ELECTRONICS HOBBY-THEORY PROJECTS

THE FUN WAY TO LEARN ELECTRONICS

VOLUME XIX

$3.95

ELECTRONICS HANDBOOK

WPS 36286

IN CANADA $4.50

BUILD A MORSE CODE PRACTICE OSCILLATOR

BUILD AN ARMSTRONG ONE-TUBE RADIO

BUILD A DIGITAL VOLTMETER

ELECTRIC GUITAR CONVERSION

BUILD A SINGLE CHIP FM RECEIVER

HOW A LOUDSPEAKER WORKS

LOW-COST ELECTRONIC GAMES AND GADGETS

19
0 70989 36286 4

Lab Test ELECTRONICS HANDBOOK For Yourself

Get switched on

In case you're not all that familiar with us, we're not a publication for electrical engineers and other wizards. No way, ELECTRONICS HANDBOOK is expressly for people who like to build their own projects and gadgets—and maybe get a little knee-deep in tape, solder and wire clippings in the process.

In fact, we have a sneaking suspicion that our readers like us because they think we're just as bug-eyed and downright crazy over great new project ideas as they are. And I guess they're right!

ELECTRONICS HANDBOOK thinks of you who dig electronics as the last of a special breed. It's more than just the "do-it-yourself" angle—it's also the spirit of adventure. In this pre-packaged, deodorized world, building your own stereo system, shortwave receiver, darkroom timer or CB outfit is like constructing a fine-tuned little universe all your own. And when it all works perfectly—it really takes you to another world.

IF YOU'RE NEW TO ELECTRONICS YOU GET A "BASIC COURSE"!

It gives you a complete, ground-floor lowdown on a variety of important electronic subjects. For example—Understanding Transistors...How Radio Receivers Pull In Signals...Cathode Ray Tubes Explained...How Capacitors Work...Using Magnetism In Electronics, and much, much more!

Of course, we can't make you a master electrician overnight. But we can show you the fundamentals of repair plus maintenance tips.

TRY A FEW ISSUES AND EVALUATE OUR...

- HOW-TO-DO-IT HELP Tips and pointers that add up to money saved. For example—tuning up your tape player...all about radios ...whys and hows of turntables...care and feeding of speakers.
- EXCITING DISCOVERIES. Whatever your particular interest in electronics, you'll be entering a world of discovery in the pages of the ELECTRONICS HANDBOOK

Th… nds of Successful …es Are Proof That …I Computer … Training Works!

CALL 1-800-321-4634, EXT. 1440 OR SEND FOR FREE CATALOG!

Only NRI gives you the training and the state-of-the-art equipment for career advancement, part-time earnings, or a business of your own.

CHECK ONE FREE CAREER CATALOG ONLY

- ☑ Microcomputer Servicing
- ☐ Industrial Electronics & Robotics
- ☐ TV/Video/Audio Servicing
- ☐ Basic Electronics
- ☐ Networking with Windows NT
- ☐ Computer-Aided Drafting
- ☐ Electronic Music Technology
- ☐ Computer Programming
- ☐ Telecommunications
- ☐ Multimedia Programming
- ☐ Desktop Publishing with PageMaker
- ☐ PC Applications Specialist
- ☐ LAN Servicing
- ☐ Computer-Based Bookkeeping
- ☐ Visual Programming in C++

OR GET YOUR DEGREE!

- ☐ New! Associate Degree in Accounting
- ☐ New! Associate Degree in Business Management

CARD E

Name (Please Print) Age

Street (No P.O. Box numbers please)

City State Zip

A Division of The McGraw-Hill Companies

Accredited Member, Distance Education and Training Council 0022-0296

For career courses approved under G.I. Bill, ☐ check for details

…ia

learn at your own pace. No classroom pressures, no night school, no need to quit your present job until you're ready to make your move.

Take Advantage of Today's Money-Making Opportunities in Computer Repair

The Department of Labor forecasts over 220,000 jobs for computer service technicians by the year 2005. With the right training and skills, you can cash in on this wide-open opportunity. Only NRI prepares you so thoroughly for a full- or part-time job as a computer service technician – even a business of your own!

…DX4/100 …e exciting

- 8 meg RAM
- 128K cache memory
- 540 meg hard drive
- Super VGA color monitor
- 14,400 baud fax/modem
- Quad-speed CD-ROM drive
- 16-bit sound card

"… training in microcomputer servicing, I set up my own company. I contract myself out to several computer retailers as their service technician. I have control over my future and total confidence in my business."

V. Bender, Calgary, Alberta

"I recommend NRI to anyone looking for a change, success, and real challenge. Hands-on projects allow you to build on what you studied in the lessons – no better way exists to learn how to troubleshoot and service computers!"

R. Buda, Tenley Park, IL

FREE Catalog Gives You the Whole Story—Call or Write NRI Today

If the coupon is missing, write to NRI Schools, 4401 Connecticut Avenue, NW, Washington, DC 20008.

What's more, you perform diagnostic tests using the professional-level Ultra-X R.A.C.E.R. II plug-in card and QuickTech-PRO software, all included in your course.

Plus, NRI training now includes Windows 95, the graphical user interface that's taken the computing world by storm.

Train in the Privacy of Your Own Home

No prior experience necessary – with your personal instructor and NRI's team of technical specialists behind you every step of the way, you

Send today for FREE catalog or call 1-800-321-4634, Ext.1440

NRI Schools
4401 Connecticut Avenue, NW, Washington, DC 20008

For career courses approved under GI Bill, ☐ check here for details.

☑ **Check one FREE career catalog only**

- ☐ MICROCOMPUTER SERVICING
- ☐ TV/Video/Audio Servicing
- ☐ Visual Programming in C++
- ☐ Networking with Windows NT
- ☐ Basic Electronics
- ☐ Desktop Publishing with PageMaker
- ☐ Computer Programming

OR GET YOUR DEGREE!

- ☐ **NEW!** Associate Degree in Accounting
- ☐ **NEW!** Associate Degree in Business Management

Name (please print) Age

Address

City State Zip

A Division of The McGraw-Hill Companies

Accredited Member, Distance Education and Training Council 0022-0296

ELECTRONICS HANDBOOK

CONTENTS

VOLUME XIX

FROM THE EDITOR'S DESK 6
NEW BOOK REVIEWS 8
SINGLE CHIP FM RECEIVER 14
HOW A LOUDSPEAKER WORKS 18
UBIQUITOUS DIODE (PART II) 21

CIRCUIT FRAGMENTS 26

REAL BASS/TREBLE CONTROLLER .....
TILT DETECTOR .....
LOW NOISE PRE-AMP .....
LED PULSE STRETCHER .....
SPECIAL RF OSCILLATOR REGULATOR .....
SOLID STATE LATCH .....
CAR FINDER BEACON .....
THE LIGHT TOUCH .....
TTL RELAY DRIVER .....
ANTIQUE RADIO (BUILD AN ARMSTRONG ONE-TUBE RADIO) 31
DX'ING OL' SOL 41

WORKBENCH PROJECTS 46

GROUND SHOOTER .....
MULTI-PURPOSE TESTER .....
REVERSIBLE VOLTAGE SOURCE .....
PRE-EMPHASIS TREBLE BOOST .....
WATER DETECTOR .....
RF SNIFFER PROBE .....
BATTERY OR ADAPTER POWER .....
LIGHT MINDER .....
BUILD A DIGITAL VOLTMETER 51
MORSE CODE PRACTICE OSCILLATOR 57
ELECTRIC GUITAR CONVERSION 65

IC TESTBENCH 69

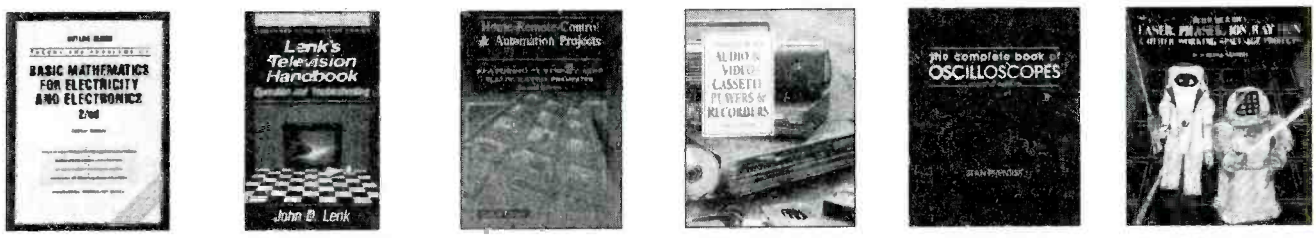
FLASHING LED .....
CABLE TESTER .....
AUTO POWER TRANSFER SWITCH .....
MODEL ROCKET LAUNCHER .....
LED BRAKE LIGHT .....
LM 386 GAIN SELECTOR RESISTANCES .....
REGULATOR PROTECTOR .....
12 VOLT POWER FLASHER .....
ELECTRONIC SIRENS 74
AC MICROVOLT PREAMP (CONSTRUCTION QUICKIE) 76
MODEL ROCKET LOCATOR (CONSTRUCTION QUICKIE) 77
HOUSEWIRING TRACER (CONSTRUCTION QUICKIE) 79
ELECTRONIC NOTEPAD 81
CATALOG CORNER 85

5 BOOKS FOR ONLY $4.95

WHEN YOU JOIN THE Electronics Book Club®

VALUES TO $153.75

The leading source of information for electronics hobbyists for over 30 years!



0044392 $12.95

0375178-XX $39.50 Counts as 2/Hardcover

1577262 $21.95

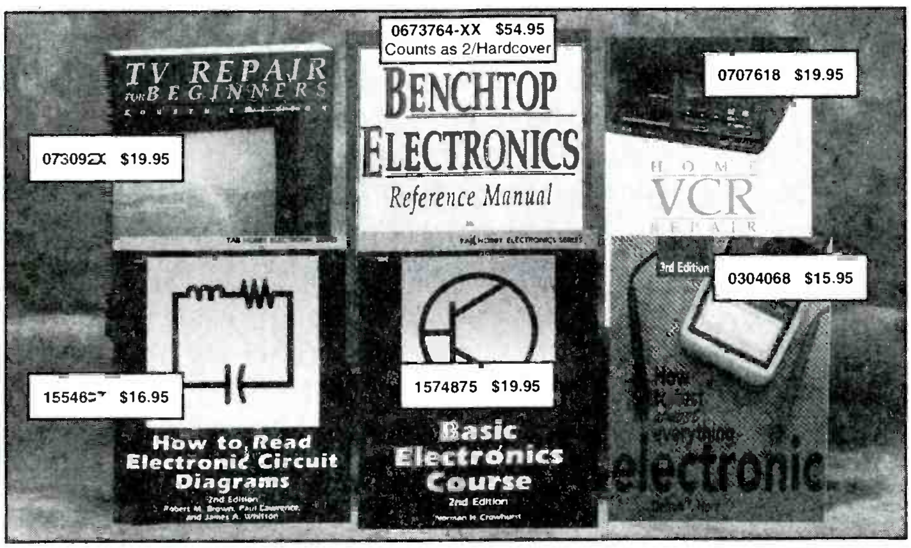
1577564-XX $22.95 Counts as 2

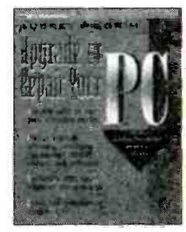
1577815 $19.95

1560696-XX $21.95 Counts as 2

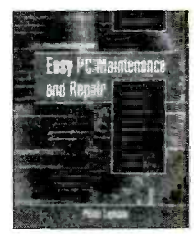
0052387 $28.95 Hardcover

0717753 $19.95

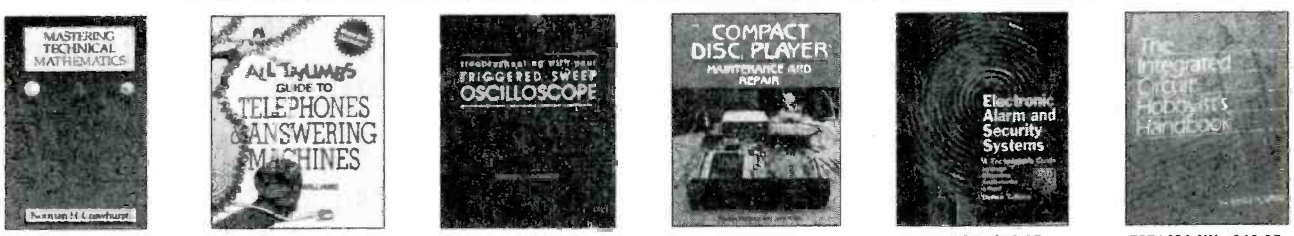




0501149 $26.95



036432X $29.95 Hardcover



1575863 $27.95

0705925 $9.95

1576568-XX $21.95 Counts as 2

1570519 $17.95

0305285 $39.95 Hardcover

5871491-XX $19.95 Counts as 2

As a member of the ELECTRONICS BOOK CLUB . . . you'll enjoy receiving Club bulletins every 3-4 weeks containing exciting offers on the latest books in the field at savings of up to 50% off the regular publishers' prices. If you want the Main selection, do nothing and it will be shipped automatically. If you want another book, or no book at all, simply return the reply form to us by the date specified. You'll have at least 10 days to decide. If you ever receive a book you don't want due to late delivery of the bulletin, you can return it at our expense. Your only obligation is to purchase 3 more books during the next 12 months, after which you may cancel your membership at any time. And you'll be eligible for FREE BOOKS through our Bonus Book Program.

A shipping/handling charge and sales tax will be added to all orders. All books are softcover unless otherwise noted. If you select a book that counts as 2 choices, write the book number in one box and XX in the next. (Publishers' Prices Shown) ©1996 EBC

If coupon is missing, write to:
Electronics Book Club,
A Division of The McGraw-Hill Companies
P.O. Box 549, Blacklick, OH 43004-9918

Electronics Book Club®

A Division of The McGraw-Hill Companies, P.O. Box 549, Blacklick, OH 43004-9918

YES! Please send me the books listed below, billing me just $4.95 plus shipping/handling & tax. Enroll me as a member of the **Electronics Book Club** according to the terms outlined in this ad. If not satisfied, I may return the books within 10 days without obligation and have my membership cancelled.

If you select a book that counts as 2 choices, write the book number in one box and XX in the next.

Name ____________________

Address/Apt. # ____________________

City/State ____________________

Zip ____________ Phone ____________

Valid for new members only, subject to acceptance by EBC. Canada must remit in U.S. funds drawn on U.S. banks. Applicants outside the U.S. and Canada will receive special ordering instructions. Publishers' prices shown. A shipping/handling charge & sales tax will be added to all orders. CEHB1296

PHONE: 1-614-759-3666 (8:30 a.m. to 5:00 p.m. EST Monday-Friday) • **FAX: 1-614-759-3749** (24 hours a day, 7 days a week)

GETTING STARTED WITH ELECTRONIC PROJECTS

Once you've decided to put together the parts that make up a circuit there are several things that you should do before starting actual work. The first is to understand exactly how the circuit works; what each part does in the circuit. Don't just put it together **hoping** it will work. You can be sure you have put it together properly, so that it'll work, only if you know what each component does to the flow of electricity (electrons) going through it, as well as through the rest of the circuit.

If you don't understand the circuit thoroughly, every part as well as its function, read the article again, carefully, until you do. If that's not enough, look up words you're not familiar with in a good electronics dictionary. Read the "teaching" articles that we include in every issue of the ELECTRONICS HANDBOOK, like the ones on "Capacitors" and "Resistors" and "Understanding Schematic Diagrams" that we have published in previous issues.

Once you understand the circuit and what each of its components does, and after you've got all the parts together, clear a good workplace. Be sure you've got a good light and that you've got all the right tools, including a small soldering iron or pencil, 25 or 35 watts is usually just right. Also be sure that you can solder properly before you start the project. If you're not comfortable with soldering, a little practice and you can become adept. Good soldering is essential for good working projects.

Another caution is in order, even if you've worked with electronic parts before but haven't handled integrated circuits (ICs). Be sure to observe these simple precautions:

Don't mount the IC directly into a circuit or solder its terminals into the circuit. Instead, do what experienced experimenters do—solder an IC socket into the circuit (unless you're using a quick-assembly experimenters board, in which case you'll just plug the socket into the board's holes). Also, don't handle the IC any more than necessary, to keep from damaging it with static electricity. Most ICs are sold mounted temporarily in a little piece of anti-static foam. Keep the IC in its foam mount until you're ready to plug it into a socket. Finally, keep excessive heat away from ICs, particularly when putting them into a circuit with a soldering iron (another good reason to use a socket whenever possible).

ELECTRONICS HANDBOOK

PUBLISHER
AND
EDITORIAL DIRECTOR
Don Gabree

SECRETARY/TREASURER
L. M. Gabree

ASSOCIATE EDITOR
Holly B. Love

CONTRIBUTING AUTHORS
Homer Davidson
Walter Sikonowiz
Tony Lee
Lance Borden
Steve Sokolowski
Darren Yates
William Hoffman
Ron Johnson
Ed Noll
John Iovine
Stephen Erst
Allen Rolf
William Templin
Don Wilcher

ISSN 0897-7631

ADVERTISING SALES
C&E Hobby Handbooks
P.O. Box #5148
North Branch, NJ 08876
(908) 231-1518

Published by C&E Hobby Handbooks, Inc. Editorial and Business address, P.O. Box #5148, North Branch, N.J. 08876 (908) 231-1518.

PERMISSIONS: Material in this publication may not be duplicated or reproduced in any form without permission. Requests for permission should be directed to — Don Gabree, C&E HOBBY HANDBOOKS, INC. P.O. Box #5148, North Branch, N.J. 08876 (908) 231-1518.

EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care; however, the publisher assumes no responsibility for the return or safety of manuscripts, artwork or photographs. All contributions should be addressed to: PUBLISHER, C&E HOBBY HANDBOOKS, P.O. Box #5148, North Branch, N.J. 08876.

As a service to readers, C&E HOBBY HANDBOOKS publishes available plans and/or information relating to products, techniques of scientific and technological developments. Because of possible variances in the quality and condition of materials and workmanship used by readers, C&E HOBBY HANDBOOKS disclaims any responsibility for the safe and proper functioning of reader-built projects based upon or from plans and/or information published by C&E HOBBY HANDBOOKS.

Second Class Entry applied for. Copyright © 1996 by C&E HOBBY HANDBOOKS, INC.

GET THE SESCOM SOLUTION!

BOXES

MODEL	SIZE W x D x H (in)	PRICE $
RSB-3	7.5 x 16.5 x 3	27.50
RSB-5	7.5 x 16.5 x 5	33.75
RSB-7	7.5 x 16.5 x 7	40.50
RSB-9	7.5 x 16.5 x 9	47.50
RSB-11	7.5 x 16.5 x 11	54.00
RSB-13	7.5 x 16.5 x 13	60.75

- ½ RACK SIZE FOR COMPACT DESIGN
- CAN BE USED ON TABLE OR IN RACK
- FULL LINE OF MOUNTING ACCESSORIES
- CLEAR FINISH STANDARD. FOR BLACK OR GOLD ADD $5.00 PER BOX

RACKEM 'N' STACKEM™ SERIES

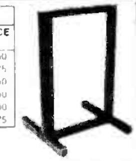


TABLE TOP RACKS

MODEL	SIZE W x D x H (in)	PRICE $
RSR-6	11.5 x 15.2 x 11.25	27.50
RSR-8	11.5 x 18.8 x 11.25	65.00
RSR-10	11.5 x 22.6 x 11.25	70.00
RSR-12	11.5 x 26.4 x 11.25	75.00
RSR-6-19	21.0 x 15.2 x 11.25	70.00
RSB-8-19	21.0 x 18.8 x 11.25	75.00
RSB-10-19	21.0 x 22.6 x 11.25	80.00
RSB-12-19	21.0 x 26.4 x 11.25	85.00

- AVAILABLE IN HALF AND FULL RACK WIDTHS
- CLEAR, BLACK AND GOLD ANODIZED FINISHES
- CONSTRUCTED OF 1.0" SQUARE ALUMINUM TUBING

RACK CHASSIS
PANELS ARE .063" ALUMINUM STANDARD FRONT AND REAR PANELS ARE CLEAR ANODIZED. BLACK OR GOLD PANELS ALSO AVAILABLE FOR ADDITIONAL $7.50

RACK CHASSIS

MODEL	SIZE W x D x H (in)	PRICE $
1RU5	19 x 5 x 1.75	34.00
1RU7	19 x 7 x 1.75	36.50
1RU10	19 x 10 x 1.75	38.75
1RU12	19 x 12 x 1.75	42.75
1RU15	19 x 15 x 1.75	45.75
1RU17	19 x 17 x 1.75	48.75
2RU5	19 x 5 x 3.5	36.50
2RU7	19 x 7 x 3.5	38.75
2RU10	19 x 10 x 3.5	38.75
2RU12	19 x 12 x 3.5	45.25
2RU15	19 x 15 x 3.5	48.25
2RU17	19 x 17 x 3.5	[illegible]
3RU5	[illegible]	[illegible]
3RU7	19 x 7 x 5.25	48.50
3RU10	19 x 10 x 5.25	51.00
3RU12	19 x 12 x 5.25	54.00
3RU15	19 x 15 x 5.25	57.00
3RU17	19 x 17 x 5.25	60.00

VISA
MasterCard

ORDER TODAY!
PREPAID ORDERS ARE SHIPPED SURFACE AT NO CHARGE (U.S. 48 STATES, MEXICO AND CANADA)

RF SHIELDED BOX
HOT TIN-PLATED STEEL BOXES FOR RF AND CLOCK TYPE CIRCUITS PLUS ALLOWS THE ELIMINATION OF UNWANTED SIGNAL SPILLOVER BOXES COME WITH DIVIDERS AND THE LIDS CAN BE SOLDERED TO THE CASE FEED THRU CAPACITORS ARE AVAILABLE AS SOLDER OR SCREW-IN TYPES

RF SHIELDED STEEL BOXES

MODEL	DESCRIPTION W x D x H (in)	PRICE $
SB-1	2.1 x 1.9 x 1.0	4.50
SB-2	3.3 x 1.9 x 1.0	6.00
SB-3	4.2 x 1.9 x 1.0	7.00
SB-4	6.3 x 1.9 x 1.0	10.50
SB-5	3.3 x 2.7 x 1.1	9.50
SB-6	4.8 x 2.7 x 1.1	11.50
SB-7	6.4 x 2.7 x 1.1	13.20
SB-8	2.6 x 2.7 x .63	7.00
SB-9	3.2 x 2.7 x .63	8.25
SB-10	4.8 x 2.7 x .63	9.00
SB-11	6.3 x 2.7 x .63	10.75
FTS-1	1000pf 50VDC SOLDER TYPE	.85
FTSI-1	1000pf 50VDC SCREW IN TYPE	3.50

HEAVY DUTY RACK CHASSIS
PANELS ARE .080" ALUMINUM AND ARE FIELD REMOVABLE

HEAVY DUTY RACK CHASSIS

MODEL	SIZE W x D x H (in)	PRICE $
3RU7 HD	19 x 7 x 5.25	120.75
3RU10 HD	19 x 10 x 5.25	127.00
3RU14 HD	19 x 14 x 5.25	140.75
4RU7 HD	19 x 7 x 7.0	127.00
4RU10 HD	19 x 10 x 7.0	135.50
4RU14 HD	19 x 14 x 7.0	140.75
5RU7 HD	19 x 7 x 8.75	132.25
5RU10 HD	19 x 10 x 8.75	139.75
5RU14 HD	19 x 14 x 8.75	150.25

METAL CABINET
PANELS ARE .063" ALUMINUM. BLACK OR GOLD FRONT & REAR PANELS AVAILABLE FOR ADDITIONAL $5.00

METAL CABINETS

MODEL	SIZE W x D x H (in)	PRICE $
MC-1A	4 x 3 x 2	12.00
MC-2A	[illegible]	14.00
MC-3A	8 x 3 x 2	16.00
MC-4A	4 x 5 x 3	14.00
MC-5A	6 x 5 x 3	16.00
MC-6A	8 x 5 x 3	18.00
MC-7A	4 x [illegible] x 4	16.00
MC-8A	6 x 7 x 4	18.00
MC-9A	8 x 7 x 4	20.00

SESCOM™
ORDERS (800) 634-3457 ■ FAX (800) 551-2749
OFFICE (702) 565-3400 ■ FAX (702) 565-4828
SESCOM, INC. 2100 WARD DRIVE, HENDERSON, NV 89015 U.S.A.
SESCOM, INC. is not responsible for inadvertent typographical errors and prices and specifications are subject to change without notice

ATTACH LABEL HERE

NEW ADDRESS HERE — PLEASE PRINT

NAME ______________________

ADDRESS ______________________

CITY ______________ STATE ______________

DATE ______________ ZIP ______________

V19

FROM THE EDITOR'S DESK

Ask The Editor, He Knows!

Got a question or a problem with a project—ask The Editor. Please remember that The Editors' column is limited to answering specific electronic project questions that you send to him. Personal replies cannot be made. Sorry, he isn't offering a circuit design service. Write to:

The Editor
C&E HOBBY HANDBOOKS INC.
P.O. Box #5148
North Branch, N.J. 08876

Reader Needs Inverter

I just purchased your magazine and found it to be interesting and informative. One small suggestion to help amateurs like me would be to include pictorial diagrams for some projects.

I am interested in building a 12-volt DC inverter to use car battery current for household use. Hopefully, around 500 watts at least. Any suggestions?

— Daniel Cardone, Montevallo, AL

Back in the old days, Dan, it used to be that practically every article in a hobbyist electronics magazine was accompanied by a pictorial diagram. However, the advent of printed circuits has lessened the need for pictorial diagrams, and they've all but disappeared from most magazines. Here at ***Electronics Handbook*** *we do run pictorials of projects that might prove challenging for a beginner, but the really simple projects don't warrant them.*

Inverters are extremely useful devices that enable 120-volt AC appliances to be operated from a standard 12-volt car battery. You must pay attention, however, to the type of waveform put out by the inverter. Those that give you a square wave or a stepped approximation of a sinewave should not be used with devices like computers that expect to see a pure sinewave. They should instead be used with various motor-driven appliances or electric light bulbs. I'm sending you a couple of circuits that should cover most needs.

Interestingly enough, I had the chance to observe an inverter in action just yesterday. One of my neighbors, a regular Mr. Fix-it, was installing some plastic drainage pipe. To cut the pipe to size, he was using a reciprocating saw connected to an inverter plugged into his car's lighter socket. It seemed obvious to me that this was the kind of job that a reasonably healthy individual could do with just a hacksaw, but I kept my advice to myself. No point in antagonizing someone who's holding a sharp instrument.

Satisfied Reader

Your magazine is excellent. I used to buy **Popular Electronics** and **Electronics Now**, but found that they seemed to be repeating the same kinds of projects. Furthermore, these projects weren't very practical, at least not for me. I like your workbench projects, and especially enjoyed the 6-to-12 volt converter—something I'd been in need of for quite some time. Keep up the good work. By the way, how about some articles on Tesla and his inventions.

— Jeff Sitter, Stanwood, WA

Thanks for the kind words, Jeff. We're glad you enjoy ***Electronics Handbook.*** *I suspect that the other magazines you mentioned are a bit too advanced for you, and that's why the projects don't seem interesting.*

As for Tesla, it's amazing that the man's work still commands attention. Perhaps it has something to do with the Tesla Coil. There are few sights as spectacular as a big Tesla Coil spewing out a cascade of brilliant, hot sparks that look like manmade lightning. Incidentally, anyone operating a Tesla Coil should be aware that radio and TV reception will be disrupted in its vicinity, so don't make a nuisance of yourself.

Foxhole Radio Update

Although I'm not a regular reader of **Electronics Handbook,** I did grab a copy of Volume 17 when I saw the Foxhole Radio on the cover. When I was in grade school, it seemed that every beginner's book on electronics had such plans, but I had not seen anything like the Foxhole Radio in a long time. I thought it would be a great first project for my son.

However, I did not realize that there might be a problem finding the necessary blued razor blades, and was a bit perplexed until the obvious solution hit me. If you can get the PAL Super Singles mentioned in the article, great, but if not, don't bother to special order them. (I guarantee that you won't be able to order just one pack.) Instead, buy the cheapest, non-stainless blades you can find, then pick up a bottle of cold-process gun-bluing fluid at your local sporting goods store. The bluing process is quick and easy, and for about $3.00 you'll have all the blue blades you, your friends, and their friends can use.

— R. L. Howard, Nampa, ID

Thanks for the good advice, R. L., but I have to take exception to the first sentence of your letter. Never tell an editor you're not a regular reader; it's like telling the Pope you don't go to Mass.

Believe it or not, I also hit on the idea of using gun bluing after reading the Foxhole Radio article, though I never got around to actually trying it. Readers who cannot find a local supply of cold-process gun-bluing fluid should check out one of the mailorder suppliers of hunting equipment, like Cabela's or Gander Mountain

Anti-terrorist Jitters

I have just been informed about a new anti-terrorism bill pending in Congress that will affect the electronics industry. I'm not clear as to the details, but from what I've been told, the bill would totally abolish the hobbyist market, and stifle inventors and new-product developers as well.

I was also told that the big parts manufacturers are the ones pushing the hardest for the bill to pass, because of their fear of lawsuits stemming from the use of their components in a terrorist device.

If such a bill is passed, what will happen to hobbyists? Will we be hunted down and arrested for having illegal electronic parts?

— John Stumpf, Calumet City, IL

Relax, John, the Feds aren't going to arrest us for owning IC chips and soldering irons. I suspect that the details of the rumor you heard were greatly exaggerated. I could find no evidence to suggest that the hobby industry is about to be wiped out, or even that we'll need a license to possess ICs. Still, just to be on the safe side, maybe we should band together and form an organization, sort of like the National Rifle Association. We'll need a slogan. "If chips are outlawed, only outlaws will have chips" comes to mind, but I think we can do better than that. Any suggestions?

VLF Receiver

I have searched high and low for schematics to build my own VLF receiver. This unit would have a frequency range of around 13 kHz to approximately 100 Hz. Receivers of this type are neither common nor usable for anything other than picking up the eerie sounds generated by the Earth's magnetic poles, plus a few unknowns from who knows where. These signals are often referred to as "whistlers." Any information you can provide will be appreciated.

— Ed McClure, Lubbock, TX

A VLF receiver such as you describe, Ed, is a relatively simple device capable of intercepting not only natural electromagnetic phenomena but commercial and military broadcast signals as well. Natural phenomena include whistlers and tweeks in the 100-3000 Hz range, and lightning-strike impulses. Because they produce increased ionization of the Earth's upper atmosphere, solar flares have a pronounced effect on radio-wave propagation. In the VLF region, this manifests itself as an increased level of atmospheric static. Consequently, VLF receivers are used by scientists as a means of monitoring solar-flare activity.

Man-made activity in the VLF region consists of frequency-standard signals, navigation beacons, military data, and ship-to-shore communication. The U.S. Navy operates many stations in the VLF region, often with power in excess of one million watts, to keep in touch with its submarine fleet.

It is interesting to note that VLF radio signals, with a maximum frequency of 30 kHz, have almost the same frequency range as the human ear. We cannot hear these signals, of course, since they are electromagnetic vibrations, not the acoustic or pressure vibrations to which our ears respond. Nevertheless, the low frequencies of these signals mean that a receiver can be simply constructed from an antenna, a tuned circuit, and an audio amplifier. The output of the amplifier can be listened to or rectified, filtered, and used to drive a strip-chart recorder or a computer. I'm passing on a couple of interesting circuits to Ed. Anyone interested in a more thorough explanation of VLF phenomena and receiver circuits should refer to ***How to Build Earthquake, Weather, and Solar Flare Monitors*** *by Gary Giusti (McGraw-Hill). We'll be reviewing this interesting book in a future issue.*

Crystal Set Amp

I pick up **Electronics Handbook** at the newsstand whenever an article or headline catches my eye. This time it was Mike Moreau's letter to the editor that did it for me (Vol. 17).

Mike mentioned in passing that he had successfully built a crystal-set amplifier which worked well for him. Hey guys, I want one, too! Is Volume 14 containing the crystal-set amplifier still available?

I have often built crystal radios for relatives, neighborhood kids, and even some fatcat CEO types who enjoy playing with them at work. The kids really get excited about these simple radios, but too often are disappointed when trying to show them off due to low volume. An amplifier would help a lot.

— Briggs Longbothum, S. Plainfield, NJ

You'll be glad to hear, Briggs, that as of this writing back issues of Volume 14 are still available. See the order form elsewhere in this issue for more details. Hmmm... fatcat CEO types playing with crystal radios at work. Next time one of my investments goes sour, I guess I'll know who to blame.

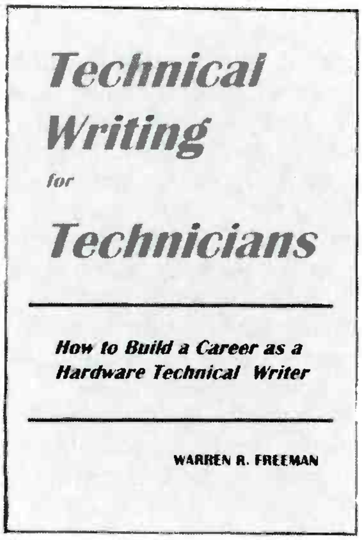
Another Long-wire Type

What is a Windon antenna?

— R.T., Mesa, AZ

A Windon antenna is a length of a long wire antenna cut to $^{1}/_{2}$*-wavelength of the band you want to receive with a feeder wire connected at the* $^{3}/_{8}$-$^{5}/_{8}$ *point of the antenna. The antenna will function to receive frequencies on other bands as well after it has been cut; poorly on the lower frequencies, and a bit better on the higher frequencies. With proper antenna loading at the receiver, the wideband performance of the antenna is greatly increased, especially on the higher frequencies.*

NEW BOOK REVIEWS



TECHNICAL WRITING FOR TECHNICIANS by Warren R. Freeman

If you've ever wondered who writes the manuals that accompany a piece of electronic equipment, it is usually someone with a technical background, i.e., either a technician or an engineer. That's why Warren Freeman titled his book **Technical Writing for Technicians.** Still, you don't have to be a technician to make use of this book.

Warren Freeman's objective, simply put, is to teach anyone to write a technical manual or article that conveys needed information in an easy-to-understand fashion. He begins by describing some of the career opportunities open to hardware technical writers, who generally earn a bit more than technicians, a bit less than engineers.

Next comes some advice on writing style—punctuation, grammar, word usage, and so on. The author provides examples of good and bad style to reinforce his advice. If you want further examples of good writing style, pick up any technical manual from Heath or Hewlett Packard. Examples of bad technical writing are too numerous to mention here.

The book also provides an overview of the text preparation process, from the initial outline to the final copy. Illustrations are an important aspect of most technical manuals, and the author devotes more than a dozen pages to the preparation of photos and line art. The bulk of the book, however, consists of a sample technical manual. This 50-page "manual" illustrates by example the contents and organization of what the author considers to be a good technical manual.

In summary, Warren Freeman has penned a quick, painless introduction to technical writing that should be required reading for anyone thinking of becoming a hardware technical writer.

Technical Writing for Technicians, by Warren R. Freeman, 170 pages, softcover: $19.95 (plus $2.50 shipping). **Contemax Publishers, 17815 24th Ave. North, Minneapolis, MN, 55447. Telephone (612) 473-6436.**

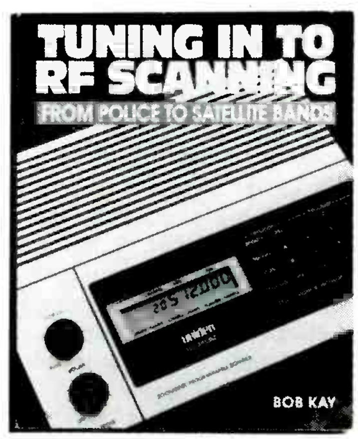
IC MASTER DIRECTORY OF IC MANUFACTURERS' DATA PAGES

Today, with dozens of manufacturers churning out tens of thousands of different integrated circuits, it's often difficult to find information on a part you're interested in. Who makes the part? In what data book is it described? How can the part and relevant data be obtained? These are tough questions. Fortunately, though, they can all be readily answered if you have a copy of the **IC Master Directory of IC Manufacturers' Data Pages** on your desk.

Using the directory is a snap. Just scan the listing until you come to the base part number you want. (The listing is arranged in ascending numerical order.) Each base number will correspond to one or more devices, differentiated by their prefixes. For example: LM313, PWR313, LXT313. Pick the device you want, and read off the manufacturer's name, the name of the data book in which the device appears, and the appropriate page number in the data book. Armed with that information, you're ready to contact the manufacturer and request the data book or data sheet you want. Currently, the directory references over 100,000 ICs and 500 data books—more than you'll ever need, no doubt.

Life is hard already, and there's no reason to make it any harder by going without good reference books. For the electronics professional, this is a reference that will pay for itself.

IC Master Directory of IC Manufacturers' Data Pages, 796 pages, softcover: $84.50. **Hearst Business Publishing,** 645 Stewart Ave., Garden City, NY, 11530. Telephone 516-227-1314.



TUNING IN TO RF SCANNING by Bob Kay

VHF scanning radios are enjoying enormous popularity. With a properly equipped scanner, you can listen to police, fire, ambulance, and governmental communications taking place right in your own neighborhood. What's more, you can even eavesdrop on aircraft communications, satellite signals, and various super-secret agencies that would rather not have you listening.

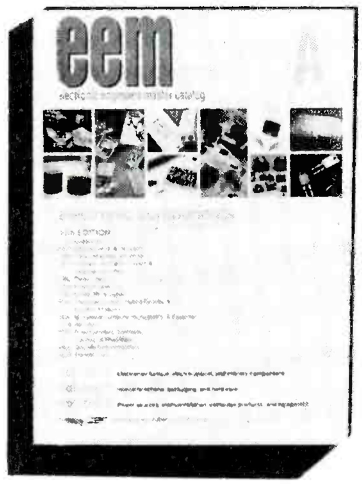
Today's scanners are hot performers, but to get the most out of them, you need to understand how they work. That's where Bob Kay's book **Tuning in to RF Scanning** comes in. Quickly and painlessly, the author imparts just about everything you need to know in order to maximize your enjoyment of the scanning hobby.

Topics covered include choosing a scanner, radio-wave propagation, antenna installation, lightning protection, properly connecting a coaxial feedline, and when and where to listen. Not everything you intercept can be repeated; there are laws regarding communication privacy. The author explains how these U.S. and Canadian laws affect the listener and his hobby. Also covered in the book are some of the more popular monitoring targets, frequency listings, computers in scanning, how to establish a listening post, scanning clubs, and periodicals devoted to the scanning hobby.

All things considered, Bob Kay has written a fine book that belongs in the library of every scanning enthusiast. Highly recommended.

Tuning in to RF Scanning, by Bob Kay, 150 pages, softcover: $14.95 (plus $4.00 shipping). **McGraw-Hill Inc., P.O. Box 545, Blacklick, OH, 43004. Telephone (800) 262-4729.**

EEM/ELECTRONIC ENGINEER'S MASTER CATALOG



The **Electronic Engineer's Master Catalog,** or EEM for short, is the world's largest catalog of electronic products. It provides the user with the latest information on over 4,000 electronic products organized in 60 different product sections. EEM comes in four volumes, each dedicated to a different class of product. Volume A features electronic components; Volume B electromechanical components; Volume C interconnections, packaging and hardware; Volume D power sources, instrumentation, and computer products.

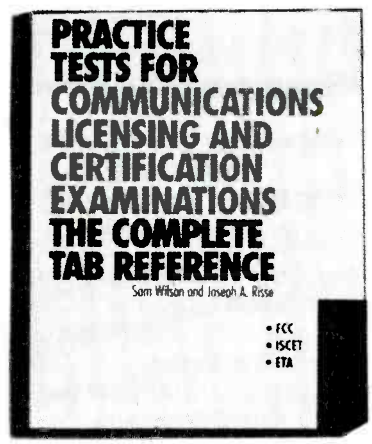
The new EEM contains more than 4,000 data pages from over 1,000 electronics manufacturers. Each data page has been updated and revised by the manufacturer to provide the latest product information.

In addition, EEM includes 36 different Product Selection Guides covering such categories as capacitors, connectors, relays, etc. And there are 20 new miniglossaries and charts containing such useful information as ASCII codes, capacitor formulas, and wire gauges.

The Manufacturers & Sales Offices Directory lists over 5,300 manufacturers. It contains complete addresses and telephone numbers including local sales offices, representatives, and distributors.

Volume W completes the set. It is a listing of the international sales offices and distributors for each manufacturer with data pages in EEM.

Annual subscription to EEM costs $99.00 plus $10.00 for shipping and handling. MasterCard and VISA are accepted. To order, contact **Marie Botta, Hearst Business Publishing/UTP Division, 645 Stewart Ave., Garden City, NY, 11530. Telephone (516) 227-1314. Credit card hotline (800) 833-7138.**

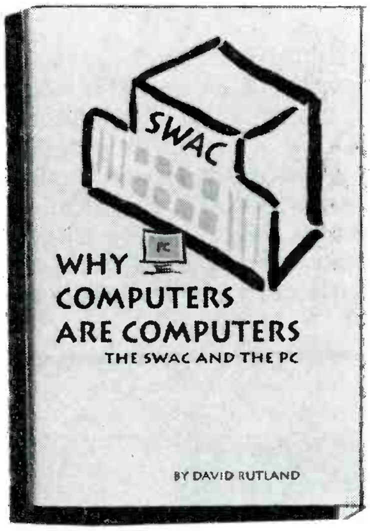


PRACTICE TESTS FOR COMMUNICATIONS LICENSING AND CERTIFICATION EXAMINATIONS
by Sam Wilson and Joseph A. Risse

A companion text to the previously reviewed book, **Practice Tests for Communications Licensing and Certification Examinations** provides more practice for the exam-bound technician. Included are answers and mathematical solutions for each practice test. These tests give you a chance to see where your knowledge is deficient and more study is required.

Practice Tests For Communications Licensing and Certification Examinations, 265 pages, softcover: $24.95. **TAB/McGraw-Hill Inc.,** Blue Ridge Summit, PA, 17294-0850. Telephone 800-822-8138.

NEW BOOK REVIEWS



WHY COMPUTERS ARE COMPUTERS: THE SWAC AND THE PC
by David Rutland

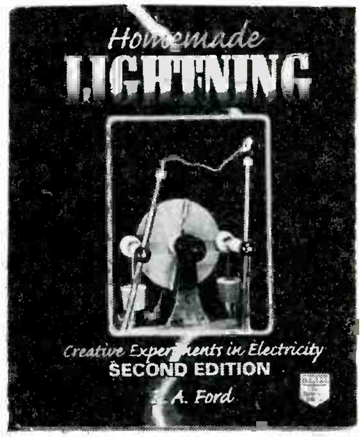
Why Computers are Computers: the SWAC and the PC is the story of one of the world's first digital electronic computers, the SWAC, known more formally as the National Bureau of Standards Western Automatic Computer. When completed in 1950 at UCLA under the direction of Dr. Harry D. Huskey, the SWAC was the first computer to be built west of the Rockies, and the fastest computer in the world. David Rutland was one of the engineers who built the SWAC, and in his new book he shares knowledge of the people who built the computer and the challenges they faced. One of the themes of the book is the underlying similarity between the SWAC and the modern PC. Both are classic Von Neumann machines that execute one instruction at a time, and both make use of programs stored in electronic memory—the so-called Stored Program Concept.

Despite these similarities, however, the SWAC was nothing like your desktop PC in physical appearance. The SWAC had 2600 vacuum tubes, weighed over a ton, and consumed 30 kilowatts of electrical power. Its "power supply," filled with huge transformers and fuses, looked like a small electrical substation. Much of the power consumed was radiated as heat; thus, the SWAC had to be air-conditioned. All internal wiring was point-to-point; printed circuits had not yet come into general use. Data was fed into the machine on punched paper tape, and results were displayed on an electric typewriter.

Internally, the SWAC operated with a clock speed of 125 kHz—about a thousand times slower than a modern Pentium processor. The machine used 37-bit data words (not much different from the 32-bit norm today), but it had a storage capacity of just 256 words. These 256 words of data were stored in an early form of random-access memory known as the Williams Tube, a highly modified cathode-ray tube. As an interesting aside, the author recounts that quality control problems with the early Williams Tubes were eventually traced to lint, a legacy of the building's prior use as a mattress factory. The SWAC had only 13 logical and arithmetic instructions, similar in concept to today's RISC microprocessors, and could only be programmed in machine language, since no other software was available.

There is more to the SWAC than simple technical details. David Rutland tells the story of the people who built the machine, inventing new technology as it was needed, and doing things no one had done before. It's a fascinating story told in readable fashion, well worth your time and consideration. By the way, the 19 photographs featured are alone worth the price of the book.

Why Computers Are Computers: The SWAC and the PC, by David Rutland, 208 pages, hardcover: $24.95 (plus $3.00 shipping). **Wren Publishers, P.O. Box 1084, Philomath, OR, 97370. Telephone (503) 929-4498.**



HOMEMADE LIGHTNING, (2ND ED.)
by R. A. Ford

Homemade Lightning is a book made to order for anyone curious about the nature of electrostatic force. In it, author R. A. Ford describes the construction of two static-electricity generators, a modified Wimshurst machine and a Van de Graaff generator. One of the most notable features of the Wimshurst machine is that it is powered by an electric motor rather than by a hand crank, making it much easier to use. Both of the designs presented require only commonly available construction materials and hand tools. Detailed diagrams and photographs make it easy for the experimenter to copy the author's work. It should be noted that in this second edition of the book Mr. Ford has simplified and improved the design of his Wimshurst generator. As the photos reveal, his Wimshurst machine is a real beauty, and so is the Van de Graaff generator. The photos also show some truly spectacular static discharges—homemade lightning bolts—which confirm that these machines are not only good-looking but powerful as well.

In addition to construction plans, the author includes interesting historical information about static-generating machines along with some theories of how these devices work. Getting the most out of your electrostatic generator often requires certain accessory instruments, and the author provides plans for these as well. He shows how to construct a Leyden jar condenser, an electrophorus, and an electroscope—the latter using an old cookie tin.

Once you've built your electrostatic generator, it's time to do some serious scientific research. Mr. Ford describes experiments in electrohorticulture (whereby electric fields influence the growth and quality of vegetation), electrotherapeutics (medical applications of electricity, though some of this was pure quackery), cold light (the evolution of light without concomitant heat), the ever-popular hair-raising experiment (beautifully photographed on page 160), countergravitation (in which small bodies are levitated by electrostatic force), exploding wire phenomena (be careful here), and electrostatic motors. Interestingly enough, though electrostatic motors have never been powerful enough to have any practical application in power tools or fans, researchers today are fabricating them on a microscopic scale using many of the same techniques used to manufacture integrated circuits.

Homemade Lightning is certainly one of the most unusual and interesting books we've had the pleasure to review here. Whether you're looking for a science-fair project or just want to learn more about electrostatics, this is a book you're sure to enjoy.

Homemade Lightning, 2nd Ed., by R. A. Ford, 223 pages, softcover: $19.95 (plus $4.00 shipping). **McGraw-Hill Inc., P.O. Box 545, Blacklick, OH, 43004. Telephone (800) 262-4729.**

MECHANICAL DEVICES FOR THE ELECTRONICS EXPERIMENTER
by Britt Rorabaugh

An electronics enthusiast venturing forth into robotics for the first time may soon find himself in difficulty. Why? Because robotics demands a knowledge of not just

electronics, but mechanics and computer programming as well. That's not to say that the newcomer needs to be an expert in these fields, but he does need to know the basics. With that in mind, you might want to check out an excellent new book called **Mechanical Devices for the Electronics Experimenter,** which is designed to acquaint the reader with the mechanical principles and devices on which robotics depends.

The book begins with a discussion of mechanical quantities, the laws of motion, and some simple machines (like the pulley, lever, and inclined plane). Later on comes a more detailed analysis of the main elements of any mechanical design: gears, gear trains, pulleys, belts, shafts, bearings, ratchets, springs, and linkages. You can buy these components from engineering supply firms, or you can fabricate them yourself if funds are in short supply. The author provides tips on where to obtain the parts you need at minimum cost.

One of the obvious characteristics of the typical robot is that it moves. The force that produces motion often has an electromagnetic origin, i.e., it comes from an electric motor or solenoid. The author explains the operating characteristics of electric motors, paying particular attention to permanent-magnet DC motors, since these are likely to be the ones you'll use most often. He also discusses the stepper motor and the circuits that drive it. When fed a brief pulse of current, a stepper motor rotates a fixed amount—typically a few degrees—and then stops. Thus it is possible to control how far the shaft of a stepper rotates by controlling the number of pulses of current fed to the motor. This makes the stepper an excellent positioning device. Another useful positioning device is the solenoid. You can buy one of the many solenoids available on the surplus market, or you can wind your own following the author's directions.

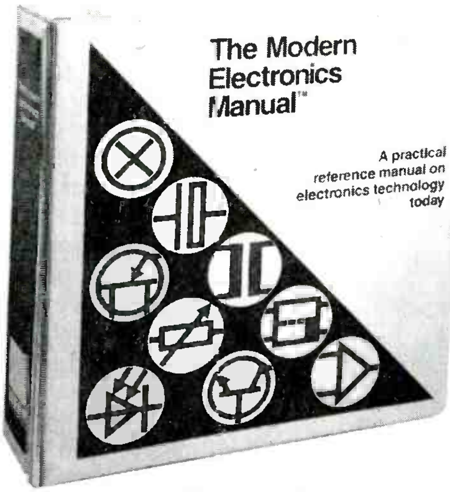
Electricity isn't the only way to produce motion; you can also use gas pressure (pneumatics) or fluid pressure (hydraulics). The author describes in detail the compressors, pistons, pressure reservoirs, and pressure gauges needed. He even shows how to make a pneumatic cylinder out of a door-closing damper from an old screen door. Before going to all that trouble, however, be sure to check the surplus market, where pneumatic cylinders can often be cheaply obtained.

The book closes with a pair of extremely valuable chapters on the specifics of robotic motion. If your robot has wheels, you face many of the same design challenges that confront an automobile designer. The author discusses the dynamics of 3-, 4-, and 6-wheeled vehicles and mechanisms of steering. Also covered are robotic arms, legs, and hands; the construction of wrist joints; and the dynamics of walking on 1, 2, 3, 4, or 6 legs.

All things considered, this has to be one of the best books for the newcomer to robotics. It stresses practical knowledge over theory, and should prove to be just what the electronics enthusiast needs to get started in the fascinating hobby of robotics.

Mechanical Devices for the Electronics Experimenter, by Britt Rorabaugh, 237 pages, softcover: $18.95 (plus $4.00 shipping). **McGraw-Hill Inc., P.O. Box 545, Blacklick, OH, 43004. Telephone (800) 262-4729.**

Build It Yourself!

