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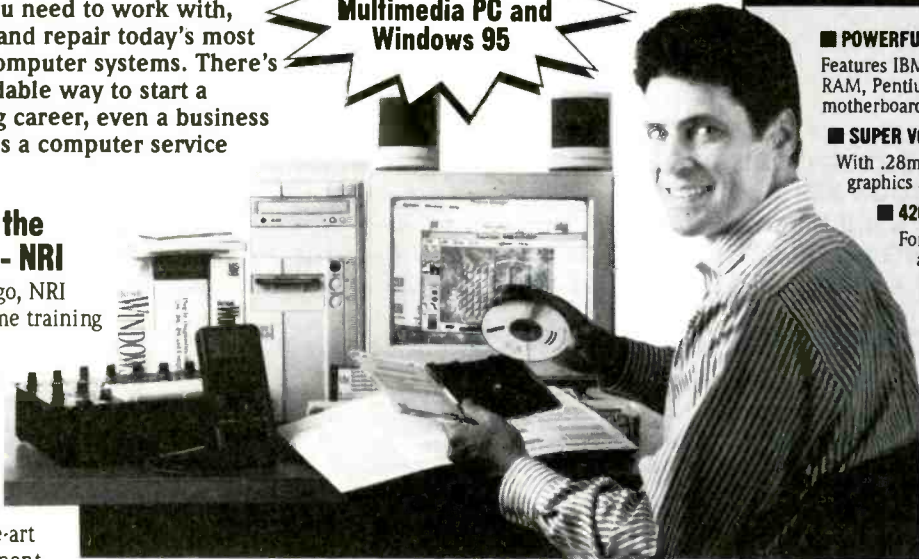
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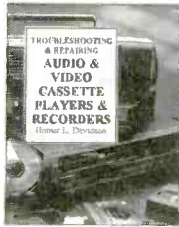
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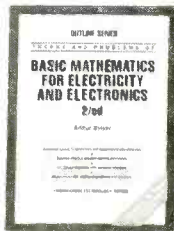
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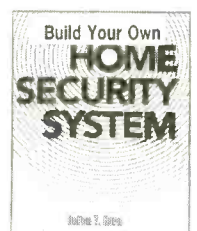
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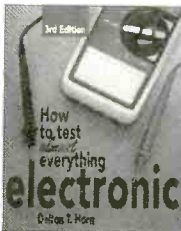
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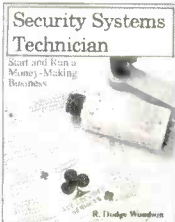
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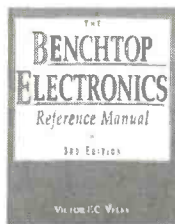
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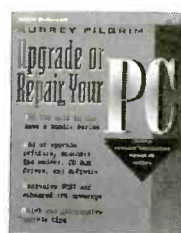
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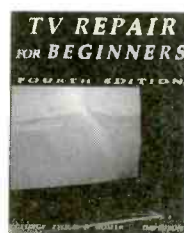
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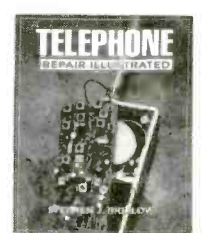
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Use any of the circuits published in the *ELECTRONICS HANDBOOK* or any other source with your description of how you used the "SINGMIN PCB" and what you particularly liked about the new hobby board.

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All entries will be judged by "*SINGMIN ENTERPRISES*" and the competition will be open for 6 months from the publication date of this issue of the "Handbook".

Mail or FAX your entries to: *Andrew Singmin Ph.D. SINGMIN ENTERPRISES, 9 Milne Crescent, Kanata, Ontario K2K 1H7, Canada. FAX (613) 592-3058.*

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The winning entry will be published in a future issue of the *ELECTRONICS HANDBOOK*.

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Write us a brief letter describing your project. Tell us what the project does. Provide us with a legible schematic diagram and a few black-and-white photographs of the project...photos, with good contrast are important. After we have read your letter describing your project, we'll let you know, one way or the other, whether we would like to purchase your article describing the project.

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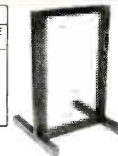


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I bought a copy of Vol. XVI of Electronics Handbook a few days ago. On page 31 you state that it is hard to find some types of components. Well, I have a lot of components that I have reclaimed from old TVs, stereos, radios, and other electronic equipment, and I will sell these parts cheap. So, if you are interested, let me know.

— **Steve Overton, Tazewell, TN**

While I admire your zeal and initiative, Steve, I suspect that most of our readers are interested in new parts rather than used. Still, if we get any inquiries, we'll let you know.

Microwave Meltdown

My three-year-old microwave oven has begun emitting a bad smell when I turn it on, and it does not heat things properly. A neighbor who knows about such things says that the problem is probably due to a bad magnetron tube, and that I can replace the tube myself without calling a repairman. The problem is, I don't know where to find replacement tubes. Can you help?

— **Ned Reilly, Overland, KS**

In cases like yours, Ned, the problem is often not the magnetron tube, which is a pretty rugged and reliable device, but the high-voltage rectifier. When you disassemble the microwave oven to check, be certain to discharge the capacitor in the high-voltage power supply before touching anything, and as always pull the AC line plug. A bad high-voltage rectifier often shows no signs of burning or deterioration. The conventional diode-test function on your multimeter won't be relevant either, because a high-voltage rectifier is made up of

a series-connected stack of low-voltage devices. Consequently, the forward voltage drop is the sum of the individual forward voltage drops — usually 15 volts or so. I would recommend replacing your high-voltage rectifier first, and if that doesn't do the trick, start looking at the magnetron and other components. Rectifiers and magnetron tubes are available from MCM Electronics (650 Congress Park Dr., Centerville, OH, 45459) and Parts Express (340 E. First St., Dayton, OH, 45402). When reassembling your microwave oven, be certain to put everything back the way you found it, so that no leakage of microwave radiation occurs. In fact, it would be a good idea to check for radiation leaks using one of the low-cost testers available at Radio Shack and other stores.

Foreign Correspondent

I am a student of computer engineering here in Cuba. I would like to exchange ideas, projects, and knowledge with other students or electronics hobbyists, and would appreciate it if you would publish my name and address in your magazine. By the way, your magazine is a great help to any hobbyist.

— **Victor Garcia Sarmiento**
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Consider it done, Victor, and good luck in your studies.

Regeneration Revisited

I am currently 75 years old. Back when I was 13 or 14, I built a one-tube regenerative detector radio from plans in Popular Mechanics

magazine, and had very good results with it. I'd like to build something like that again, only this time using a transistor instead of a tube. Do you have any information on such a circuit?

— **Thomas Backus, Port Rowan, Ont., Can.**

It's quite feasible, Thomas, to use a field-effect transistor as a regenerative detector. We haven't published such a project in Electronics Handbook, but I have seen advertisements for a regenerative radio kit from MFJ Enterprises (P.O. Box 494, Mississippi State, MS, 39762; telephone 601-323-5869). Although not as frequency selective as superheterodyne circuits, regenerative detectors have the advantage of simplicity. They also have a nostalgic quality for a lot of readers.

Ambitious Youth

I am 12 years old and just getting started in electronics. Currently, I am putting together a computer and rebuilding an old tube amplifier. I am writing to inquire if you have any literature on the construction of small robots with feet or wheels.

— **Amos O'Connor, Ozark, AR**

*Slow down, Amos, or you'll be burned out by the time you're 15. Seriously, though, it's nice to hear from a reader who's as enthusiastic about electronics as we are. I think you'll find a lot of useful information in a pair of books from TAB/McGraw-Hill: **Mechanical Devices for the Electronics Experimenter** by Britt Rorabaugh, and **Build Your Own Intelligent Mobile SPACE Robot** by Steven Montgomery.*

Circuit-design Software

Do you know of any inexpensive



software for IBM compatibles that could be used to draw schematic diagrams?

— **Larry King, Omaha, NE**

*Let's put things into perspective first, Larry. Circuit-design software for professionals goes for about \$1,500 to \$12,000 a copy, depending on the features you need. Anything less than \$1,500 would be regarded as inexpensive in such circles. I'm assuming that \$1,500 is a lot more than you're willing to pay. That being the case, you might be interested in **Electronics Workbench 3** from Interactive Image Technologies (908 Niagara Falls Blvd., North Tonawanda, NY, 14120). This program sells for \$299 and got a favorable review in Vol. XVII of *Electronics Handbook*. The best bargains by far, however, are to be found in shareware. **EditSch**, **EEDraw**, and **Skem** are three of the better known shareware schematic-drawing programs, while **EditPCB Intro** will allow you to design printed circuit boards. Shareware and public-domain software can be purchased from PC-SIG (1030-D East Duane Ave., Sunnyvale, CA, 94086); Discount Micro (10881-B Portal, Los Alamitos, CA, 90720); and Public Brand Software (P.O. Box 51315, Indianapolis, IN, 46251).*

Reader Lacks Guts

Please tell me where I can find just the "guts" of an infrared motion detector. I am trying to design my own type of alarm system. All I need is the motion sensor.

— **David Goldberg, Fremont, CA**

*The type of sensor you seek, a passive infrared (PIR) detector, is available from a wide variety of vendors, David. Try **Electronics 1-2-3** (17921 Rowland St., Industry, CA, 91748). Also check out the surplus market—for instance, **Electronic Goldmine** (P.O. Box 5408, Scottsdale, AZ, 85261).*

Over Our Heads

Could you tell me where I can find the detailed information necessary to build a complete computer-controlled EPROM programmer or universal IC programmer (for EPROMs, flash memories, PLDs, and the like)? Are there any books that fully explain the algorithms and the hardware needed to implement them?

My goal is build a complete EPROM programmer and, if possible, a universal programmer, including all the necessary hardware and software. Thanks for your help, and keep up the good work.

— **Roberto Barnes, Panama City, Panama**

*You're talking about some heavy-duty digital design tools, Roberto, and that's out of our league (remember our motto: "the fun way to learn electronics"). However, there is a magazine devoted entirely to the kind of advanced microprocessor-based electronic projects you seem to enjoy. It's called **Circuit Cellar Ink** (4 Park St., Vernon, CT, 06066). They're smarter than us, but we're better looking.*

No Reflection On Us

I like your magazine with its large print and pictures, and paper that doesn't reflect the light. However, I'm a real beginner who sometimes does not understand the schematic symbols you use. Additional explanation would be welcome. By the way, I am a machine mechanic and would like to see some articles on DC power supplies, a demagnetizer for grinding-machine magnets, readouts and how they work, etc. I could go on, but...

— **Ted Jonak, Colonial Hts, MN**

C'mon, Ted, our pages must be reflecting some light, else how could you read 'em? We do try to be consistent in our use of schematic symbols and to explain the strange ones when they occur, but we have to assume that our readers

are already familiar with the more common symbols. Anyone who has trouble reading schematics should pick up one of the many books on electronic schematics and study it carefully.

PIP is a Pip!

I am using a disk operating system very much like CP/M and when I PIP (Peripheral Interchange Program) from one disk to another I place a V at the end of the command between two square brackets. Yet, when I do the same PIP procedure with this V or brackets, the results are the same. What's happening that I don't know about?

— **P.U., Denver, CO**

What the V-option does is that provides an optional process whereby the copy is verified to be correct by comparing the memory buffer with the newly created file(s). This occurs only when the destination is a disk file, otherwise the option is ignored. Gary Kildall, creator of CP/M, never uses the V-option, and members of the Digital Research staff indicate that in over five years they have yet to see a "verify" error. So, it is as useful as a seat belt. My advise is buckle up and use the V.

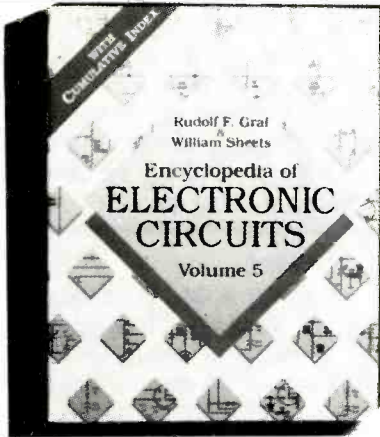
Red Alert

I would like to build a radar transmitter and receiver. Do you know of any publications that would have the kind of information I need? Thanks.

— **Bob Keener, Ashland, OH**

You're not interested in simple projects, are you, Bob? Nope, you want radar. I'm not sure whether you mean relatively mundane stuff like police radar or sophisticated navigation equipment for a yacht, but in either case I'm stymied. However, we don't give out prizes for stumping the editor. All you get is the personal satisfaction of having done so.

