, or abrasive disc, or with a jeweler's saw, or a fine coping saw blade.

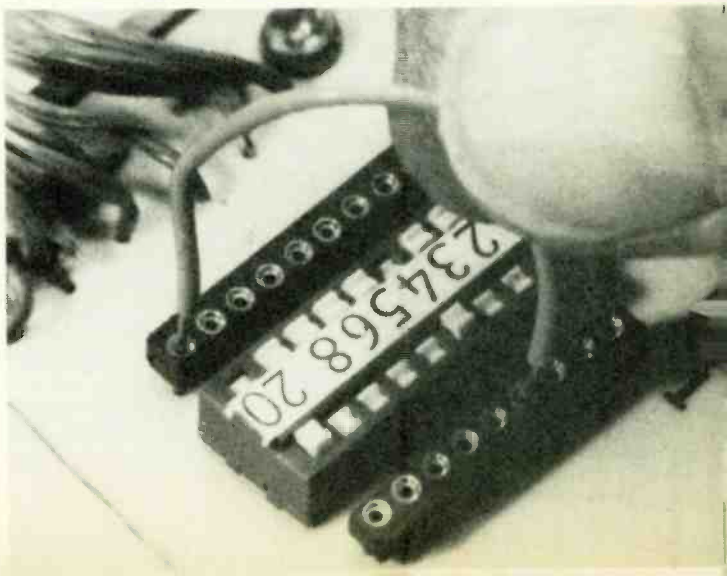
Virtually any LED can be used, though the diffused-lens LED's are usually the easiest to distinguish from a distance. All the red LED's in the RS-232 Breakout Box came from a 20-for-$1 LED kit. All red LED's have their cathodes connected to the RS-232-7 line. The yellow one (LED20-b) is connected with reversed polarity; that is, its anode connects to the RS-232-7 foil line.

To limit the current *stolen* from the circuits by the status LED's resistors R1 and R2 should be 1500 ohms—don't substitute anything smaller. The remaining resistors can be

THE SOCKET strips are installed on the printed-circuit board flanking the 8-section DIP switch. Notice the original DIP switch engraved numbering which should be masked in order to avoid confusion with RS-232 signal lines.



TO INTERCHANGE CIRCUITS, simply open the corresponding DIP switch section(s) and use a No. 22 solid-wire jumper from SO1 to SO2. Here, sections 4 and 20 of the DIP switch are open and a jumper is placed from cable-side 20 to box-side 4.



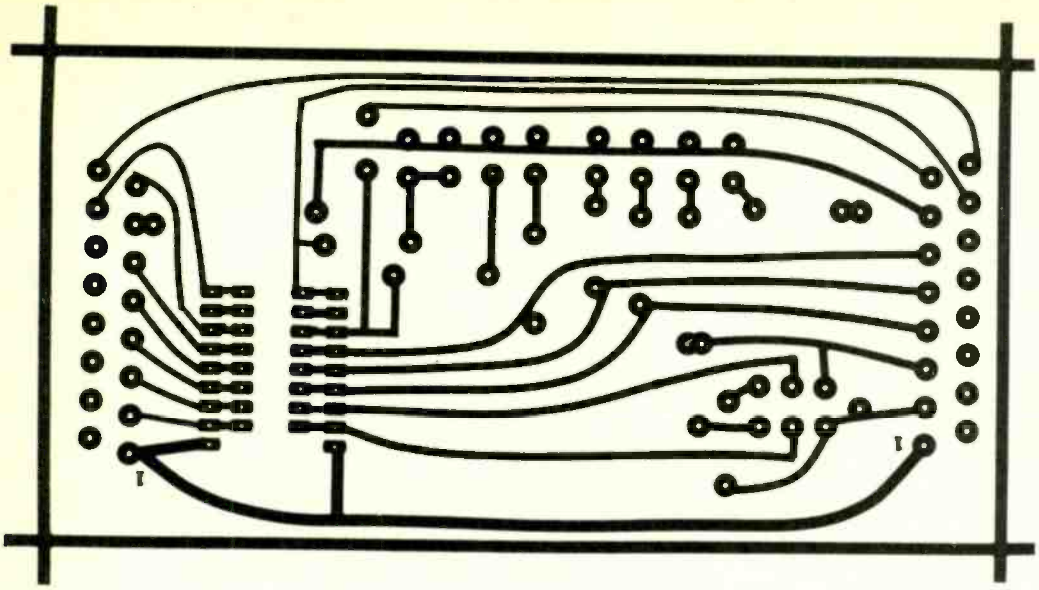


FIG. 2—FOIL PATTERN of the printed-circuit board is shown here same size so the builder could either trace it or photographically copy it onto a light-sensitive foil surface for etching. You may want to use a perfboard with 0.1-inch holes spacing and save yourself a lot of time.

270 to 560 ohms because their circuit voltage is normally ±5-volts DC, in contrast to the common voltage of ±12-volts DC on the RS-232-2 and -3.

Finishing Up

The schematic diagram (Fig. 1) for the RS-232 Breakout Box doesn't show the DB-25 connectors used for input and output connection, because you must select the type that fits your needs. In actual fact, either the A or B connections can be the input or output. The most common arrangement, however, would be a female connector for the A terminals and male connector for the B terminals.

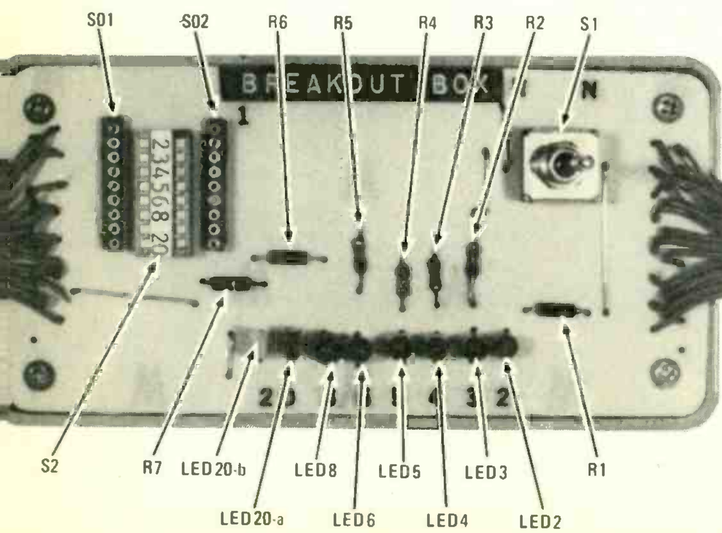
The solder pads on the printed-circuit board will accommodate both solder-type and ribbon DB-25 connectors. Should you use solder connectors, use a round, multi-wire cable and connect to the printed-circuit solder pads for RS-232 terminals 1-8, 20 and 21.

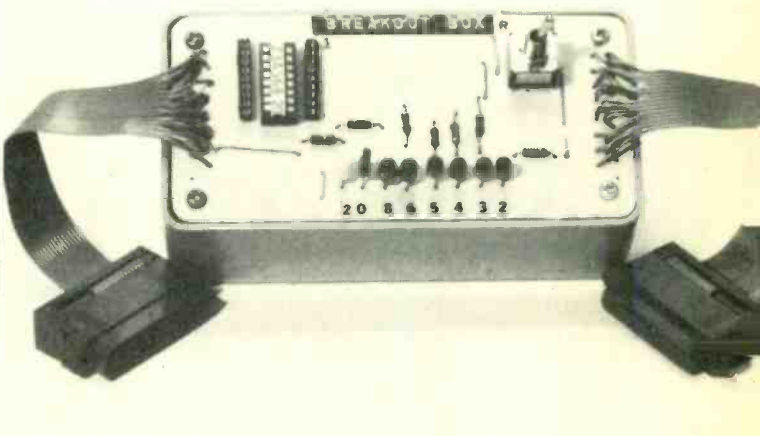
Should you use ribbon cable, extra solder pads are provided on the printed-circuit board just to tie down the ribbon neatly. If you have no need for RS-232-21, use a 15-wire ribbon cable. When you *squish* the connector(s) on the ribbon cable, you will automatically make terminals 1-8 and 14-20. At the free end, carefully separate the wires for a depth of about 2 inches, remove ¼-inch insulation from each wire and insert the wires in the correct holes in the printed circuit board. Take care to remember that ribbon wire alternates; that is, the first wire is No. 1, the second wire is No. 14, the third wire is No. 2, the fourth wire is No. 15, etc. In short, the odd wires are Nos. 1, 2, 3, 4, 5, 6, 7, and 8, while the even wires are Nos. 14, 15, 16, 17, 18, 19, and 20.

If you need the RS-232-21 connection, use a 16-wire ribbon cable; the extra wire is automatically RS-232-21. The printed-circuit board has the necessary foils for the RS-232-21 connection. (The 15-wire ribbon cable is suggested because it is a standard width—16-wire ribbon cable must usually be peeled from 24, 30 or 26 wire ribbon cable.)

When the unit is finished, apply RS-232 circuit numbers to DIP switch S2 selectors. For standard DIP switches, the section spacing exactly matches pica typewriter spacing, 10 characters to the inch; so if you just type the RS-232 line numbers on a small gummed label they will line up precisely with the DIP selectors.

THE BREAKOUT BOX is a special test unit for RS-232 I/O lines that allows the user to open any of the common signal circuits, and interchange the connections through wire patches. LED's indicate the signal condition on these lines.





THE COMPLETED PROJECT is shown here. Switch S1 at the upper right reverses the RS-232-2 and RS-232-3 signal connections. *N* means normal straight-through connection while *R* means that these RS-232 signal lines are reversed.

Calling All Hams

Tips On Dipoles

THE DIPOLE REMAINS AN EFFECTIVE low-cost antenna for all radio bands 6 through 160 meters. Its broad figure-eight pattern means that it is essentially omnidirectional, especially on bands 40, 80, and 160 meters. On the higher-frequency bands there can be a serious drop-off (nulls) at narrow angles near the two bearings in line with the antenna wire. In setting up the dipole you can usually position the lay of the antenna wire to have those nulls in a least-important direction. Also give thought to the fact that the inverted dipole is more nearly omnidirectional than the straight dipole.

Dipoles are found in three common forms, as in Fig. 1. The classic dipole (A) is a straight horizontal half-wave length antenna separated into two quarter-wave segments and fed at the center. Another version (B) is called a *sloper*, because of its slant from a high mounting position toward the ground. If a metal mast is used, that style has some directivity in the direction of the slope as shown. The third form (C) is the popular inverted dipole (often called an inverted-V).

The inverted dipole requires but a single high mast and a couple of short poles, or metal fence posts, at ground level. Inverted dipole ends are near ground level and are easily accessible for trimming to obtain a minimum standing-wave ratio (SWR) on a specific frequency.

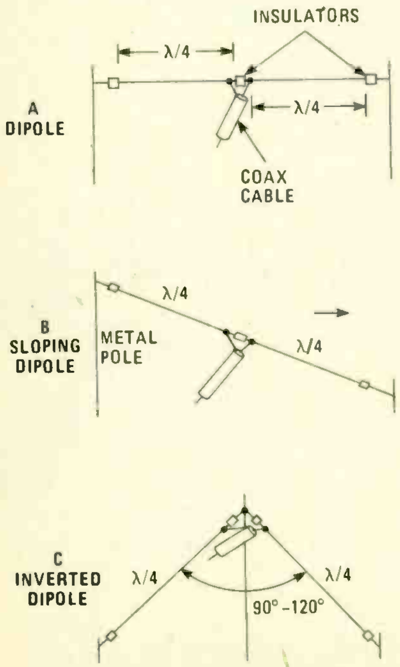


FIG. 1—TYPES OF DIPOLES

TABLE 1
¼ Leg Dimensions for Dipole Antennas

MHz	Ft-In
160 Meters	
1.825	128-0
1.850	126-6
1.875	124-9
1.900	123-0
1.925	121-6
1.975	118-6
80-meters	
3.60 CW	65-0
3.72 N	62-10
3.90 P60-0	
40 Meters	
7.05 CW	33-2
7.12 N	32-10
7.20 P	32-6
30 Meters	
10.10 CWx	3-2
20 Meters	
14.10 CW	16-7
14.25 P	16-5
15 Meters	
21.05 CW	11-2
21.15 N	11-1
21.35 P	10-11
10 Meters	
28.15 N	8-4
28.25 CW	8-3
28.60 P	8-2
29.30 P	8-0
6 Meters	
50.05 CW	4-8
51.00 P	4-7
53.00 PR	4-5

Making It

All three of those dipole styles can be built using the quarter-wavelength dimensions given in Table 1. Nearness of ground and other obstacles may require a bit of trimming to set the SWR to a very minimum on a specific frequency. Remember: the lengths given are for just *one* quarter-wave segment of the two sections that comprise a half-wavelength dipole. Dimensions are given for various frequency spectra of each band, such as code (CW) and phone (P) segments. Values are also given for the four novice bands (N).

Dipoles can be built economically, especially if you do a little wire shopping at flea markers and hamfests. Recently, I bought 2500 feet of 16-gauge stranded plastic-covered hook-up wire for $12.95 at a military surplus outlet. The fact that the wire is insulated has little or nothing to do with antenna performance. In fact, it provides additional strength, and safety, and can be routed through trees without loss. Certainly there is no problem in handling 200 watts or more. Dipole leg dimensions are given in feet/inches; cut frequency in megaHertz.

Another step toward cost saving, convenience, and versatility is to use telescoping sections of PVC piping as your mast, as I have advocated in the past. Two 10-foot telescoping sections, as in Fig. 2, can give you a height of approximately 20 feet for your inverted dipole. PVC ID diameters are 2 inch and 1.5 inch. Three telescoping sections and appropriate guying can provide additional height. Twenty-foot sections of PVC piping are also available.

In the arrangement of Fig. 2, the top section is telescoped 1.5 feet into the bottom section. The mast is supported by a metal fence post that is driven into the ground to the top of its wedge as shown. At the base of the bottom section of the mast a thru-bolt is inserted about two feet from the bottom. The serves as a resting bolt and rests against the top of the metal fence post. That arrangement supplies additional maximum height to compensate for the 1.5 foot of the top section that is telescoped into the bottom section of the mast. Additional details on using PVC piping in antenna construction was given in the previous column. Put that informa-

(Continued on page 93)

Designing Practical DC Power Supplies

Engineering concepts used in the design of DC power supplies for hobby and amateur projects are easy to understand and apply to practical situations once you understand the theory related to rectifiers, filters and regulators!

By Joseph J. Carr

☐THE COMMON DC POWER SUPPLY IS MOST OFTEN RELEgated to a position of no importance by project builders who design electronics devices. Even in industry, where the designer should know better, the job of power-supply design is often given to newcomers who do not yet appreciate the problems associated with power-supply design.

But the power supply is far more important; consider some examples: A microcomputer power supply with too little current capacity drops out of regulation and allows the +5 volts DC to sink to +4.1 volts DC. The result is erratic operation causing programming errors. In another case, insufficient heat sinking causes a series-pass voltage regulator transistor to short out placing +8-volts DC on the +5 volt DC bus causing a $127 digital panel meter to turn to carbon.

In addition to output voltage, we must consider current capacity, internal resistance, voltage regulation, heat transfer, component reliability, and sensitivity to abuse. We might also have to consider whether we want certain features such as transient-noise suppression, over-voltage protection, and output-current limiting. Also, we might want to remotely sense the output voltage of a high-current power supply located only a few inches from the equipment it serves.

Power Supply Components

The principal components of a low-voltage DC power supply are as follows: transformer, rectifier, filter, and (sometimes) voltage regulator. If our requirements dictate additional features, then we might add transient suppressors, current limiting, overvoltage protection, and/or status indicators.

Transformers are used as voltage and current converters. The main job of the transformer is to convert the AC power-line potential (nominally 117-volts AC at 60 Hertz in the US) to the voltage required for the electronic device being powered. A secondary use for the transformer is to provide isolation between some electronic device and the AC line.

The transformer consists of two or more coils of wire wound over a common core of (usually) an iron alloy. Figure 1-A shows the basic transformer configuration. There are two windings shown in Fig. 1A—the primary and secondary

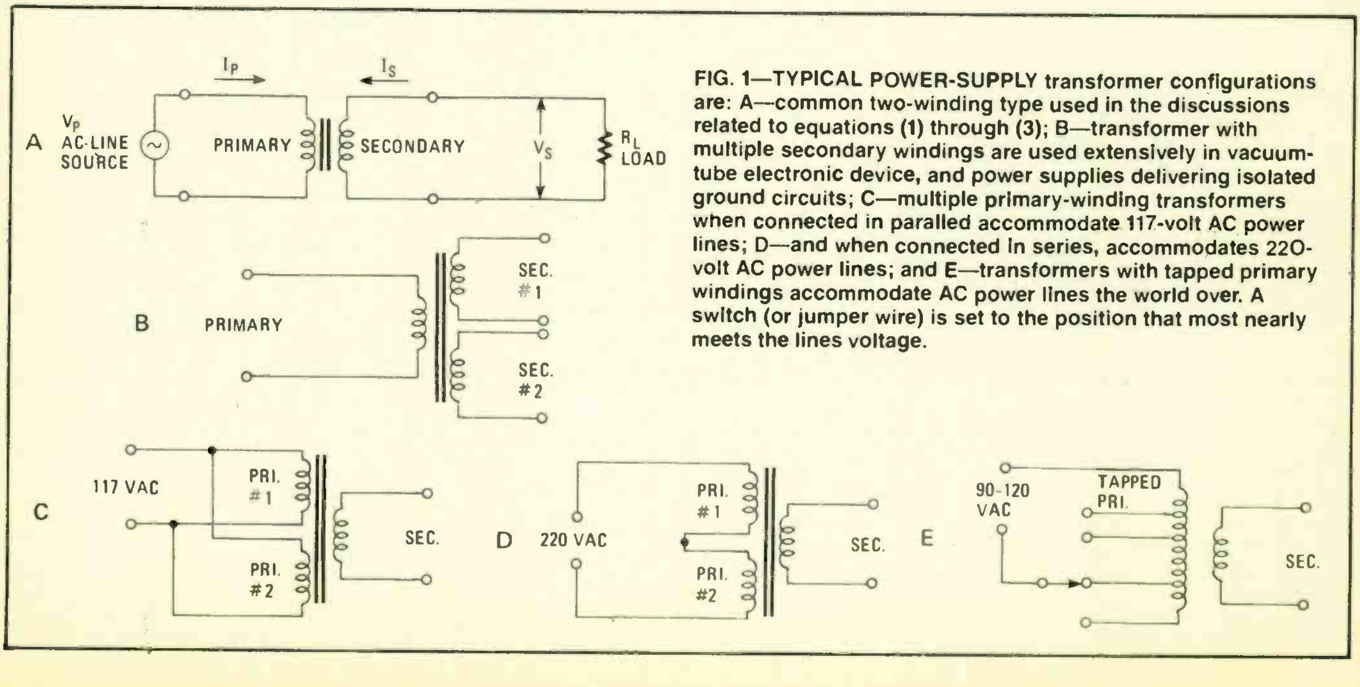


FIG. 1—TYPICAL POWER-SUPPLY transformer configurations are: A—common two-winding type used in the discussions related to equations (1) through (3); B—transformer with multiple secondary windings are used extensively in vacuum-tube electronic device, and power supplies delivering isolated ground circuits; C—multiple primary-winding transformers when connected in paralled accommodate 117-volt AC power lines; D—and when connected in series, accommodates 220-volt AC power lines; and E—transformers with tapped primary windings accommodate AC power lines the world over. A switch (or jumper wire) is set to the position that most nearly meets the lines voltage.

windings, each electrically isolated from each other.

There is a mathematical relationship between primary and secondary voltage/current values:

(1) $$V_P I_P = V_S I_S$$

where V_P is the voltage applied to the primary winding, V_S is the voltage appearing across the secondary winding, I_P is the current flowing in the primary winding, and I_S is the current drawn from the secondary winging.

We can rewrite equation (1) in a more useful form, as follows:

(2) $$V_P/V_S = I_S/V_S$$

In order to maintain the important equality of equation (1), we find in equation (2) that the voltage and current ratios are reciprocals of each other.

The voltage ratio is totally dependent upon the turns ratio of the transformer, and obeys the following equation:

(3) $$V_P/V_S = V_P/V_S$$

where N_P and N_S are the numbers of turns in primary and secondary windings, respectively, and V_P and V_S are as previously defined.

Unless otherwise specified, the voltage rating of a transformer is the root-mean-square (*rms*) value. Thus, a 6.3-volt AC transformer produces a peak voltage will be 1.414 times the *rms* voltage; or 6.3-volt AC produces a peak voltage of 8.9.

Volt-Ampere Rating

A principal rating of a power transformer is the volt-ampere (VA) rating. The VA rating basically tells us how much power the transformer will provide. Transformers tend to be highly-efficient devices (96 to 99 percent), so that the primary VA rating is usually considered equal to the secondary VA rating (see equation 1). For most cases, however, it is the primary VA rating that is of importance. That is done because the primary winding is innermost, and is closest to the core. Hence, the primary winding receives less cooling from the environment. It is not safe to exceed the primary VA rating.

Transformers come in configurations other than the basic type shown in Fig 1-A. Other transformer variations are shown in Figs. 1-B through 1-F.

Rectifiers

Electronic circuits don't usually operate on alterating current—direct current (DC) is a strict requirement. The main feature of DC is that it is unidirectional—that is, DC flows in only one direction. A rectifier is a device that permits current to flow in only one direction; therefore, a rectifier is a one-way valve (gate or switch) for electric current. Both vacuum-tubes and solid-state diodes are used as rectifiers.

A word of explanation: Early in the study of electricity, it was decided to mark one terminal of the battery positive (+) and the other negative (−). Not knowing about atomic physics and the electron, either selection would have had a 50-50 chance to be correct. We lost, because the incorrect choice was made. Thus, current flows from positive to negative, and electrons flow from negative to positive. The diode symbol has its arrow pointing in the direction of current flow. Remember that, and you'll have no problem following the text below.

Figure 2-A shows a simple circuit using a solid-state diode rectifier. When the polarity of the AC is such that the anode of the rectifier is positive (Fig. 2-A), then the diode is forward biased so current (i) flows. On the negative half-cycle of the AC, the rectifier anode is negative (Fig. 2-B), making the diode reverse biased. Under that condition, no current flows because the diode is cut-off—it is essentially an open circuit.

The result of rectfication action by the diode is shown in Fig. 2-C. Since only one-half of the AC waveform causes current to flow, the circuits of Figs. 2-A and 2-B are called a halfwave rectifier. Since the rectifier output waveform consists of undirectional pulses of current, it is refered to a pulsating DC. That pulsating DC is not useful in most circuits. It must be filtered to produce pure (or nearly pure) DC voltage that appears to be steady when measured by a voltmeter.

Filtering is not the only problem with halfwave rectifiers—they are also inefficient. The transformer used in halfwave rectified circuits typically must have a primary VA rating at least 40 percent higher than that of a transformer feeding a fullwave recitfier circuit providing the same voltage and current capaciy. The average output potential for halfwave circuits is 45 percent of the applied RMS potential. The ripple, degree of pulsation or departure from pure DC, is 120 percent.

Fullwave Rectification

A fullwave rectifier is shown in Fig. 3-A. The transformer is a special type that has a center-tapped secondary winding. On any give cycle, one end of the secondary winding will be positive and the other end is negative. The potential at the center tap is half the overall potential. With the center-tap as the common, the potentials at the points A and B will be equal in amplitude but have opposite polarity.

On one-half the AC input cycle point A will be positive with respect to the center-tap, while point B is negative. Under that condition, diode D1 is forward-biased and D2 is reverse-biased. Current flows out of the transformer at point

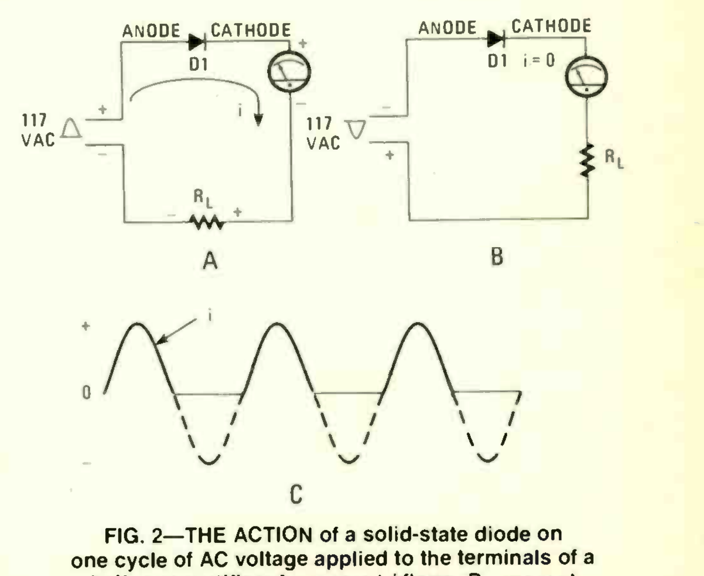


FIG. 2—THE ACTION of a solid-state diode on one cycle of AC voltage applied to the terminals of a halfwave rectifier: A—current *i* flows, B—current cutoff, and C—graph of current *i* for three cycles.

A, through through diode D1, load resistor R_L, and then back to the transformer at the center tap. Note the direction of current flow in R_L when diode D1 conducts on the positve half cycle.

On the second half-cycle, the transformer secondary winding polarities reverse. Under that condition, diode D1 is reverse-biased and D2 is forward-biased. Current flows out of point B, through diode D1, resistor R_L, and returns to the secondary winding at the center tap.

The important thing to note is that current flows in the load resistor R_L in the same direction on both halves of the AC cycle. That action produces the waveform of Fig 3-B. The double-humped current waveform is easier to filter and is more efficient than that of the halfwave rectifier. The ripple is 48 percent, while the ripple frequency is twice the AC line frequency (120 Hz in the US). The average potential of the unfiltered output is approximately 90 percent of the applied *rms* potential.

The Bridge Rectifier

Another form of fullwave rectifier is shown in Fig 4. That circuit is called a bridge rectifier, and consists of four diodes. No transformer secondary-winding centertap is needed in the bridge circuit.

As on any other transformer, the polarities of the transformer secondary ends are opposite each other. Thus, on each half-cycle, two diodes are forward-biased and two are reverse-biased. It could be said that, in effect, the diodes were center-tapped!

On the first half-cycle, the voltage at point A is positive with respect to point B, so diodes D1 and D2 are forward-biased while diodes D3 and D4 are reverse-biased. Current flows out of the transformer at point A, through D1, load resistor R_L, diode D2, and then back to the transformer secondary winding at point B.

On the second half-cycle, the AC polarities reverse, making point A negative and point B positive. Under that condition, diodes D3 and D4 are forward-biased and diodes D1 and D2 are reverse-biased. Current leaves the transformer at point B, travels through D3, R_L, D4 and then returns to the transformer via point B. Again, as in any fullwave rectifier, the direction of the current in the load resistor is the same on both halves of the AC cycle (see Fig. 3).

The pulsating DC produced by a bridge rectifier is not usuable in most electronic circuits. To produce nearly pure DC from the rectifier output a filter must be used. The simplest form of filter is a single capacitor in parallel across the load resistor. See Fig. 5. The operation of filters will be discussed shortly, but included here, because the filter capacitor affects rectifier ratings which is our real topic. For now, let's be content with the fact that the filter capacitor (C1) is charged to the peak of the AC waveform. That means that the bridge rectifier's output voltage under no load is 1.414 × $volts_{rms}$. It comes to 165.4-volts DC from a line isolation transformer T1 delivering 117-volts AC.

Rectifier Ratings

There are four main specifications used with rectifiers: surge current, leakage current, forward current and peak-inverse voltage (PIV). Of those, the latter two are of greatest importance most of the time.

Surge current is the maximum short-term current usually defined as on AC cycle (1/60 second, or about 17 milliseconds). That current can be extremely high and is not the operating current!

Leakage current is the current that flows when the rectifier diode is reverse-biased. This value is typically very low, and the lower, the better.

The forward current is the maximum sustained current that the diode will handle without damage to itself.. When a *spec* sheet says that a diode is a *1-ampere* type, it is the forward current that is being quoted.

There seems to be a little creative specification writing with respect to forward current. Some blister-pack venders rate a diode at 1.5 to 2 times the actual current rating. They get away with that practice as long as the diode is specified as operating under Intermittant Commercial and Amateur Service Code (ICAS), instead of Continuous Commerical Service (CCS) code.

In general, it is best to select a rectifier with a forward

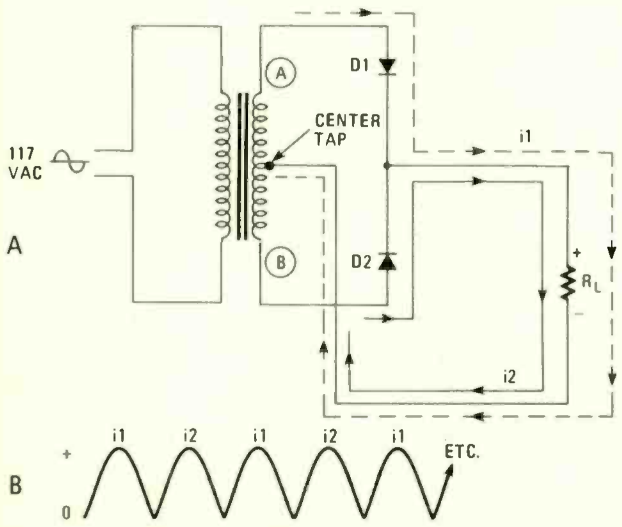


FIG. 3—A FULLWAVE RECTIFIER (A) takes current from both halves of the AC voltage cycle so that two positive current pulses per cycle (B) flow through the load resistor.

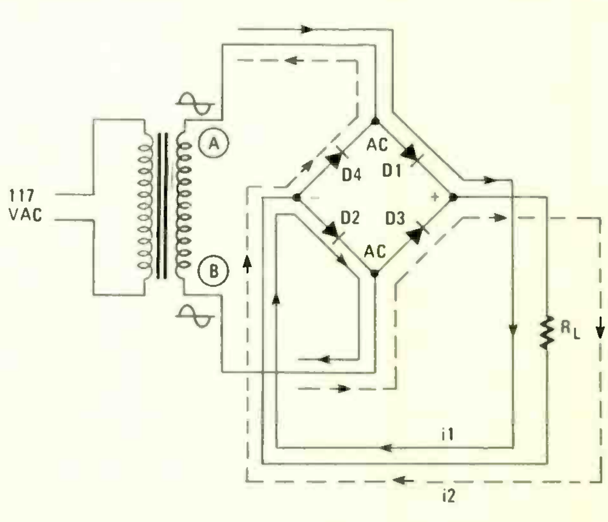


FIG. 4—THE BRIDGE FULLWAVE RECTIFIER provides the same rectification action as in Fig. 3 but it does not require a center-tapped power transformer.

current rating that is twice the expected average current. For rectifiers of *uncertain parentage*, one-fourth to one-third (rather than one half) would be an appropriate *de-rating* factor.

Peak-inverse voltage (PIV), also called peak-reverse voltage (PRV), is the maximum reverse bias potential that the diode will sustain without damage to itself. The PVI rating is the one that causes the most trouble with power-supply designers! Whenever a power supply routinely blows diodes, it is almost a sure bet that the PIV rating is insufficient.

Some designers fail to recognize the true reverse-bias voltage in a filtered power supply. On one half-cycle, the diode will be forward-biased and current flows. On that half-cycle, the filter capacitor (C1 in Fig. 5) charges to peak positive voltage (i.e. 1.414 × *rms*). That voltage charge remains on C1. On the next half-cycle, the AC voltage reverse-biases the rectifier to the peak negative voltage (again, 1.414 × *rms*). That potential is added to the capacitor voltage to make the actual PIV twice normal peak voltage (i.e. 2 × 1.414 *rms* = 2.83 *rms*; or approximately 320.8 PIV). It would be wise to use diodes in the bridge circuit rated at a standard value of 400 PIV.