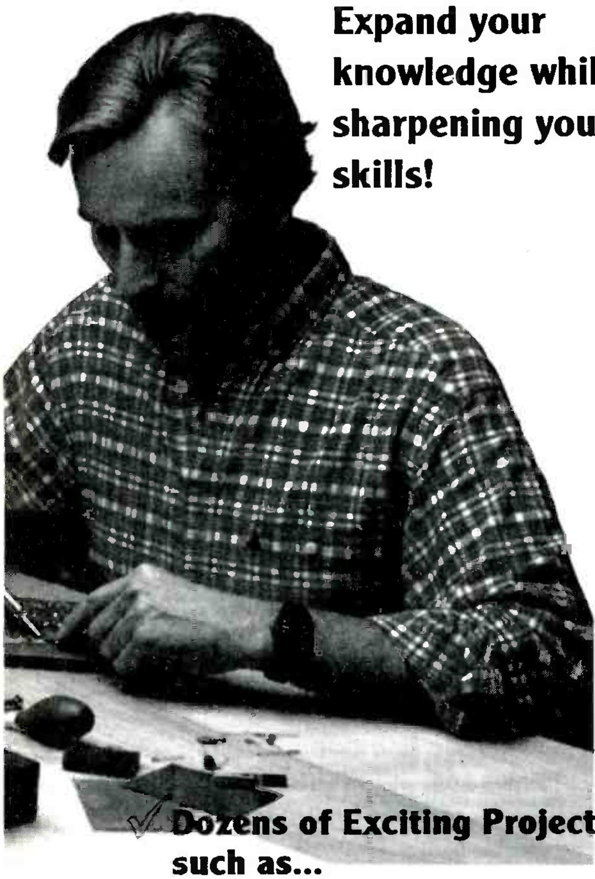


- A lifetime of exciting electronics projects
- Complete project plans
- Step-by-step instructions, flow charts, schematics, and photos
- Troubleshoot and repair
- Make your own printed circuit board (acetate board layouts provided)
- Component suppliers' addresses
- Handy 3-ring workbench binder

Electronics Fundamentals...
- Electronic Components and their Characteristics
- The Op-Amp Explained
- General Diagnostic Techniques

...plus much more!

Expand your knowledge while sharpening your skills!



✓ Dozens of Exciting Projects such as...

- ☐ Simple Logic Probe
- ☐ Multi-Purpose Gas Detector
- ☐ Digital Combination Lock
- ☐ Radiation Detector
- ☐ Portable Frequency Counter

...and many other projects!

30 Day Free Trial Order Form

☐ Yes! Please rush me my copy of:

☐ Electronics Repair Manual for only $59.95 33017

☐ Modern Electronics Manual for only $59.95 33018

☐ Both Manuals for just $99.95. 33019

I may take $10 off the total price when I enclose my check or credit card authorization by 12/31/96.Plus, I get free shipping and handling! I understand that if I am not satisfied, I may return the book(s) within 30 days for a full 100% refund of the purchase price.

☐ My payment is enclosed. I've deducted $10 if I am ordering by 12/31/96.

☐ VISA ☐ MasterCard No. ____ Exp. ____

☐ Check Enclosed.

☐ Optional express delivery (available in U.S. only).
Enclose an additional $10 and we'll guarantee delivery within 5 business days from receipt of your order (prepaid orders only; no P.O. Boxes).

☐ Bill me later including $6.50 shipping and handling per book, subject to credit approval. *Signature and phone number required to process your order. P.O. Box addresses must be prepaid.*

Signature (required) ____

Daytime phone ( ) ____

Mr./Mrs./Ms. ____

Company ____

Street Address ____

City ____ State ____ Zip ____

Shipping and handling to Canada, $10 (U.S. Currency); Overseas, $15 (foreign orders must be prepaid); CT residents add 6% sales tax. Supplements will be sent 4-5 times a year on a fully guaranteed, 30-day trial basis. They may be cancelled at any time.

MAIL TO: WEKA Publishing, Inc.
1077 Bridgeport Avenue, P.O. Box 886, Shelton, CT 06484

Call 1-800-222-WEKA or fax to 1-800-256-5915 for fast service!

Fix It Yourself!

- Hands-on, detailed, troubleshooting instructions
- "How to" primer for test equipment: oscilloscopes, frequency counters, video analyzers, etc.
- Schematic diagrams
- Trouble analysis flowcharts
- Preventive maintenance techniques
- Safety precaution checklists
- Comprehensive replacement parts list
- Directory of manufacturers

Leading Manufacturers Represented...

• Emerson	• Nintendo	• RCA	• Technics
• Hitachi	• Panasonic	• Sanyo	• Toshiba
• IBM	• Pioneer	• Sharp	• Zenith
• NEC	• Quasar	• Sony	and others!

It's easy, fast, and rewarding to repair it yourself with the Electronics Repair Manual!

30-Day Free Trial!

Dozens of Fix-It-Yourself Projects for...

- ☐ CD Players
- ☐ VCRs
- ☐ Televisions
- ☐ Camcorders
- ☐ Computer Equipment
- ☐ Fax Machines
- ☐ Telephones
- ☐ Amplifiers
- ☐ Car Radios
- ☐ Home Appliances
- ☐ AM/FM Tuners
- ☐ Thermostats

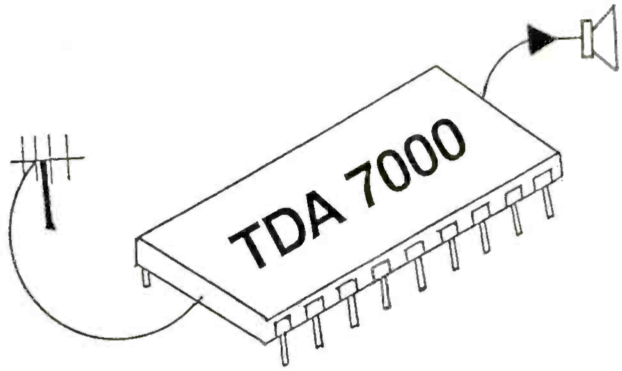
...and more!

Keep Your Skills Up-to-Date!

The Electronics Repair Manual and the Modern Manual Electronics Manual will be a valuable reference for years to come. Supplements, each containing over 125 pages, add new repair projects, valuable insights into new technologies, diagnostic and repair techniques, electronics projects, and more schematic diagrams into your manual. Just $35 each for Electronics Repair and $49.50 each for Modern Electronics plus shipping and handling. Supplements are sent 4-5 times a year and are fully guaranteed. Return any supplements you don't want within 30-days and owe nothing. Cancel anytime.

SINGLE CHIP FM RECEIVER

By Andrew Singmin Ph.D.



BREADBOARD A PROTOTYPE FM RECEIVER IN ONE EVENING WITH THE EASY-TO-USE AND STABLE TDA 7000 INTEGRATED CIRCUIT

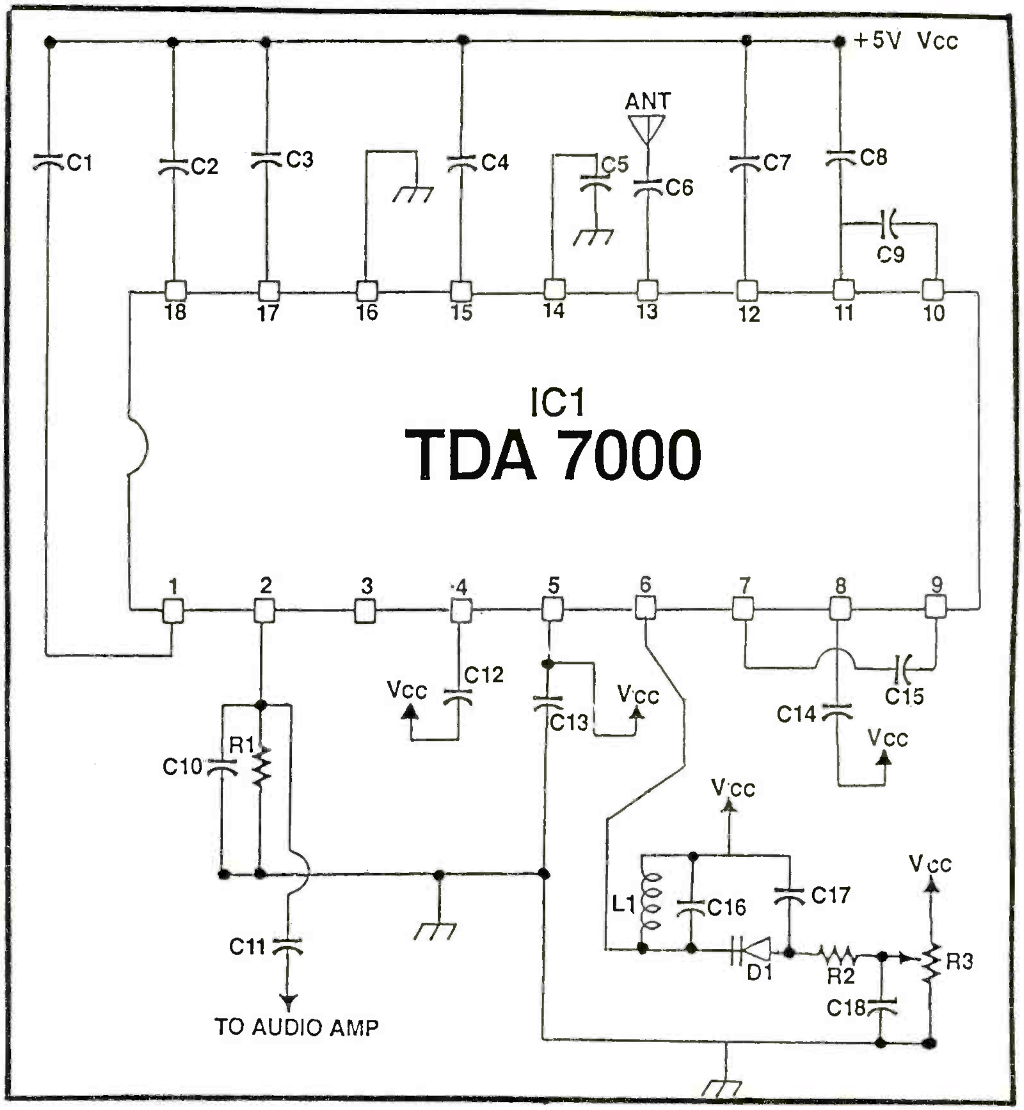


Figure 1: Circuit schematic for FM receiver.

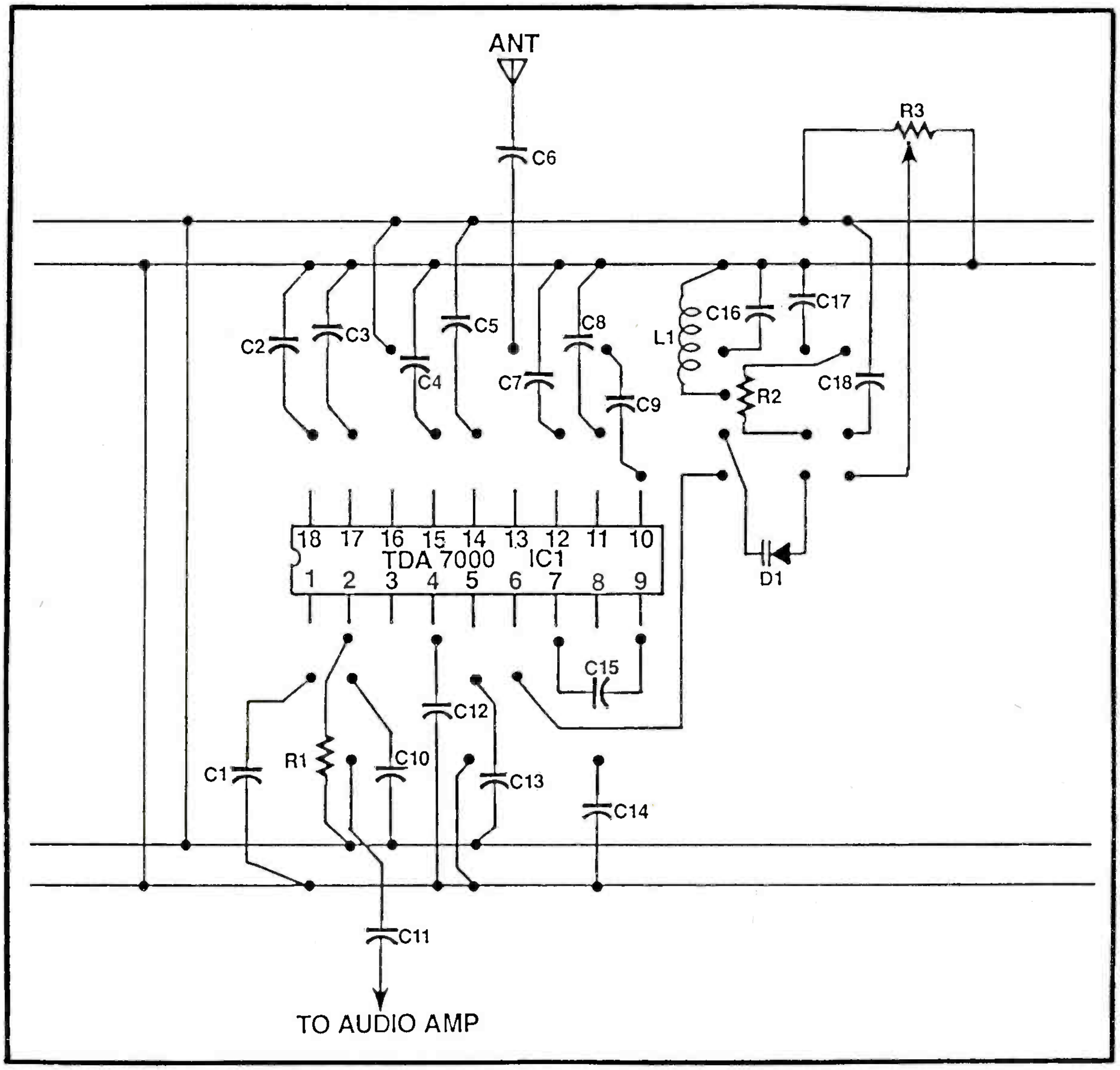


Figure 2: Component layout for solderless plug-in prototype board.

You've no doubt looked at hundreds of receiver circuits in the past, all fired up with enthusiasm, soldering iron at the ready—all to no avail, when impossible to find components, such as special coils that are nowhere to be found! Other than the ubiquitous crystal set, which is plagued with sensitivity & selectivity limitations, there is very little option, except to move onto a less irritating project. Even today special coils in receiver designs, prevent most hobbyists, from ever building these units. Complex alignment procedures requiring expensive equipment and in-depth knowledge are other obstacles. One remarkable integrated circuit, the TDA 7000, has changed all that and allows the beginner to build a stable, sensitive and selective FM receiver. There are no special coils required (only one non-critical easy-to-wind home-brew coil) and no set up procedures needed. Contrary to all the sage advice given on laying out an RF design, i.e. short wiring, ground planes etc., I deliberately wanted to evaluate this chip in the worst case situation—hence the relatively untidy plug-in prototype board design. The chip performed beautifully even in this mode and it was impossible to get it to go unstable.

This is, therefore, a remarkably satisfying circuit to build and experiment with, since there are so few components involved, no hard to find coils are needed and the circuit works as soon as the power is switched on. I am positive that this will provide many hours of enjoyment, both in the ease of construction and the quality of sound output.

General Description

The TDA 7000 is a complete FM receiver on a single 18 pin chip manufactured by Signetics. The total integration of an FM receiver on a single chip has been prevented to date by the need for LC tuned circuits in the RF, IF, local oscillator and demodulation stages. Signetics consequently has reduced the normal IF frequency of 10.7 MHz to a much lower frequency of 70kHz, so that active RC filters can now be used as tuning devices. The resultant Op Amps and resistors can of course be integrated very easily into a IC format. Capacitors are mounted off board—notice the relatively large number required. Supply voltage recommended is +5 volts, drawing about 8 mA of supply current. Frequency tuning is done with a variable capacitor or as you will see later, with a varactor diode, which gives a much easier to use set up. The varactor or varicap tuning diode arrangement allows for tuning to be easily carried out with a standard potentiometer.

A variable capacitor, in reality, is more cumbersome to use, larger in size and very difficult to obtain. A short 12" wire acts as an efficient antenna for experimental purposes and the audio output is more than adequate when fed into a standard LM 386 low power AF amplifier.

Circuit Description

A complete schematic for a solderless prototype is shown in Figure 1. The input FM Mono signal (88 MHz to 108 MHz) is captured by the short 12" wire antenna capacitively fed via C6 to pin #13. Frequency tuning components are L1 (defined later), C16, D1, C17, R2, C18, and R3, coupled to pin #6, Vcc and ground. D1 is the varicap tuning diode, with potentiometer R3 supplying the DC voltage. The capacitance of D1 varies with applied DC voltage and the resultant tuned circuit of L1 and D1 selects the required FM frequency. The audio signal is capacitively coupled from pin #2, via C11. Any AF power amp such as the popular LM 386 can be used to drive a small 8 ohm speaker. The rest of the components are needed to support the internal operation of the TDA 7000. These have limited user value and once in place can be considered as 'glue' components and forgotten.

Construction Details

Begin by winding coil L1. This is done by taking a length of insulated, solid hook up wire and winding about 7 turns on a regular pencil (used as a former). Remove the coil and space the turns slightly. Experiments have shown that the coil dimensions are very non-critical. Turns have been tried ranging from 3 to 9, formers smaller and larger than a pencil, and both tight and very loose coil turns. All without exception have worked successfully. With the extreme ease of the prototype plug-in layout, coil changes are extremely simple.

A small size solderless plug-in prototype board was used as there are so few components. Insert the TDA 7000 chip first and carefully add the peripheral capacitors to the board. Be very careful that the capacitors are the correct value (the physical dimensions and characteristics can be similar) and the correct board holes are used. The capacitors are very close to each other and it's easy to make a mistake. Figure 2 shows the board layout for inserting components. Potentiometer (R3) is mounted off board e.g. in a small plastic box, as it will be subjected to much mechanical usage. Insert the rest of the components as shown. The solid lines represent links between various points. Note: C16, typically 10pF to 20pF, is chosen to additionally vary the tuning range of L1 and D1. For a wider tuning range R3 can be taken to a 'Vcc' voltage of greater than 5 volts e.g. 9 volts.

Final Checks Before Applying Power

1. The VHF varicap tuning diode pin connection is shown in Figure 3. Holding the diode with the pins facing down and the 'flat' surface facing you, the left hand pin is the anode (see 3a). The variation of capacitance with reverse bias is shown in 3b.

2. Vcc and ground link connections are correct.

3. Supply voltage does not exceed +5 volts.

4. Capacitors are of correct value and are plugged in the correct locations.

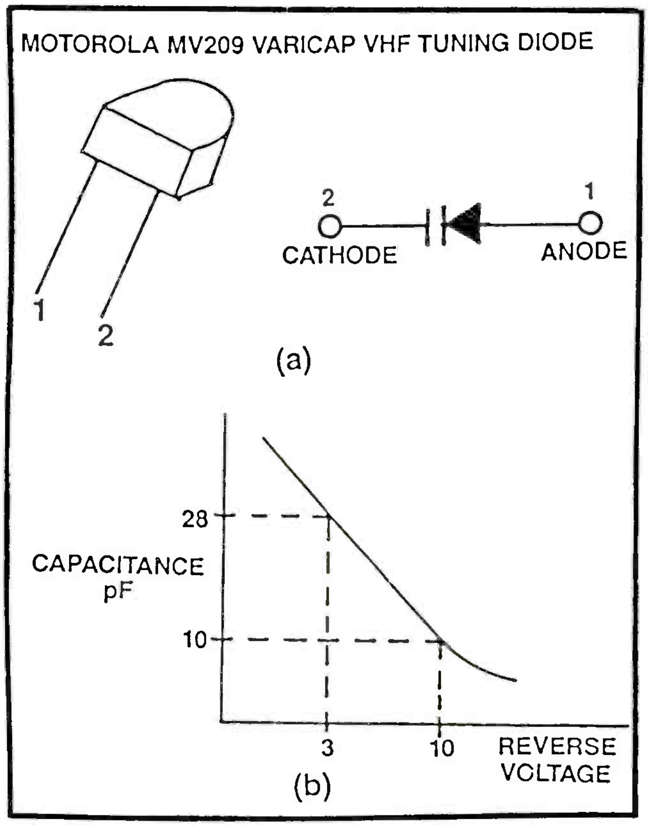
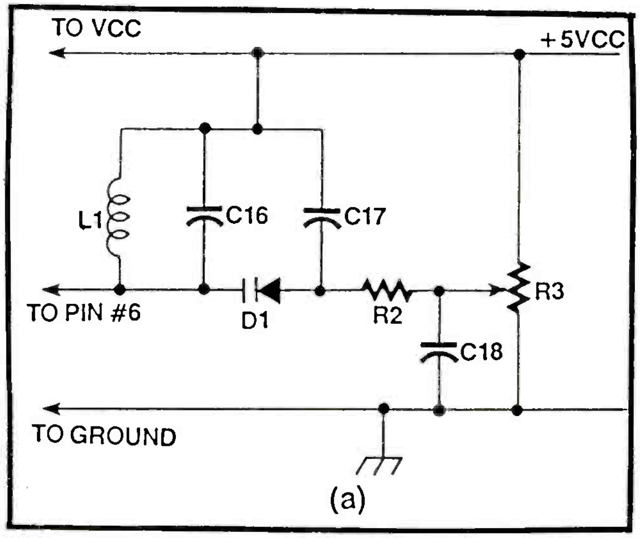


Figure 3: (a) Varicap pinout connections
(b) Capacitance tuning range

Set up Details

Couple the output via C11 into a suitable audio amplifier. Apply power to the TDA 7000 circuit and adjust R3 to search across the FM broadcast band. Given that no mistakes have been made, you should be getting a pretty good signal. Figure 4 shows the option of using a standard tuning capacitor instead of the varicap diode, if you have difficulty in finding the tuning diode.



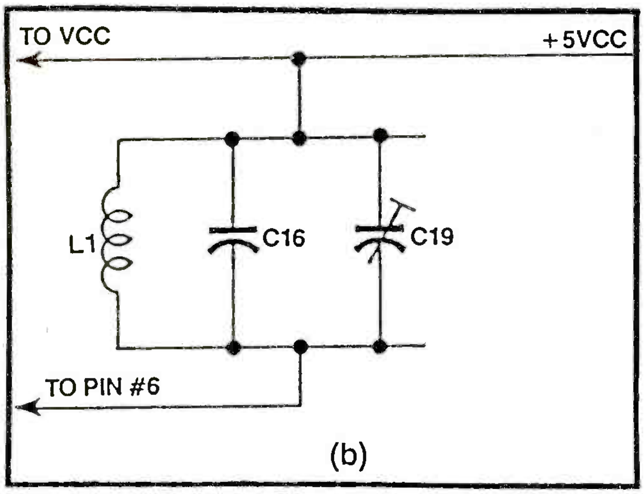


Figure 4: Frequency tuning options.
(a) Varicap tuning diode version
(b) Trimmer capacitor version

Conclusions

The TDA 7000 is a super simple chip to use and gave surprisingly stable and good results with the design shown, given the usual recommendations for very high frequency board requirements. It was impossible to get the circuit to be unstable, regardless of the length of untidy wiring used. ■

PARTS LIST FOR THE SINGLE CHIP FM RECEIVER

Semiconductors
IC1—TDA 7000 Signetics single chip FM receiver, 18 pin DIL package.
D1—MV209 Motorola varicap tuning diode

Capacitors
C1—0.1uF, ceramic disc
C2—220pF, ceramic disc
C3—220pF, ceramic disc
C4—0.1uF, ceramic disc
C5—0.001uF, ceramic disc
C6—200pF, ceramic disc
C7—100pF, ceramic disc
C8—0.001uF, ceramic disc
C9—100pF, ceramic disc
C10—0.01uF, ceramic disc
C11—0.1uF, ceramic disc
C12—0.01uF, ceramic disc
C13—0.01uF, ceramic disc
C14—220pF, ceramic disc
C15—0.001uF, ceramic disc
C16—Value not critical. Select to suit L1 & D1 tuning combination. Typical range, 10pF to 20pF, ceramic disc.
C17—0.01uF, ceramic disc
C18—0.1uF, ceramic disc

Resistors
R1—22K ohm, ¼W, 5% tolerance
R2—100K ohm, ¼W, 5% tolerance
R3—100K ohm linear potentiometer

Additional Parts
Solderless Plug-in Prototype Board
Solid hook up wire
5 volt power supply
plastic case for R3

Note: For the trimmer capacitor option shown in Figure 4b, C19 is non-critical and can be between 5pF to 50pF. C16 is chosen, if needed, to additionally vary the tuning range of L1 & C19. Dimensions for L1 are as described earlier in the circuit.

Note: The TDA 7000 is a Signetics part. Check local adverts for availability. The MV209 is a Motorola part, but not critical as other VHF tuning diodes will also work. Check for similar reverse biased capacitance to that shown in Figure 3b.

Lab Test
ELECTRONICS
HANDBOOK
For Yourself

ELECTRONICS HANDBOOK

P.O. Box #5148, N. Branch, N.J. 08876

☐ Yes. Enter my subscription—4 issues ONLY $15.00
(Canada $18.00...Foreign Postage add $10.00 U.S. Funds)
☐ Payment enclosed. (Payable to: C&E Hobby Handbooks)

PLEASE PRINT
NAME: ____________________
ADDRESS: ____________________
CITY: ____________________
STATE: ____________________ ZIP ________
V19

HOW A LOUDSPEAKER WORKS

By William R. Hoffman

Those of us that are regular readers of Electronics Handbook, and who build some of the many projects published in each issue, or have a stereo system at home or in our car, are constantly using something called a speaker. But how many of us really know anything about them? Woofers, tweeters, horns, crossovers, amps, ohms, and watts? Yet this doesn't have to be so. With a little help even the least knowledgeable beginner can learn a lot about them very quickly, because, for the most part they really are very simple. And that's what this work is all about.

Before we begin, let's define just what it is we are talking about. A loudspeaker makes sounds when a particular part of it—the "driver" as it is called—is supplied electrical power down a pair of wires from an amplifier. And its this driver that we are going to be talking about here. As we go on, we will see why they come in different shapes and sizes, and why some produce only bass and others just the midranges or highs.

PHOTO #1 Two bass drivers...The larger one is 12" in diameter and the smaller is 8". These are acoustic suspension types, suitable for small, sealed cabinets. Both are capable of reproducing substantial bass output.

Driver History

To understand just what a driver is and how it works we must first begin with a little history. Long before the invention of the phonograph by Thomas Alva Edison, over a century ago, natural musical instruments were with us. All of these instruments worked by creating patterns of sound waves in the air around them, either by a diaphragm of some kind being made to oscillate back and forth, or by the action of air being blown through a pipe and setting it into a resonant oscillating condition. So, naturally, when the phonograph was invented, a part of it was a diaphragm that could be made to vibrate like a musical instrument, and imitate the sounds of any instrument—even the human voice. And this, then, brings us to our modern day speaker driver: a diaphragm usually in a circular cone or dome shape, and a source of mechanical force that causes it to move.

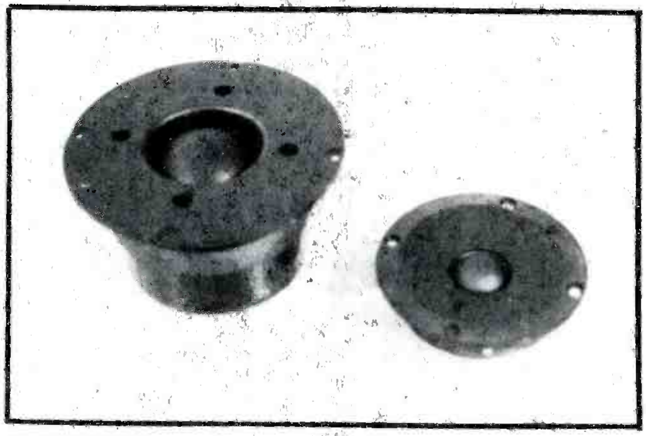


PHOTO #2 Both of these are dome type drivers and have enclosures built integral to their housings. Because of their dome shapes, they reproduce the middle and high frequencies with great accuracy.

What's A Driver?

Photos 1, 2, and 3, show some typical "raw" drivers (not installed in a cabinet.) These are the conventional types most commonly found in speaker systems. They are all called "moving coil drivers" because the force that moves their cones or domes comes from a coil of wire suspended in a magnetic field. But before we get into that part, let's first take a look at a typical driver assembly. Fig. 1 shows us a side view of one cut-away so that we can see all its parts clearly. (If there happens to be an old speaker system around, go and get a screw driver and remove a driver from it, or if a driver by itself is handy, go and get it, working or not, and together we can identify the various parts.)

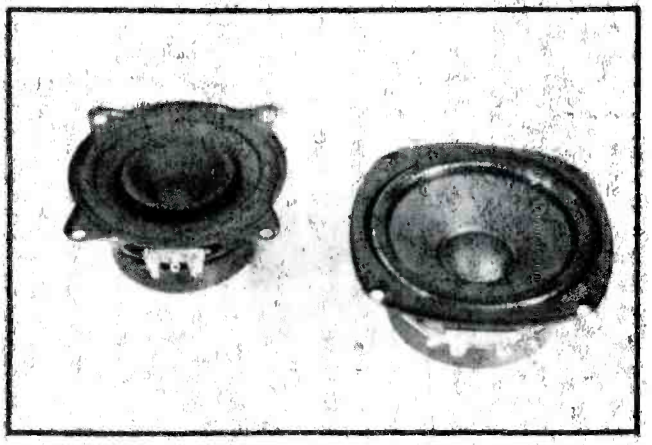


PHOTO #3 These are small, full range drivers, capable of handling almost the full range of audible frequencies with a single cone. The smaller one has a "whizzer" cone in its center to aid in the reproduction of high frequencies.

The Moving System

Let's first look at the front of the driver. Here we see the moving parts of the system: the cone, which is usually made from felted paper, although some newer cones are also made of plastic as well. Around its outer periphery is the flexible suspension, or "surround" as it is sometimes called. This keeps the front rim of the cone accurately suspended from the rigid metal rim of the frame and yet allows the cone easy axial movement (in and out). This "surround" can be made of cloth, or

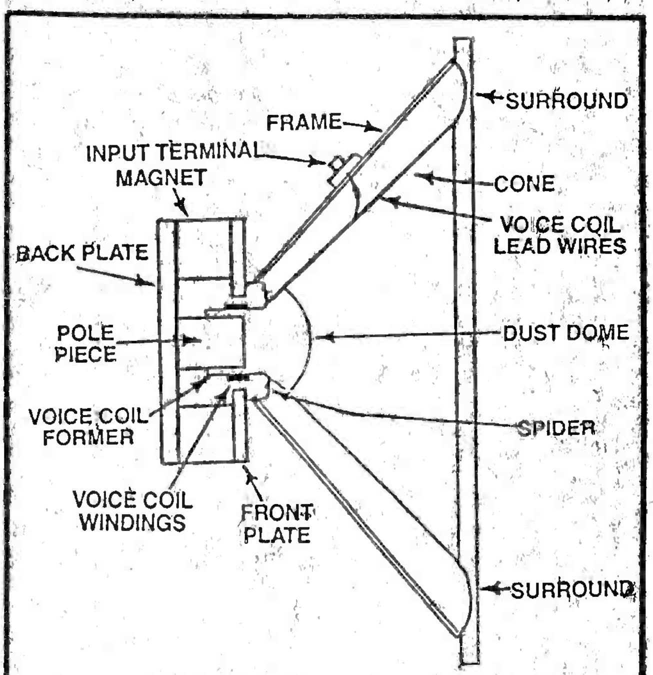


Figure 1 Cutaway view of a typical moving-coil loudspeaker.

foam, of of some plastic materials, or even of the same material as the cone itself. Now also notice down at the apex of the cone the (usually) dome shaped dust dome which keeps dirt or dust and any small objects out of the moving voice coil mechanism. Sometimes the dome is made of solid material, like the cone, other times it can be of cloth or felt.

Next: The Motor

The heart of a loudspeaker driver can only partially be seen from the outside. We are talking here about the "motor." If we have a driver in our hand, we can see only the magnet assembly. But now, if we go to Fig. 2, we can see a simplified illustration of what's inside as well.

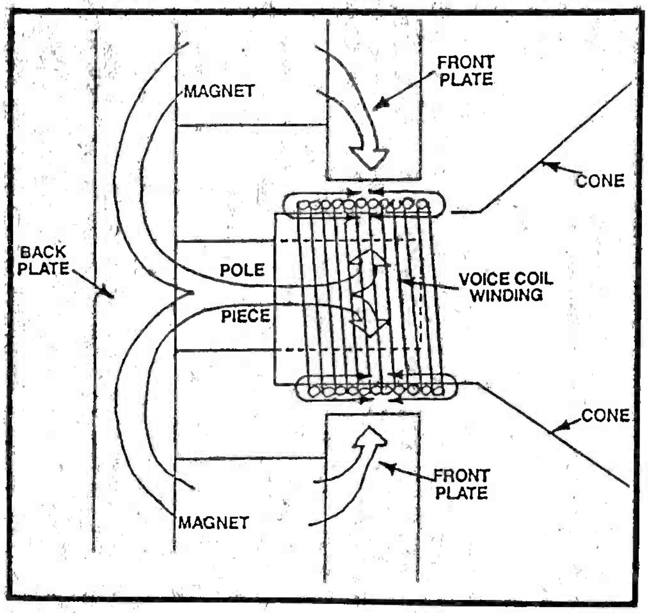


Figure 2 Cutaway showing driver motor.

Here is the heart of the driver; the magnet with the front and back plates on either side of it, and the pole piece coming up from the back plate and being surrounded by the voice coil. The magnet is supplying a constant field of force, directed by the plates and pole piece, to a circular gap inside the assembly. We see this illustrated in Figure 2. The result is now a strong fixed magnetic field within the circular gap where the cylindrical voice coil is. This then is the motor.

But why do we call it a motor? Let's look again at Fig. 2. We call it a motor because what we have here is very much like the conventional electric motor we are all familiar with: a coil on a moving form along with a magnet for a field. Except this motor has one difference; it makes a linear back-and-forth motion instead of the very familiar circular motion we normally think of. Another way to put it is that the voice coil is like a solenoid, it is pulled in or pushed out of the circular front plate gap. Let's look a little closer now.

The Details

In Fig. 2, notice the thick white arrows in the illustration. (One each above and below the voice coil and pole piece, and two joined ones coming from the back plate.) Notice that they converge across the voice coil gap in the front plate. This illustrates the fixed magnetic field path whose source is the permanent magnet.

Now, notice around the voice coil windings there are dark arrows, and they are pointing in both directions. They are indicating that the field produced by current flowing through the voice coil (an electro-magnetic field) can change direction, (or polarity if you will) and go either way. This happens when the direction of current flowing through the coil changes, and is what the musical signal coming down the wires from the amplifier are constantly doing. So now we have the working voice coil: it is following the simple laws of science that says that opposite poles attract, and like poles repel. In other words, when the current from the amplifier goes one way in the voice coil, and the resulting fields in the gap (the permanent field from the magnet, and the changing field of the voice coil) are of opposite polarity, the voice coil is attracted, or pulled into, the gap. But when the amplifier's current goes the opposite way through the voice coil and the two fields have the same polarity, they repel each other, and the voice coil is forced out of the gap. As the voice coil moves, so does the cone which is attached at its apex. This is how the loudspeaker voice coil is made to move back and forth, and how the cone, moving along with it, generates the sound waves we hear.

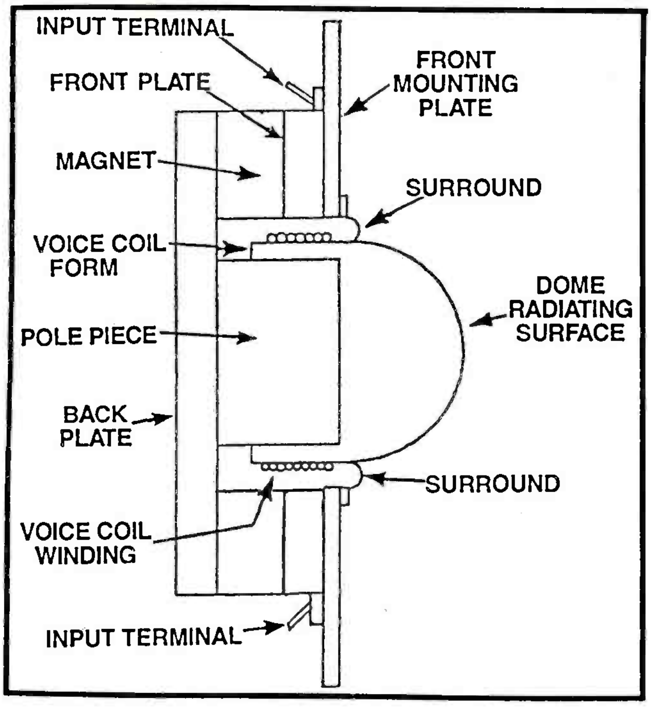


Figure 3 Typical dome type driver.

Driver Differences

What we have just learned is the basic principle by which all drivers work. But not all drivers used in speaker systems are built in quite the same way. Let's now look at some of these variations.

Up to now we have been talking about drivers in the "traditional" form. That is, like those shown in Photo 1. But today, in an attempt to get better sound, engineers have learned to create specialized forms like those shown in Photo 2. Here we have some dome drivers, the larger one for reproducing the middle ranges of sound frequencies, while the smaller one is for the highest frequencies.

How do these work? Take a look at Fig. 3. Here is a cutaway drawing of a dome driver. If you look carefully, and compare this drawing with that in Fig. 1, you will see that the dome driver is just our standard driver less its frame, cone, and "surround:" the little dust dome has now become the sound radiating surface!

Well, then you may ask, why aren't all drivers made this way? Several reasons. To begin with, we must understand that the laws of physics have decreed that as our speaker attempts to reproduce progressively lower frequencies of sound, the amplitude of the motion of the cone must increase in order to maintain the same sound loudness level. Specifically, every time we halve the frequency, we must make the cone move 4 times as far. (Yes, that's right, the cone must move 4 times farther!) So we immediately have a problem here. Our little dome might work okay at middle and high frequencies, but because of this increased cone motion requirement at lower frequencies, it will quickly run into its excursion limits, and its bass output will be severely limited.

More Bass

An alternative is to make a driver with a large cone. Why? Because a very large cone always has to move less than a smaller one to begin with. That is, because the large cone has more surface area exposed to the air it, therefore, produces more sound output with less motion. A typical bass driver (woofer) is what we see in Photo 1. The larger driver shown is 12" across with a large cone area, much larger than the tiny (typically 1" across) dome. It is designed to reproduce bass, and can do so with great power before the quadrupling requirement makes it run into its cone motion limits. Thus, we see why a large driver is necessary for good bass reproduction.

Now The Highs

But what about high frequencies? The problem with a big driver and its large, heavy cone is that it has great difficulty reproducing high frequencies. Specifically, the heavy weight, more properly, "mass," of the cone would require great amounts of force to make it move fast enough to reproduce the high frequencies. In order to overcome this problem, we make small drivers with very light cones (or domes) which are easily moved, like those in Photo 2.

Also, some compromises are possible. In Photo 3, we see two medium sized drivers (about 5" across) that can do a pretty good job of reproducing both the bass, and the highs. Both have a cone that is just large enough and yet light enough, that a single driver can do a good job of reproducing a full range of frequencies. The left one even has a small extra cone attached at the voice coil which is extremely light and can extend the high frequency response of the driver. This extra cone is sometimes called a "whizzer."

There you have it. How a speaker system works and why drivers have different shapes and sizes. Now when you look at a speaker system in a store or your own home, you can understand its construction and the reason for its particular design. ■

THE UBIQUITOUS DIODE

By Darren Yates

PART II

Last time we explained the more basic uses for the diode. Now we'll show some of the more unusual and imaginative applications that can save you time as well as big money on many special purpose ICs.

Just about everybody knows from the days of the old crystal radio sets that diodes are very useful for demodulating AM radio but not everybody knows you can also use them to modulate a signal as well.

In the circuits we described in the last issue, the diode was used for its blocking capabilities, allowing current to travel in one direction only. Now we will use the diode as a variable resistor.

You might be asking how we can do this? Remember the last time we said that current flow through a diode is dependent upon the voltage across it. Simply, a diode with 0.4 volts across it will conduct more current than one with only 0.2 volts across it.

If we vary the voltage across the diode, we can actually vary its dynamic resistance, and this is sometimes called "conductance".

This makes the diode even more useful than before. We can do many useful things particularly in the audio field. As we mentioned briefly at the end of last issue, we'll take a look at how we can vary the volume of an audio amplifier and how we can make our own automatic gain control circuit.

BASIC BUILDING BLOCK

We'll show you some of these examples in circuit form in a moment but first, we'll show you the basic circuit that will be in all of these projects.

DIAGRAM IN FIGURE 1 HOW THE CIRCUIT WORKS.

It's important to see that in this circuit, it is only possible to vary the AC resistance since any DC component will cause the diode to either be on or off.

Although this is a circuit block, don't try and build it up on its own because it won't do anything.

The two 0.1uF capacitors provide the DC blocking, preventing the signal we want to control, which flows through these capacitors, from upsetting the diode.

We now need some way of providing the diode with the DC voltage for it to partially turn on and vary its resistance. If you look at Fig. 1, you'll see that there are two 100k resistors, one connected to the anode and the other connected to the cathode of the diode (D1).

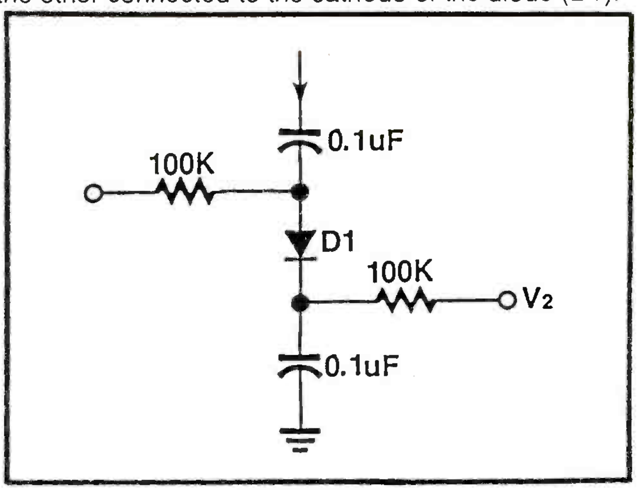


FIGURE 1

This allows us to set up a differential voltage system here. While voltage (V1) is higher than voltage (V2), the diode will either be partially on or fully on. If the V2 is higher than V1, the diode will be reverse biased and remain off.

For example, let's say we have a voltage of 5V at input V1 and a voltage of 4.7V at input V2. Because V1 is higher than V2, the diode will be partially on, allowing a small flow of AC current to flow through the two 0.1uF capacitors.

If we now take the voltage at V2 to 5.5V, it is now higher than V1 and so the diode is reverse biased. The diode stays off, and there is a very high resistance between the two 0.1uF capacitors.

Although this may not sound very exciting, it does allow us to do a few unusual and interesting things.

VOLTAGE CONTROLLED AMPLIFIER

Take a look at the circuit in Fig. 2. Here we use the circuit in fig. 1 as part of the feedback network for a non-inverting amplifier made from IC1.

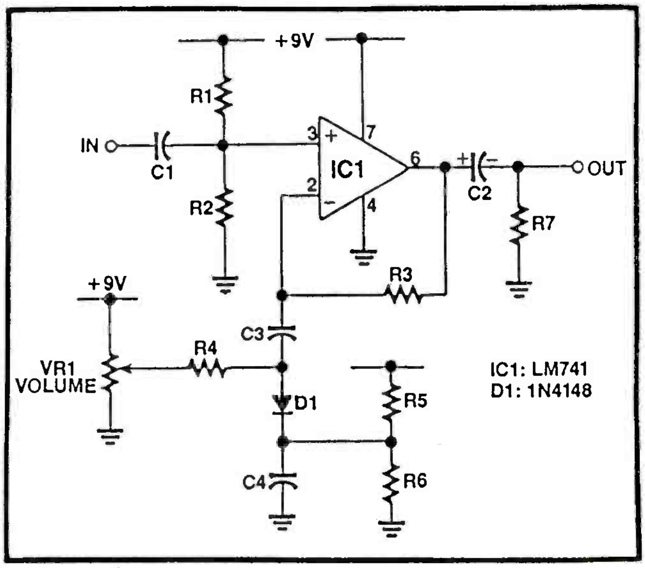


FIGURE 2

PARTS LIST FOR FIGURE 1 AND FIGURE 2 VARIABLE GAIN AMPLIFIER

C1, C3, C4—0.1uF Mylar capacitors
C2—2.2 uF, 25VW Electrolytic capacitor
D1—1N914 Signal diode
IC1—LM358 Dual OpAmp IC
R1, R2—100K, 0.25W, 5% Resistors
R3—560K, 0.25W, 5% Resistor
R4—180K, 0.25W, 5% Resistor
R5, R6—220K, 0.25W 5% Resistors
VR1—10K Log Potentiometer

The 10K Pot is used here as a volume control. By applying different amounts of DC to the diode, we vary its AC resistance and, therefore, the gain of the Amp.

Ths occurs because we change the ratio of the resistance in the feedback network. The closer the control of the potentiometer is to the positive supply rail the more gain the amplifier has, and hence the more volume. This is because the diode has more and more voltage across it, so that it will conduct.

Conversely, if the Pot is wound down so that the anode voltage is less than the cathode voltage, the diode is turned off, so there is no current flow down from the output of the OpAmp, and through the two 0.1uF capacitors.

By changing the value of the bottom 220K resistor, you can also change how much effect the volume control has. If you wish to use this circuit as part of a stereo amplifier, we must warn you first that this circuit has a fair amount of distortion, about 2 to 5%, because of the non-linear characteristics of the diode.

What we mean by this is that the current flow through the diode is not linearly proportional to the voltage across it.

As an example, if we increase the voltage across the diode from 0.2V to 0.4V, we obviously double the voltage, but the current will rise tenfold. This is what is known as nonlinearity. If the diode was a linear device, doubling the voltage would result in a doubling of the current flow through it.

This circuit is most suitable for CB radio or amateur radio shacks or other communication systems, but not Hi-Fi.

For Hi-Fi systems, there are special ICs available that do this job with very low distortion, but these ICs cost upwards of $5. As with most things, you get what you pay for or what the diode can do, I still think it is worth it.

SIGNAL COMPRESSION AND EXPANSION

While we're on the subject of CB radio, many radio operators use signal compressors to get maximum signal modulation when they transmit.

A signal compressor is a circuit which amplifies signals that are below a set amplitude and reduces those above that amplitude.

This method is used by most TV stations as well as all radio stations to keep the sound that you hear at a constant level. The benefits of this system are most noticeable when you're driving a car.

Say, for example, that you're listening to some classical music. Without compression, the quiet passages of music disappear below the sound of the car engine. You do the only thing possible which is turn the volume of your tape deck up, and then your ear drums are shattered when the louder passages come along.

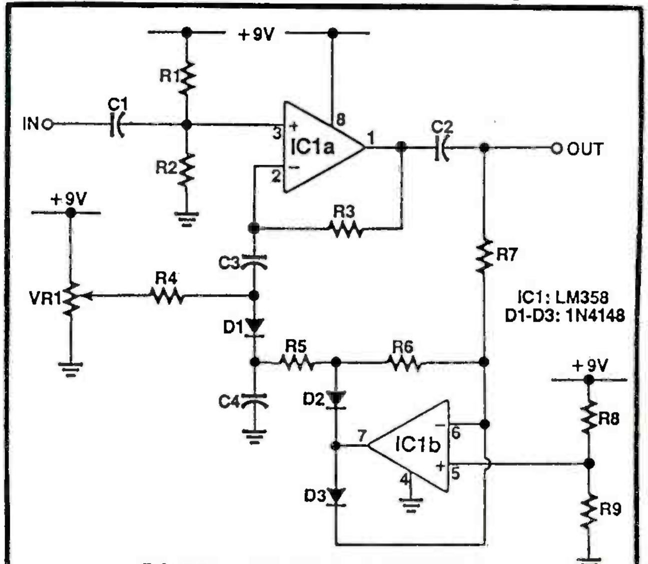


FIGURE 3 AUDIO SIGNAL COMPRESSOR

But when the sound is passed through a compressor like the circuit shown in Fig. 3, the softer passages are amplified to sound louder, and the louder passages are attenuated to sound softer. The main trick is to do this so that you can still tell which of the passages should be a bit quieter than the others.

PARTS LIST FOR FIGURE 3 AUDIO SIGNAL COMPRESSOR

C1, C2, C4—0.1 Mylar capacitors
C2—2.2uF, Electrolytic capacitor
D1. D2. D3—1N914 Signal diodes
IC1—LM358 Dual OpAmp IC
R1, R2, R6, R7, R8, R9—100K, 0.25W, 5% Resistors
R3—560K, 0.25W, 5% Resistor
R4, R5—220K, 0.25W, 5% Resistors

The circuit in fig. 3 shows the diode being used in two different ways. Diode D1 is used as a variable resistance element whereas D2 and D3 are used as rectifier diodes.

OpAmp IC1a is configured as a variable gain amplifier with our diode doing the varying of the gain, but the section of the circuit based around IC1b may be new to many readers so we'll take a brief look at it now.

PRECISION HALF-WAVE RECTIFIER

This part of the circuit is known as a precision half-wave rectifier. Now, remembering back to the last issue, we talked about the diode itself being a half-wave rectifier. So why do we need all this fancy circuitry?

The very thing that allows us to use the diode as a variable resistance device (VRD) is the main reason why we need the extra circuitry as it turns out.

In order for a diode to conduct, it requires 0.6V across it. But what happens if we have only 0.2V? Well, yes it will conduct but the amount of current flow will be negligible and in this circuit, it is the voltage which is most important.

The input of IC1b is connected via a 100K resistor to the output of IC1a, which is where our audio output comes from. Now what we want is to derive a DC voltage that is linearly proportional to the AC output signal.

IC1b is connected as a type of inverting amplifier that produces DC only from an AC input. The bonus of this circuit is that the very high open loop gain of the OpAmp, in this case which is about 15,000, overcomes the voltage drop across our diodes D2 and D3.

So in the end we get a DC voltage which goes to within a few millivolts of zero volts and follows the AC voltage at the output of IC1a.