NEW BOOK REVIEWS



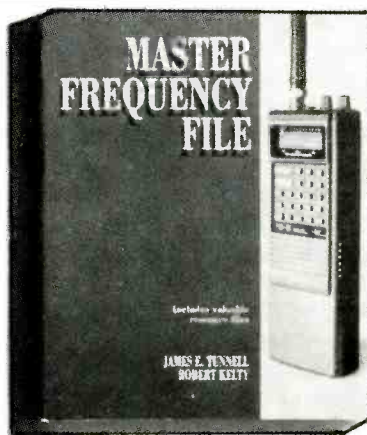
**ENCYCLOPEDIA OF
ELECTRONIC CIRCUITS, VOL. 5**
by Rudolf F. Graf
and William Sheets

It's here, the latest volume (#5) of the **Encyclopedia of Electronic Circuits**, one of the best-known circuit reference books. Volume 5 is just like its predecessors, which might sound bad, but is actually meant as a compliment. The authors have a winning formula and are sticking to it. There are 112 separate sections in Volume 5, each of them devoted to a specific class of circuit, such as amplifiers, oscillators, or comparators. Each entry within a section consists of a schematic diagram and a brief description of circuit operation. If you need more information, bibliographic citations tell you where to look. The circuits themselves are abstracted from various popular magazines and professional journals, though a few of them have been devised by the authors.

At the back of Volume 5 you'll find a comprehensive index covering not just Volume 5 but the preceding four volumes as well. Since similar circuits are found in all of the volumes, each can stand on its own as a circuit reference. Thus, a hobbyist could buy just Volume 5 and feel comfortable knowing that he's not missing much by not having a complete set. On the other hand, engineering libraries and those with deep pockets will want the whole set.

The library of an electronics enthusiast is not complete without some form of circuit reference book. The **Encyclopedia of Electronic Circuits** is comprehensive and reasonably priced, which makes it a good choice for the hobbyist as well as the engineer.

Encyclopedia of Electronic Circuits, Vol. 5, 753 pages, softcover: \$34.95. **TAB/McGraw-Hill Inc.**, Blue Ridge Summit, PA, 17294-0850. Telephone 800-822-8138.



MASTER FREQUENCY FILE
by James E. Tunnell
and Robert Kelty

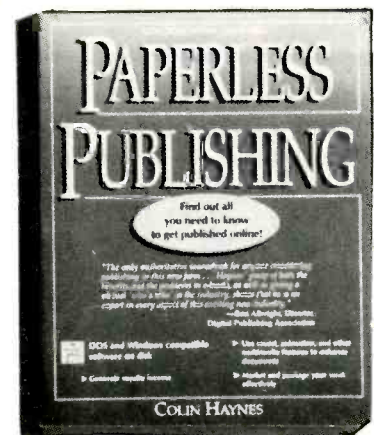
The purchaser of a scanner or shortwave receiver often finds himself in a quandary, because there is so much activity to monitor that it's hard to know where to begin. How do you tell what is important from what is not, and how do you know when and where to listen? You could answer these questions in the time-honored way, through diligent listening and experimentation, or you could do it the easy way by picking up a copy of **Master Frequency File**, the radio listener's equivalent of TV Guide.

Master Frequency File is a directory of U.S. government usage of the radio spectrum. It identifies the frequencies, callsigns, and user IDs for a variety of U.S. government agencies. The frequency range covered is from 25 to 2110 MHz. Agencies covered include the U.S.

Forest Service, the U.S. Commerce Department, Transportation Department, Veterans Affairs Department, General Services Administration, Land Management Bureau, National Park Service, Drug Enforcement Administration, Federal Bureau of Investigation, Immigration Service, Marshal Service, Prisons Bureau, ATF Bureau, Customs Service, Federal Law Enforcement Training Center, Internal Revenue Service, and Secret Service. All of this is augmented by maps and a Master Resource File which points the way toward other books and organizations related to monitoring.

There is also some interesting trivia to be gleaned from the book. For instance, I learned that Henry Kissinger's code name during the Nixon years was "woodcutter." And there are some lengthy appendices devoted to the terrorist threat to police and fire communications, encrypted voice communication, and radio monitoring for earthquake precursors. All in all, quite an interesting book for the radio buff.

Master Frequency File, 530 pages, softcover: \$29.95. **TAB/McGraw-Hill Inc.**, Blue Ridge Summit, PA, 17294-0850. Telephone 800-822-8138.



PAPERLESS PUBLISHING
by Colin Haynes

For centuries now, the dissemination of words and ideas has been

a cooperative effort between two vastly different groups of people: publishers and writers. The publisher is the businessman whose job it is to see that writers are turning out script, printers are printing it, and distributors are delivering it to the readers. From the writer's point of view, this is all pretty dull stuff. The writer's job is to think and peck at a keyboard. Since the writer rarely shows signs of exertion, publishers feel that writing is a fairly simple job and pay accordingly.

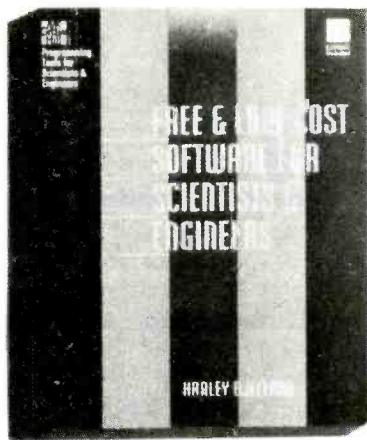
This cozy symbiotic relationship between writer and publisher may now be in jeopardy thanks to the emergence of new forms of electronic publishing. According to author Colin Haynes, electronic publishing (either on disk, on CD-ROM, or over the Internet) allows the writer to also act as publisher. Mr. Haynes goes on to describe multimedia publishing and some of the software available for that purpose. He describes the impact of electronic publishing on in-house business communications. And he offers advice on marketing and distributing electronic books. Also discussed are the packaging and duplication of disks and CD-ROMs.

Electronic publishing presents opportunities for photographers, artists, and musicians as well as writers, and the author briefly covers some of the possibilities. He offers tips, tricks, and techniques to aid the would-be author/publisher, and includes four well-regarded shareware authoring programs on a disk bound into the book. The programs are Dart, Multimedia Workshop, Softlock, and Writer's Dream.

Colin Haynes does a good job of explaining the new forms of electronic publishing and how they can be exploited. No doubt there are people who can function as both author and publisher, and they will relish the book, but I have a feeling that most writers who also don the hat of publisher are likely to starve.

Paperless Publishing, 370 pages, softcover: \$27.95. **Windcrest/McGraw-Hill Inc.**, Blue Ridge Summit, PA, 17294-0850. Phone 800-822-8138.

FREE & LOW-COST SOFTWARE FOR SCIENTISTS & ENGINEERS
by Harley Bjelland



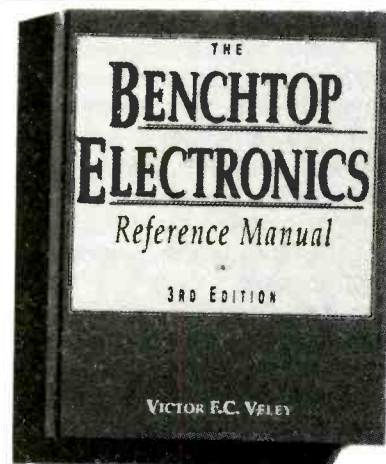
Most people who own a computer have heard the terms **freeware** and **shareware**. Freeware is software that has been released into the public domain by its author. You can use it without paying the author anything. Shareware is software that is distributed under the honor system. If you try a shareware program and decide to keep it, you must pay a small registration fee (\$20-\$30), which then entitles you to future updates of the program. Human nature being what it is, shareware authors don't earn much more than their freeware counterparts most of the time.

Freeware and shareware have always been a boon for the economy-minded computer user. The only problem is that freeware and shareware have proliferated to such an extent that it's hard to know which program to try. Author Harley Bjelland saw the problem and decided to solve it by writing a book that separates the wheat from the chaff. **Free & Low-cost Software for Scientists & Engineers** is a compendium of the programs the author feels are the best to be had in the following categories: computer tutorials, computer utilities, personal/professional advancement, word processing, engineering & science, databases, scheduling, graphics/CAD, telecommunications, computer programming, and games. The features and system requirements of each program are summarized in a few descriptive paragraphs. The author also tells where to obtain the programs (which, by the way, are all for IBM-compatible systems). Bound into the book is a 3.5-inch disk containing three programs to get you started: AsEasyAs, a spreadsheet

program that is compatible with Lotus 1-2-3; Wyndfields, an excellent database program; and RGB Techwriter, a scientific word-processing program.

Anyone contemplating a plunge into shareware/freeware pool would be well advised to read Harley Bjelland's book first. It will save you time and money—what better recommendation could a book have?

Free & Low-cost Software for Scientists & Engineers, 367 pages, softcover: \$34.95. **McGraw-Hill Inc.**, Blue Ridge Summit, PA, 17294-0850. Telephone 800-822-8138.



THE BENCHTOP ELECTRONICS REFERENCE MANUAL
By Victor F. C. Veley

The Benchtop Electronics Reference Manual was conceived as a reference book for the working electronics technician or for the student of electronics. Two hundred and forty of the more common topics were selected from the fields of DC circuit theory, AC circuit theory, solid-state-device physics, vacuum-tube theory, radio communications, introductory mathematics, and digital logic. Each topic is thoroughly explained, equations are derived, and the use of those equations is then illustrated by means of one or more practical examples.

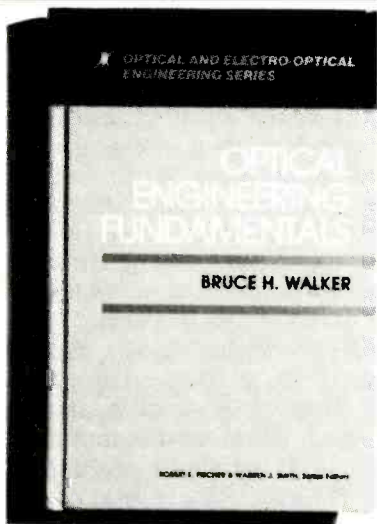
You might consider the book to be a hybrid formed of parts of a conventional textbook and a set of worked problems. When you need to know more about a given topic, this is the place to turn for a quick, painless tutorial. I imagine you could also use it as a textbook. Practice problems accompany each topic, and answers are to be found

NEW BOOK REVIEWS

at the back of the book.

This is a very well written book with an abundance of charts, graphs, and schematic diagrams. It will be a valuable reference for the electronics technician or student. Here are some highlights of the topics covered: node and mesh analysis, Thevenin's theorem, magnetic flux, the motor effect, magnetomotive force, induction, time constants, differentiator circuits, integrator circuits, the cathode-ray oscilloscope, inductive and capacitive reactance, resonant circuits, transformers, zener diodes, amplifiers, op amps, negative feedback, AM and FM transmitters, antennas, the Smith chart, number systems, Boolean algebra, DeMorgan's theorems, and Karnaugh maps.

The Benchtop Electronics Reference Manual, 730 pages, hardcover: \$54.95. **TAB/McGraw-Hill Inc.**, Blue Ridge Summit, PA, 17294-0850. Phone 800-822-8138.



OPTICAL ENGINEERING FUNDAMENTALS
By Bruce H. Walker

A basic understanding of optics is mandatory if one is working with certain electronic systems such as projection TV, compact laser-disc players, and fiber-optic transmission systems. But where do you gain such knowledge? Most books on optics are laden with mathemat-

ical baggage—too heavy a burden for anyone who is not an engineer or physicist. Well, there is a new book by Bruce Walker that looks like the perfect introduction to optics for the mathematically challenged. It's called **Optical Engineering Fundamentals**.

The book begins with a thumbnail sketch of the history of optics, and then delves into the nature of light (wavelength, frequency, refraction, diffraction, etc.). After that, it discusses the theory of thin lenses and image formation. A few equations pop up here and there, but nothing to make you shudder.

Next comes an introduction to optical design using the computer program known as OSLO MG. Several examples are presented. The author then discusses primary lens aberrations such as spherical aberration, coma, and astigmatism. One of the goals of lens design is to minimize these aberrations.

Mirrors and prisms warrant a chapter of their own. Then we move on to an interesting discussion of basic optical instruments such as the magnifier, the microscope, binoculars, the riflescope, surveying instruments, the periscope, the borescope, and the endoscope.