I personally prefer to use 1000-volt PIV diodes for all low-voltage (under 165-volts) applications in the low- to medium-current 1 to 3 amperes range. The popular 1N4007 is rated at 1000-volts PIV at 1-ampere. They are cheap and easily available.

When laying out a DC power supply, be sure to give the rectifier plenty of *breathing* room. Rectifiers generate heat, so they need room for ventilation. Stud-mounted rectifiers often require ample heat-sinking. Axial-lead rectifiers should be mounted with ⅛-inch-space between the printed-circuit board and the rectifiers, and with .4-inch of lead showing on either end. Also, do not mount rectifiers close to heat sensitive devices and such as op-amps, oscillators and transistors.

Geting into Filters

The purpose of the filter in a power supply is to smooth out the pulsating DC produced by the rectifier, and make it as near to pure DC as possible. Very few electronics circuits will operate properly on unfiltered DC.

The simplest form of filter is a single capacitor connected in parallel with the rectifier output and the load. Such a filter is called a *brute-force* filter. An example is shown in Fig. 5.

During the time when the rectifier output voltage is increasing, capacitor C1 will be charging. See Fig. 6. After the peak voltage (V_P) passes, however, the rectified voltage decreases and will soon reach a point where its potential is lower than the potential across the filter capacitor, C1. At that time, the charge stored in the capacitor begins to dump into the circuit load, R_L. That action has the effect of filling in the space between peaks (shaded area in Fig. 1B), therefore raising the average output voltage to a value closer to the peak voltage (Vp). The discharge slope noted in Fig. 6 indicates that current is being taken from the filter capacitor during the interval when the rectifier's output voltage is below the capacitor's voltage.

The degree to which the filter smoothes the output voltage (reduces the discharge slope to a horizontal line in Fig. 6) depends on both R_L and C1, and is expressed by a nondimensional ripple factor (R.F.):

(4) $$R.F. = V_R \div V_a$$

where R.F. is the dimensionless ripple factor; V_R is the ripple amplitude with C1 disconnected, and V_a is the average ouput voltage with C1 in the circuit.

Equation (4) can be replaced with the more useful general form shown below:

(5) $$R.F. = 1 \div 3.46fR_LC1$$

where f is the ripple frequency in Hertz, R_L is the load resistance in ohms, and C1 is the capacitance in Farads. (Note: R_L is the output voltage divided by the output current—$V_O \div V_O$.)

In the U.S., the AC line frequency is almost universally 60 Hz, so the power-supply ripple frequency will be 60 Hz when halfwave rectification is used, and 120 Hz when fullwave rectification is used. Therefore, we rewrite the general form equation to simpler specific forms:

Halfwave rectifiers:

(6) $$R.F. = 1 \div 208R_LC1$$

Fullwave rectifiers:

(7) $$R.F. = 1 \div 416R_LC1.$$

Example

Find the ripple factor (% RF) of a 12-volt DC (V_O), 2-ampere (I_O) power supply that uses a fullwave rectifier and a 1000-uF filter capacitor (assume line frequency of 60 Hz). Equation (7) is used in this instance. However, it should be noted the load resistance, R_L is determined by:

$$R_L = V_O \div I_O = 12 = \text{div } 2 = 6 \text{ ohms.}$$

Then,

$$R.F. = 1 \div (416)(6)(10)$$
$$R.F. = 0.4.$$

Normally, we will have a ripple-factor percentage in mind as a design goal, and the load resistance is set by other requirements. We will want to rearrange Eqs. (6) and (7) to find the minimum value of capacitance (C1 in Fig. 5) required to do the job. Also, we will want our result in microfarads (μF), not Farads. To accomplish those goals we can rewrite Eqs. (6) and (7) into a final form:

Halfwave Circuits:

(8) $$C1\ (\mu F) = 10 \div 208R_L(\%\ R.F.)$$

Fullwave Circuits:

(9) $$C1\ (\mu F) = 10^6 \div 416R_L(\%\ R.F.)$$

Equations (8) and (9) are valid for power supplies using brute force filtering as diagrammed in Fig. 5 and operating from 60 Hz AC power lines. On 50-Hz power systems, increase the value of C1 by approximately 20 percent.

There's a rule of thumb calling for a minimum value for C1 of 1000 microFarads per ampere of load current. That advice is based upon a ripple-factor of 0.5, and is especially valid if a voltage regulator follows the filter section. Incidentally, many designers prefer to double the rule-of-thumb value to 2000 μF/ampere.

The filtering action has the effect of raising the average output voltage. The voltage produced by Fig. 5 will be as follows:

Halfwave Circuits:

(10) $$V_O = V_P - (I \div 120C1)$$

Full-wave Circuits:

(11) $$V_O = V_P - (I \div 240C1)$$

Where V_O is the DC output potential, V_P is the peak rectifier voltage (1.414 × V_RMS), I_O is the output load current in amperes, and C1 is the capacitance in Farads.

RC Pi-Section Filter

A pi-section filter of Fig. 7 offers improved filtering, because of improved ripple reduction at the expense of poorer voltage regulation and current limiting caused by R1. Both of those defects result from the fact that R1 has the effect of increasing the series output impedance of the power supply.

The defects of the pi-section filter can be overlooked if ripple reduction is of prime concern, and the load current is relatively constant. A good example of such an application is a class-A, audio-preamplifier stage. Such a circuit offers low power, but nearly constant-current requirements. At the same time, the audio preamplifier needs to be free of ripple-produced, power-supply hum.

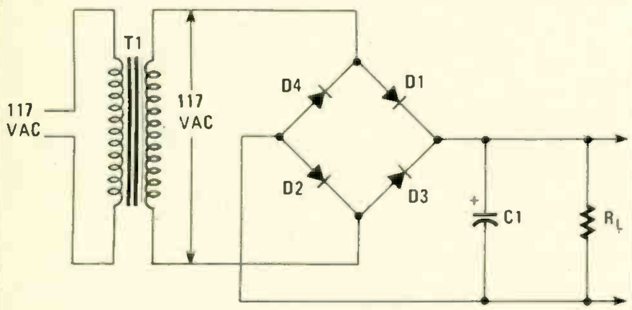


FIG. 5—CAPACITOR C1 provides ripple voltage filtering so that R_L always has a DC voltage across it. Refer to text for discussion on PIV rating of C1.

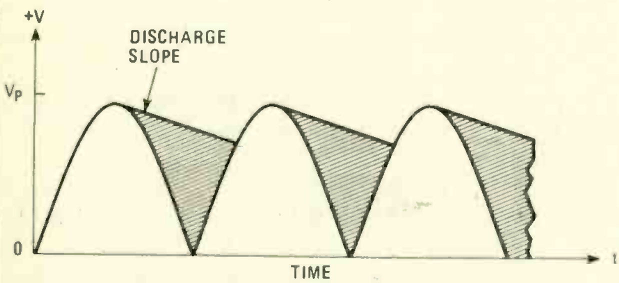


FIG. 6—THE DISCHARGE SLOPE of the voltage curve will droop even more than it does should the current drain from the power supply be increased.

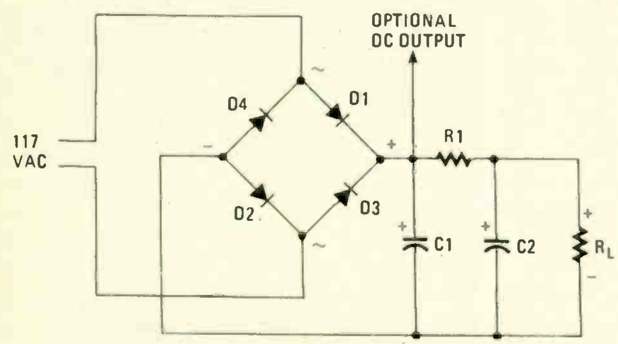


FIG. 7—THE PI-SECTION RC FILTER offers improved filtering at the expense of voltage regulation. This circuit best suits near constant-current loads.

The ripple factor at the output of Fig. 7 (across R_L) is given by the equation:

(12) $$R.F. = K \div C_1C_2R1R_L$$

where C_1 and C_2 are in Farads, R1 and R_L are in ohms, K is a constant (10^{-5} for halfwave circuits and 2×10^{-6} for fullwave circuits). Here is a simple example: Find the ripple factor of a 12-volt DC, 500 mA power supply in which C1 is 1000 µF, C2 is 500 µF and R1 is 68 ohms. Assume fullwave rectification. The solution is as follows:

$$R.F. = 2 \times 10^{-6} \div (10^{-3})(5 \times 10^{-4})(68)(12 \div 0.5)$$

$$R.F. = 2 \times 10^{-6} \div 8.2 \times 10^{-4}$$

$$R.F. = 0.002$$

In many cases, practical DC power supplies similar to Fig. 7 will have two output connections. The low-ripple output is across C2, and an optional high-current output across C1. Each DC output will have its own ripple factor.

Selection of Filter Capacitors

Power supply filter capacitance values are generally considered *high*, or *large* compared to the values of other capacitors found in the circuits fed by the power supply. A high-voltage DC supply will have filter capacitors in the 5-µF to 100-µF range (especially where RC or LC pi-sections are used), while low-voltage supplies have filter capacitors in the over-500-µF range. You can expect to find filter capacitor values of 150,000-µF in some computer power supplies.

Complicating the issue is the fact that power supplies in many multi-stage equipments provide decoupling between stages in order to prevent oscillations due to unwanted feedback paths.

The equations presented thus far provide the ripple-factor percentage reduction required, but may not be sufficient for by-passing low frequency AC signals. For audio, the calculated value % R.F. is generally sufficient, but as the low-frequency response of the amplifier approaches DC (as it might in instrumentation or control system applications) we might need a larger value capacitance to accommodate decoupling. The usual rule is to select a capacitor value that: (a) gives the desired low-frequency response, or (b) gives the desired ripple reduction. When those values are not equal, use the higher value capacitance.

The general rule of thumb is to select a capacitive value for decoupling that offers a reactance equal to one-tenth the apparent circuit resistance at the lowest frequency of operation. The equation is:

(13) $$C = 1 \div 2F(0.1R_S)$$

where C is the capacitance in Farads, F is the −3 dB low-frequency response point, and R_S is the circuit source resistance.

The proper design procedure is to calculate the minimum capacitance from both ripple factor and frequency response and then use the higher of the two values.

High values of capacitance are available only in the form of electrolytic capacitors, of which there are two kinds: aluminum and tantalum. For most filter applications it is the aluminum that is most commonly used.

The two ratings for electrolytic capacitors which must be observed are the capacitance and the DC working voltage (WVDC). Typically, the capacitance value of aluminum electrolytics has a tolerance of −20%/+100%. If either ripple factor or frequency response is critical, then increase the value of the calculated filter capacitance by 20 to 30 percent. Normally, there is no penalty for using *too much* capacitance!

The WVDC rating is normally subject to a tolerance +20 percent. As a result, it is not good design practice to operate a filter capacitor at potentials greater than 80% of the WVDC rating. Also, keep in mind that circuit potentials may vary by ±20 percent, so it may pay to select a WVDC-rating at least 40-percent higher than the anticipated nominal voltage.

Earlier we referred to a design error in a piece of equipment that caused massive failures of filter capacitors. The power supply was +200-volt DC regulated supply in which the pre-regulator potential across the filter section was nominally +280 volts. The designer used 350-WVDC electrolytic capacitors for the filter section. Good practice, right. Wrong!. let's consider the worst case in which the capacitor voltage (V_C) is −20% lower than its rated working voltage and the power-supply voltage (V_{PS}) is +20% higher than the nominal 280 volts.

$$V_{PS} = 280 + (0.2 \times 280) = 336\text{-volts DC}$$
$$V_C = 350 - (0.2 \times 350) = 280\text{-volts DC}$$

In the worst case situation, we have a 280-volt DC capacitor in a 336-volt DC circuit!. True, the worst case may never occur, but those capacitors were over stressed to cause massive failures in critical equipment. The cure was to replace all of those 350-WVDC electrolytic capacitors with 450-WVDC replacements of the same capacitive value.

It is sometimes necessary to combine capacitors in order to obtain higher capacitive values. When two or more filter capacitors are connected in parallel (Fig. 8), the total capacitive value C_T is determined by the equation:

$$C_T = C_1 + C_2 + \ldots + C_n$$

The WVDC rating of a parallel combination of capacitors, however, is the lowest of the individual WVDC rating in the parallel group. For example, if a 50-WVDC capacitor is connected in parallel with 25-WVDC unit, then the usable rating of the pair is only 25-WVDC.

Figure 9 shows capacitors connected in series in order to increase the WVDC rating. Unfortunately, that method reduces the effective capacitance by the usual rule for series capacitors. In most cases, all series capacitors in the stack have the same capacitive value, so the total capacitance is merely $C \div n$, where C is the capacitance of each unit, and n is the number of units.

If all capacitors have equal capacitance and WVDC ratings, then the total WVDC rating is the sum of individual WVDC ratings. Thus, four 200-μF, 450-WVDC capacitors in series are equal to a single 50 μF, 1800-WVDC capacitor. It is quite common to find such capacitor stacks in high-power, vacuum-tube, linear-RF amplifiers used by Amateur Radio operators.

There are some caveats in the scheme, however. One is that voltage-balance resistors, R1, R2, etc. (Fig. 9) must be connected in parallel with each capacitor. Those resistors should have a resistance (R_O of approximately 100-ohms per volt, and a power rating greater than $V_C^2 \div R$. In a case where 450-WVDC capacitors are used, then $R = (450 \times 100) = 45{,}000$ ohms (47,000-ohms standard fixed value) with a power rating greater than $(450^2 \div 45{,}000)$ or, 4.5 watts. In that case, a 5-watt resistor will *do*, but a 7-watt or 10-watt unit is preferred. Some designers use lower wattage resistors in hope that power supply voltages will never approach the WVDC rating. For example, if we are certain that not more than 250 volts will appear across a capacitor, then we might get away with using 2-watt resistors

Another possible caveat involves the voltage drops across unequal capacitances. Normally, we can sum the WVDC ratings. If the capacitances are not equal, then the actual voltage drops will be unequal. We will have to calculate the reactances of each capacitor at the ripple frequency, and then calculate the voltage drops across each reactance (they will divide according to the voltage-divider equation). It may be that one or more capacitors will receive more than a fair share of the voltage drop.

Finally, in Fig. 10 we see a scheme used sometimes in power supplies that power RF amplifiers. The electrolytic capacitors are not readily capable of bypassing RF, or even high, ultrasonic frequencies. For those applications we need a high-value electrolytic for ripple reduction, and a disc ceramic, or mica, capacitor for high-frequency decoupling, or by-passing. In Fig. 10 we have a 2200-μF capacitor for power supply ripple reduction, and 0.1 μF for high-frequency decoupling.

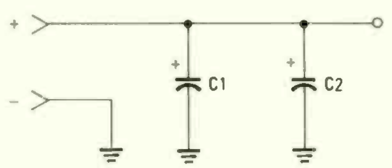


FIG. 8—FILTER CAPACITORS are ganged in parallel —their total capacitance is the sum of each capacitor.

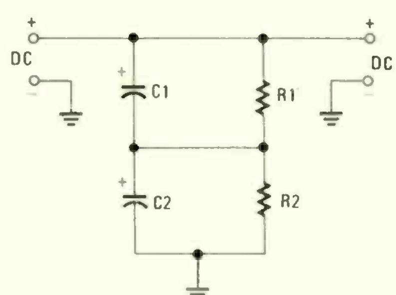


FIG. 9—FILTER CAPACITORS connected in series effectively increase the overall DC working voltage.

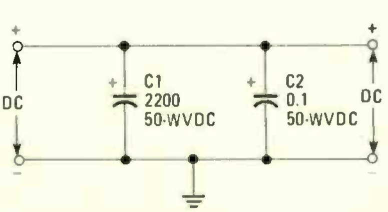


FIG. 10—ELECTROLYTIC capacitors cannot readily pass high frequencies—a small ceramic does the job.

Voltage Regulators.

The purpose of a voltage regulator is to maintain a constant output voltage despite changes in either output load current, input voltage, or both. There are two primary sources of voltage-regulation problems that cause considerable difficulty with consumer appliances. One is variation of the supply voltage from the AC power line that can fluctuate 20 percent (the usual range is 105 to 125 volts RMS). Many areas of the U.S. suffer *brown-outs* when the area power lines drop to 100-volts AC, or even as low as 90-volts. Some motor-vehicle battery voltages vary 40 percent, with 20-25 percent being typical. Those extreme battery-supply variations play havoc with consumer audio equipment, Amateur Radio gear, and CB rigs installed in cars.

The second cause of output-voltage variation is changes in output current. The root of the problem is that no practical power supply is ideal. All power supplies have internal resistance (sometimes called source resistance, R_S). That internal-resistance problem is modeled in Fig. 11 by R_S in series with a perfect voltage source, V_I.

When no output current is drawn, the output voltage V_O is equal to V_I. But, when an output current is being drawn there will be a voltage drop ($I_O \times R_S$) across the power supply internal, series resistance. Under that condition the actual output potential is $V_O = V_I - (I_O \times R_S)$. We can minimize output-voltage change by: (1) making I_O constant (not always possible), (2) minimizing R_S (often expensive and always impossible), or (3) providing a voltage regulator. The last option is the most reasonable.

The percentage of regulation (%REG) is the measure of voltage regulation, and is given by the equation:

$$\%REG = (100)(V_O - V_{Lmax}) \div V_O$$

where V_O is the open-terminal, no-load, output voltage, and V_{Lmax} is the output voltage when the power supply's maximum, rated-output current is drawn.

Series-vs.-Parallel Regulators

Voltage regulators fall into two basic categories—series and parallel. A parallel (*shunt*) regulator is one in which the actual regulating element is in parallel with the load. An example is a circuit that uses a Zener diode as the regulating element. The series regulator uses an active element in series with the load; examples include all circuits using a series-pass transistor to control output-voltage level.

Zener Diode Voltage Regulator

The Zener diode is the simplest form of regulator available. Figure 12 shows the schematic symbol for a Zener diode and the I-vs.-V characteristic curve.

The Zener diode is an ordinary PN junction diode with a predetermined and well controlled avalanche voltage (V_Z) called the *Zener potential*.

The Zener diode behaves exactly like any other PN junction diode when operated in the forward-bias region illustrated in Fig. 12. Between 0 volts and about 0.7 volts (V_g) the current increases from elementary leakage current (I_L) to some specific forward current, but in nonlinear manner. Above V_g, the current rises linearly with increasing voltage; that is called Ohm's law region of operation.

The Zener diode acts like any PN junction diode in that portion of the reverse-bias region between 0 volts and V_Z. Only a minute reverse-bias leakage current (I_L) flows.

The difference between the Zener diode, and other PN diodes, is seen where the reverse-bias potential reaches the Zener point, V_Z. At that potential, the diode junction *breaks over* (avalanches), and the current increases rapidly. Furthermore, the voltage drop across the Zener diode remains constant despite changes in applied voltage. It is that phenomenon that permits voltage regulation by the Zener diode.

Figure 13 shows a Zener-regulated DC power supply. Resistor R_L represents the load applied to the power supply (i.e. $V_Z \div I_3$). Capacitor C1 is the regular filter capacitor used in any DC power supply. A good rule of thumb is to make C1 not less than 1000-μF per ampere of load current, or 500 μF (whichever is larger).

Capacitor C2 in Fig. 13 is used to suppress avalanche *hash* noise produced by the Zener diode. In many circuits that noise is negligible, so C2 may be deleted.

Designing a Zener-diode regulator circuit as seen in Fig. 13 is a four-step process: (1) Determine the operating condition (explained below); (2) select the Zener potential; (3) select the resistance and power rating of R_S; and, (4) calculate the power dissipation of Zener diode.

There are three circuit conditions under which the Zener diode might have to operate. Step (1) of the design process

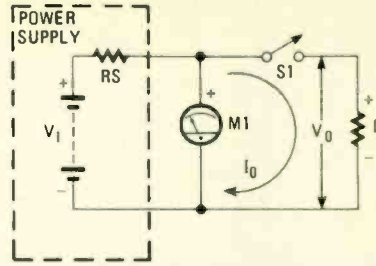


FIG. 11—LOW INTERNAL RESISTANCE, R_S, assures the designer of good voltage regulation under conditions where the value of R_L varies considerably.

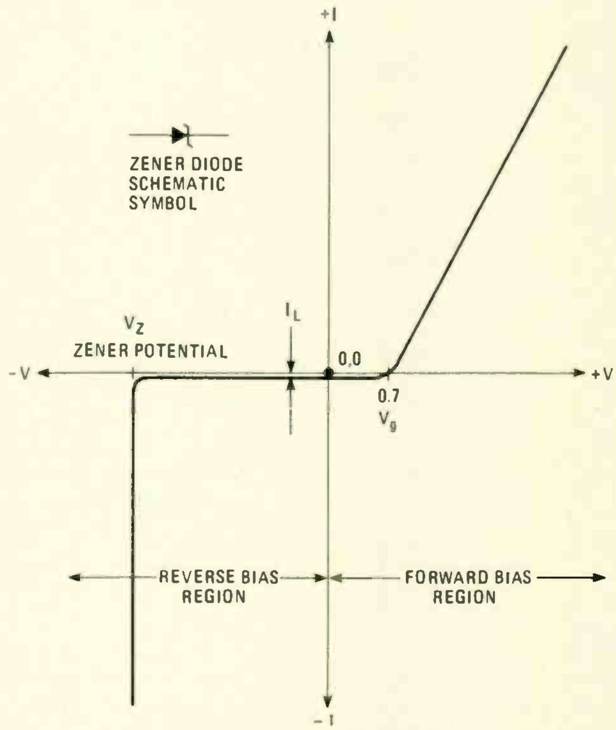


FIG. 12—ZENER DIODE voltage regulation is experienced in the reverse-bias region. Under forward-bias conditions its just another high-current diode.

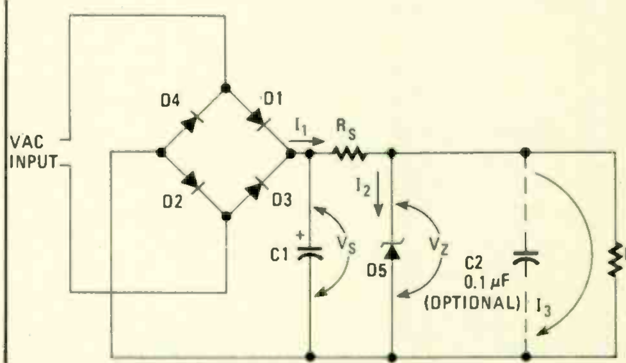


FIG. 13—ZENER-REGULATED DC power supply provides constant voltage to R_L. Capacitor C1 provides basic filtering keeping V_s always higher than V_Z.

TABLE 1
FORMULAS FOR ZENER DIODE REGULATOR

Calculation of Value of R_S in Ohms

Condition 1:

$$R_S = \frac{V_{MIN} - V_Z}{1.1I_3}$$

Condition 2:

$$R_S = \frac{R_{IN} - V_Z}{1.1I_3(\text{maximum})}$$

Condition 3:

$$R_S = \frac{V_{MIN} - V_Z}{1.1I_3(\text{maximum})}$$

Power Dissipation of D5 in Watts

$$P_{D5} = \frac{(V_{MIN} - V_Z)^2}{R_S} - (I_3V_Z)$$

Power Dissipation of R_S in Watts

$$P_{Rs} = \frac{(V_{MAX} - V_Z)^2}{R_S}$$

or $P_{Rs} = P_{D5} + (I_3)(V_Z)$

requires that we determine which of those conditions most nearly represents the conditions in our circuit. The three conditions are:

1—Variable supply voltage V_S, constant load current I_S
2—Constant V_S, variable I_3
3—Variable V_S, variable I_3

The equations used to design for those three cases are shown in Table 1 that is found immediately above. Below are the design steps, and an example for Condition 1. The three conditions are so similar that providing examples for all three would be repetitive.

Design for Condition 1

Follow the listing of steps below to determine circuit parameters:

1—Select V_Z from the application
2—Select load current I_3
3—Calculate R_S (see Table 1)
4—Calculate Zener diode power dissipation
5—Select Zener diode power rating
6—Calculate resistor (R_S) power dissipation
7—Select resistor (R_S) power rating

Example:

Design a Zener diode voltage regulator such as Fig. 13 to provide a 6.8 VDC to a circuit that draws 75 milliamperes. The power source is an automobile battery, which normally varies 12 to 15 VDC as the engine speed changes from an idle to high RPM.

Step 1. Select V_Z = 6.8 VDC (given)
Step 2. Load current = 0.075 Amperes (given)
Step 3. $R_S = (V_{min} - V_Z) \div (1.1I_3)$
(Note: 1.1I is used to allow added 10% current flow in R_S)

$R_S = (12 - 6.8) \div (1.1 \times 0.075)$
$R_S = (5.2V) \div (0.083A) = 63$ ohms

Step 4. Calculate P_{D5}

$P_{D5} = [(V\max - V_Z)^2 \div Rl] - (I_3V_Z)$
$P_{D5} = [(15 - 6.8)^2 \div 63] - (0.075)(6.8)$
$P_{D5} = [(8.2)^2 \div 63] - (0.5)$
$P_{D5} = [(67.2) \div (63)] - (0.5)$
$P_{D5} = 1.07 - 0.5 = 0.57$ watts

Step 5. Select D5 power rating. Since P_{D5} is 0.57 watts, we can reasonably use a 1-watt Zener diode. In general, it is good practice to use a diode with a rating that is 20% (or more) higher than the computed value for P_{D5}.

Step 6. Calculate P_{Rs}

$P_{Rs} = P_{D5} + (I_3 \times V_Z)$
$P_{Rs} = 0.57 + (0.075)(6.8)$
$P_{Rs} = 0.57 + 0.5$
$P_{Rs} = 1.08$ Watts

Step 7. Determine R_S power rating. Since P_{Rs} is 1.07 watts, we must use a 2-watt resistor for R_S—the next higher standard rating. We follow the same "120% or more" rule here as for the diode power rating.

Design for Conditions 2 and 3

The technique for designing to conditions 2 and 3 are exactly the same as for condition 1, except as follows:

Condition 2—use I_{3max}, instead of I_3 (condition 2 represents variable current)

Condition 3—use V_{min}, as in condition 1 and I_{3max} as in condition 2.

Limitations

Some people erroneously believe that the Zener diode is a universal voltage regulator—it is not! For most situations, it is limited to power supplies of low- to medium-current capacity. Higher current levels can be accommodated by using a circuit in which a Zener diode is used to provide a reference voltage, but requires some other active device to handle the current.

Zener diodes suffer from voltage error due to temperature change, and also from the fact that Zener voltage tends to be nominal rather than rigidly fixed. There are strategies available to overcome those limitations. For the present, however, be aware that precision, relatively-stable, reference voltages are available both from special-reference diodes, and integrated-circuit devices, that contain an internal Zener diode.

Series-pass Transistor Regulator

We can boost the current capacity of a Zener diode by using a power transistor to carry the current load, and the Zener diode to control the transistor *b-e* junction.

Figure 14 shows the circuit of a voltage regulator that uses a series-pass transistor (Q1). Figure 4 is an example of a series regulator, because the c-e path of Q1s in series with the load (R_L).

Capacitor C1 in Fig. 4 is the regular filter capacitor at the output of the rectifier. That capacitor should have a value of at least 1000 µF per ampere of rated maximum output current, I_{Omax}.

The output voltage is determined the Zener potential V_Z, and is approximately:

$$V_O = V_Z + V_{be}$$

where V_{be} will be approximately 0.7 volts on silicon transistors.

The load current for the Zener diode in Fig. 14 is the base current of Q1 (I_b). Since that current tends to vary, as does V_{IN}, we use the design equations for Condition 3 stated above for the Zener diode regulator.

We must select a transistor for Q1 that will: (1) Carry the maximum value of output current I_O, (2) sustain collector voltages at least as high as the maximum value of V_{IN}, (3) dissipate the power represented by $(V_{IN} - V_O) \times (I_O)$, and (4) have sufficient current gain (h_{fe}) to be driven by a reasonable I_b.

Current gain (beta, or h_{fe}) is the ratio of collector current (I_g) to base current (I_e):

$$h_{fe} = I_C \div I_B.$$

The transistor selected for Q1 must meet that criteria.

A variation on the series-pass regulator scheme is shown in Fig. 15. The series-pass transistor (Q1) is the same as in Fig. 14, but there is a new circuit to control the transistor base. In Fig. 15, the base-control voltage is the output potential (V_B) produced by amplifier A1. That amplifier has differential inputs. A reference voltage (V_{REF}) is applied to the noninverting input, while a sample of the actual output potential is applied to the inverting input of A1. The latter voltage may be either the actual V_O, or a percentage (V_1) of V_O derived through a voltage divider (R1 and R2).

The output of amplifier A1 is proportional to: (a) the differential voltage gain of A1, and (b) the differential voltage (V_{REF} - V_1).

The regulator of Fig. 15 is sometimes called a feedback voltage regulator, because it operates by comparing the actual output voltage with what it should be, as represented by V_{REF}.

The sense line is used to acquire the output-voltage sample. In many cases, the sense line is connected directly to the output terminal of the regulator. In other cases, however, the sense line is separate, so that it can be connected to the V+ line at the load. That feature becomes important where a high-current supply is connected to its load through more than a few inches of conductor. The voltage drop in such a conductor can be substantial, and a separate sense line allows the regulator to see the voltage at the load rather than at the power-supply output.

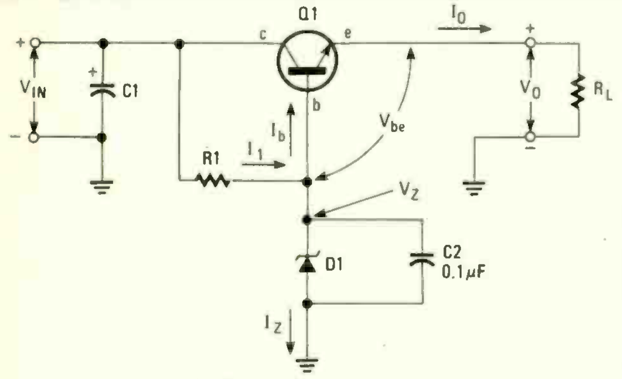


FIG. 14—CURRENT CAPACITY of a Zener diode can be boosted by the addition of a series-pass transistor. V_{be} is added to V_Z to obtain regulator's output, V_O.

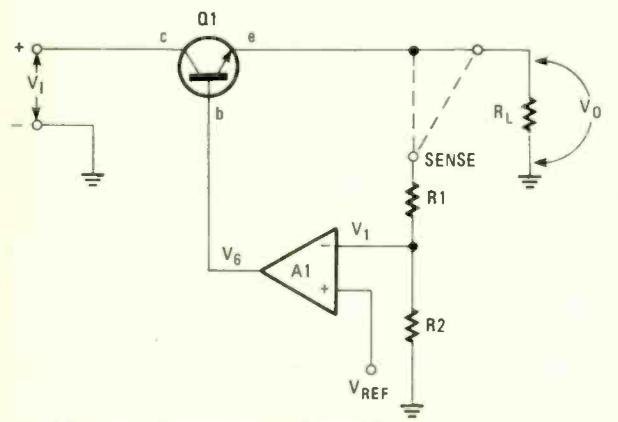


FIG. 15—VOLTAGE FEEDBACK from the output is compared to the reference voltage in an amplifier that controls the series-pass transistor current flow.