If you follow the path of the circuit around, you'll eventually see that there is only one way the current can flow and this occurs for positive going signals i.e. those that are rising towards the supply rail. Negative going signals are blocked by the two diodes. And this produces a DC voltage.

Now this DC voltage appears at the output of IC1b. We now use this to control the cathode of our VRD. The larger this DC voltage, which corresponds to a high audio output, the more we turn the diode off.

From before, we know that this will cause the amplifier to reduce its gain, and hence, the output will be lower. But what happens with softer passages of music?

Well, with little output signal from IC1a, there is only a small DC voltage controlling the cathode of diode D1 so it is turned on more, providing a lower resistance flow through the two 0.1uF capacitor, increasing the gain, and the output voltage. The end result is a signal of compressed amplitude at the output.

SIGNAL EXPANDER

A signal expander is the exact opposite of a signal compressor. It attenuates the softer passages of music and amplifies the louder ones. So where would you use one?

As we mentioned before, most radio and TV stations use compression on their sound to keep the output level fairly constant. The problem is that by the time it comes out across your TV set, crickets that sound as loud as cannon fire just isn't very realistic.

That's where this circuit comes in. By putting one of these circuits between the output from your TV and your amplifier, you can put back what is known as the "dynamic range" into the sound.

Dynamic Range is simply the ratio in decibels between the voltage of the softest sound and the loudest sound. Most audio cassettes have a dynamic range of about 60dB whereas CDs have a dynamic range of about 100dB. The larger the dynamic range generally, the more realistic the sound you will hear.

OK, looking at the circuit in fig. 4, you'll notice that it's almost the same as that in fig. 3. The only difference comes in that the DC voltage from our precision half-wave rectifier controls the anode of diode D1 instead of the cathode as before.

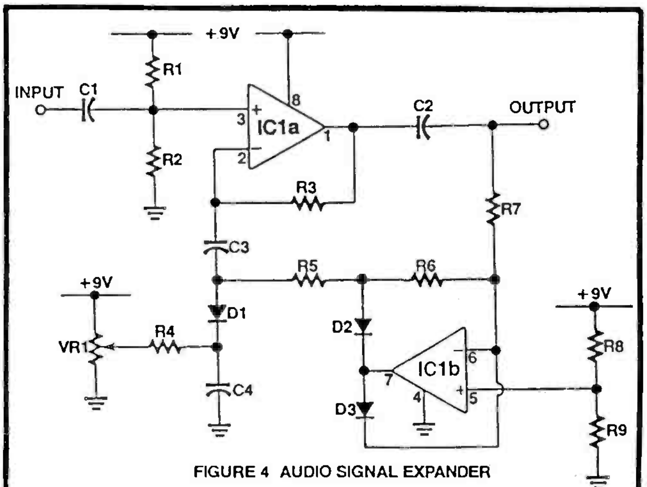


FIGURE 4 AUDIO SIGNAL EXPANDER

PARTS LIST FOR FIGURE 4 AUDIO SIGNAL EXPANDER

C1, C3, C4—0.1uF Mylar capacitors
C2—2.2 uF, Electrolytic capacitor
D1, D2, D3—1N914 Signal diodes
IC1—LM358 Dual OpAmp IC
R1, R2, R6, R7, R8, R9—100K, 0.25W, 5% Resistors
R3—560K, 0.25W, 5% Resistor
R4, R5—220K, 0.25W, 5% Resistors

This means that a large DC control voltage, which corresponds to a high output level, causes the diode to conduct, reducing its resistance, which increases the gain and increases the output level.

The opposite occurs for small signals. The low DC control voltage causes the diode to almost turn off, which increases the dynamic resistance, and also the gain of the amplifier. Again, the circuit is not Hi-Fi quality but there are many applications where this type of circuit would be useful.

For HI-FI applications, there are again ICs available which do the job with very low distortion but they too cost about $5 or more, the diode wins again......

HIGH VOLTAGE CONVERTER

One area which we haven't as yet covered that diodes excel in is that of voltage converters. Quite often there is a need to have a supply voltage which is not easily obtainable. For example, you need a 24VDC supply for a car radio that usually sits in your truck, but you want to use it in your car. The problem is that your car only has 12VDC.

This is where a DC-DC converter comes in. It uses a switching regulator to step up the voltage from 12 to 24VDC. A circuit for this is shown in fig. 5.

IC1a is configured as a squarewave oscillator whose non-inverting input bias is switched on and off by the output from IC1b.

The output of IC1a is used to drive the transistor which in turn charges up an inductor (L1).

When the transistor is turned off again, the electric field around the inductor begins to collapse and this induces a large voltage across it.

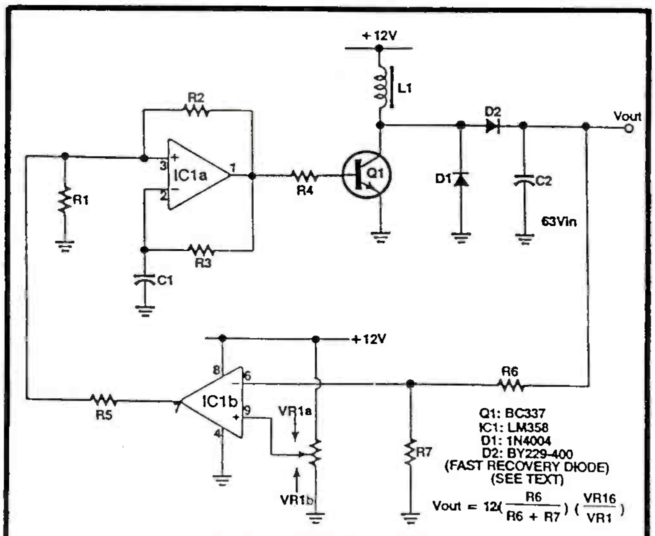


FIGURE 5 DC-DC VOLTAGE CONVERTER

PARTS LIST FOR FIGURE 5 DC-DC VOLTAGE CONVERTER

C1—0.01uF Mylar capacitor
C2—470uF, 63VW, Electrolytic capacitor
D1—1N4004 Power diode
D2—BY 229-400 Fast recovery diode
IC1—LM358 Dual OpAmp IC
L1—Ring toriod core 15(OD) x 8(ID) x6mm(H) 60 turns of 0.63mm diameter
R1, R2, R3—100K, 0.25W, 5% Resistors
R4—470 Ohm, 0.5W, 5% Resistors
R5, R6—100K, 0.25W, 5% Resistors
VR1—10K Lin Pot

Here we see two diodes used in different roles. Diode D1 is a normal 1N4004 type and is connected to protect transistor Q1. When the field of the inductor collapses, the voltage at the collector of the transistor can initially go as low as a couple of hundred volts below ground, which can instantly destroy the transistor.

By putting diode D1 in place, we can see that if the collector of the transistor is pulled below the ground line by the inductor, the diode becomes forward biased and holds the collector to only −0.6V.

Diode D2 has a different function. It is also a different type of diode. Known as a fast-recovery diode, it is used particularly in this type of circuit, where high power voltages need to be rectified at high frequency.

The frequency of the power coming from your wall outlet is only 60Hz (In Australia it is only 50Hz) and normal 1N4004 type diodes are designed to rectify power at this frequency but in many switching type converters, the frequency of the converted voltage can be as high as 40kHz or 800 times faster than that of your wall outlet.

A normal 1N4004 diode, would heat up very quickly and destroy itself. And this is where the fast-recovery diode comes in. Ordinary diodes require a certain amount of time to switch off when they have been turned on. The fast-recovery diode is a good example. It has a fast recovery rate so that when the voltage across the diode has been removed or reverse biases the diode, it switches off much more quickly than an ordinary diode.

Looking back to our circuit in fig. 5, diode D2 is used to dump the high voltage into the 470uF reservoir capacitor.

So what is IC1b used for? Well, all good circuits use some form of negative feedback to control them and make sure they don't go haywire.

From the output, we have a voltage divider made up of two 100K resistors and the junction of this divider is fed into the inverting input of IC1b. This sets up the feedback voltage to half of whatever the output is.

The 100K potentiometer is used as our voltage selector and it is used to set up the reference voltage.

If the voltage at the inverting input of IC1b, which is half the output voltage across the 470uF capacitor, is higher than the non-inverting-input, the output of IC1b goes low. This turns off the DC bias for IC1a which causes it to stop oscillating and producing our voltage. This in turn causes the voltage at the output to drop and the voltage at the inverting input of IC1b to fall. If it falls below the voltage at the non-inverting input, then the output of IC1b will go high again, and start the oscillator up again, producing more voltage and so on.

The whole procedure may sound long winded but it keeps the output voltage very stable instead of floating around all over the place.

If you can't obtain the BY229-400 diode, then any high-powered fast recovery diode will do but it must be a fast-recovery type! There you have it. A few circuits that should get your mind working and your soldering iron heated up. Maybe they will inspire some ideas of your own and you can send them to the ELECTRONICS HANDBOOK. Who knows, you might end up seeing your name in print. ■

GET HERE.

FREE One Year Subscription of Electronics Now When You Enroll in Any CIE or World College Program!

LEARN A SKILL YOU ENJOY... ...THEN FIND A JOB THAT HAS A FUTURE.

Everyone has to start somewhere.

As 150,000 CIE graduates have discovered, independent-study from The Cleveland Institute of Electronics can get you were you want to be. *In a secure, financially rewarding, exciting career field of your choice.*

Industrial Robotics

Since 1934, CIE has been on the forefront of an ever expanding technological revolution. CIE's curriculum is unique from other independent-study schools in the respect that we not only provide hands-on training utilizing today's technology we also instill the knowledge and understanding of why technology works the way it does. This is the foundation upon which every CIE graduate can trace their success back to and in which CIE's reputation as a quality learning facility is based on.

Project Engineer

Independent study is not for everyone. But, if you have the desire, the basic intellect and the motivation to succeed, CIE can make it happen. Our learning program is patented and each lesson is designed for independent study while our instructors are available to assist you whenever you feel you need help. In fact, CIE's curriculum is so well respected many Fortune 1000 companies utilize it for their own employees.

Telecommunications

CIE offers personalized training to match your background with over ten career courses, an Associate Degree Program and a Bachelor Degree Program through our affiliation with World College. And every CIE graduate got started in a successful career the same way you can...by sending for your free CIE course catalog and judging for yourself if CIE's for you.

Computer Programming

START HERE...

Electronics

Back then it was radio and TV, today it's computer technology, programming and the electronics that make it all possible. Today and yesterday's similarities are uncanny... *Employers are looking for qualified applicants to hire and having a hard time finding them.*

Students at CIE receive the training and the education needed to get hired and to succeed in challenging fields such as computer programming, robotics, broadcast engineering, and information systems management.

YES! Please send me more information on:

- ☐ CIE's Associate Degree Program
- ☐ CIE's Computer Programming Course
- ☐ CIE's 12 Career Courses
- ☐ World College's Bachelor Degree Program

AEE 11

Name ______________________

Address ______________________

City ______________________

State __________ Zip __________

Phone ______________________

Check for G.I. Bill Details
☐ Active Duty ☐ Veteran

CIE

It's More Than Just Training... ...It's an Education.

1776 East 17th Street
Cleveland, OH 44114
(216) 781-9400 • 1-800-243-6446

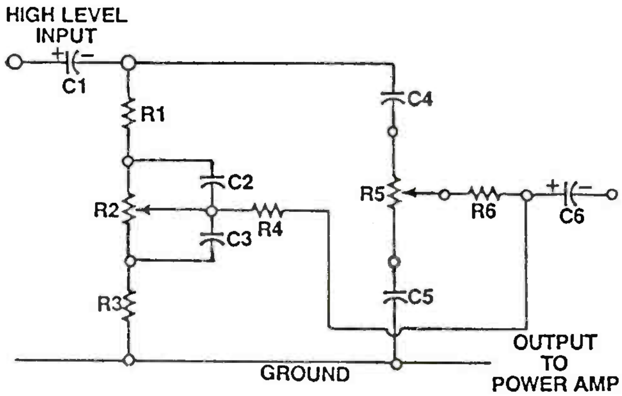
CIRCUIT FRAGMENTS

Reading about electronics can be fun and instructive, but the only way to become a knowledgeable technician is to get hands-on experience, by actually connecting resistors and capacitors together in circuits that do something. These circuits can be as simple as turning a light on or off, or making some kind of alarm sound. As long as we have a power source and a load connected together by wires, we have a functioning circuit.

REAL BASS/TREBLE CONTROLLER

Budget priced radios and cassette recorders often have a tone control alongside the volume control, that simply gives you a sound quality ranging from 'sharp highs' to 'muffled lows'. This is unsatisfactory for anything but the most mediocre of requirements. For a really 'satisfying tone controller', of the type found on hi-fi quality amplifiers, you need an independent bass and treble controller that will actually boost or attenuate the bass or treble frequencies separately—that's the difference. This circuit will do just that and should be fed with a healthy high level signal, say from the output jack of a radio, since there is an inherent insertion loss (the circuit is really a frequency sensitive potentiometer network). When the output is taken to a power amplifier, even the ½ watt LM386 will suffice, and terminated with a decent quality (about 8") speaker, the quality is awesome!

The circuit might look a little complex but can be broken down into easy to manage pieces. Being an AC audio signal circuit, we need a DC blocking capacitor C1, at the input. A resistor network, R1, R2 (the potentiometer), R3 follows next from there, forming a potential divider network. Together, with the rest of the associated components, shunt capacitors C2, C3, we have the 'bass control circuit'. The audio signal feed is taken via the buffer resistor R4. The treble half is similarly constructed, being made up of C4, C5 and R5 (the potentiometer). Note, R2 and R5 are audio taper types and it is preferable to get these rather than the ordinary linear types. The treble signal feed exits through resistor R6 and both 'halves' (i.e. the bass and treble signals) combine through C6, the last capacitor. When the controls are set to the mid way positions, the response is essentially flat, i.e. there is no gain or attenuation. Independent cut and boost for the bass and treble frequencies is achieved when R2 and R5 are rotated counter-clockwise or clockwise. An extra stage of preamplification can also be added if desired before feeding into the power amp, but this is not always necessary and depends on the level of your input signal. ■



PARTS LIST FOR THE REAL BASS/TREBLE CONTROLLER

R1—10K resistor
R2—100K audio potentiometer
R3—1K resistor
R4—10K resistor
R5—100K audio potentiometer
R6—10K resistor
C1—10uF capacitor
C2—0.01uF capacitor
C3—0.1uF capacitor
C4—0.001uF capacitor
C5—0.01uF capacitor
C6—10uF capacitor

TILT DETECTOR

Remember when pinball machines were popular? Many would be equipped with a tilt detector in them to prevent the player from bumping the machine with too much "body english" to improve his score. Usually the tilt detector would consist of a metal ball that would short-out two wires whenever the machine was bumped. Technology has come a long way, and devices such as the mechanical ball tilt detector have been replaced with a more advanced version, possibly similar to the circuit shown here. Instead of a metal ball, our circuit uses a glass enclosed bead of mercury available from Radio Shack. The applications for the Tilt Detector are numerous, the most obvious being a burglar alarm.

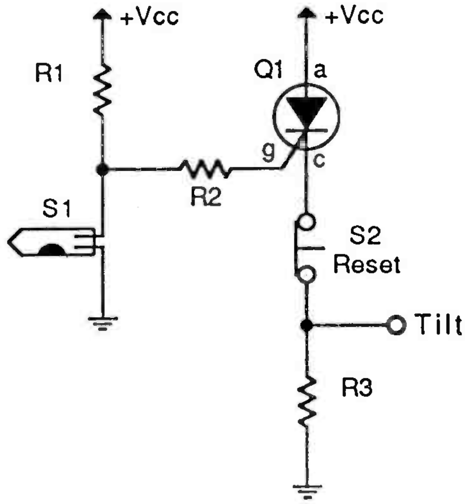
Circuit use is quite simple. The output at "Tilt" will remain low until the mercury switch causes the SCR to conduct, at which time "Tilt" is pulled to $+V_{cc}$. The output will then stay at $+V_{cc}$ until the "Reset" switch is open, even if the mercury switch is not conducting.

The theory behind the operation of Tilt Detector is elementary. Whenever a tilt occurs, the little bead of mercury in the detector will short its connections, causing the gate of the SCR to go low. This triggers the SCR to begin conducting. The SCR will continue to conduct even if its gate is at $+V_{cc}$. The only way to stop the SCR from conducting is to press the "Reset" button, which opens its conducting path. When this is done the "Tilt" output is pulled low via a pull-down resistor, R3.

If you are using the Tilt Detector as a burglar alarm, you will need to connect some type of warning system off of "Tilt", such as a buzzer or light. Once you've done this, place the circuit on whatever you want protected, press Reset, and feel confident that your valuable is safe from being stolen.

PARTS LIST FOR TILT DETECTOR

R1—100k ohm Resistor
R2, R3—10k ohm Resistor
Q1—1 Amp, 50 Volt SCR
S1—Normally Open Mercury Switch (Radio Shack 275-027)
S2—SPST Normally Closed Pushbutton Switch
(All resistors are 5%)

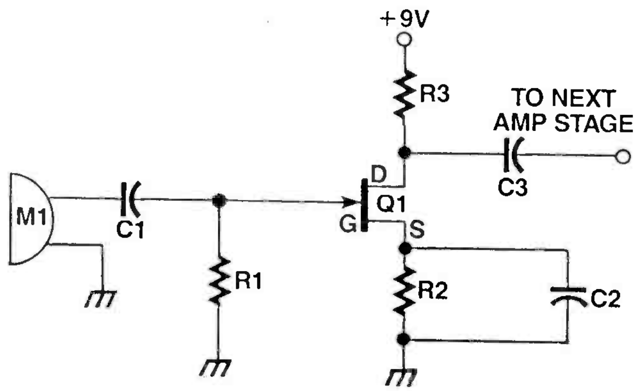


LOW NOISE PRE-AMP

The commonly available 741 OpAmp is widely used for audio applications. It is, however, somewhat noisy for more critical needs, such as microphone pre-amps. A better method is to use an FET as a pre-amp, for a quieter noise level. The general purpose MPF102 FET is configured as a standard A.C. voltage amplifier. The resistors and capacitors shown go to set up the correct bias and coupling conditions. A crystal microphone is A.C. coupled to the gate terminal and the low noise output taken from the drain terminal via a capacitor. Component values are not critical but are a good starting point to experiment with.

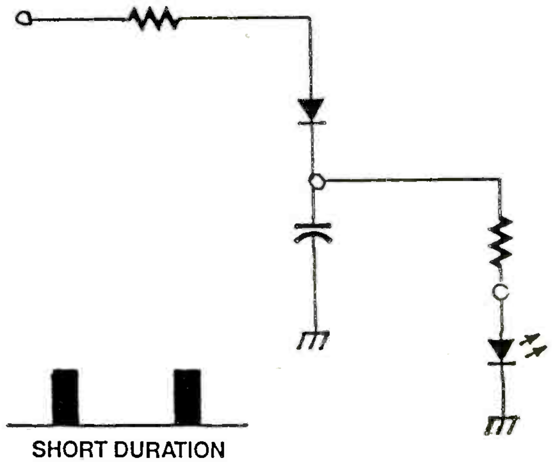
PARTS LIST FOR THE LOW NOISE PRE-AMP

Q1—MPF102 FET (field effect transistor)
C1—0.1Mfd capacitor
C2—100Mfd capacitor
C3—0.1Mfd capacitor
R1—1Mohm resistor
R2—2.2Kohm resistor
R3—10Kohm resistor
M1—crystal microphone



LED PULSE STRETCHER

A short duration pulse has insufficient width to light an LED indicator. For monitoring purposes, where it is desirable to increase the LED 'on' time, the circuit shown will do this. Capacitor (C1) is charged by the incoming short pulse. Because of its 'high' value it will remain charged for an extended period. The LED will now appear to stay on longer. D1 prevents the charge from leaking back into a low impedance load (e.g. emitter follower). R1 is part of the charging RC time constant. The circuit works best with a low repitition rate input pulse train, so that the differences in LED illuminations can be detected. R2 is the current limiter for LED, D2. ■



PARTS LIST FOR THE LED PULSE STRETCHER

R1—47 ohm resistor
D1—1N4001 diode
C1—47uFarad capacitor
R2—1K resistor
D2—LED

SPECIAL RF OSCILLATOR REGULATOR

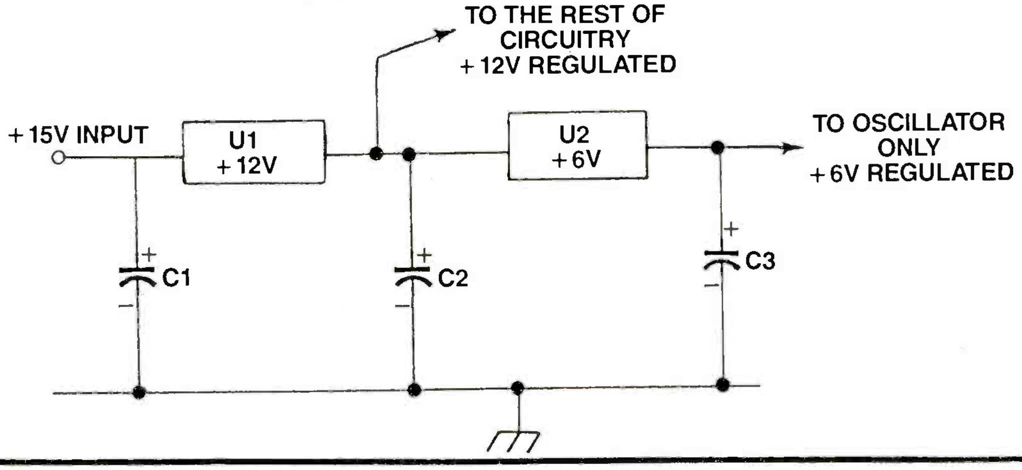
When constructing high frequency MHz range RF oscillators for use as signal sources or transmitters, it is easy to find the end result less than satisfactory when the project has been completed. What is likely to occur is that you have coupled a number of circuits together, say oscillator, power amplifier and filters, to the same power source i.e. battery or low voltage adapter. RF oscillators are notorious for not wanting to share—they need their own power supply! There's no need to go and get a totally separate battery or separate adapter. All you need is to have a separate voltage regulator feeding the RF oscillator.

The diagram shows how this is done, using a cascaded power supply arrangement, i.e. each successive stage of regulated voltage is less than the previous. We start off with an unregulated +15 volt supply, as an example. Typically you would get this from a so-called '12 volt' adapter. Measured without a load, a voltage in excess of the stated 12 volts is always in existence. The first regulator, U1 gives a nice clean +12 volt stable output and can be used to feed the rest of the circuitry other than the RF oscillator. A +9 volt regulator can also be used instead, but they sometimes appear to be less available than the 12 volt type.

The output from U1, now feeds a second regulator, U2, this time a lower voltage type, shown here as a +6v type. This supply feeds the oscillator exclusively. With this arrangement, any fluctuations in the rest of the circuitry are not fed back to the oscillator and hence the frequency is now protected against drifts arising from that particular source. Capacitors C1, 2, 3 are the usual components found in regulator circuits. ■

PARTS LIST FOR THE SPECIAL RF OSCILLATOR REGULATOR

U1— +12V regulator e.g. 78L12
U2— +6V regulator e.g. 78L06
C1, 2, 3— 100uF 25 volt electrolytic capacitors



SOLID STATE LATCH

A latch performs a very useful function i.e. in that it can be used to indicate that a voltage transition has taken place, a noise pulse has occurred, or be used as a trigger source for enabling a secondary circuit. This circuit thus allows you to verify that an electrical event has taken place without laboriously having to patiently watch meter, oscilloscope or LED. The heart of the detecting device uses a silicon controlled rectifier of SCR.

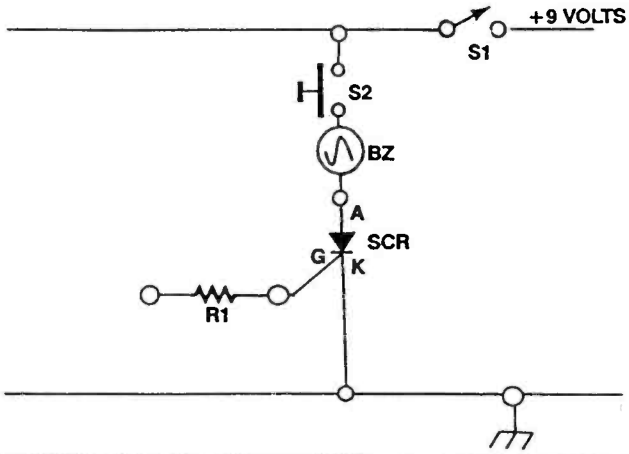
The special feature of the SCR lies in the fact that this device is normally in a nonconducting state i.e. no current flows through this three terminal device. When a positive voltage is applied to the trigger or gate terminal, then the SCR goes into conduction. Now, even with the trigger voltage removed, the SCR will still stay on, i.e. what we have is a latch.

In the circuit example shown, a piezo buzzer is placed in the anode lead of the SCR. For an actual practical use, you can replace the piezo buzzer with a solid state relay. Now the relay contacts can be used to switch any desired circuit. The input to the gate terminal is very sensitive to any positive voltage even transients i.e. it does not have to be a steady dc voltage. This makes it ideal for capturing fast signal pulses. To reset the latch once it has been triggered, push button switch S2 is momentarily pushed to open circuit the anode connection. The circuit is now reset. Switch S1 is the normal switch for the power supply (9v battery). R1 is a current limiting resistor whose value is not critical (it can also be removed if extra sensitivity is required and where the trigger source is limited in terms of voltage and current drive capability).

When you have the circuit built, apply any positive signal to the gate (a simple potentiometer divider across a battery will do if no other source is available). By varying the magnitude of the input signal you can observe at what level latching will take place (generally a very small signal is all that is needed). ■

PARTS LIST FOR THE SOLID STATE LATCH

SCR—any general purpose device e.g. MCR 106-6
BZ—general purpose piezo buzzer (Radio Shack)
R1—1K resistor
S1—SPST on/off switch
S2—normally on/momentarily off push button switch



CAR FINDER BEACON

Ever had your car in a large parking lot and not be able to find it? This is bad enough during the day, but how about at night?

There is an answer, and this is it. An LED, perhaps even a flashing one, mounted on your car, even on the tip of your cars' radio antenna. High brightness LEDs can be seen from far away, even in lighted lots. Also, the LED could look like it belongs to an alarm system, perhaps convincing car thieves to seek other prey.

The circuit has a photocell that turns the transistor on only at night. This saves power, making the circuit relatively energy efficient.

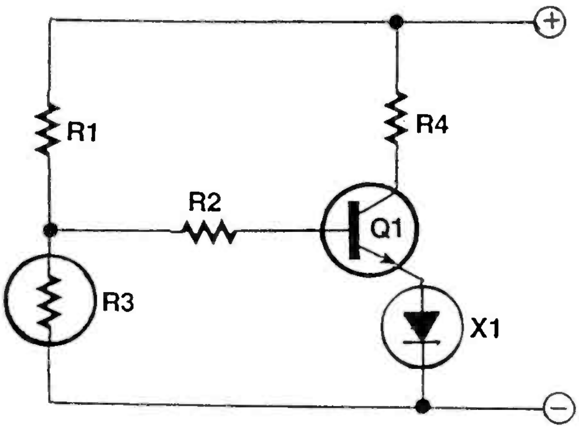
Since this entire circuit could hide behind a postage stamp, it could be put just about anywhere in the car.

You might consider weatherproofing the circuit with varnish or lacquer. Make sure the circuit is functioning properly before you do this. Removing and replacing components once they are coated is difficult and frustrating.

Mounting the LED separate from the rest of the circuit can be done, also you can mount the photocell away from the other components. Try not to use more than 20 feet of wire to connect these. Longer lengths may affect circuit operation. ■

PARTS LIST FOR THE CAR FINDER BEACON

R1, 2—47K Ohm resistors
R3—Photocell
R4—390 ohm resistor, ½ watt
Q1—2N3904 transistor
X1—LED, a flashing type will work



THE LIGHT TOUCH

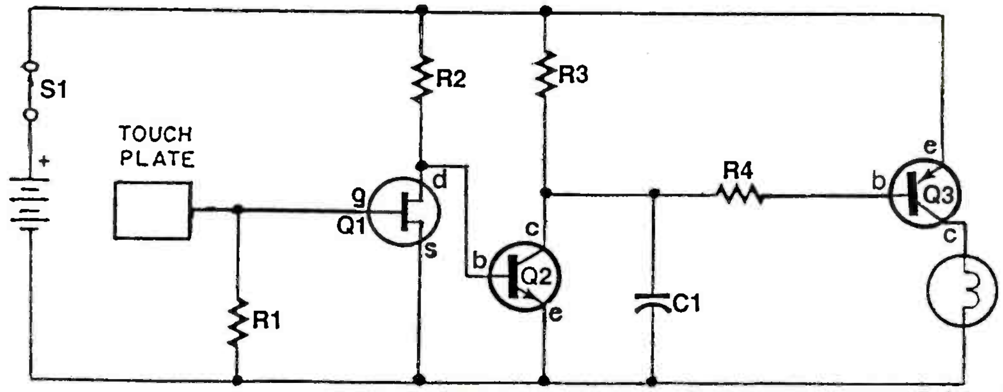
Here's an intriguing substitute for that light you're always flicking on for just a second, then right off again. This touch-actuated switch stays on only for as long as you need it, just as long as you keep your finger on the touch plate.

R1 sets the input impedance of the very sensitive JFET Q1 to a very high 10 Megohms. Q1 picks up stray signals coupled through your body to the touch plate and amplifies to turn on Q2, which turns on lamp driver Q3. Lamp I1 is any small 12 Volt lamp, such as are found in auto dashboards.

R4 and C1 add a small amount of hysteresis (delay) to keep the light from constantly flickering. If a light isn't what you need to switch this way, try substituting a relay for I1. You may want to raise B1 to 12 or 15 volts.

PARTS LIST FOR THE LIGHT TOUCH

B1—9VDC battery
C1—15-uF capacitor
I1—Any 12 volt lamp
Q1—FET (Field Effect Transisotr), 2N5458 or equiv.
Q2—NPN transistor, 2N2222, 2N3904 or equiv.
Q3—PNP transistor, 2N3906 or equiv.
R1—10-Megohm resistor, ½-watt
R2—47,000-ohm resistor, ½-watt
R3—120,000-ohm resistor, ½-watt
R4—470-ohm resistor, ½-watt
1—SPST switch

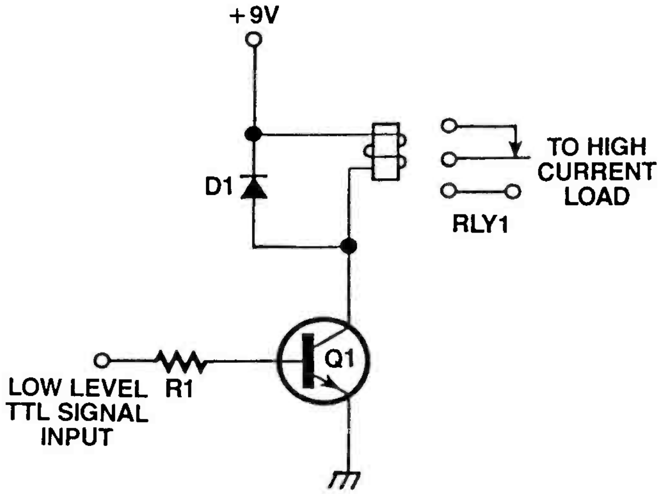


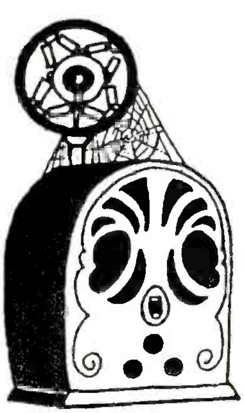
TTL RELAY DRIVER

TTL circuits are inadequate for driving high current loads such as relays. The simple circuit shown here allows you to do this, using a single transistor current booster. Q1 is a general purpose NPN transistor, fed with a low level TTL signal through resistor (R1), which limits the input current to the base of Q1. The relay coil winding is connected as the collector load. A positive going low level TTL signal, fed to R1, will turn Q1 on, allowing collector current to flow and energize RLY1. Diode (D1) is included to protect Q1 against inductive surges across the relay coil. ■

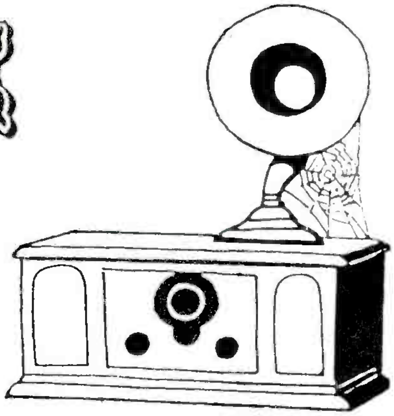
PARTS LIST FOR THE TTL RELAY DRIVER

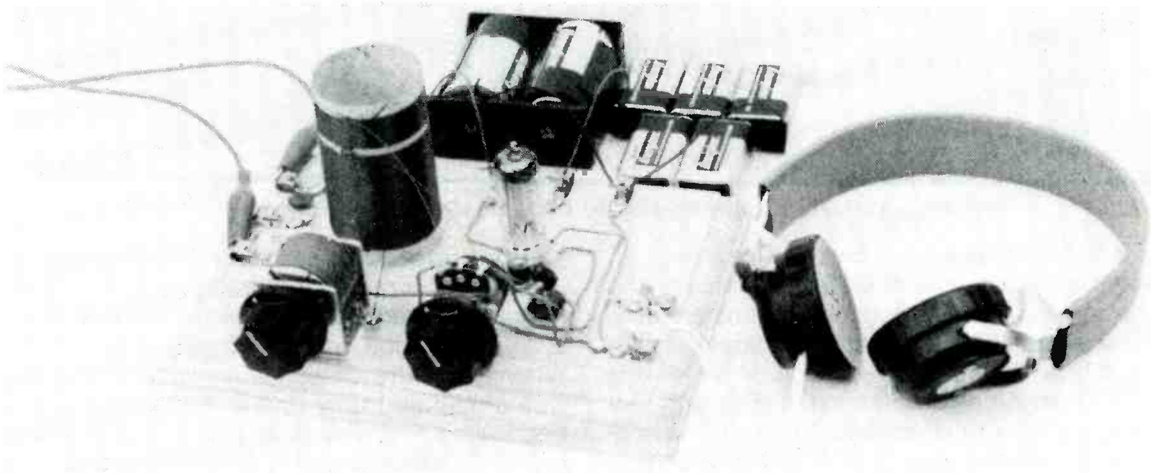
R1—1K ohms Resistor
Q1—2N2222 NPN Transistor
RLY1—9V, 2 Amp, SPDT mini-relay (500 ohms) Radio Shack #275-005
D1—1N4001 Diode





ANTIQUE RADIO CORNER





BUILD AN ARMSTRONG ONE-TUBE RADIO

By Lance Borden WB5REX

In 1879, when Thomas Edison was developing his incandescent light bulb, one problem he ran into was that as a carbon filament bulb burned, some of the carbon would evaporate off the filament and then be deposited on the inside of the glass bulb. As time went on, this resulted in the lamp burning dimmer. A bulb would often become so dim as to be useless, even though the filament was still good.

Edison tried many experiments during his attempts to eliminate this problem. One method he tried was to install a small metal plate inside the bulb in hopes that the metal would attract the carbon atoms and thus eliminate them from being deposited on the glass. In 1883, he discovered that when he applied a positive voltage to this plate that an electric current would flow through the vacuum in the bulb, from the negative filament to the positive plate. This was an astounding discovery, because until then it was believed that electricity would only flow through an electrical conductor. Even lightning, which was known at the time to be electricity, was believed to be conducting through the gas molecules of the air.

More astonishing to Edison was the fact that the current in the bulb would only flow in one direction. Edison was a proponent of D.C. and he fought the use of A.C. Because of this, he failed to recognize the value of his discovery as a rectifier. He did report his findings to the scientific community, who gave him credit for his discovery by calling it "The Edison Effect." Edison did not realize the significance of his discovery at the time, but it became the basis for the development of a whole new discipline in science and engineering. This new disci-

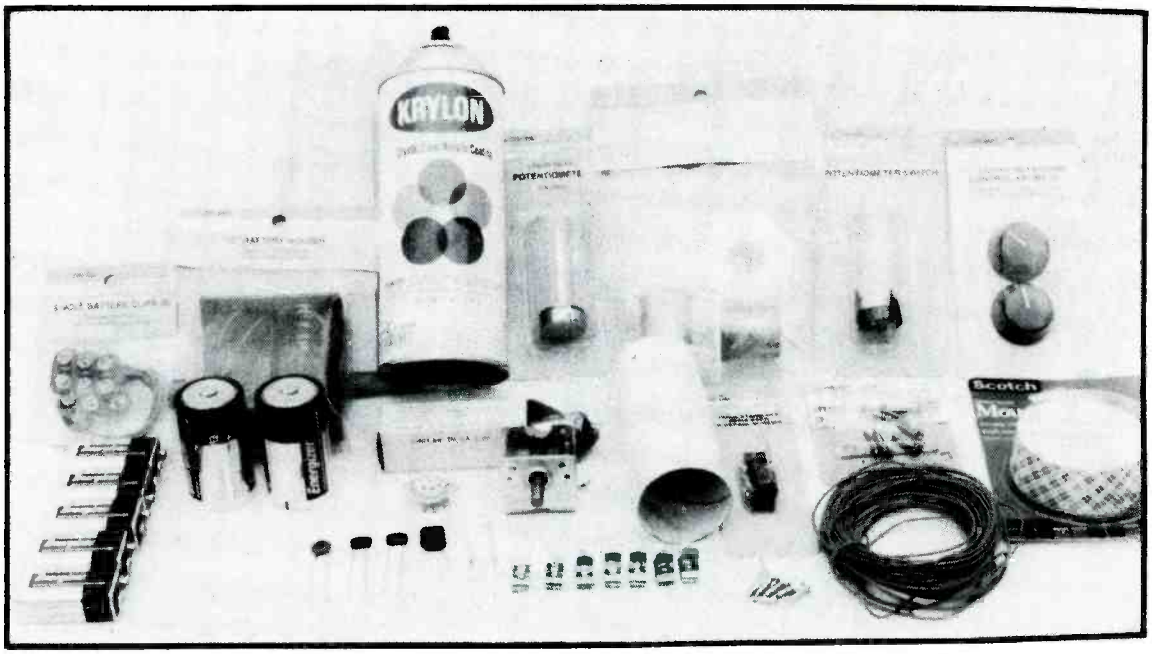


PHOTO #1–Parts required to build the Armstrong One-Tube Radio.

pline was to become known as, **Electronics.**

In the 1890s the inventions of Tesla, Marconi and others were making wireless communications a reality. Scientists were searching for a sensitive detector of radio waves in order to improve reception. In 1904, one scientist, Sir John Ambrose Fleming, in England, applied a modified Edison effect bulb to the task of detecting wireless waves. The Fleming Valve, as it was called, (because it acted as a one-way check valve for electrons) proved to be a very good radio signal detector, due to its efficient rectifying characteristics. Fleming went on to market wireless receivers using his valve as a detector. His device was a good detector for wireless receivers but it would not amplify the signals.

About the time that Fleming was experimenting with Edison effect bulbs in England, Dr. Lee deForest was working on a way to use a variation of this principle to not only detect radio waves, but to amplify them as well. In 1906, Dr. deForest's experiments led to his invention of the **Control Grid.** The control grid (or just, grid) was a zigzag piece of wire that was placed between the filament and the plate of an Edison effect bulb. He found that a small negative charge on this grid would repel the electrons being emitted by the filament and thus prevent them from reaching the plate. By setting the negative voltage on the grid to a precise level that he called **BIAS,** he found that he could cause a large change in the electron flow from the filament to the plate with a very tiny change in voltage on the grid. When he connected a small radio signal to the grid, the output on the plate was increased many times. This was the first practical vacuum tube amplifier. DeForest marketed his device as the **Audion.** The Audion, because of its one-way current flow, was an effective radio detector and because of the grid, was also an efficient amplifier. This device revolutionized the science of electronics and was the basis of many inventions to come.

In 1912, Edwin H. Armstrong, a brilliant young college student at Columbia University, invented the principle of **positive feedback,** or **regeneration,** in vacuum tube radio circuits. His regenerative circuit worked by "feeding back" a small amount of the output of a vacuum tube detector-amplifier to its input, or grid. When this feedback was properly controlled, the signal was amplified many times over what it would have been without regeneration. This principle was also applied to make vacuum tube oscillators that could be used as radio transmitters.

Armstrong's regenerative circuit revolutionized the wireless world. It became the standard configuration used for commercial, shipboard, and military vacuum tube communications receivers throughout the world. Armstrong is also credited with the invention of the superheterodyne receiver, which is still in use today and frequency modulation, (or FM) that allows us to transmit and receive high fidelity audio over the airwaves.

The purpose of this article is to describe how to build an Armstrong regenerative one vacuum tube receiver using simple construction techniques and readily available parts. This little radio can be built in a couple of evenings and will provide many hours of listening enjoyment from a set of batteries because the current drain is so low. It covers the entire AM broadcast band and can be used to pull in stations from amazing distances because of its sensitive, selective, regenerative circuit.

CONSTRUCTION

Begin construction by acquiring all of the parts and materials you will need before you start. A list of parts, materials, and sources is included at the end of this article. (See Photo #1) Refer to the parts list, photos, and illustrations while building the Armstrong one-tube radio.

A NOTE ABOUT PARTS SUBSTITUTION:

The prototype of this set was built using a type 3A4 vacuum tube. A type 3S4 or 3Q4 will work if the connections shown for pin 3 are connected to pin 4 and the connections shown for pin 4 are connected to pin 3. The values for the capacitors and resistors are not extremely critical. The values shown are what were used in the prototype. Values for these components within plus or minus 20% should work satisfactorily.

STEP 1. Spray the coil form inside and out with one good coat of clear acrylic spray lacquer and let it dry. Spray the board with three coats, letting it dry between coats.

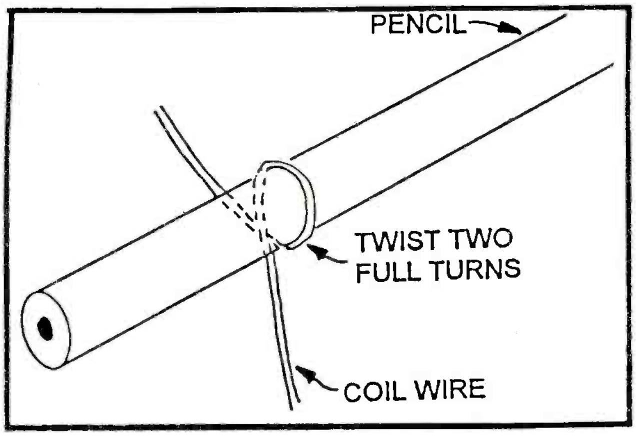


Figure 1: Attaching wire to the coil form

STEP 2. (Refer to Figure #1) Punch two small holes in the coil form, 1/4 inch apart and 1/2 inch from the end. Pass 4 inches of the #26 AWG coil wire through one hole from the outside of the coil form and then pass it back through the other hole. Repeat this process once more and pinch the resulting loops with pliers to hold the coil lead in place.

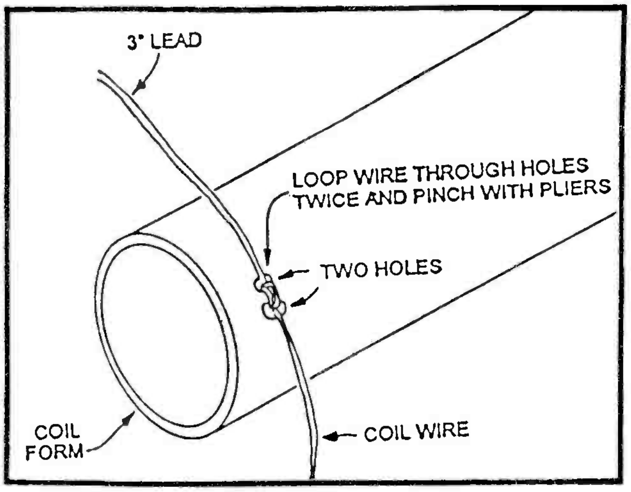


Figure 2: How to twist a coil tap

STEP 3. (Refer to Photos #2 and 3 and Figures 1 and 2) Wind twenty turns, close but not overlapping, on the coil form and make a tap by securing the coil with a drop of super glue, and then looping the wire around a pencil. Twist the loop twice and then remove the pencil. This is coil, L3. Wind eighty more turns and then punch two holes as in Step 2 and secure the end of the coil at the 80th turn, using pliers to pinch the wire the same as before. Leave a lead wire 6 inches long at this end of the coil. This is coil, L2. Coils L2 and L3 make up a total of 100 turns. Punch two more holes 1/8 inch from the two you just used to secure the end of coil, L2. Pass

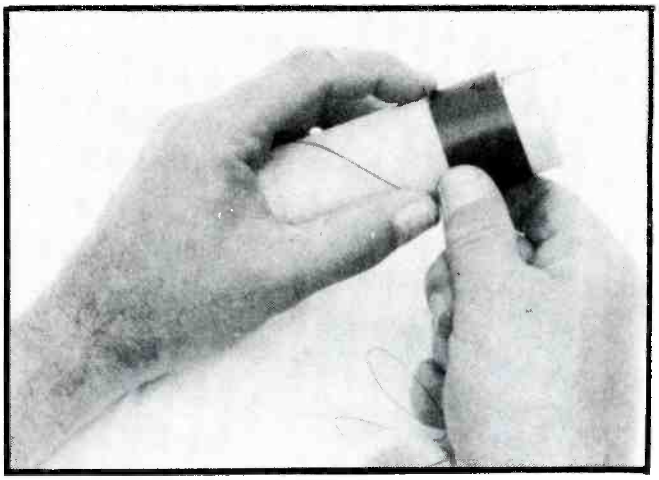


PHOTO #2–Winding the coil by feeding coil wire with right thumb, while turning coil form with left hand.

seven inches of the #26 AWG coil wire through these holes as in Step 1 and wind thirty turns in the same direction as the first coil. This coil should be spaced 1/8 inch from coil, L2. Punch two holes at the end of this coil and secure as before. This is coil, L1. Leave a lead wire six inches long at the end of this coil. Use a razor blade to trim the excess coil form off 1/2" past the end of the coil.

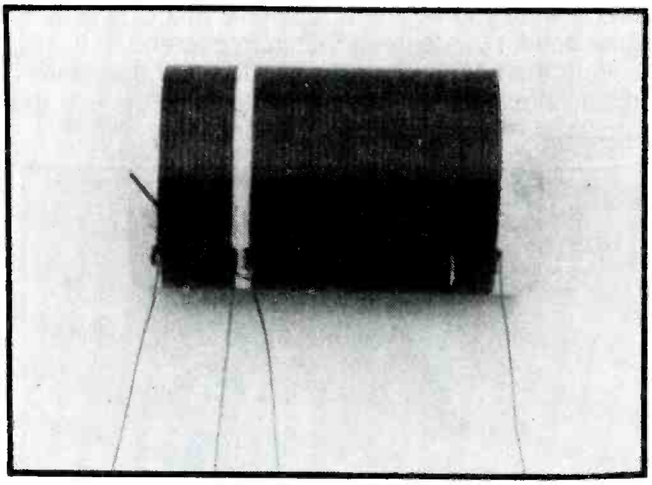


PHOTO #3–The completed coil.

STEP 4. Spray the coil with three coats of clear acrylic lacquer, letting it dry between coats. The clear acrylic will hold the coil winding in place and will also prevent moisture from affecting the coil's efficiency.

STEP 5. The tuning capacitor is a 365 picofarad unit obtained from one of the suppliers referred to in the parts and source list at the end of this article. If the capacitor does not have a solder lug spot-welded to the back of the case, scrape the left rear upper corner (when viewed from the front) of the case to remove oxides and deposits. Use a hot soldering iron and plenty of rosin core solder to tin a small area on the capacitor case. This will make it easier to solder the wiring once the capacitor is mounted to the board.

STEP 6. (Refer to Photos #4 and 5) From the rotating shaft end of the threaded mounting shaft of the potentiometer, R1, measure 9/16" along the rotating shaft and mark it with a file. Mount the end of the rotating

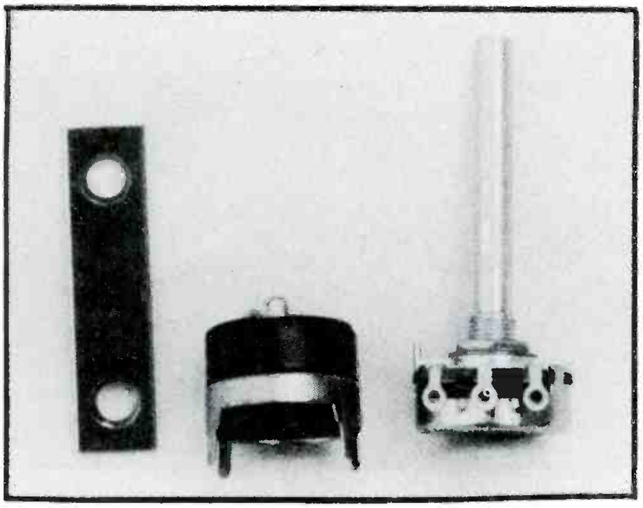


PHOTO #4–Potentiometer, R1, switch, S1, and mounting bracket before modification.

shaft in a vise, or hold it with pliers, and use a hack saw or file to remove the excess shaft length. Remove the back cover of the potentiometer and install switch, S1 according to the instructions supplied with the switch. The potentiometer mounting bracket is a 2″ x 1/2″ brass plated steel mending plate from the hardware store. You could also make a bracket out of aluminum or tin-can metal, if you desire. If the brass mending plate is used, bend it 90 degrees 9/16″ from one end. Drill, file, or ream the hole in the long end to allow the potentiometer threaded mounting shaft to pass through the bracket.

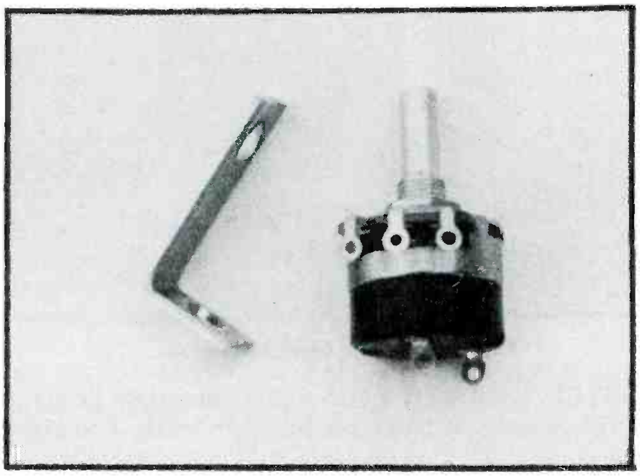


PHOTO #5–Potentiometer, R1, switch, S1, and mounting bracket after modification.