Lenses can be made of optical glass or plastic. The author discusses the properties of each, and the use of antireflection coatings on the surface of a lens. Next we get an introduction to one of the true marvels of optics, the human eye. The book concludes with several examples of practical lens design using the principles presented previously.

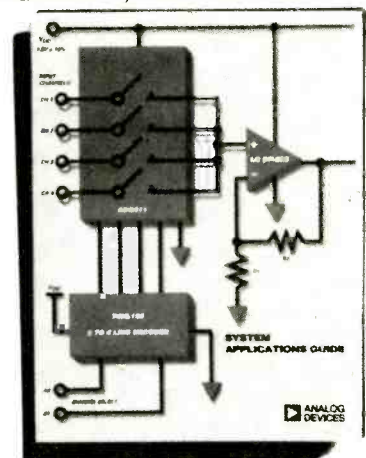
I won't mince words here. This is the best introduction to optics I've seen yet. Grab it while you can.

Optical Engineering Fundamentals, 341 pages, hardcover: \$44.95. **McGraw-Hill Inc.**, Blue Ridge Summit, PA, 17294-0850. Telephone 800-822-8138.

ANALOG DEVICES
SYSTEM APPLICATIONS GUIDE
The new **System Applications**

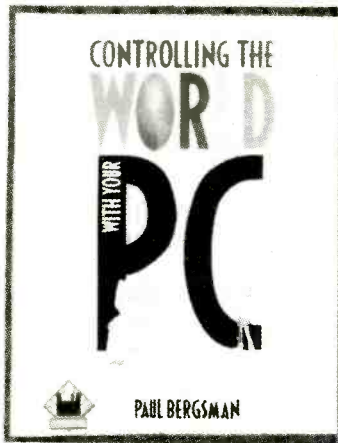
Guide from Analog Devices is a reference book made to order for anyone who needs a no-nonsense introduction to the real-world applications of linear integrated circuits. Since it's published by Analog Devices, the book features ICs made by that company. Nevertheless, the principles discussed in most cases apply equally well to the products of other manufacturers.

More like an encyclopedia, the **System Applications Guide** covers an enormous range of circuit applications: precision-sensor signal conditioning, multiplexing with analog switches, programmable-gain amplifiers, sample-and-hold circuits, voltage references, A/D conversion, audio applications, high-speed signals, high-speed amplification, video signal processing, high-speed ADCs, sigma-delta ADCs and DACs, direct digital synthesis, signal computing in communication, and motor control.



To the authors' credit, the tone of this book is more practical than theoretical. Thus, even though it deals with topics that are sometimes quite advanced, the presentation is concise and easy to understand. It's also easy on the eyes, because the type and diagrams are large.

System Applications Guide, 8.5 x 11" format, 800 pages, softcover: \$30 (price includes shipping). **Analog Devices Inc.**, One Technology Way, P.O. Box 9106, Norwood, MA, 02062. Telephone 617-461-3392.



**CONTROLLING THE WORLD
WITH YOUR PC**
by Paul Bergsman

What's your computer doing right now? Chances are that if you're not using it for word processing, spreadsheeting or some other standard application, it's just sitting there like a potted plant. Well, for shame. You should be putting that machine to better use, and you can with the help of Paul Bergsman's new book, **Controlling the World With Your PC**.

The author assumes you've got an IBM PC or compatible computer equipped with a standard parallel port, and that you possess basic circuit-building skills. He also assumes that you want your computer to do interesting things, like run a model-railroad system, keep an eye on your house, or monitor the weather. With the interface circuits and program examples he presents, plus a little imagination, you should be able to do all that and more.

The book is divided into five parts, the first of which deals with display devices, like LEDs and LCDs, and circuits to interface them with your computer. Part 2 deals with the control of real-world devices using relays and optocouplers. It also covers the generation of audio tones and speech. Motor control is the topic of Part 3, where

the author does a fine job of explaining the use of stepping motors and DC servos. Part 4 deals with digital input signals, such as might be obtained from optical sensors, proximity switches, Hall-effect devices, and fluid detectors. Finally, Part 5 deals with analog input signals and analog-to-digital conversion.

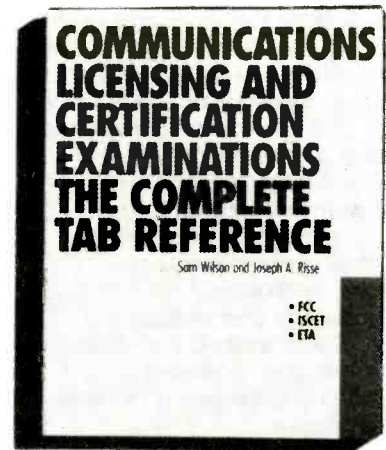
In all, forty useful projects are presented. Each consists of a few pages of description followed by a schematic and—get this—software listings in *three* languages (Pascal, C, and BASIC). Moreover, the book comes with a 3.5" DOS disk containing all the source-code files as well as compiled (.EXE) files.

According to his publisher, Paul Bergsman has taught technology and mathematics in the Philadelphia public schools for 21 years. The clarity and thoroughness displayed in this book suggest to me that he's a pretty good teacher. I'm giving his book an A+.

Controlling the World With Your PC, by Paul Bergsman, 8.5 x 11" format, 257 pages, includes 3.5" disk, softcover: \$29.95 (plus \$3 shipping). **HighText Publications**, P.O. Box 1489, Solana Beach, CA, 92075. Telephone 619-793-4141.

**COMMUNICATIONS LICENSING
AND CERTIFICATION
EXAMINATIONS**
by Sam Wilson
and Joseph A. Risse

One of the best ways of advancing your career as an electronics technician is by marrying the boss's daughter. If that's not possible, however, you should seriously consider taking one of the communications licensing and certification exams given by the Federal Communications Commission and other organizations. Passing such an examination shows your drive and initiative, and may even be mandatory for securing some jobs.



**Communications Licensing
and Certification Examinations**

was written to prepare you for the following: General Radio Operator License, Global Marine Distress and Safety Service certification, Radio Telegraph Certificate, Radar Endorsement, Amateur Radio Technician Class License, Marine Radio Operator Permit, Electronic Technicians Association certification, International Society of Electronics Technicians certification, Society of Broadcast Engineers certification, National Association of Radio and Telecommunications Engineers certification, and others.

This is not a textbook. It serves as a review of the important principles you will need to know in order to pass the various exams. Topics covered include voltage, current, resistance, components, passive circuits, signals, transmission lines, antennas, and digital basics. The text is accompanied by quizzes that test your mastery of the material. The book also includes some practice exams similar to the ones you will eventually have to take.

In summary, this is must reading for the upwardly mobile technician.

Communications Licensing and Certification Examinations, 437 pages, softcover: \$29.95. **TAB/McGraw-Hill Inc.**, Blue Ridge Summit, PA, 17294-0850. Telephone 800-822-8138.

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THE R.U.S.H. RADIO

By Robert L. Williams

The Challenge

Revered as The Doctor Of Democracy by the right-thinking majority, loathed by the Feminazi and their long-haired, dope-smoking FM crowd brothers, feared by the secretly entranced bleeding-heart TV news and national print-press establishment, Rush Hudson Limbaugh III is the hottest voice on AM talk-radio today.

His three hour top-rated broadcasts reach multi-millions of devotees daily through 630 commercial radio outlets. However, many have recently recognized an insidious liberal plot, apparently intended to stifle and impede the educational intercourse so necessary between student and teacher, an electronic surgical strike that cuts at the heart of participatory talk-radio; I refer, of course, to those so cleverly cloaked abridgements of the First Amendment called *The Presidential Press-conference Pre-emption and Taped Delay Programming*.

But fear not, O'ye loyal Head's O'Ditto, the conservative underground has now perfected a technologically superior weapon allowing you to successfully wage counter-electronic-warfare against this dastardly leftist threat, a state-of-the-art computer-generated, yet ultra-conservative, solid-state device which, when energized with only three AA alkaline cells, will allow you real-time access to the golden tones of the "Great One", *LIVE*, via his 19 Meter Band Short Wave Excellence-In-Broadcasting World-Service 15.420 Megahertz (Mhz) beacon of freedom:

Da-Da Da-Da Da-Da Da-Da Da-Da Da-Daaaa...
Presenting The R. U. S. H.

(Receiving Uncensored the Superlative Hudson) Shortwave Radio!!!

The Design

In considering an electronic counter-measure to this hidden civil-rights attack, available quality commercial and hobbyist shortwave receivers capable of receiving 15.420 Mhz amplitude-modulated (AM) broadcasting were considered. However, most seemed to be retailing at prices in excess of \$100. Inexpensive I'm sure by Democratic Party Congressional Spending standards, but then again, they never, ever, seem to spend their own money.

So, we (a conservative-underground R&D team) determined that a simple cost-effective home-built receiving device, easy on the parts-count as well as near-automatic in operation seemed the logical right-minded answer. And anyway, we are secure in our knowledge that the real Rush-enthusiast is a fun-loving self-starting do-it-yourselfer, so we guarantee that the moderately-skilled Ditto-Head will reap full measure in reward having built and operated this "home-brewed" equipage.

Designed around the NE602 and LM386 ICs, using a direct input single-conversion superhetrodyne principle with a series-diode-detector and tunable IF, popular when The Ronald was still riding off into the celluloid sunset, this simple crystal-controlled circuit will allow clandestine reception of EIB World-Service transmissions without the need of an external long-wire or telescoping-whip antenna.

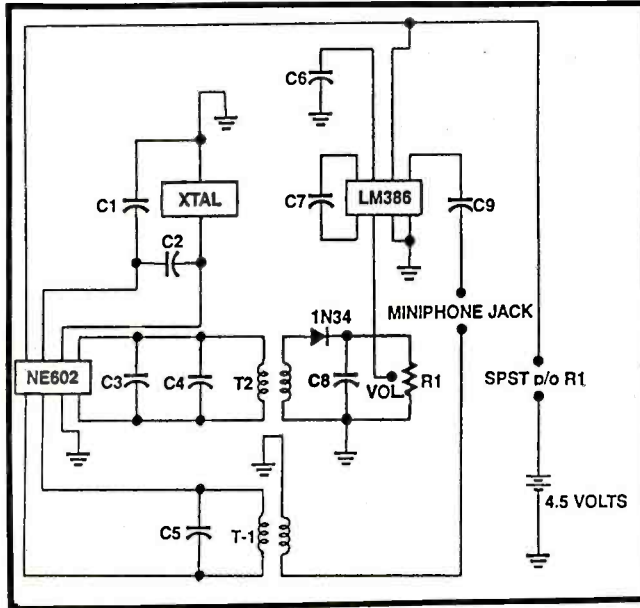


Figure 1:
Using a minimum in parts-count and circuit complexity, the R. U. S. H. Radio receives only worthwhile EIB World-Service Short-Wave transmissions.

The design uses the minimum in parts-count and circuit complexity, as can be seen schematically in Figure 1, while allowing *ONLY* the reception of worthwhile EIB World-Service transmissions on 15.420 Mhz. A complete listing of the radio's parts requirements is included.

Preferring breadboard-style circuit building as the quickest method to prototype a circuit and get it on the air, we used a single 2 inch by 2.25 inch section of the newly available **SINGMIN-PCB-1** printed circuit board as our R. U. S. H. Radio construction platform. A top-view of the PCB is shown in Figure 2. Component layout and wiring diagrams of the R. U. S. H. Radio's breadboard circuitry are shown. T-1 (RF) and T-2 (IF) Transformer winding data is also referenced.

This device was designed so as to make its construction as easy and painless as possible. However, the layout shown can be easily adapted to other construction techniques if you choose. In either case, just mimic the building diagram's component layout making sure that you observe proper schematic circuit continuity. If constructed using the component parts at the values listed, while keeping component lead-lengths as short as possible, you should have no problems with this simple receiver circuit.

The Circuit

The R. U. S. H. Radio contains two 8-pin plastic DIP ICs (an NE602 RF system chip and an LM386 AF system chip) and one Germanium small-signal diode. All

receiver components were selected so as to be both inexpensive and readily available to the builder.

Our prototype used a surplus military 15.000 Mhz mini-crystal. It was purchased at a swap-meet for 25 cents some years back but manufacture outlet and surplus dealer prices well-under \$2 for these crystals are not too uncommon today.

The NE602, an oscillator and double-balanced modulator integrated RF circuit, is circuit-configured at pins #6 and #7, using capacitors C1, C2 and the 15.000 Mhz Crystal (XTAL), for simplified crystal-controlled oscillations.