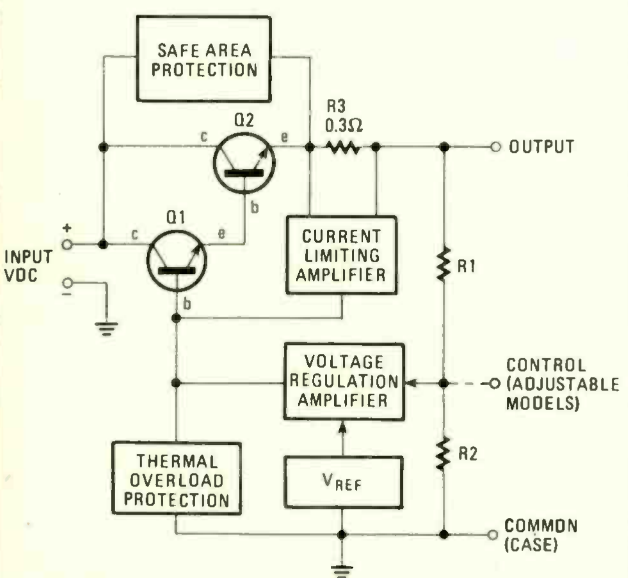


FIG. 16—BLOCK DIAGRAM of a typical three- and four-terminal voltage-regulator integrated circuit used in countless circuits, and available everywhere.

IC Voltage Regulators

Very few people still design discrete voltage-regulator circuits, because of the large number of highly reliable integrated circuits (IC's) and other hybrid regulators available. Some of those devices are simple-minded, while others are highly sophisticated. Devices are available in current ranges from 100 mA to 35 A, and voltages from 2 VDC to 24 VDC. Some devices have only three terminals (input, output, and common), and they operate at fixed *standard* voltages, while others have more terminals and are adjustable. Device packaging runs from simple three-terminal transistor cases (including TO-5, TO-3, and TO-220), to DIP, and metal-can, IC cases, to special packages used on no other device.

Figure 16 shows the internal block diagram for a typical high-quality, three- or four-terminal voltage-regulator IC of the sort normally mounted in standard transistor packages. The over-current protection feature will be discussed later.

In general, three-terminal IC voltage regulators will operate with input voltages from (V_O + 3 volts) to 35 or 40 volts (depending upon model); some models require only (V_O + 2 volts) input-output differential. For a +5 volt regulator, then, an input voltage of 7 to 8 volts is required; that is the reason why the S-100 microcomputer bus uses +8 volts (unregulated) on the main power bus. Note that a 6.3 volt AC *rms* filament transformer will supply the correct voltage if a fullwave bridge rectifier, and 1000-µF/amp filter are used.

(Continued on page 101)

ALCUL

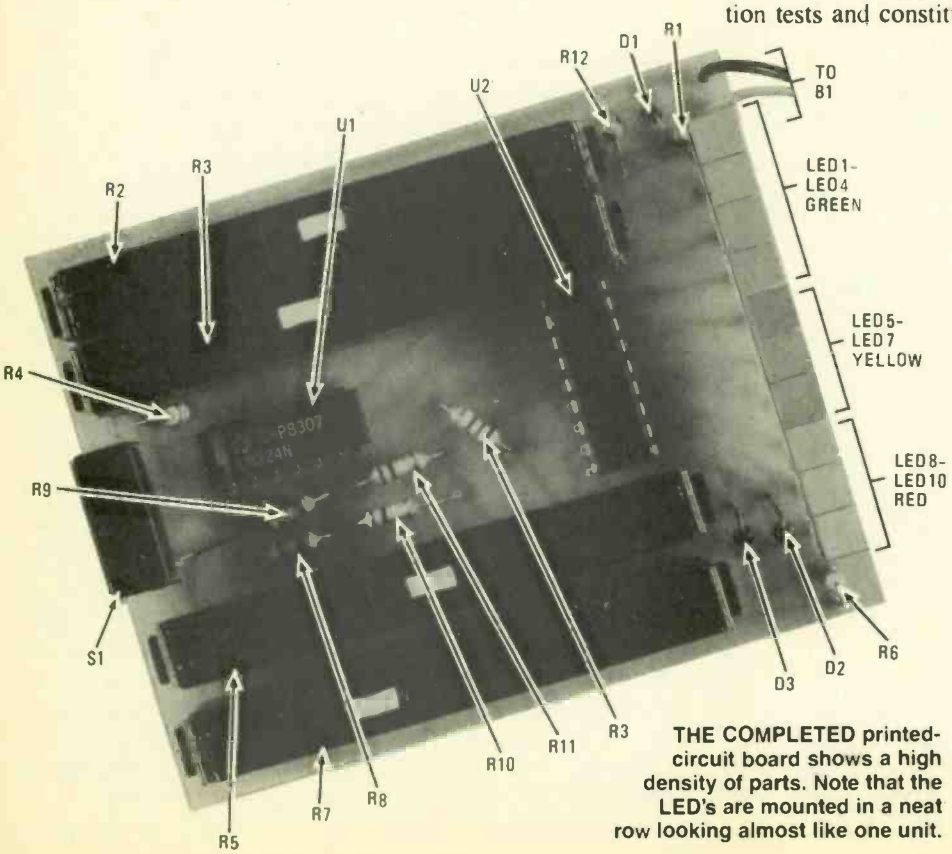
An analog computer calculates the probable blood alcohol level!

By R. Craig Virnelson

☐DRINKING DRIVERS HAVE BEEN RESPONSIBLE FOR HALF OF all traffic fatalities. But only recently with the formation of organizations like M.A.D.D. and other groups have the laws been stiffened to discourage drinking and driving. General Motors Corporation has advertised heavily to announce their efforts to reduce drinking and driving by designing an ignition system that an intoxicated person would have difficulty operating. Other companies have proposed ignitions with integral breath analyzers. Unfortunately, like seatbelt buzzers these devices could easily be defeated.

A number of personal breath analyzers are now on the market, but they suffer from several drawbacks. The sensors are not specific for ethanol, and even when they work, the information is too late to be really helpful. The ALCULATOR information can be used to anticipate the blood alcohol level that will result from drinking a known amount of alcohol and can thereby help prevent a person from having *one too many*.

Normally, law enforcement agencies use the Breathalyzer (tm) or similar instrument to determine blood alcohol levels of drivers who are suspected of driving while intoxicated (DWI). A blood alcohol level of 0.10 percent is usually sufficient to result in prosecution regardless of any coordination tests and constitutes *legal* intoxication. Blood alcohol levels between 0.10 percent and 0.05 percent are interpreted as impairment and can, along with poor coordination tests, also result in prosecution for DWI.



THE COMPLETED printed-circuit board shows a high density of parts. Note that the LED's are mounted in a neat row looking almost like one unit.

Figuring It Out

Blood alcohol levels are the primary criteria for prosecution in DWI cases. For individuals who have been drinking, to know their maximum possible blood alcohol level there are four primary variables to consider; body weight, number of drinks, alcohol content of drinks, and number of hours since consumption began. This relationship is well known and has been published by Dr. Leon A. Greenburg of Rutgers Center for Alcohol Studies (Table 1). Many charts have been published showing two of the four variables, body weight and number of drinks, but these charts do not indicate the impor-

ATOR

tance of drink strength or time, which are necessary to accurately predict the maximum possible blood alcohol level.

Since these calculations can be done with a hand calculator, the first consideration was to build a dedicated digital device or a ROM look-up table with the necessary values stored for recall with a computed address. However, a simple graphic presentation of the information similar to a bargraph VU meter seemed more appropriate especially using the traffic light analogy of green for *go*, yellow for *caution*, and red for *stop*. This would correspond to blood alcohol levels of less than 0.05 percent, 0.05 percent to 0.10 percent, and greater than 0.10 percent, respectively.

Most hobbyists are familiar with the LM3914 operation and this project appeared to be a good application for it. The next step was to convert the blood alcohol formula to an appropriate analog circuit. The choice of of ranges had to be made without too much compromise. The drink scale was chosen to have ten drinks (more than enough for anyone), the maximum drink strength is equivalent to one ounce of pure alcohol and the minimum four tenths of an ounce, the weight scale of 100 to 260 pounds should suffice for most people, and the ten-hour time scale was used mostly for convenience. The LM3914 has a linear response between 0.0 volts and 1.2 volts, therefore, the steps are 0.12 volts each. Each 0.12-volt step was given the equivalent of 0.015 percent blood alcohol for a total range of 0.135 percent (only nine steps are used). The body eliminates alcohol at the rate of 0.015 percent per hour, or one step for each hour.

Tieing in the Circuit

Using the blood alcohol formula with the values for the maximum level (ten drinks, one ounce of alcohol, 100 pounds, and 0 hours) and converting that value to voltage necessitates an input voltage of 6.0 volts. The starting voltage is 6.0 volts, all other computed values will be less. In this way the simple series of dividers shown in Fig. 1 can be used with the first two op amp stages serving as followers and the initial voltage supplied by a 6.0-volt Zener diode.

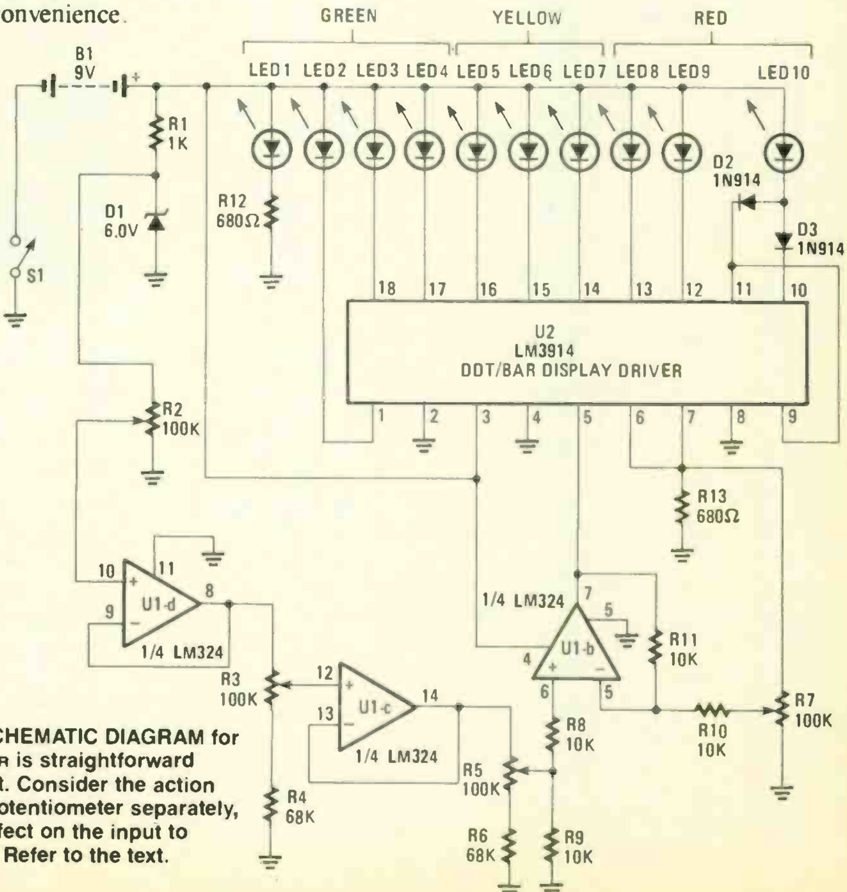


FIG.1—SCHEMATIC DIAGRAM for ALCULATOR is straightforward and direct. Consider the action of each potentiometer separately, and its effect on the input to B2, pin 5. Refer to the text.

PARTS LIST FOR ALCULATOR

SEMICONDUCTORS
D1—6-volt, ½-watt Zener diode
D2, D3—1N914 silicon diode
LED1-LED4—Green light-emitting diode, 5-mm square (AEG-Telefunken)
LED5-LED7—Yellow light-emitting diode, 5-mm square (AEG-Telefunken)
LED8-LED10—Red light-emitting diode, 5-mm square (AEG-Telefunken)
U1—LM324 quad op amp
U2—LM3914 dot/bar display driver integrated-circuit chip

RESISTORS
(All resistors are ¼-watt, 5%, carbon-film types unless otherwise specified)
R1—1000-ohm
R2, R3, R5, R7—100,000-ohm slide potentiometer, 20%, PC mount
R4, R6—68,000-ohm
R8-R11—10,000-ohm
R12, R13—680-ohm

ADDITIONAL PARTS AND MATERIALS
B1—9-volt transistor-radio battery
S1—SPST miniature slide switch
Printed-circuit board, battery clip, wire, solder, plastic case, labels, etc.

The following are available from ALCULATOR, Inc., Box 22051, Beachwood, OH 44122. Complete kit, including printed-circuit board and all parts including custom-molded case and labels—$29.95. Printed-circuit board, custom-molded case and labels only—$9.95. All prices include postage inside USA.

The first stage varies form 0.0 to 6.0 volts, the second stage is from 100 percent to 40 percent of the first stage (1 oz. to .4 oz. of alcohol), and the third stage varies from 100 percent to 38 percent of the second stage (260 pounds to 100 pounds). The tolerance on the slide potentiometers R3 and R5 are 20 percent, but the divider must be accurate to 5 percent. If the actual value of R3 and R5 are more than 5 percent off then R4 and R6 must be changed to maintain the specified range of 40 to 100 percent of the input voltage. A value of 80,000 ohms for R3 would mean that R4 would have to be changed to 53,000 ohms; or if R5 was 120,000 ohms, then R6 would need to be 80,000 ohms. The values of R2 and R7 are not critical.

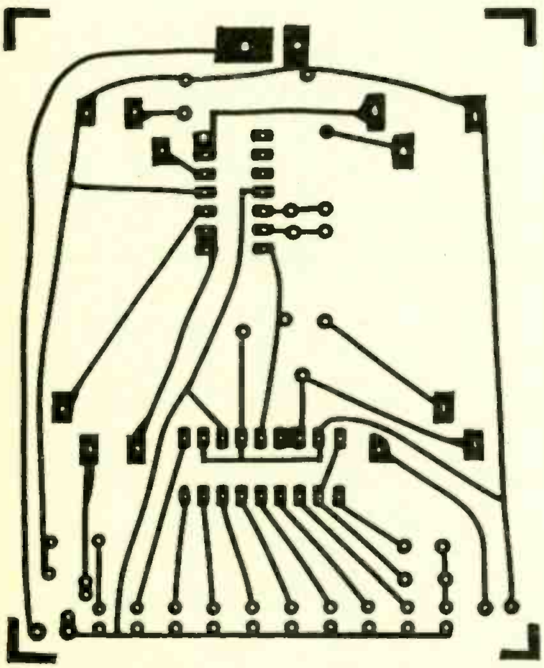


FIG. 2—FOIL PATTERN for the ALCULATOR is provided here on a 1:1 scale so that experimenters who wish to make their own printed-circuit board may do so.

The time function uses the 1.2-volt internal reference of the LM3914 to represent 10 hours, or a proportional fraction of that voltage for less time. The time can then be subtracted from the product of the alcohol content and body weight by using the third op amp as an analog subtractor. The output is then connected to the input of the LM3914 and displayed on nine LED's. A tenth LED was used to indicate power on. This necessitated connecting both the ninth and tenth outputs of the LM3914 to the last red LED because the tenth output is active for overvoltages.

TABLE 1
FORMULA FOR CALCULATING PERCENT ALCOHOL IN BLOOD

$$AB\% = \frac{7.3(N)(D)}{W} - .015H$$

where AB% = percent Alcohol in Blood, W = body weight in pounds, N = number of drinks, D = Alcohol content of drink in ounce/drink, and H = hours since consumption began.

Build It

Construction is facilitated by using the printed-circuit board layout in Fig. 2 and shown with parts mounted in Fig. 3. The only components that require particular care in mounting are the 10 LED's which must be at the same level for the sake of appearance. Those particular LED's were chosen because they form a continuous display without a special lens.

Although the case shown was specially molded for this application, early prototypes were constructed using commercially available cases. The slide potentiometer stems were shortened so they would rise just above the surface of the case. The scales along the slides are linear except for the weight which is an inverse relationship. The positions for the

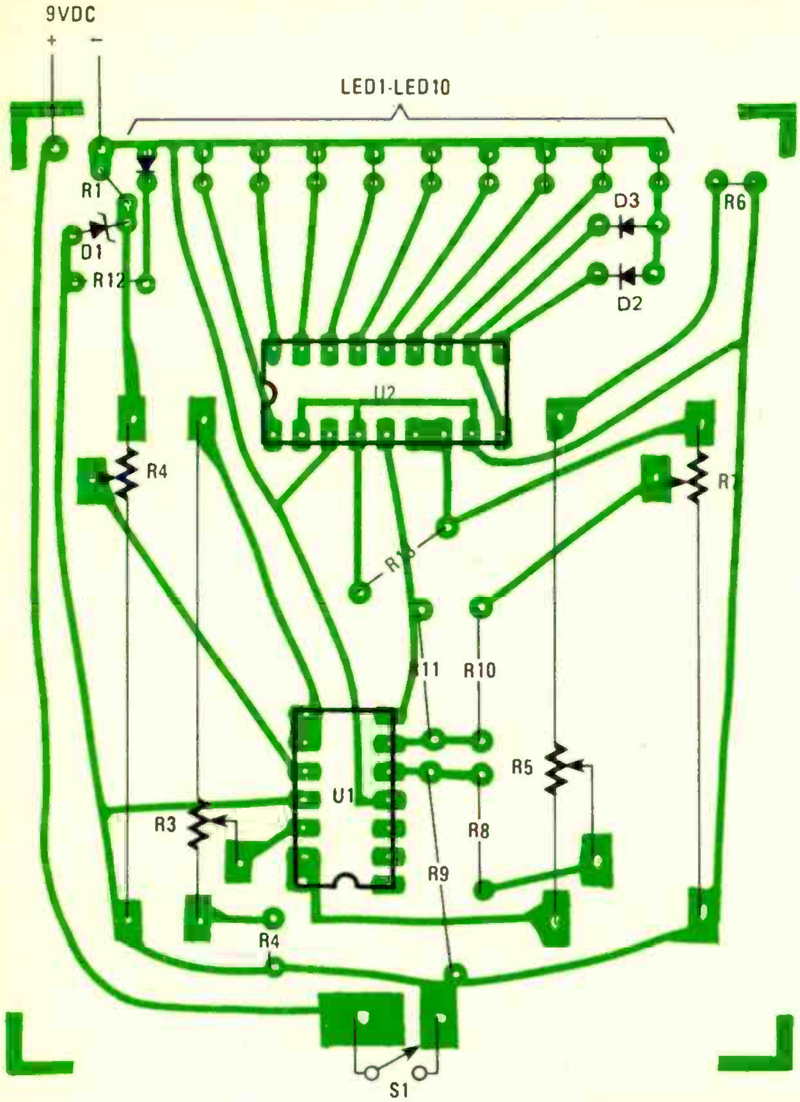


FIG. 3—X-RAY VIEW OF printed-circuit board with parts in place and foil side underneath. All parts are mounted on the board except for the battery and its clip connector.

weight scale values can easily be calculated in the following way: Divide 100 by the fraction of the input voltage at any point on the slide and that value in pounds will correspond to that position on the scale, i.e. if the divider is .40 of the input voltage that position corresponds to 250 pounds.

One option to consider is to use the fourth op amp on the LM3914 as a comparator to indicate low battery condition. The positive input would be connected to the 6.0-volt reference and the negative input to 90 percent of the supply voltage through a resistor divider. The output would go high if the supply voltage fell below 6.4 volts and light an LED.

To Operate

Operation of the ALCULATOR should start by checking to see that the battery is good and the unit is properly calibrated. When the slides are set to 10 drinks, minimum strength, maximum weight, and 0 hours, the first red LED indicates proper operation and a good battery. For an individual to compute their maximum possible blood-alcohol level they need only enter the appropriate information on the four slides and the blood alcohol level will be displayed on one of the nine LED's. Here's an example: If a 200-pound person drinks 5 beers in 2 hours, the first red LED should light indicating intoxication.

The completed ALCULATOR as pictured was the topic of a report by the ABC television network affiliate in Cleveland, Ohio, in which a group of people drinking at a bar were asked to keep track of their drink intake and submit to a Breathalyzer (tm) examination administered by a qualified police officer. These same people used the ALCULATOR to successfully predict their blood alcohol levels as measured by the Breathalyzer (tm). Hopefully, the ALCULATOR will function to educate and inform people when to stop drinking before they have *one too many*. ■

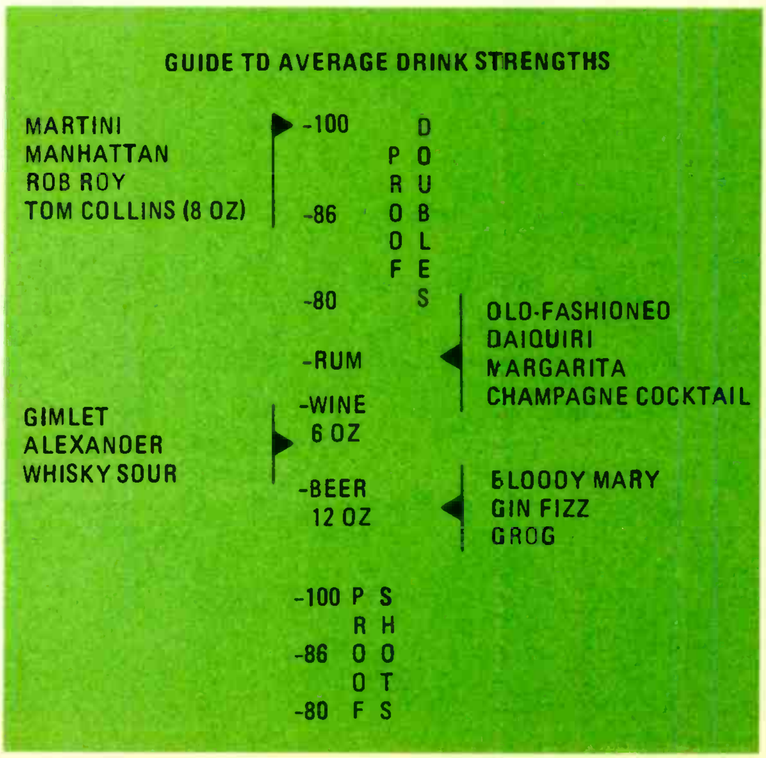
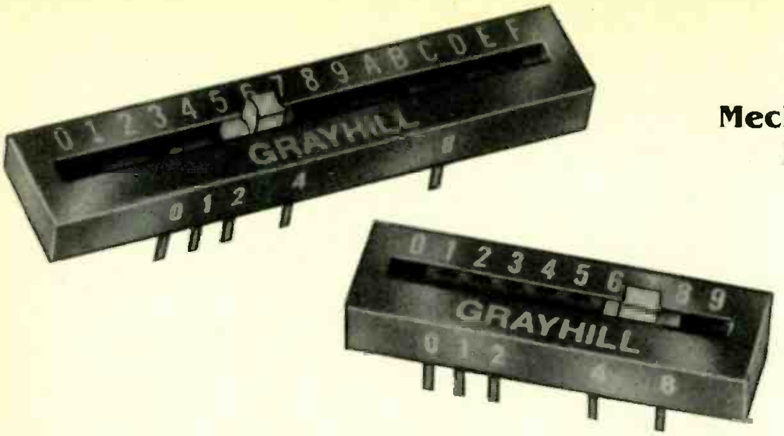


CHART indicates where to set average drink strengths on the ALCULATOR. As each LED lights, the blood alcohol level increased 0.015%. Push all controls to top to light all red LED's checking out the 9-volt battery.



Mechanical slide switches provide 4-bit binary outputs from 0000 to either 1001 or 1111 in a mini-DIP case you can mount on printed-circuit and solderless-circuit boards and test in an active circuit!

By Ed Noll

HEX/BCD Code Switches

A *CODE* SWITCH IS A MECHANICAL DEVICE THAT CAN BE set for a specific 4-bit binary output. Grayhill has two versions of that switch. The first, a BCD type, has ten positions that provide 4-bit binary outputs from 0000 to 1001; the second, a hex type, has 16 positions that provide 4-bit binary outputs from 0000 to 1111. Both devices are slide switches.

The switches are mounted in a mini-dip case convenient for mounting on printed-circuit or solderless-circuit boards. Such binary code DIP switches are convenient for setting up modes of operation in digital circuits, programmable controllers, computer systems and in test equipment used to check out digital systems.

Pinouts and truth tables of the two styles are given in Fig. 1. Four-bit binary logics appear at pins 8, 4, 2, and 1. Switch wiring is such that the output for pin 0 is also active for zero position setting of the switch. Note that the hex switch has 16 positions, and, as shown in its truth table (Fig. 1), sets up the first 16-possible hex combinations. The BCD version has only ten positions, setting up the binary equivalents of decimal 0 through 9. On one side of each type of switch there are a series of pins that are joined internally. Common ground can be established by making connection to any one or more of those pins.

A schematic diagram for a hexadecimal generator and demonstrator is shown in Fig. 2. In the circuit arrangement +6-volts DC is connected to the bus of the hex switch and the 4-bit binary outputs are connected to common ground through individual 10,000-ohm resistors. An LED circuit is connected to the zero-output pin. Whenever the hex switch is positioned at zero setting, a logic 1 appears at that pin and turns on the associated light-emitting diode (LED). The 4-bit binary output is available at outputs D, C, B, and A.

The 4-bit binary signal is also applied to the Motorola 14495 hex-decoder integrated circuit (Fig. 2). The hexadecimal equivalent of the binary switch setting is displayed on the common-cathode, 7-segment LED display (Radio Shack 276-75 or equivalent). When using the 14495 decoder, it is not necessary to use series resistors between the decoder outputs and the segments of the common cathode display. An LED connected to pin 4 turns on whenever hexadecimal A, B, C, D, or F is displayed.

Hook up the switch and decoder system on a solderless breadboard. Check out operation for each switch position. Note that in the transition between any two such switch positions, the logic changes back to 0000. That action is analogous to a rotary non-shorting switch.

Interfacing

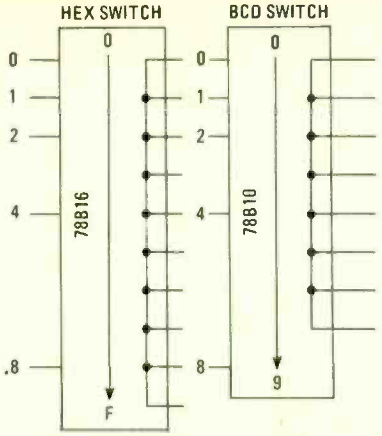
Inverting and non-inverting buffers can be used to interface the 4-bit binary output to digital circuits and/or control systems. The 4049 and 4050 hex buffers are appropriate. When supplied to the non-inverting 4050 integrated circuit (Fig. 3), the output level from the chip is such that additional CMOS circuits or two TTL input circuits can be driven with the 4-bit binary signal. Sensitive relays, as well as opto devices, can be driven from those outputs.

If your application requires complementary outputs, the inverting 4049 hex buffer can be used. That manner of operation might be attractive when the binary logic 1 is to operate relays using a high sink current.

The hex switch itself can be wired to provide a complementary output. The basic circuit is given in Fig. 4. In that application the bus line is connected to common ground, while each of the individual 4-bit binary outputs are connected to the plus voltage through 10,000-ohm resistors. In that case, the output logic at DCBA will be 1111 when the switch is set to hex 0. Complementary logics decline with switch setting reaching a DCBA value of 0000 when the switch is set to hex F.

Adding a Storage Latch

In your application it might be advisable that the 4-bit



POS	HEX CODE 0	1	2	4	8
0	•				
1		•			
2			•		
3		•	•		
4				•	
5		•		•	
6			•	•	
7		•	•	•	
8					•
9		•			•
A			•		•
B		•	•		•
C				•	•
D		•		•	•
E			•	•	•
F		•	•	•	•

POS	BCD CODE 0	1	2	4	8
0	•				
1		•			
2			•		
3		•	•		
4				•	
5		•		•	
6			•	•	
7		•	•	•	
8					•
9		•			•

FIG. 1—TWO CODE SWITCHES are diagrammed here, presenting the pinouts and the truth tables for each. The 0 pinout is high at zero and all other settings are low. You may want to tie an LED indicator to the zero output, should that be the home position of a circuit you are designing.

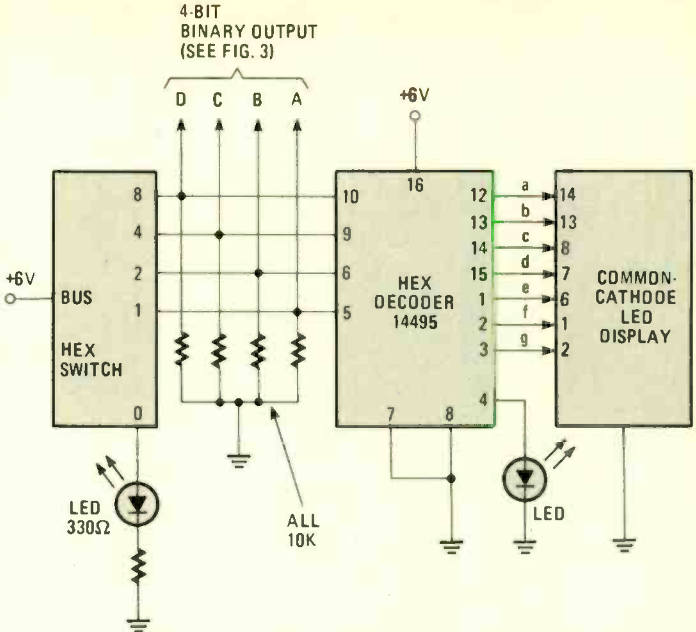
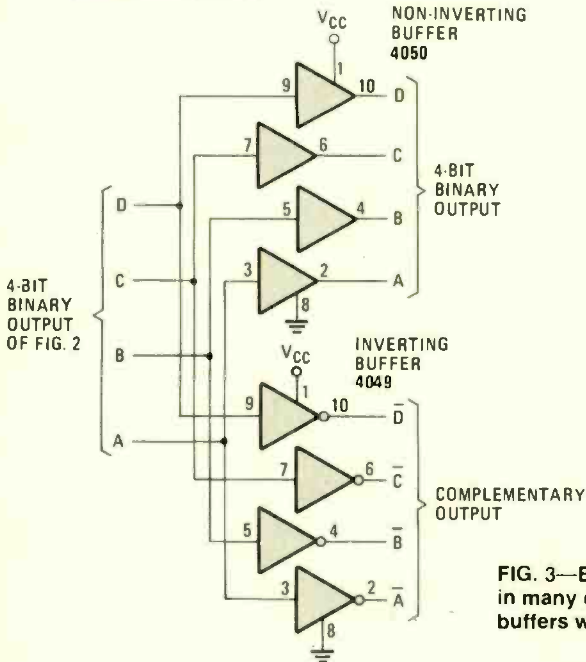


FIG. 2—WITH A LITTLE BIT of simple circuitry, the hex-code switch can control the display of an LED numerical indicator via a hex decoder. The 14495 used requires current-limiting resistors at its outputs.



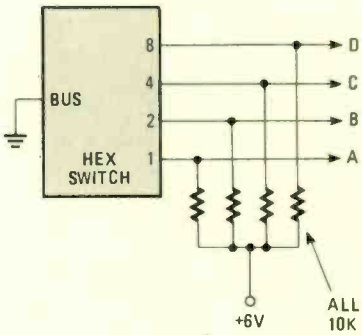


FIG. 4—CONNECTIONS for obtaining a complementary hex output from a binary code DIP switch. Here, the resistors connect the switch's output to a high until the switch grounds the outputs via the bus nput.

FIG. 3—BUFFERS provide the circuit isolation required in many circuits. Shown here are the 4050 and 4049 Hex buffers with the latter providing inverting buffering.

binary output be placed on hold for a specific application. Two advantages are offered by that arrangement. First, the 4-bit binary output logic will not change as the switch is moved to another position. Second, the switch can be pre-set to the next position to be used and held there. Operations will continue as per the previous setting, and at an appropriate time a fast changeover can be made simply by depressing a pushbutton switch.