STEP 7. (Refer to Photos #6, 7, and 8 and Figures 3 and 4) Temporarily place the tuning capacitor, coil, potentiometer, tube socket and fahnestock clips on the board and lightly outline their locations with a pencil. Use super glue to attach the coil to the board with the 20th turn tap closest to the board and with the leads facing the front of the set. Cut a strip of double-sided foam mounting tape to the size of the capacitor base and press into place on the board. Place the capacitor on the mounting tape and press down hard, being careful not to bend the capacitor plates. Install the antenna, ground, battery and headphone fahnestock clips with

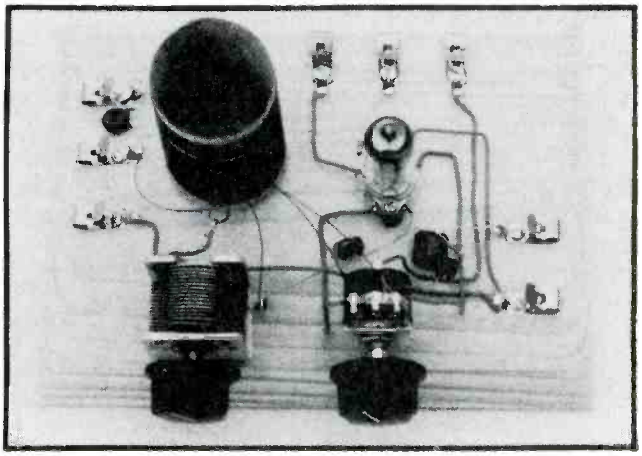


PHOTO #6–Parts layout, before wiring.

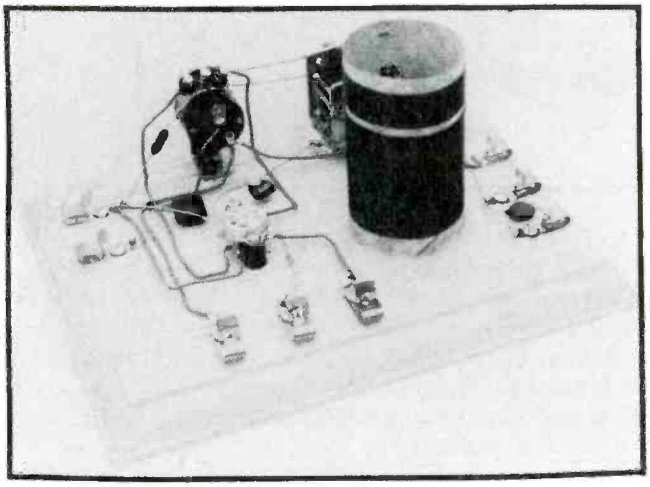


PHOTO #7–Rear view; showing wiring.

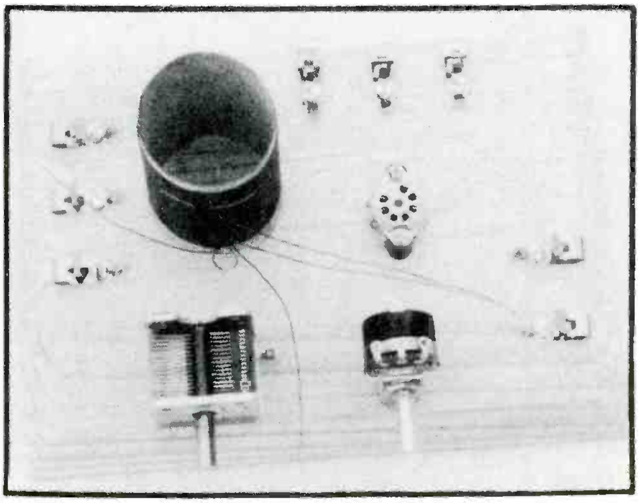


PHOTO #8–Top view; showing wiring.

#4 x 1/2 inch round-head wood screws. If your fahnestock clips have built-in solder lugs, tighten the screws. If the fahnestock clips do not have solder lugs, do not tighten these screws yet because the wiring will go under the fahnestock clips in step 8. Install the potentiometer bracket to the board with a screw and mount the potentiometer to it with the hardware provided with the potentiometer. Install two standoffs on the tube socket with the screws provided with the standoffs. Do not in-

BATTERY CONNECTIONS

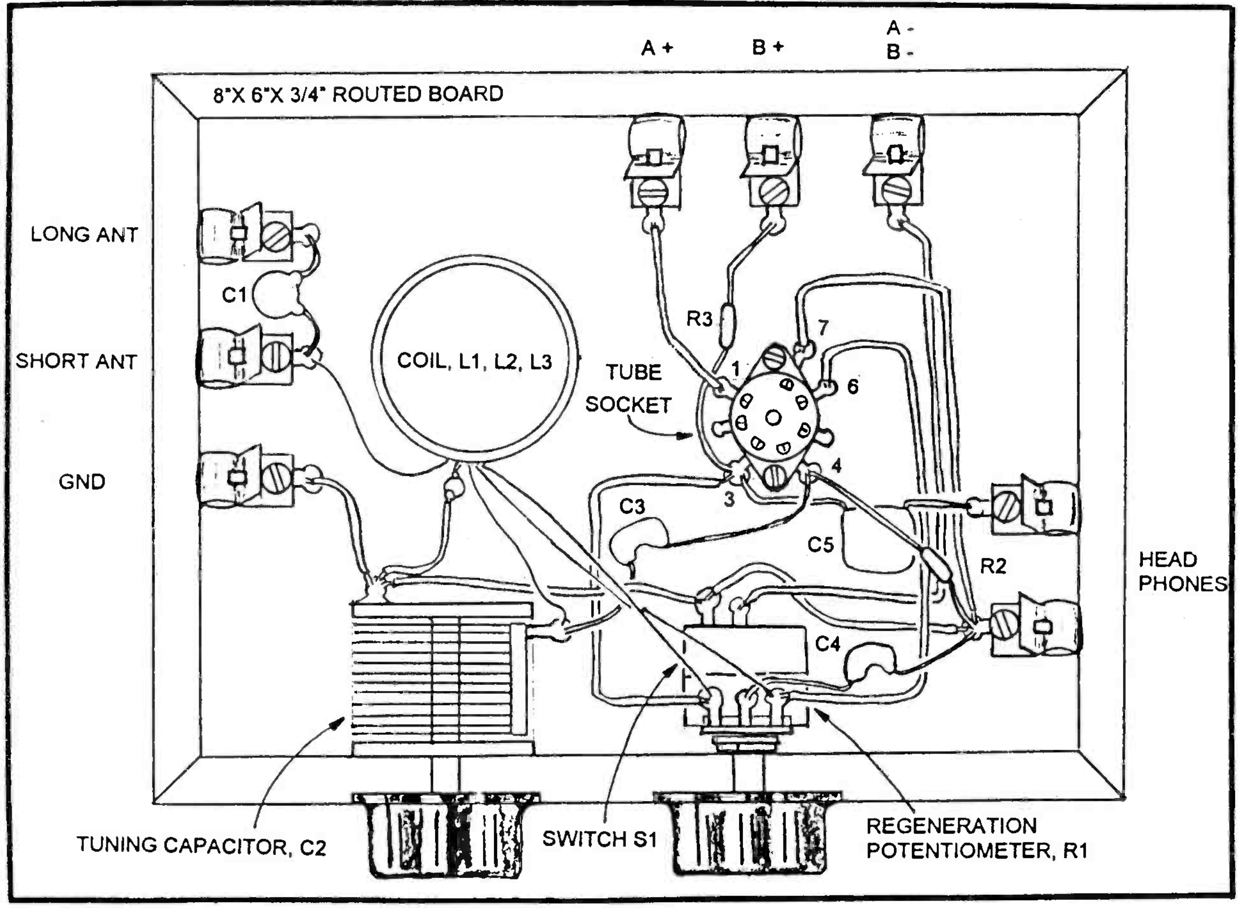


Figure 3: Armstrong One-Tube Radio–TOP VIEW

stall screws on the other ends of the standoffs. Bend the tube socket lugs out, so they will be accessible once the socket is mounted on the board. Use a drop of super glue on each standoff to mount the tube socket to the board, oriented as shown in Figure 3 and Photo #6.

STEP 8. (Refer to Photos #7 and 8 and Figures 3, and 5) Begin wiring the set by scraping the enamel off of the ends of the coil lead wires and coil tap. Refer to the drawings and photos and wire the set as shown. Make all leads as short as possible, while still maintaining a neat appearance. When connecting the tickler coil, L1, to the regeneration potentiometer, R1, be sure that the lower coil lead goes to the right potentiometer lug (as viewed from the front) and the upper lead goes to the left lug. If these are connected backward, the set will have negative feedback, instead of positive feedback, and will not regenerate. Install the knobs on the

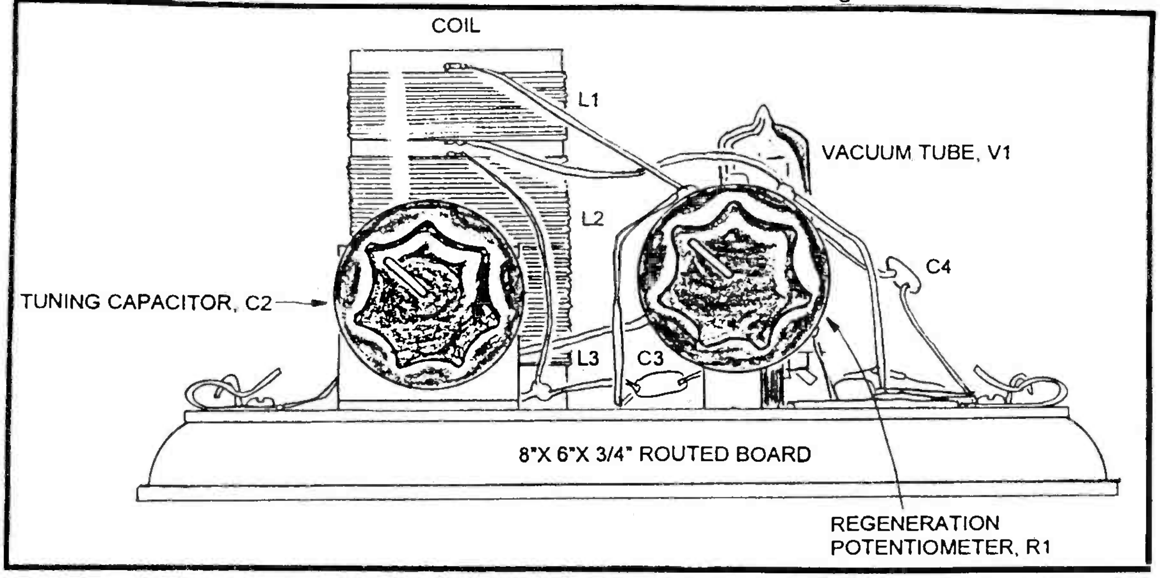


Figure 4: Armstrong One-Tube Radio–FRONT VIEW

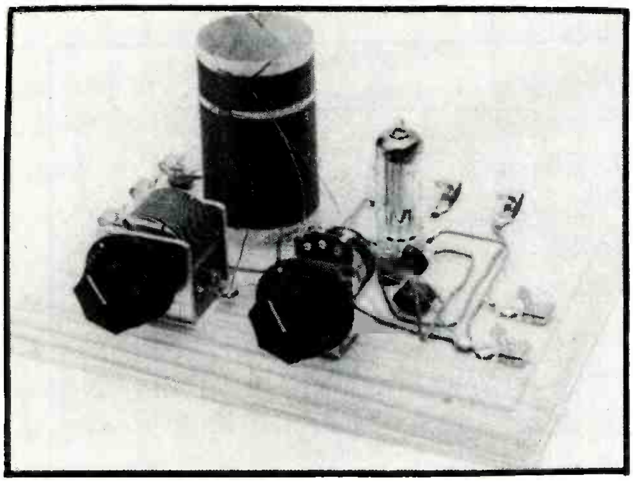


PHOTO #9–The completed Armstrong One-Tube Radio.

tuning capacitor and potentiometer. Turn the potentiometer fully counter clockwise until switch, S1, clicks off. Install vacuum tube, V1, in its socket.

STEP 9. (Refer to Photo #10) The 45 volt "B" battery is made up of five, nine-volt transistor batteries snapped together, in series. The current drain on these

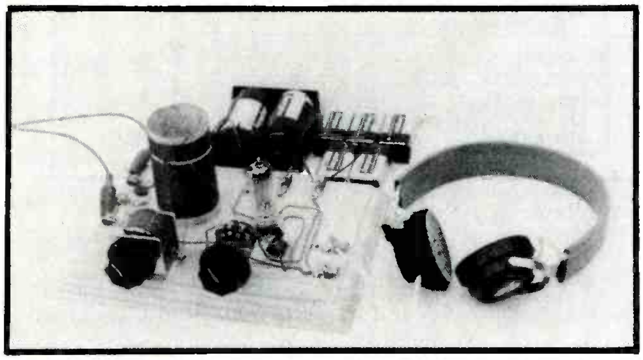


PHOTO #10–The completed Armstrong One-Tube Radio with batteries and 2000 ohm headphones.

batteries is extremely low, so it is not really necessary to use the more expensive alkaline batteries shown in the photo. Non-alkaline batteries usually cost about 79 cents each and are often on sale for as little as 39 cents. Make "B" battery snap connectors by using a razor blade to divide a standard nine-volt battery snap connector into two separate pieces. Use super glue to seal the ends and secure the wires in place. The "A" battery is made up of two "D" size alkaline cells mounted in a standard battery holder. Alkaline cells will have a much longer life than regular batteries when used to heat the vacuum tube filament.

This completes the construction of the Armstrong One-Tube Radio.

ANTENNAS

This set requires an outside antenna and a ground connection in order to provide optimum performance. The Armstrong circuit is very sensitive and will work with a short inside antenna that can be made up of some of the left over coil wire in the Radio Shack package. More stations and longer distances will be received with a longer outside antenna. If a short antenna is used, then it should be connected to the "Short Ant" fahnestock clip on the radio.

The "rule-of-thumb" on antennas is to make them as long and as high as possible. A 50 to 100 foot length of wire, strung outside, from your house to a tree makes an excellent antenna for this radio and for other radios, as well. The antenna should be insulated at both ends and should not touch anything, **especially power lines! Always disconnect the antenna and connect it to the ground during stormy weather and when not in use, to protect from lightning and static charge build up.**

Most any type of wire will work for an antenna, or if you prefer, Radio Shack sells an excellent antenna kit that contains everything you need to string up a fine outside antenna. The Radio Shack part number is referenced in the parts list at the end of this article.

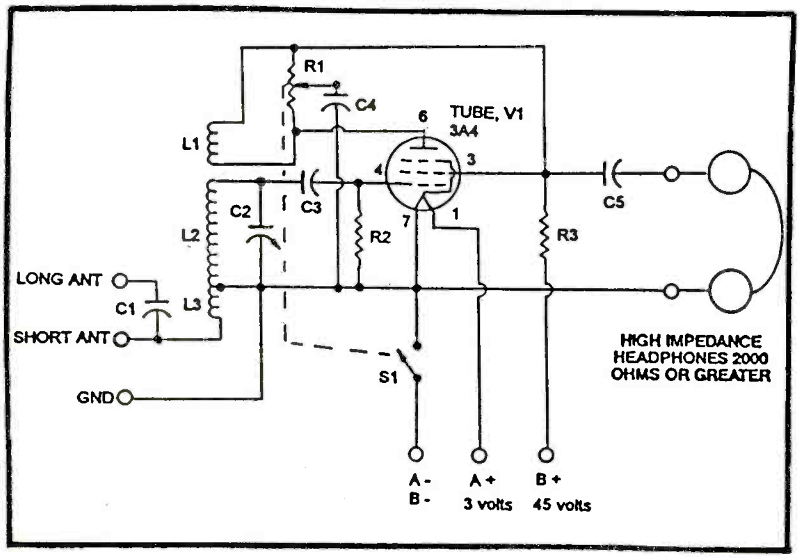


Figure 5: Armstrong One-Tube Radio–SCHEMATIC DIAGRAM

PARTS LIST FOR THE ARMSTRONG ONE-TUBE RADIO

CAPACITOR, C1 250 PF, 100WV or greater	CAPACITOR, C5 .1 MFD, 100WV or greater
TUNING CAPACITOR, C2 365PF AIR VARIABLE	POTENTIOMETER, R1 50K OHM LINEAR TAPER
CAPACITOR, C3 120 PF, 100WV or greater	RESISTOR, R2 2.2 meg ohm, 1/4 watt
CAPACITOR, C4 120 PF, 100WV or greater	RESISTOR, R3 10K ohm, 1/4 watt

L1, 30 turns #26 AWG enameled magnet wire (see text)
L2, 80 turns #26 AWG enameled magnet wire (see text)
L3, 20 turns #26 AWG enameled magnet wire (see text)

As for a ground connection, cold water pipes used to be employed for this purpose, but most newer homes use PVC pipe, which is an insulator and won't work. The best ground to use, if your house is plumbed with PVC, is one of the copper plated steel ground rods sold by Radio Shack and hardware stores.

HEADPHONES

High impedance headphones are required for this set to work. These should be magnetic phones of 2000 ohms, or greater, impedance. High impedance headphones are sold by Antique Electronics Supply and are available via mail order. See the parts list for ordering information. Don't try to use stereo headphones because they have a very low impedance and simply won't work. (See **ELECTRONICS HANDBOOK,** Volume 14 for an article by this author about building an amplifier for one-tube sets and crystal sets that will drive a loudspeaker or low impedance headphones.)

CAUTION! BE VERY CAREFUL WHEN CONNECTING BATTERIES TO THIS RADIO! THE VACUUM TUBE FILAMENT IS DESIGNED TO OPERATE ON 3 VOLTS. ACCIDENTALLY CONNECTING THE 45 VOLT "B" BATTERY TO THE FILAMENT WILL INSTANTLY BURN IT OUT AND RUIN THE TUBE!

OPERATING THE ARMSTRONG ONE-TUBE RADIO

To operate the Armstrong One-Tube Radio, connect antenna and ground wires to the appropriate fahnestock clips. Antennas over about 25 feet in length should be connected to the "Long Ant" clip and shorter antennas should be connected to the clip marked "Short Ant." Connect a headset, as mentioned above, to the headset fahnestock clips. Connect "A" and "B" batteries, as described above in construction Step 9, to their appropriate fahnestock clips.

Set the tuning capacitor, C2, about mid-range and rotate the regeneration control, R1, clockwise until switch, S1, clicks to apply power to the vacuum tube filament and plate circuits. The vacuum tube was designed to operate on batteries and will warm up to operating temperature within one or two seconds. Slowly continue rotating the regeneration control until a loud "squeal" is heard. This is the point at which the set breaks into over-regeneration. Rotate the regeneration control counterclockwise slightly until the squeal just stops. This is the point of optimum regeneration and greatest sensitivity. Adjust the tuning capacitor until you hear a station and then touch-up the regeneration control for best reception without distortion or squealing.

You should be able to hear, and separate, several stations as you tune the capacitor across its range. You will find that the regeneration control will have to be readjusted as you change frequencies across the broadcast band. If you don't hear anything, something is definitely out of order and you need to go back and check your wiring until you find out what is wrong. If the set works but does not regenerate, try swapping the leads to the tickler coil, L1.

Once you have the set operating, you will find that, with a good antenna, many stations can be received. At night you will be able to receive real broadcast band DX from many miles away. You can test the amplifying effect of Armstrong's invention of regeneration by turning the regeneration control fully counterclockwise (without turning off the switch.) The radio will still receive some local stations, but with reduced volume and weaker stations will not be audible at all.

Always turn off the radio when not in use to conserve the batteries. The "B" batteries will out last several "A" batteries. You can monitor battery life by occasionally checking their voltage while playing the set. Many hours of operation can be expected from a set of batteries because the current drain is very low.

HOW THE ARMSTRONG ONE-TUBE RADIO WORKS

A signal voltage is impressed on electrical conductors as radio waves pass by them at the speed of light. The antenna is one such conductor, that has been suspended in the open, just for this purpose. The signal voltage flows down from the antenna and to the coupling coil, L3. The ground completes the circuit for the signal. The signal is coupled directly to L3 when using a short antenna and via capacitor, C1, when using a long antenna. C1 helps keep the long antenna from loading down the resonant circuit, which would decrease its efficiency and make the set less selective. The signal is then induced into the next 80 turns that make up coil, L2. Coil, L2 is connected in parallel with tuning capacitor, C2, to make a fairly efficient resonant circuit that is somewhat independent of the capacitance and inductance of the antenna and ground circuit.

The radio signal (the radio frequency signal, or R.F., is actually a varying A.C. voltage that can pass through a capacitor, while the capacitor will not pass a D.C. voltage) is then coupled to the control grid (pin 4) of vacuum tube, V1, through coupling capacitor, C3. The purpose of capacitor, C3 is to pass the weak radio frequency energy to the control grid while blocking the flow of the negative D.C. bias voltage from the grid to ground through coil, L2.

Resistor, R2, is called a "Grid Leak Bias" resistor. Its purpose is to provide a high resistance path for electrons to flow, or "leak", from the control grid to ground. In order for the vacuum tube to operate in the linear portion of its characteristic curve, a small negative D.C. voltage must be present on the control grid. This negative "Bias" voltage is developed when electrons boil off the hot filament, collect on the control grid, and then flow to ground through the high resistance path formed by resistor, R2. The filament is heated by the 3 volt "A" battery connected to pins 1 and 7.

A small change in the signal voltage on the grid causes a large change in the electron flow to the plate (pin 6) of the tube. This difference in change manifests itself as amplification of the signal. As an added feature, the rectification action of the tube detects the audio modulation signal present in the radio signal by only conducting one half of the R.F. envelope.

Vacuum tubes must have a fairly high positive D.C. voltage on their plates in order for the electrons to flow through the vacuum between the filament (cathode) and the plate (anode.) This D.C. voltage is provided by the 45 volt "B" battery through the plate load resistor, R3, and coil, L1. The audio output signal is developed across resistor, R3 and coupled to the headphones through coupling capacitor, C5. The purpose of C5 is to pass the audio while blocking the D.C. plate voltage from the headphones. Many early designs passed the D.C. plate voltage through the headphones and did not use plate load resistors or coupling capacitors. This was O.K. as long as the polarity of the headphones was properly observed. Many headphones were ruined by connecting them incorrectly because the high D.C. voltage de-magnetized their internal magnets. C5 and R3 were added to this design to eliminate the possibility of this happening.

Armstrong's regenerative action is accomplished by coupling a small portion of the output signal at the plate back to the control grid by applying the signal to the "Tickler Coil", L1 which then induces it into coil, L2. (These coils have been called ticklers since the early days of radio because they "tickle" the input circuit with a portion of the output signal.) The signal is then re-amplified by the vacuum tube. This cycle is repeated many times per second, with the signal getting bigger each time. The amount of regeneration is limited by the circuit breaking into an uncontrolled oscillation, known as over-regeneration. When this happens, the set squeals loudly. The amount of regeneration is controlled by adjusting the amount of signal fed back to the control grid by potentiometer, R1. R1 accomplishes this task by forming an adjustable voltage divider in the signal ground path for coil, L1. Capacitor, C4 acts as a signal path to ground for the tickler circuit, while blocking the D.C. plate voltage from flowing to ground.

The "Screen Grid" (pin 3) improves the tube's efficiency by accelerating the flow of electrons to the plate by providing a positively charged "screen" which attracts the electrons in the direction of the plate. The "Suppresser Grid" (internally connected to the filament, or cathode), which is negatively charged in respect to the plate, suppresses "secondary emission" of electrons from the plate to the screen grid as they have a tendency to "bounce" off, after being accelerated at high speed to the plate. The 3A4 vacuum tube used in this circuit is known as a "Pentode" from the word penta, which means five. This tube has five elements; the three grids, the filament, and the plate. (3S4 and 3Q4 tubes have the control grid on pin 3 and the screen grid on pin 4.)

CONCLUSION

Edwin Armstrong was a phenomenal electronics genius and a true pioneer in the days when the science of electronics was young. We owe much of what we take for granted in electronics today, to this brilliant man. His 1918 superheterodyne circuit is the standard receiver circuit in use today in everything from radios and televisions, to RADAR and space communications. FM radio would not be possible without his inventions. His regenerative circuits were used for decades.

The little one tube regenerative receiver described in this article effectively demonstrates Armstrong's 1912 invention of positive feedback. It is very sensitive and selective. Using only one vacuum tube, it is capable of receiving stations half a continent away. It is fun and educational to build and will provide many hours of listening pleasure. Today's solid-state receivers can not duplicate the experience of spending an evening in a darkened room, listening to a one-tube set you built yourself, lit only by the faint orange glow of a single vacuum tube.

This article is dedicated to the memory of Edwin Howard Armstrong (1890-1954); a gifted American inventor and significant contributor to the science of electronic communications. ■

REFERENCES

(1) SAGA OF THE VACUUM TUBE
By Gerald F.J. Tyne
Howard W. Sams & Co., Inc.
4300 West 62nd St.
Indianapolis, Indiana 46268 USA
ISBN 0-672-21470-9
Copyright 1977

(2) VINTAGE RADIO
By Morgan E. McMahon
Published by Vintage Radio
Box 2045
Palo Verdes Peninsula, CA 90274 USA
ISBN 0-914126-01-6
Copyright 1973

(3) THE RADIO AMATEUR'S HANDBOOK
AMERICAN RADIO RELAY LEAGUE
Newington, Conn. USA
Library of Congress Number 41-3345
Copyright 1964

(4) MRL 1-TUBE D.C. ALL-WAVE RECEIVER
By Elmer G. Osterhaudt
Modern Radio Laboratories
Oakland, California
Copyright 1953

(5) POPULAR SCIENCE RADIO ANNUAL
Popular Science Publishing Co., Inc.
353 Fourth Avenue, New York 10, N.Y.
Copyright 1943

(6) THE BELLINGHAM ANTIQUE RADIO MUSEUM
Internet Web Site
Internet Address (URL) http://www.pacificrim.net/radio/old _html/
February 1996

NOTE TO READERS

Back issues of *ELECTRONICS HANDBOOK* that contain other articles by this author can be obtained from the publisher. Look in this issue of *ELECTRONICS HANDBOOK* for information on ordering these magazines.

VOLUME NUMBER	ARTICLE
12	How To Build And Use A High Performance Crystal Set
13	Build A QRM Filter For Crystal Sets
14	Build A Crystal Set Amplifier
15	Build A Crystal Set Antenna Tuner
16	Building and Testing The Antique Audio CRS-1 Crystal Set Kit
17	Build A World War II Foxhole Radio
18	Restore An All-American Five-Tube AC-DC Superhet Radio
19 (Present)	Build An Armstrong One-Tube Radio

PARTS AND SOURCE LIST FOR THE ARMSTRONG ONE-TUBE RADIO

PARTS	SOURCE
Coil Form	Cardboard toilet paper tube or paper towel tube. 1¾ x 4½ inches. Note: Some brands of toilet paper come on tubes that are less than 1½ inches in diameter. Be sure to use a tube that is 1¾ inches in diameter.
Tuning Capacitor, 365 Pf Air Variable	Antique Electronic Supply P/N CV-231 Antique Electronic Supply 6221 S. Maple Avenue Tempe, AZ 85283 (602) 820-5411 Ask for their catalog Or see parts kit available below
Resistors	Antique Electronics Supply, Radio Shack, or other electronic supply Or see parts kit available below
Capacitors	Antique Electronics Supply, or other electronic supply Or see parts kit available below
Potentiometer, R1, 50k ohm linear taper	Radio Shack P/N 271-1716
Switch, S1	Radio Shack P/N 271-1740
Coil Wire, Approx. 75 feet of #26 AWG enameled copper magnet wire.	Radio Shack or other electronic supply. Radio Shack P/N 278-1345 contains #22, #26, and #30.
Knobs and Hook-up Wire	Radio Shack P/N 274-407 (knobs) or other electronic supply.
Fahnestock Clips	Antique Electronic Supply P/N SH-11-4034 (They only sell fahnestock clips in lots of 100.) Or see parts kit available below
Vacuum Tube, Type 3A4 (3S4 and 3Q4 will work, see text)	Antique Electronic Supply P/N 3A4, 3S4, 3Q4 Or see parts kit available below
Vacuum Tube Socket, 7-Pin Miniature	Antique Electronic Supply P/N PS-201 Or see parts kit available below
Stand-Offs for Tube Socket	Radio Shack P/N 276-1381
Battery Holder for 2 "D" Cells	Radio Shack P/N 270-386
Battery Clips for 9 Volt Batteries	Radio Shack P/N 270-325
Batteries	"A" Battery is 2 "D" alkaline cells "B" Battery is 5 nine-volt transistor batteries

PARTS AND SOURCE LIST FOR THE ARMSTRONG ONE-TUBE RADIO

PARTS	SOURCE
Mounting Board, Approximately 8 x 6 x 3/4 inch routed plaque or plain board.	Plaques can be purchased at hobby and craft stores. A plain board will work find as long as it is very dry before spraying with acrylic.
Antenna Kit	Radio Shack P/N 278-758 is a complete kit of every thing you need to put up a 70 foot long antenna with a 50 foot lead in.
High Impedance Double Headphones	Antique Electronics Supply P/N PA-466
Miscellaneous	Local Hardware Store. Clear acrylic spray, #4 x 1/4 inch round head wood screws, washers, double-sided foam mounting tape, super glue, brass plated steel mending strap
Armstrong One-Tube Radio Special Parts Kit	As a service to readers, a kit of the harder to find parts to build this radio is available. This kit contains: 1ea 365pf tuning capacitor 1ea 3A4, 3S4 or 3Q4 vacuum tube 1ea 7-pin miniature tube socket 7ea Fahnestock clips 2ea 120pf capacitors, or equivalent 1ea 250pf capacitor, or equivalent 1ea 1 mfd capacitor, or equivalent 1ea 10K ohm 1/4 watt resistor 1ea 2.2 meg ohm 1/4 watt resistor (Everything else needed to build this radio is readily available locally at Radio Shack, hardware store etc.) To order the parts kit: Send $12.00 plus $4.50 for postage and handling, for a total of $16.50 (Air Priority Mail in USA, all others write for shipping information) Sorry no credit card orders. Borden Radio Company 13911 Kensington Place Houston, TX 77034
Schematic diagrams for antique radios	Antique Radio Schematic Service 13911 Kensington Place Houston, TX 77034 Copies of schematics for most radios built from the 1920s through the 1940s and some radios from the early 1950s. Send make & model needed and business size self-addressed stamped (32 cent for USA) envelope with $3.00. If schematic is unavailable, money will be refunded.
Another good source of parts for antique radios and construction projects	Frankenstein's Radio Laboratory 304 North High Street Lake Helen, FL 32744 (904) 228-3984 Ask for their catalog

MODERN RADIO LABORATORIES
P.O. BOX #14902
MINNEAPOLIS, MN 55414-0902
CRYSTAL SET INSTRUCTIONS,
RADIO PARTS & SUPPLIES
CATALOG $2.00 (POSTPAID)

DXing Ol' Sol

Joseph J. Carr

You won't be a radio buff long before you find out that radio propagation conditions on Earth are profoundly affected by conditions on the Sun. When events erupt on the Sun (Fig. 1), energy is radiated into the solar system, and some of it impinges the Earth's atmosphere. Radio propagation is dependent on the state of ionization in the upper atmosphere, in a region called the ionosphere.

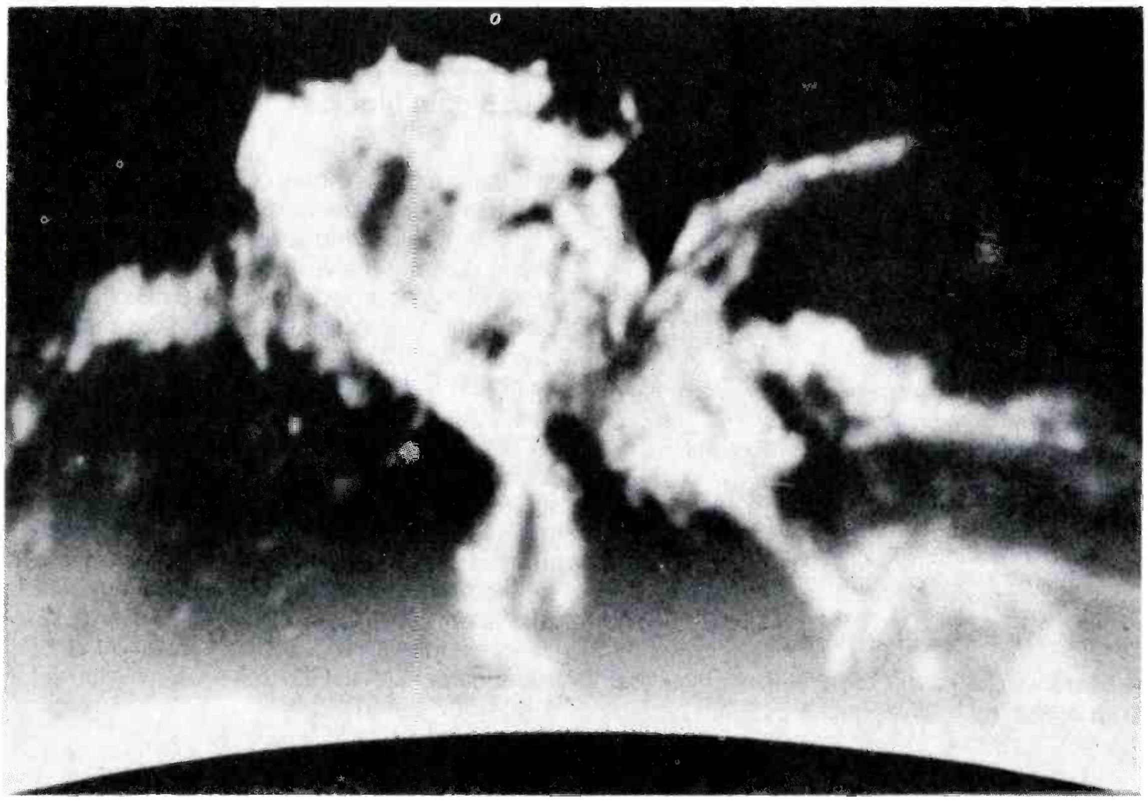


Fig. 1: Solar event (courtesy National Solar Observatory, Sunspot, NM).

Shortwave listeners recognize the effects of this ionization on a daily basis. At night, the DX comes rolling in on the lower frequencies (up to about 12 MHz), and in the AM broadcast band. But, as the Sun comes up, the DX in these bands fades out and DX in the upper bands comes alive. During the daylight hours, the AM BCB is limited to local reception, out to a few dozen miles, while the lower shortwave bands see distances of only 200 to 500 miles (typically). At the same time, the DX in the upper bands becomes intercontinental. You can arise in the morning to a show from Radio New Zealand, or hear 15-meter band hams in Australia or Japan.

When a solar event occurs, however, things can get disrupted for periods lasting from a few minutes up to a few days. A Sudden Ionospheric Disturbance (SID) is produced by solar flares, and can wipe out the shortwave reception in a big way. Paradoxically, while wiping out the HF shortwave bands, the same flare will actually enhance reception on the very low frequency (VLF) bands, especially in the 10 to 60 KHz region.

A number of amateur radio astronomers monitor VLF bands for solar flares. If you are lucky enough to own a VLF receiver, a VLF tunable voltmeter (e.g. Hewlett-Packard HP-312) that can function as a VLF receiver, or a shortwave receiver with a 30 KHz and up VLF band (e.g. the British-made **Lowe** HF-150 or HF-225) then the chore is relatively easy. But if you lack such a receiver, then we've got a construction project for you.

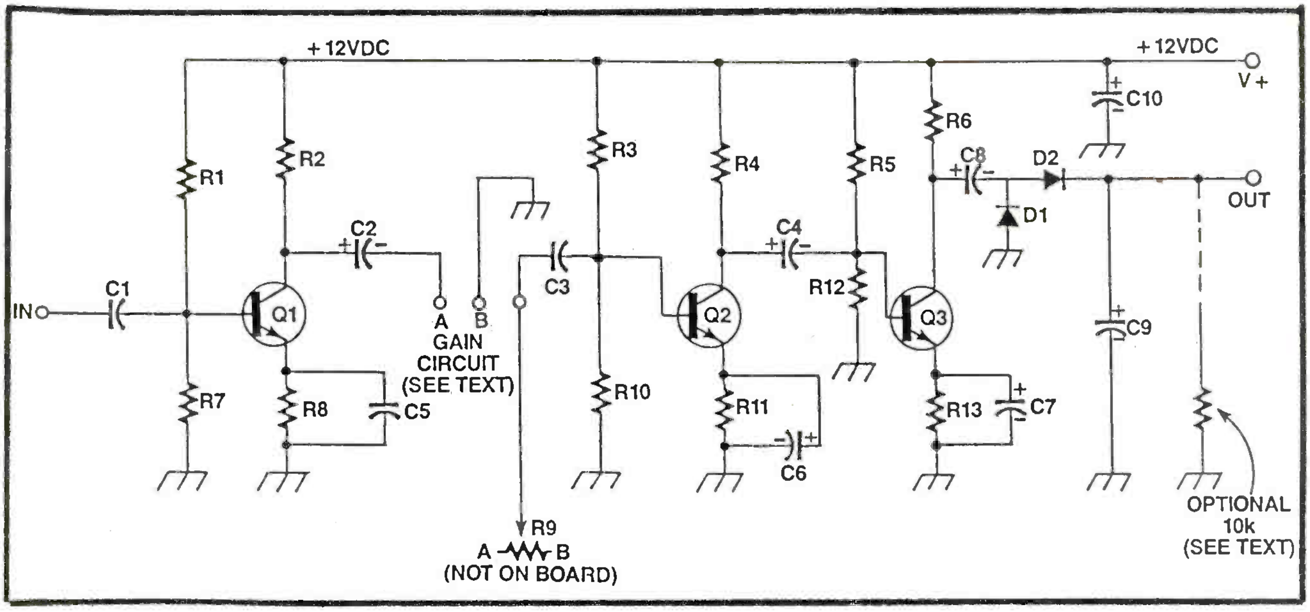


Fig. 2: Circuit for 70 dB gain block.

VLF RECEIVER PARTS LIST

C1, C3—100 pF disk ceramic capacitors
C5—0.1 uF capacitor
C2, C4, C6—2.2 uF tantalum electrolytic capacitors
C7, C8, C9, C10—220 uF/16 WVDC (or higher) radial lead
R1, R3, R5—100k ohm resistors
R2, R4, R6, R7, R10, R12—10k ohm resistors
R8, R11, R13—470 ohm resistors
R9—10k ohm potentiometer, panel mount (do not use wirewound)
Q1, Q2, Q3—2N4401, ECG-129AP, NTE-129AP, or equivalent
All capacitors 25WVDC or higher, unless otherwise noted
All resistors ¼-watt carbon composition or metal film, 5% tolerance

VLF Receiver Project

Figure 2 shows the circuit for a VLF receiver that is based on a design by Mr. Art Stokes (N8BN), and used extensively by members of the American Association of Variable Star Observers Solar Division. The circuit of Fig. 2 is the gain block and rectifier-integrator portions of the overall receiver circuit. The three transistor amplifier of Fig. 2 provides about 70 dB of gain at frequencies in the VLF range. The original transistors used for Q1, Q2, and Q3 were 2N4401 devices. If you can easily obtain these transistors, then use them. Otherwise, use a service-type replacement device such as the ECG-129AP or NTE-129AP. I tested a version of this receiver using the NTE-129AP and had no difficulties; the results compared favorably with the performance of a 2N4401 version made earlier. The replacement type transistors can usually be bought from local parts distributors, especially those that deal with the television and electronics repair trade in your area. A mailorder source for the NTE-129AP is **Ocean State Electronics** (6 Industrial Drive, P.O. Box 1458, Westerly, RI, 02891; 1-401-596-3080).

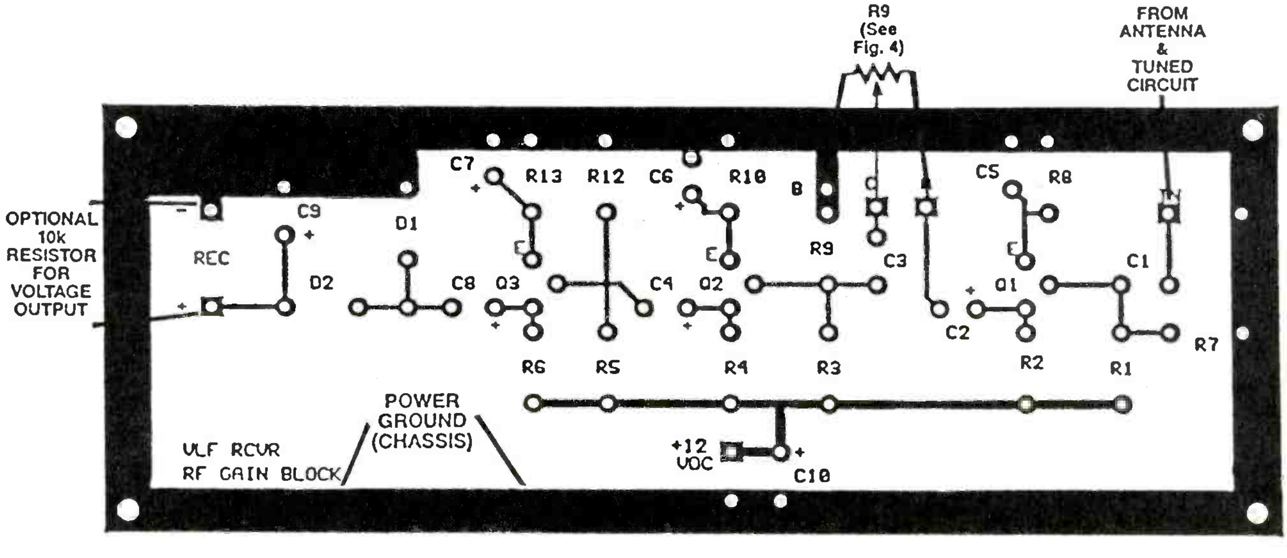


Figure 3 Printed circuit pattern and parts layout on PCB.

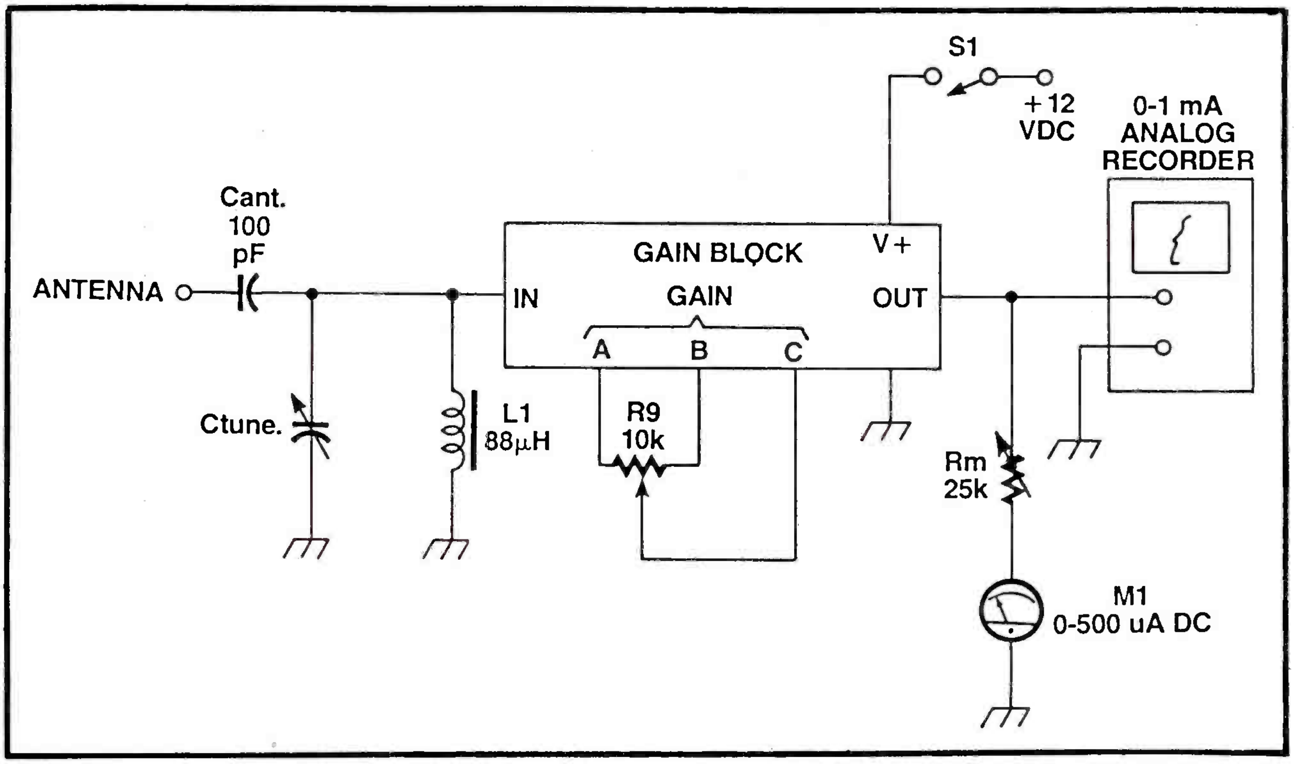


Fig. 4: Connections to the PCB.

The three transistor amplifier stages are common emitter amplifiers using an emitter bias resistor for thermal stabilization and a resistor voltage divider network for base-emitter bias. All three stages are identical, with the exception that gain is controlled in the first stage by limiting the emitter bypass capacitor (C5) to 0.1 µF rather than the 2.2 µF used in the other stages. This is done to prevent overload.

The output of this receiver is either a voltage or a current that is proportional to the signal strength. The output signal is developed by rectifying the output of stage Q3. A voltage doubler rectifier circuit consisting of C8, D1, D2 and C9 provides the DC signal from the RF available at the collector of Q3. The diodes used in the rectifier are ordinary germanium signal diodes. The specified part is the 1N60 device, which can be obtained from **Radio Shack,** Jameco (**"Jim-Paks"**) and elsewhere. Alternatively, you can use the ECG-109 or NTE-109 (**Ocean State Electronics** stocks these also).

Because C9 is very large (220 µF), it also serves to integrate the output signal. What this means is that variations over short periods of time are integrated out of the signal. Although C9 tends to filter out short-term noise, it also makes the tuning broad.

The output as shown will produce a current of 0 to 1 milliampere (mA) for strong VLF signals. Many solar observers use a 0-1 paper recording milliammeter for recording the output. Others, however, use either a computer with an A/D converter, or an analog voltage recorder. If a voltage output is desired, then connect the optional 10K ohm resistor (actually, up to 33K ohm seems to work just as well) across the output. Figure 3 shows the printed circuit board layout for the gain block circuit, while Fig. 3 shows the components layout for the PCB.

Note that this circuit is basically a VLF amplified voltmeter or milliameter. Although it is intended for use in solar monitoring via VLF radio, it can also be used for an ac/rf voltmeter up to about 100 KHz.

The connections to the 70 dB gain block PCB are shown in Fig. 4. This circuit is intended to be built inside a shielded aluminum cabinet, or inside an aluminum chassis (if you don't want to be fancy). The Gain Control circuit consists of R9, which is a 10K ohm, linear taper potentiometer on the front panel of the receiver.

There are two output circuits shown here. Some people use both in parallel, as shown, while others keep them separate and use a single-pole double throw (SPDT) switch to select between the two. One circuit is for a panel meter readout. Although any DC current meter from 0-100 µA to 0-1 mA can be used, I've found that the 0-1 mA tends to be a bit sluggish, and the 0-100 µA tends to be a little too active. Thus, the 0-500 µA range is specified for the microammeter (M1). The meter sensitivity is controlled by a 25K ohm potentiometer mounted on the front panel close to the meter movement.

The output analog recorder is a 0-1 mA analog recording milliammeter such as the **Rustak** Model 288. Although used extensively by amateur solar observers, these recorders are a bit expensive. Now that analog-to-digital (A/D) converters are a lot cheaper than analog recorders, anyone who owns a microcomputer might be well advised to use the computer instead. For those cases, the voltage output version may be preferred (note: if you use the microammeter for output display, then you won't need the optional 10K ohm resistor shown in Fig. 2).

The tuning network consists of a variable capacitor and an inductor. The inductor shown in Fig. 4 is an 88 mH toroid of the type used by ham operators for audio filter circuits. These are found advertised in ham magazines, as well as at hamfest flea markets. The capacitor is any form of AM broadcast variable with 365 pF maximum capacitor, or more. Some people use two section 365 pF or 380 pF variables, and then use a switch to select either one section or both sections in parallel to change the tuning range. Because of the low frequencies involved (20 KHz or so), the wider the range of capacitance available, the more of the band that can be tuned. It's not unreasonable to use 400 pF, 500 pF or even more. With a 380 pF capacitor from **Ocean State Electronics** my unit tuned 18 to 30 KHz with an 88 mH toroid coil.

The antenna is connected to the circuit at the L-C tuning network through a 100 pF disk ceramic capacitor. The antenna can be a VLF loop (60 to 120 turns, 2 foot square), or a simple vertical pipe about 8-10 feet long. Art Stokes told me that he's even used a drain downspout on his house and the metal dome of his observatory.

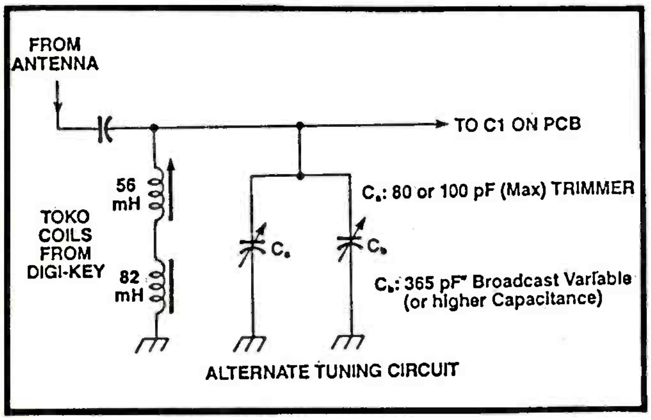


Fig. 5: Alternate tuning circuit no. 1.