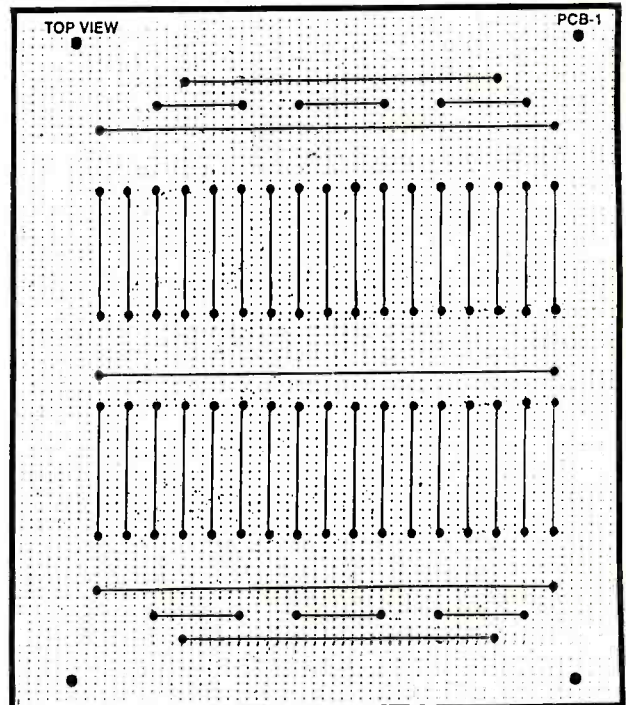


Figure 2:
A top-view of the single-section SINGMIN-PCB-1 printed circuit board used in R. U. S. H. Radio construction.

A possible oscillator circuit configuration option allows you the choice of replacing the Crystal with an off-the-shelf 3.3uH HI-Q mini-inductor and a 33pF series capacitor. Proper receiver tuning adjustment with this L/C option will also provide reception at 15.420 Mhz but we would recommend the use of a 15.000 Mhz Crystal for stable and automatic EIB-only receiver operation.

The NE602's internal RF input circuit is a buffered-input balanced signal mixer. Pin 1 and 2 on the NE602 are the chips RF input points. Transformer T-1 (secondary) and resonating capacitor C5 provides receiver input selectivity. 15.420 Mhz RF is taken from the Low-Z headphone leads, the headphone's cable shielding functioning as the receiver's clandestine antenna.

The NE602's mixer circuitry outputs at pins #4 and #5. This output signal is the difference between the oscillation frequency present at pin #6 and the receiver input at pins #1 and #2.

With NE602 15.000 Mhz oscillation and an AM RF 15.420 Mhz signal input on pins #1 and #2, this difference frequency, or Intermediate Frequency (IF), is the received AM EIB Golden-Tones simply reduced in frequency to 420 KHz.

IF signal energy present at pins #4 and #5 is developed across transformer T-2's primary and its resonating capacitors C3 and C4. Adjustment of C3, a #7 to the 45pF trimmer capacitor, fine tunes the frequency-center of the IF circuit. T-2's secondary serves to couple the 420 Khz AM, IF signal to the 1N34A Diode Detector circuitry.

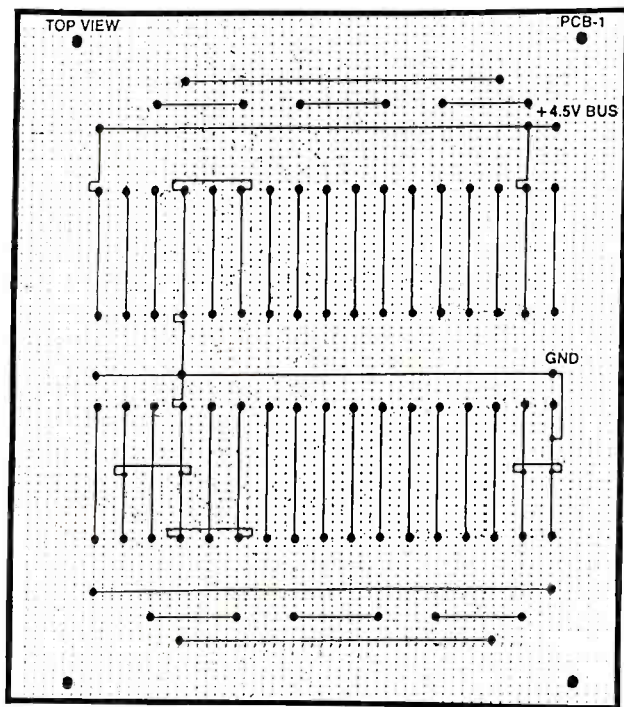


Figure 3:
Start your R. U. S. H. Radio construction project by "top-loading" these jumpers.

Note: Transformers T-1 and T-2 are the only receiver components requiring hand-winding construction. These two transformers could be constructed as air-core types but we recommend using toroid-core construction. Toroid-core transformers have proven simpler to hand-build to exacting values and are less susceptible to mechanically-induced resonate frequency variations than air-core types. See the Winding Data table for further information.

The detector circuit, the 1N34A Germanium Diode and C8, rectifies and filters the IF signal, re-producing the audio information originally broadcast. This series-diode-detected audio is developed across R1, a 100K ohm audio-tapered variable resistor (potentiometer).

The wiper of R1 provides volume control and the audio input to the LM386 IC Audio Amplifier. Note that R1 also includes the SPST switch necessary for powering the receiver.

The LM386 IC is a 400mW Audio Frequency Amplifier and is circuit-configured, by capacitors C6 and C7, to provide an audio signal amplification gain factor of about 200 times its input. Audio can be input to the LM386 on pins #2 or #3. Pin #2 is used in this circuit, pin #3 being returned to ground.

The LM386 IC outputs amplified audio on pin #5, through C9, to a miniature headphone Jack. A Low-Z Monaural Headphone set, with matching mini-plug, as-

sembled on a shielded audio cable of about 3 feet minimum in length, is required. The headphones' cable shielding will function as the antenna.

4.5 Volt receiver power, provided by three series-connected AA batteries, is applied to the NE602 at pin #8 and the LM386 at pin #6. Ground return is obtained on the NE602 at pin #3 and on the LM386 at pin #4. AA Cell life in this circuit should approach 100 hours in normal operation and at moderate volume levels.

Construction and Alignment

Start your R. U. S. H. Radio construction by "top-loading" the jumpers shown in Figure 3 on to the **SINGMIN-PCB-1 universal hobby PC board**. Next, load the components as shown in the layout diagram, Figure 4. Wind and install Transformers T-1 and T-2 at this time. Double-check your progress to insure proper component placement, remembering to keep the lead-lengths above the board to a minimum.

Turning the PC board over, solder and clip the components and jumpers. A 17 to 25 Watt iron is recommended. Also, **use ONLY Rosin-Core Electronic solder**. No acid-core plumber's stuff please!!!

Now, referring to Figure 5, "top-load" the NE602 IC, the LM386 IC, the 1N34A Diode and the Crystal. Make sure the ICs are placed as shown in Figure 4 by correctly identifying the IC's notch. Turning the **SINGMIN-PCB board**, over, solder-in these components.

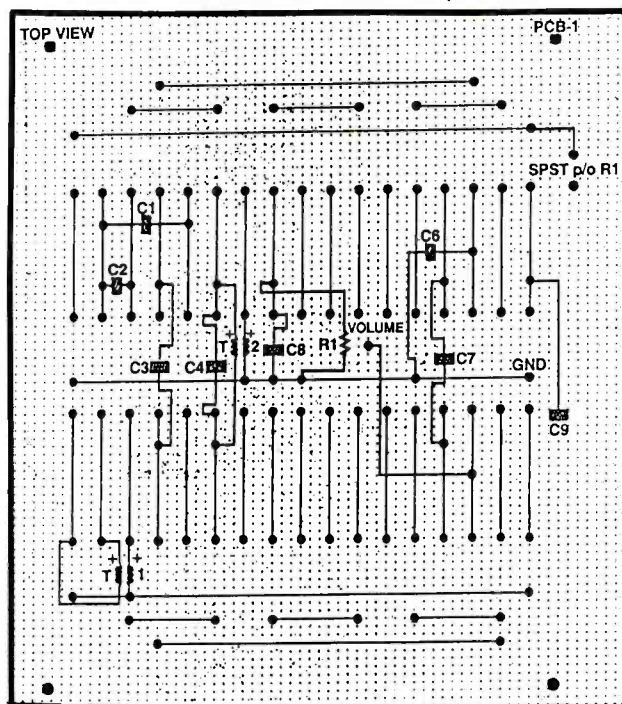


Figure 4:
Carefully load these components double-checking your progress to insure proper placement. Keep those lead-lengths as short as possible above the board.

The project is now ready for the attachment the 4.5 Volt Battery Pack; positive to the free-side of the SPST switch on R1 and negative to the circuit's ground. The other side of the switch on R1 should have been connected to the circuit's +4.5 Volt bus.

Now wire-in the monaural mini-headphone jack; cen-

ter conductor to C9 and outside conductor to T-1's primary. Remember, the outer headphone cable conductor (shield) is actually the receiver's antenna. The headphone cable shielding must connect, through the Jack and to T-1, if the receiver is to operate as engineered.

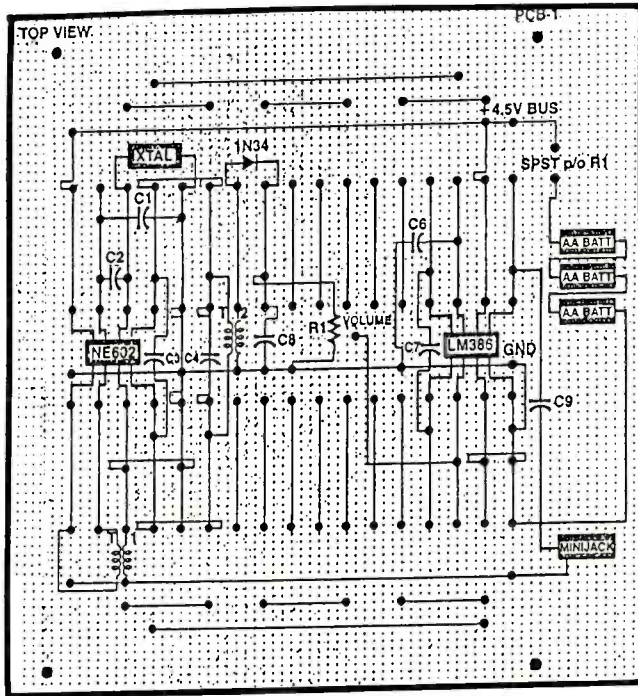


Figure 5: PCB construction is completed with the NE602 and LM386, the 15Mhz Crystal, the 1N34A Diode, the Battery Pack and the Headphone Jack, wired as shown here.

You can now plug-in the phones, turn on the switch and fine-tune the trimmer-cap, the R.U.S.H. Radio was designed to allow on-air IF alignment without the need of additional test equipment.

Lastly, install the completed circuit board and the battery pack in the hobby-box of your choice. An el-cheep-o 99 cent 1-inch by 2.5-inch by 3.5-inch clear plastic inclosure will work fine.

The entire PC-board assembly can be front-panel suspended in the hobby-box by the mounting hardware associated with the headphone jack and R1. You might also want to consider painting your plastic inclosure some inconspicuous color—like ours:

a flame-proof high-gloss \$2.98 spray can "Florida (international) Orange".

Operation R. U. S. H.

Now fully complete, the R. U. S. H. Radio is ready for

operation. As we stated, the R. U. S. H. Radio is almost fully automatic, even from the front seat of your B'mer. This nifty little device, if crystal controlled, requires no operation other than simply switching it on and adjusting the volume to a comfortably conservative level. If you have opted for the L/C oscillator variant you may occasionally need to re-tune the #7 to the 45pF trimmer cap for proper on-frequency EIB operation.