That mode of operation can be established using a 4175 storage register chip as shown in Fig. 5. The 4-bit output of the circuit of Fig. 2 is supplied to appropriate DCBA pins of the 4175. A pushbutton switch is connected to storage pin 9 of the 4175. New DCBA outputs are applied to your 14495 decoder. In addition complementary outputs as may be re-

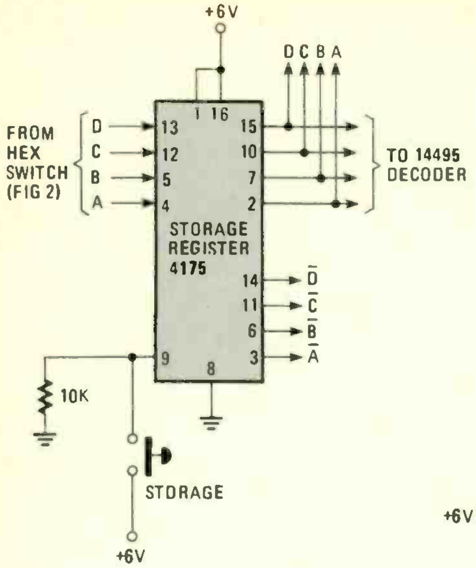


FIG. 5—STORING THE OUTPUT from the hex switch is a useful idea. Actually, a similar circuit is used in displaying telemetered data presentations. For example, your weight on an electronic scale is constantly changing, due to your shifting weight, breathing, etc. So, a pulse generator closes the storage switch circuit every two seconds (typical) and the data is displayed without the rapid flashing that makes the last digit so hard to read.

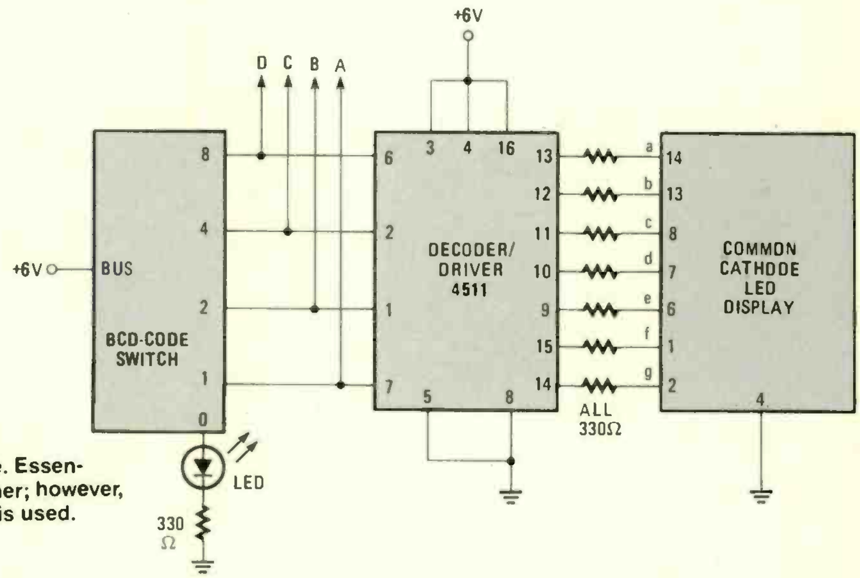


Fig. 6—A VARIATION of Fig. 2 is shown here. Essentially, the circuit performs in the same manner; however, an inexpensive decoder/driver, CMOS 4511, is used.

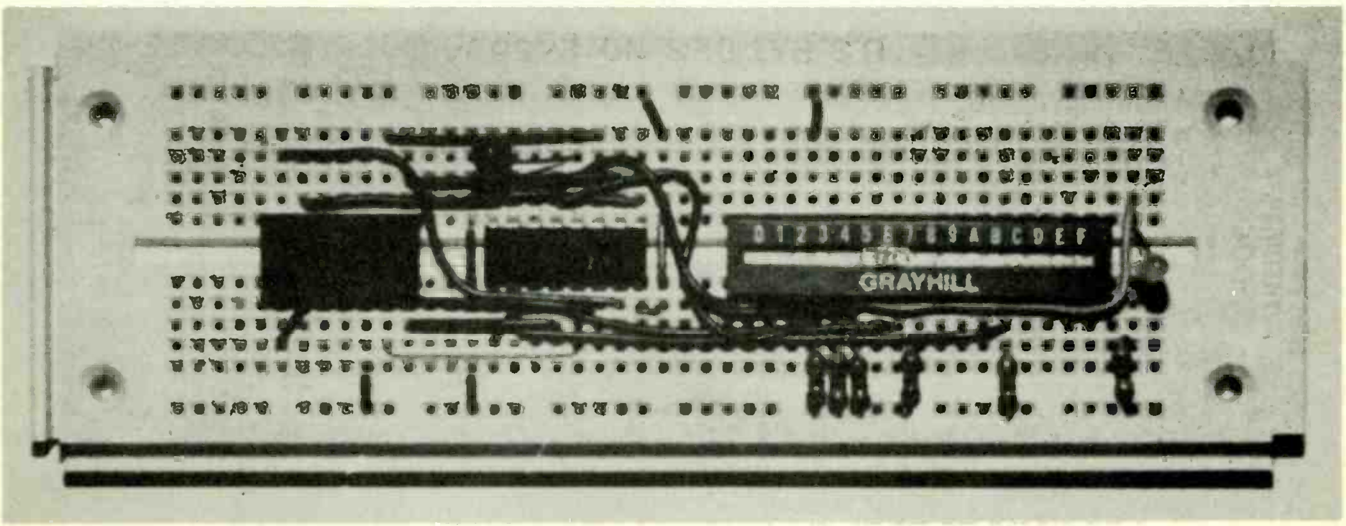
quired are made available at pins 14, 11, 6, and 3.

Add the storage latch to your basic circuit. Set the code switch to hex 8. Momentarily depress the store pushbutton. The 4-bit binary equivalent of hex 8 will appear at the DCBA outputs of the 4175. Now move the hex decode switch to different positions above and below hex 8. Observe that the output is latched on hex 8. Set the switch to hex C. Now depress the store pushbutton, noting that the output switches over to the 4-bit binary equivalent of hex C and holds.

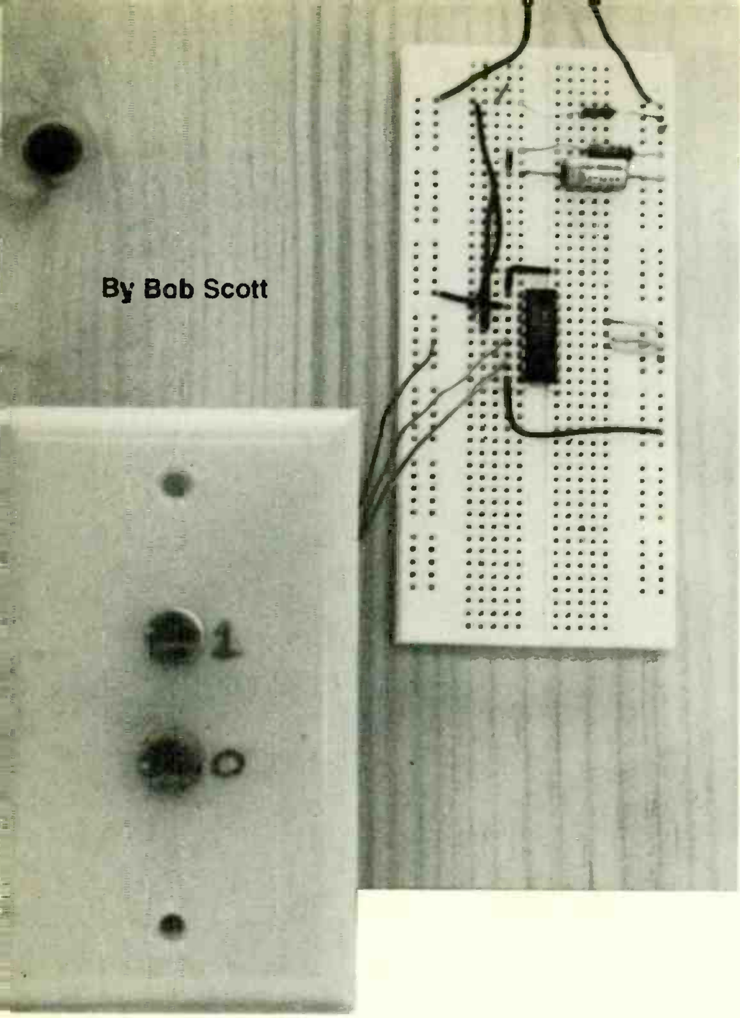
The previous procedures demonstrate two advantages of using a storage latch circuit in generating a 4-bit binary signal for test use or other applications.

The circuit of Fig. 6 shows how the BCD code switch can be used to generate the BCD 4-bit binary signal. The switch circuit is identical to that of Fig. 2. However, the less expensive 4511 BCD decoder/driver is used. Any 4-bit binary number above decade 9—namely, 1010 to 1111—will not be displayed. In using the 4511, current-limiting resistors must be connected in the path between each decoder output and its 7-segment input. Wire the circuit and check out operation.

You may find the mechanical code switch useful in a variety of practical and educational applications. A most favorable attribute is the ability to mount it on printed-circuit and solderless-circuit boards. ■



THE SOLDERLESS-CIRCUIT BOARD has been wired to duplicate the schamatic drawing illustrated in Fig. 2. The Grayhill switch is a HEX-code type set to HEX 6. The HEX decoder chip (center) drives the common-cathode LED display at the left.



By Bob Scott

2PB/ECL

An electronic combination lock you can assemble in one evening.

IF YOU ARE LOOKING FOR AN *E*LECTRONIC *C*OMBINATION *l*ock (ECL) that is almost impossible to open by a random combination of input-keying pulses, look no farther! This ECL is for you! It uses only *two* push-*b*uttons (2PB), with which you can program any one of 512 possible 9-bit code combinations. The 2BP/ECL (guess how we got the name) is operated by the correct sequence of ones and zeros fed in via two pushbutton switches.

Inside the Lock

By depressing two switches, S1 and S2, to a preset 9-bit pattern, you will be able to unlock the 2PB/ECL (see Fig. 1). Any out-of-sequence bit disables the 2PB/ECL so as to lock out any further attempts to open the lock. Another coded input sequence can be entered only after a delay period set by an RC network consisting of R1 and C1. If the combination (9-bit code) is entered in the correct sequence, a logic *one* is passed through the LS7229 9-bit shift register, U1, to produce a logic *one* at its output terminal (pin 11).

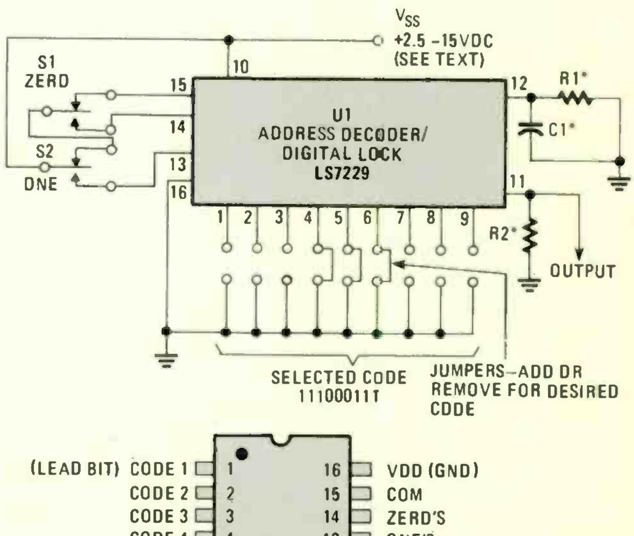
The combination is entered at pins 1 through 9 of U1—the *leading bit* on pin 1 and the *end bit* on pin 9. Leave a code pin floating for a logic 1, or tie it to ground for a logic zero. Initially, the ONE and ZERO input ports (pins 13 and 14 of U1, respectively) are at logic-one levels. To open the lock enter the code by pressing the ZERO and the ONE switches, S1 and S2, in the correct sequence. As each switch is pressed, the corresponding input port goes to a logic one and then returns to a logic-zero level as the switch is released.

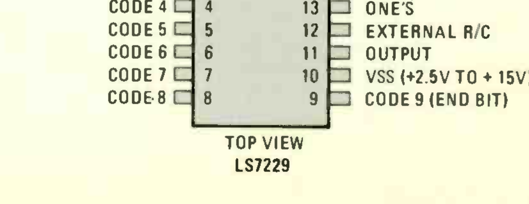
In the circuit in Fig. 1, code pins 4, 5, and 6 are shown grounded; all others are open (floating). Thus the combination is 111000111. (I selected that combination for my personal application because it's easy to remember. With the ones representing dots and the zeros dashes in Morse code, the combination is the equivalent of the International Distress Signal, SOS. To operate the lock, press the ONE switch S2 three times in rapid succession, then the ZERO switch S1 three times, and finally the ONE switch three more times. The lock output at pin 11 goes high at the instant that the last entry bit returns to zero. The output remains high for a period about 30% longer than the period of the external RC network. If you want to hold the output high for a longer period, enter a tenth bit and hold that switch closed for as long as is necessary.

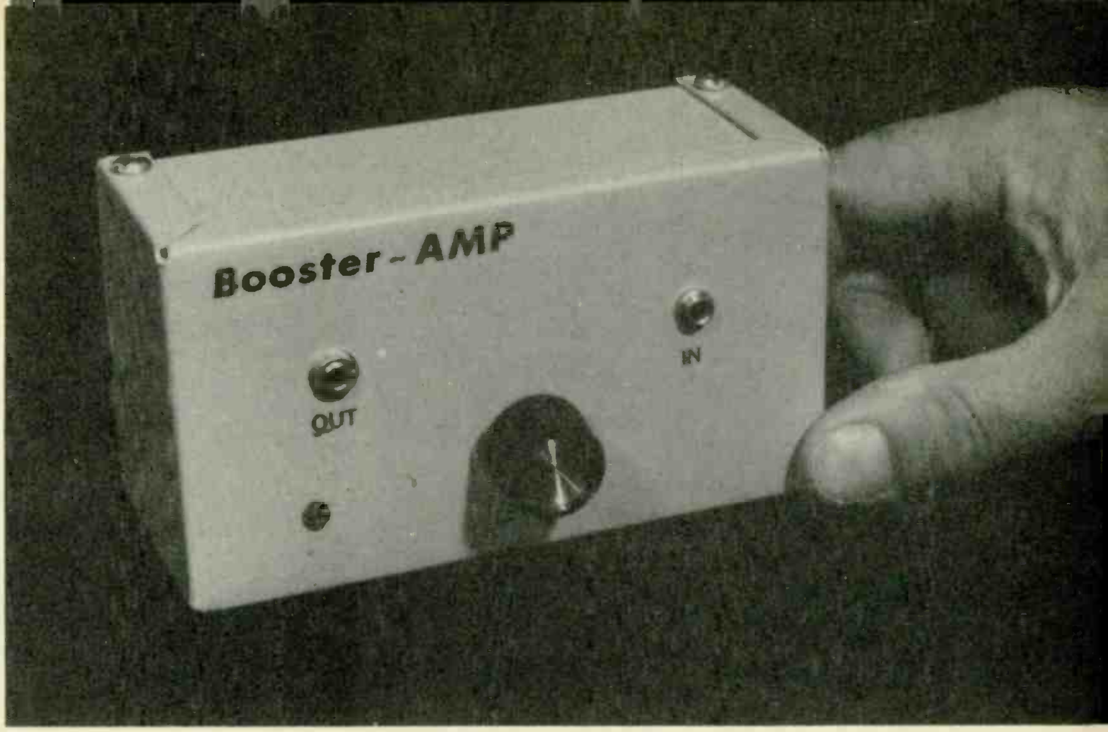
(Continued on page 101)

PARTS LIST FOR 2PB/ECL

- C1—See text. Watch polarity if you use an electrolytic type
- R1—2200-ohm to 3,300,000-ohm, ¼-watt resistor (See text)
- R2—10,000-ohm, ¼-watt resistor (See text)
- S1, S2—SPST momentary pushbutton switch (Radio Shack #275-1549 or equivalent)
- U1—LS7229 2-push-button digital lock (LSI Computer Systems, 1235 Walt Whitman Road, Melville, NY 11747. $2.70 per unit. Add $5.00 for shipping and handling.)
- B1—2.5-15-VDC battery supply (See text)
- Solderless circuit board, wire, battery clip, printed-circuit board, solder, etc.







Build this 20-dB booster at almost no cost from parts in your junkbox!

AN AUDIO BOOSTER AMP IS A HANDY GADGET TO HAVE ON the work bench. It can be used to provide extra oomph for a microphone circuit when you're recording a conference; it will turn a high-level auxiliary (AUX) input into an extra microphone input; and it can even be used to convert a small utility amplifier into an audio-signal tracer.

For general and experimenter uses, a booster amplifier doesn't have to be made of gold-plated components. Even if your junkbox isn't crammed to overflowing with parts salvaged from a hundred discarded radio and TV sets, you'll probably find it has most of the stuff needed for our Audio Booster Amp.

The Audio Booster Amp has an input impedance of approximately 50,000 ohms, so it can be used with both Lo-Z (50-600 ohms) and Hi-Z (about 50,000 ohms) microphones. We have installed the booster amplifier assembly inside a small 5¼- × 3- × 2⅛-in. aluminum cabinet so the project can be used as a microphone or general purpose preamplifier. You can just as easily install the printed-circuit assembly directly inside another piece of equipment.

The Specs

The amplifier's gain is nominally 20 dB. Its frequency response is determined primarily by the value of just a few components—primarily C1 and R1. The values in the schematic diagram and Parts List provide a response of ±3.0 dB

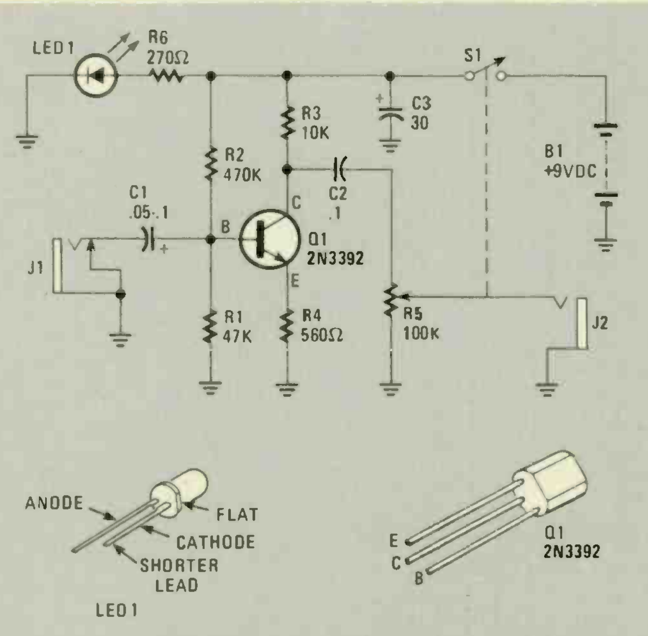


FIG. 1—THE SCHEMATIC DIAGRAM for the Audio Booster Amp could not be simpler unless some manufacturer provided a chip with input and output jacks mounted on the device. Resistor R6 limits the current through LED1. Using the larger value for C1 lowers the frequency bandpass.

PARTS LIST FOR AUDIO BOOSTER AMP

SEMICONDUCTORS
LED1—Light-emitting diode (see text)
Q1—2N3392 PNP transistor or equivalent (see text)

RESISTORS
(Use ¼-watt, 10% values unless otherwise specified.)
R1—47,000-ohm
R2—470,000-ohm (see text)
R3—10,000-ohm
R4—560-ohm
R5—100,000-ohm, audio-taper potentiometer with on/off switch S1 (Radio Shack 271-216, or equivalent)
R6—270-ohm

CAPACITORS
(Rated 10-WVDC or higher)
C1—0.05- or 0.1-µF (see text)
C2—0.1-µF
C3—30- to 50-µF, electrolytic

ADDITIONAL PARTS AND MATERIALS
B1—9-volt transistor battery, type 2U6 or equivalent
J1, J2—Miniature phone jacks (see text)
S1—SPST switch (part of R4)
Battery connector, battery mounting clip, cabinet, printed-circuit materials, wire, solder, hardware, etc.

AUDIO BOOSTER AMP

By Herb Friedman

from about 120 Hz to better than 20,000 Hz. Actually, the frequency response is *ruler flat* from about 170 Hz to well over 20,000 Hz; it's the low end that deviates from a flat frequency response. Refer to Fig. 1

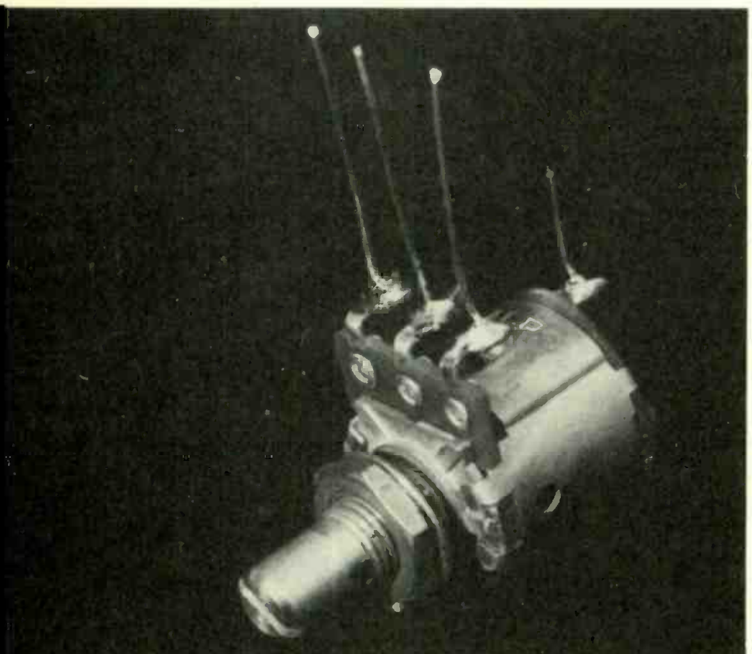
The low end's roll-off is primarily a function of capacitor C1 (since R1's resistive value is fixed). If C1's value is changed to 0.1 μF, the low end's *corner* frequency—the frequency at which the low-end roll-off starts—is reduced to about 70 Hz. If you need an even *deeper* low-end roll-off, change C1 to a 1.0-μF capacitor; if it's an electrolytic type, make certain that it's installed into the circuit with the correct polarity, with the positive terminal connected to Q1's base terminal.

A small light emitting diode (LED1) on the front panel illuminates as long as the power is on. The 3-mA pulled by LED1 is essentially the total current drain of the circuit, so battery B1 will deliver almost its *shelf life* in typical, or non-continuous, use.

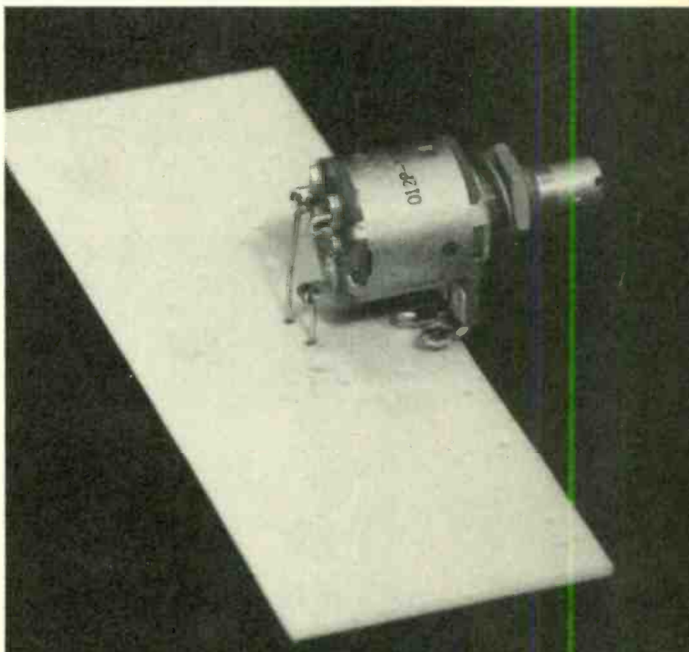
Construction

Except for the transistor's gain range, nothing is critical, so feel free to make any changes you would like in the printed-circuit foil layout, cabinet, jacks, etc. For example, the unit shown uses miniature input and output jacks, because they match the miniature plugs usually supplied with modern cassette-recorder microphones. If your equipment requires standard phone jacks, simply substitute them for the miniature jacks. Just be certain that the printed-circuit assembly's location leaves enough room for the larger phone jacks.

Transister Q1 is a 2N3392 type, which has a beta (DC gain) of 250. You can substitute any similar transistor as long as the gain is essentially that of the 2N3392. If you're not quite certain that the substitute Q1 is correct, you can *fine-tune* the circuit by adjusting R2's value. Measure the battery voltage (across C3) and then the DC voltage from Q1's collector to ground. If the voltage at Q1's collector ranges from about half to one-third the battery voltage, your parts' values are *on the mark*. If Q1's collector voltage is not within that range, trim down resistor R2's value until the collector voltage approximates half the battery voltage. Increasing R2's value will increase the collector voltage; decreasing R2's value will decrease the collector voltage.

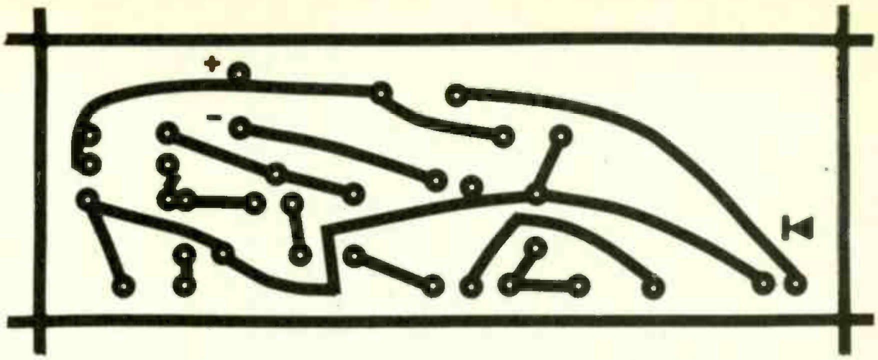


SINCE AUDIO-TAPER potentiometers for printed-circuit assembly are hard to come by, you'll have to make your own by soldering short, solid bare wires to the specified potentiometer's solder lugs. Bend the wires so that they are perpendicular to the body of the control.



PASS THE WIRES from the potentiometer through the drilled holes in the printed-circuit board, then pull the potentiometer up tight to the board and solder the wires to the copper foils. It will all go together, as if the potentiometer were originally a printed-circuit type.

FIG. 2—HERE'S the author's pattern for the printed-circuit board's foil surface. It is presented same-size so that you can copy it and produce your own board quickly. Drill holes for #22 wire.



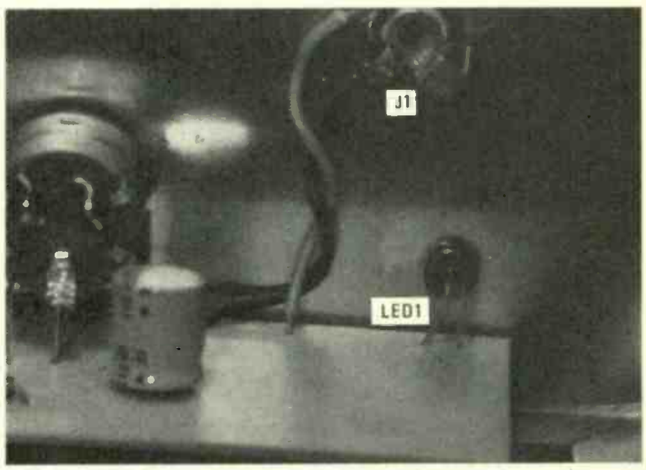
If you substitute for the 2N3392, make certain that the printed-circuit foil pattern matches the transistor's terminal positions. The foil pattern shown in Fig. 2 is for the 2N3392, which has an ECB (*e*mitter, *c*ollector, *b*ase) lead arrangement. A substitute transistor might have an EBC layout. If so, simply change the printed-circuit foil layout accordingly.

The required audio-level control, R5, is not generally available with printed-circuit wire connections, so a standard miniature potentiometer must be adapted for the printed-circuit assembly. The potentiometer shown in the photographs is a miniature volume control with switch (Radio Shack 271-216 type) having an 100,000-ohm audio taper. Solder a 1-inch bare, solid, #20 or #22 wire to each of the three potentiometer lugs, and a like wire to the common switch lug. (The remaining switch lug will be connected later.) Bend the four wires so that they are at right angle (perpendicular) to control and slip the wires into their respective holes in the printed-circuit board. Push the control as close as possible to the board, carefully position the control, and solder the four wires to the printed-circuit foils. Then, using an ohmmeter or other continuity-tester, determine which of the two remaining switch terminals closes a circuit when the control's shaft is advanced. Connect a wire from that terminal to the appropriate printed-circuit foil. (Looking at the back of the switch, directly at the switch contacts with the common terminal at the bottom, the left-hand terminal is the one that's on when the shaft is rotated from the off position.

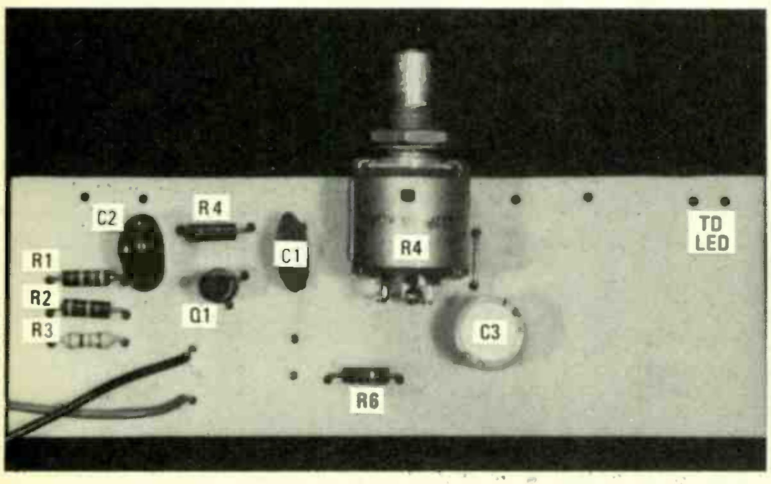
Install the remaining components—except LED1—after level-control R5 is fully secured to the printed-circuit board. LED1 is installed after the printed-circuit assembly is mounted in the cabinet. If LED1 is installed earlier, it will probably be damaged when you try to push it through its panel hole. To keep the battery drain as low as possible, LED1 works at very low current and it isn't all that bright. To insure that LED1 can be seen in a brightly lit room, use an unit with a Fresnel lens that focuses the light so tat it appears to be very bright when viewed straight in. If you're pinching pennies on this project, substitute any light-emitting diode you have in stock.

Here's how to handle LED1. First, install the printed-

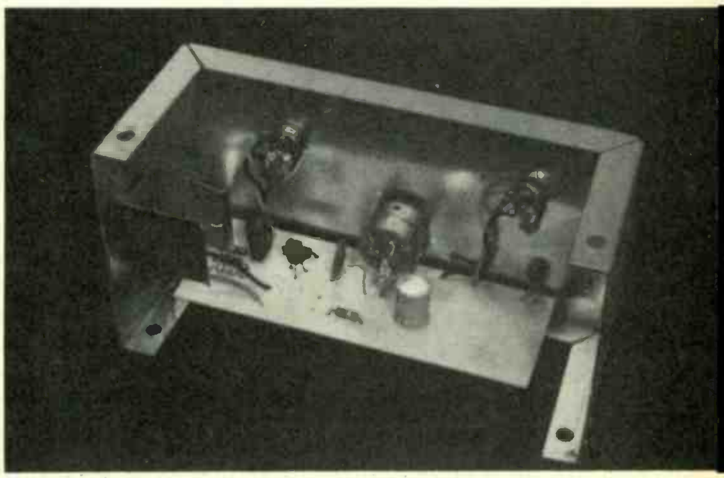
(Continued on page 97)



THIS IS HOW LED1 is mounted. Bend the two leads perpendicular to the body. Slip the leads into the board, push the LED into the hole in the panel—now solder them.