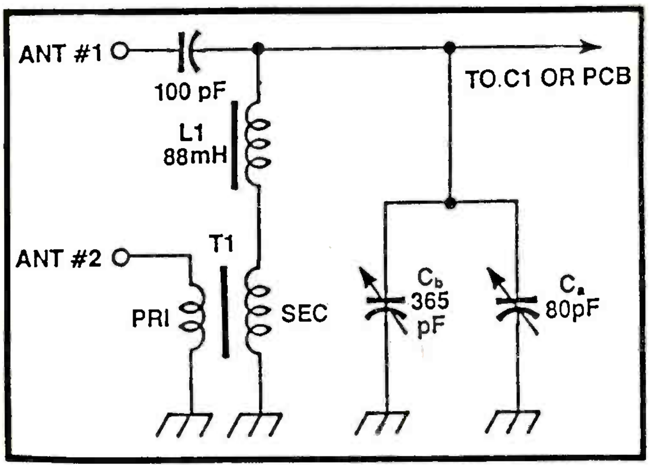


Fig. 6: Alternate tuning circuit no. 2.

Figures 5 and 6 show two variations on the tuning circuit scheme. These circuits can be built on perfboard, if desired. The inductance in Fig. 5 consists of two inductors connected in series. I used **Toko** coils from **Digi-Key** (P.O. Box 677, Thief River Falls, MN, 56701-0677; 1-800-344-4539). A 56 mH variable coil (**Digi-Key** no. TK-1724) is connected in series with an 82 mH fixed coil (**Digi-Key** TK-4424). The fixed coils in this series go up to 100 mH (**Digi-Key** TK-4425) and 120 mH (**Digi-Key** TK-4426). Because there is no interaction between the magnetic fields of the two coils, the total inductance is the sum of the two inductances, or 138 mH. The capacitor is the same as in the previous case, but a trimmer is added to aid alignment.

The variant of Fig. 6 uses an 88 mH toroid (although an 82 mH, 100 mH or 120 mH coil as above could be used as well) in series with a small transformer (T1). The primary of the transformer provides an alternate antenna input. The transformer that I tried was a xenon tube trigger transformer (6K V size). The low inductance side of the transformer is used as the primary while the high inductance side (typically 5 mH or more) is connected in series with the other inductor.

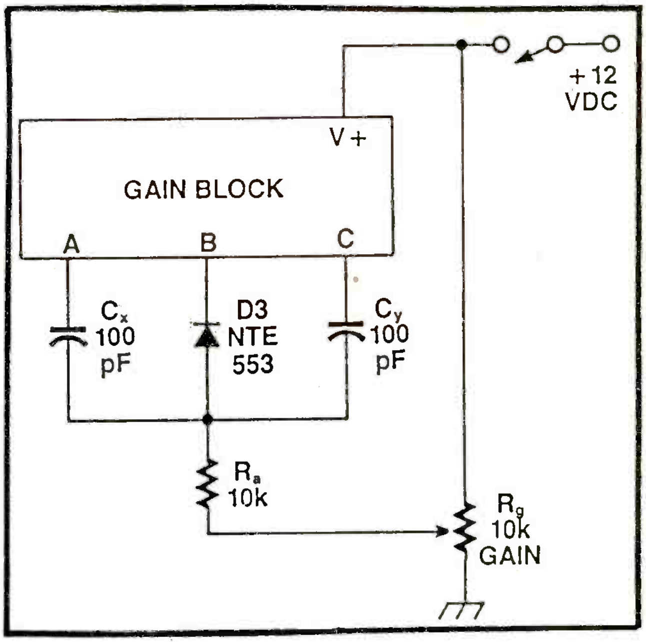


Fig. 7: PIN diode gain setting circuit.

An alternate Gain Control circuit is shown in Fig. 7. This circuit solves the problem of routing VLF RF across the chassis to a panel potentiometer (as in Fig. 4) because it uses a DC voltage applied to forward bias a Schottky hot carrier PIN diode (NTE-553 or NTE-555 suitable). When the bias voltage is high, then the diode is heavily forward biased and, because it is across the signal path, causes the signal level to be low. Alternatively, when the applied voltage is low or zero (e.g. when the GAIN potentiometer wiper is close to the ground end), then the diode is essentially unbiased and the signal level is high.

Figure 8 shows the connection of the output scheme when the voltage output is used to drive an A/D converter. Voltage levels for strong signals tend to be 2.5 to 4 volts DC, so will fit nicely into the range of a 0 to 5 volt A/D converter. The output of the converter is fed to a personal computer. Suitable A/D converters can be found that either plug into one of the motherboard slots inside the PC, or connected externally. Several modes are available that derive power from the PC, but connect to either the RS-232 serial communications port, or the parallel printer port (yes, the parallel printer output port can be used as a parallel input port under the right conditions).

Figure 9 shows some recordings made available by Art Stokes. These show proper operation of the receiver. The receiver is adjusted to about 25 KHz (where there is a strong Navy VLF radio station) at mid-day, and the output adjusted to mid-scale on the recorder or A/D converter. At sunset, VLF levels drop, so there will be a drop in output level (Fig. 9A), followed by a rise of a more ragged looking signal that is formed by "night noise." The night noise phenomenon continues all night long, until sunrise when the so-called "Sunrise Effect" is seen (Fig. 9B). The Sunrise Effect is an S-shaped deep dip in signal level, followed by a return to the daytime value. If a solar flare occurs during daylight hours you will see a sudden increase followed by an exponential decay (Fig. 9C).

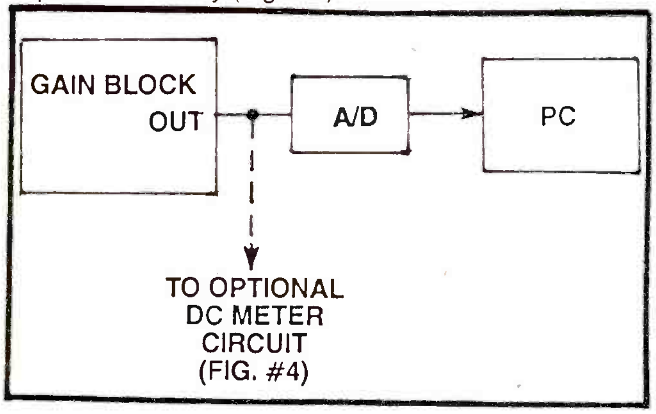


Fig. 8: Using an A/D converter and PC for recording output data. If you already have a PC, then it's a lot cheaper than an analog recorder.

Conclusion

VLF DXing can be a fun experience, especially when linked to something like solar amateur astronomy. Readers who want to build the VLF receiver can either make the printed circuit board, or obtain one from the author (P.O. box 1099, Falls Church, VA, 22041) for $12. If you want to build a VLF loop antenna (which is highly recommended), see my book **Joe Carr's Receiving Antenna Handbook** (HighText Publications, Inc.; 1-800-247-6553). A computer program for finding the inductance and tuning capacitance for loop antennas is **Antlers for Windows Ver. 2.00,** also available from me at $30. **Antlers** is also used for calculating the lengths of many popular antennas for frequencies from 500 KHz, through the HF shortwave bands, and into the VHF-UHF scanner receiver bands. ■

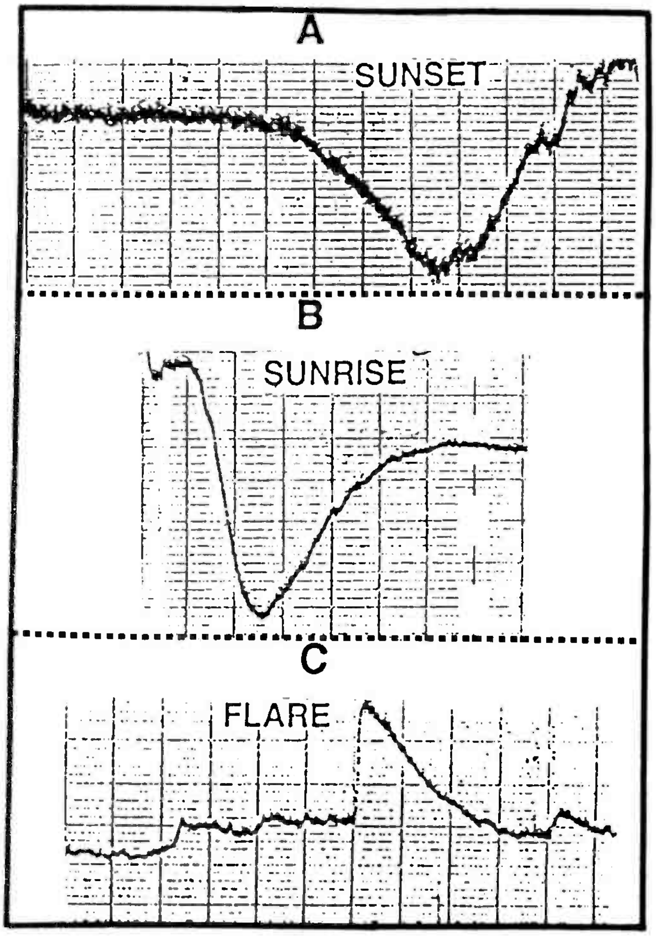


Fig. 9: Results: A) day-time and sunset patterns; B) Sunrise Effect; C) solar flare event.

ELECTRONICS HANDBOOK

P.O. Box #5148, N. Branch, N.J. 08876

☐ Yes. Enter my subscription—4 issues ONLY $15.00
(Canada $18.00,..Foreign Postage add $10.00 .U.S. Funds)

☐ Payment enclosed. (Payable to: C&E Hobby Handbooks)

PLEASE PRINT
NAME: ______
ADDRESS: ______
CITY: ______
STATE: ______ ZIP ______

V19

WORKBENCH PROJECTS

The projects we've prepared for you in this section are more complicated than those in our **Circuit Fragments** section, but they are less complicated than the ones in our **IC Testbench** section.

GROUND SHOOTER

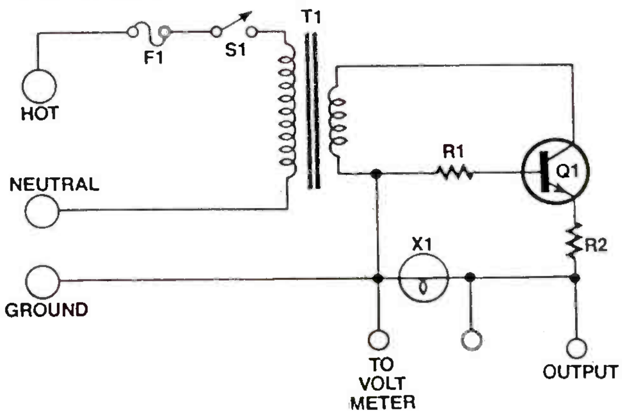
In order to determine if a ground is good, it's always nice to be able to test it. Most meters that are used for testing resistance on a ground do not do a very good job, and even bridge circuits don't deliver much current through the ground to determine if it's good or not. This circuit, however, does deliver some current through the ground.

It works very simply by taking 110 volt power and making 6.3 volt power out of it at 2 amps. When Q1 is turned on, which it is as soon as power is delivered to the transformer, it passes 2 amps through resistor R2 from the connection that's marked "output" through to the ground. You can connect an alligator clip to this output connection, and then you can connect it to a given ground. Since this circuit plugs into 110 volts, the ground pin in the AC plug is the return. Therefore, you're checking out the ground wiring that you're testing, plus you're checking out the ground wiring in the wall. This will give you an adequate idea whether or not a given ground in your electrical distribution system is truly a good ground. What happens if the ground is not good, X1, a #47 pilot light, will light up, and the brighter it lights up the worse the ground is because, you see, when you have a good ground connection, X1 is shorted out.

Another way to tell if you have a good ground connection, is to connect a volt meter across X1, and that will tell you by how many volts there is, how good the ground is. This isn't really a resistance check, but it is a good go, no-go check of whether the ground is capable of carrying some serious current. And that can be more important sometimes than a mere resistance check which may not show up a ground connection that's only capable of handling a few milliamps, or possibly less than an amp. This meter will tell you if you can pump 2 amps through that ground or not and, for electrical distribution, that could be quite important. ■

PARTS LIST FOR THE GROUND SHOOTER

R1—5.6K, 1/2 watt resistor
R2—3 ohm, 10 watt resistor, wire wound
F1—1/2 amp fuse
S1—single pull, single throw normally open switch
T1—110 volt to 6.3 volt to 2 amp transformer
Q1—NPN power transistor. (A 2N3055 would work good for this, and you wouldn't have to use a very big heat sink, or any other power transistor capable of passing over 2 amps, which should be heat sinked.)
X1—#47 pilot light.
You will need a box and a good power cord with three-wire capability for this.



MULTI-PURPOSE TESTER

One of the problems that many people seem to have with test equipment is that it is either very expensive, bulky, or troublesome to deal with. I decided a long time ago that I wanted equipment that was simple, reliable, and could be used to test a multitude of devices.

Such a circuit is the Multi-Purpose Tester. It uses only a handful of components, but it's usefulness is limited only by your imagination and creativity.

As an example, if you look at the circuit, you can see that there are three connections, labeled one, two, and three. To start with, let's test some transistors with this circuit.

An NPN transistor connects the following way. The collector lead goes to pin one, the base lead goes to two, and the emitter goes to three. As soon as you connect the base lead to pin two with the other two connected, the transistor should turn on, unless it's a special enhancement mode type, which may not work. But you can use this to test small signal and certain power transistors if they aren't too big.

You can also use the same hook-up to test SCR's. Pin one would be the anode, pin three would be the cathode, and when you touch pin two to the gate, it should trigger the SCR, and the SCR should lock on.

You can also use this to test one mode of a TRIAC by testing it in the following manner. Connecting the emitter to pin one, collector to pin three, and using pin two to switch the base on and off, you can check PNP transistors.

You can check diodes by connecting them with the anode to pin one, and the cathode to pin three. The LED should light if the diode is good.

In all cases, LED X1 will light when the component is good or on. If the component is shorted and you haven't connected anything to the base or the gate, as the case may be, that LED shouldn't light.

I would recommend also that when you test these components, you realize that certain components may not switch on if they require more energy than you can force through R1, in which case you may want to substitute R1 with a potentiometer and a series resistor. I would recommend using a 100K potentiometer and 100 ohm series resistor just for the protection of the components. If you use no series resistor and you turn the Pot way down, it could deliver the whole power from the battery to the components, which may damage them. Certain small signal devices may also be damaged but this tester should be able to test just about anything, including unijunction and FET transistors which connect the same way as bipolar transistors and will switch the LED on. Since the LED only takes a few milliamps to turn on, the smallest signal devices I know of that are able to be grasped by small clipleads will test fine with this tester.

Another thing you can do very simply is use pins one and three as a continuity checker. If you have a circuit that has continuity, it will be revealed by making these same connections to the circuit to see or test cables. It works as a good cable tester or wire checker, or any kind of continuity test you want to run.

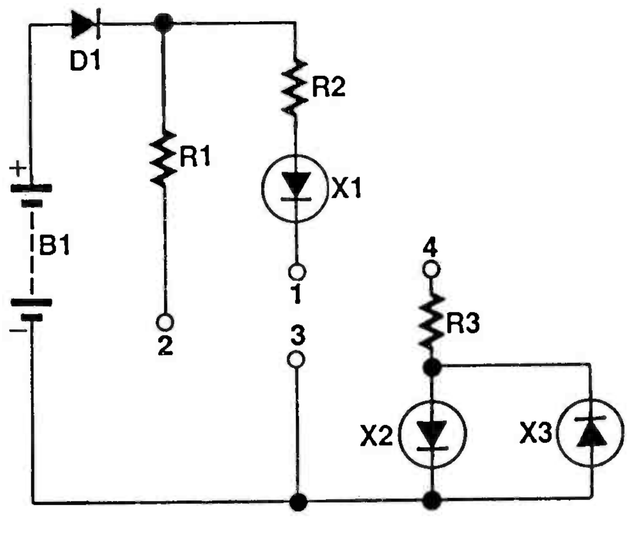
There is another aspect to this circuit. By using pins three and four, we have an AC or DC voltage indicator. Voltages up to 24 volts can be detected using pins three and four. Four is the plus, and three is the minus, and if it is DC, X2 will light, if it's AC, X2 and X3 will light. It is probably a good idea to use three different colors of LED's for X1, X2, and X3, and, since you can now choose between yellow, blue, red, green, or orange LED's, you should be able to find a color you like.

The circuit has some other uses too. If you want to check zener diodes that are low voltage, for instance, up to about 7 or 8 volts, connect them as you would connect another diode, and they should switch on once they're in place. If you have a potentiometer in the place of R1, you can use pins two and three, using two as the anode and three as the cathode, adjust that accordingly and read right across the zener to see what voltage is triggering it.

The multi-purpose tester can be built in a very small box. The prototype used by the author has four leads with alligator clips on the ends that are color-coded that they can be connected as desired. Enjoy yourself, build one of these little testers, and see just exactly how many different things you can do with it! ■

PARTS LIST FOR THE MULTI-PURPOSE TESTER

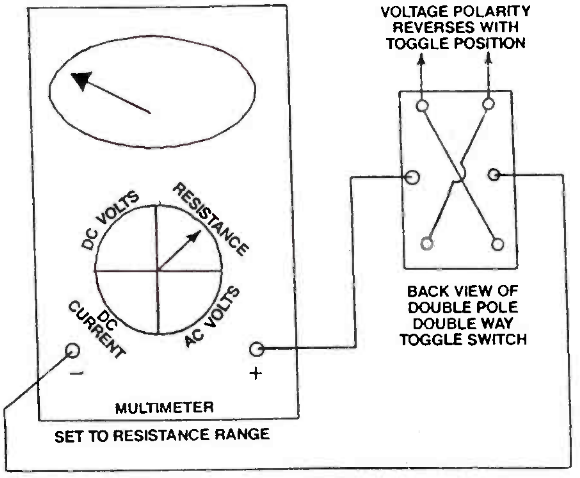
R1—10K ohm, ½ watt resistor
R2—390 ohm, ½ watt resistor
R3—1,000 ohm, ½ watt resistor
D1—1N4007 diode
X1, X2, and X3—LED's. You can use any kind of LED you like, high brightness, or whatever. The author chose high brightness LED's because they can be seen at a distance.



REVERSIBLE VOLTAGE SOURCE

A budget priced analog multimeter i.e. one that typically measures, DC volts, AC volts, DC current and resistance can serve as a useful tool for providing a low voltage source (typically a few volts). On the resistance range, when the meter is set to measure resistors, the meter is actually applying a voltage through your resistor under test and measuring the resultant current. Since the source voltage is known and fixed, the 'current meter' can thus be calibrated in terms of resistance values or ohms. This is the basic principle of measurement for simple ohmmeter circuits. On this low cost analog meter, with the meter set to measure resistances on the highest range (in this case x1K scale factor), the voltage appearing across the test leads is about 3 volts but of the **opposite polarity** to the color of the tests leads. The red test lead is actually the negative voltage source and the black test lead the positive voltage source. Knowing this fact, you can then understand why simple forward versus reverse 'resistance' measurements on diodes and transistors, give the results that they do. When checking diodes and transistors, for determining whether the component is faulty or to identify an unmarked transistor, you often have to reverse the leads. This can be awkward, given the small size of transistor or diode leads.

To make things easier, we use a double-pole double-throw toggle switch and wire this as shown. The multimeter leads (set to the resistance range) go to the center pair of terminals and the source voltage comes from the remaining pair. Use insulating wire for the 'cross' connections to the switch to prevent any shorts. Now as you toggle the switch, the voltage will change in polarity. Label the switch to correspond to the correct polarities. If you have a second multimeter, **set to the DC voltage range,** you can verify the polarities. ■



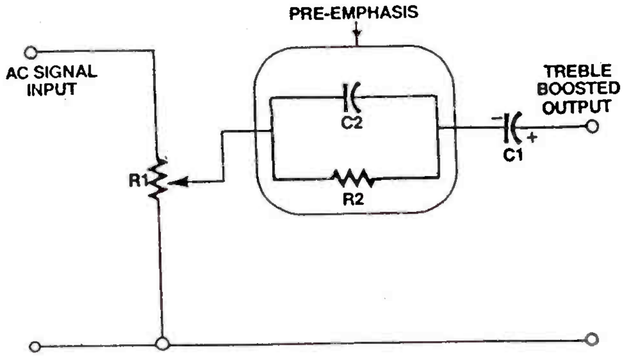
PARTS LIST FOR THE REVERSIBLE VOLTAGE SOURCE

Analog multimeter
Double pole double throw toggle switch.

PRE-EMPHASIS TREBLE BOOST

Pre-emphasis is a technique used at the transmitter source when FM (frequency modulated) signals, such as the regular 88 MHz to 108 MHz commercial FM radio band is broadcasted, to your standard 'FM' radio. For noise reduction purposes, the higher frequencies are given a treble boost or 'pre-emphasis' as it's called. At the receiver end, there is a corresponding treble cut, called 'de-emphasis' which compensates for the 'treble boost' that was added at the transmitter. Two very simple components are all that is needed to provide pre-emphasis and since the technique is so simple it's shown here as a nice quick way to gain extra treble in audio amplifier stages. Potentiometer, R1, adjusts the level of the incoming audio signal and **normally** this would be coupled through the DC blocking capacitor, C1. However, by simply adding the extra shunt components, R2 & C2, before C1, the extra treble boost is achieved.

The values shown for R2 & C2 are typically used for FM transmissions, however, it will serve as a good starting point to experiment with. As the frequency increases, the impedance of the R2/C2 combination will decrease, lowering the series impedance to the incoming audio and hence giving the effect of 'more treble gain'. High values for R2 will attentuate the overall signal. If you find this to be a problem, reduce the value to an acceptable level and then experiment with values for C2. ■



PARTS LIST FOR THE PRE-EMPHASIS TREBLE BOOST

R1 — 10K potentiometer
R2 — 75K resistor
C1 — 10uF electrolytic capacitor
C2 — 0.001uF capacitor

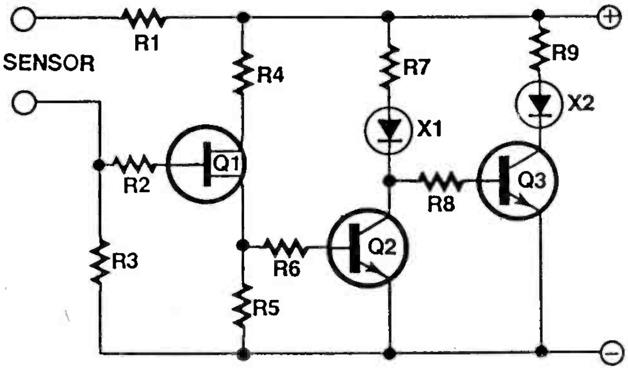
WATER DETECTOR

There are many ways to detect water electronically. Some are more sensitive than others. This one is fairly sensitive and doesn't require too much help. It's a very simple circuit that uses two contacts which can be made in the form of a maze, or it can be two wires running next to each other. But whatever you use, they should be no closer to each other than 1/8 inch, and no farther apart than 1/4 inch. It sometimes enhances the sensitivity of these devices to sprinkle just a little bit of salt around so that when the water does come, if it's pure water, it will have a little salt in it to conduct electricity. But this circuit uses Q1, which is a field effect transistor, in order to make the circuit function a little more effectively, even if there isn't much salt or conductivity in the water.

The circuit operates very simply. Q1 is a high impedance input transistor that requires very little power to function, so water that isn't very conductive (pure water isn't very conductive), will still conduct from the two electrodes, one at the bottom of R1 and one other at the junction between R3 and R2, passing just enough current to energize the gate of the field effect transistor and allow conduction from source to drain. When this conduction takes place, the transistor, Q2, receives power through the field effect transistor and R6, and turns on, lighting X1, which is a red LED. Under normal conditions, there is not enough power going through X1 to light it fully, just enough power to turn Q3 on, that had the green LED lit, X2. The green LED indicates there is no water present, and when the red LED is lit, Q2 effectively shorts out the base current going to Q3, turning off the green LED. ■

PARTS LIST FOR THE WATER DETECTOR

R1, R2, and R5—100K ohm, 1/4 resistors
R3—1 megohm resistor
R4, R6, and R8—10K 1/4 watt resistors
R7, R9—390 ohm, 1/4 watt resistors
Q1—N-channel, field effect transistor
Q2, Q3—2N3904 transistor
X1—red LED
X2—green LED
The power applied to this circuit can be anywhere from 6 to 15 volts DC.



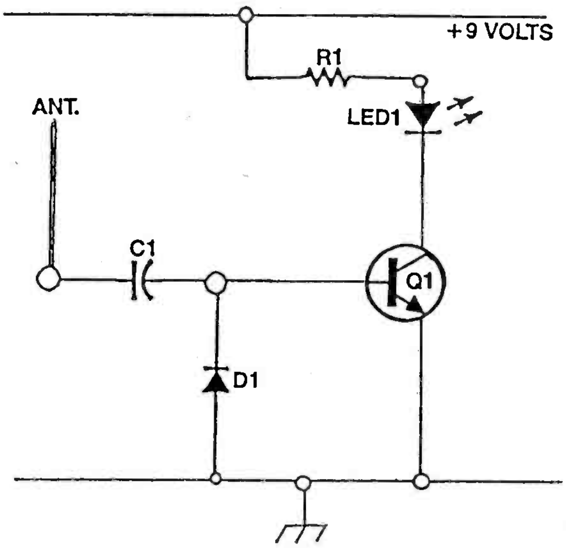
RF SNIFFER PROBE

High power sources that emit RF (radio frequencies extending from about 20kHz to well into the microwave region) can be troublesome as sources of interference. Ham radio operators, for example, use high powered RF amplifiers to send their legitimate signals to the far flung corners of the world. If you happen to be next door to them, some of this 'RF soup' could well be spilling over and upsetting your favorite TV program. To detect RF signals coming from **high power** sources, a handful of ordinary components are all you need. Transistor Q1, is your common NPN workhorse device, used as a DC switcher (even microwave RF signals are 'converted' into DC, so no special RF transistor is needed).

A short whip antenna is coupled into capacitor C1 and rectified by the germanium diode, D1. D1 will provide a small DC voltage every time the whip antenna encounters a very strong RF signal. Make sure the polarity is as shown. LED1 and limiting resistor R1 are placed in the collector lead and provide a visual indication when RF is present. C1 can be decreased in value if frequencies above a few 10's of MHz are expected. The value shown will cover most of the typical short wave radio band (1.8kHz to 30MHz). Power is from a 9V battery and current drain will depend on the value of the LED series limiting resistor. To conserve power use a higher value, however, too high a value makes the LED difficult to see. ■

PARTS LIST FOR THE RF SNIFFER PROBE

ANT.—Short whip antenna
C1—470pF capacitor
D1—1N34 germanium diode
Q1—2N3904 NPN transistor
LED1—Light emitting diode
R1—680 ohm resistor

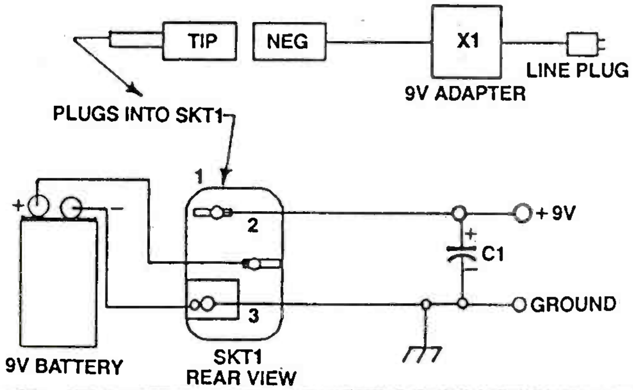


BATTERY OR ADAPTER POWER

If you want the portability of battery power and also the sustainability of adapter power try building this neat arrangement for using either battery or adapter options. Let's start with the adapter itself. The Radio Shack 270-1560 adapter will give you 9 volts with a 300mA capacity, which is more than sufficient for most circuits. You get a selection of output connectors with this adapter. To match the adapter, you need the coaxial DC power jack (274-1565). Any one of the many supplied output connectors that comes with the adapter, will fit this jack. It is the one that is 2.5mm in size. To make absolutely certain, identify the one that fits absolutely snugly. Be careful of the larger size (2.8mm) which appears to fit, but is really only making intermittent contact. Push the coaxial connector into the adapter termination, so that the **'neg' marking lines up with the 'tip' marking!** This is important! The diagram shows the connections for having a 9v battery or adapter option. Take very careful note of the way the terminals are identified. The capacitor, C1, reduces the 'hum', inherent with these types of adapters. When the adapter is out of the jack, pins 1 and 2 are connected and you can see that the 9v battery goes normally to the load. Pin 3 is the negative or ground pin. When the adapter is pushed in the jack, pins 1 and 2 are an open circuit and pin 1 now goes to the load, i.e. the power feed is from the adapter. Verify carefully with a voltmeter that all polarities are correct before connecting your load. ■

PARTS LIST FOR THE BATTERY OR ADAPTER POWER

X1—9v adapter (Radio Shack 270-1560)
SKT1—coaxial DC power jack (Radio Shack 274-1565)
C1—4700 uF 25v electrolytic capacitor



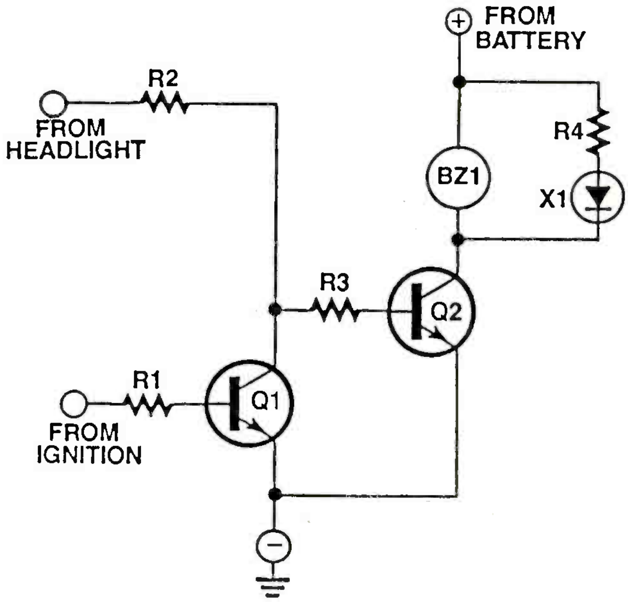
LIGHT MINDER

My wife gets on my case quite a bit because I leave the lights turned on in the car, and you know what, I get out of that car and ignore the normal chirping and honking of the alarms, especially since, when I take the key out of the alarm, there is no indication that the lights are still on unless I happen to look at them, which can be a real problem in the daylight. So, I had to come up with an answer, and this circuit is it. It uses a buzzer and an LED to indicate those lights are still on, and it will stay on and squawking even when you take the key out, in fact, that's the general idea.

The way this circuit works is real simple. Power is picked up from the lights themselves so, if the lights are on, 12 volts are at the top of R2, and are feeding through R2 and R3, turning Q2 on. Q1 is off at this point and, with Q2 on, the buzzer screams and X1, the LED, lights. What happens is, when you turn on the ignition, the load side of the key switch is connected to R1. With the ignition switch on, R1 receives power, and that switches Q1 on, which effectively grounds the connection between R2 and R3, shutting Q2 off, and the circuit shuts up. Whenever you have the ignition switch off and the lights are still on, it screams. When the ignition switch and the lights are both off, nothing happens. You use the 12 volt power from the car battery to power the buzzer and the light, and the power is switched off once you switch off both the lights and the ignition. But if only the lights are on and the ignition isn't, you get the screaming. It might save you an extensive recharging or replacement of the battery in your car. ■

PARTS LIST FOR THE LIGHT MINDER

R1, R2, R3—10K ohm, ¼ watt resistors
R4—390 ohm, ¼ watt resistor
Q1, Q2—2N3904's, or 2N32N2222's can be substituted, or use just about any NPN transistor, small signal or fairly large signal is not going to be doing too much in the way of power, and will work.
BZ1—Sonalert. (Radio Shack has a couple that are good for 12 volts and are pretty piercing. You can pick whatever you like.)
X1—LED



BUILD A DC DIGITAL VOLT METER

By
Fred Blechman

This project teaches you about analog-to-digital conversion, 7-segment digital displays, and making voltage or current readings. You'll end up with a portable digital voltmeter that will directly measure and display up to 20 volts DC with a resolution of .1 volts, well within the voltage range and resolution most common electronic products use. If you choose to make the modifications described, you can make a digital multimeter for measuring various ranges of DC voltage and current.

The schematic, basic theory of operation, and a complete parts listing, are provided. All the parts and a printed circuit board are available as a Complete Parts Kit (including a case), as well as a Special Parts Kit of several special or hard-to-find parts.

Introduction

There is hardly a handier piece of test equipment than a voltmeter. Equipment failures often result from a problem in the power supply. This can be anything from a weak or dead battery to a failed diode or transistor. The cardinal rule of troubleshooting is to check voltages.

But you need a volt meter to measure voltages, and there are several problems associated with this. If you use a common analog meter with a needle that swings up a scale, you should be aware that some of these meters draw significant current when making their measurement, and can actually upset circuit operation. In effect, when you touch the meter probes to the circuit, you effectively create another circuit path for current to flow. The better analog volt meters are rated at an input resistance of at least 20,000 ohms per volt (meaning it looks like 20,000 ohms resistance for each volt it is measuring.) While a low input resistance is not significant when measuring voltage in high-current circuits, such as in an automobile, it can have a significant effect when measuring typical consumer transistor or integrated circuit voltages.

Additionally, analog meters often have problems with fragility and accuracy. Most meters of this sort have a zero adjustment because frequent handling causes the delicate jewelled meter movement to get out of balance. Mistreat these movements badly enough and the needle will bend and stick, or the needle pivots will jam.

Also, some analog meters are hard to read, especially those with multiple scales. Some even have a mirror behind the needle so that you can eliminate the "parallax error" of looking at the needle from the side (and misreading the scale markings) instead of reading directly above the needle.

On the other hand, digital meters read numbers (no parallax error) and usually have the decimal point properly placed. Most digital meters also show a polarity sign in case you have the leads connected in reverse. Most importantly, the input resistance of most digital meters is somewhere around 10,000,000 ohms (10 megohms), regardless of the voltage being measured. This means digital voltmeters have virtually no effect on the circuit they are measuring.

The digital volt meter described in this construction project has a 10 megohm input resistance, and is designed to read and display DC voltage from .1 to 19.9 volts in .1 volt increments. While this may seem like a limited range, most transistor, integrated circuit and automotive voltages are below 20 volts.

No negative polarity indicator is displayed, but can be easily added. For convenience and portability, this project is battery-operated, and four AA alkaline penlight batteries provide about 15 to 20 hours of continuous operation. Since no fragile moving needle movement is involved, this unit is relatively rugged. For those of you who like to experiment, later in this article we will describe some changes you can make to add a polarity indicator, and read higher voltages or DC currents.

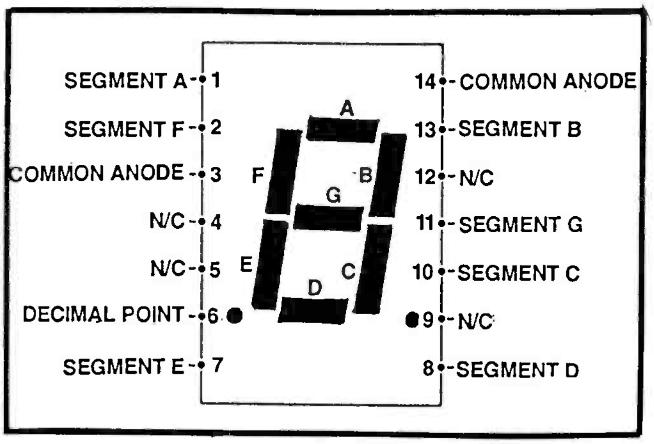


Figure 1. HP 5082-7730 Display or equivalent

7-Segment Displays

Figure 1 shows the pin connections for the 7-segment LED (light-emitting diode) displays used in this project. These are "common-anode" displays, meaning each "segment" (lighted bar) is connected to positive voltage. Note that each segment has a letter designation—A, B, C, D, E, F, or G. In order for a segment to light, its pin must be connected to circuit ground, usually through a "driver" that consists of a resistor, or a transistor and its biasing resistors.

The combination of segments lighted at one time form a number. For example, light segments B and C for a number 1. Segments A, B, C, D, and G form the number 3. All segments together form the number 8. Get the idea?

These displays also appear to have a left and right decimal point. However, the actual displays used in this project have only the left decimal point connected internally.

A-to-D Converter

Figure 2 shows the heart of this design, the Teledyne TC807CPL 2½ digit analog-to-digital converter. This 40-pin integrated circuit (IC) is designed to drive standard 7-segment LED displays WITHOUT external drive electronics. That is, the resistors and transistors normally needed to light 7-segment displays are provided INTERNALLY in this IC. This is a significant saving in parts. Although it would normally require 16 external transistors and up to 48 external resistors to light the 16 segments of 2½ digits, they are not needed with the TC807CPL, since the necessary driver circuitry is built into the IC!

The operation of the TC807CPL is fairly complex, as reflected by the strange designations of some of the pins shown in Figure 2. Most of these functions will be explained—or at least touched upon—in the following section.

Circuit Operation

The schematic diagram of the 2½ Digit Digital Voltmeter is shown in **Figure 3**. U1, the TC807CPL, is a 2½ digit analog-to-digital converter. The left digit can only count to 1, the others can each count from 0 to 9—hence the term "2½ digit." This IC contains all the necessary internal circuitry to process analog input voltages, convert them to digital signals, digitally count up to 199, latch and decode the count, and drive the three 7-segment LED displays.

When switch S1 is closed, four AA alkaline batteries

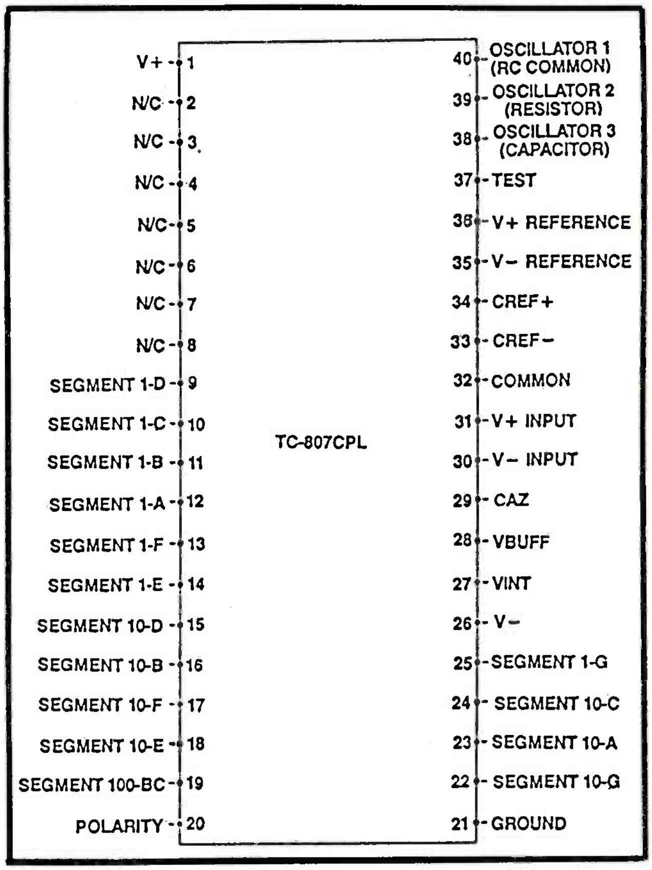


Figure 2. TC807CPL A/D Converter pinout

in a battery holder (B1) supply a positive 6 volts to U1, the TC807CPL IC, at pin 1, and also the common anodes of the three 7-digit displays, L1-L3. The negative side of B1 is connected to pins 26 and 21 of U1, power ground. Capacitor C1 acts as a battery voltage filter.

VR1 is a voltage regulator that provides a stable reference voltage for the internal A-to-D converter at pins 36 (positive) and 35 (negative.) Resistor R6 is used to limit the current through VR1. Resistor R7 and potentiometer P1 form a voltage divider to set the calibrating voltage at pin 36 of U1. Notice that pin 35, the V- Reference voltage, is connected back to the V− Input, pin 30 and Common, pin 32. This insures that the input voltage to be measured is compared with the stable voltage-controlled reference rather than the diminishing power supply voltage.

The DC voltage to be measured is applied to the input, with the positive applied to resistor R3, and the negative to pin 30. R3 determines the meter's 10 me-

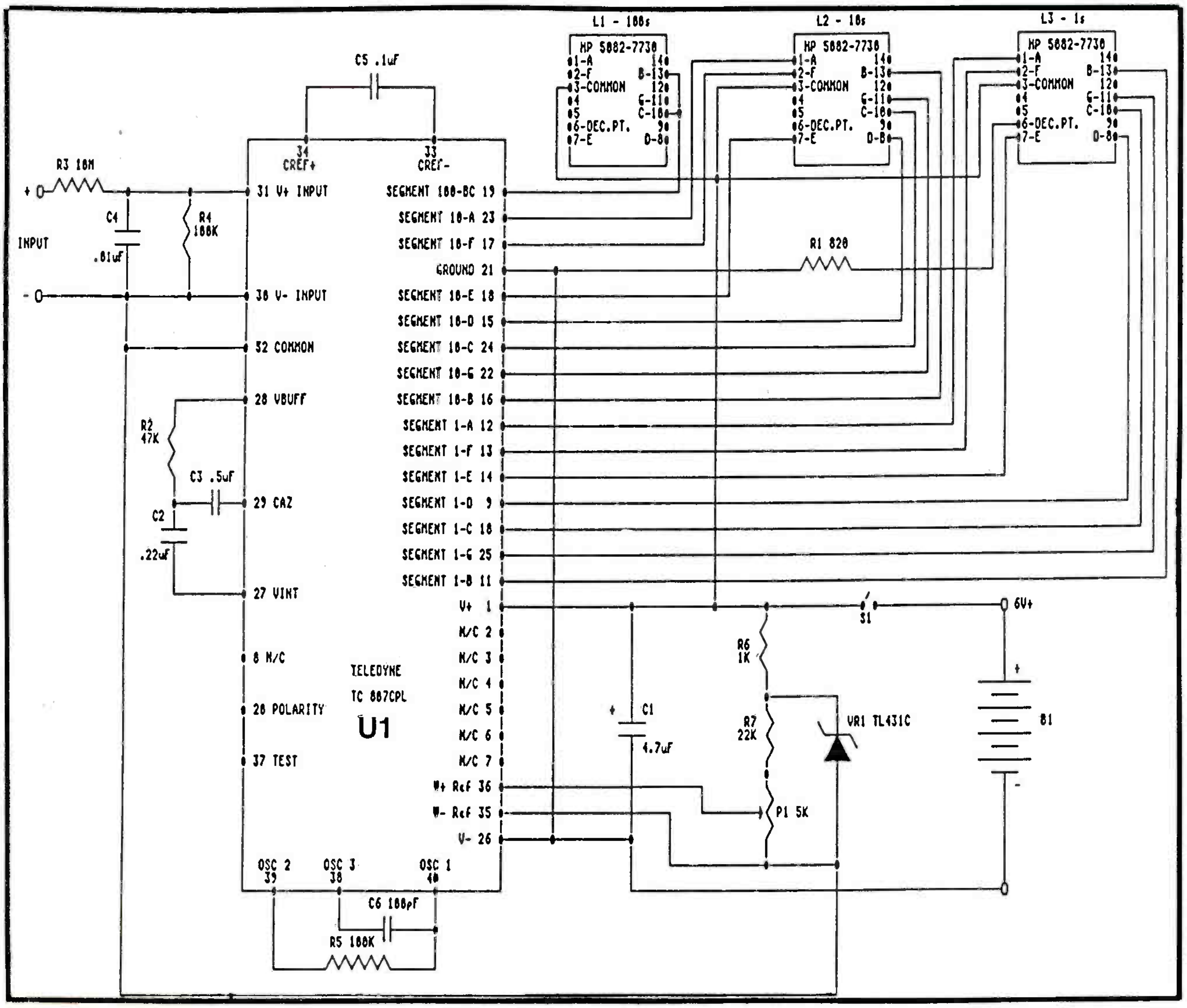


Figure 3. 2½ Digit digital voltmeter schematic

gohm input resistance. Capacitor C4 filters out any AC noise which might be riding on the DC input voltage.

R3 and R4 form a voltage divider that reduces the input voltage applied to pin 31 down to the input operating voltage required by U1—199 millivolts (.199 volts) or less. The ratio of R4 to (R3 + R4) is 100,000 divided by 10,100,000 or .0099, or about .01. That means if you are measuring 15 volts at the input, 15 times .01, or .15 volts (which is 150 millivolts) appears between pins 31 and 30. The meter would read 15.0 when properly calibrated.

How does this conversion from analog to digital happen? Each measurement cycle is divided into three phases: (1) auto-zero; (2) signal integration; and (3) reference integration. The conversion rate is set by the clock oscillator frequency, which is controlled by capacitor C6 and resistor R5, connected to U1 pins 38, 39 and 40. Using these components, the conversion routine measures and displays about three times each second.

The first phase takes place at pin 29, using auto-zero capacitor C3 and IC internal gates to establish a zero-input condition. Next, signal voltage integration takes place for a fixed number of clock cycles as a charge accumulates on capacitor C2 (pin 27) proportional to the input voltage. At the end of the signal integration period, reference integration is accomplished by having C2 discharge through buffer resistor R2 and pin 28. An internal digital timer measures the discharge time back to zero; the longer it takes, the higher the original input voltage.

The digital timer count is then decoded into three 7-segment LED drive signals through pins 9-19 and 22-25. In effect, each segment that is to be lighted is grounded through U1 with the appropriate internal driver circuitry.

The L3 decimal point (pin 6) is always ON, with its cathode grounded through current-limiting resistor R1 and the negative side of the power supply.

For proper reference in most applications, capacitor C5 is connected between U1 pins 33 and 34. Pin 20 provides a negative-polarity signal if the input voltage polarity is reversed; more on that later. Pin 37 provides a convenient test to see if all the display segments are correctly wired.

Construction

Because some of the parts used are special, or hard to find, the simplest way to build this project is to get the

Cal West HK621BN Complete Parts Kit offered in the Parts List. This includes an etched and drilled printed circuit board (**Figure 4**) and all the required parts. A plastic case and mounting hardware are also included.

PCB ARTWORK

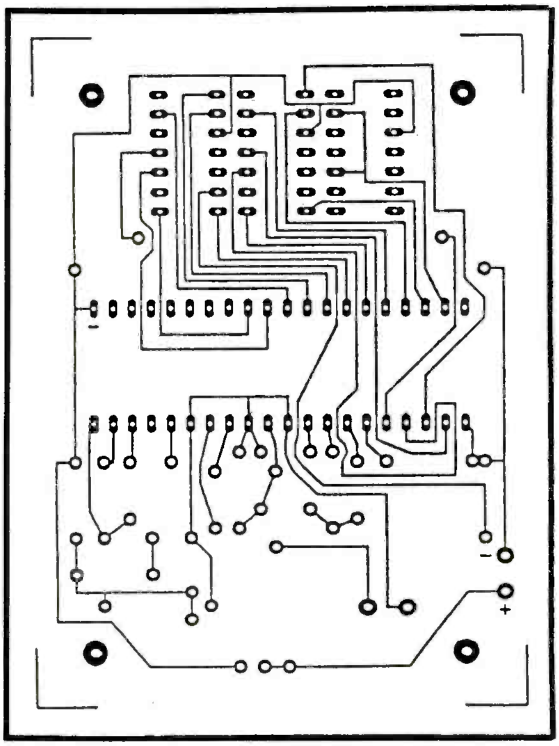


Figure 4. Digital Volt Meter printed circuit layout

If you'd like to use parts you already have, or can get from other vendors, you may want to order just the HK621SPBN Special Parts Kit that consists of the etched and drilled printed circuit board, Teledyne TC807CLP (very hard to find in single quantities), a 40-pin socket for the TC807CLP, the unusual TL431C regulator, and the special potentiometer and switch that mount in the printed circuit board. Since Cal West has a minimum $10 order policy, the plastic cabinet and mounting hardware are available only with the complete kit.

Most of the parts, except those offered in the Special Parts Kit, are common parts. However, the 7-digit displays deserve further discussion. There are many similar-looking 7-segment displays available, especially from dealers that sell surplus items. You can substitute for the specified Hewlett-Packard HP 5082-7730 displays only if they are common anode displays with a left decimal point. If you use the printed circuit layout shown in Figure 4, you must also be sure the display pin connections are as shown in Figure 1, and that they will each fit in a 14-pin socket.

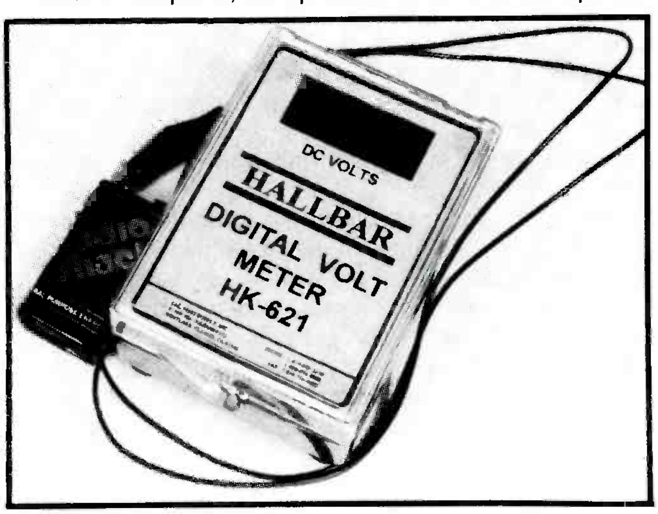


Photo 1. The complete kit includes a plastic cabinet with mounting hardware.