But, once turned-on, simply check the time and then sit back and listen to the Democracy Doctor, victorious in the electronic battle field against those ever so cleverly cloaked abridgements of our Constitutional Right to Life, Liberty, and of course,

Live-Limbaugh

PARTS LIST FOR THE R. U. S. H. RADIO

- 1 — T-50-3 CORE
- 1 — T-50-6 CORE
- 1 — Spool #26 Magnet Wire
- 1 — NE602 IC
- 1 — LM386 IC
- 1 — 1N34A Diode
- 1 — 15.000Mhz Xtal
- or —
- 1 — 3.3uH Ind & 1 33pF Cap
- 1 — 100K ohm Pot w/SPST Switch (R1 & Switch)
- 1 — 7-45pF Trimmer (C3)
- 3 — 47pF Caps (C1, C2 & C5)
- 3 — .0047uF Caps (C4, C6 & C8)
- 1 — 10uF Cap (C7)
- 1 — 470uF Cap (C9)
- 1 — Miniature Headphone Jack
- 1 — Low-Z Monaural Headphone Set w/Shielded cable & plug
- 3 — AA Batteries and Holders (Wired in series for 4.5 Volts)
- 1 — Hobby PCB
- 1 — Hobby PCB Circuit Inclosure
- 2 — Transformers (T-1 & T-2)
- **see winding data table for parts and information

T-1 & T-2 WINDING DATA

T-2 IF Transformer: The Primary of T-2 (IC side) is close-wound, on a T-50-3 (Gray) core to a value of 30uH, 41 turns of #26 Enameled Magnet Wire so as to cover 75% of the core. The Secondary is 10 turns, close-wound over the remaining 25% of the core.

T-1 RF Transformer: The Secondary of T-1 (IC side) is wound first, on a T-50-6 (Yellow) core to a value of 2.25uH, 22 turns of #26 Enameled Magnet Wire so as to evenly cover 75% of the core. The Primary (Headphone Jack Side) is 10 turns, close-wound over the remaining 25% of the core.

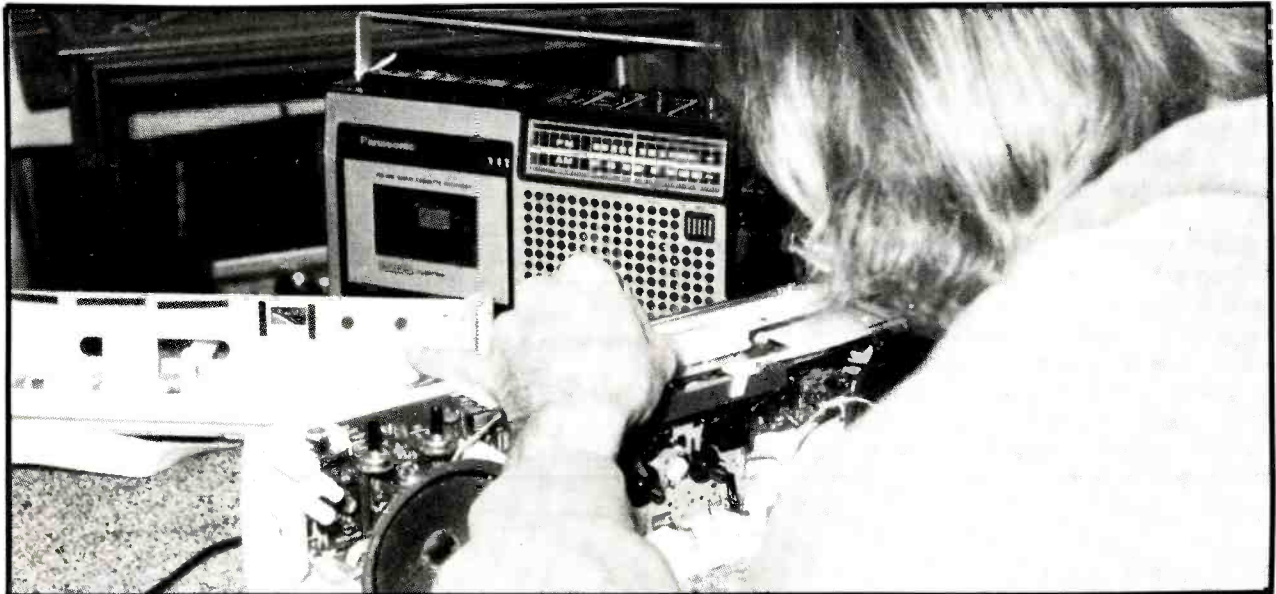
PERSISTENCE

"Nothing in the world can take the place of persistence. Talent will not; nothing is more common than unsuccessful men with talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination alone are omnipotent."

TESTING AND REPLACING INTEGRATED CIRCUITS

BY
Homer L. Davidson

The integrated circuit (IC) is a component made with various parts connected together in one chip. The chip is a semiconductor material constructed from silicon. IC's are made up of capacitors, resistors, transistors, and connecting wires in several circuits inside one component. Today, IC components are found in radios, receivers, amplifiers, telephones, CD and cassette players, computers, VCR's, TV sets and other electronic devices.



The first linear IC's were used in the audio amplifier section of the cassette player and TV chassis. The first IC's were mounted in a round case, like the transistor, and now are found in flat packages, mounted vertically, horizontal and flat against the PC board.

Later, digital, Op-Amp, COS, MOS, CMOS, PMOS, DTL and TTL integrated circuits and microcompressors were introduced and are located in many electronic circuits.

A micro-compressor may have from 22 to 80 terminals and are found in VCR's, camcorders, CD players and the TV chassis. The microcomputer component in

a single integrated circuit is designed around a micro-compressor. You may find a separate micro-compressor and microcomputer component inside the tuning section of the TV chassis. (Fig. 1).

IC Symbols

The IC symbol found in the schematic may appear as a rectangular box or a three cornered drawing. The IC may have numbers around the component indicating the terminal connections. Most schematics do not show the internal components or stages, inside the IC, connected together (Fig. 2). The integrated-internal component block diagram can be found in universal

semiconductor replacement manuals.

Usually, the operational amplifier (OP-Amp) is identified with a triangular shaped box with inputs 1 and 2, and output terminal. The Op-amp IC can be found in a round or flat package. You may find two or more OP-Amps inside one component within the VCR, camcorder and TV set (Fig. 3). Notice the OP-Amp has negative and positive input terminals. The OP-Amp is used in amplifiers, linear control applications, and in motor control circuits.

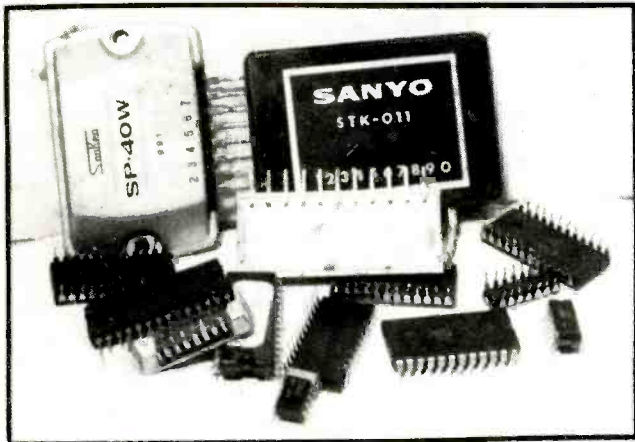


Fig. 1. IC parts appear in many different sizes and shapes, with flat or edge mounting.

Identification

IC components can be mounted through holes in the PCB or surface mounted. Some are mounted or plugged into a socket (Fig. 4). Surface mounted IC's (SMD) mount directly on the PC wiring, while other IC components are on the top side of the chassis. IC parts in VCR's and the TV set may have SMD parts mounted between the IC pins of a regular IC component, that is mounted on the top side with SMD parts on the PC wiring.

All terminals on the IC component, in the circuit, are identified with different numbers on the IC. To determine the input and output terminals, operating supply voltage (Vcc), bias and ground terminals, the correct numbers maybe found on the top side of the IC. The supply voltage pin is always the highest measurable voltage. Locate terminal #1 of the IC and count down each side for the correct pin terminal. Sometimes you

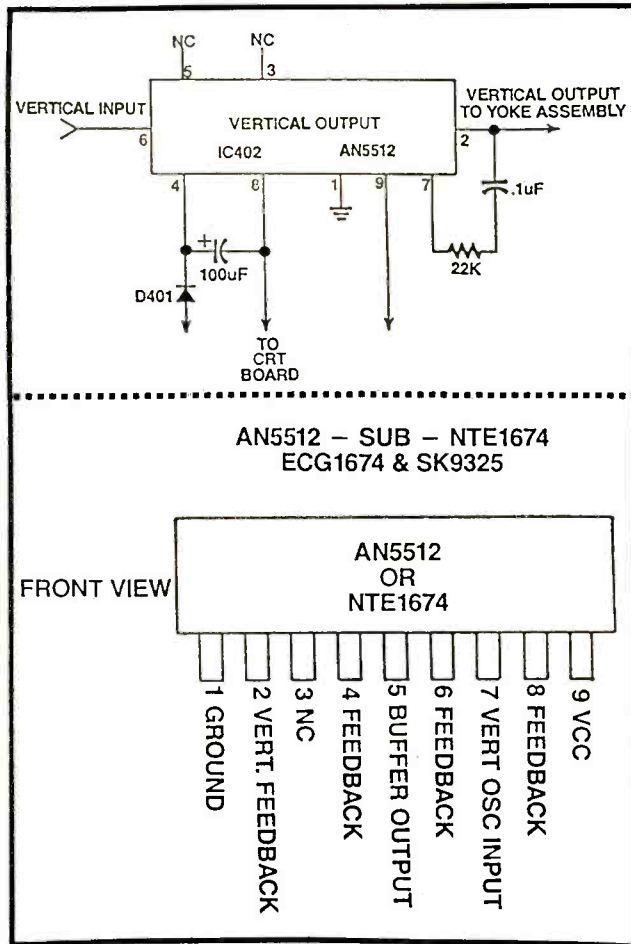


Fig. 2. A schematic of a vertical output IC402 (AN5512) with corresponding numbered terminal pins.

may find no terminal pin numbers stamped on the IC terminals, while in other circuits the pin terminal may be numbered at the corners of the PCB.

Locate terminal one with a white or black line at one end of IC, a white dot or circle, and an indent "U" shape at one end of IC (Fig. 5). You may find only one of these identifications on the body of IC or two or more identifying markings. Terminal #1 is always to the left side of the indent, white or dark line. A white or clear circle indicates terminal one is on top of the IC body. Notice that in this 16 pin IC, terminal 9 is across from 8 at the opposite ends.

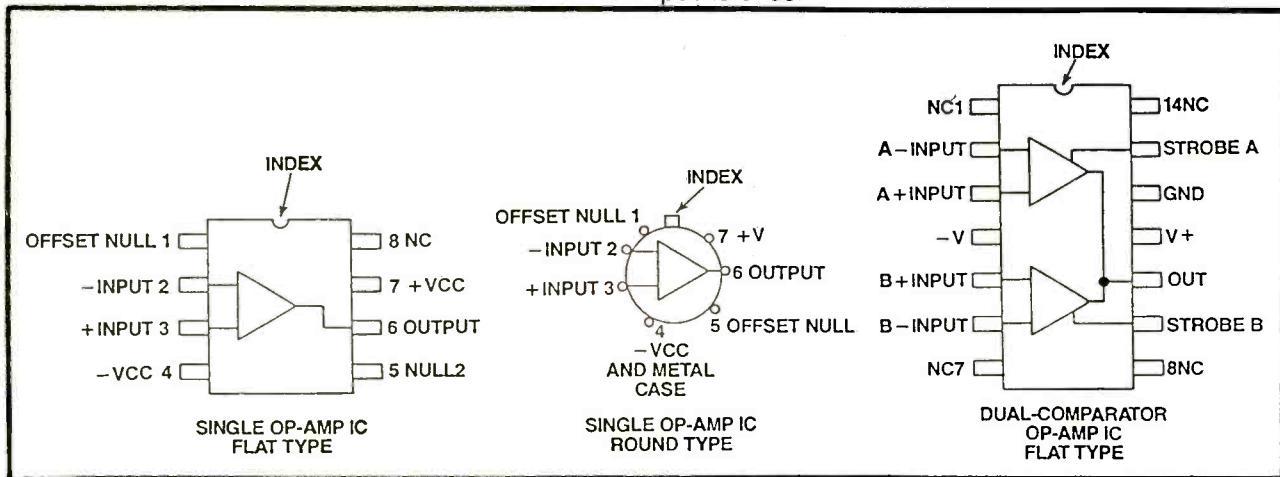


Fig. 3. The OP-Amp semiconductor may be found inside a flat or round mounting with one or more circuits.