THIS IS HOW the printed-circuit assembly appears when it's ready for installation in the cabinet. The only things missing are the jacks and the power indicator, LED1.



THE PRINTED-CIRCUIT ASSEMBLY is held to the top panel by the potentiometer's mounting nut. The battery is secured by the clip on the left side of the cabinet.

Electronic Crossover Circuit

By Fernando Garcia Viesca

EVER SINCE THE INITIAL SUCCESS BY THOMAS ALVA EDISON at sound reproduction, and as that art was constantly upgraded into hi-fi, it was recognized that somehow the audio band of frequencies should be split into smaller frequency bands in order to faithfully reproduce the complete audio spectrum. In fact, that was Alexander Graham Bell's original approach to the telephone. Because of their electromechanical origin, speakers were the first audio component to establish that practice. In early stages of electronics, vacuum-tube amplifiers had the same trouble dealing with such a wide band—10 octaves. Most of the troubles existed in the power-amplifier sections, so it was logical then to divide the audio frequencies and feed a separate power amplifier for the low- and high-frequency bands, a technique known as biamping. Lower intermodulation distortion, better coupling to the speakers, and freedom of the high-frequency units from low-frequency overloads were quickly realized benefits. Biamping was used in professional sound systems, but it was too large, heavy, complicated, and expensive for the average electronics and hi-fi enthusiast.

With the advent of the transistor, the problem was lessened, but still remained complicated. Not until the arrival of the linear integrated-circuit chip could such a project be built easily and inexpensively. Even then, the available IC's didn't deliver the performance for true hi-fi. With the introduction of BIFET and hybrid IC's at affordable prices, the construction of a biamp system is a reality for the hobbyist, and a home-made project can deliver excellent sound fidelity.

This article is a description of an Electronic Crossover Circuit and an optional power-amplifier setup for a complete biamp project.

The Electronic Crossover Circuit

An audio source, such as a mixer, preamplifier, equalizer, or recorder, is fed to the Electronic Crossover Circuit's input (Fig. 1). That signal is either AC- or DC-coupled, depending on the setting of switch S1, to the non-inverting input of buffer-amplifier U1-a, one section of a quad, BIFET, low-noise TL074 op-amp made by Texas Instruments. That stage has a gain of 2, and its output is distributed to both a lowpass

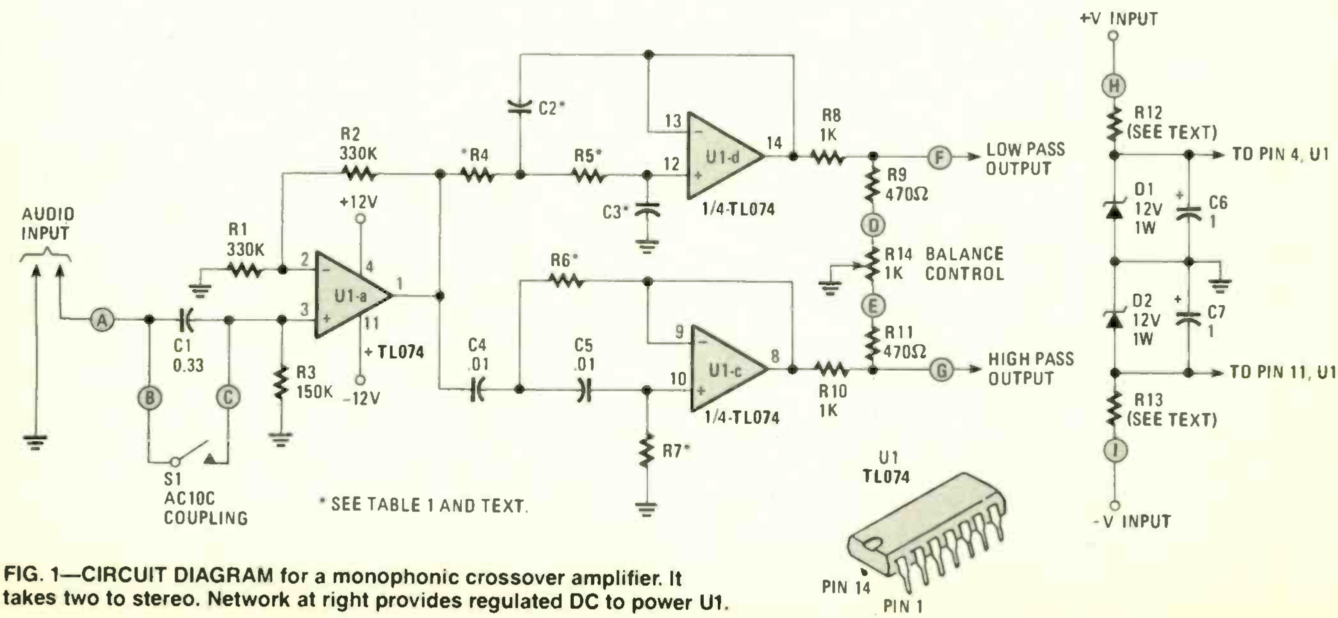


FIG. 1—CIRCUIT DIAGRAM for a monophonic crossover amplifier. It takes two to stereo. Network at right provides regulated DC to power U1.

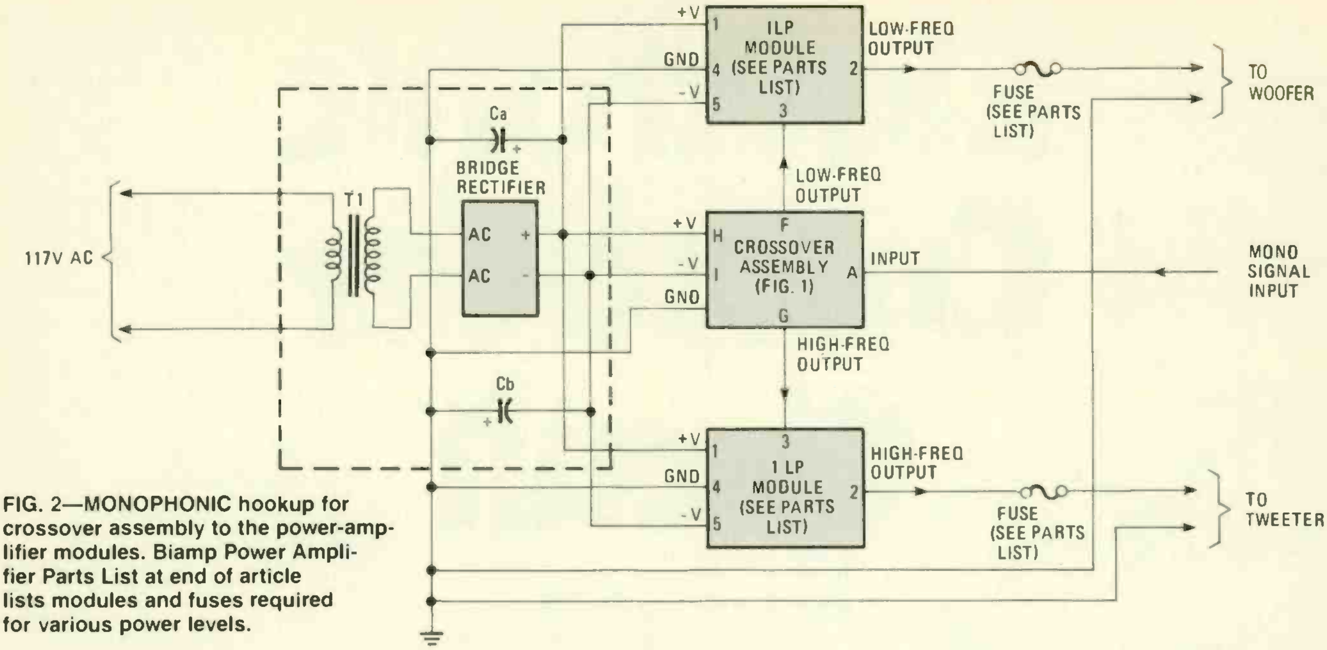


FIG. 2—MONOPHONIC hookup for crossover assembly to the power-amplifier modules. Biamp Power Amplifier Parts List at end of article lists modules and fuses required for various power levels.

TABLE 1—COMPONENT VALUES

Freq. (Hz)	R4, R5 (Ohms)	C2 µF	C3 µF	R6 (Ohms)	R7 (Ohms)
750	15.0K	0.002	0.01	15.00K	30.00K
1000	10.2K	0.002	0.01	11.25K	22.51K
1250	8.2K	0.01	0.005	9.00K	1.80K
1500	15.0K	0.022	0.01	7.50K	15.00K
2000	5.1K	0.01	0.005	5.62K	11.25K
2500	8.2K	0.01	0.005	4.50K	9.00K
3000	15.0K	0.005	0.0025	3.75K	7.50K

PARTS LIST FOR ELECTRONIC CROSSOVER CIRCUIT

SEMICONDUCTORS

D1,D2—12-volt, 1-watt Zener diode (such as ECG142A)
U1—TL074 Quad, BIFET, low-noise op-amp; TL084 (slightly noisier) may also be used

RESISTORS

(Fixed resistors are ¼-watt, 5% units)
R1, R2—330,000-ohm
R3—150,000-ohm
R4-R7—select values given in Table 1
R8, R10—1000-ohm
R9, R11—470-ohm
R12, R13—see text
R14—1000-ohm, linear-taper potentiometer

CAPACITORS

C1—0.22-µF, 100-WVDC
C2, C3—select values given in Table 1
C4, C5—0.01-µF.
C6, C7—1-µF, 25-WVDC electrolytic

ADDITIONAL PARTS AND MATERIALS

S1—SPST switch, very low-current capacity
Wire, cable, solder, mouhting hardware, printed-circuit materials or perfboard, cabinet, etc.

filter made by R4, R5, C2, C3, and op-amp U1-d, and a high-pass filter made by R6, R7, C4, C5, and op amp U1-c. Those are 12-dB/octave Butterworth-type filters. The *Butterworth filter response was chosen because it gives the best compromise between damping and phase shift. Refer to Table 1 for the values of those capacitors and resistors whose values vary with the selected crossover at which your unit will operate.

The filter's outputs are fed to a balancing network made by R8, R9, R10, R11 and balance potentiometer R14. When the potentiometer is at its mid-position, there is unity gain for the passbands of both the high and low filters.

DC power for the Electronic Crossover Circuit is regulated by R12, R13, D1, and D2, and decoupled by C6 and C7.

*Active filter theory Involves many equations beyond the scope of this short article; readers Interested In greater details should read: *Handbook of Operational Amplifier Circuit Design*, D.F. Stout and M. Kaufmann, Mcgraw-Hill 1976, chapters 10 and 11.

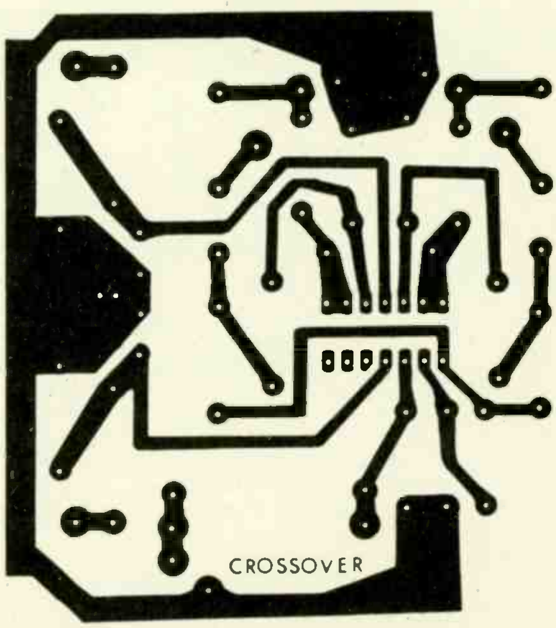
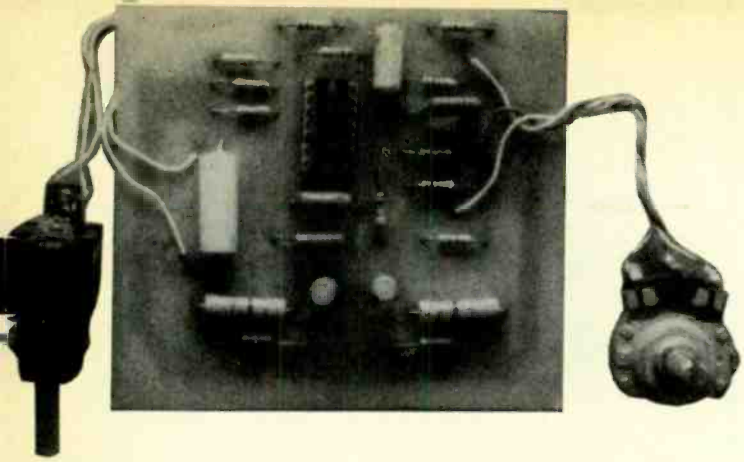


FIG. 3—SAME SIZE foil pattern used by author to fabricate his circuit-board for the crossover circuit.



THE CIRCUIT BOARD could be made smaller, but there's no need to crunch the circuitry into a small box. You may want to use shielded leads to limit hum and crosstalk pickup.

Power Amplifier Circuit

Although it's possible to build the electronic crossover circuit only (Fig. 1), and to use power amplifiers you have, you should be interested by the diagram of the amplifier circuit shown in Fig. 2. That simple circuit is centered around the new ILP power modules. Those modules are extremely easy to use, have built-in heatsinks, offer true hi-fi performance, and are reliable enough to be backed by a 5-year warranty. The modules are available in power ratings from 15 to 240 watts, including some ultra-low distortion MOSFET types. With only five connections per amplifier, only the power supply has to be built—plus the Electronic Crossover Circuit, of course. Contact the address in the Parts List for pricing and a brochure.

Construction

Wire-wrap or printed-circuit board construction may be used to build the Electronic Crossover Circuit's board, although the latter technique is recommended. The foil pattern and parts-location diagrams are shown in Figs. 3 and 4. The power-amplifier section is so easy to build that point-to-point wiring may be used. For the power amplifiers' high-current sections, use at least #18 wire for the V −, V +, ground, and output connections. The electronic crossover may use #24 wire, but use of shielded cable for the input, output, and switch connections is advised to avoid hum and noise pickup. It is extremely important that *all* ground connections be made by individual wires back to the power supply's common terminal. If AC coupling is always desired, delete switch S1. If DC coupling is always desired, delete switch S1 and replace capacitor C1 by a jumper.

Note also that balancing potentiometer R14 is mounted outside the cicuit board. Mount the Electronic Crossover Circuit's board away from the power transformer. The performance of the circuit is dictated by the quality of its components, so metal-film resistors, and polystyrene, mica or NPO-ceramic capacitors are strongly recommended. The resistor values are non-standard, so if you want to avoid expensive precision resistors, use a digital multimeter (DMM) to hand-pick usable resistors from a sample of standard-value resistors that are within 5% of the target value. Remember, the circuit will work with standard parts, but it will work better if you follow this sampling suggestion.

A bipolar supply of any voltage greater than 15 volts is needed to power the Electronic Crossover Circuit. Resistors R12 and R13 (Fig. 1) drop the excessive voltage to a correct level via the action of the Zener diodes, D1 and D2. Calculate the ohmic value of those resistors by subtracting 12 volts from your supply's rated voltage, and

(Continued on page 90)

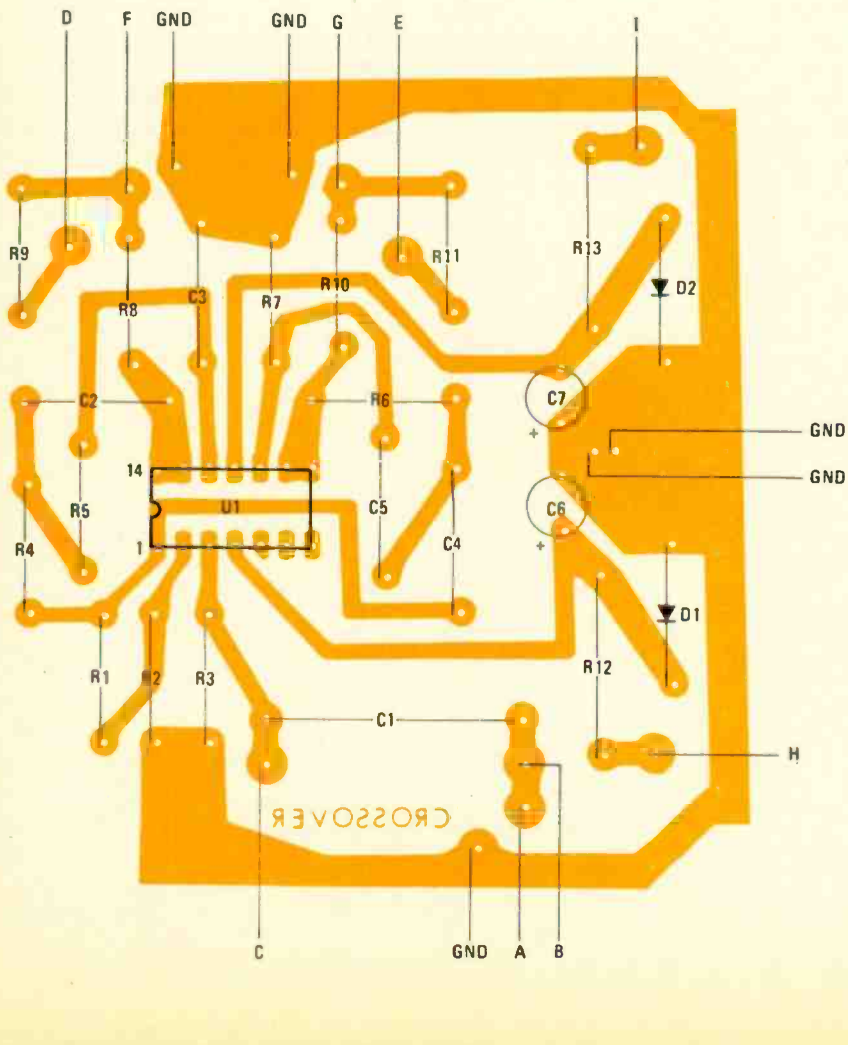


FIG. 4—ENLARGED VIEW of flopped foil pattern pinpoints parts location on the printed-circuit board. Considering that two are needed for stereo, it's a good idea to make several boards—two for yourself, and some for friends.

By W. N. Hubin
Kent State University

DIGITAL AUTOTACH

This true-reading engine tachometer is suitable for permanent monitoring in your car—monitor your engine's performance!

CURB-SIDE AUTO MECHANICS AND PEFORMANCE-ORIented drivers have been dreaming of an easy-to-read, sure-fire engine tachometer. With a bit of electronics background, they'd ask for a digital-readout tachometer that uses digital-counter and phase-locked-loop circuits to measure and present very accurate *rpm* information in a large-image, liquid-crystal display. They have it now in a project that we call Digital AutoTach. This easy-to-build unit uses CMOS and liquid-crystal technology to keep the battery-current requirements from a 12-volt battery to a very modest 8 milliamperes. Resolution of either ± 10 or ± 100 *rpm* is selected with a HI/LO slide switch; the lower resolution goes along with a rapid 0.1-second sampling time that is useful during rapid changes in engine *rpm*.

Circuit construction is simplified by designing the Digital AutoTach around a specialized oscillator/controller chip and a counter/decoder/driver integrated-circuit chip. The cost of the project to the builder, not including the case, is about $50. Of course, a packed junkbox of parts will help to reduce the overall cost.

Circuit Operation

Resistors R1, R2, and R3, capacitors C1 and C2, and diodes D1 and D2 (Fig. 1) condition the pulsating signal from the engine ignition system and reduce its maximum amplitude to 3.9 volts. (See Reading Reference 1.) Signal comparator U1 converts the conditioned pulsating signal into a 0 to 5-volt squarewave. Phase-locked-loop circuit chip U2 and flip-flop chip U3 form a phase-locked-loop that multiplies the signal frequency by three, so that in one second the counter will count and display a number equal to one-tenth the number of revolutions in a minute for a four-cylinder, four-cycle engine. That follows from the fact that such an engine will fire two of its four cylinders on every revolution, producing two voltage spikes that, in turn, will generate two counts in the tachometer. If that engine were rotating at 1000 *rpm*, for example, it will generate 2000 counts in a minute, but only 2000 ÷ 60 counts in a second. Thus, if we sample for only one second (as is done in the HI resolution switch setting), we must multiply the count by three to read one-tenth of the actual *rpm*:

$$(2000 \div 60) \times 3 = 100$$

In the LO resolution switch setting, the sample period is one-tenth of a second and the tachometer will repetitively count to 10 for that same *rpm*. From that, you can see that the multiplier circuit with chip U3 will have to be modified to use the tachometer with other types of engines. Those modifications will be discussed later.

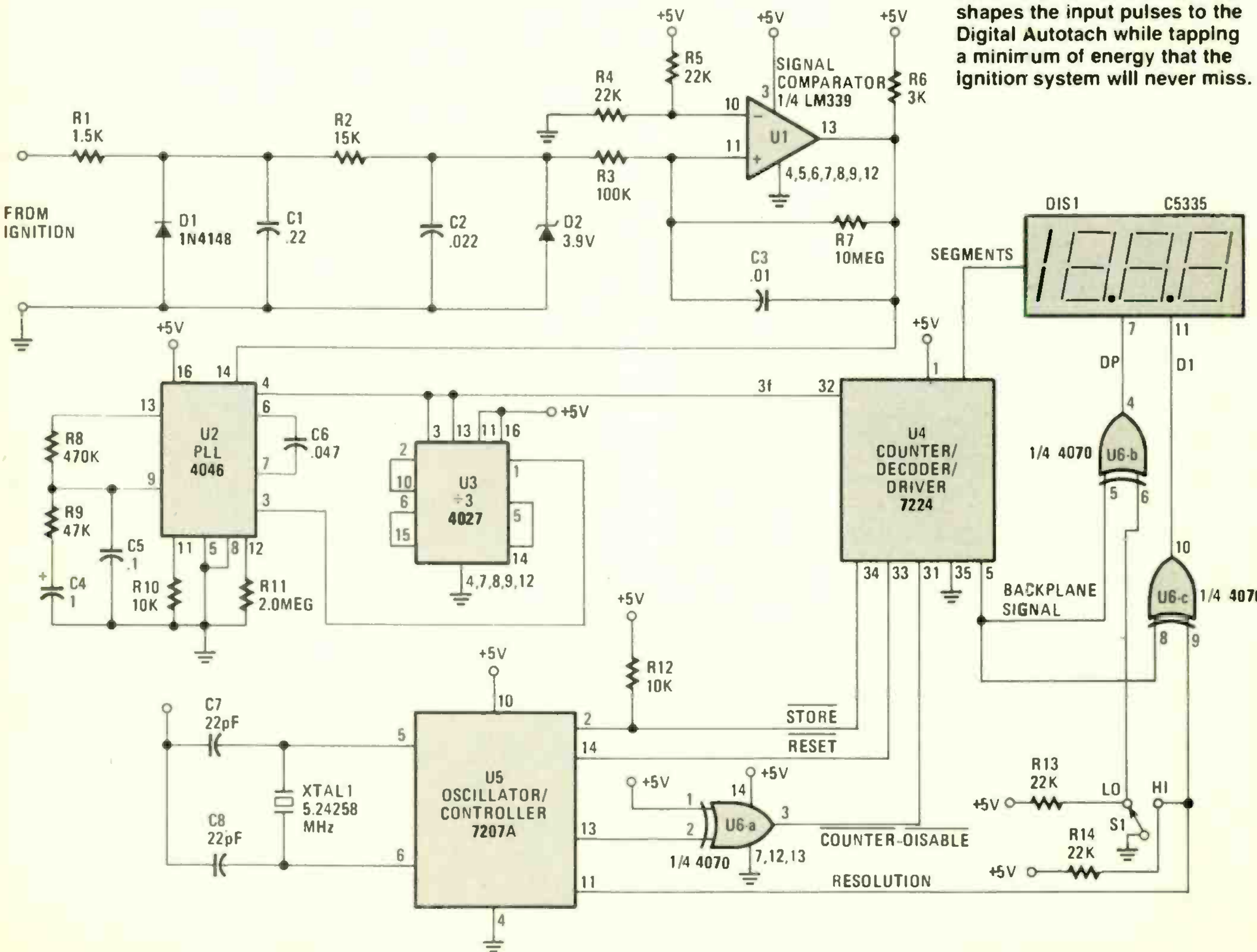
Circuit chips U4 and U5 form a basic frequency-meter building block. Chip U5 provides the crystal-based 0.1-second or 1.0-second sampling period (as selected by switch S1), as well as the necessary timing signals that transfer counter contents to the display latches and reset the counters. Counter/Driver chip U4 also provides the symmetrical backplane and segment signals required by the liquid-crystal display, DIS1. The exclusive-OR gates of U6 turn on the decimal point that is appropriate to the chosen resolution.

The power supply (Fig. 2) provides the regulated 5-volt power required by the circuit. The resistor/diode/capacitor input network (R15, D3, D4, and C9) is designed to shield the Digital AutoTach's circuit chips from the damaging voltage spikes that commonly occur on the power lines in an automobile. (See Reading Reference 1.) Diode D3 protects the circuit from voltage reversals that often occur as negative 50-volt spikes due to voltage/inductive kicks during the starting period.

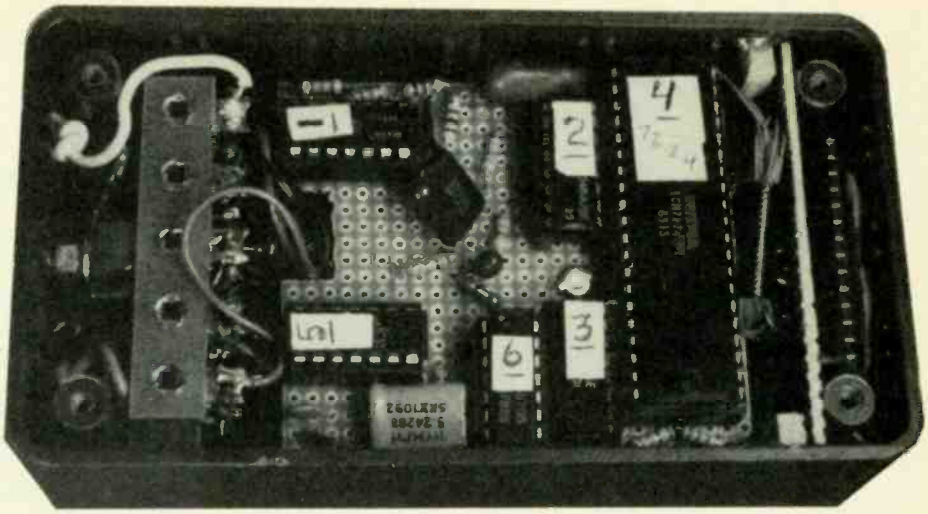
TABLE 1
WIRING LIST FOR 7224 TO C5335

DIS1 Segment	Pin Number 7224 (U4)	C5335 (DIS1)
A1	37	16
B1	38	15
C1	39	14
D1	40	13
E1	2	12
F1	4	17
G1	3	18
A2	6	20
B2	7	19
C2	8	10
D2	9	9
E2	10	8
F2	12	21
G2	11	22
A3	13	24
B3	14	23
C3	15	6
D3	16	5
E3	17	4
F3	19	25
G3	18	26
B4	21	2
Backplane	5	1,3,27,28

FIG. 1—THIS PROJECT is so simple, you will wonder why you did not conjure it up yourself. Pulses from ignition coil can be tapped continuously without affecting engine's performance. Network consisting of R1–R3, C1, C2, D1, and D2 shapes the input pulses to the Digital Autotach while tapping a minimum of energy that the ignition system will never miss.



THE AUTHOR did a clever deed when he attached self-adhesive, paper lables to the integrated-circuit chips housed in the Digital AutoTach. At a glance you can pin-point the IC you want to pin out. This idea made testing easier during the circuit-design stage, and it could make your troubleshooting procedure a snap should it become necessary.



Construction and Checkout

Either wire-wrap the circuit on a perfboard or resort to printed-circuit construction. The liquid-crystal display, DIS1, plugs directly into a standard 28-pin DIP socket. Refer to Table 1 for the wiring connections between U4 and the display, DIS1.

Before applying power to the Digital AutoTach, verify that all the pins on the circuit chips have a wire connection to them except for pins 1, 2, and 14 of U1, pins 1, 2, and 10 of U2, pin 11 of U3, pins 20 and 22-30 of U4, pins 1, 3, 7, 8, 9, and 12 of U5, and pin 4 of U6. Every pin of the liquid-crystal display, DIS1, must be connected, too; unused display segments should be connected to the backplane signal from pin 5 of U4.

When no signal is applied, the liquid-crystal display, DIS1, should read about .20 because 200 *rpm* represents the minimum frequency for the voltage-controlled oscillator in the phase-locked-loop (as determined by R10 and C6; see Reading Reference 2); the maximum *rpm* with the given circuit should be about 20,000. Another bench check can be made by applying an 8-volt (or somewhat greater) 60-Hz sinewave to the input; the display should then read 1.80 in the high-resolution position and .18 in the low-resolution position. If it doesn't, check for the proper 60-Hz squarewave (rather than a steady low state) from the output of U1 and then for a 180-Hz squarewave at the output of U2. The store and reset lines (Fig. 1) to counter U4 should be at a high-logic level except for a short pulse that appears every 0.1 second or 1.0 second, for low- and high-resolution respectively. The counter-disable line should have a symmetric squarewave on it with the same periods.

With a conventional ignition system (with breaker points), connect the tachometer to the plus (+) terminal of the coil and to a good engine ground. The three flexible leads coming from Digital AutoTach should be long enough to reach the battery terminals and coil without placing leads dangerously near the fan blades, belts, or other moving parts under the hood. For an electronic ignition system, it is advisable to check the service manual. VW, for example, recommends

PARTS LIST FOR DIGITAL AUTOTACH

SEMICONDUCTORS

D1—1N4148 silicon switching diode
D2—1N5228B 3.9-volt, ½-Watt, silicon, Zener diode
D3—1N4004 400-PRV, 1A, silicon rectifier diode
D4—1N4742 12.0-volt, 1-Watt, silicon, Zener diode (Radio Shack #276-563, or equivalent)
DIS1—3½ digit, 0.3-inch, liquid-crystal display (Crystaloid Electronics C5335 or equivalent)
U1—LM339 quad voltage-comparator, integrated circuit
U2—4046 phase-locked-loop, integrated circuit
U3—4027 dual JK flip-flop integrated circuit
U4—Intersil ICM7224 4½-digit, counter/decoder/driver, integrated circuit (Jameco 7224IPL)
U5—Intersil 7207A frequency-counter timebase (5.2488-MHz),integrated circuit (part of Jameco 7207AEV/Kit—see XTAL1)
U6--4070 quad exclusive-OR gate, integrated circuit
U7—7805 (340T-5) +5-volt, 750-mA, voltage-regulator integrated circuit

RESISTORS

(All resistors are ¼-watt, 5% values)
R1—1500-ohm
R2—15,000-ohm
R3—100,000-ohm
R4, R5, R13, R14—22,000-ohm
R6—3000-ohm
R7—10-Megohm
R8—470,000-ohm
R9—47,000-ohm
R10, R12—10,000-ohm
R11—2-Megohm
R15—150-ohm

CAPACITORS

C1—.22—μF, 100-volt, Mylar
C2—.022—μF, 100-volt, Mylar
C3—.01—μF, 50-volt, disc
C4—1.0—μF, 35-volt, tantalum
C5—.1—μF, 100-volt, Mylar
C6—0.047—μF, 100-volt, Mylar
C7, C8—22pF, 50-volt, disc
C9—1000—μF, 35-volt, electrolytic
C10—.1—μF, 50-volt, disc

ADDITIONAL PARTS AND MATERIALS

S1—SPST slide switch
XTAL1—5.24258-MHz crystal (part of Jameco 7207AEV/Kit—see U5)
DIP sockets for IC's (3-14-, 2-16-, 1-28-pin, and 1-40-pin), wire, 2 heavy-duty alligator clips, standard-size alligator clip, 2 5-terminal strips, wire, solder, plastic case, etc.

using the circuit of Fig. 3 when connecting a tachometer to its Rabbit.