PICTORIAL DIAGRAM

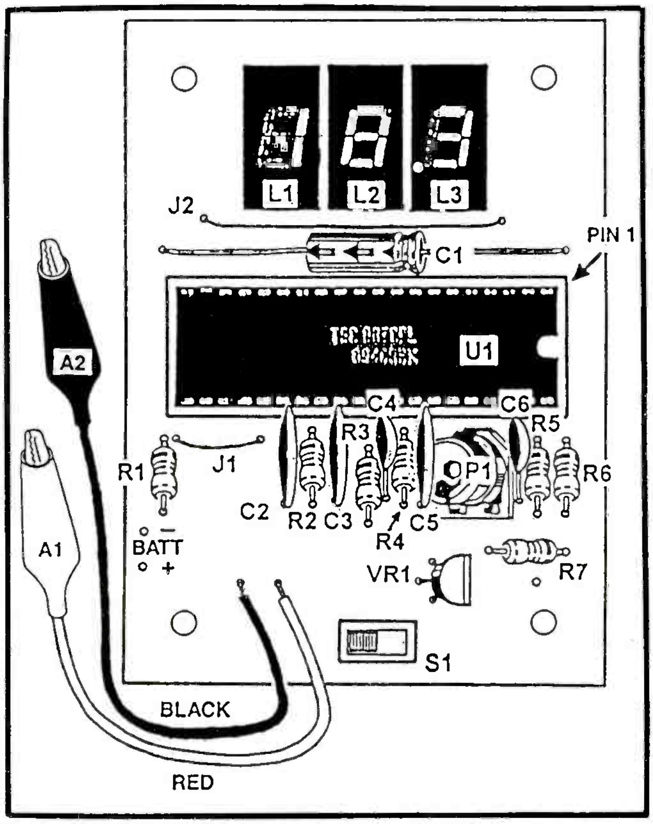


Figure 5. Digital Volt Meter parts layout

Figure 5 shows a pictorial of the assembly using the printed circuit board of Figure 4. Use a 25- or 35-watt soldering iron with a small tip to avoid overheating the components or having solder flow between pins or traces where it shouldn't be. Assuming you use a printed circuit board, mount all components on the side of the board that does NOT have metal traces, and mount each part close to the board. First install and solder the resistors, then the capacitors (watch the polarity of C1), then the potentiometer, switch, voltage regulator (facing as shown), and sockets. Don't forget the two jumpers, using bare wire.

This is followed by soldering the battery holder wires to the board, and then the input lead wires, watching the polarity in both cases (red is positive, black is negative.) Now insert the displays and U1 into their sockets, with the display decimals at the bottom, and U1's notch on the right.

Testing and Troubleshooting

Insert four AA alkaline batteries in the battery holder, making sure you observe battery polarity so the batteries are in series to provide a total of about 6 volts. Now turn on switch S1. After a short settling period during which L1 will probably display a "1" for a moment, displays L2 and L3 should each display a "0", with the left hand decimal point of L3 lighted. L1 should not now be lighted.

Now connect a fresh 9-volt radio battery to the input clip leads. The red clip lead should go to the solid (plus) 9-volt contact of the battery, the black lead to the other 9-volt contact. The display should now read somewhere around 9 volts. It may change from 8.9 to 9.0 or 9.1 (or other numbers, since the unit is not yet calibrated) as U1 samples the voltage about three times each second.

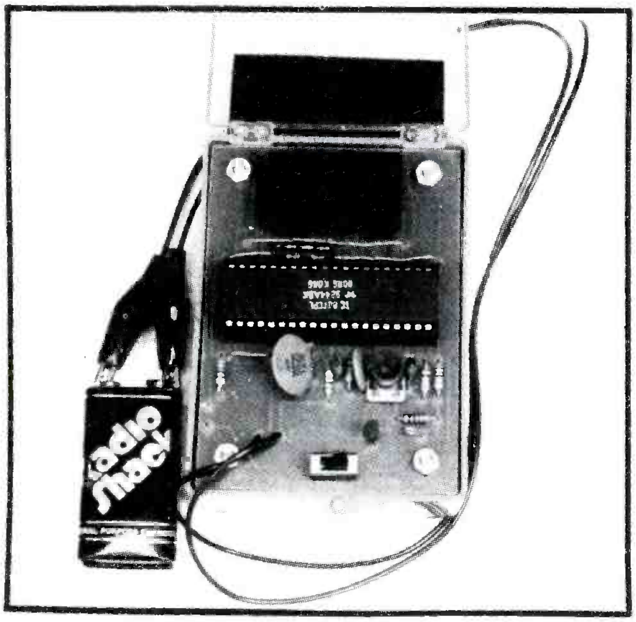


Photo 2. With the case lid open, you can see all of the parts.

Now reverse the clip lead connections to the battery, intentionally connecting the polarity "backwards." The readings should be the same! In other words, this digital volt meter is not polarity dependent.

But what if the digits don't light at all? In this case, check that your power supply batteries are connected properly and supplying about 6 volts. Be sure the polarity of the 6 volts as it connects to your circuit is not reversed.

Look to see if any solder bridges (pieces of solder crossing copper traces) have formed. If so, break or cut them with cutters, or with a desoldering iron, or using solder-absorbing copper braid. If you have a voltmeter, use the Figure 3 schematic to check for 6 volts wherever it should be. Be sure that U1 and the displays are plugged into their sockets in the right orientation, and that C1 and VR1 are not reversed.

If some display segments light, but others appear dead, connect a jumper wire from pin 1 of U1 (or the positive side of capacitor C1) to the Test pin 37 of U1. This should display a "1" on L1, and an "8" on L2 and L3. If any of these segments don't light, the Figure 3 schematic should lead you to the display segment pin and the pin on U1 that enables that segment. Probably a poor solder joint—

Using the Digital Volt Meter

To display the proper voltage, your Digital Volt Meter (DVM) needs to be calibrated. This is simply a matter of connecting a known voltage to the input clip leads, and adjusting potentiometer P1 until the displays show that voltage. It is best if you have a known-accurate digital voltmeter also connected across the clip leads at the same time, and adjust P1 until your display reading agrees with the known-accurate voltmeter.

Once your DVM is properly calibrated, it will read voltages from .1 to 19.9 with good accuracy. Don't be alarmed if the digits flicker as the sampling is taken; some voltages vary by .1 or .2 volts as they are being sampled three times a second.

If you "overload" your DVM by connecting the input to a source greater than 1.99 volts, the last two digits (L2 and L3) will flash on and off, the over-voltage signal. I would avoid connecting the input to AC at all, or DC voltages above 30 volts. I don't know the limits, and I wasn't willing to destroy my DVM to find out!

It is important that you note that the V- power ground (pin 26) and the V- Input ground (pin 30) are NOT the same. In other words, the input voltage to be measured is compared with the reference voltage, NOT the power supply voltage. For this reason, you can't measure its own power supply with this meter! If you try, you won't hurt anything; you'll just see a decimal point on L3, and a "1" displayed on L1, with L2 and the other segments of L3 apparently dead! This is also the reason you can't use this meter, without modification, to read car battery voltage if it's powered by the car battery.

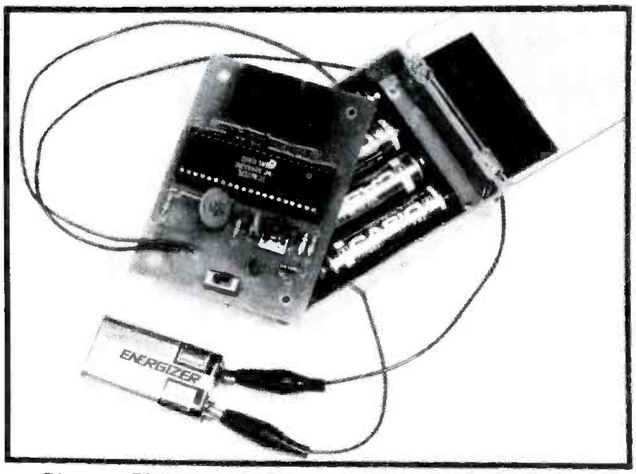


Photo 3. The printed circuit board fits over the batteries.

Packaging

It is recommended that the DVM be mounted in a case. A metal, wood, or plastic case is usually used for this purpose. If you use a metal case, be sure none of the circuitry is in contact with the case. Cal West provides a 2⅝" x 3⅝" x 1½" plastic case and hardware with their HK621BN Complete Part Kit. The printed circuit board fits perfectly in this case, which also has room for the battery holder under the printed circuit board. The mounting hardware includes screws, nuts, spacers and rubber mounting feet.

Modifications

The easiest modification is to add a polarity indicator. Just take a standard jumbo LED and connect the anode to positive 6 volt power, and the cathode (usually the lead at the flat spot on the LED base) to pin 20 of U1. Now when you reverse the polarity of the input voltage, this LED will light. No current-limiting resistor is necessary. You could also use Segment G of L1—not presently connected—for this purpose; just connect pin 11 of L1 to pin 20 of U1.

If you'd like to read higher DC voltages, it is only necessary to change the relationship of input voltage divider resistors R3 and R4. The smaller R4, the greater the input voltage before exceeding the 199 millivolt maximum between pins 31 and 30 of U1. Just for fun, temporarily connect another 100K resistor directly across R4. This effectively makes the resistance of this leg of the divider about half of what it was. This should also cut the input voltage reading in half; 9 volts will now read 4.5 volts. Just double the DVM reading.

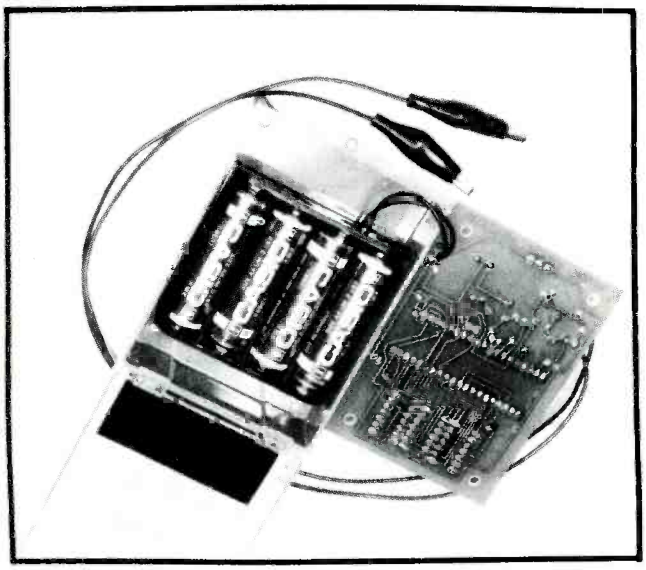


Photo 4. The batteries are in the bottom of the case.

You can go hog-wild by paralleling R4 with a switch that selects various resistor values, then using a display reading multiplication factor for the true input voltage. If you parallel R4's 100K with another 100K, multiply the display reading by 2; with 47K in parallel, multiply by 3; with 33K, multiply by 4; with 22K multiply by 5; with 10K in parallel, multiply by 10.

In this last case, with 10K in parallel with R4, you would have 199 volts at the input for the display to read 19.9 volts. Bear in mind the accuracy with these modifications is not great unless you create a calibration chart for each parallel resistor setting.

You can also use your DVM to read DC current flowing in a circuit. You do this by putting a known accurate resistance in series with the circuit you wish to measure, and then using the DVM to measure the voltage drop across the known resistor. Using Ohm's Law (E/R = I), you then know that the measured DVM voltage divided by the resistance value equals the current flowing in the circuit.

For example, suppose you put a 1-ohm series resistor in the circuit you're testing. Now use the DVM to measure the voltage across the resistor. If it displays 1.0 volts, then 1 ampere is flowing in the test circuit.

This is fine for circuits that draw a lot of current, such as automobile circuits. But what about low-current circuits? Here you're faced with a dilemma. You'll need a higher value of series resistor to measure a voltage in the range of your DVM—but that could easily affect the circuit you're testing. With a 10 ohm series resistor, 1.0 volts on your DVM display means .1 amps (100 milliamps) of current is flowing in the test circuit. But how much would flow without the series test resistor? Ah, there's the rub! I'll leave calculating the intermediate series resistor values and display multipliers to those of you who plan on doing this experimentation.

Caveat

Don't expect this DVM to compete with the flexibility and accuracy of the typical 3½ digit $50 (or more) digital multimeter. It is entirely practical and useful for measuring DC voltages below 20 volts, and lends itself very easily to experimentation—from which you learn and have fun at the same time. Considering the low kit price of under $20 (including shipping), this is an excellent buy! ■

PARTS LIST FOR THE DIGITAL VOLT METER

C1—4.7uF 35 WVDC electrolytic capacitor
C2—.22uF ceramic disc capacitor
C3—.5uF ceramic disk capacitor
C4—.01uF ceramic disc capacitor
C5—.1uF ceramic disc capacitor
C6—100pf ceramic disk capacitor
L1, L2, L3—Hewlet-Packard 5082-7730 .3-inch 7-segment LED display, or equivalent. See text.
P1—5K ½-watt potentiometer
R1—820 ohm ¼-watt 10% carbon resistor
R2—47,000 ohm ¼-watt 10% carbon resistor
R3—10 megohm ¼-watt 10% carbon resistor
R4, R5—100,000 ohm ¼-watt 10% carbon resistor
R6—1,000 ohm ¼-watt 10% carbon resistor
R7—22,000 ohm ¼-watt 10% carbon resistor
S1—Single-pole single-throw (SPST) slide switch.
U1—Teledyne TC807CPL 2½ Digit Analog-to-Digital Converter (see text)
VR1—Texas Instruments TL431C voltage regulator
Miscellaneous: 3 14-pin sockets, 40-pin socket, 4 AA-cell battery holder, alligator clips, wire, solder. Optional: printed circuit board, plastic case, mounting hardware.

NOTE: The following items are available from Cal West Supply, 31320 Via Colinas, Suite 105, Westlake Village, CA 91362. Phones: (800) 892-8000 or (818) 889-2209. Minimum order is $10, not including shipping. All orders in the Continental U.S.A. must include $3.50 shipping and handling per order. CA residents add 7.25% sales tax. Alaska, Hawaii and Canada must include 20% (minimum $6) for shipping and handling.

HK621BN—Complete Parts Kit: all items listed above, including printed circuit board, plastic case, and mounting hardware—$15.65

HK621SPBN—Special Parts Kit: printed circuit board, U1, 40-pin socket, VR1, P1, S1—$10.70

MORSE CODE PRACTICE OSCILLATOR

By
Andrew Singmin

If you are a short wave listener and wondering what all those Morse code 'beeps' mean, build this 'Code Practice Oscillator' and learn a new language that will open up a new and exciting part of the short wave band.

The short wave band extends from 1.8MHz to 30MHz and is the hunting ground for the SW DX'er (short wave listener enthusiast searching for and logging weak and exotic foreign stations from around the world). Unlike scanner enthusiasts who roam the ultra wide frequency spectrum starting from around 30MHz and extending way into the GigaHertz region listening for very short distance (local) transmissions, short wave listeners are the complete opposite. The short wave band is relatively narrow with practically no limit on 'pickup' distances. The very popular ham (amateur) radio bands also fall within the short wave sector. Amateur radio operators commonly use AM (amplitude modulation)/SSB (single sideband mode) type of transmission. SSB transmissions have the carrier removed at the transmitter end, in order to make more efficient use of the transmitter's output power, but the sound at the receiver is garbled unless you have a BFO (Beat Frequency Oscillator) on your set, that will re-insert the carrier and 'degarble' the sound. A lot of ham transmissions, especially in the popular 40M band, use SSB for their contacts. There are a number of distinct frequency bands set aside for ham operators, that are also recognized by their 'metre tags', for example, the 40M ham band corresponds to the 7.0 MHz-7.3 MHz frequency allocations and so on as seen below in Table 1.

Ham Bands

160 metres	=	1.8 to 2.00	MHz
80 metres	=	3.5 to 4.00	MHz
40 metres	=	7.0 to 7.30	MHz
20 metres	=	14 to 14.35	MHz
15 metres	=	21 to 21.45	MHz
10 metres	=	28 to 29.70	MHz

Table 1

Another group of distinct operators in the SW spectrum are the international broadcasting stations that also have their own specific bands set aside for them (see Table 2). If this is your hobby, then having a knowledge of a foreign language (or several) is exceedingly valuable, in being able to fully identify and log (record) these sites. Because of the time differences around the world, both the program start times and quality of re-

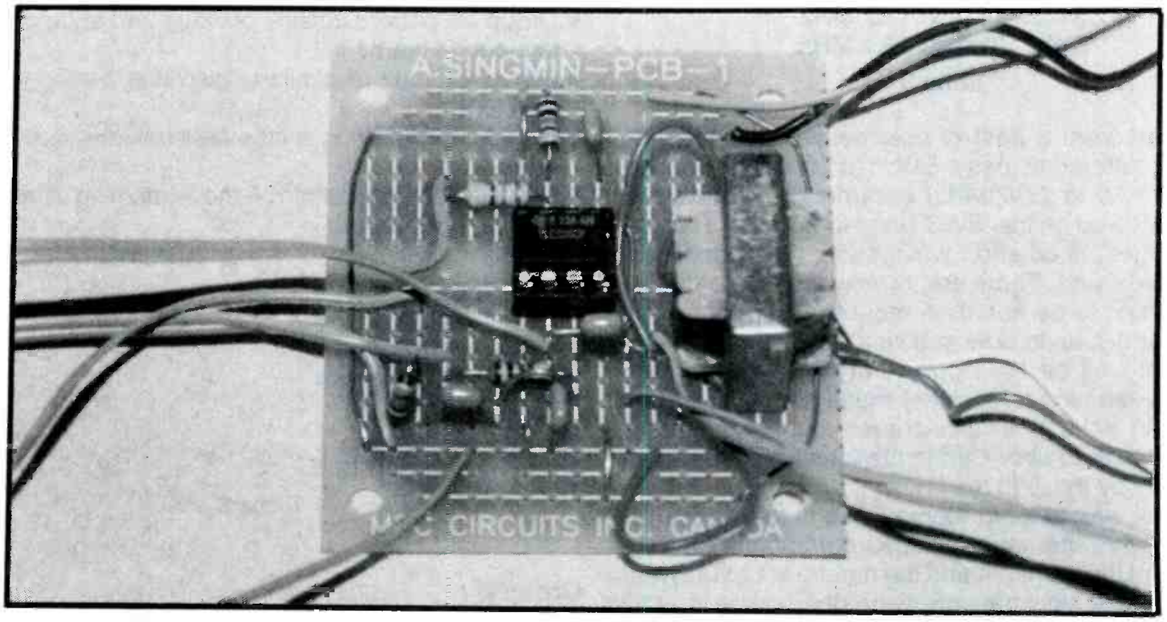


Photo 1: There is plenty of room on a single mini-SINGMIN PCB to accommodate the audio transformer, mounted as shown to the right of IC1.

ception will depend on the time of day or night. Program times for SW stations are, therefore, always given in UTC (Universal Coordinated Time), so that everyone, regardless of where they are located, can refer UTC time to their local time. SW enthusiasts are often late nighters, awake in the early morning hours to catch the 'wee hours' transmissions. This is unlike commercial stations on your FM or AM dial where the transmission time is of course the same as your local time and most of their listeners tend to be during the day.

Broadcast Bands

49 metres	=	5.95	to 6.20	MHz
41 metres	=	7.10	to 7.30	MHz
31 metres	=	9.50	to 9.78	MHz
25 metres	=	11.7	to 11.99	MHz
19 metres	=	15.1	to 15.45	MHz
16 metres	=	17.7	to 17.90	MHz
13 metres	=	21.45	to 21.75	MHz
11 metres	=	25.6	to 26.1	MHz

Table 2

A good quality short wave receiver will cover all these bands continuously from 1.8 MHz to 30MHz. For any serious SW listener, this is an essential pre-requisite when choosing a new receiver. Less sophisticated, budget-price short wave radios, only cover select portions of the full short wave band, for example the DX-360 receiver once supplied by Radio Shack offers the following short wave bands (Table 3). There is no BFO on this set and hence the popular 40M ham band is for most parts useless. The popular CB band centered around 27MHz just falls outside the limits of this set and is hence also missed.

DX-360 short wave bands

SW1:	4.5	to 5.5	MHz
SW2:	5.8	to 7.5	MHz
SW3:	8.2	to 10	MHz
SW4:	11.4	to 14.0	MHz
SW5:	14.6	to 18.2	MHz
SW6:	21.0	to 26.1	MHz

Table 3

So apart from a host of commercial broadcasting stations scattered across 4.5MHz to 26.1MHz, only the 40 metre (7.0 to 7.30 MHz) ham band, **in principle**, can be received on the 'SW3' band for this set. This being a budget priced short wave radio, the restrictions, are not surprising. There are, however, plenty of Morse Code signals to be heard on more or less any budget receiver and if, up to now, you've always ignored them, this could well be the opportunity to start learning Morse. By learning to decipher these dots and dashes or 'dits' and 'dahs,' you can increase your 'listening ability' and tune in to secret transmissions that can be decoded only by those in the know.

The best way to learn Morse Code is to practice listening to what the various codes correspond to, (the 26 letters of the alphabet and the numbers 1 to 0). Waiting for suitable slow transmissions (they come in at all speeds) is just a little too frustrating. A much better solution is for you to generate, slowly and carefully at first, the various Morse Code signal tones for each of the letters/numbers. The principle is exactly the same as learning the piano where you start with which 'black dot' corresponded to which note. It's the same principle here.

The Morse Code as traditionally shown in publications is shown below (Table 4). There is one letter that practically everyone will recognize already, the dit-dit-dit-dah 'V for victory sound' and perhaps the SOS code.

Morse Code

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

Table 4

At first the table looks a little foreboding. How is one to decipher all of these letters let alone make out intelligent sentences? However, there is a much better way of learning the code than going through the alphabet—you do this by rearranging half of the letters into specific groups that now form a pattern that makes it much easier to learn. Look at the new grouping sequences now.

- Group 1's pattern is fairly obvious and shouldn't take too long to learn.
- Group 2's pattern similarly also has a recognizable look to it.
- Group 3's pattern is a little less obvious, but is also helpful.
- Group 4 has no pattern—the remaining letters just have to be learned!

Group 1

E —— dit
I —— dit-dit
S —— dit-dit-dit
H —— dit-dit-dit-dit
T —— dah
M —— dah-dah
O —— dah-dah-dah

Table 5

Group 2

A —— dit-dah
W —— dit-dah-dah

J —— dit-dah-dah-dah
N —— dah-dit
D —— dah-dit-dit
B —— dah-dit-dit-dit

Table 6

Group 3

U —— dit-dit-dah
V —— dit-dit-dit-dah
G —— dah-dah-dit
Z —— dah-dah-dit-dit
K —— dah-dit-dah
R —— dit-dah-dit
P —— dit-dah-dah-dit
X —— dah-dit-dit-dah

Table 7

Group 4

F —— dit-dit-dah-dit
C —— dah-dit-dah-dit
L —— dit-dah-dit-dit
Q —— dah-dah-dit-dah
Y —— dah-dit-dah-dah

Table 8

This project, therefore, will show you how to construct a Morse Code Practice Oscillator to get you on the way to really decipher those up till now mysterious 'dit-dahs'. The circuit design has several very useful extra features over the standard 'bare bones' design often found elsewhere.

Load your favorite tape into your cassette deck and let's get the construction process going. My stack of Nashville country tapes are already running, with Lorrie Morgan, Tanya Tucker, Patty Loveless, Pam Tillis............providing inspiration for this project!

Unique Design Features

Rather than go for a basic bare bones design, I've decided to incorporate numerous extra 'user features' into this Morse Code Practice Oscillator. By now, hopefully, most of the readers will have become acquainted with the 'SINGMIN PCB' and my style of writing, so there should be no difficulty in following the more adventurous design features. Everything will still fit on a mini-SINGMIN PCB, but we will have more mechanical components in this project.

Feature List:

- A rotary variable tone-frequency control allows the user to choose the best sound/frequency to suit their individual preferences.
- A rotary volume control will keep the 'beeps' low enough, without disturbing others, or crank it up for other occasions, where the background might be a little noisy.
- A very useful recorder output is available so that you can record the tones you've generated and play them back later as practice tones.
- An LED indicator pulses in sync with the 'dots' and 'dashes' giving a form of visual signal as well as the audio.
- A minimum parts count design uses a miniature audio transformer from Radio Shack as a driver for the low impedance speaker.
- A 1-chip design (the ever favorite 555 timer) is chosen to conserve battery power.

Circuit Description

The Morse Code oscillator is based on the 555 timer chip, IC1, configured to provide a continuous train of pulses i.e. functioning as a tone generator. The frequency controlling components are 1) R1, a resistor running from pin #7 to Vcc (+supply rail), 2) fixed resistor R2 in series with variable resistor R3 connected across pins #6 & #7, and 3) capacitor C1 connected from pin #6 to ground. Note: pins #6 and #2 are shorted together in this particular mode of operation. Capacitor C2 is a regular decoupling capacitor from pin #5 to ground. Those are all the first set of components needed to generate a series of square waves. By varying the potentiometer, R3, the frequency of the output signal (as taken from pin #3) can be increased or decreased. The component values have been chosen to produce a tone that is within the audio frequency range—similar to what you would hear from a radio set tuned to decode Morse. Pin #1 is the ground connection and pins #4 & #8 go to the +supply rail (power is from a 9 volt battery). In order to generate the dots and dashes corresponding to the 'dits' and 'dahs', the oscillator has to be turned on and off momentarily—a long 'on period' will simulate the sound of a 'dash' and a short 'on period' similarly replicates the sound of the 'dot'.

To avoid having to locate and purchase an actual Morse keyer, we use instead a readily available and inexpensive momentary push to make switch, S1, from Radio Shack. This switch is wired in series with the + battery terminal and the positive supply rail. When the push button is depressed and turned on, power is applied to the circuit and the 555 produces a tone, when it is released, the tone disappears. The spring action automatically returns the switch to the off position. By varying how long you keep the push button down with your finger, you can thus generate very acceptable sounding Morse Code dots and dashes. If you happen to have a Morse Code key, then by all means use it instead of our makeshift keyer.

The output signal is taken from pin #3, via a DC blocking capacitor C3 in series with a variable resistor R4. R4 will serve as a volume control for the 'beep' generator and hence give you a nice means of adjusting the sound level to suit the listening environment. A small 8 ohm speaker, a few inches in diameter, is ideal as the load (it's the type used as a replacement for transistor radios). Since the 555 is not designed to feed directly into a low impedance load, an audio transformer is used to provide the correct matching interface. The primary winding has a high impedance (1K ohm) and the secondary has a low (8 ohm) impedance to match the speaker. The transformer is a nice quick 'minimum parts count' means to drive a low impedance load, it draws no extra current and since we're not concerned about saving space, is ideal. Also wired across pin #3, and going before capacitor C3, we have a light emitting diode, LED1, and current limiting resistor, R5. The LED will pulse in sequence every time the switch, S1 is depressed, thereby giving a visual indicator to the audio tones.

Finally, capacitor C4 and series resistor, R6 lead off from pin #3 to terminate into a sub-miniature 1/8" jack socket. From this socket, you can couple the signal into a regular mono cassette recorder (use the mic input socket of the recorder) and record the Morse Code tones. Later, play back the tones as a learning aid to decipher the corresponding letters. As you get more proficient, the speed can be increased. Power for this circuit is from a 9 volt alkaline battery and very little current is drawn, especially as the circuit is only 'on' when, the push button is 'keyed'. The complete circuit that you will need to build this unit is shown in **Figure 1.** Go through it carefully and identify the components we've described so far.

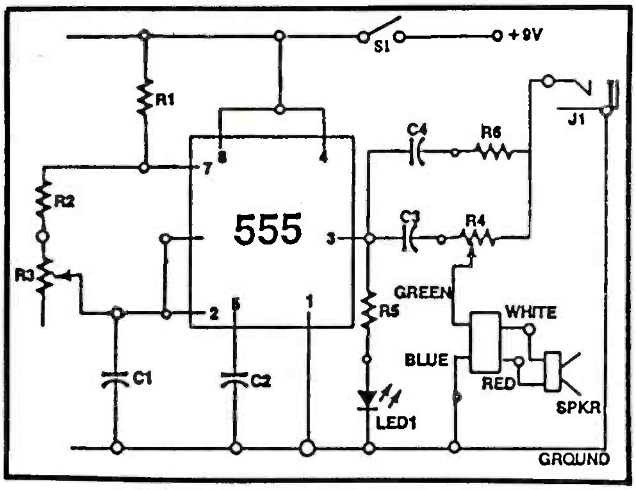


Figure 1: Morse Code Practice Oscillator Circuit

Construction Details

The entire project, including speaker, takes up very little space and can be easily accommodated in a suitable Radio Shack plastic enclosure. If this is your first project, go for a larger size case to give you plenty of room to work with. I always find that you need more space than estimated, as mechanical components have a tendency to be 'larger' than calculated! As always, sockets are used for the integrated circuit as this makes it much easier to replace the IC later, should it be necessary. Prepare the SINGMIN PCB by snapping off one of the '1/4' section mini-boards. If you wish, smooth down the edges with a file, along the 'snap lines'. Locate the 8 pin DIL IC socket as shown in the layout diagram, **Figure 2.** Make sure that the notch faces to the left. This is the standard orientation direction used for IC sockets. Carefully solder one of the corner pins and check the socket to make sure it's both flush and straight with the board. If not—reheat the pin and correct. This can only be done if just one pin is soldered. After that, it is impossible to do any corrections! Next, solder the opposite pin, to provide an even hold. The remaining 'corners' are done next. After that, the rest of the pins can be done in any order.

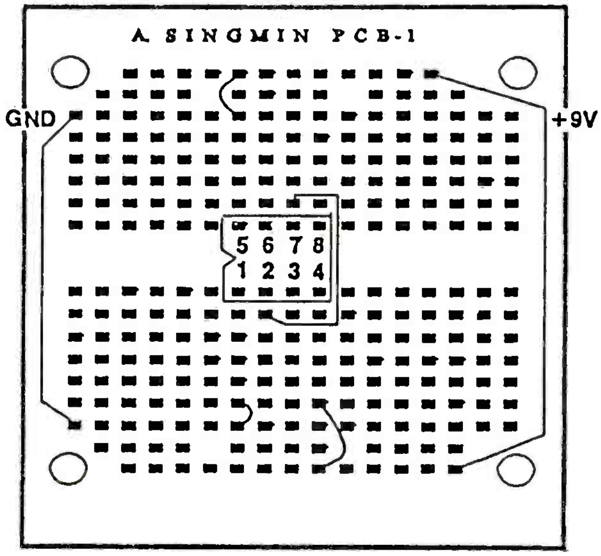


Figure 2: Locate the IC socket as shown, with the notch facing left.

Since both the 'upper and lower' halves of the 555 IC have pins (#8 & #4) going to Vcc (+power rail), there is a bridging link running down the right hand side of the board, bringing the + power rail to the 'bottom' of the board also. This makes soldering much more convenient later. For the common ground rail, we also have a bridge wire link, running down the left hand side. This saves having to run long wires back to the top edge of the board. It all goes towards having a neater layout design. The rest of the solid wire links are routed as follows:

- Pin #1 to ground.
- Pins #4 & #8 to Vcc.
- Pins #2 shorted to #6.

Solid hookup wire, with the insulation removed is ideal for making these jumper connections. Cut to length and bend to shape before inserting. Check that all the links are correct before soldering.

After this stage of adding the links, carefully check out your work before proceeding.

- No solder bridges or splashes?
- No 'insufficient solder' points?
- No unsoldered pins?
- Solder joints bright and shiny?

Excess wire lengths can be cut off cleanly with a sharp pair of miniature wire cutters.

Components can now be added. Begin with the resistors as these are nice and easy. Start with R1. Position in place as shown and bend to fit the appropriate location holes. Flip the board over and solder the resistor leads. If the resistor drops out when the board is inverted, use a small piece of masking tape to hold R1 in place during soldering. The second resistor R2 needs to have one lead taken off the board, to the potentiometer R3, hence R2 is terminated in an 'isolated' solder point. From there, take a flexible lead off to the potentiometer, R3 (the first of many components located off-board). A return lead from R3, terminates at pin #2. Capacitor C1 goes in neatly from pin #2 at the lower end of the board to the ground rail. C2 is similarly connected at the top end of the IC, from pin #5 to ground. You can now see how much more convenient it is to have the Vcc and ground links in place as there is no need to have components crossing over each other. Solder capacitor C3 into place as shown. Bring out a pair of flexible wires from the free end of C3 and ground, and connect this to your speaker. It's best to apply the soldering iron to the speaker terminals as quickly as possible to avoid damaging the fine speaker wires. For the first quick test, the transformer can be omitted. Switch, S1 and a 9v battery terminal clip are the last components to go in, before we get ready for the first stage test. One end of S1 goes to the board while the other end goes to the red wire on the battery clip. The black battery clip wire goes to ground. Your setup should look like the diagram in **Figure 3.**

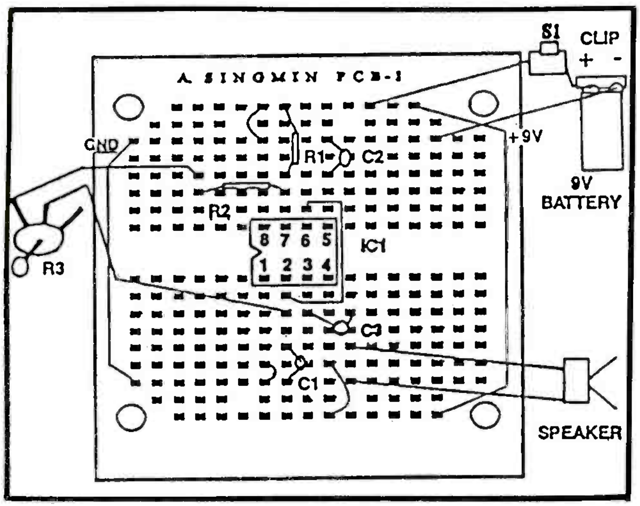


Figure 3: First test setup/frequency check

Test #1: Basic tone check with frequency control

Insert the IC carefully into the socket, making sure that pin #1 on the IC lines up with the lower left hand edge of the socket. Bend the IC pins gently inwards if necessary to get it in the socket. Set R3 approximately midway. Connect a fresh 9v alkaline battery to the battery clips. Press S1. All being well, you should hear a tone from the speaker. Adjust the tone control. The frequency will change accordingly and should increase in pitch as the control is rotated clockwise. Use the other 'outer terminal' of R3, if the opposite happens. That's the first stage test completed. No sounds! OK, go through the troubleshooting checklist.

- Are all the connections going to the right places?
- Are all the connections soldered correctly?
- Check the polarity of the voltage at pin #4 or #8. This should be around plus 9 volts (depending on your battery voltage).
- Are the resistors the right value (color code OK?) similarly for the capacitors?
- If all else fails check the positive supply current. This should be low, a few mA only, when S1 is depressed.

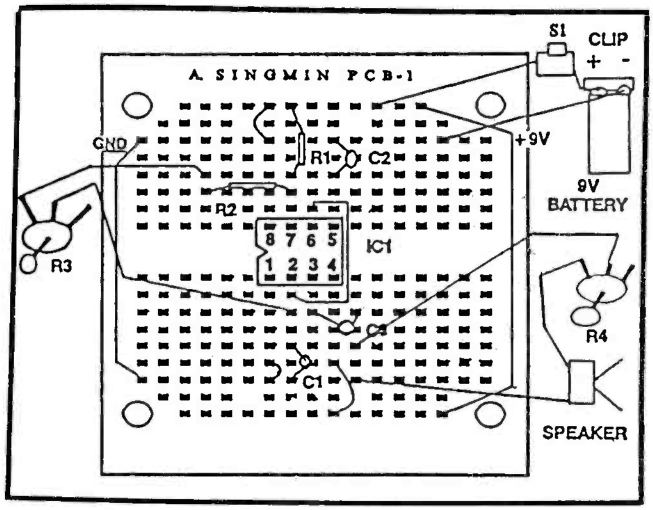


Figure 4: Addition of the volume control

Test #2: Volume control check

Remove the flexible lead joining C3 to the speaker at the speaker end. Couple this lead to the new potentiometer, R4. The other end of R4, is coupled to the free speaker terminal with another length of flexible wire. See **Figure 4** for details. Reconnect the battery once more. Test as before. Now R4, acts as a volume control and the sound should increase as the knob is turned clockwise. Use the other 'outer terminal' of R4 if the opposite happens.

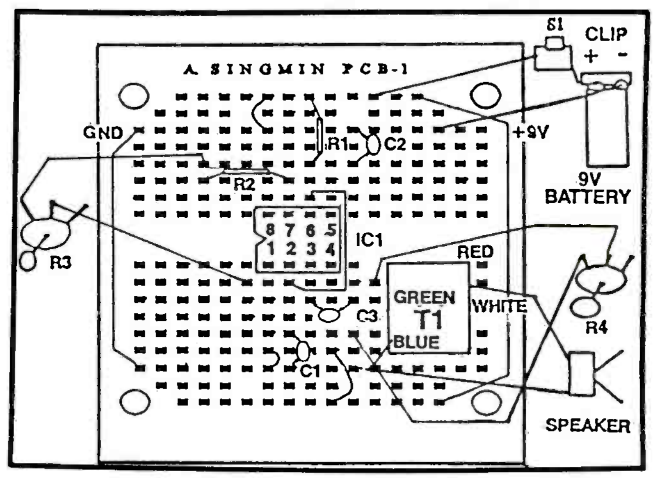


Figure 5: Addition of transformer, T1

Test #3: Output matching transformer check

Assuming all is well, we'll carry on with the construction. Remove the battery and speaker wires, and add the transformer, T1, across R4 and ground as shown in **Figure 5.** Note, the primary 1K impedance winding has three primary wires. The two outer (green and blue) wires only are used. The red and white low impedance secondary windings go directly to the speaker. If the wires are too short just terminate the secondary wires to any two free solder points on the board and bring out two new flexible wires to the speaker. It's not critical where you make these take-off points. Apply the battery and test as before. The volume of sound will now be much louder as the speaker impedance is correctly matched to IC1. After you're finally happy that all is well, the transformer can be attached to the board with the help of your glue gun.

Test #4: Visual dot/dash LED check

Remove the battery and add LED1 and it's series resistor, R5, as shown in **Figure 6.** We need a connection to pin #3. Reconnect the battery. Now the LED indicator should come on as long as S1 is depressed. If the LED is not lighting, you might have the polarity reversed. Check it out. Once more remove the battery if all is well.

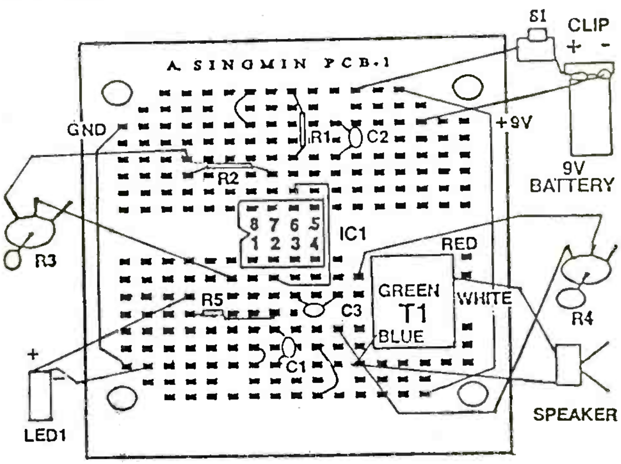


Figure 6: Addition of output LED

Test #5: Recorder output check

The final two components can now be added. Capacitor C4 and series resistor R6 runs from pin #3. A jumper wire is used as there are quite a few components around this area. The other end of R6 now goes directly to the live terminal of a 1/8" jack socket, J1. Since a mono recorder is intended to be used, this will be a mono socket. **See Figure 7.** Connect the battery. Connect a mono shielded connecting cable (terminated with 1/8" jack plugs) between this socket and the recorder's mic input socket. Switch on the recorder and start recording. Generate a series of sample tones and check that all has been recorded properly. That now concludes connection of all of the individual functions.

Usage

The aim of this project has been to learn Morse Code. The equipment is all completed and waiting. The rest is up to you. Start with the first Morse set shown in Group 1 earlier and become familiar with the sound of the tones until they become second nature. Record and

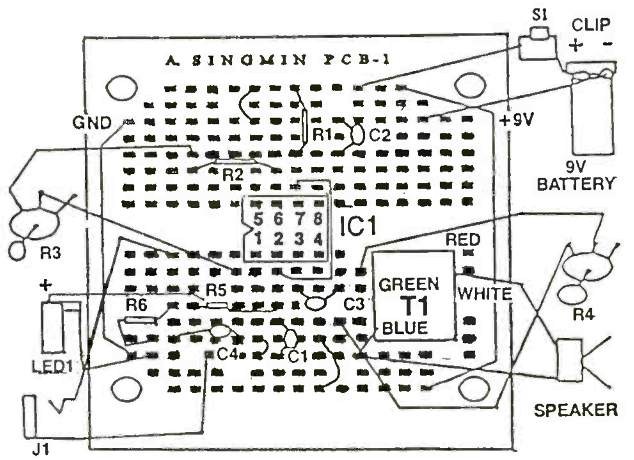


Figure 7: Recorder output connections

replay the 'letters' until you can read them off without errors. Increase your speed. Go on to the next group. Mix and match until it becomes second nature.

Conclusion

This Morse Code Practice Oscillator makes a useful addition to your short wave listening area and should open up a whole new area of exciting listening in the short wave bands. ■

PARTS LIST FOR THE MORSE CODE OSCILLATOR

All resistors are 5%, 1/4 watt
IC1 — LM 555 timer IC
R1 — 10K resistor
R2 — 47K resistor
R3 — 100K potentiometer
R4 — 100K potentiometer
R5 — 1K resistor
R6 — 100K resistor
C1 — 0.01 uF disc ceramic capacitor
C2 — 0.01 uF disc ceramic capacitor
C3 — 0.1 uF, disc, ceramic capacitor
C4 — 0.1 uF, disc, ceramic, capacitor
T1 — audio transformer, Radio Shack 273-1380
LED1 — light emitting diode indicator
S1 — momentary push to make switch, Radio Shack 275-1566
J1 — 1/8" mono jack socket
SINGMIN-PCB
9V Battery clip
8 pin IC socket
Control knobs
9V alkaline battery
Mounting hardware
Project case

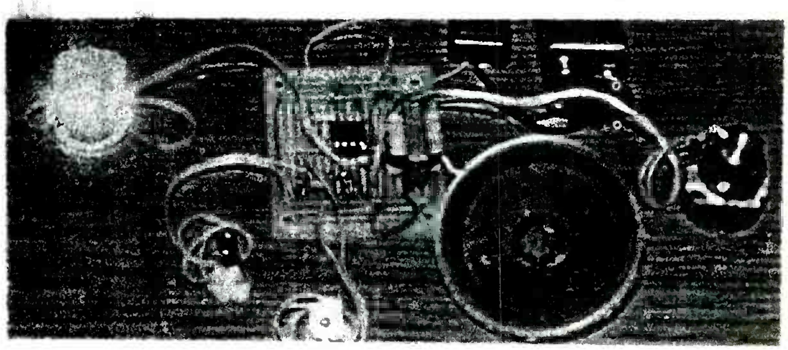
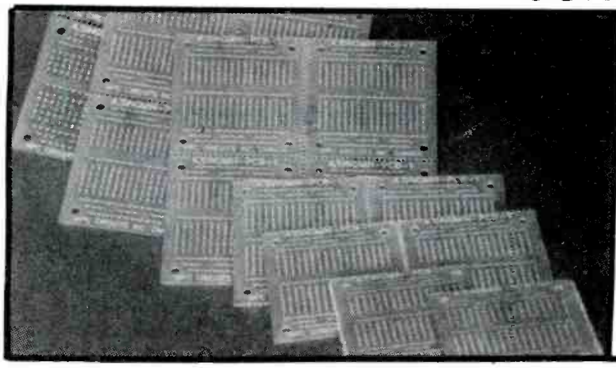


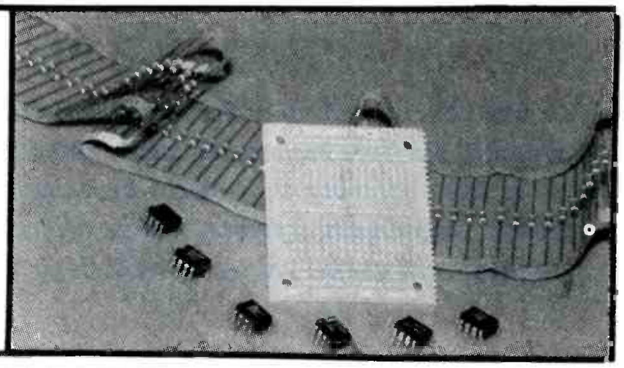
Photo 2: Here is the final layout of the completed SINGMIN PCB, volume and tone potentiometers, LED indicator, recorder jack socket, speaker, battery and switch.

THE SINGMIN PCB

A NEAT, FLEXIBLE, PURPOSE-DESIGNED SOLDER ASSEMBLY BOARD FOR THE ELECTRONIC HOBBYIST

THE SINGMIN PCB IS AN IDEAL SOLUTION FOR THE HOBBYIST WANTING A NEAT ASSEMBLY PLATFORM FOR THEIR FIRST-TIME PROJECT. CLEAR MARKINGS ON THE FRONT OF THE BOARD ENABLES THE HOBBYIST TO BE SURE THAT ALL COMPONENTS ARE PLACED CORRECTLY.





SPECIAL FEATURES

1. PURPOSE-DESIGNED SOLDER ASSEMBLY BOARD FOR ELECTRONIC HOBBYISTS
2. DEDICATED AREA FOR LOCATION OF Vcc/2 BIAS COMPONENTS
3. GENEROUS SOLDER CONTACT POINTS FOR IC PINS
4. PRE-DRILLED SCRIBE LINES FOR EASY SUBDIVISION OF BOARD
5. FOUR MINI-BOARDS PER MAIN UNIT
6. SIZE, APPROXIMATELY 4″ X 4$\frac{1}{2}$″ FOR FULL BOARD
7. SIZE, APPROXIMATELY 2″ X 2$\frac{1}{4}$″ FOR EACH MINI-BOARD
8. FOUR MOUNTING HOLES ON EACH MINI-BOARD
9. 4 X 8 PIN IC's CAN BE LOCATED ON EACH MINI-BOARD
10. CAN BE CUT INTO DIFFERENT SHAPES TO FIT PROJECT REQUIREMENTS
11. VERY FLEXIBLE LAYOUT CAN ACCOMMODATE ALMOST ANY PROJECT
12. CAN BE USED AS A SOLDER PRACTICE BOARD FOR BEGINNERS
13. CLEAR IDENTIFICATION MARKINGS ON TOP OF BOARD
14. DESIGNED BY AN ELECTRONICS HOBBYIST FOR ELECTRONIC HOBBYISTS

UNIT PRICE (4 MINI-BOARDS): $25.00 (U.S. FUNDS)

(Includes Shipping & Handling U.S.A. & Canada) Foreign orders add $5.00 per unit for Postage & Handling.

Yes! I would like to purchase ______ Singmin PCB's. My check or money-order is enclosed. Payable to C&E Hobby Handbooks, P.O. Box #5148, North Branch, N.J. 08876 (U.S. FUNDS ONLY).

Please ship my PCB boards to the address below: (Please print) My check or money-order for $________ (U.S. Funds) is enclosed.

NAME: ____

STREET ADDRESS: ____

CITY & STATE: ______________________________ ZIP: __________

(Please allow 4 to 6 weeks for delivery) V19

NOTICE TO READERS OF ELECTRONICS HANDBOOK FROM ANDREW SINGMIN

"If you have been reading some of my construction projects and feeling the urge to get started in electronics - but have been held back because of the difficulty in buying electronic components, here's a new offering that could be of interest to you. In conjunction with C&E Hobby Handbooks, Singmin Enterprises, will be offering a general purpose starter pack containing the most popular and useful values of new electronic components."

Orders plus check (U.S. funds) can be sent to:

☞C&E Hobby Handbooks, P.O. Box #5148, North Branch, N.J. 08876, USA

☞For both the 'SINGMIN PCB' & the 'Electronics Starter Pack'

☞Note: The SINGMIN PCB is available for $25 (U.S).

Electronics Starter Pack (part No: ESC-AS-01)

This pack contains a selection of the following items (identification sheet provided with each pack).

- Resistor values: 100 ohm, 1K ohm, 10K ohm, 100K ohm & 1M ohm
- Capacitor values: 0.001uF, 0.01uF, 0.1uF
- Electrolytic capacitor values: 1uF, 10uF, 100uF
- Transistors: General purpose NPN small signal type (e.g. 2N3904)
- Diodes: Silicon small signal (1N4148 type)
- Diodes: Germanium small signal (1N34A type)
- Diodes: General purpose rectifier (1N4001 type)
- Integrated circuits: 741op-amp
- Integrated circuits: 555 timer
- Integrated circuits: LM386 audio amp
- General purpose LED.
- 8 pin DIL IC sockets

Price is $50 (U.S.) plus $5 postage and handling = Total cost of $55 (U.S).

ELECTRIC GUITAR CONVERSION

By William J. Huber

Recently, a musician friend, who plays a "gut string" classical guitar, asked me to convert his favorite guitar to electric. He wanted to sound like he always had, only louder.

Several commercial pick-ups are available. Some of these fit a magnetic coil in the front sound hole, under the strings of the guitar. Sound is created by moving a metallic wire "string" through the magnetic field and amplifying the disturbance of the field. The nylon (we don't use real gut anymore) strings have no effect on this kind of device.

Another type of commercial pick-up uses a crystal material attached to the inside front face of the guitar. When a string is plucked, the guitar face vibrates in time with the string, slightly warping the special crystal. Twisting or bending the crystal (called a Piezo Electric-Crystal) generates a small electric current ... c.

... to ... ny

Does your career need a boost?

Call for help!

1-800-243-6446

CIE CLEVELAND INSTITUTE OF ELECTRONICS

See our ad in this issue.

Figure 1

The main components of the circuit are: (1) the microphone cartridge (M1), which picks up the guitar sounds, (2) the pre-amp (IC1), which amplifies the output of the microphone cartridge to useable levels, and (3) the battery pack which powers the whole thing (B1-B4).