Flat vertical and horizontal mounting IC's can be identified with a white dot, clear circle, "U" at one end, and a slanted cut off corner at one end of IC (Fig. 6). You will find this type of IC mounting in motor and control circuits of CD, camcorder and VCRs. The metal flange or IC's with a metal back are found in power output amplifiers and vertical output circuits within the TV chassis. Lower signal or power IC's are mounted like transistors, without a metal heat sink. All high powered IC's are mounted on separate heat sinks. Most IC's can be mounted directly into holes of the PC board and soldered to the PC wiring.

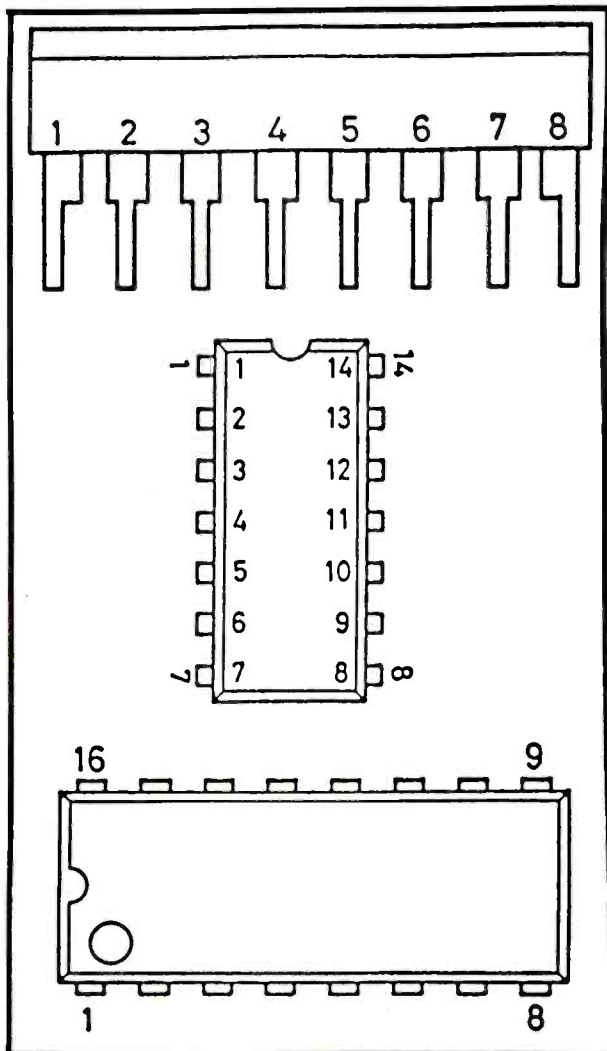


Fig. 4. Notice where terminal one starts at the indent, circle and slanted edge mounted IC.

Simple Project IC Components

Today, you will find more IC components used in electronic experiments and construction projects than transistors (Fig. 7). A single shortwave receiver may have a high gain AF IC to drive a pair of earphones. The LM386 IC can be found in many audio circuits of electronic projects. Here, a low audio signal can be amplified to drive earphones or a small speaker.

The LM386 IC can be identified with a white line or circle. Notice the pin connections shown on the body of the IC, while looking down on the IC component (top view). The audio signal is coupled to input pin 3, am-

plified and capacity coupled through a 220uF electrolytic capacitor to the PM speaker. Pin 6 is the voltage supply pin connected to a 9 volt battery source (Fig. 8). The 220uF capacitor connected to pin 6 and ground prevents oscillations occurring in the audio circuit.

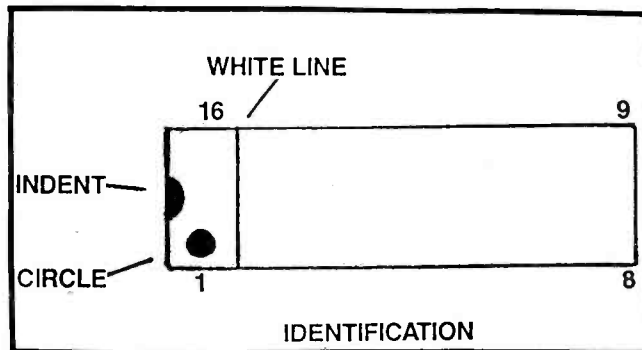


Fig. 5. Identify pin number 1 with indent, circle or white and dark line, on top, at one end of the IC.

Simple Tests

The IC component can be checked with an input-output signal and voltage tests. Check the input signal at the input terminal and then the output terminal of an audio IC with another external audio amp or scope. If the audio signal is found at the input and not at the output terminal, suspect a defective IC, outside components, or improper supply voltage. Then take voltage and resistance measurements on the IC terminals, to locate a defective IC or connecting part.

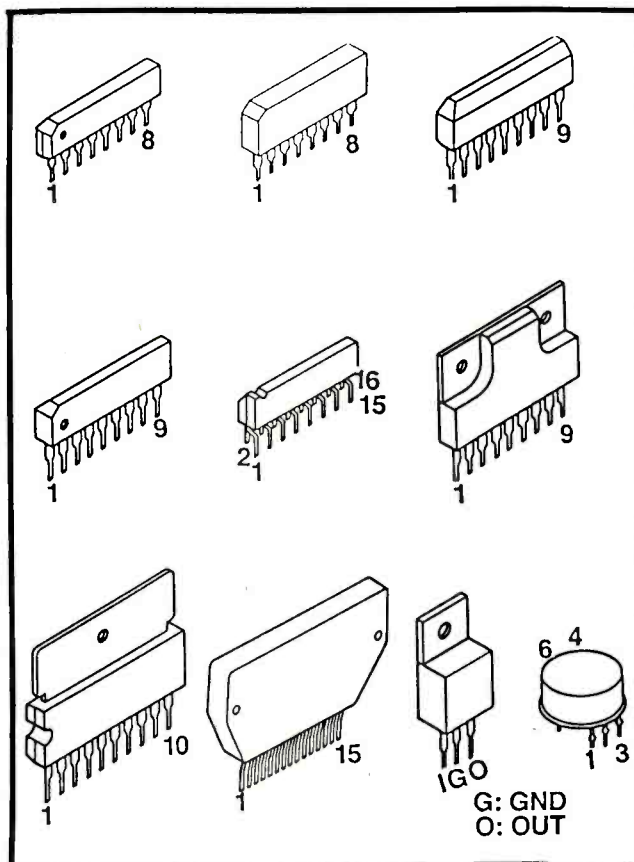


Fig. 6. Notice the slanted edge mounted IC for terminal #1. Large power IC devices mount flat against a metal heat sink.

Besides voltage and resistance tests on the IC terminals, a defective IC can be located with the oscilloscope in the VCR, CD, and TV chassis. Waveforms taken on the input and output terminals can identify a defective IC or circuit. Critical waveforms taken on transistor and IC components within the vertical and horizontal circuits of the TV chassis can determine what stage is defective. The defective IC can become leaky, open internal circuits, or have shorted terminals. Remember, the integrated circuit cannot be tested like a regular transistor.

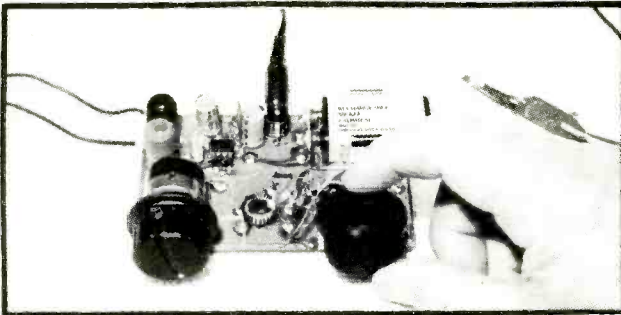


Fig. 7. This small audio amplifier project is constructed around an 8 pin LM386 IC.

Voltage and resistance tests

Critical voltage and resistance measurements on each terminal pin to common ground may determine if the IC is defective. Start with the voltage pin and compare voltage measurements with those on the schematic (Fig. 9). If a diagram is not available, the supply voltage should equal the battery or low voltage supply source. Then check each voltage on the remainder of the pin terminals.

Often, a low DC supply voltage indicates a leaky IC or improper battery or DC voltage source. Remove the supply pin from the PCB circuit, with a soldering iron and solder wick. Make sure all solder is removed from pin terminal and pc wiring. Now take a voltage measurement at the pc wiring, where the pin terminal was connected. The IC is leaky if the voltage increases at

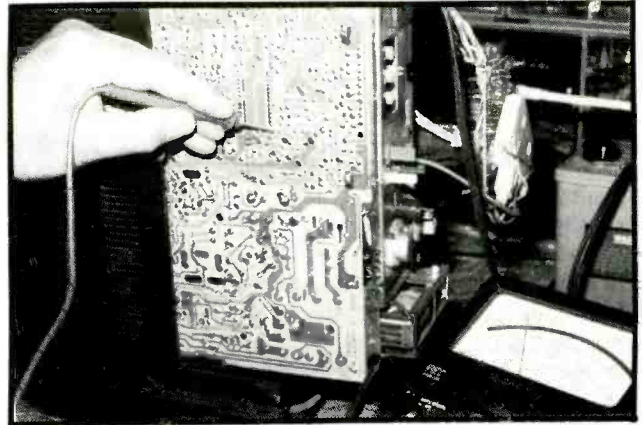


Fig. 9. Take critical voltage and resistance measurements on the suspected IC to determine if the IC is defective.

the voltage supply source. A low voltage measurement indicates improper low voltage source. Check for weak batteries or low voltage power supply.

When taking a low resistance measurement that is lower than shown on the schematic, suspect a leaky IC component or part tied to that pin terminal. Remember, these voltages may be less than 1 volt and should be taken with a DMM. The supply voltage source is always the highest voltage found at any IC pin terminal. In battery operated projects the supply voltage IC source equals the total voltage of all batteries (Fig. 10).

With a low voltage measurement on a certain pin number, take a critical resistance measurement to chassis ground. Make sure a low ohm bias resistor or ground IC terminal is found on the schematic. Check the resistance measurements of each pin terminal to ground, to determine if the IC is defective or a leaky component is tied to it. Bypass capacitors have a tendency to become leaky between pin terminals and common ground. Likewise, resistors can become open or increase in value. Remove one terminal of the component and take another resistance measurement.

Make sure all components tied to the suspected IC are normal before attempting to remove the integrated

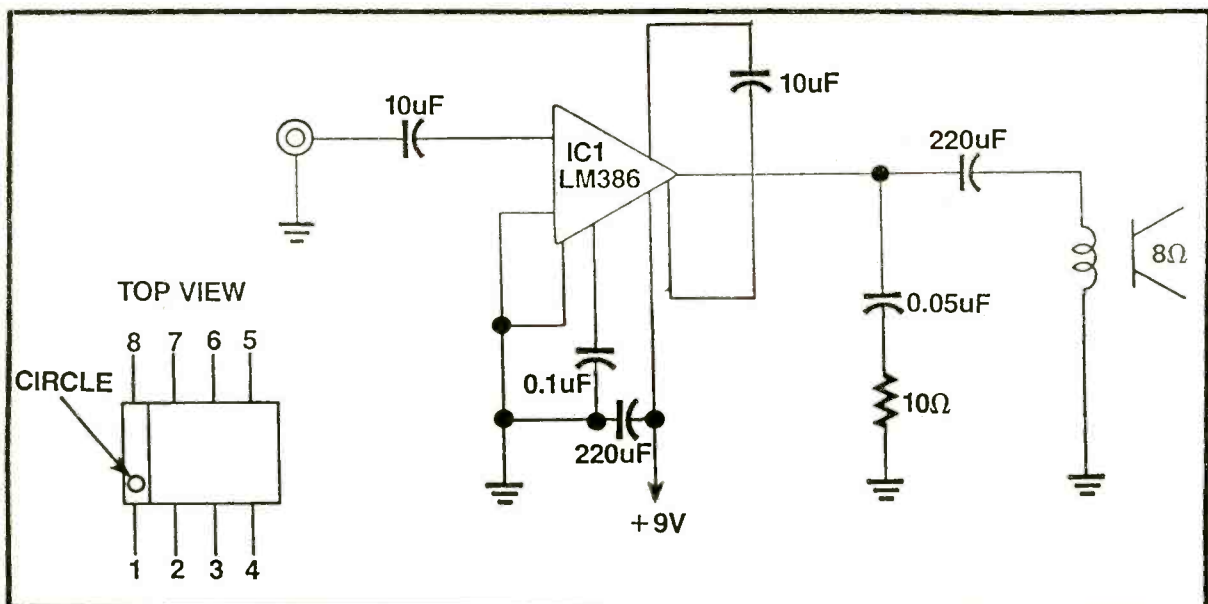


Fig. 8. The 8 pin (LM386) amplifies the weak detected short-wave signal to drive a pair of low impedance earphones.

circuit (IC). If not, the IC may be good and you have gone to a lot of work removing and replacing the suspected IC. When voltage and resistance measurements are normal with normal input and no output signal, install a new IC replacement.