Circuit Variations

The Digital AutoTach can be adapted to other engines, or to other precision *rpm* requirements, by modifying the counter network between pins 3 and 4 of U2. For example, if the

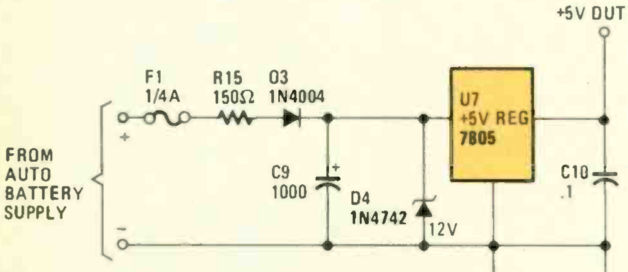


FIG. 2—+5-VOLT regulated power supply is standard except for network that ties it to car's battery. D3 protects against reverse voltage peaks.

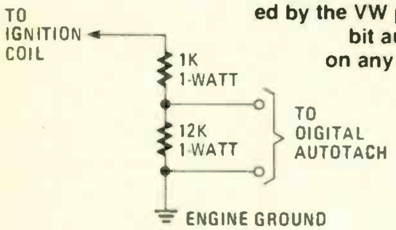


FIG. 3—THIS NETWORK is recommended by the VW people on their Rabbit auto. It could be used on any car as a precaution.

counter network is changed to a divide-by-thirty network, the signal frequency will be multiplied by thirty and the display will read directly in *rpm* in the high-resolution position; that would be appropriate for a very stable *rpm* for which very high precision in measuring is required. Increase the loop setting time (by increasing the product of R8 and C1) and increase the loop damping (by increasing the ratio of R2 to R1). See Reading Reference 1.

Also, if U3 is exchanged for a divide-by-six counter, such as can be made from a 4018 (Fig. 4), the tachometer would display the proper *rpm* for a two-cylinder, four-cycle engine. A six-cylinder engine fires three of its plugs on every revolution, so for 1000 *rpm* this would give

$$3 \times 1000(rpm) \div 60 = 50 \text{ counts}$$

in a second, and we see that the incoming frequency must be multiplied by a factor of two in order to get a display of one-tenth of the actual *rpm*. A single D flip-flop chip can do that as seen in Fig. 5.

An 8-cylinder engine has four plugs firing on every revolution, so that will give

$$4 \times 1000(rpm) \div 60 = 200 \div 3 \text{ counts}$$

in a second; from that we could multiply the incoming frequency by a factor of 15 to get the actual *rpm* in the LO resolution switch setting. Alternately, we can use only the upper 3½-digit drivers on U4 and obtain the same resolution as before. (Chip U4 contains a 4½-digit driver for which Fig. 1 and Table 1 show the use of only the lower 3½ digits.)

The sampling periods can also be altered by exchanging the crystal for one of a different frequency, although Intersil recommends a reduction in supply voltage if the frequency is significantly reduced because the 7207A uses dynamic frequency counters.

Finally, an LED display can be used with that circuit if an

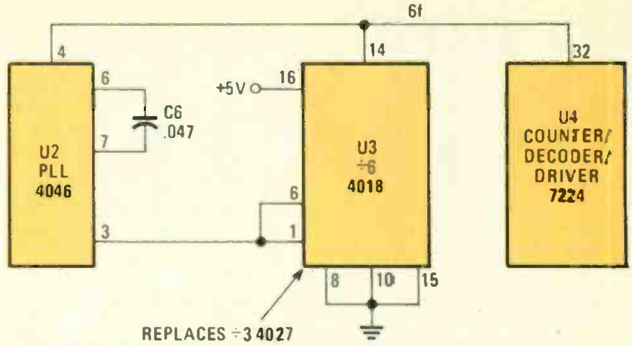


FIG.3—THE DIAGRAM provides details to modify the Digital AutoTach in Fig. 1 for use on 6-cylinder engines.

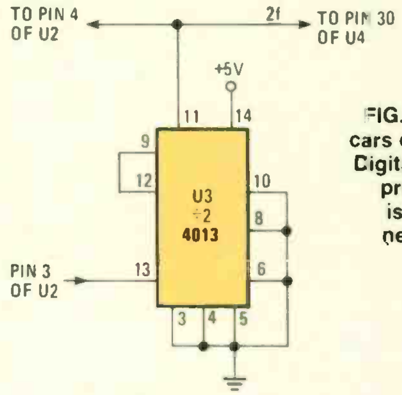
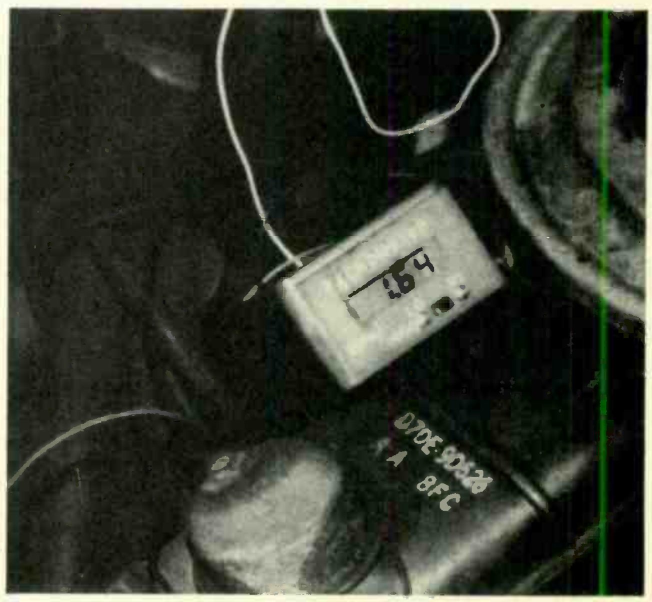


FIG. 5—EIGHT-CYLINDER cars can be handled by the Digital AutoTach with ease provide the 4013 IC chip is used for U3 and connected as shown at left.

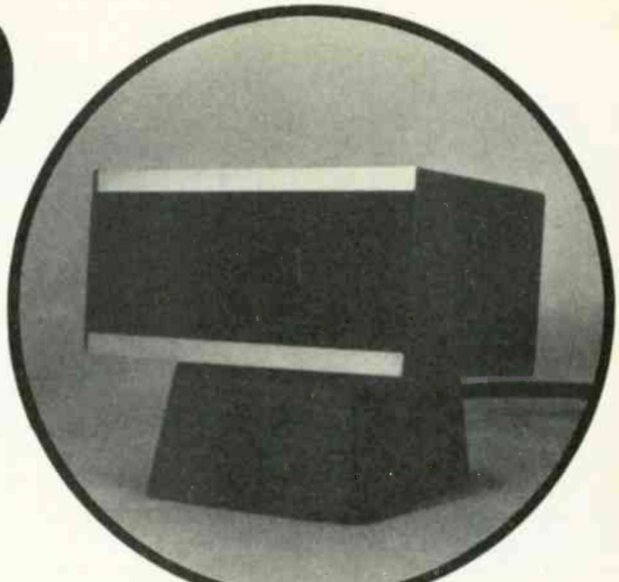
Intersil 7225 is substituted for the 7224. The pinouts of the 7225 chip are the same as the 7224 chip except that pin 5 functions as a brightness control rather than as a backplane driver. Thus, pin 5 on the 7225 chip should be connected to the wiper of a 100,000-ohm potentiometer that is connected across the power supply. ■

Reading References—The author suggests that the project builder refer to the following two texts: (1) *Voltage Regulator Handbook*, National Semiconductor Corporation, 1982, and (2) *CMOS Cookbook* by Don Lancaster, Howard W. Sams and Company, Inc., 1977.



EVEN IN THE DIM LIGHT in the engine compartment of this old Ford, the Digital AutoTach liquid-crystal display clearly idnicates the engine's *rpm*. The unit shown was constructed as an outboard tester for tune-ups.

AUTO-TEMP



All the variations of the MA1026 Clock/Temperature module can now be operated in a hands-off fashion with electronic switching of modes!

By Rich Hampton

☐THE POPULAR MA1026 CLOCK/TEMPERATURE MODULE OFfers the electronics experimenter the opportunity to build a low-cost digital clock and *thermometer*. One disadvantage with many time/temperature systems using the MA1026 module is that the systems require manual switches to select time or temperature, or a dedicated system that displays *only* time or temperature. If more than one temperature sensor is used, additional switches are required. There may be periods when hands-off time and temperature are desired.

The Auto-Temp circuit will automatically display the time for six seconds. It then displays indoor temperature for three seconds followed by the outdoor temperature for three seconds. If temperature only is selected, the display will alternate indoor and outdoor temperatures every three seconds.

Circuit description

Power is supplied to the switching circuit via pin 6 (V_DD) and pin 8 (V_{SS}) from the MA1026 module. (Note: A printed-circuit board approximately the same size as the MA1026 module connects to the module by wire jumpers such that both the module and the printed-circuit board physically parallel each other; and the electrical connections to both are

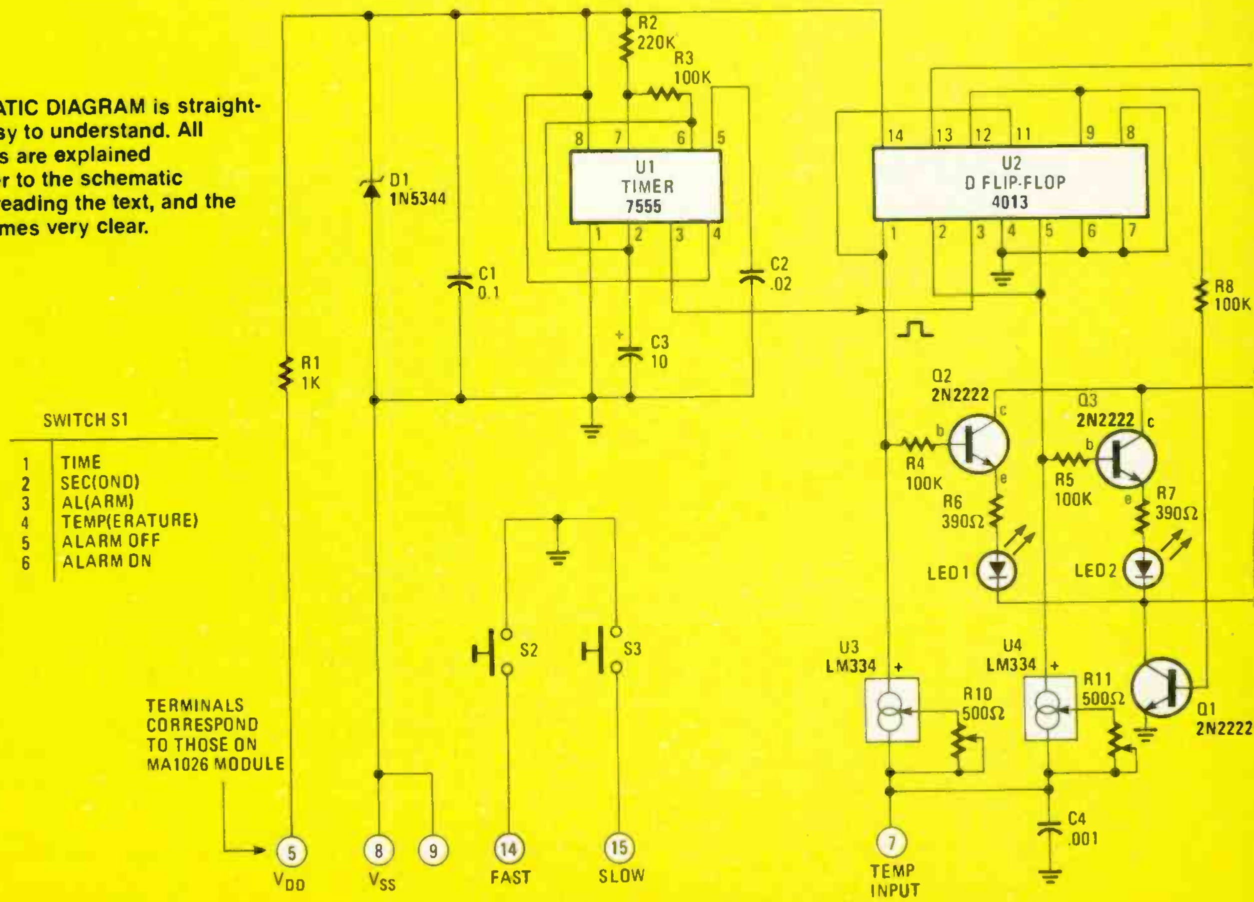


FIG.1—SCHEMATIC DIAGRAM is straightforward and easy to understand. All circuit functions are explained in the text. Refer to the schematic diagram while reading the text, and the operation becomes very clear.

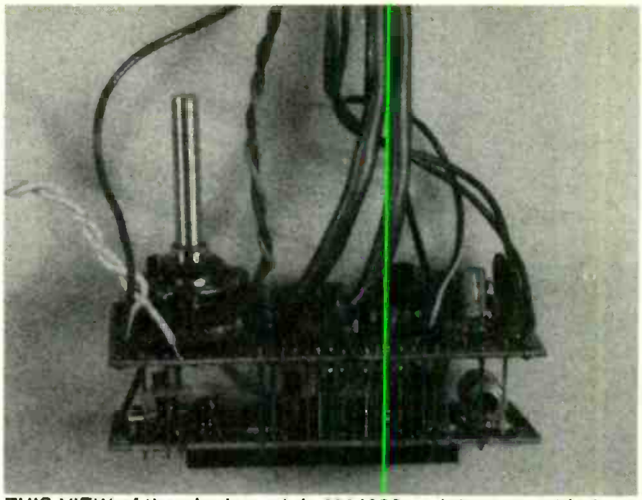
identical in construction, so that the pin numbers on one correspond to the pin numbers on the other. Refer to the photos.) The voltage output of the power supply (on the printed-circuit board—see Fig. 1) is Zener-regulated by D1, Zener current is limited by R1. Additional filtering is supplied by capacitor C1.

Clocking is produced by U1 (7555 timer) wired as an astable multivibrator. Circuit elements R2, R3, and C3 control the frequency of the switching. The output of the timer is applied to the clock input (pin 3) of U2, the D flip-flop.

The $\overline{Q}$ output (pin 2 of U2) is connected to the D input (pin 5 of U2) of flip-flop A so that it will toggle (Fig. 1). The output is also used to switch the outdoor temperature sensor. The Q output (pin 1) of flip-flop A is used to display the indoor temperature. Outputs from Q and $\overline{Q}$ are also used to supply current to the LED-driver transistors Q2 and Q3. LED1 and LED2 indicate if temperature is indoor or outdoor. Transistor base currents are limited by R4 and R5; R6 and R7 limit the LED currents.

The Q output (pin 1) of U2-a is applied to the clock input (pin 11) of U2-b. That half of U2 is used to alternate clock and temperature displays. The $\overline{Q}$ (pin 12) to D (pin 9) connection causes the flip-flop to toggle as the input is clocked. The Q output of the flip-flop is applied through S1 to temperature display (pin 20) of the module. Switch S1 is wired so that automatic time-temperature display may be used. Temperature-only can be selected by disconnecting the Q output and applying V_{SS} to the temperature input. The $\overline{Q}$ output (pin 12) of U2b is applied to the LED cathode-driver transistor Q1 through current-limiting resistor R8.

Transistor Q1 disables the indoor-outdoor indicators while the time is being displayed.



THIS VIEW of the clock module MA1026 and the assembled printed-circuit board shows the wire spacer/connections to like terminals on both assemblies. These connections serve as sturdy spacers that fix the boards together as one piece.

The MA1026 module is designed so that the alarm is turned off by closing pin 21 to V_{SS} (Fig. 1). It was desirable to have the alarm on at only one setting of S1, so Q4 is used to invert the output of S1. The alarm-off pin is held low by Q4 until the base voltage is removed by setting S1 in the ALARM-ON position. Resistor R9 provides base-bias current to Q4 from the LED supply of the module.

The Modes of Operation

Switch S1 (Fig. 1) allows selection of several display modes: TIME SET, SECONDS DISPLAY, ALARM DISPLAY, TEMPERATURE ONLY, TIME/TEMP WITH ALARM OFF, and TIME/TEMP WITH ALARM ON. In the TEMP ONLY position the Q output of U2-b (time/temp alternate) is bypassed and the temperature display (pin 20) is held low. That also holds the indoor-outdoor LED cathodes low, so that they will not cycle on and off as they do for the TIME/TEMP display.

Construction

The Auto-Temp circuit can be constructed using the printed-circuit board template in Fig. 2. Use of the printed-circuit board will simplify construction. Install jumpers on the printed circuit first (see Fig. 3). The long jumpers should be insulated with scrap insulation from hookup wire.

Four mode-selecting jumpers should be installed (or omit-

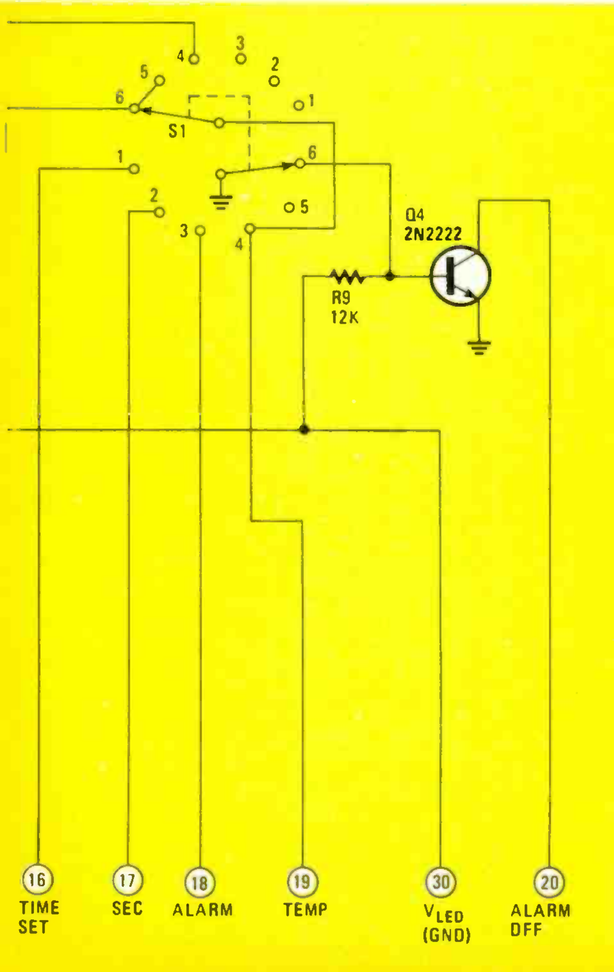
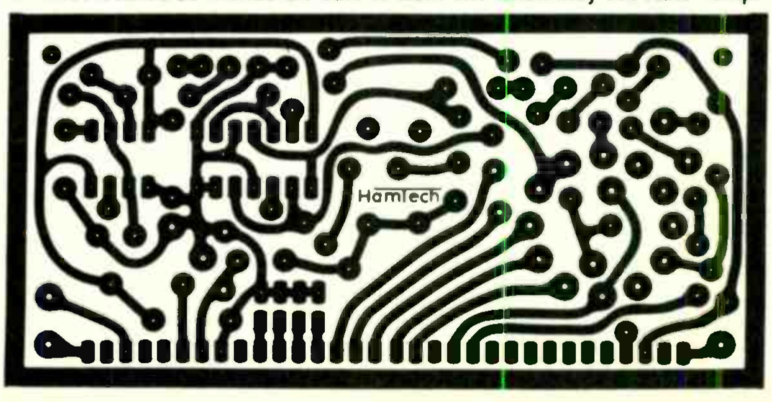


FIG.2—SAME-SIZE, etched, circuit-board layout is provided for those who wish to *roll-their-own*. Make a couple of these boards as friends are sure to want one when they see Auto-Temp.



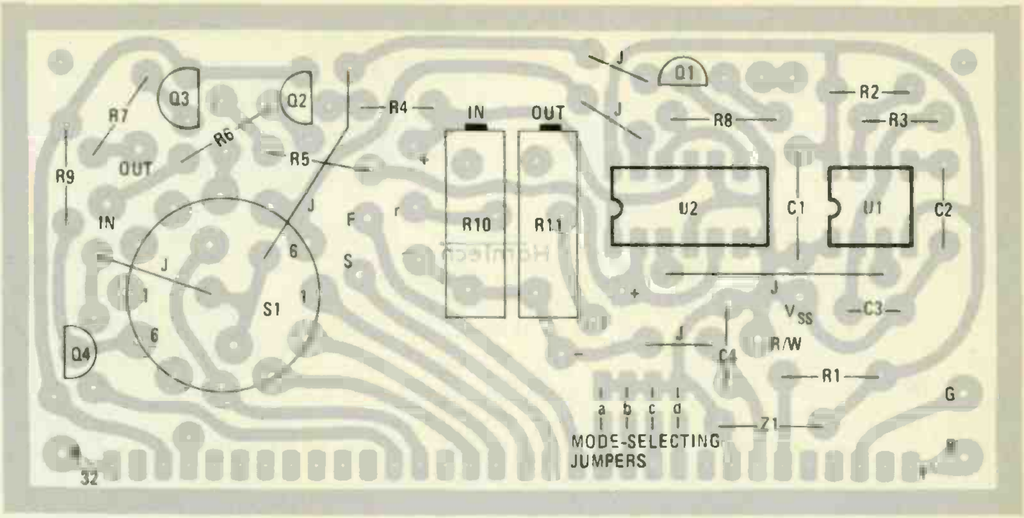
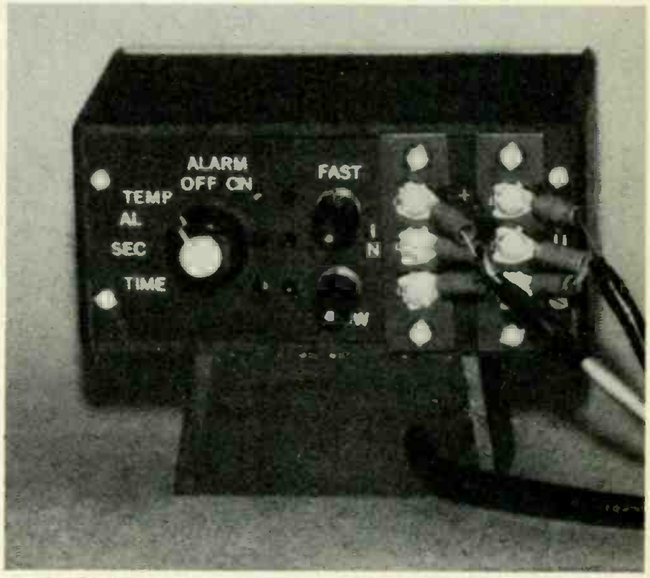


FIG.3—PRINTED-CIRCUIT board parts placement is shown here. An alternate construction technique would be to use perf-board and wire-wrap all interconnecting circuit parts.

ted) at points (a) through (d) on the printed-circuit board (Fig. 3). A jumper should be installed at location (a) only if 24-hour time is desired instead of 12-hour. Jumper (b) is used only if the clock is to be used on 50 Hertz instead of 60 Hertz. If jumper (c) is installed, the display *colon* will remain on instead of blinking at a one-Hertz rate. Jumper (d) will cause the temperature to be displayed in °C instead of °F. Jumper (d) should be replaced by an SPST switch if you desire to change from °F to °C at the flip of a switch.

Install all resistors, capacitors, transistors, and integrating circuits using the parts layout in Fig. 3. Pay special attention to orientation of transistors, electrolytic capacitors, and integrated circuits. Mount S1 on the printed-circuit board and solder carefully. Refer to Fig. 4 for external connections to the board. Switches S2 and S3 should be attached to the circuit board with stranded hookup wire. Switch S2 should be connected to point F on the board. S3 is to be attached to point S. A wire from V_{SS} is attached to each switch. Solder a four-inch piece of stranded hookup wire between the points on the board marked "L." The indoor-outdoor LED cathodes will be soldered to that wire. Also solder four-inch wires to the points marked "IN" and "OUT" on the printed-circuit board. After visually inspecting all solder joints, mount the Auto-Temp board behind the MA1026 module using ¾-inch



REAR PANEL of Auto-Temp provides all necessary controls. Terminal strips give a convenient, easy access for connecting outboarded temperature sensing elements. Mode selecting switch S1 and FAST and SLOW switches S2 and S3 are easy to reach and use. Transformer and fuse are in the base.

PARTS LIST FOR AUTO-TEMP

SEMICONDUCTORS

D1—1N5344 8.2-volt, 5-watt, Zener diode
LED1, LED2—Light-emitting diode, any color (Radio Shack #276-070 or equivalent)
Q1-Q4—2N2222 NPN silicon transistor
U1—7555 timer integrated circuit
U2—4013 D flip-flop integrated circuit
U3, U4—LM334 constant-current source integrated circuit (used as temperature sensors)
Z1—MA1026 clock/temperature module (available at Jameco)

RESISTORS

(All resistors are ¼-watt, 5%, composition type unless noted otherwise)
R1—1000-ohm
R2—220,000-ohm
R3,R4,R5,R8—100,000-ohm
R6,R7—390-ohm, ½-watt
R9—12,000-ohm
R10, R11—500-ohm, 15-turn Weston 830P potentiometer

CAPACITORS

C1—.1µF, Mylar
C2—.02µF, disc
C3—10µF, 25-WVDC electrolytic
C4—.001µF, disc

ADDITIONAL PARTS AND MATERIALS

F1—1A, 3AG fuse
S1—2-pole, 6-position rotary switch (Radio Shack #275-1386 or equivalent)
S2,S3—SPST,normally-open pushbutton switch
T1—Line step-down transformer; 10.5-volt AC, 25-mA and 6-volt AC center-tapped, 125-mA secondary windings (Jameco 102-P22 or equivalent)
SPKR1—8-ohm, PM loudspeaker
Printed-circuit board materials, stranded hookup wire, fuse holder, solder, hardware, knob, red plexiglass, customizing materials, and enclosure

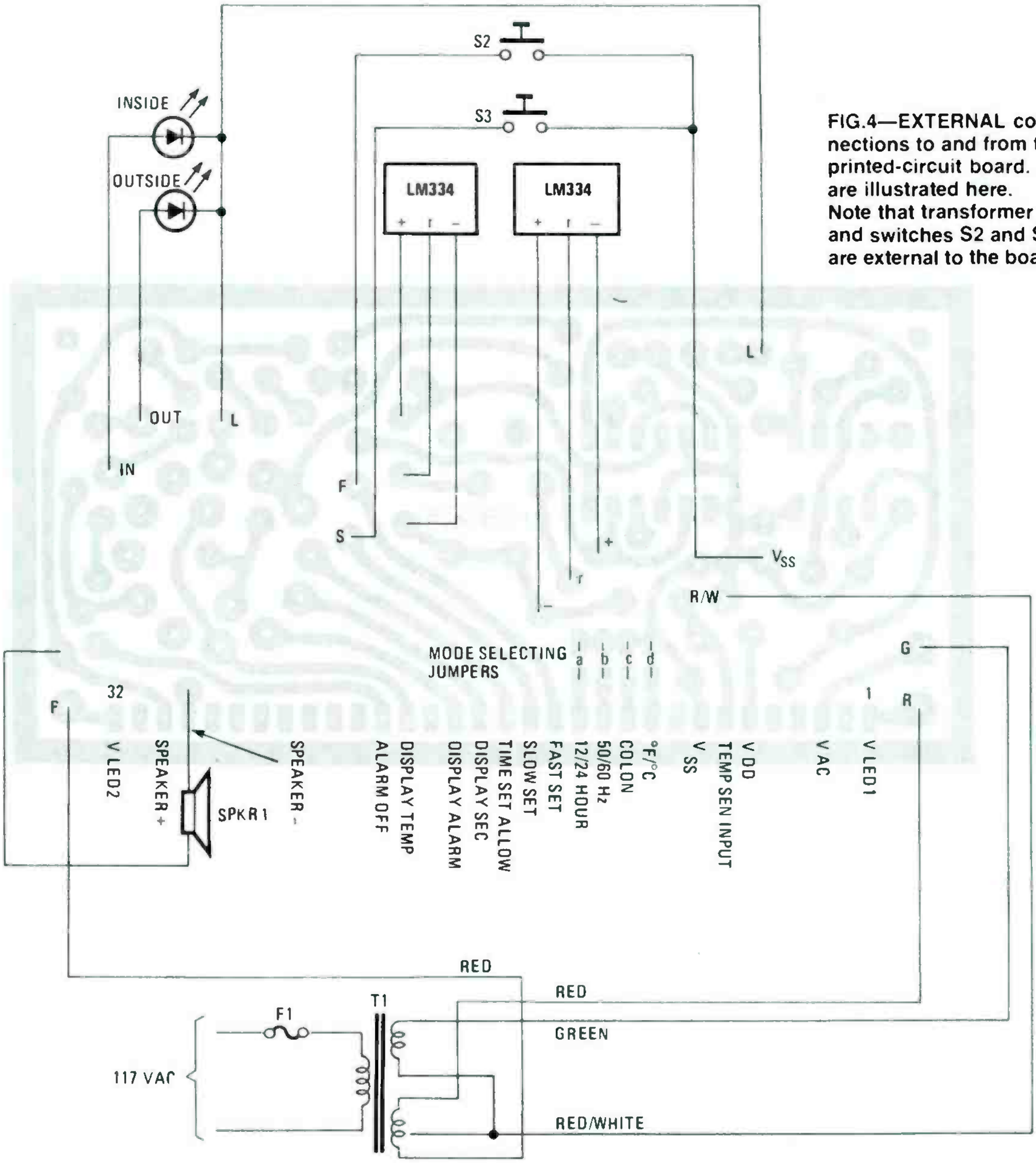


FIG.4—EXTERNAL connections to and from the printed-circuit board. are illustrated here. Note that transformer T1 and switches S2 and S3 are external to the board.

stand-offs and No. 4 screws at the top of the board. Install 1-inch pieces of wire between the two boards. The component side of the Auto-Temp board will be to the back. Carefully solder the pins between the two boards. Wires are not needed on pins 22 through 28. Take care to keep the wires straight, so that they do not touch adjacent wires.

You will observe that the edge connectors on the etched circuit board are spaced exactly the same as the edge connectors on the MA1026. The distance between the two boards is determined by the length of the wires that interconnect the boards. For additional rigidity, you can add more wires to those terminals that are *not* used. Also, you may want to play it safe by slipping insulating tubing over those bare wires.

Connect the wires from an 8-ohm speaker to the speaker locations on the Auto-Temp board. Drill two small holes in the clock module on each side for placement of the indoor-outdoor LED's. Be sure to avoid all printed-circuit foil paths on the module. Remove insulation from two small areas on the wire from "L" on the switching board. Solder the wire to the cathodes of the two LED's. Solder the wire marked "IN" to the anode of one of the LED's and "OUT" to the other. Those will indicate indoor and outdoor temperatures currently being displayed. Attach transformer T1 secondary-winding wires to points R, R, R/W, and G.