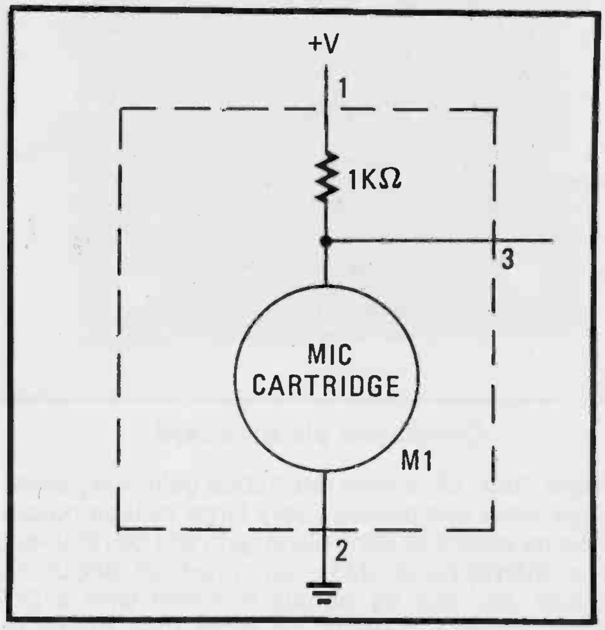


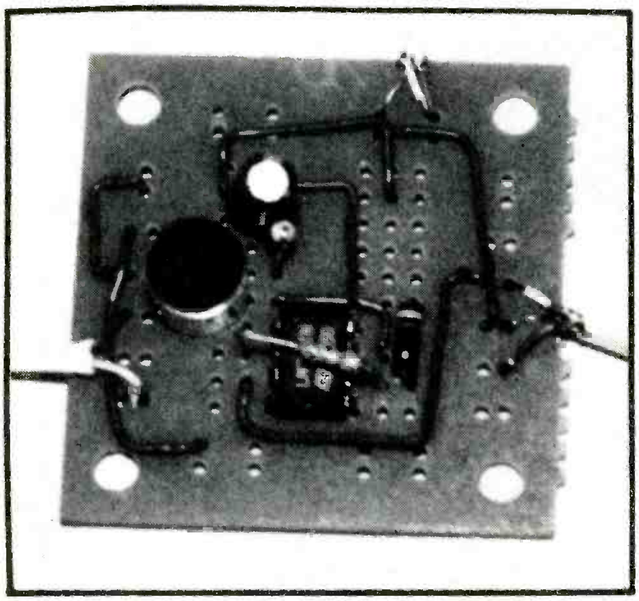
Figure 2

First, the easy stuff. The batteries are alkaline type because they last longer than carbon-zinc (regular flashlight) batteries. I decided to try some AA type, which have a rated drain of 130 milliamps. Since each cell has a 1.5 volt potential, the series arrangement of the batteries provides a 6 volt potential from B1+ to B4-. By connecting ground at the B2-/B3+ connection, +3 volts and –3 volts can be supplied to IC1. Connecting M1 (the microphone cartridge) to +3 volts and ground rather than to 6 volts, reduces the current used by M1. The current used by M1 is about 1 milliamp and about 2 milliamps will be used by the IC1. Remember, that when batteries are connected in series, voltage increases but current remains the same. Available current from the battery pack is the same as from one battery or about 130 milliamps. Dividing rated current supply by the current used will give about the amount of time the batteries will last. 130 divided by 3 equals approximately 43 hours. Just good enough for my friend's purposes.

My figures may not be exactly correct but they are pretty close.

The microphone cartridge is one used by several manufacturers of finished microphones. It will reproduce sounds from the lowest tones of a bass guitar to the very high tones made by a violin or cymbal. This wide range will pick up all of the neat sounds inside the guitar body.

IC1 is an op-amp (Operational Amplifier). As a group, op-amps have some things in common that you should keep in mind. First the "+" input is called the non-inverting input, and it means that a positive voltage input gives a positive voltage output. the "–" input is inverting and means that a positive voltage input gives a negative voltage output.



Completed circuit board.

These "fun" I.C.s have enormous gain. Very small voltage input can produce very large voltage output and some means of controlling gain will be required.

The microphone (M1) can produce about 75 millivolts AC, but its output is mixed with a DC voltage, which IC1 would be more than happy to amplify. The DC voltage could be very hard on a guitar amplifier. C1 blocks the DC voltage while passing the desired AC voltage to P1. P1, a potentiometer, first provides a 10Kohm ground reference for the AC signal from C1. The center tap of P1 provides a ground reference for IC1's non-inverting input and keeps the output voltage at about 0 volts DC. It also creates an adjustable AC voltage divider allowing larger or smaller signals to be passed to IC1. P1 then becomes our volume control.

Now the fun begins. (Fun meaning hard part). Connected to the inverting (–) input are the resistors R_c, (c=control) and R_f, (f=feedback). These two resistors provide gain control as mentioned above. I hate formulas, but every now and again we must do some figuring. The formula:

$$\text{Vo (output)} = \text{Vi (input)} \times \frac{1+\text{Rf (feedback)}}{\text{Rc (control)}}$$

predicts the output voltage (V_o) based on input voltage (V_i) and the quotient of R_f (feedback resistor) divided by R_c (control resistor) plus 1.

We already know the output of M1 is maximum of 75 millivolts or .075 volts. This is V_i. Most guitar amps are not compatible with more than 750 millivolts at their inputs, or about .75 volts. This is V_o. Our formula now looks like:

$$.75 = .075 \times \frac{1+Rf}{Rc}$$

By dividing both sides of our equation by .075, we can see that

$$10 = \frac{1+Rf}{Rc}$$

by substracting 1 from both sides,

$$9 = \frac{Rf}{Rc}$$

A search through my junk box yielded 4.3K ohm and 33K ohm resistors.

If we install the 4.3K ohm resistor as Rc and the 33K ohm resistor as Rf, then

$$\frac{Rf}{Rc} = \frac{33}{4.3} = 7.67$$

(Note that the "kohm's" cancel during the division)

Back to the original formula, substituting the numbers, we now know:

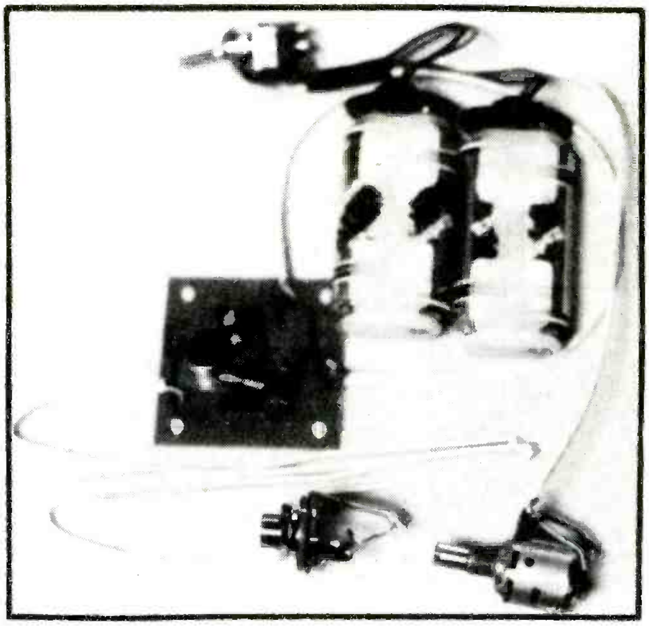
$$Vo = .075 \times (1 + 7.67)$$

and by doing the addition:

$$Vo = .075 \times 8.67$$

and now the multiplication:

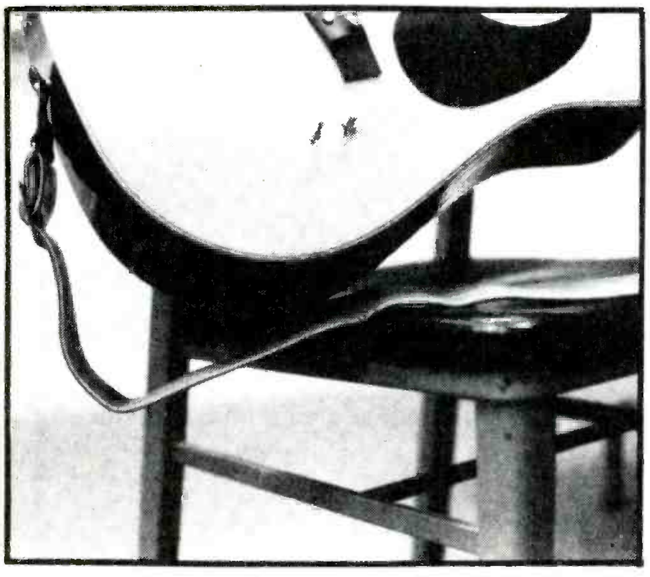
$$Vo = .65 \text{ (Approx.) volts.}$$



Completed circuit with Batteries, Switch, Potentiometer, and Jack ready for installation.

Since the guitar amplifier will require some voltage at less than .75 volts, it is safe to say that the circuit will not destroy the amplifier's speaker because of too much input signal voltage.

Guitar with P1 and SW1 mounted on the face.



Guitar close-up, showing P1 and SW1 installed and J1 in the guitar body (the dark part of the guitar).

Now, a note about wiring. The wires between T_1 and T_2, and T_3 and T_4, and T_5 and T_6, end up being fairly long due to the size of the guitar. These wires must be shielded. The shields at T_2 and T_3 should be soldered together and to the metal case of P1.

This point makes a convenient place to connect the ground terminal of the jack (J1), and the center of the Battery Pack (B2–/B3+). This makes the ground complete from our circuit all the way through to the guitar Amp.

Needless to say, it would not create a good impression to hear a "Preparation H" commercial in the middle of your favorite guitar solo. To this end, solder connections are very important. Proper soldering techniques are described in Volume VIII of the Electronics Handbook.

Components are available from Radio Shack and are listed by Cat # and description. ■

PARTS LIST FOR ELECTRONIC GUITAR CONVERSION

QUAN.	SCHEMATIC ID	DESCRIPTION	CAT#
1		IC Board	276-148
1	M1 (See Fig. 2)	Microphone Cartridge	270-090
2	B1-4	Battery Holders	270-382
2		Battery Connectors	270-326
4		Batteries	23-552
1	C1	Capacitor (16VDC) 22ufd	272-1437
1	P1	10kohm Potentiometer	271-215
1	*Rc	4.7kohm Resistor	*271-1330
1	Rf	33kohm Resistor	271-1341
1	J1	Jack	274-252
1 Package		Shielded Cable	278-1282
1 Package		Wire, Hook-Up (22ga)	278-1306
1	IC1	Opamp	276-007
1	Sw1	DPDT Switch	Selected for Appearance

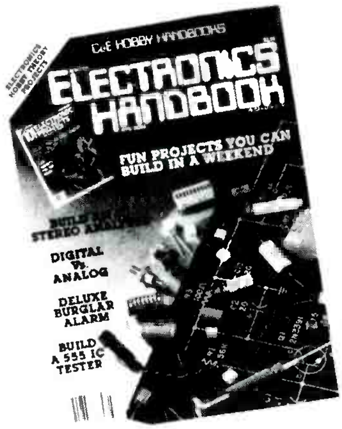
*Suppliers nearest value.

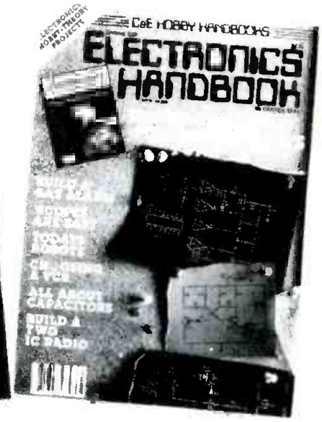
THE MICROPHONE CARTRIDGE MUST BE POWERED THROUGH A 1K OHM RESISTOR. THE OUTPUT IS TOKEN BETWEEN THE RESISTOR AND THE CARTRIDGE.

THE COMBINATION OF THE MICROPHONE CARTRIDGE AND THE 1K OHM RESISTOR MAKES UP M1 IN FIGURE #1.

SW1 "OFF POSITION" M1 (SEE FIGURE 2)

TO GUITAR AMP





$$$$$ SAVE-A-BUCK $$$$$

BACK ISSUE
INVENTORY REDUCTION
WHILE THEY LAST

ANY COMBINATION OF THE FOLLOWING ISSUES FROM OUR SHELF STOCK WHILE THEY LAST

- ☐ SPRING 1987
- ☐ VOLUME #6
- ☐ VOLUME #7
- ☐ VOLUME #8
- ☐ VOLUME #9
- ☐ VOLUME #10
- ☐ VOLUME #11
- ☐ VOLUME #12
- ☐ VOLUME #17
- ☐ VOLUME #13
- ☐ VOLUME #14
- ☐ VOLUME #15
- ☐ VOLUME #16
- ☐ VOLUME #18

BACK ISSUES ELECTRONICS HANDBOOK...$5.00 EACH

- ☐ 2 ISSUES ($9.00)
- ☐ 3 ISSUES ($12.45)
- ☐ 4 ISSUES ($16.25)
- ☐ 5 ISSUES ($20.00)

Check the issues you want and mail, with this "Order Form" and your check/money-order (U.S. Funds), payable to C&E Hobby Handbooks, P.O. Box #5148, North Branch, N.J. 08876. Foreign orders, add $2.50 per issue for shipping and handling (surface mail).

☐ Yes! Please send the "Back Issues" checked to the following street address: I have enclosed my check/money-order for $ __________ (U.S. Funds).

SHIP TO: (Please print)

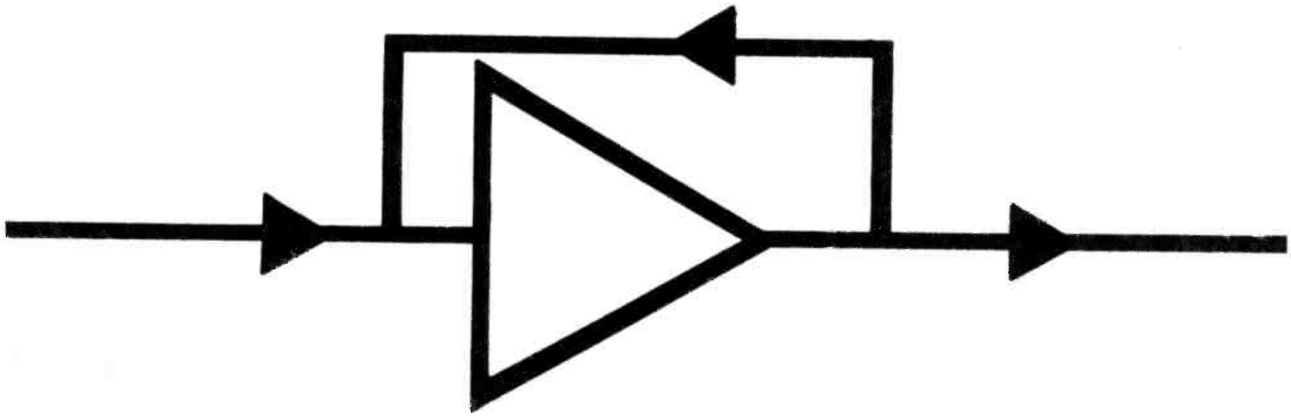
NAME: ______________________________

STREET ADDRESS: ______________________________

CITY & STATE: ______________________________ ZIP: __________

V19

IC TESTBENCH

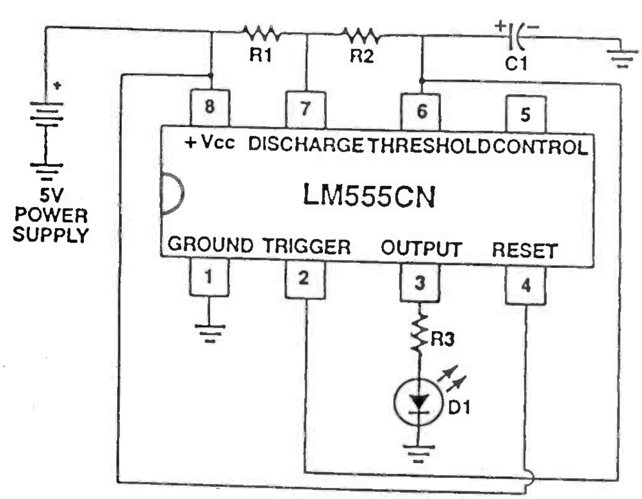


We have said it before but it bears repeating. For the beginner project builder who is considering a try at some of the projects in this project section, it would be wise to polish your skills on some of the simpler transistor projects in the "Circuit Fragment" section of this issue. With a little experience, you should be better prepared to tackle some of these projects and maybe some of the more complicated projects in the "Workbench Projects" section.

FLASHING LED

You can turn your electronic project into an eye catcher. All you need to do is add a few flashing LEDs and you have an eye catcher. To make an LED flash is very simple.

A beginner can do this. The main part of this circuit is the 555 timer which constructs an astable multivibrator circuit. The output from pin 3 is determined by this equation: $1.44/(R1 + 2 * R2) * C1$. If you would like a lower frequency, change the value of R1, R2, and/or change C1, until you have it flashing at the speed you want. Experiment with this circuit by putting two LEDs in parallel from R3. Most of all have fun with this little circuit. ■



PARTS LIST FOR THE FLASHING LED

R1—1kΩ resistor
R2—1kΩ resistor
R3—100Ω resistor
C1—22 uF capacitor
L1—LED
IC1—LM555CN

CABLE TESTER

Testing cables of various kinds is not often easy. However, if you test a lot of cables and you need something where you can just plug the cable in to see if it's good, or if it's not good, to see just exactly which wires are bad, this device is what you are looking for.

The author built a circuit similar to this to test 8-lead telephone or data cables. Plug the cable in, and the LED's tell you exactly which wire is defective. If they don't light, the wire is not defective if they do light, it is defective.

You can also tell if connectors are bad with this tester. It works very simply. Strobing the LED's through a 4017 IC that's driven by a 555 IC, which is an oscillator chip, the 4017 acts as a decade counter. All you have to do is supply the power, which could be anywhere from 6 to 15 volts, to the circuit, and add two sockets for the cable to plug in. You can even isolate one part of the circuit from the other. The oscillator-driver circuit can be in one box, and the LED display circuit can be in another. The schematic only shows one LED, but all of the LED's that are wired to the different connectors are connected to the top lead. All you have to do is decide how many leads you want to use and tie onto those leads, wired the same way as X1 and R3 are wired.

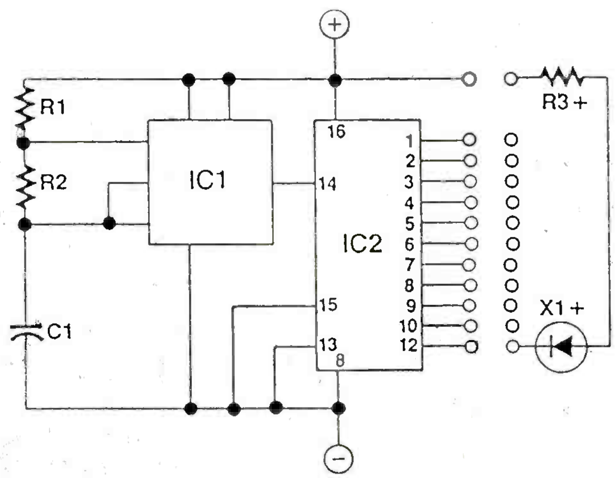
The circuit is very straightforward, can be built in any box with any kind of connector. Each pin is independent in the connector. This tester will test 12-lead cables.

There is one little problem with the tester that you may want to avoid. The top lead is, of course, connected to all of the LED's. If that particular wire is defective, the whole cable will show negative. If you want to avoid that problem, simply run the common line separately with a different wire that doesn't go through the cable.

This cable tester can be built inexpensively and can save you a lot of money and time troubleshooting defective cables. ■

PARTS LIST FOR THE CABLE TESTER

R1, 2—100 K ohm 1/4 watt resistors.
R3 and all other resistors used in series with the LED's are 470 ohm resistors. They can be anywhere from 1/2 watt to 1 watt. C1 is selected according to what strobe rate you would like the circuit to have. You can start with a 1 microfarad capacitor and go from there. It probably will be between 1 and 10 microfarads, depending on whether you want the LED's to flash or strobe. What will happen is, when the circuit is operational, each LED will go on and off at a different time and it will look rather cute. You could possibly even use this as a chase light control.
IC1—either a 555 oscillator chip, or you can use the CMOS, which is a 7555, and uses less current, in case you want to battery operate the circuit.
IC2—4017 IC, a decade counter to mount the IC's and sockets, that way if anything goes wrong with them you can replace them real easily. Usually they don't fail, however, but they have been known to fail on occasion.
X1—LED. Any color, style, brightness, will work just fine.



AUTO POWER TRANSFER SWITCH

Sometimes it is a nice idea to be able to switch between two power sources automatically so that a piece of equipment would not shut down very easily. One good reason might be, if you have some power that you turn on and off occasionally, you may want to be able to switch something over automatically if it's on that power. This circuit would allow you to do that. It's also useful as a transfer switch in a UPS.

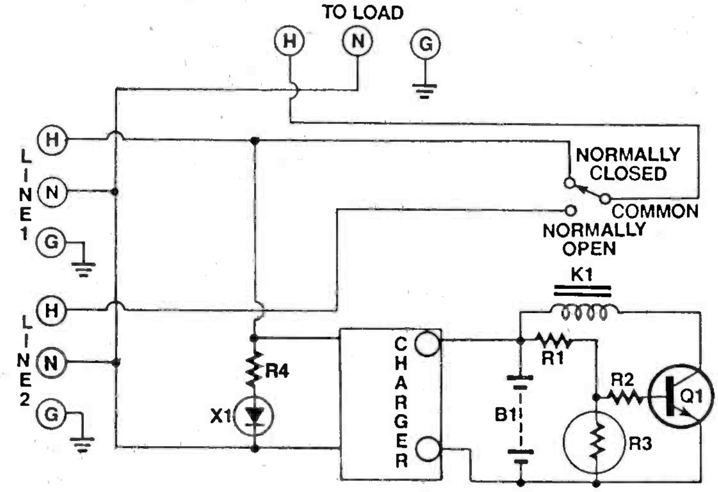
Anyway, here it is. The way this circuit works is simple. With 110 volt AC power, you have hot, neutral, and ground wires. The ground wire is just that; it's a ground wire that connects to the circuit ground and an electrical ground outside, which is usually in the ground. The neutral is the return wire and it, too, is grounded somewhere in the electrical distribution system. The only wire that has the 120 volt or 110 volt nominal potential above ground is the hot wire.

So, all we have to do to build a transfer switch is to connect the neutrals together, connect the grounds together, and then just switch the hots. The two hot wires from the line side go to K1's relay contacts. I used a 12 volt, 30 amp relay as the basis for the circuit. There is a 12 volt coil, and it has 30 amp contacts. This will switch a lot of power. You need at least 15 amp contacts, depending on how much current you're going to have to switch. The center pole of the relay goes to the hot lead on the load. Therefore, if the power should fail on the primary source, the LED X1, stops lighting. R3, the photocell, will then go high resistance and allow the current to enter the base junction of Q1, turning it on and pulling in relay K1, which pulls the contact down to the normally open side, switching the power from primary to secondary.

This circuit uses a battery charger and a gel cell lead acid battery so that it always has power. You don't want it to fail in the midst of switching power, so it's a good idea to use this kind of a system (although you could run it off a dry cell battery that could supply the quiescent current involved). You can figure out the quiescent current by measuring R1 and R3 under conditions where R3 is being lit by the LED. The current may be a little steep, but you could still run it off a larger battery. It has to supply 12 volts, though, when the relay needs to pull in, so it's probably better to use the charger. ■

PARTS LIST FOR THE AUTO POWER TRANSFER SWITCH

R1 and R2—47K ohm, 1/4 watt resistors
R3—photo resistor photocell
R4—10K ohm, 1 watt resistor
Q1—2N2222A transistor
B1—12 volt gel cell battery with a charger. (You can buy the battery with a matched charger from companies like Allied Electronics.)
X1—LED, (Any color that's optically coupled to R3 by using a tube and by taping it over with black tape so no light gets in except from the LED.)
K1—(Any relay with a 12 volt coil that has contacts that can carry 10 amps or better, depending on how much current you have to switch).



MODEL ROCKET LAUNCHER

What's made of paper, cardboard, plastic, and a bit of Balsa, and can be launched into the wild blue yonder?

A model rocket, of course! On a clear and calm day, it's lots of fun to launch these colorful little rockets high in the sky and watch them fly.

One problem, however, has been a safe and reliable launch control. This launcher solves that problem.

For power, the clips can be small and used on a 12 Volt lantern battery, or large, for use on a car battery. The leads from the battery clips to the control box should be no smaller than #16 wire and at least 6 feet long.

SO1 is a normal 110 volt receptacle and PL1 is a 110 volt plug, permitting the use of an extension cord between the control box and the rocket, saving money on heavy wire.

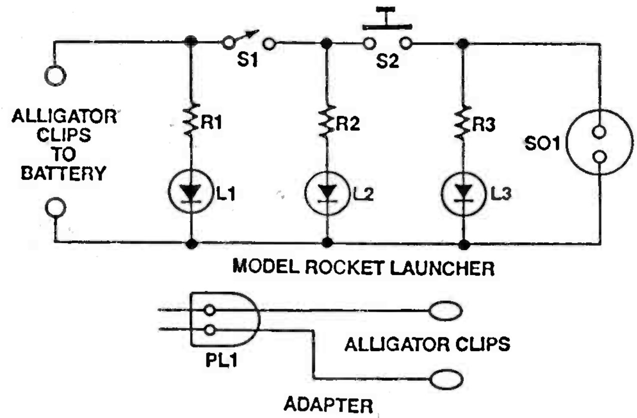
The clips on the adapter connect to the resistance wire ignitor that you install in the engine. The adapter plugs into the receptacle on the extension cord, which plugs into the control socket.

When battery power is applied, the green LED, L1 lights. When S1, the ARM switch is thrown, the yellow LED, L2 lights. Upon pushing the FIRE button, L3 lights red, and power is applied to SO1, through to the ignitor.

This unit adds a measure of safety to a fun hobby. ■

PARTS LIST FOR THE MODEL ROCKET LAUNCHER

R1, 2, 3—390 Ohm resistors
L1—Green LED
L2—Yellow LED
L3—Red LED
S1—Single Pole, Single Throw Switch, normally open, rated at least 6 amps.
S2—Normally Open pushbutton, rated at least 6 amps.
SO1—2 wire wall socket or 110 volt female receptacle.
PL1—110 volt 2 wire plug.
Misc.—Battery clips, wire, alligator clips, case.



LED BRAKE LIGHT

All these nice new cars going by with their red lights at the bottom of their rear windows gave me the idea for this unit. For the one who has a "mature" vehicle, this will snazz it up, and you should never need to replace the LEDs like you would a lamp. LEDs are neat, a diode that emits light, hence, Light Emitting Diodes. They run cool and long. I had one that ran 105,000 hours!

LEDs are not as bright as regular car lamps so, even though we will use 12 of them, they should all be the new high brightness type. Radio Shack is selling several high brightness ones that would work in this unit.

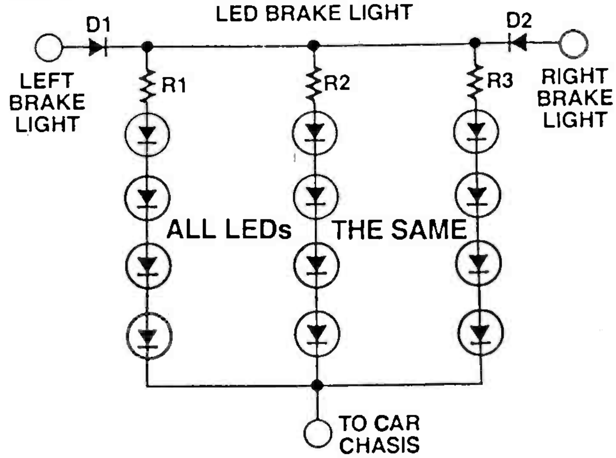
Mount the LEDs on a perfboard for wiring into 3 series strings, being sure to observe correct polarity. The resistors should be kept away from direct contact with plastic.

You can easily find the right wires to connect this unit, first locate the wire in the tail light assembly that has 12 volts on it only when braking.

Shave off just enough insulation to expose 1/4 inch of copper without breaking contact with the tail light.

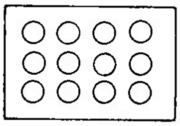
Twist your wire around the exposed copper of the wire, solder and tape. Use Scotch 88 or other electrical tape suitable for auto work.

Mounted in a nice housing, this light will be a nice addition and a safety feature for your car. ■



PARTS LIST FOR THE LED BRAKE LIGHT

D1, 2—1N4007 Diodes
R1, 2, 3—100 Ohm, 5 or 10 Watt resistors (at least 5 watt, but here bigger is running cooler)
All LEDs—Red, high brightness
See Radio Shack. For this quantity, you may need to order them special.



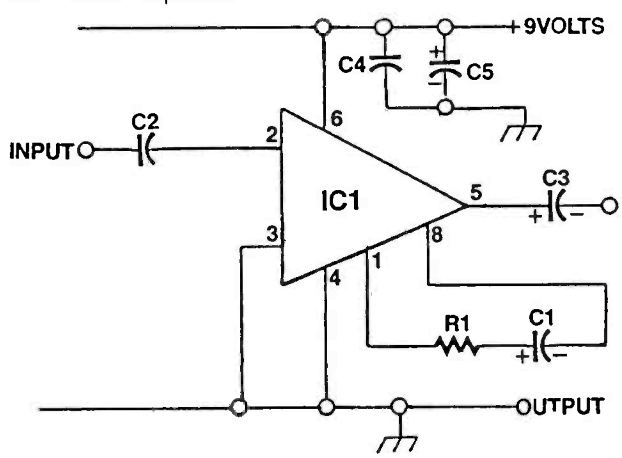
POSSIBLE ARRANGEMENT OF LEDs IN RED LENS

LM 386 GAIN SELECTOR RESISTANCES

The LM 386 audio power amplifier is a convenient 8-pin integrated circuit requiring only a few components to pump out a healthy dose of useful power into a 8 ohm load. The manufacturer's data sheet spec's the device to have a **typical voltage gain** of either x20 or x200 (with a 10uF capacitor connected across pins 1 and 8). A gain of x200 is very generous but at that high gain you also get unwanted high frequency 'hiss' as the '386' has a flat response over the audio frequency band (20Hz to 20kHz). A better way of using this device is to add a variable resistor, R1, 10K, in series with the 10uF gain enhancing capacitor C1 and select the amount of gain. With a 10K potentiometer the gain can be varied from x20 (R1 = 10K ohms) to x200 (R1 = 0 ohms). With an oscilloscope and signal generator you can measure the resistor value corresponding to specific gain values between these two extremes. The table below shows the measured results for a 1kHz input sine wave. Note the gain changes rapidly as R1 is varied between 1K to zero ohms. Values are actually measured as opposed to manufacturer's spec's. C1 is the input coupling capacitor, C3, the output capacitor, and C4/C5 the supply decoupling capacitors. ■

PARTS LIST FOR THE LM 386 GAIN SELECTOR

IC1—LM 386 audio power integrated circuit
C1—10uF capacitor
R1—see values in table
C2—0.1uF capacitor
C3—100uF capacitor
C4—0.1uF capacitor
C5—100uF capacitor



R1	10K	2K	1K	632R	442R	319R	252R	183R	147R	105R	75R	53R	37R	18R
Gain	20	30	40	50	60	70	80	90	100	110	120	130	140	150

REGULATOR PROTECTOR

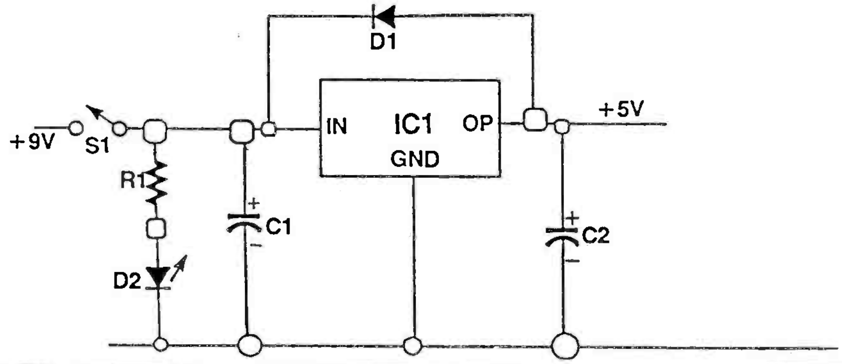
The three terminal regulator is a very simple device to use, available in a variety of convenient formats. A particularly useful type is the 5v regulator, useful for powering TTL circuits from a 9 volt battery source. Typically, in its simplest configuration, when 9 volts is fed to the input terminal, 5 volts is available on the output terminal. It's as simple as that! Often you will find a capacitor C1, across the input terminal and ground (ranging in value from 0.1uF to 100uF typically) and similarly so, C2, across the output terminal and ground.

The regulator under certain conditions can be damaged if the voltage at the output terminal rises above that at the input terminal. This condition could arise under certain switching arrangements where the capacitor C1 would discharge through the input LED indicator (R1 and D2). The remedy is very simple. By the addition of a rectifier diode D1, across the input and output terminal as shown, this condition is prevented from occurring and destroying the regulator.

Most regulator circuits rarely show the addition of the protector diode, but should you come across it in the future you can now see why this particular component has been included. ■

PARTS LIST FOR THE REGULATOR PROTECTOR

D1—1N4001 rectifier diode
IC1—5v regulator (78L05)
R1—1K resistor
C1—10uF electrolytic capacitor
C2—10uF electrolytic capacitor
D2—LED
S1—switch



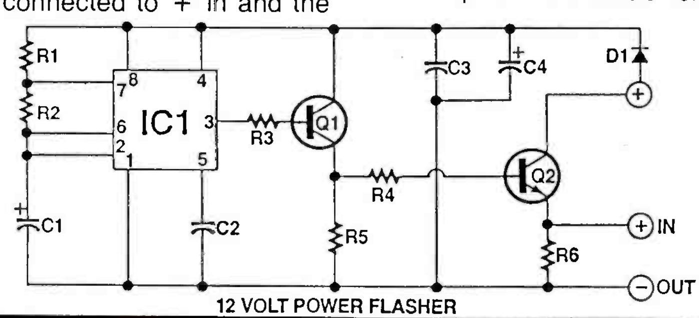
12 VOLT POWER FLASHER

Want to flash lots of lights, or big lamps on a car or other vehicle? This flasher is for you. IC1 sets the flash time, which can be changed by changing the value of C1, or R1 & R2. The higher C1s' value, the longer the flash time. Using a potentiometer with two sections to replace R1 & 2 will allow you to vary the flash rate as desired. For most uses, such as an emergency flasher for your car headlights, that would do. This unit could be used as a replacement for your cars' flasher, but it will be bigger. Better uses are for emergency lights, or just bright attention getting lamps.

Q2 determines how much power the flasher will handle. Using the specified transistor and properly heatsinking it, this circuit can flash up to 8 Amps of lights at 12 volts. If you want to flash more than 8 Amps, Radio Shack makes a 12 Volt 30 Amp relay that can be used. Connect the coil of the relay from + out to − or auto ground. The contacts are connected to + in and the output contact supplys + DC to the lamp load. ■

PARTS LIST FOR THE 12 VOLT POWER FLASHER

R1, 2—100K ohm Resistors
R3, 4—100 ohm ½ Watt Resistors
R5, 6—10K ohm Resistors
C1—10 Mfd, 35 V Capacitors
C2, 4—.1 Mfd, 50V Capacitors
C3—1000 Mfd, 25V Capacitor
D1—1n4004 Diode
IC1—Lm 555 timer IC
Q1—2n3053 transistor
Q2—2n3055 transistor
Also a large heatsink for Q2 and a mounting kit to mount that TO-3 transistor to the heatsink. TO-3 is the number showing what type of package the transistor is mounted in. These parts are available from Digi-Key



12 VOLT POWER FLASHER

ELECTRONIC SIRENS

By Christopher W. Kirk

Now you can build you own electronic police siren using inexpensive parts that are readily available from your local Radio Shack. It's easy to construct, requires no adjustment or calibration, and sounds quite realistic.

Other circuits for sirens have been published, but they either produce the simple alterating tones of a European police siren or they require a button to be pushed each time you want the siren's pitch to rise and fall. These circuits are designed to initiate the continuous wailing of an American police siren automatically, by a simple modification of a standard design.

This siren could be used as part of a formidable alarm system in your house, car or garage. It could warn you of burglars, fire or just rising water in the basement. You could even install it on the handlebars of a youngster's bicycle—an exciting accessory that would be the envy of his friends. You could also use it as a sound effects generator in amateur theatrical productions.

How It Works

The siren in Figure 1 used two 555 timers while that in Figure 2 uses a 556 dual timer. Since both circuits operate basically the same way, we will just describe the circuit in Figure 1.

Both U1 and U2 are 555 timers designed to act as square-wave oscillators. The frequency of U1 is determined by R2 and C2; the frequency of U2, by R7 and C4. U1 is a low frequency oscillator and is used to modulate the frequency of the audio oscillator, U2. The output of U1 alternately charges and discharges capacitor C2 gradually through resistor R2. The voltage across C2 is divided by R3 and R4 and applied to the base of transistor Q1. (R3 and R4 must be large to prevent C2 from discharging through the base of Q1 rather than through R2.) Q1 produces an inverted version of the voltage across C2. Thus, as C2 charges and its voltage rises, the collector voltage of Q1 drops. This voltage is applied to pin 5 of U2 where it causes the frequency of U2 to rise. Conversely, when U1 discharges C2, the collector voltage of Q1 rises and the frequency of U2 drops. The net result is an alternately rising and falling wail like that of a police siren.

Power requirements

Although the supply voltage is specified as 9V, I've used both siren circuits with supplies ranging from 6V to 12V. Using a lower voltage causes the pitch and speed of the siren to drop slightly. If you want, you can compensate for this by slightly decreasing the values of R2 and R7. Conversely, raising the supply voltage causes the pitch and speed of the siren to increase slightly. To compensate, just increase R2 and R7 slightly.

R1 and C1 serve to decouple the power supply. The circuit draws an average of about 50 mA d.c. from a 9V supply and can be powered by either a 9V transistor radio battery or a regulated power supply. You could also use a 12V automobile battery.

Components

Resistors rated ¼ W or more can be used. With a 12V supply, R1 should be rated ½ W or more. The electrolytic capacitors should be rated 16 WVDC or more, while C3 and C4 may be disc-ceramic or plastic/metal-film capacitors. Q1 can be any small-signal NPN transistor: 2N2222, 2N3904, etc. I've tried using a CMOS version of the 555, namely the TLC555, but its current-handling ability is limited. It can't be substituted for U2 without some modifications to prevent overloading: C5 must be reduced to 1uF and R7 raised to 15K. (If used only as U1 in Figure 1, no changes are needed.)

Construction

Although the circuit doesn't draw much power and doesn't operate at high frequencies, you do have to be

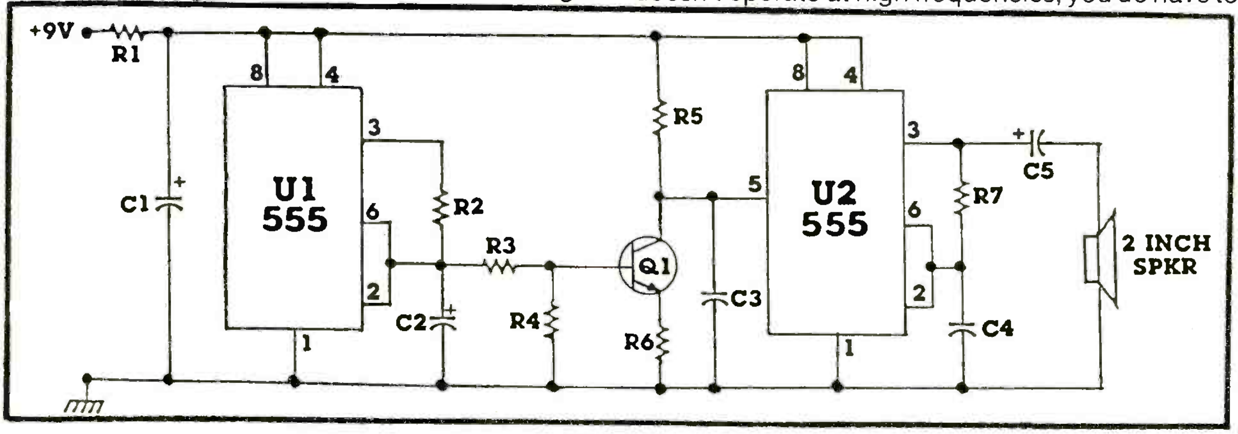


Figure 1.

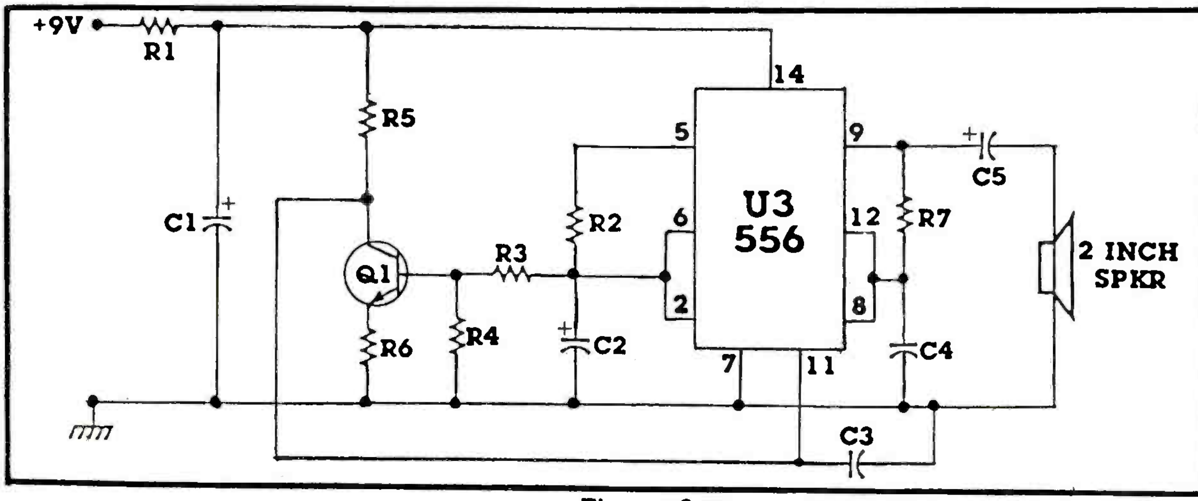


Figure 2.

a little careful in constructing it. The problem is that if the lines to the speaker get too close to Q1 or the modulation input (pin 5 of U2 in Figure 1 or pin 11 of U3 in Figure 2), transients radiated by the speaker lines are picked up and cause false triggering in the audio oscillator. This results in distorted sound or clicking. C3 helps bypass these transients to ground so it should be mounted close to the modulation input and its leads kept short. Also, you should try to minimize radiation from the speaker lines by twisting them together or by connecting the speaker with shielded cable.

I mounted the components on perf board and then connected them using wire-wrap. If the circuit is likely to be subjected to moisture or vibration, as would be the case of a car alarm or bicycle siren, you should solder the components together. You might even consider etching and drilling a p.c. board.

I put the circuit board in a plastic project box from Radio Shack after drilling holes in the cover to let the sound out. I glued a piece of waterproof polyester cloth behind the holes to keep out dust and moisture, and then used a few drops of glue to secure the speaker to the cover. Finally, I drilled a hole in the side of the box and mounted the on/off switch in it.

If you want to secure the siren to the handlebars of a bicycle, use a couple of hose clamps. Drill holes through each hose clamp and the box. Pass small machine screws through the holes and secure them with washers and nuts, then tighten the hose clamps around the handlebars.

Other Options

Unfortunately the siren doesn't have a provision for volume control, so you might find it too loud to use indoors as a toy or too weak to use in a theater or as an outdoor alarm. To reduce the volume, you could reduce the supply voltage or make C5 smaller or use a smaller speaker. Decreasing C5 or the speaker size would raise the pitch of the siren so you might want to increase R7 slightly to lower the pitch. If you want the siren to be louder, you could raise the supply voltage or make C5 larger or use a larger speaker; however, if either C5 or the speaker is made too large, the IC will become overloaded and produce distorted sound. Increasing either C5 or the speaker's size lowers the pitch of the siren so you might want to decrease R7 to compensate.

The siren output could also be applied to an amplifier, but if you do that, you'll probably have to attenuate the siren's output to avoid overloading the amplifier's input.

This siren is so small you might even be able to fit it inside a toy police car: with a flashing red L.E.D. on top it would make an impressive gift for a little boy. If you try this, you might want to replace the speaker with a piezoelectic one or with an earphone cut in half to expose the metal diaphragm.

Finally, a word of warning. Some readers might feel tempted to play policeman by driving around with this siren blaring. Don't try it: it's illegal. ■

PARTS LIST FOR FIGURE 1

C1—100uF 16VDC or higher electrolytic capacitor
C2—220uF 16VDC or higher electrolytic capacitor
C3, 4—0.1uF 50VDC ceramic or metal film capacitor
C5—10uF 16VDC or higher electrolytic capacitor*
R1—10 ohms resistor*
R2—22K resistor
R3—220K resistor
R4—100K resistor
R5—15K resistor
R6—4.7K resistor
R7—10K resistor*
Q1—any small-signal NPN transistor: 2N2222, 2N3904, etc.
U1, 2—555 or TLC 555 timer
Sp1—8 ohm, 0.2W, 2" speaker
All resistors are ¼W, 5% unless otherwise noted.
*See text. (If TLC555 is used for U2, reduce C5 to 1uF and raise R7 to 15K. If 12V supply is used, use ½W resistor for R1.)

PARTS LIST FOR FIGURE 2

C1—100uF 16VDC or higher electrolytic capacitor
C2—220uF 16VDC or higher electrolytic capacitor
C3, 4—0.1uF 50VDC ceramic or metal film capacitor
C5—10uF16VDC or higher electrolytic capacitor
R1—10 ohms resistor*
R2—22K resistor
R3—220K resistor
R4—100K resistor
R5—15K resistor
R6—4.7K resistor
R7—10K resistor
Q1—any small-signal NPN transistor: 2N2222, 2N3904, etc.
U3—556 timer
Sp1—8 ohm, 0.2W, 2" speaker
All resistors are ¼W, 5% unless otherwise noted.
*See text. (If 12V supply is used, use ½W resistor for R1.)

CONSTRUCTION QUICKIES

A-C MICROVOLT PREAMP

By Lawrence T. Fleming

This preamp will extend the 200-millivolt AC range on a DMM by 100 times—down to 2 millivolts full-scale—or raise a microphone output up to the "AUX" input level on a stereo. Its maximum gain is 100. Frequency response is within 1 dB from 25 Hz to above 20KHz. Noise level is 2 to 9 microvolts referred to the input, depending on source impedance (Build it in a metal box). It runs off a 9-volt battery.

At these gain and bandwidth levels this discrete-component circuit outperforms an IC OpAmp, such as the LM356, and uses about the same number of resistors and capacitors.

The first stage (Q1), a J-FET, is direct-coupled to the second stage, a PNP transistor (Q2), which then drives an NPN emitter follower (Q3). The DC operating point is stabilized by DC feedback from the emitter of Q2—labeled point "H"—back to the source of Q1, via R2, and P2 and R1. The AC signal gain, however, is set by the ratio of R2 and R1 because P2 is bypassed for signal frequencies.

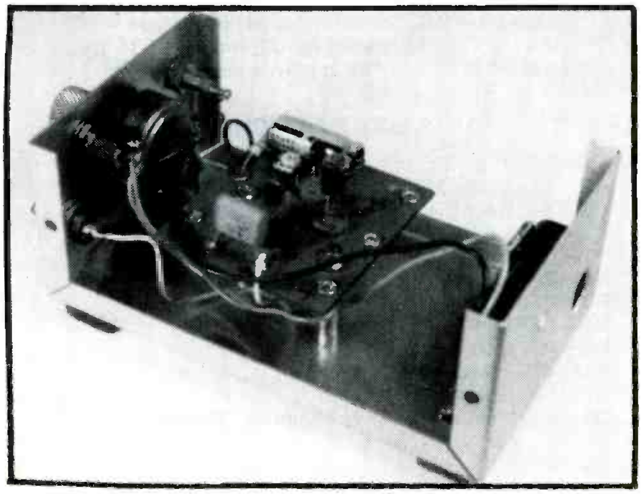


Photo 1. This photo illustrates the placement of parts in the finished Preamp. Note the compact neatness of the layout.

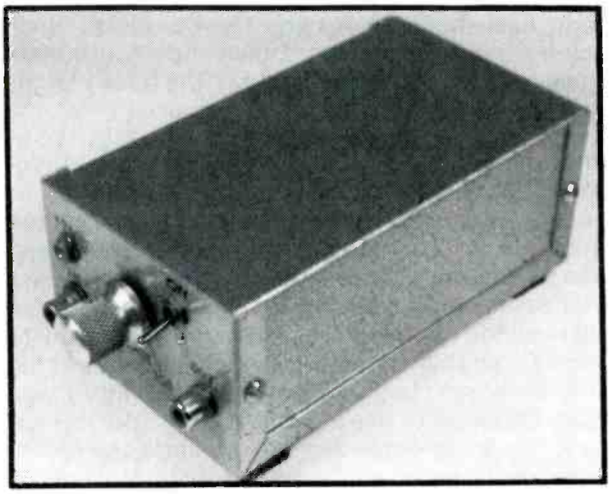


Photo 2. Here is a photo of what the Microvolt Preamp should look like when it is completed.

R3 is the load resistor for Q2; R4 and R6 are protective resistors, and R5 prevents "latch up" if Q3 gets cut off. D1 and D2 are the usual protective diodes at the input.

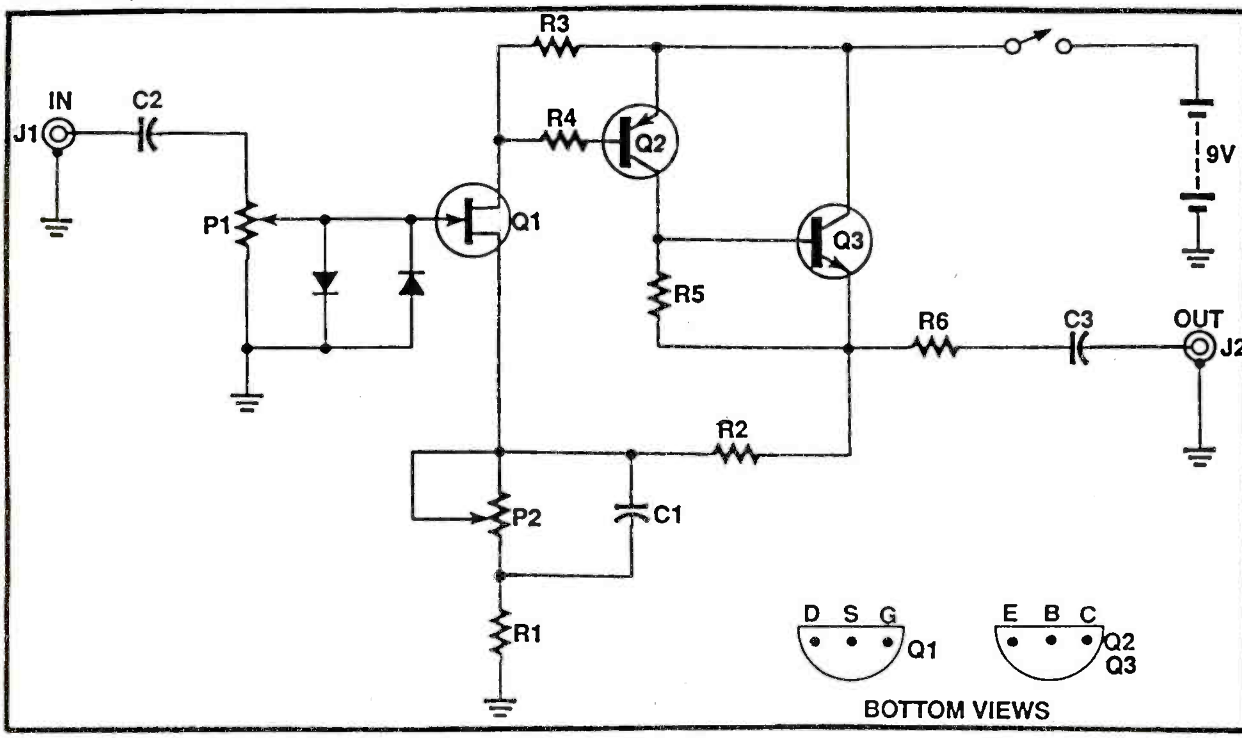
Drain current of Q1 is around 60 microamps. The gate bias for this current is rated at −0.5 to −3 volts. Most JFET types suffer from this broad spread; that's why P2 has to be adjustable.