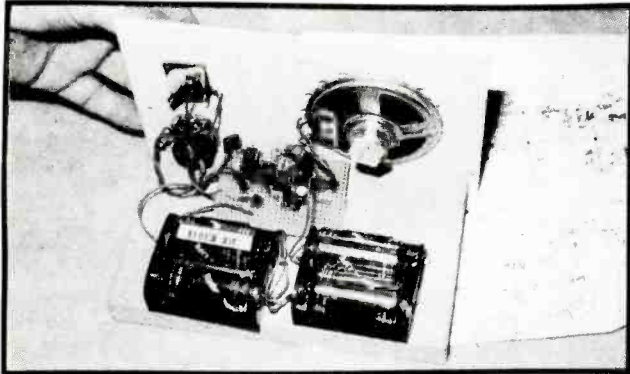


Fig. 10. In battery operated projects, the voltage supply pin of the suspected IC should equal the total battery voltage in that circuit.

Intermittent IC

In the stereo audio output circuit, one channel may be normal and the other distorted and weak in a dual-IC audio component. Usually, when both channels are weak or distorted, suspect a common IC component. If one channel is intermittent and the other normal, you may find a defective IC or intermittent component tied to the intermittent audio channel.

Check the audio output IC for an extremely warm body by holding a few fingers nearby. If not, momentarily touch the body of the IC. A red hot IC will show signs of overheating, with white and brown stains on the body of IC. Be careful not to burn your fingers with a red hot IC. A normal IC may operate warm, but not be too hot to touch.

Sometimes the intermittent IC can be located by applying several coats of coolant on the IC. If the intermittent condition does not exist again, give it another spray treatment with coolant. Replace the intermittent IC when cold spray makes the sound go up or down (Fig. 11).

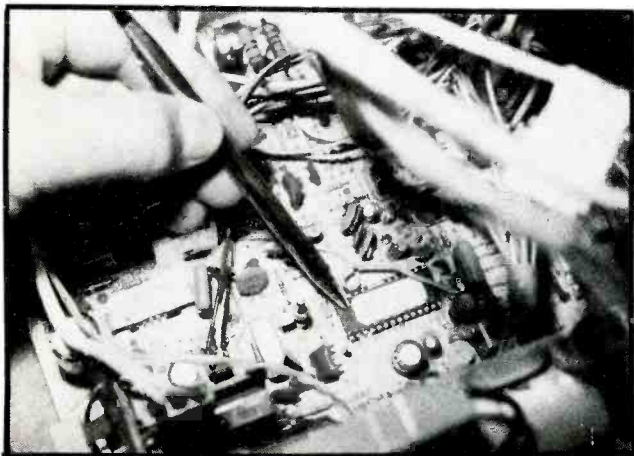


Fig. 11. The Intermittent IC can be located by spraying several coats of coolant on the body of the IC or microprocessor.

Removing the Defective IC

After making all tests and determining if the IC is defective, remove it from the pc wiring. The best and cheapest method is with a soldering iron and solder wick. The copper or tinned mesh material picks up the melted solder from the pins and the board wiring. Place the solder wick braid along side the row of bottom pin terminals. Place the iron tip on top of braided mesh and slowly go down one side of IC pins as the solder melts.

Now go down each side of pin terminals to unsolder each pin. Go over each pin to be sure the pin is loose from the copper PC wiring. Be very careful not to apply too much heat to pull or lift the foil from the PC board. Also, be very careful not to damage other components with the hot iron. Take a pocket knife or screwdriver and flick each pin to make sure it is loose and no solder is left around it.

Before lifting the IC out of the PCB holes, mark terminal #1 on the PC board with a felt pen or a dab of white correction fluid. Some chassis may have an indent or terminal one (1) marked on the PC board, while others may have each pin at both ends marked on chassis. Do not use the removed IC again.

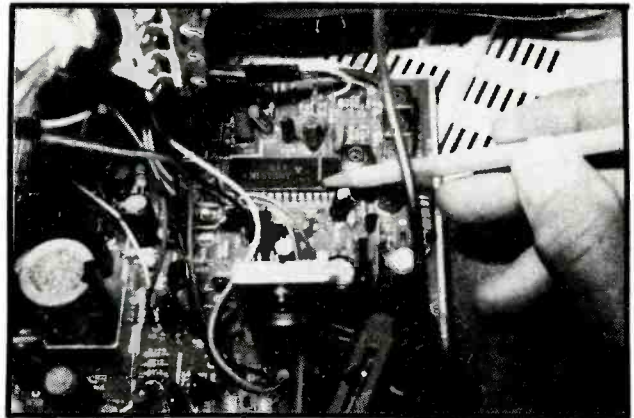


Fig. 12. Check the unknown IC part number located on top of IC and refer to a universal semiconductor manual to determine what stage it operates in, voltage and current ratings, and what circuit each pin number ties to.

IC Replacement

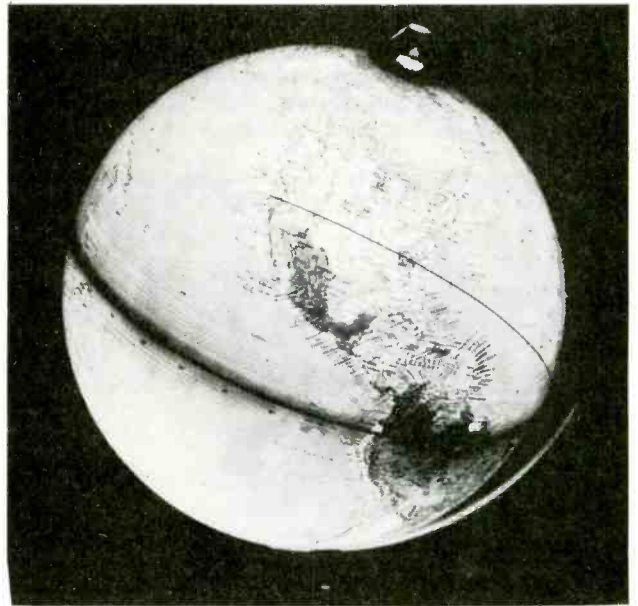
In electronic projects, the IC part number can be found within the part lists. Likewise, in all consumer electronic products, the service manual provides a parts list. If you do not have a schematic, and no part list is found, check the letters and numbers on the top side of IC (Fig. 12). This component number can be looked up in universal replacement semiconductor manuals for the correct replacement. Look up the part number in an NTE Electronic (NTE), Sylvania Corp (ECG), and Thomson Consumer Electronics (RCA SK Series) replacement manuals.

Universal replacements can be replaced in most commercial electronic products when the original part is not available. Always, try to obtain the original part from the place where the product was purchased, manufacturers parts depot, or the manufacturer. Try to obtain the part from a local electronics dealer or wholesale distributor. Sometimes exact foreign or Japanese IC components can be purchased from mail order firms. Check with your local Radio Shack store.

(Continued on page 25)

BUILD A GLOBAL ANTENNA DIRECTOR

By
Fred Blechman

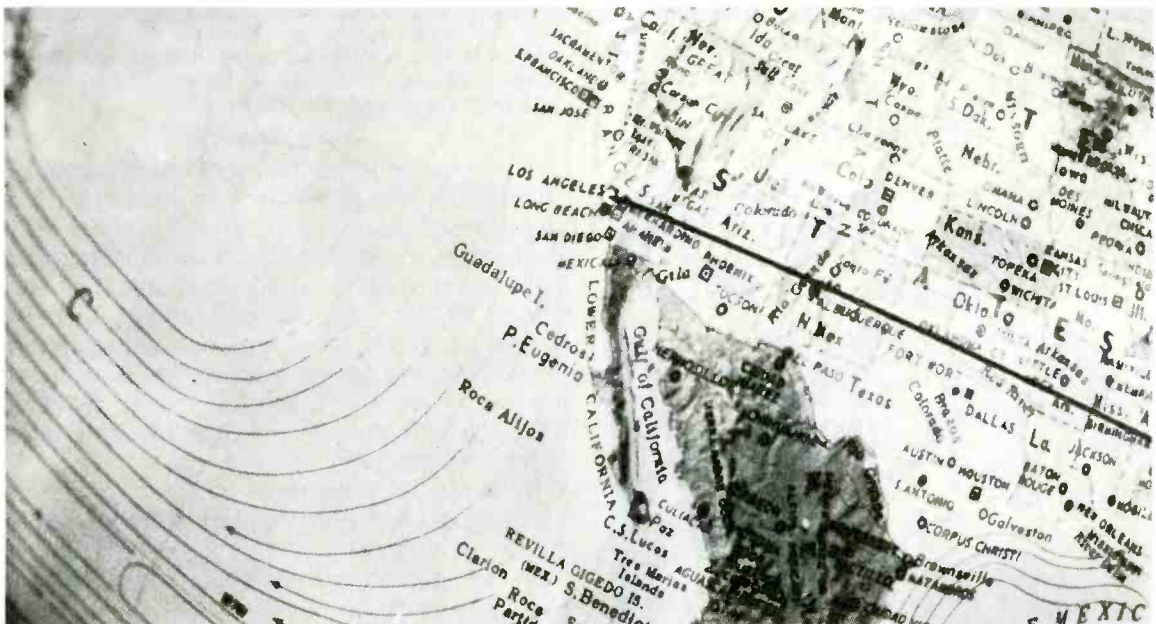


Add a wire to a globe and you can tell the distance and direction to any point on Earth! Los Angeles, California, is the "home town" shown here, but you can make it anywhere on Earth! The wire is set to show the Great Circle path between Los Angeles and Johannesburg, South Africa—or anywhere in between.

Purists may take issue with my capitalization of terms like Great Circle, East, North, Earth, etc. This was done for clarity in highlighting some terms used in this article that have particular significance to the subject.

If you're a radio amateur "ham" who likes to operate DX (long distance) stations, or you're a shortwave listener (SWL), you know that your best transmission and reception path is a "Great Circle" bearing to the station you're working. But just what is that bearing, and what's a Great Circle?

Using an inexpensive world globe, a short piece of piano wire, a couple of simple calculations, and a small-hole punch, you can make your own custom "Global Antenna Director." Follow the simple instructions in this article and you'll quickly be able to estimate the bearing and distance to any spot on Earth from



Los Angeles, California, is the station location in this closeup view. The wire is aimed at Johannesburg, South Africa, and shows a Great Circle bearing of about 5-degrees North of East. And you thought the bearing would be southeast! Distance markings could be added to the wire.

your home town! Then just swing your beam antenna to this bearing, and you'll be working the optimum signal path (barring oddball atmospheric conditions.)

And, just to give this project additional value, I'll be describing things about maps and globes that can make you an "expert" on this subject compared to most folks.

Flat Maps A Sphere Do Not Make!

Most people are familiar with maps, especially road maps. With these you travel point-to-point by roads. You "navigate" by road signs that show route names or specify cities ahead. You aren't concerned with "Great Circle" routes (the shortest distance between two points on Earth), since you are confined to the roads. Similarly, those who traverse rivers in small boats simply follow the course of the river.

Even if you travel long distances, by airplane for example, it's up to the pilot to get you there. If you take off from Los Angeles and fly directly to London, you probably assume the pilot heads straight East, or maybe a little North of East. That's because you're used to seeing typical maps that show the entire spherical world spread out on a flat piece of paper, and London seems to be just a little North of East from Los Angeles. Actually, to fly the shortest distance—the Great Circle—from Los Angeles to London, the pilot would fly a true compass heading of about 33 degrees from North, or about 57 degrees North of East!

The Earth is a sphere (except for some minor flattening at the poles.) Think of a rubber ball. Not the entire ball, or even a part of it, can be flattened without tearing or "stretching"—unless the part is very, very small. So it is with trying to accurately represent parts of Earth on flat maps.

Mapping countries, continents, or the entire Earth, require "projections," of which there are many different types—Mercator, rectangular, sinusoidal, Mollweide,

Goode's, Eckert, conic, Bonne, polyconic, azimuthal, gnomonic, orthographic, and more. In any projection, only some lines are true (the same length as on a globe); all other lines are too long or too short.