Connect the sensors (U3, U4) with shielded cable to the sensor inputs marked "+," "R," and "−." Select the proper length of cable for indoor and outdoor temperature sensors. The sensors are connected to the ends of the cable; after soldering them in place, slip a length of heat-shrinkable tubing over each sensor so that it goes from nearly the end of the sensor to well along the cable length (about an inch-and-one-half). Apply heat from a hot-air blow dryer to shrink the tubing and then apply epoxy cement to each open end of the tubing to completely seal and waterproof it. Connect the primary wires to a power cord through fuse F1.

Operation

After all assembly is completed, plug the module into a 110-volt source. The display will flash (indicating a power loss) until the time is set. Rotate S1 counterclockwise to the last position—TIME. Press S2 (FAST) or S3 (SLOW) for fast or slow set to select the proper time. When S1 is rotated to the next position (SEC), the time should be displayed in minutes

(Continued on page 99)

HAPPY BIRTHDAY, HUGO GERNSBACK

Born in Luxembourg 100 years ago, Hugo Gernsback illuminated the publishing world as Edison lit up its dark cities!

100 YEARS AGO, AUGUST 16, 1884 TO BE precise, Hugo Gernsback was born in Luxembourg. At the age of 19, he emigrated to the United States, and proceeded, in his own quiet way, to make some vast changes in the way we live, the way we think, and the way that things happen.

While he originally thought of himself as an inventor, he soon learned that there was a good deal more profit in importing electrical devices from Europe, for those in this country who were interested in experimenting with that relatively new field. To help forward that end, he wrote and prepared catalogs; and those catalogs became the forerunners of his first magazine, *Modern Electrics*, which first saw the light of day in April, 1908.

His influence was felt in many areas, but one of the greatest areas of influence that he exerted, was in the field of science fiction. He coined the term *Scientifiction* and originated the science-fiction magazine. His own tales combined his wide knowledge of scientific principles with his vivid imagination, to produce short stories and novels that were fiction, but were founded on firm, scientific fact. How influential was he? To this day, when the science fiction fans have their annual conventions, and give out awards for noteworthy achievement, those awards are called *Hugo's*.

In 1925, he founded radio station WRNY. In 1928—yes, as early as that—station WRNY began transmitting television signals. These were transmitted on a daily basis, and those who were properly equipped could receive them; those who were not, simply received jumbled noises.

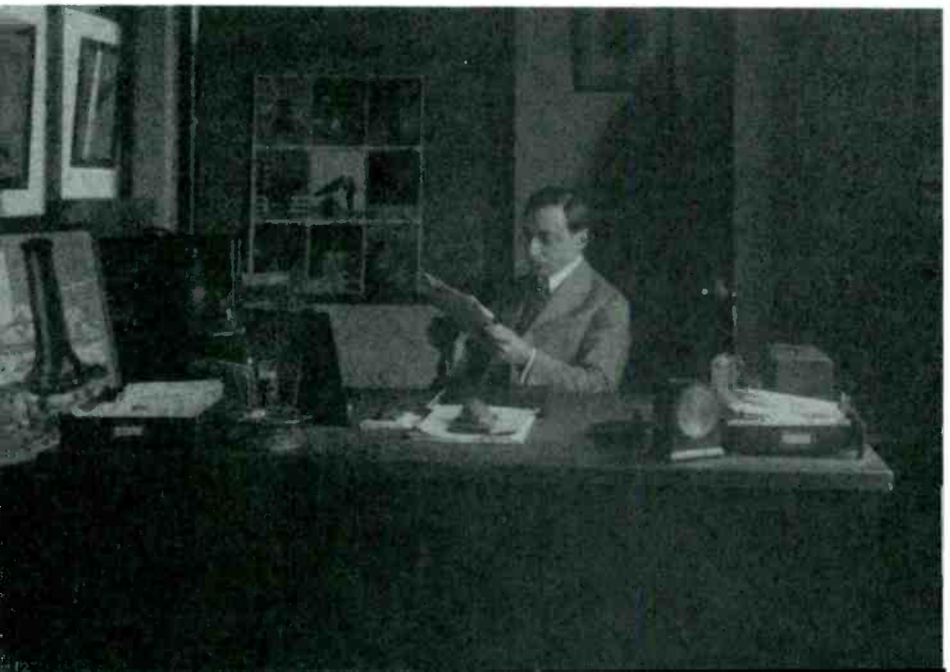
Hugo Gernsback was not by any means a somber intellectual. He had a sense of humor that still makes you stop and wonder. He invented a character called *Mohammed Ulysses Socrates Fips*, an office boy who was an émigré from Mars. Some of his April-fool stories were so believable that in 1933 people actually tried (for example) to order a *pocketable radio* called the *Westingmouse*.

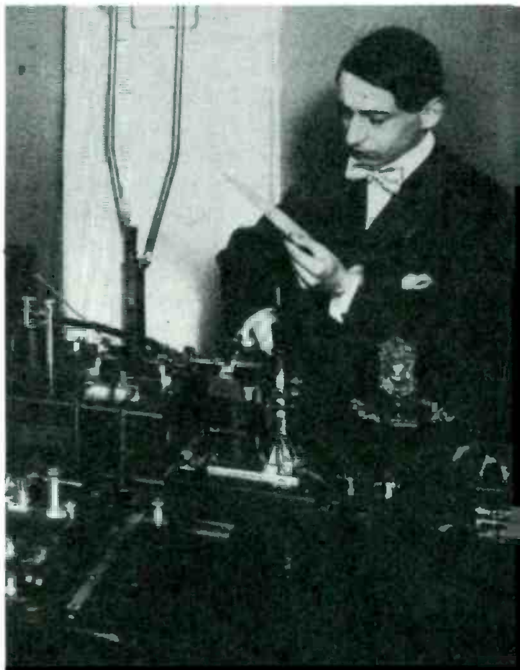
And he held over 80 patents.

On August 19, 1967, Hugo Gernsback passed away. To quote one admirer, "If Hugo Gernsback had stayed home, everything would have been different." Hugo Gernsback left his footprints in our sands of time, and we are grateful.

Happy birthday, Mr. G!

HUGO GERNSBACK was involved with a growing hobby, electronics experimenting, and is seen (lower-left) at his desk in the Experimenter Publishing Co. office in New York City about 1922. About 1909 he visited the DeForest wireless station (lower-right) atop the old Waldorf-Astoria Hotel. In 1948 Hugo Gernsback (upper-right) celebrated the 20th anniversary of Radio-Electronics.





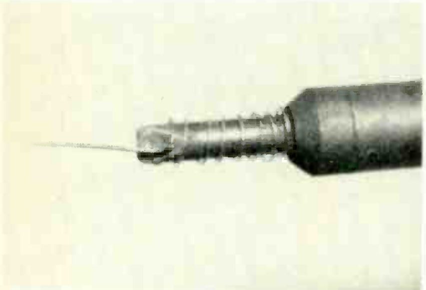
YOU EARN $20 FOR EACH TIP

TESTBENCH TIPS

The very next time you come up with a simple, but clever, idea that helps you build a better project, or do a better job of installing, or testing, a project, let us know about it. Put your idea on paper (typewrite it), spelling out the details on one shet. Take a black-and-white photo of the idea in action and send it to the Editor. (Color photos lose too much contrast.) If your tip is used in this column, you will receive a check for $20. Sorry, we will be unable to return your tip or photo, and all entries become the property of **Hands-on Electronics**. Send all mail to **Hands-on Electronics Testbench Tips**, Room 1101, 200 Park Avenue South, New York, New York 10003.

Tip on a Tip

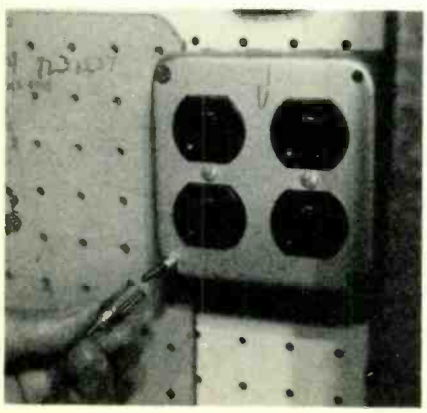
Some printed-circuit boards are so delicate that anything more than a touch of heat will destroy the copper foils. If you're stuck with a *monster* soldering iron, and you can't wait to make repairs, wrap a length of #20 or #22 bare solid wire into a tight spiral around the tip of your soldering iron and extend one end about an inch beyond the iron's regular tip.



Plug the iron in, and after a few minutes you'll have a *needle-point* soldering tip suitable for delicate repairs. To prevent the wire tip from moving backward when pressed against a connection, stretch the spiral so that the end is right up against the body of the soldering iron. The spiral serves as a spring, producing a slight *give* as the tip is pressed against the foil surface. —L.M., Price, UT

Shocker Stopper

Modern electronics hardware is so sensitive to static electricity that very often you have to connect yourself, the tools you're using, or the equipment being repaired to an electrical ground. If you install a banana plug on the cover of a grounded electrical box you get the ground connection almost instantly. The plug will hold an alligator clip; you can just wrap several turns of a *ground wire* around the plug; you can attach the wires from your *grounding bracelet* to a banana jack for quick connect/disconnect, or even use a VOM's test lead for a ground wire by placing a banana jack-to-jack adapter on the test lead's plug. However you do it, having a ground plug mounted on an outlet box's cover is a lot easier and safer than trying to wedge a clip lead under the metallic cover.



—S.J., Silver City, NM

Shock Absorber

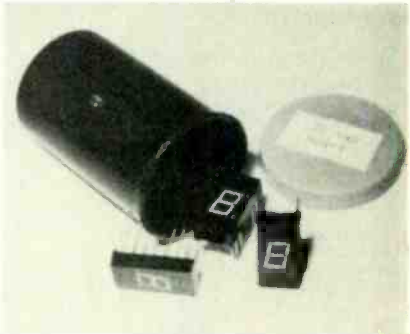
Polyester clothes, carpet on the floor, household pets: They all cause static electricity—which can instantaneously *zap* a home computer's memory or a disk. I eliminated the problem by placing a piece of grounded conductive foam adjacent to the computer. (The pad is grounded by a short length of wire connected between

the pad and the nearest electrical ground.) Prior to touching the computer or its accessories, I brush my fingers against the pad, instantly discharging any static voltage I might have accumulated. The conductive foam is the stuff used to store or ship integrated circuits. Many electronics shops sell small sections, or will give the scraps away at no charge.

—*A.B., Twin Falls, ID*

Film Containers

Those little black or gray plastic containers that protect 35-millimeter film cartridges are handy storage containers for small parts in your junkbox. For example, the photo shows a container used to store delicate LED displays. Those DIP de-



vices, like other DIP chips, are prone to pin damage when stored in a bigger container where the weight of other parts will bend the pins. Also, with the lid of the container marked to indicate the contents, the experimenter will have no trouble finding the desired part quickly!

—K.O., Macon, GA

Polarized Connector

Polarized connectors are all around the workbench, and still the experimenter purchases them for each project. Use the matching connectors for a DC power plug-pack and a damaged calculator. Salvage the connector in the calculator and tape it to the plug-pack. That way, when the time comes, the power plug-pack can be connected to a project with its original mating connector. Should the plug-pack and the caluclator both be defective, then snip off the defective parts leaving as much cable length as possible attached to molded parts. Store in a safe place, and the day will come—not too far away—when you'll be using the polarized connectors. —D.F., Muskogee, OK

ELECTRONIC CROSSOVER CIRCUIT

(Continued from page 79)

divide by a 60-mA current. Use the nearest standard-value resistor. The power rating for the two resistors is determined by the equation $I^2 \times R$, but allow a safety margin of at least 50% of your calculations.

To dissipate better the heat produced by resistors R12 and R13, mount them with their body axies about 3⁄16-inch away from the circuit board.

The schematic diagram (Fig. 1) for the Electronic Crossover Circuit is monophonic, so a second circuit board should be built for each audio channel used.

PARTS LIST FOR BIAMP POWER AMPLIFIER

(Specifications for matching parts in power amplifier)

Power Rating (Watts)	Module Type and Quantity	Supplied Parts	Fast-Blow Fuses—2 Amperes)
15/15	2 HY30	PSU36	1.0
30/30	2 HY50	PSU50	1.5
60/60	2 HY120	PSU70	2.0
120/120	2 HY240	PSU180	2.5
240/240	2 HY400	PSU180*	3.0

*2 sets of supplied parts required.

The modules and supplies are available from Gladstone Electronics, 901 Fuhrmann Blvd., Buffalo, NY 14203. The *Supplied Parts* include all parts plus a toroidal-wound transformer designed for compactness and high efficiency. Send a stamped, self-addressed business-size envelope for a quote on prices.

POWER MODULE connects to crossover circuit providing from 15- to 240-watts output depending on which module type is selected. Refer to Parts List.

Putting It to Work

Once everything is assembled, it's wise to check the audio system's frequency response with an audio oscillator and a scope before connecting it to a speaker. That test could save an expensive tweeter from being overheated by a high-frequency spike, due to oscillations. Slight frequency deviations are of no importance. When connections to the speakers are made, start with the balance control at its mid-position and adjust to suit the "liveness" of the room. Unless the audio source is of high quality with no DC leakages, and the subsonic frequencies of very low levels, it's best to AC-couple the amplifier. In a 3-way system, the best of both worlds can be achieved: Use the Electronic Crossover Circuit between the low- and midrange-high frequencies, while a standard, passive network between the midrange and high frequencies will do the remainder of the job.

One last word of caution: Since phase shift occurs in any filter, and additional phase shift may occur in the speaker-enclosure combination, reverse the leads (polarity) at the woofer terminals should you detect a "notch" in the crossover region. ■

RESISTOR BANK

(Continued from page 51)

ting. The resistors used for the Resistor Bank are *5-percenter's* used just as they came from the store. None were *Hand-selected* by resistance measurement.

TABLE 2
ACTUAL PROTOTYPE RESISTANCE VALUES

Resistance (ohms)		±5% Limits (ohms)		Read on Ohmmeter (ohms)
Marking	Actual	Low	High	
10	10	9.5	10.5	10.5 (=11.1 − 0.6)
15	15	14.2	15.8	15.5 (=16.1 − 0.6)
22	22	20.9	23.1	23.9 (=24.5 − 0.6)
33	32	30.4	33.6	34.0 (=34.6 − 0.6)
47	49	46.6	51.4	49.3 (=49.9 − 0.6)
68	71	67.4	74.6	72.8 (=73.4 − 0.6)
1K	1K	0.95K	1.05K	0.99K
1.5K	1.5K	1.42K	1.58K	1.51K
2.2K	2.2K	2.09K	2.31K	2.26K
3.3K	3.2K	3.04K	3.36K	3.25K
4.7K	4.9K	4.66K	5.14K	5.07K
6.8K	7.1K	6.74K	7.46K	7.33K
100K	100K	95K	105K	102K
150K	150K	142K	158K	154K
220K	220K	209K	231K	225K
330K	320K	304K	336K	328K
470K	490K	466K	514K	497K
680K	710K	674K	746K	722K

Customizing

A final word. Now that you have read this article and understand the switching circuit, you may wish to tailor it to your special needs. Here are some tips for your consideration.

You may have no need for the 10-Megohm to 68-Megohm range. Just eliminate the ×1 Megohm multiplier section entirely from your Resistor Bank.

You could use 2-watt resistors for heavier current applications. However, you'll soon discover that these specialized ranges are limited so that not all the resistors need be 2-watt units. Also, think of providing ventilation holes in the unit's chassis box.

Smaller-tolerance resistors may be desirable for greater accuracy. That could be done on any particular range, or all of them. You could either resort to 1% tolerances, or hand-select specific values.

Any of those modifications, as well as others you can dream up, can be done without affecting the basic switching connections detailed in the Resistor Bank construction. ■

Note: The measured values in the 10- to 66-ohm range have been *improved* by subtracting the lead and contact resistance. The good readings of the other ranges show the value of starting out with accurately-marked, within-tolerance resistors. That won't always happen unless you make it so by screening the resistors first. Remember, you could go out of tolerance permanently by soldering the resistors in place that have been exposed to a series of high-humidity days.

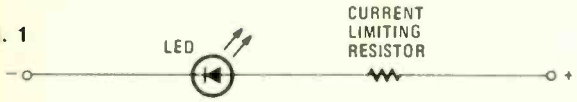
BATTERY-SAVER PILOT LIGHT

By Evert Fruirman

HOW MANY TIMES HAVE YOU REACHED FOR A PIECE OF battery-operated equipment only to be disappointed upon finding the batteries drained, because someone had forgotten to turn it off? Some kind of pilot light might have saved the day, and the batteries! But a pilot light wasn't used because of the current it consumes. Even a light emitting diode (LED) with a current-limiting resistor, Fig. 1, represents a moderate drain on the battery when compared to the circuit's normal battery load.

Cheer up! The Extra-Low-Power Pilot Light does just what its name implies. It draws very little power from a battery and its periodic flicker serves as a reminder for the user to turn off the portable equipment. Its wide range of operating voltage, (5-30 DC), and small size make it versatile enough to be added to almost any project that might require its use. Of course, it could be added to new equipment too! There is, or was, a LED chip on the market made to do almost the same thing. I ran into three little problems with it. It has a limited voltage range; it was expensive, and it wasn't always available. The first problem was solved with a Zener diode in series with the power-supply line. The last problem was solved with the circuit shown in Fig. 2. The

FIG. 1



middle problem remained the same unless you salvaged parts from the junkbox—then the price is right.

The circuit, Fig. 2, consists of a simple cross-coupled free-running oscillator with an LED in between the battery and the collector of Q2. As the transistors, Q1 and Q2, are alternately switched on and off, so is LED1. The values of resistance and capacitance are chosen so that minimum current is drawn in the off mode, and LED1 is off longer than it is on during each cycle. An added feature of that design is that electrolytic capacitors are not needed. The values for the resistors specified in the diagram could be varied over a wide range of ohms because the circuit is not too critical, and the experimenter may select those values he currently possesses (different from those in Fig. 2) so that project cost may be kept very low. Also, the chances are that you may be able to

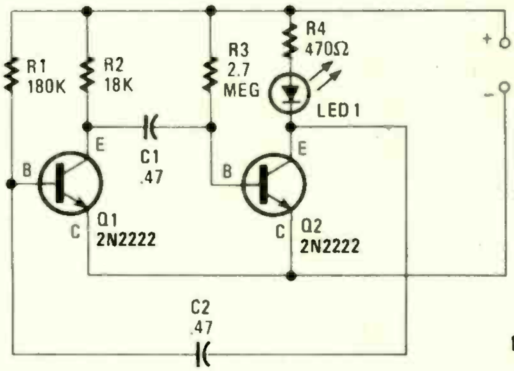


FIG. 2

assemble the project this very evening from parts presently in your junkbox.

Typical current drain using a 10-volt power supply runs from less than one-half mA (.5 mA) in the off mode to about 14 mA during the on mode, or light burst. At 5-volts DC the drain is a quarter of a mA (.25 mA) and 3 mA, respectively. The higher the voltage, the faster the Extra-Low-Power Pilot Light blinks. That friendly colorful wink from LED1 (you pick the color) could be enough of a reminder to save you the loss of perfectly good batteries, and the use of valuable equipment when you need them most. ■

ELECTRICAL SAFETY FIRST

By Donald K. Roeber

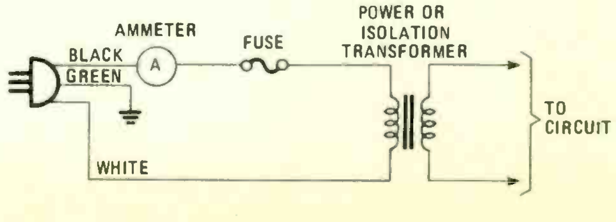
WHEN DESIGNING AND BUILDING HOME ELECTRONICS PROJECTS, important safety factors should not be overlooked. If the project is powered by the 117-volt AC line, it is a good idea to have the chassis grounded and the circuit properly fused.

If you are using a metal project box, purchase a three-conductor line cord instead of the usual two conductor. After the line cord has been fastened to the box with a suitable strain-relief clamp, attach an eyelet to the end of the green ground wire. Next, place a lock washer on the ground screw of the box, push the eyelet onto the screw, and secure it tightly with a nut. If there is no ground screw in the chassis, one can easily be drilled and inserted. For those project boxes that have a separate cover and base, you may want to connect the ground circuit to the cover, also. That is done by inserting an insulated jumper wire between the ground screw of the base and the ground screw of the cover. Leave enough slack so that the case and cover can be pulled apart for servicing.

Lastly, check for good continuity by placing the test leads of an ohmmeter between the center ground prong of the line-cord plug and the metal box. The reading should be zero. Proper grounding will protect the user of the project from electric shocks in the event that the unit shorts out.

To avoid dangerous current flow during a short circuit, the unit should be fused. If the schematic diagram of the circuit you are using does not specify the type of fuse to use, the total current flow of the project can be measured by using an AC ammeter as shown in Fig. 1. Note the meter reading and select a fuse which is slightly larger. For example, if your circuit draws .420 amperes, install a fuse rated at .500 amperes in the black lead circuit. Likewise, if your circuit draws 3.1 amperes, install a 4.0 ampere fuse. The "normal-blo" fuses are adequate for most digital circuits. If your circuit involves magnets, solenoids, motors, or lamps, the "slo-blo" type fuses are recommended because they are designed to withstand momentary high-current surges but still break down quickly if a short occurs.

With proper soldering and insulation, most home projects are reliable and quite safe. The addition of those safety measures, though, will add an extra feeling of security when you or someone else uses your project. ■



DECIBELS

(Continued from page 35)

2 is multiplied by the dB level desired.

For example, to determine the factor for 3 dB, you have $2^{3/6} = 2^{1/2}$, which is the square root of two, or 1.414. In a similar manner, we can determine that 6 dB $= 2^{6/6} = 2$. The factor for 9 dB is $2^{9/6} = 2\sqrt{2}$.

It's not necessary to determine the sixth root of two. The usefulness of the method is that it often provides a more common factor of a whole number times the square-root of 2. Then the problem can often be done simply. To find the voltage ratio corresponding to 15 dB, we take $15 \times 1/6 = 2½$. Two raised to 2½ can be written as $2^2 \times 2^{1/2}$ or $4\sqrt{2}$.

The error using this method is only 0.4% when taken up to 100 dB! The sixth-root of 2 is 1.122461 while the true factor for 1 dB is 1.122018. The method doesn't work easily for those dB levels that would result in some power of 2 other than $3 \times n/6$, such as $2^{1/3}$. (Then you won't get a multiple of the square root of two.

By using the methods we have discussed in this article, you should be able to work with decibels as the need arises. If you remember our few simple rules about adding dB's, multiplying factors, etc., you can do voltage-ratio-to-dB conversions quite rapidly. Table 2 lists the only voltage ratios, or factors, you need to remember to construct the entire Table 3, which lists all of the dB (voltage) ratios from ½ to 21 dB. (Note that 21 dB, as we discussed before, is 10 times the value of 1 dB.) All you'll probably need to remember from Table 2 are the ratios for 3, 6, and 10 dB. If you still have trouble determining

TABLE 4—WHOLE-NUMBER FACTORS

Ratio	dB		
1.5	3½	7	17
2	6	8	18
3	9½	9	19
4	12	10	20
5	14	40	32
6	15½		

ratios that correspond to dB levels, then Fig. 1 can be cut out and used as a handy reference.

If you want to use Fig. 1 to find the dB value corresponding to a ratio larger than 16, then divide the ratio by 10, 100, or 1000 so that it is smaller than 16. Look up the resultant, and add 20, 40, or 60, respectively, to the result. For example, to find the dB level corresponding to a voltage ratio of 130: 130/10 = 13. From Fig. 1, we see that a ratio of 13 corresponds to about 22.3 dB. Adding 20 yields 42.3 dB.

You can also find the ratio corresponding to a dB level over 24 by subtracting 20, 40, or 60 so that the dB level is less than 24. Then look up that value, and multiply the resulting ratio by 10, 100, or 1000 respectively. As usual, an example should clear things up: How would you find the voltage ratio corresponding to 93 dB? We know that 93 = 80 + 13. (We chose 80 because it is equal to 60 + 20, both of which we know how to work with—but we could also have used 40 + 40, etc.) That yields 1000 × 10 = 10,000. Using Fig. 1 we find that 13 dB is a ratio of about 4.5. Therefore, 93 dB corresponds to a voltage ratio of 4.5 × 10,000 = 45,000. ■

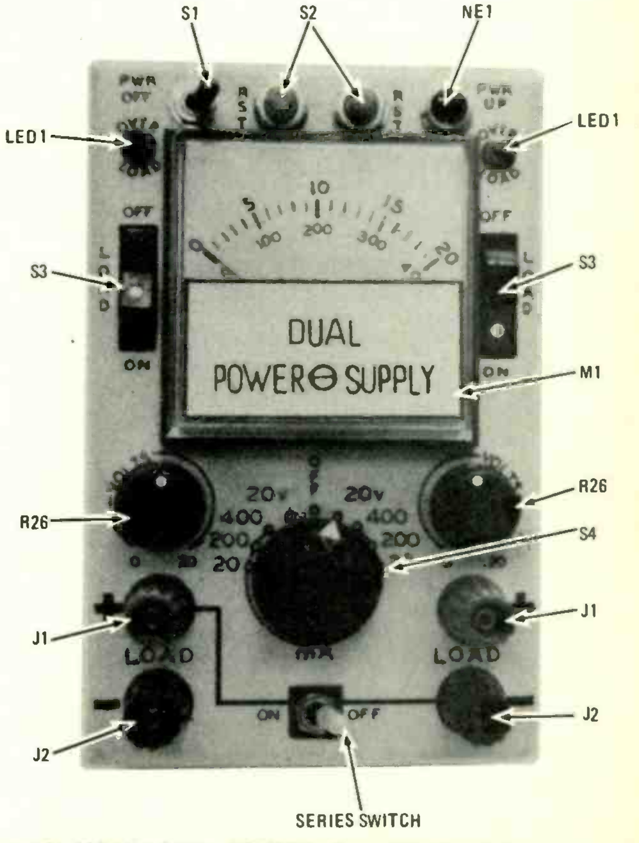
DUAL POWER SUPPLY

(Continued from page 26)

minals and the voltage output VOLTS potentiometer, R26, set to zero (it actually will have a few ohms at the *zero* resistance setting) adjust the NULL potentiometer, R25, for zero output as shown on the DMM. It will be found that the output can be varied from a small negative voltage to a small positive voltage, and that the adverse effect of a few ohms of terminal end resistance of R26 will be nullified. The other adjustment is the overload set point. Connect a suitable load resistor to the output terminals and adjust the output voltage until the desired trip current is indicated on the current meter. Then adjust the current TRIP ADJ potentiometer, R27, until the comparator trips.

This article is, basically, a design article giving data on how to design and construct a power supply with two improved features to specifications of your choice. The prototype referred to herein was built using the circuit of Fig. 4, but with a variation. What I built was a Dual Power Supply consisting of two identical and separate power supplies in one case. Using a front panel switch, the two supplies can be connected in series to give a total of 40 volts. The power transformer, again from my junk box, had two 20-volt secondary windings, thus eliminating the need for two large components. The case measures 5¾ high × 3½ wide × 7½-inch deep, however you need not pack its contents in so small a case.

By using the design data in this article it should be easy to duplicate the performance of my chosen specifications, or to design a power supply to your requirements. ■



DUAL MEANS DUAL CONTROLS—and that's what you see on the unit's front panel. SERIES SWITCH **is not in Fig. 4. It is used to strap the power supplies in series. See text.**

CALLING ALL HAMS

(Continued from page 56)

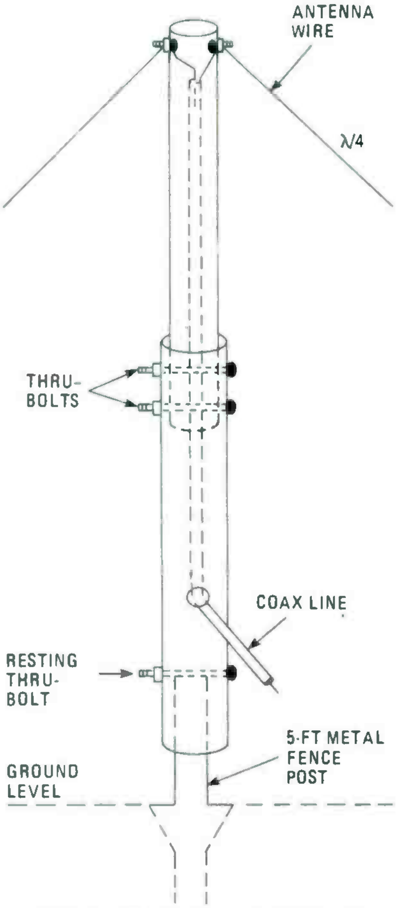


FIG. 2—MAST CONSTRUCTION

tion in your file, because there will be additional antennas described in this column that will use PVC piping masts.

Hookup

The manner of connecting antenna wire to a transmission line is unique. A short length of coaxial cable is cut to extend from the top of the upper PVC section down to a hole drilled in the bottom section at chest level. Two holes are also drilled in the PVC piping at the very top. Bolt and nut combinations are used as two terminals. Solder two eye-rings to the inner and outer conductors of the coaxial line. A standard PL-259 plug is connected to the other end. Before erection, the coaxial line is fed through the hole in the bottom section and up through the center of the PVC piping to the upper section. Here the two eye-rings are looped over bolts inside the piping and the two bolts are fed through the two top holes. Fasten firmly with outer nut and lock-washers. You now have a completed mast, and antenna wires can be connected externally to the top screw terminals by using another pair of nuts.

The photograph of Fig. 3 looks into the top of the mast, and shows the two leads from the coaxial line connected to the terminal bolts. Caps are available for the PVC piping. As shown in Fig. 4, such a cap has been pushed over the top to provide weather protection for the internal connections between the coaxial line and the bolt terminals.

FIG. 3—COAXIAL LINE termination to two points inside PVC piping. Solder eye-rings to ends of leads.

At the bottom section of the mast, tape the exiting coaxial line to the mast. Epoxy can be used over the hole to provide an additional weather seal. The exiting line can be seen in Fig. 5. Transmission line to the radio shack can be connected to the exiting line by using a PL-258 coupler (Radio Shack 278-1369). Here you have

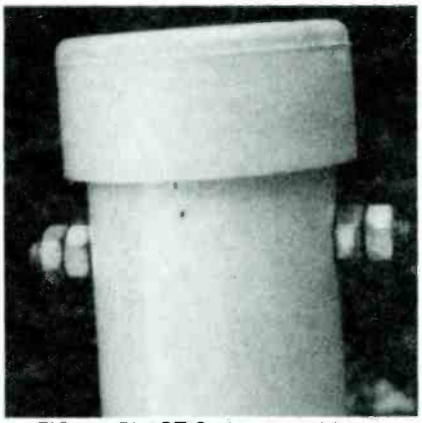


FIG. 4—PLASTIC pipe cap at top of antenna mast protects coaxial cable inside pipe from the weather.

the best lightning protection. When a storm is coming, or you are to be away from the house for a considerable time, disconnect the coaxial line that runs back to the shack from the coupler. If you wish to leave things connected, use a coaxial lightning protector at the coupler. Establish a good ground by driving a copper-plated metal rod into the ground; obtain a commercial type. I prefer the complete disconnect.