Set P2 for maximum no-feedback gain (with R1 shorted), then back off about 20 percent toward the high-resistance side. Alternatively, set P2 so that the DC voltage level at point "H" is about 5.5 or 6 volts above ground.

The circuit was tried with 10 2N5457's and 10 J230's at Q1, and with 2N2907's at Q2 and 2N2222's at Q3. They all worked. Battery drain is just under 1 milliamp. Maximum output is 0.5 volt. ■

PARTS LIST FOR A-C MICROVOLT PREAMP

C1—470uf, 6-volt electrolytic capacitor
C2, C3—0.1uf capacitors
D1, D2—signal diodes, 1N914 or equivalent
R1—39 ohm resistor
R2—4.7K resistor
R3—10K resistor
R4, R5—1K resistors
R6—220 ohm resistor
P1—500K pot, audio taper (Gain control)
P2—2K trimpot
Q1—2N5457 FET
Q2—2N3906 PNP transistor
Q3—2N3904 NPN transistor
Misc.: J1, J2—RCA jacks, Metal box, 9-volt battery



SCHEMATIC OF AC MICROVOLT PREAMP

MODEL ROCKET LOCATOR

By
Jerry Baumeister

Rocket science doesn't have to be difficult. At least that's the case with the following circuit which was designed to assist in the location and recovery of small model rockets. Its light weight, small size, and inexpensive construction make it especially suited to the small model rocket enthusiast. Don't let its simplicity deceive you. It does an exceptional job for its designed purpose.

The "locator" functions by providing audio and visual signals. The audio signal, produced by a piezo alert is useful for locating during both day and evening operations while the visual signals, produced by two blinking LEDs, work extremely well for evening and night recoveries. Working range for the piezo alert is approximately 50 yards during the day and over 100 yards on a still night. The range of the LEDs is seriously limited during the day but is at least 100 yards at night.

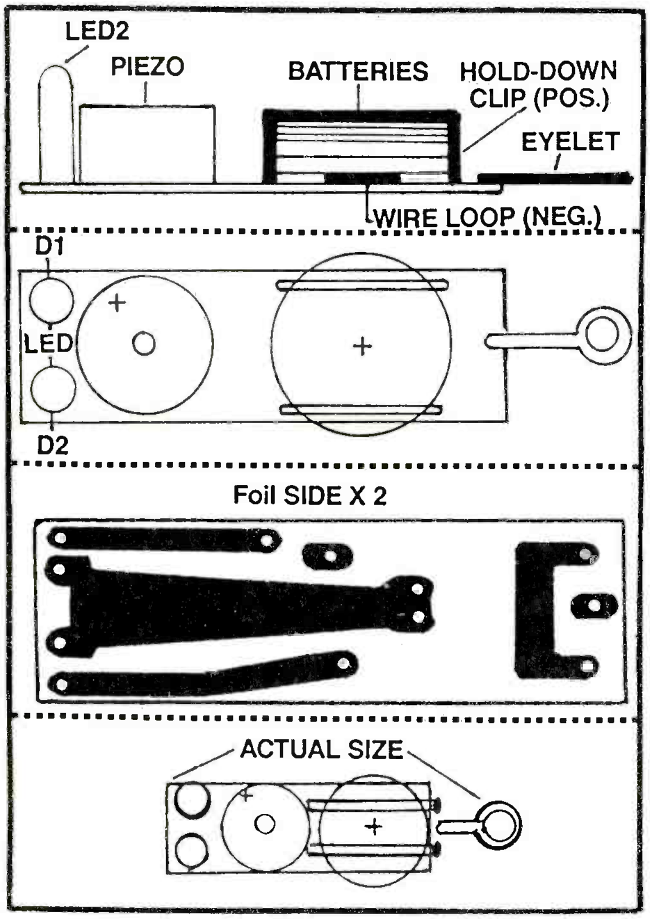


Figure 1. Shows the layout of the Model Rocket Locator.

CIRCUIT DESCRIPTION

Figure #1 shows the layout and figure #2 shows the schematic of the locator. D1 is an LED and is connected in series with the piezo alert. D2 is a blinking LED and is connected in parallel to D1 and the piezo alert. The current in the circuit alternates between D2 and the D1/piezo alert. When the blinking LED, D2, is lit most of the current in the circuit is shunted through D2. This drops the current through the piezo alert below its operational threshold thus turning it "off". With the piezo alert off D1 is also off. When D2 cycles, off current is available for the piezo alert and D2 and they turn on. This produces alternating blinking LEDs and a "beeping" sound.

Power is provided by one or more lithium batteries stacked in series. The more batteries the brighter and louder the "locator" and also, the greater the weight. Two batteries seem to be a workable compromise between power and weight.

CONSTRUCTION

The device can be constructed on a small piece of "perf" board or a circuit board can be etched using the pattern in figure #1. The battery hold-down clips and the eyelet are constructed from a paper clip. Be sure to construct the battery hold-down clips to accommodate the number and size of batteries you wish to use. The hold-down clips act as the positive terminal and a small loop of wire mounted on the PCB form the negative terminal. Also, be careful to observe proper polarity on all the components when assembling.

After assembly, place the desired number of batteries in the holder and ensure that the batteries are very snug. The device should begin to operate. Next hold the locator by the eyelet and sling the locator back and forth. If the batteries remain in the unit and operation continues it is ready for flight testing. If not, crimp the battery hold-down clips to increase the tightness of the fit and retest the unit.

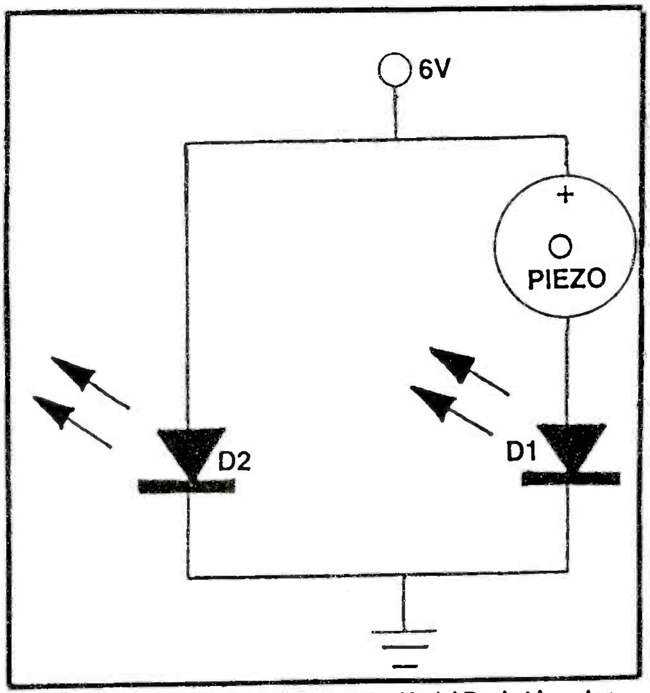


Figure 2. Shows a schematic of the Model Rocket Locator.

OPERATION

Connect the locator close to the parachute or streamer on the elastic ejection cord using the eyelet on the locator. Pack the locator between the chute and the wadding or beside the parachute. Attach the nosecone and you're ready for launch. ■

PARTS LIST FOR THE MODEL ROCKET LOCATOR

D1—Red LED (Radio Shack 276-044)
D2—Blinking LED (Radio Shack 276-036)
Piezo alert (Radio Shack 273-074)
Battery (Radio Shack CR 1220)
Paper clip

CONSTRUCTION QUICKIE

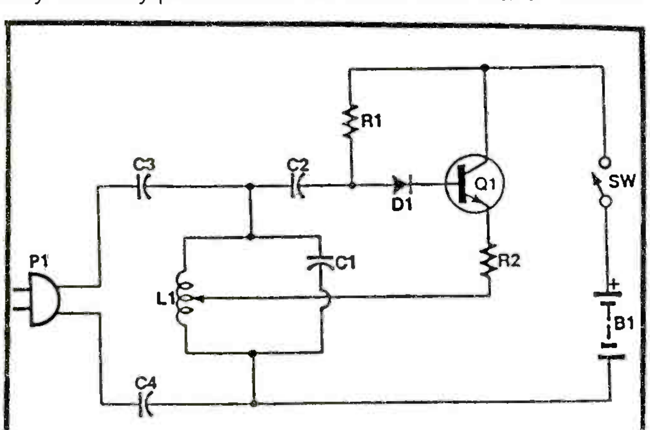
HOUSE WIRING TRACER

By Lawrence T. Fleming

To add a wall outlet or troubleshoot a wiring installation is a problem that can run into snags, trying to trace what is connected to what, and where. When the Romex inside the walls comes out into view down in the basement or out in the garage, it is not easy to follow. In the photo, for example, (my basement) the overhead wiring coming out of the top of the panel box looks like a serving of giant noodles.

Any individual circuit can, however, be traced by feeding a little rf into it and then probing along with a radio receiver. Transmitters and receivers to do this are used by electricians; they are expensive. A cheap but not very effective way to do the same thing is to plug in an electrically-noisy appliance such as a vacuum cleaner or a hair dryer (anything with a brush-type motor, preferably in poor condition) and do the probing with an ordinary portable AM radio. Sparking commutator noise, however, spreads over a huge bandwidth and sounds like fluorescent lamp noise, hard to identify.

What's needed, therefore, is a cheap and simple transmitter with a distinctive signal. Together with this, any ordinary pocket-size AM radio is all that's needed.



Circuit of "squegging" rf oscillator for feeding tracer signal into house wiring. Detect with any AM radio. Signal is milli-watt-level bursts of 650-KHz repeated at 800Hz rate.

Tracer Transmitter Circuit

The circuit of Figure 1 provides the necessary signal. Exceedingly simple and inexpensive, it uses the old and almost forgotten principle of the quenching oscillator, well-known in the days of vacuum tubes. Sometimes called, not quite accurately, a blocking oscillator, its action is called "squegging" in England. The idea is that rf oscillation starts to build up, and the diode "D" rectifies the rf and charges up capacitor "C2" until the base of transistor "Q" is biased to stop oscillation. Then the charge leaks off through "R1" until oscillation can start again, and so on and on. The waveform generated is a string of short bursts of rf. With the constants shown the rf frequency is about 650 KHz and the repetition rate about 800 Hz. In the radio tuned to 650 KHz it sounds like a simple 800 Hz tone. The signal is broader than a proper CW signal, so tuning is easy.

The circuit draws about 1.5 mils at 1.5 volts. In air, the range of this "transmitter" is about 3 feet. When coupled to a house power circuit by plugging the plug "P" into an outlet the signal radiated from the Romex line can be heard in the radio up to about a foot from the line. The signal is easily followed through the typical "drywall" (It won't work through metal lath or with BX, naturally).

Construction

The whole thing is built on a piece of perfboard which, along with the battery, will fit in a project box around 1 by 2 by 3 inches. The a-c plug, which is used to inject the signal rather than to receive power, is on the end of a short piece of cord. The inside ends are held to the perfboard with glue. The coil is also glued in place. A good kind of glue is "Goop®", which dries to a rubbery consistency and adheres very well.

A single AA cell is adequate for power, although the circuit will work on anything up to 10 volts. For more power, use more volts.

As for the components, any ordinary NPN small-signal transistor is OK except for 2N3904's, which seem to modulate the carrier with noise. Capacitors C3 and C4 must withstand the line voltage. The ones in the photo

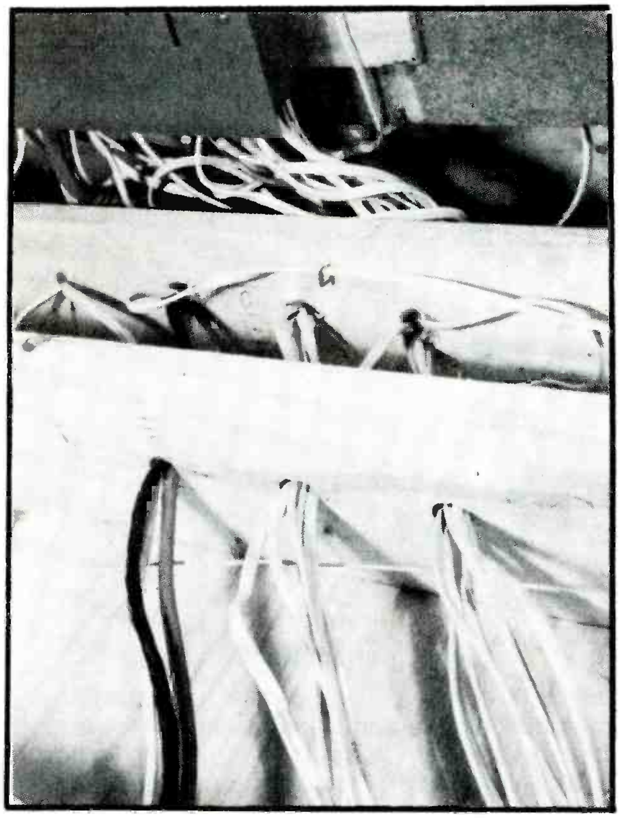


Photo #1 Modern hard-to-trace house wiring.

are 1000-volt ceramic discs.

To change the repetition frequency change C2. Output can be increased a bit by reducing the emitter resistor R2 but it must always be high enough to limit the collector current to a safe value; in L-C transistor oscillators generally the collector current flows in very short pulses of correspondingly high current.

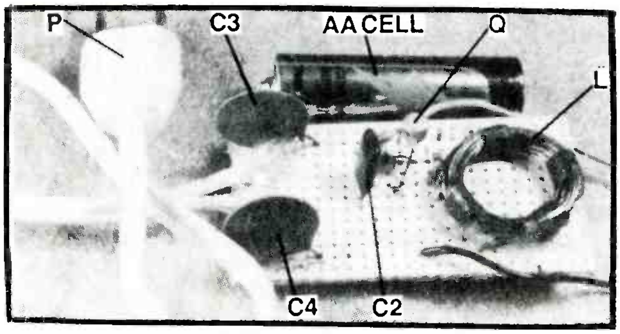


Photo #2 Tracer "transmitter".

The tuned circuit has a low L/C ratio to make it less sensitive to loading. The coil was wound by cutting off an 8-foot length of magnet wire and just wrapping 32 turns around the barrel of a marking pen that happened to be 0.7 inches in diameter, pulling out a tap at 16 turns. It was then slipped off, squeezed into a sort of doughnut shape, taped and glued. This shape of coil gets the most inductance per foot of wire but the "Q" is only about 20. In this application however, high "Q" is not needed. The exact diameter is not critical. Inductance varies linearly as diameter but varies as the square of the number of turns. With a different size form, act accordingly. The frequency needs only to be in the broadcast band, although the low end is a bit better. ■

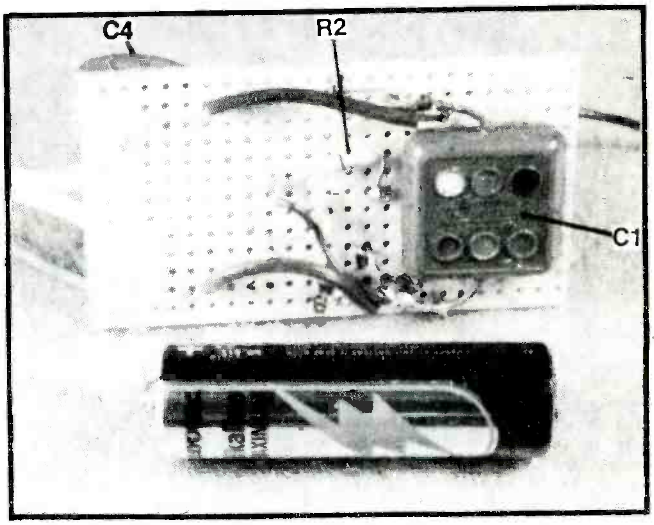
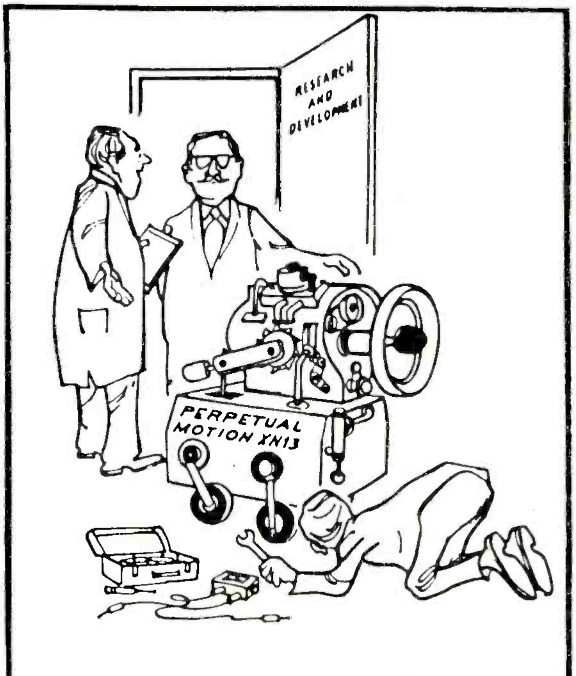


Photo #3 Tracer "transmitter"—Back of perfboard.

PARTS LIST FOR THE HOUSE WIRING TRACER

C1—.002 mfd mica
C2—.03 mf.
C3, C4—100 pf ceramic, 400 volts or higher.
R1—47K
R2—68 ohms
D—1N914 diode
Q—2N2222 or similar transistor (not 2N3904)
B—1.5 volts, AA or AAA cell.
P—standard plug to fit wall outlet.
L—30-micohenry coil, center-tapped. 32 turns No. 24 wire bunch wound on a marking pen 0.7" diameter, slipped off, taped and glued.
SW—miniature SPST toggle switch or any convenient type.



"We're right on the threshold, sir ... but we've hit one snag ... it keeps stopping!"

THE ELECTRONIC NOTE PAD

By Carl J. Bergquist

Since their appearance, a few years back, voice message integrated circuits have been employed in a wide variety of applications. From telephone answering machines, that repeat extremely lifelike audio messages, to greeting cards with a special voice note, to repeater announcements on amateur radio networks, these clever digital recording chips have been effectively utilized. The ICs are easy to work with, requiring very few support components, and do produce very high quality audio, even to a small speaker. The two most commonly available varieties are the ISD1000AP, and the ISD1016AP. Both chips are 28 pin DIP arrangements, featuring on board logic circuitry, multi-message capability, and a power amplifier output. Either operates from a single 5 volt power supply, delivering voice, music, or other audio, up to 20 seconds in length, to an 8 to 16 ohm speaker, and have virtually identical pin outs and discrete support.

With all that in mind, let's take the ISD1000AP, and develop it into a pocket sized message center, or "on the go" idea reminder. The 1000 was chosen because it is readily available, through Radio Shack, and, the data sheet, that comes with the chip, provides additional information that will be helpful if you want to expand the capability. So, the assembly, described in this article, will familiarize you with the technology, and basic application, of voice message ICs, and is an enjoyable, one evening project, that results in a very useful "gadget".

CIRCUIT OPERATION

Figure 1 illustrates the schematic diagram, and the simplicity of the circuit. Bear in mind, that, as a single message configuration, the logic capability was not accessed but, even when it is, the layout remains remarkably straight-forward. Wiring of the chip follows the recommendations of the data sheet, with a few exceptions in component values. For example, the microphone compression capacitor, C4, was reduced from

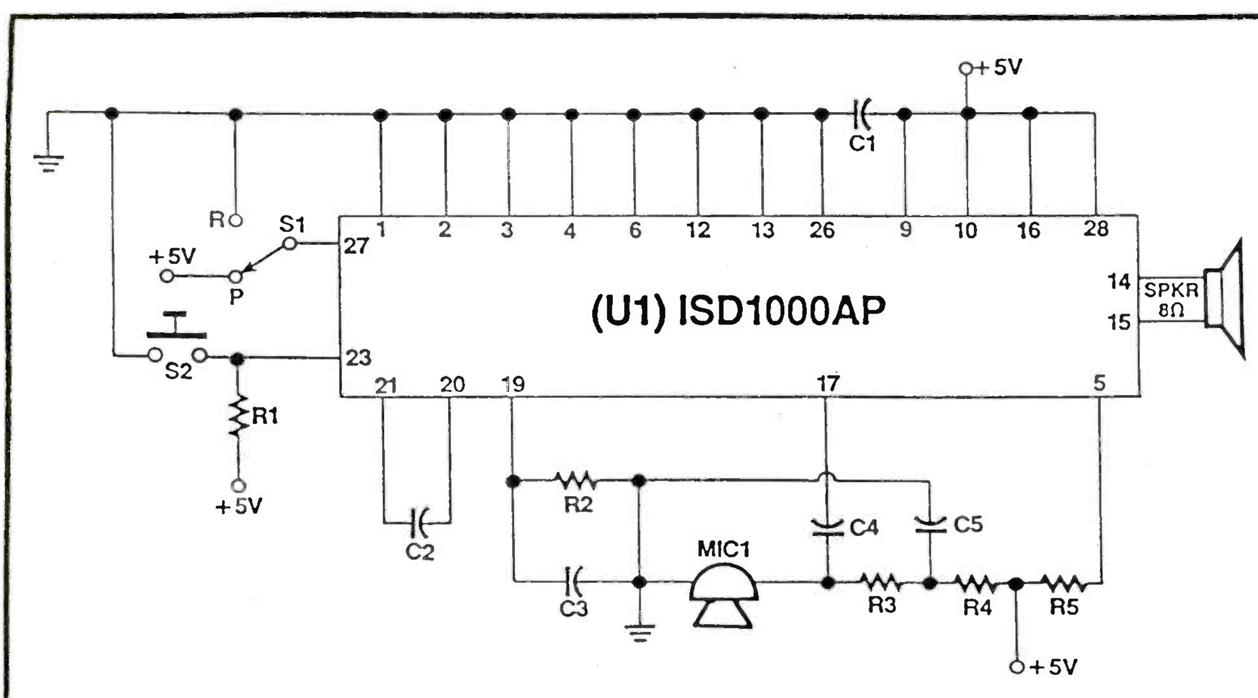


FIGURE 1: VOICE MESSAGE CHIP SCHEMATIC

.22 mF to .1 mF, and, capacitor C3, in the R2/C3 network, was increased to 6.8 mF. On the breadboard, these values seemed to perform as well, or better, than that prescribed, but, otherwise, the circuit was adhered to.

The audio signal is introduced to the chip via an electret microphone, MIC1, and, recording is controlled by switch S1. When S1 takes pin 27 low, the ISD1000 is in the record mode, and when switched to +5 volts, or high, it's ready for play-back. In both cases, the desired operation is initiated by pressing switch S2. S3 acts as the power on-off switch, as the chip needs a couple of seconds of power-up prior to use.

The remaining parts perform the usual tasks, C1 is a bypass, or decoupling capacitor, the resistors provide correct bias, and the audio power Amp terminates at the speaker. The prototype uses an 8 ohm speaker alone, but a 10-ohm resistor can be placed in series, at pin 14 or 15, to reduce volume, and adjust the output impedance closer to the preferred 16-ohm value.

The completed circuit operates quite well off a 9 volt alkaline battery, as the output power is rated at 50 mW with a maximum of 80 mA current draw, during playback, thus keeping the unit portable. A fresh battery should deliver at least 100 hours of service, but, be sure to turn S3 to the off position in between operations. There is no need to worry about the message, as the ISD1000's memory will be retained for 10 years, or longer, without power, even if the battery is completely exhausted.

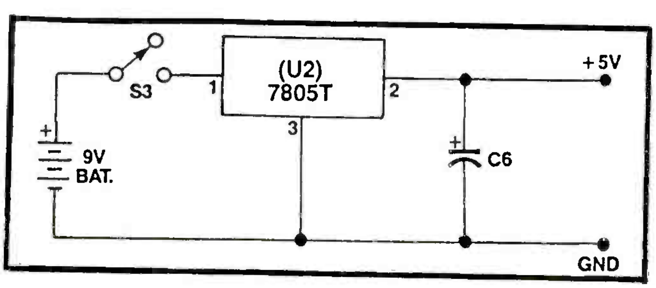


FIGURE 2: POWER SUPPLY

Figure 2 is a schematic for the power supply. As is seen, U2 regulates the 9 volt battery to the +5 volts DC required for proper operation, and, C6 functions to prevent oscillation of the 7805. This arrangement will also provide consistent performance over the life of the battery.

CONSTRUCTION:

The circuit can be constructed employing conventional methods, such as, point to point wiring, solder style bread board, or printed circuit. To insure compactness, as well as durability, the prototype utilizes a printed circuit board, and, the foil pattern is illustrated in figure 3. The board measures 2 inches square, and holds all active and discrete components, except the microphone, speaker, and switches. First install the IC socket, U2, and jumper wire J1, then proceed with the passive components; resistors and capacitors. Room is provided to lay the larger capacitors flat, thus keeping the depth, of the finished assembly, at less than 1/2 inch.

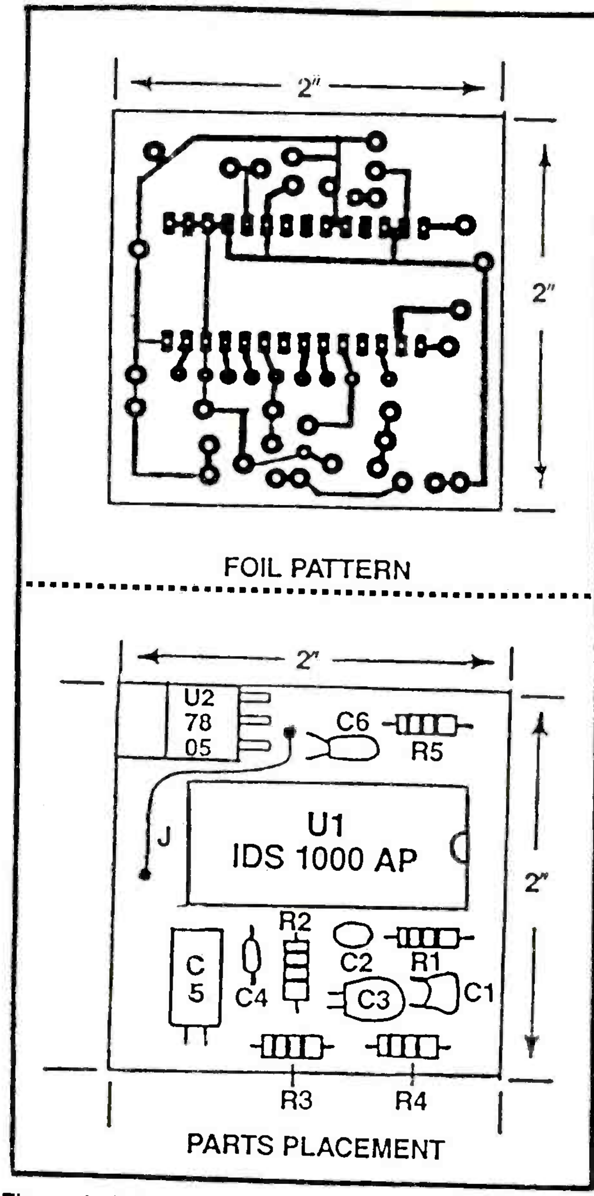


Figure 3: Printed Circuit Board Foil Pattern and Parts Placement Diagram.

There are a number of options for the enclosure, as the completed circuit, and support components, will easily fit into a case measuring in the 4 by 2 by 1 inch range. For the prototype, an old, "pocket size", AM radio was chosen. At 4 1/2 by 2 5/8 by 1 1/8 inches, the size is right, and, with the receiver board removed, the 2" speaker remained. With slight modification, cutouts for the switches, and mic are already present, and, a handy battery compartment is located on the back. A small PC style momentary contact switch is used for S2, and, four small holes, to accommodate the leads, are drilled in the front. All three switches, and the microphone, are secured to the front cover with epoxy, and connected to the main board by appropriate lengths of hook-up wire. The PC board is attached to the back of the case with a small strip of Velcro. This allows for easy removal, and replacement, as needed.

A quick check of U2's pin 2 to ground should reveal +5 volts DC. If this is not obtained, make sure the battery is fresh, and securely attached to the snap connector. If the proper measurement is still not present, U2 may be defective. Once the +5 VDC reading is confirmed at U2, test U1's pins 9, 10, 16, 28, and the "play" pole of S1 for the +5 Volt reading. If all is well, install U1, and proceed. Figure 4 illustrates the completed, and tested, prototype, in it's enclosure, and ready to be put into service.

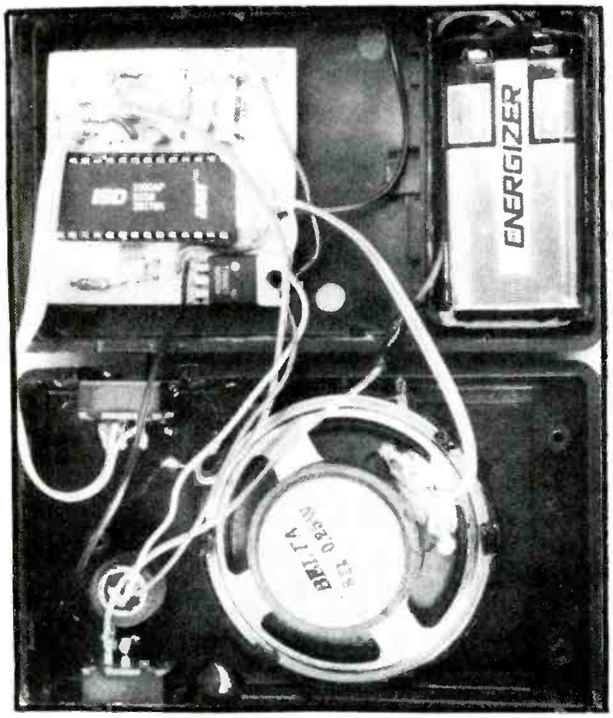


Figure 4: View of inside of the completed and tested prototype. Note the switches and mic are cemented to the front cover on the left.

OPERATION:

With the device securely in it's case, operation is quite simple. Slide switch S3 to the "on" position, place S1 in "record", and press S2 while speaking into the mic at normal volume, and a distance of about six inches. When your message is complete, release S2, and it is on the chip. To review your message, or that of someone else, slide S1 to play, and press S2 to hear the audio. Remember, that the voice chip is configured in a single message mode, so, if you wish to add to the message, you'll need to repeat the entire communique. The ISD1000 starts at the beginning, and will run to the maximum 20 second memory each time the "record" function is used. Of course, not all of the memory has to be used. It is a good idea to return S1 to play, following the recorded information, as, this will prevent accidental erasure the next time the unit is activated. Also, return S3 to the "off" position when finished. Power off will not affect storage of the message, and, while the 1000 requires very little current, in the stand-by mode, it will eventually exhaust the battery, if left on continuously. The switching may seem excessive at first, but, once you get used to it, the procedure becomes routine.

On an additional note, ISD1000s can be cascaded to provide more recording time, in 20 second blocks. Details, on this, are covered in the data sheet.

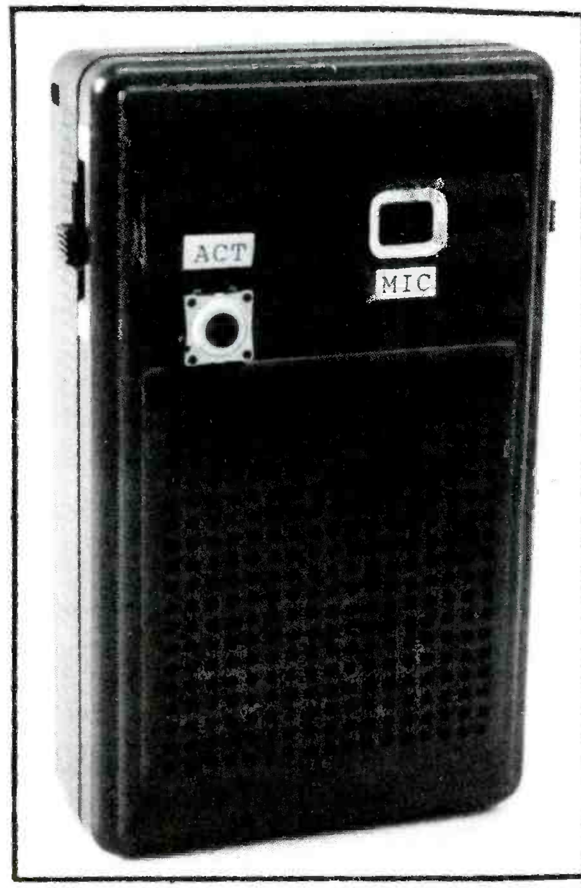


Figure 5: View of the finished prototype. The mic and switches are marked with lettering to indicate function.

CONCLUSION:

As a final touch, add some lettering, for function ID, and, your message center/idea reminder is set for action. If your household is like mine, there is usually someone coming or going, and, placing this unit in a prominent place has been a great help in keeping track of everybody. Messages like, "Hi, this is Fran. It's 3:35 pm, and, I had to go to the grocery store. Be back in about thirty minutes." are always appreciated when you return home expecting Fran to be there. This method is so much easier than a written note, that could get misplaced, it encourages everyone to use it. Since the cost of construction is so reasonable, I have a second unit in my briefcase for those "spur of the moment" thoughts that come up. All in all, this is a quick, and very enjoyable project that yields a highly practical device, and, once you have worked with the voice message chip, I am sure a number of other applications will come to mind. ■

Figure 6: The completed prototype held in a hand to give an idea of the size.

PARTS LIST FOR THE ELECTRONIC NOTE PAD

RESISTORS: (all resistors are 1/4 watt)

R1 — 1,000 ohms
R2 — 470,000 ohms
R3, R5 — 10,000 ohms
R4 — 22,000 ohms

CAPACITORS:

C1, C4 — 0.1 mF Monolithic
C2 — 1 mF Tantalum Electrolytic
C3 — 6.8 mF Tantalum Electrolytic
C5 — 33 mF Aluminum Electrolytic
C6 — 2.2 mF Tantalum Electrolytic

SEMICONDUCTORS:

U1 — ISD1000AP Voice Message Integrated Circuit (Radio Shack #276-1325 or Equivalent)
U2 — 7805T +5 Volt Integrated Circuit (Radio Shack #276-1770 or Equivalent)

OTHER COMPONENTS:

MIC1 — Electret Microphone (RS-#270-090, etc.)
SPKR1 — 2 1/4 inch, 8 ohm Speaker (All Electronics #SK-214 or Eqiv.)
S1 — SPDT Slide Switch (RS-#275-327)
S2 — SPST Momentary Contact Push Button Switch (Electronic Goldmine #2340)
S3 — SPST Slide Switch (RS-#275-327)

MISCELLANEOUS:

1 — 4" x 2" x 1" (Approx.) Plastic Enclosure
2 — 9 Volt Battery Connector
3 — Hook-Up Wire
4 — Solder
5 — Epoxy Cement, Adhesive Velcro

NOTE: An additional source for the voice message chip is **Jameco Electronics,** 1355 Shoreway Road, Belmont, CA 94002-4100, Phone: (800) 831-4242. It is listed as ISD Voice Chip, part number 107334, and, a data sheet is available.

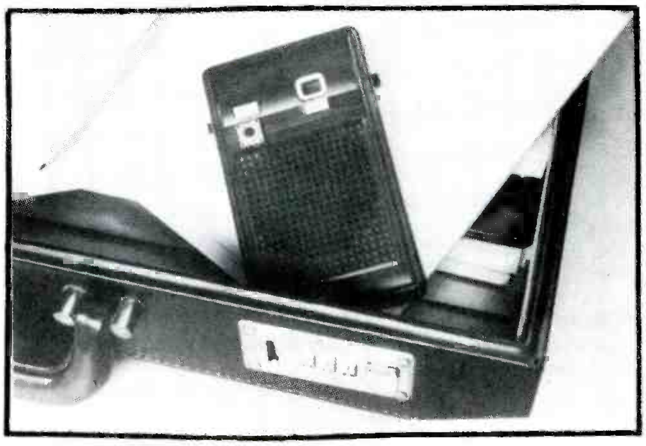


Figure 7: Completed unit laying in a briefcase, to show the size and a possible use for the message center.

NEW DEVELOPMENTS

Using the novel iron core shown below, the Joe Wisenheimer Corp. now manufactures transformers that convert three-phase (380 VAC) current to 220 VAC. The intermetallic transition of three legs to two...known as the Wisenheimer effect (Pat. Pend.,) is responsible for the transformation. Lamination of the core is no longer necessary. Stray currents do not form, since they cannot decide where to flow. Also, hysteresis is kept extremely low, if only the center leg of the core is wrapped and when the current is off. Wrapping the center leg also saves considerable amounts of wire, an additional plus from the view of the environmentalists. This ingenious device has already conquered a major part of a large non-existent market...

Wisenheimer made headlines several years ago with his foolproof fuse-blowing machine and research on a stabilized source of "0 VDC" for calibration purposes...APRIL FOOL!

THE CATALOG CORNER

If you live in a relatively remote area that doesn't have ready sources for electronic parts, you can send away to numerous supply houses, who have good catalogs of electronic parts and assemblies...many of them real bargains.

Following are several catalogs that we have recently received in the mail, with brief descriptions and comments. Most of these suppliers send out new catalogs every four to six months, with many of the items repeated and new ones added, plus some new "specials"...usually on the first couple pages and the last few pages of each issue.

SMALL PARTS INC.

Sometimes it's difficult to tell from a name the kinds of products a company sells. Take Small Parts Inc., for example. We know they sell something small, but what might that be? The answer is small precision mechanical components of every imaginable kind. That includes gears; pulleys; belts; chains; shafts; metals like aluminum, brass, and steel; plastics like ABS, delrin, and fiberglass; fasteners; bearings; bushings; and o-rings.

Along with parts, the company sells things you need to build projects out of parts: tools like taps, drills, and wrenches; books; lubricants (grease and oil); adhesives; and paint. These are things all experimenters can use, but they will be most appreciated by those of us who like to build robots and small machines. For a free copy of one of the most interesting catalogs around, write to **Small Parts Inc., 13980 N.W. 58th Court, Miami Lakes, FL, 33014. Telephone (800) 220-4242.**

ELECTRONIX EXPRESS

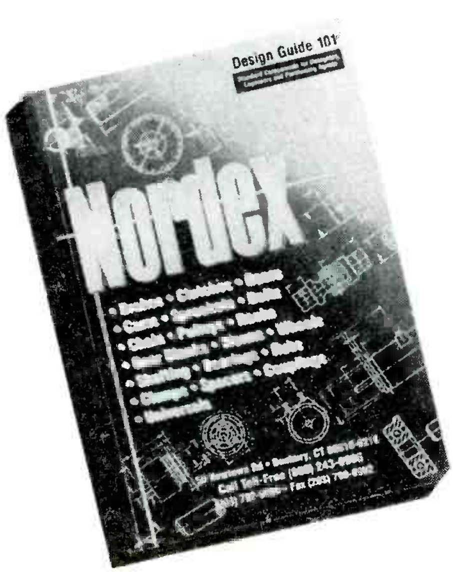
Some electronics retailers are specialists with a limited range of sometimes esoteric products, while others are generalists who carry a little bit of everything. Electronix Express falls into the generalist category; their new 170-page catalog is practically a one-stop shopping source for the hobbyist or professional.

The catalog features electronic test instruments, semiconductors, tools, tool kits, soldering equipment, enclosures, books, video tapes, wire, connectors, computer products, educational kits, hardware, chemicals, fiber optics, pots, transformers, resistors, capacitors, relays, and some surplus items. The company has been serving the educational and industrial markets for 20 years, and their product line-up should appeal to many of our readers, particularly those of you in electronic and technical education. Contact **Electronix Express, 365 Blair Rd., Avenel, NJ, 07001. Telephone (800) 972-2225.**

ELECTRONIC GOLDMINE

One of the obvious benefits of buying parts from a surplus dealer is that you'll save a substantial amount of money. Another is that you can pick up parts that would not normally be available to the hobbyist. For instance, the latest 64-page catalog from Electronic Goldmine starts off with a selection of components from the Maverick missile: gyros, nosecones, and motors. You're not going to be able to assemble your own missile with this stuff, but it might be fun to experiment with.

Electronic Goldmine carries more down-to-earth material as well. That includes semiconductors, potentiometers, resistors, capacitors, displays, relays, motors, speakers, switches, connectors, fans, solar cells, solder, sensors, and more. This is definitely one of the best surplus catalogs. For your copy, write to **Electronic Goldmine, P.O. Box 5408, Scottsdale, AZ, 85261. Or call (800) 445-0697.**



NORDEX

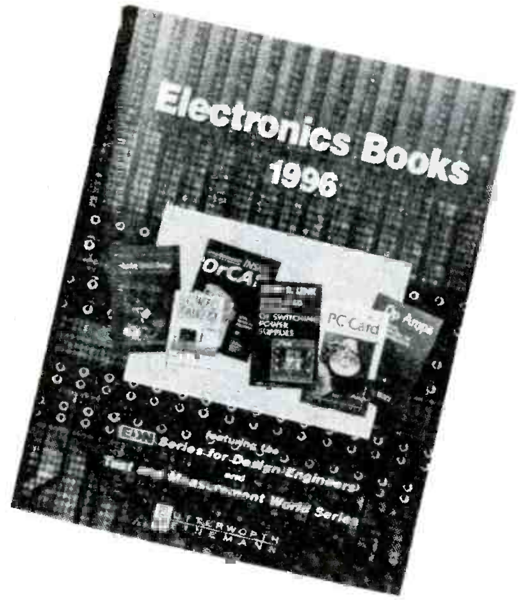
Robotics experimenters often have a difficult time finding the mechanical components they need. Since local hardware stores never carry much of a selection of mechanical components, many experimenters get their parts from scrap-metal yards or by dismantling old appliances and tools. It is a tedious process that yields only a few useful parts. Consequently, many parts have to be fabricated by hand (slow work at best for someone with few tools at his disposal).

What the robotics experimenter needs is a ready source of precision mechanical components, and that's where Nordex comes in. The 500-page Nordex catalog is chock full of gears, shafts, pulleys, belts, fasteners, bearings, bushings, wheels, couplings, clutches, cams, sprockets, o-rings, tubing, and more. The minimum order is a reasonable $20, making these parts accessible to most experimenters. Contact **Nordex Inc., 50 Newtown Rd., Danbury, CT, 06810. Phone (800) 243-0986.**

ELECTRONICS BOOKS

Books on electronics are often hard to find. If you browse through a typical mall bookstore, you'll see aisle after aisle of books on pop psychology, mystery, and romance. You'll also find plenty of titles dealing with astrology and the occult, but I bet you won't find much about science and technology. Has the United States become a nation of knuckleheads? We'll have the answer to that and other provocative social questions in an upcoming issue (just another reason to keep reading **Electronics Handbook**).

In the meantime, let me assure you that good books on electronics are indeed available. Begin by checking out the new 25-page catalog of electronics books from Butterworth-Heinemann. Titles range from simple to advanced and cover all facets of electronics—for example, op amps, digital audio, motion control, hobby projects, electronic surveillance, and more. Contact **Butterworth-Heinemann, 313 Washington St., Newton, MA, 02158. Phone (800) 366-2665.**



C&S SALES

Anyone just getting started in electronics can expect to spend a considerable amount of time acquiring the necessary electronic test equipment and tools. Of course, you don't want to spend too much money on such things, especially if electronics will just be a hobby. With that in mind, you might want to check out the new 60-page catalog of tools and test equipment from C&S Sales.

The catalog features oscilloscopes and multimeters from Elenco, Hitachi, and B&K Precision. Also included are digital, analog, and microprocessor training equipment; prototyping boards; laser training systems; component testers; signal generators; frequency counters; TV test equipment; power supplies; logic probes; handheld transceivers; various tools; tool kits; books; educational videos; and more. Prices are affordable, too. Write to **C&S Sales Inc., 150 W. Carpenter Ave., Wheeling, IL, 60090. Or call (800) 292-7711.**

MENDELSON ELECTRONICS

The old saying that you can't get something for nothing is as true in electronics as it is anywhere else. However, by buying from an electronic surplus dealer, you can often get something for next to nothing. How do surplus dealers do it? They're selling parts that some company no longer wants. Sometimes these parts are obsolete; sometimes they've been salvaged from a used piece of equipment. Most of the time, however, the parts are excess inventory—the result of a design change or diminished demand for a product. Whatever the reason, it makes sense for a company to liquidate excess inventory rather than keep it in storage.

Mendelson Electronics claims to be the world's largest electronic surplus company, and I have no reason to doubt it. The new 100-page Mendelson catalog is brimming with every imaginable kind of electronic component. For a copy, write to **Mendelson Electronics, 340 E. First St., Dayton, OH, 45402. Phone (800) 344-4465.**

SUPERCIRCUITS

We've all seen the undercover news reports on television in which nefarious deeds are documented by means of hidden video cameras. Often these cameras are concealed somewhere in the clothing of the reporter. If these devices were the same size as the average camcorder, even the dumbest crook could spot them. But the latest microvideo cameras are incredibly small—often no more than an inch long, and that's including the lens.

Supercircuits sells a wide variety of super small video cameras, color and black-and-white, with fixed or interchangeable C-mount lenses. They also carry diminutive wireless transmitters and downconverters. The more powerful transmitters have a range of several miles and require an amateur-radio license to operate, but Supercircuits sells low-power, no-license units, too. Monitors, video recorders, and antennas are available as well. Write to **Supercircuits, One Supercircuits Plaza, Leander, TX, 78641. Phone (800) 335-9777.**

JENSEN TOOLS

One of the things that distinguish human beings from other animals is our use of tools. Almost every human activity involves a tool of some kind: we have pencils for writing, saws for cutting, brushes for cleaning. Some tools will even perform more than one function. Take, for example, the common salad fork. Not only is it useful for tossing a bowl of greens and dressing, it's also handy for scratching your back (though not in front of dinner guests).

Tools are, of course, essential in electronics, which brings us to the subject of this discussion, the new 96-page catalog from Jensen Tools. In it, you'll find hand tools, power tools, test instruments, soldering equipment, cable, and some very long screwdrivers that are as effective as the above-mentioned salad fork at relieving an itch. Contact **Jensen Tools Inc., 7815 S. 46th St., Phoenix, AZ, 85044. Telephone (602) 968-6241.**

CRUTCHFIELD

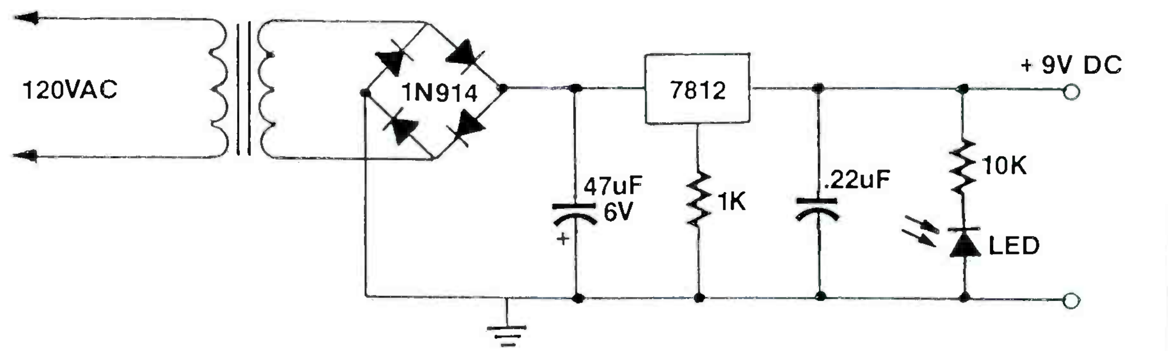
One of the nice things about electronics is that it has a fun side as well as a serious side. That's something you can't say about many other kinds of technology. For instance, take hydraulics or nuclear power. Can you think of any recreational applications for these technologies? Probably not. But I bet you can think of lots of entertaining electronic toys, and just about anything you can think of will be found in the latest catalog from Crutchfield.

For car-stereo buffs, Crutchfield has speakers, amplifiers, and CD players. For the stay-at-home crowd, the company carries a wide variety of audio and video equipment, including home-theater systems, televisions, digital satellite dishes, VCRs, laserdisc players, FM radio receivers, cassette decks, headphones, and CD players. For a free catalog, write to **Crutchfield, 1 Crutchfield Park, Charlottesville, VA, 22906. Phone (800) 955-9009.**

ELECTRO-QUIZ

By Tony Lee

A "Regulated Power Supply" is a handy piece of equipment to have on your workbench but before you start building the one described below, there are a few bugs to be ironed out...thirteen to be exact (unlucky for some)...Give it a little thought and note your observations on a separate piece of paper before you turn this page upside down and check your answers below...NO PEEKING.



9 VOLTS REGULATED POWER SUPPLY

ANSWERS: (WORKING FROM LEFT TO RIGHT OF THE CIRCUIT DIAGRAM)

1. No fuse or isolating switch shown on the primary side of the transformer.

2. The secondary coil voltage should be at least 3 volts higher than the output required, when using a regulator.

3. The secondary should be AC, not DC.

4. 1N914 diodes are signal diodes and not suitable as rectifiers. Use 1N4002 or higher.

5. The two lower diodes are fitted the wrong way around.

6. The 47uF smoothing capacitor should be at least 470uF, or, better still, 1000uF.

7. 6 volts rating is far too low. Use a 16 or 25 volt capacitor.

8. This polarized capacitor has been fitted upside down. Electrolytic capacitors can be seriously damaged if they are fitted incorrectly.

9. The 7812 regulator should be a 7809 for a 9 volt output. The last two figures indicate the rated voltage.

10. The 1K Ohm resistor should not be there. A resistor is only placed in the common line when it is necessary to boost the voltage above the rated regulator voltage.

11. The indicator LED is fitted the wrong way around.

12. The two arrows are pointing the wrong way. They are there to indicate that the component emits light, not receives it.

13. The 10K Ohm current limiting resistor is far too high a value. Something like 470Ohms would be more suitable.

Did you look suspiciously at the .22uF capacitor? It is quite in order and helps to reduce voltage spikes.

After you have corrected all of the above mistakes, you may proceed to build this unit, providing you match the correct transformer and regulator for the output voltage you require. Don't forget the fuse!