To complete the antenna, cut two quarter-wave antenna wires for the desired

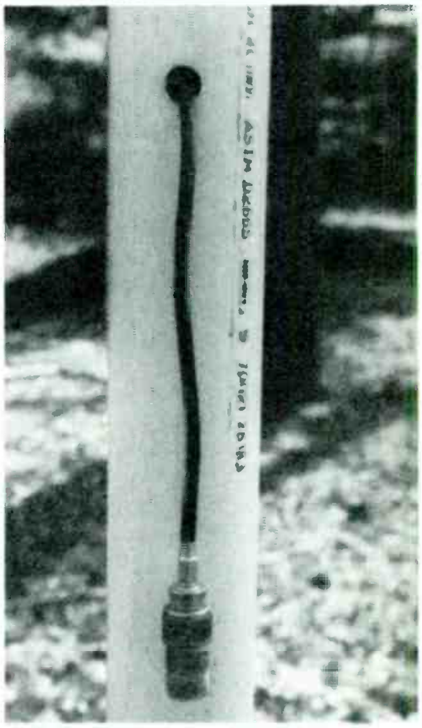


FIG. 5—EXITING coaxial cable and connector appear at bottom of the mast.

frequency. Solder an eye-ring to one end of each of the two antenna wires. Connect to terminals, Fig. 6. Appropriate insulators should be fastened to the other end of each antenna wire. There is no need to remove the insulation. Feed it through the insulator hole, loop tightly, and tape. Feed strong rope through the opposite hole of each insulator and make an appropriate tie-down to each of the two stakes that will hold out your inverted dipole.

A pair of wires can be prepared for each band, or as many bands as you wish. Those not used can be rolled up and stored. As a result, you can put up a dipole for any band you wish at a moment's notice. All you need, do is lift off the mast, lay it down, and make the appropri-

(Continued on page 94)

FIG. 6—ANTENNA quarter-wave wires attached to mast before installation.

SAXON ON SCANNERS

(Continued from page 42)

heavily used nationally. The more heavily used Police Intersystem frequencies are 39.46, 45.86, and 155.37 MHz. Fire Mutual Aid operations are frequency to be found on 45.88, 154.265, 154.28, and 154.295, MHz.

The frequency 155.475 MHz has also been designated as a nationwide frequency which, may be used by police vehicles from different agencies to communicate with one another (or their respective base stations) during coordinated activities, such as high-speed chases which cover different or changing jurisdictions. It doesn't seem that that frequency has yet been placed into full use, but from time to time it has provided some pretty hairy listening. Keep an ear on it.

From The Mailbag

We received an inquiry from Lawrence Montalvo of Boston, MA, asking if we knew the frequency used to provide weather information to aircraft in flight. I presume that you mean private aircraft, Larry: that frequency would be 122.0 MHz, which the FAA calls its "Flight Watch channel 11. Airliners receive their weather data on a wide assortment of frequencies in the VHF aeronautical band.

Andy Wilson, Fayetteville, NC, observes, that since he is a medical student, he'd be interested in monitoring communications relating to medical emergencies and asks if we have any advice to pass along. Andy, our best advice is to take two aspirins and give us a call in the morning—also try listening on 155.325, 155.34, 155.355, 155.385 and 155.40 MHz for communications between ambulances and hospitals. Portable medical emergency units (the kind in suitcases which can transmit vital signs to hospitals) are found operating on 462.95, 462.975, 463.025, 463.05, 463.975, 463.10, 463.125, 463.15, and 463.175 MHz.

"There was some odd communications traffic on 150.98 MHz," says Charles Mendes of Atlanta, GA, "and I'd like to know what they were." Unfortunately, Charlie, you didn't give us very much information to go on, but the fact that it was on 150.98 MHz indicates that you overheard communications relating to an oil-spill cleanup. That is a frequency which has been reserved nationally for such purposes. Other similar oil-spill cleanup frequencies include 36.25, 40.71, 156.255, 157.075, 159.48, 161.58, 454.00, and 459.00 MHz. Chances are that any time you're hearing activity on one of those frequencies, others in the grouping will also be active. Those frequencies are worthy of scrutiny by scanner owners within listening range of any port or waterway used by oil tankers. Accidents do happen, and when they do, those frequencies are where the action is.

Say, why not keep in touch with us? Pass along your questions, frequency data, photos of your stations, and any information you'd like; we seek and solicit lots of input from you—regularly and often! —Mark Saxon

CALLING ALL HAMS

(Continued from page 93)

ate dipole wire change. Such is an excellent plan for making sure that an emergency antenna is available. It can also be used as a standard on almost any band on which you would like to check another antenna. Of course, you can put up any number of such dipoles. All you need to do is to drive in additional metal fence posts at the appropriate mounting side.

Two Banders

That construction style is especially useful when erecting cross-dipoles to permit two-band operation from a single transmission line. For example to operate 20- and 40-meter dipoles from the same line, simply connect one 20/40-meter pair to one mast terminal and a second 20/40-meter pair to the other mast terminal. Now stretch out your two inverted dipoles at right angles to each other. The arrangement of Fig. 7 did very well on the sideband segments of the 20 and 40 meter bands. *—Ed Noll W3FQJ*

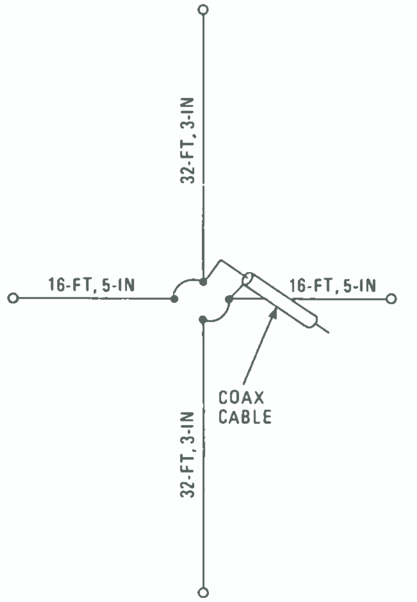


FIG. 7—CROSSED DIPOLE arrangement is diagrammed here for coverage of the amateur 20- and 40-meter bands.

FRIEDMAN ON COMPUTERS

(Continued from page 36)

printer? You guessed it! A DB-25-to-Centronics adapter cable!

Anyway, let's concern ourselves with DB-25 and RS-232. The most important terminals are 2 and 3 (input and output) and 7 (ground, or common). See Table 1. Those three wires will handle many, if not most of your *non-automatic* RS-232 situations; *non-automatic* meaning that the computer, a modem, or whatever, will be switched, or turned on and off, manually.

The Handshake

As we get more sophisticated in how we apply the RS-232 I/O, terminals 4 and 20 come into common use. They are generally used for *handshaking*, which is how one device can temporarily stop a data feed, or turn equipment on or off. Terminal 8 is a *biggie* if you get into automatic modems. It is the *carrier detect*, meaning that it is a signal created by your modem if it senses an input signal from a remote computer/modem. Special software will automatically disconnect your modem from the telephone line if the carrier signal turns off. For example, if the remote computer hangs up on you, it turns off its carrier. Your modem senses the loss of carrier so the signal on terminal 8 is removed. When your computer senses the loss of terminal 8's signal it disconnects your modem from the telephone system. (Is that a handshake? Certainly!) For most personal computers used with modems, only the 8 signals shown in Table 2 are commonly used. For RS-232 ports designed to drive serial printers, only three reversed paired connections are often necessary: 2-3, 4-5, and 6-20. Often, many devices require only terminals 2-3 to be reversed.

Multi-Purpose

There would probably be no real problems with RS-232 if it were used for one single purpose; unfortunately, it doesn't work out that way. There are really two sets of RS-232 terminal connections, one for what is called DTE, or *Data Terminal Equipment*; the other for DCE, or *Data Communications Equipment*.

Why the confusion? Because the same system is used for two different jobs. Imagine for a moment that you have your computer (or terminal) connected to a modem through terminals 2, 3, and 7. The modem receives a signal from the telephone line and sends that signal to the computer on terminal 2; the terminal sends its data to the modem on terminal 3. But you also have a serial printer that can be connected directly to the modem. (It's done every day of the week.) The printer receives its data from the modem on terminal 2.

TABLE 2—MOST COMMONLY USED CIRCUITS

Pin	Name	Function	DTE/DCE
2	TD	Transmitted Data	→
3	RD	Received Data	←
4	RTS	Request To Send	→
5	CTS	Clear To Send	←
6	DSR	Data Set Ready	←
7	SG	Signal Ground	—
8	DCD	Data Carrier Detect	←
20	DTR	Data Terminal Ready	→

Assume that you want to disconnect the printer from the modem and use it with your computer. You plug printer's RS-232—connector into the computer's RS-232 I/O and nothing happens, because the computer outputs on terminal 3; the printer never receives the signal, because it is looking for a signal on terminal 2. It is that reversal of roles for the printer that creates problems with RS-232 interfacing. To get around the problem, some of the connections must be reversed; that's how we wound up with two different connections for RS-232: DTE and DCE.

It has come to pass (no one really knows where or how it originated) that the devices used for communications are identified as DCE and use the DCE RS-232 connections, the computer equipment, or anything that generates information for the modem such as terminals, are identified as DTE. Wonderful; DCE and DTE eliminate all problems.

Always One Problem

But the powers that be didn't know what to do with the printer. Often, it is called a DCE (communications) device because it can be used for communications through direct connection with the modem. But that is incorrect! If the modem's RS-232 is DCE and the printer's RS-232 is DCE they can't exchange data—no way. In order for the modem to feed data to the printer, the printer's RS-232 must be DTE. But if the printer is DTE, then it can't get data from a computer/terminal, because the terminal is DTE. That is called being stuck between a rock, a hard place, and what was originally a dumb idea. The RS-232 standard should have had a third set of connections for the printer.

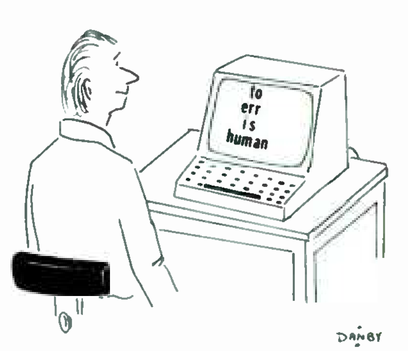
But we don't have the third connection, so how is the computer or terminal's printer output handled? If it is DTE, to work with the modem, it won't work with the printer; if it's DCE, to work with the printer, it won't work with the modem.

The answer is two separate outputs or a lot of tears. For example, Kaypro provides two serial outputs: one DTE for a modem, the other DCE for a printer. Radio Shack's Model I computer has a signal-reversing switch on the RS-232 I/O for *terminal* or *communications* emulation. On the other hand, Osborne uses just one conventional RS-232 I/O, which is wired DCE for use with a printer. In order to use the computer with a standard modem it is necessary to use a special connecting cable that reverses the connections to terminals 2 and 3 on one end.

Often, simply reversing terminals 2 and 3 does the trick; but there are actually three pairs of wires that must be reversed for complete DTE/DCE operation, and some devices require all three interconnects. The terminal pairs that must be reversed are 2 and 3, 4 and 5, and 6 and 20. Of course, some manufacturers don't even use those more or less conventional variations, their connections have no relationship to anything else on this earth. IBM even goes so far as to require the PCjr's RS-232 port to be configured as a modem in order to use a serial printer. Without the special connecting cable (from IBM) or the engineering note (from IBM's technical manual) there is no way for anyone to determine how to connect a standard RS-232 printer to the PCjr.

Though it is really quite easy to use the RS-232 as a standard, one major reason why it isn't a real standard is because forcing the user to purchase a relatively expensive *interface cable* insures the sale of a rather profitable accessory. The very same printer interface cable that's sold for $45 can be made from standard, list-price parts for $17. That's a lot of extra expense because a manufacturer decides to use terminal 6 instead of terminal 20.

Perhaps the Tables will give you enough of an insight into RS-232 so that the next time you run into an unusual RS-232 connection you can work it out yourself—with the connectors and cables you have on hand. —*Herb Friedman*



It's like no other magazine in the world!

Between the covers of this special annual publication are carefully selected articles on scientific developments, recent technical advances, consumer products trends, development of services, exotic communications advances, design information, hobbying tips, and "what's new" material compiled for your reading pleasure and information. Each article was specifically chosen and prepared for publication by the editorial staff of *Radio-Electronics* magazine, updated to the moment it went on press and printed. Here's what you will read about in the 1984 edition:

VIDEO ENTERTAINMENT—It couldn't be said all in one article so we compiled a 16-page special section covering the changing and growing field of entertainment in the home: new video components with screens from the gigantic to the tiny postage-stamp size, accessories that didn't exist last year, and tips on getting the most from what you own or plan to buy.

SATELLITE TV—The countryside is strewn with parabolic tracking dishes installed by home owners to pull-in the countless television channels transmitted back to earth by satellites poised in space in geosynchronous orbits. You, too, can enjoy the programming selection—and much of it is commercial-free, too!

MOBILE TELEPHONES—What was once a status symbol for the idle rich is quickly becoming a working tool for the common man. Cellular technology promises more channels with a little help from applied computer technology.

DIGITAL AUDIO DISCS—Laser rays are bringing new noise-free, pulse-encoded audio programming to your stereo system embedded in a plastic disc immune to strawberry jam, sandpaper, and desert heat.

MAIL ORDER BUYING—You've heard the bad points, including the myths. Now, here are the facts and economics of buying mail order that will be an asset to your business or hobby.

PLUS—There's so much more, we have space only to mention an electronic guitar tuning project, theory on digital filters, how to make inexpensive computer cables, build a programmable home thermostat, tips on buying pocket-size shortwave receivers, stereo audio for TV, all about VLF active antennas, news on pagers, how to restore antique radios, and....

Radio-Electronics ANNUAL 1984

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JENSEN ON DX'ING

(Continued from page 13)

the SWL hobby, although a bit dated in some respects, is *The Complete SW Listener's Handbook, 2nd Edition*, published by Tab Books Inc., Blue Ridge Summit, PA 17214. It is priced at $8.95.

For Groupies

There are a number of hobby clubs, which publish bulletins on a monthly, or more frequent basis, for their members. Those who want to keep current on what is happening in their hobby and want to learn more, really should join one or more clubs. Membership costs, bulletin coverage, services offered, and other factors differ from club to club.

A leaflet with capsule information about its various affiliated clubs is available from the Association of North American Radio Clubs, the umbrella organization covering the individual clubs. For a copy of the leaflet, send a stamped, self-addressed envelope and 25 cents in coins (Canadians should include an unstamped envelope, addressed to themselves, with 50 cents in mint Canadian stamps), to ANARC Club List, ANARC Publisher, 1500 Bunbury Drive, North Whittier, CA 90601.

On the Broadcast Band

While we usually focus on shortwave listening, letters received indicate that some of you also enjoy tuning distant stations on the regular AM medium-wave radio band. A list of U.S. and Canadian AM, FM, and TW stations, their frequencies, locations, call letters and transmitting powers, is included in *White's Radio Log*. It is available by mail for $4.95 from Worldwide Publications Inc., P.O. Box 5206, North Branch, NJ 08876.

Action for Computer Buffs

And finally, for those of you who may want to combine interests in SWL'ing and computers, there is a unique service for Radio Amateures and SWL's called UBIX, a computer-based bulletin-board service catering to your interests and needs. For free information about UBIX, write Universal Amateur Radio Inc., 1280 Aida Drive, Reynoldsburg, OH 43068.

Or if you're simply interested in using a computer in connection with your radio listening hobby, write to Bill Krause, ANARC Computer Info Committee, 6700 153rd Lane, NW. Anoka, MN 55303. Please include a SASE with your letter for a reply.

Around the World by Kilohertz

Let's take a look at what's being heard on the shortwave frequencies. All times are in Universal Coordinated Time (abbreviated as UTC, or sometimes GMT, for Greenwich Mean Time, equivalent to EST#5 hours, GST#5 hours, MST#7 hours or PST#8 hours).

—**Falkland Islands**: 2,380 kHz. The South Atlantic war between Great Britain and Argentina had one unexpected result for DX listeners. A formerly very-hard-to-hear station, Falkland Islands Broadcasting Service got new equipment, a new frequency, and new schedule, making it considerably easier to log in North America. Look for that one either during the evening hours, to about 0330 UTC, or when it signs on at 0900 UTC.

—**Belize**: 3,285 kHz. Belize, formerly British Honduras, is probably the least known country in Central America. It is English-speaking, too, which is a benefit to those who dodge Latin listening because of the language barrier. Listen for *Radio Belize*, which sometimes uses programming from the BBC and Radio Canada International. Try during the evening hours, say from 0100 to 0300, or later.

—**Greenland**: 3,999 kHz. Greenland Radio was off the air for quite a while, but again is being reported during the morning in North America, 1000 to 1200 UTC. Listen for its tuning signal, a slow series of chimes.

—**Djibouti**: *4,780 kHz. Radio Djibouti*, located on the northeastern *Horn* of Africa is a nice piece of DX. You may hear it signing on the air just prior to 0300 UTC, with an anthem, brief announcements and Islamic prayer chants.

—**Vatican**: 6,015 kHz. *Vatican Radio*'s English-language programming is not extensive, but it is easily heard. Tune in at 0050 UTC for English. A French program preceeds it at 0030 UTC.

—**Poland**: 7,125 kHz. *R. Polonia* is one station that many readers ask about. Listen at 2230 UTC for the European transmission in English from Warsaw.

—**Greece**: 9,460. *The Voice of Greece* is reported as signing on at 1500 UTC with Greek programming, beginning with the national anthem and announcements, followed by Greek music. Very interesting programming. Other frequencies for this station include 11,645 and 17,565 kHz.

—**Albania**: 7,300 kHz. The old fashioned *Cold War* of the '50s is still alive and well in Albania. Those folks don't like us very much and make no bones about it. Makes for some "strange" listening. Radio Tirana can be heard around 0300 UTC.

—**Belgium**: 5,910 kHz. *Belgian Radio-TV* is widely reported in English from 0030-0100 UTC with its *Brussels Calling, and other programs*.

That wraps it up until next time. I welcome letters, questions, and logging items from you readers. And if you'd like to see your photo, with your DXing listening post, in these columns, send along a picture. A good-contrast color or black-and-white photo will do, but—sorry—I can't return the photos, so make it that one you can spare.

Black-and-white photos reproduce best in magazines and newspapers. Avoid using color prints; but, if you must, obtain smooth-surface, glossy prints. Pictures should have a high degree of contrast. ■

*CREDITS: Charles Bolland, FL; John Mosman, IL; Ted Gurley, TX; Richard D'Angelo, PA; Sam Alcorn, PA; John Prath, FL; Rufus Jordan, PA; Kraig Krist, VA; North American SW Association, 45 Wildflower Road, Levittown PA 19057)

AUDIO BOOSTER AMP

(Continued from page 76)

circuit assembly in the cabinet, but not the jacks. Next, determine which of the two LED leads is the anode (see Fig. 1). That wire must fit into the LED hole closest to the side of the printed-circuit board. Decide which LED lead is which and then grasp the leads directly behind the body of the LED with the tips of long nose pliers. Fold the leads at right angle to the LED. Slip the LED into the printed-circuit board and push it down, so that the LED is about ½-inch above the board, and mark the LED's location on the cabinet. Remove the printed-circuit assembly, drill the appropriate size hole in the panel (usually 3/16-in.), then reinstall the printed-circuit assembly; position the LED so it protrudes through the hole in the front panel, and then solder the LED leads to their respective foils solder pads. Now check your wiring.

Finishing Up

The battery is held in place by a battery mounting-clip. Note that in the unit shown we have positioned the clip so that the battery normally rests on the printed-circuit board. If you plan to give the project some rough handling, simply place a strip of masking tape around the battery and sides of the clip.

No checkout is needed. If you haven't made a wiring error, or used a defective component, the project will work straight-off. About the only difficulty you might have is with LED1 because it's not unusual to get the wires reversed. If LED1 doesn't light, remove the solder from each lead with solder wick and reverse the leads. If the LED still doesn't light, it's probably defective. The failure rate on 10-for-a-$1 LED's is very high. ■

AUTO-TEMP

(Continued from page 87)

and seconds. The next position of the switch (AL) displays the contents of the alarm counter. Press the FAST or SLOW set until the alarm is at the desired time. Moving S1 to the next position (TEMP) will cause the temperature to be displayed alternating between indoor and outdoor. The temperature sensors must be calibrated before the temperature is displayed accurately. When S1 is rotated to the next position (ALARM OFF), the display should alternate between time and temperature. To activate the alarm, S1 must be rotated to the fully clockwise position (ALARM ON). Once the alarm sounds, it may be turned off by rotating the mode switch, S1, back one or more detent positions.

Calibration

The Auto-Temp circuit uses the LM334 constant-current source (U3, U4) as a temperature sensor. The slope of the MA1026 is set at 1μA/°C. Thus, with the temperature sensor, only the intercept needs to be set during calibration. The intercept may be set while using a fan to blow ambient air across both sensors and a mercury thermometer. The calibration potentiometers R10 and R11 are adjusted until both displays read the same as the mercury thermometer.

If the sensors are waterproof, an ice-water bath may be used instead of a mercury thermometer. Fill a container with ice that is covered with water. Allow the bath to stabilize for fifteen minutes before beginning calibration. Place the sensors in the ice bath and adjust for a display of 32°F. After the intercept calibration, the sensor should be accurate at all temperatures displayed within its range. In fact, more accurate than the typical household thermometer.

Completion

Finish Auto-Temp with a suitable and stylish enclosure. The author's prototype was mounted in a walnut and plexiglass housing. The transformer and fuse were placed under the main enclosure. Be sure that all 117-volt AC wires are properly insulated and strain relief connections are made where wires attach to the case. Position the two temperature sensors in the area where temperature is to be monitored. The outdoor sensor should be placed in an area out of direct sunlight to prevent errors. Auto-Temp should now offer a convenient display of time and indoor-outdoor temperature.

TONE-RINGER

(Continued from page 40)

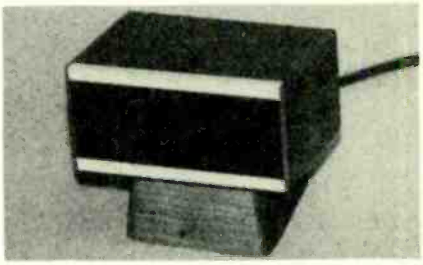
printed-circuit board. The foil diagram is given in Fig. 2 and the parts location on the reverse side of the foil pattern is given in Fig. 3. You may have to vary the mounting and connection details on the foil pattern to accommodate the PZ1 transducer you obtain for the project. Part values are not critical so long as capacitor minimum working-voltages are respected. Location of parts in a hand-wired or wire-wrap construction project is are not critical. Just remember that neatness counts!

When selecting the piezo-sound transducer, PZ1, a rule of thumb is—the larger the better. As the physical size increases, the sound producing diaphragm gets bigger which produces more sound. Also, the transducers resonant frequency drops which better matches the output frequency of the Tone-Ringer. There are two types of piezo transducers, self-drive (like a Sonalert) and external drive. That application requires the external drive type.

Connection to the phone line is very simple. There are usually two wires (denoted Tip and Ring) coming into the subscriber's location. The Tone-Ringer's input is connected to those wires. Depending on your location, the phone may connect to the lines via a four-prong connector or a modular plug. Either of those connectors is available at your local electronics or telephone store. Inside there are four wires. Connect the Tone-Ringer to the red and green wires, and fasten the connector to the back of the ringer circuit board.

Now sit back, and wait for your first call. ■

FRONT VIEW of Auto-Temp reveals clean, modernistic appearance that is uncluttered by any controls. Housing selected offers a professional look.



LETTERS

(Continued from page 20)

be that a filling in my tooth is acting like a semiconductor, sort of a diode receiver. He told me that a dentist could grind down the filling and thereby detune the frequency to a quiet spot on the "dial" so I wouldn't hear the station any more.

Is all that possible? Is my tooth really acting like a detector?

S. P., Greeley, CO

Yuh. And your nose is a volume control!

Likes Broadcast Booster

I just completed the Broadcast Booster described in your last issue, and tried it out. I guess that I've been living in "Death Valley" as far as signal strength is concerned; but short of erecting an antenna atop the nearest local mountain, and running a coaxial cable to my receiver, that booster has been the greatest thing to come down the pike since sliced bread. The stations that I've been accustomed to hearing badly now come in as though they were located right next door. And I'm also pulling in stations I never knew existed. Thanks muchly, I'm really delighted with the Booster.

G. L., Rome, GA

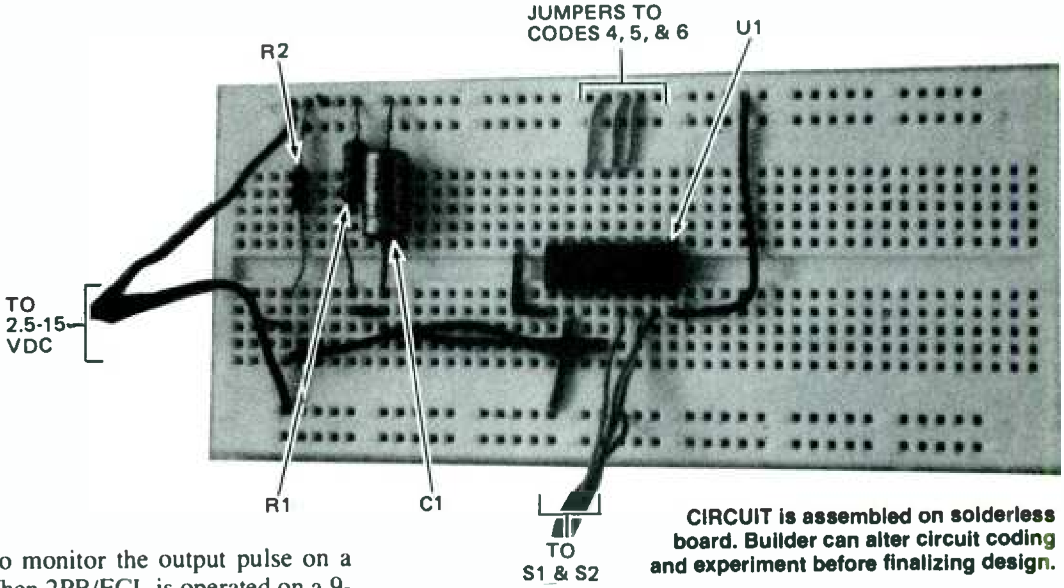
Glad that you're enjoying the Broadcast Booster, George. As we often say, building the projects we offer is only half the fun. We try to select those projects that will be fun to build and fun to use!

ADVERTISING INDEX

HANDS-ON ELECTRONICS magazine does not assume any responsibility for errors that may appear in the index below.

2PB/ECL

(Continued from page 73)



CIRCUIT is assembled on solderless board. Builder can alter circuit coding and experiment before finalizing design.

The output is a current source, so a resistor, R1, is connected between pin 11 and ground should you want to monitor the output pulse on a VTVM or oscilloscope. When 2PB/ECL is operated on a 9-volt supply, the maximum lock output-control source current ranges from 13 mA to 36 mA. That current can be used to trigger an SCR or activate a solid-state or mechanical relay.

If you anticipate making frequent changes in the 9-bit lock code, you might consider using an 8-pole SPST DIP switch instead of encoding jumpers. The switch mounts readily in a DIP IC socket or can be wired directly to a printed-circuit board. More on that later. If you use the 8-pole switch such as the readily available Radio Shack #275-1300, assign the same code level to two adjacent code pins and tie them together on one switch pole. In that way you can encode 9 pins with an 8-pole switch.

The duration of the output current pulse and the maximum allowable time lapse between valid input bits is proportional to the time constant established by R1-C1. The time constant in seconds is equal to the product of the capacitance in microfarads and the resistance in megohms. For example, the time constant of a 2μF capacitor and a 500,000-ohm (0.5-Megohm) resistor is 2 × 0.5 = 1 second. Similarly, a .05-μF capacitor and 1-megohm resistor will develop a 5-second time constant. With a 9-volt V_{SS} supply, the minimum recommended value for R1 is 2200 ohms and the maximum is 3,300,000 ohms.

Quick Code Practice Oscillator

(Continued from page 44)

capacitor leads are long enough to make the on-board connections.

Checkout

Do make sure that pin 7 of U1 (Fig. 2) goes to the plus (+) battery terminal through the key jack, J1; and, that pin 14 is connected to ground. Plug U1 into its socket, connect battery B1, and plug a telegraph key into J1 and a pair of headphones into J2. Press the key, or lean a weight on it (some keys have shorting switches), and adjust the TONE control R3 and VOLUME control R4 for a comfortable listening frequency and level. Long after you have mastered he International Morse Code (See Table 1) and achieved that valued Amateur Radio operator license, the Quick Code Practice Oscillator will make a good adjustable signal source for checking out other home-brew projects that you will find published here in **Hands-On Electronics**. ■

DESIGNING DC POWER SUPPLIES

(Continued from page 65)

On most three-terminal IC voltage regulators, the type number tells us something about the specifications. We can tell, for example, the voltage rating, approximate current rating, and whether the device is for positive or negative voltages.

The main part number gives us the voltage polarity. Two main families exist for both positive and negative types, making four type numbers:

Positive: 78XX and LM340NXX
Negative: 79XX and LM320NXX

In all four cases, the XX denotes the output-voltage rating. For example, 7805 and LM340N05 are 5 volt regulators, while 7812 and LM340N12 are 12-volt regulators.

The *N* term in the above designations gives us the package style, and, indirectly, the approximate current rating. The package destinations are:

H	TO-5	100mA
K	TO-3	1 A*
T	TO-220	750 mA

*Suspended in free-air; may be increased with appropriate heat-sinking and/or an air blower. TO-3 devices are seen with ratings of 3.5 and 10 A, but most are 1 Amp rated.

Thus, a LM340L05 device is a 5 volt, positive regulator in a TO-3 package, and will safely handle 1 Amp of output current.

Concluded Next Issue

We have covered considerable ground this issue on designing power supplies.Justice to you, our reader, demands that we cut this special feature into two parts, so that we would have additional articles in this issue of **Hands-on Electronics**. In the next issue, we will conclude this theory article when we cover three-terminal voltage regulators, problems common to power supplies, high-voltage power supplies, and inverters. To be assured of obtaining a copy of **Hands-on Electronics**, the Editor suggests you seriously consider becoming a first-year charter subscriber to the magazine. One small payment sent by you to us will insure that the mailman delivers your future copies of *Hands-on Electronics*. See the subscription advertisement in this issue. ■

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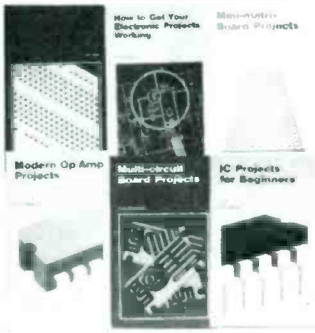

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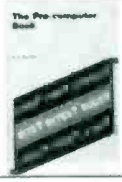

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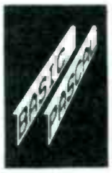

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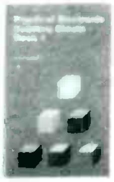

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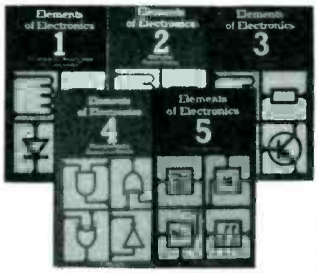

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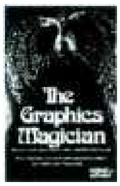

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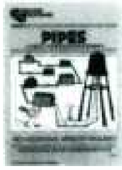

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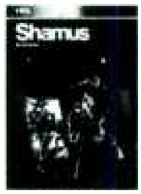

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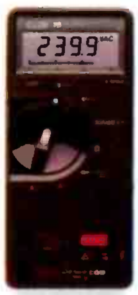

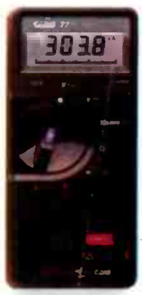

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