This is why maps, except for relatively small areas, give you erroneous bearings and distances between any two points on the Earth. In terms of the size of the Earth, local maps (your city, for example) are very small, so they are reasonably accurate. However, as soon as you try to map larger areas (your state, for example) distance and bearing inaccuracies creep in.

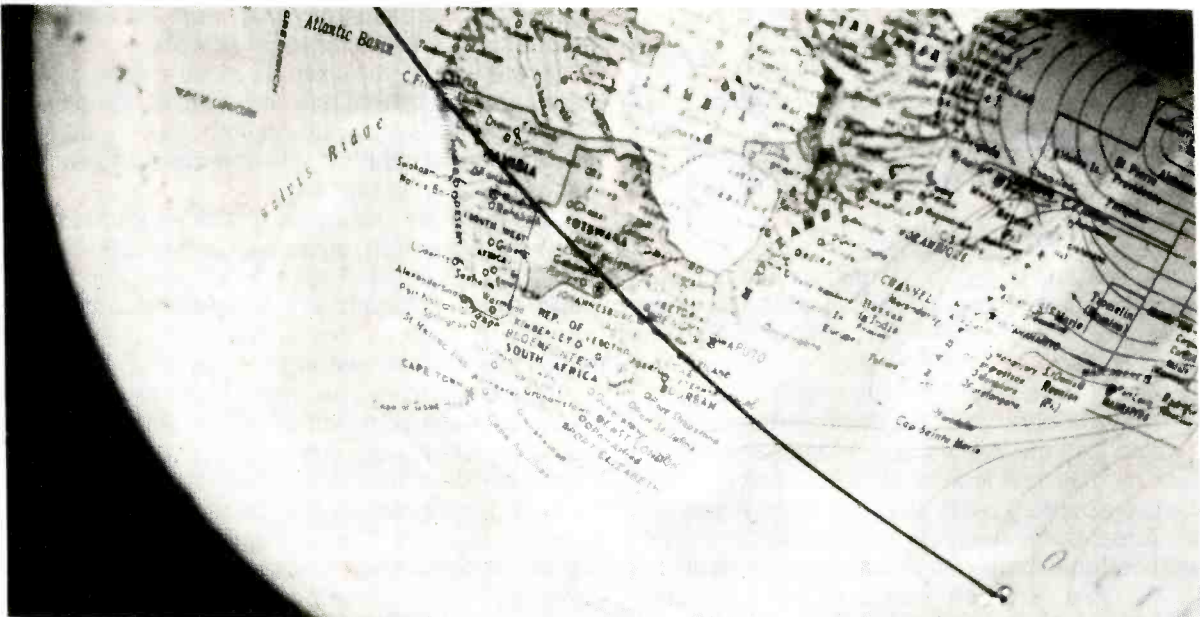
Terminology

When describing the Earth's coordinate system, some special terms, not in the general vocabulary, are used. Look at any globe for a better understanding of the following discussion.

The Earth rotates around its "axis", which goes through the center of the Earth. The two axis end-points are called the "North Pole" and the "South Pole." The line completely circling the Earth midway between the poles is called the "equator."

The arc from either of the poles to the equator is divided into 90-degrees. The arc from the equator to any point, North or South, is its "latitude," and circles of equal latitude are called "parallels." Each of these parallel circles are smaller and smaller in diameter as they are located further from the equator, finally disappearing completely at the poles.

The equator is divided into 360-degrees, with each degree further divided into "minutes" and "seconds" (60 seconds of arc equals 1 minute, 60 minutes of arc equals one degree.) The same applies to imaginary circles going around the Earth from pole to pole. These are called "meridians," with the "prime meridian" passing through the Greenwich Observatory in London, England. The arc from the prime meridian to any point



The other end of the wire, passing over Johannesburg, South Africa, ends at the antipodal point—the point on the Earth exactly opposite Los Angeles. Note that the author made two previous "eyeball" attempts to find the antipodal point before calculating it.

is its "longitude," measured East or West, up to 180-degrees.

To specify any point on Earth, you simply state the latitude and longitude. For example, Los Angeles County is centered at 34-degrees 20-minutes North and 118-degrees 10-minutes West. To convert the minutes to decimal parts of a degree, divide by 60. This would make Los Angeles County 34.33N latitude and 118.17W longitude.

A "Great Circle" is the intersection on the Earth's surface with any flat plane passing through the center of the Earth. Therefore, the equator and all meridians are Great Circles. Also, the shortest distance between any two points on the surface of the Earth is the arc of a Great Circle between them.

It is also very handy to know that one-degree of an arc on a Great Circle is exactly 60 "nautical miles" (used for Earth navigation) or 69 "statute miles" (the kind we're used to, where 5280 feet equals one mile.) One nautical mile equals 1.15 statute miles, therefore, you can multiply nautical miles by 1.15 to get statute miles.

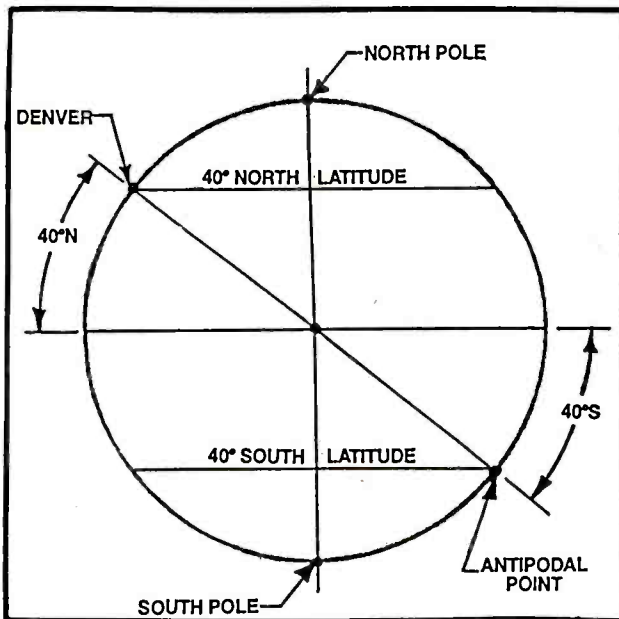


Figure 1. Determining opposite latitude

Finding The Bearing

All this is fine and dandy, but what has this got to do with finding the distance and direction from your home town to any point on Earth? And isn't this available in a book somewhere?

If you have been a "ham" for any length of time, you probably have a copy of "The Radio Amateur Callbook," which lists the names and addresses of Radio Amateurs by their call letters. My latest copy (Winter 1962-1963—about 30 years old!) has three tables that show the Great Circle bearings to countries throughout the world; perhaps more recent copies have additional tables. One table assumes you live at "the geographical center of the United States," another is from New York City, and the third from San Francisco. But what if you live in Little Rock? Or what if you want contact with a city or country not listed?

You may have access to charts that are centered somewhere near you, or you may have a computer program that allows you to enter the latitude and longitude of any two points on Earth, and calculates the bearing and distance between them.

But if you already have a globe, and are willing to poke a couple of small holes in it, it will only cost you about 10-cents to use the globe to provide relatively accurate bearing and distance information from your home town.

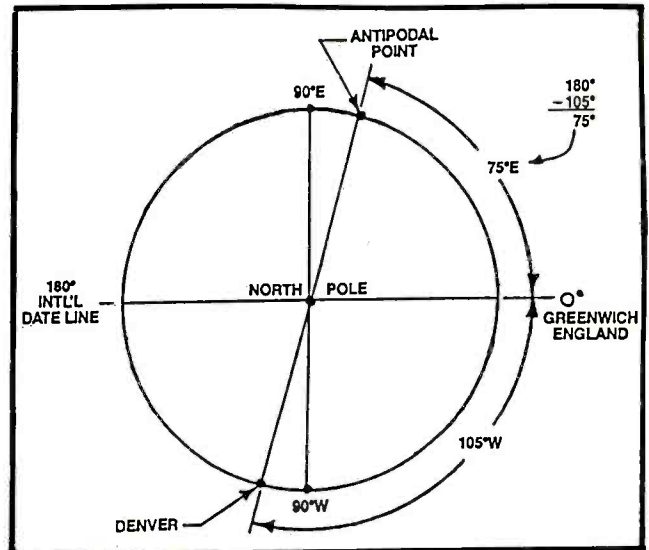


Figure 2. Determining opposite longitude

Making the Holes

The photos show the author's Global Antenna Director centered on Los Angeles; it could just as well be centered anywhere on Earth. To make your own Antenna Director, you'll need a world globe. This does not have to be an expensive or particularly large one, just so long as it is reasonably well made. The closer it is to a perfect sphere, the better it will work.

Locate your home town as closely as you can, and punch a small hole at this point with an ice-pick or awl. Now for some simple calculation; you'll need to determine the "antipodal point"—the location diametrically opposite yours on the globe.

Determine (as closely as you can from the markings on the globe, or from an atlas or encyclopedia) your latitude and longitude. The latitude is the number of degrees North or South of the equator; longitude is the number of degrees East or West of Greenwich, England (0 degrees longitude.)

Figure 1 shows you how to find the point on the globe opposite your home town in latitude. This turns out to be exactly the same number of degrees on the opposite side of the equator. What could be simpler?

To find the point on the globe opposite your home town in longitude, look at **Figure 2**. All you do is subtract your home town longitude from 180 degrees; the difference is the number of degrees of longitude of the opposite point in the other hemisphere.

A typical case is shown in Figures 1 and 2. Say your town is Denver, Colorado, located at 40 degrees North latitude and 105 degrees West longitude on the globe.

BUILD A GLOBAL ANTENNA DIRECTOR

To find the opposite point in latitude, just locate the same number of degrees South latitude, below the equator. To determine opposite longitude, subtract 105 from 180; the difference is 75, the number of degrees of longitude East of Greenwich. So the antipodal point on the globe is 40S and 75E.

Once you have properly located the antipodal point, punch another small hole there. Obtain some piano wire about $\frac{1}{32}$ in. diameter (not at all critical) from a hobby shop, and gently form it into a semi-circle equal to the globe diameter. Leave about $\frac{1}{4}$ in. of wire on each end to act as pivot points when the wire is snapped into the holes in the globe. Bend these ends at about a 120-degree angle, toward the center of the arc, to keep the ends from popping out of the holes.

Now comes the moment of truth. Snap the wire ends into the holes and swivel the wire. If you have been careful in your calculation, measurements, and workmanship, and your globe is spherical and accurately marked, you will successfully have "girdled the globe." If the wire won't fit in the holes, jams when swiveled, or is too sloppy, either adjust the wire or try a new antipodal hole.

Until I realized the ease of calculating the opposite point, I made two improperly located "eyeball" holes;

the calculated hole was right on target.

The Final Touches

Marking increments of distance on the wire is another easy matter if you take advantage of the markings on the globe—but you must first decide if you want to mark the wire in nautical miles or statute miles. Since each degree of arc of a Great Circle (equator or longitude lines) is equal to 60 nautical miles, then 16.67 degrees of arc is equal to 1000 nautical miles (1000 divided by 60.) For statute miles, 14.49-degrees of arc equals 1000 statute miles (1000 divided by 60, then divided by 1.15.)

Use a strip of paper or a string to measure the arc equal to 1000 miles, blacken the piano wire with a felt marking pen, and put a dot of white ink or paint every 1000 miles.

To determine bearings closely, you could put a "compass rose" showing headings under the hometown pivot, but that could be considered "gilding the lily with a rose."

Just swing the wire on the globe to the location of the station you're working. Estimate the bearing angle, swing your antenna to that direction, put on your ears, and enjoy! ■

TESTING AND REPLACING INTEGRATED CIRCUITS

Soldering Up

Check for terminal #1. Mount the IC replacement from the top side of the chassis. If the IC is mounted backwards, you can destroy the new IC and other board components. Bend over two terminals at each end of the IC, so that when the chassis is turned over for soldering, it will not fall out. Make sure each pin is through the corresponding holes. Likewise, when mounting the IC into a socket, make sure all pins are in the socket.

Solder all terminals with a low wattage (30 watts) sol-

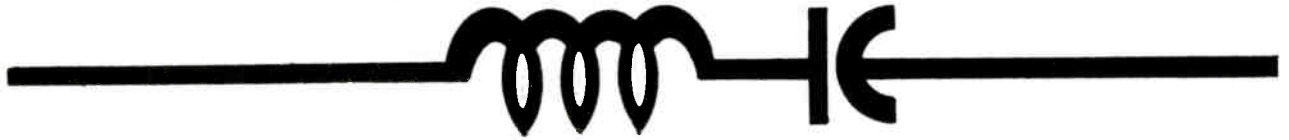
dering iron. The battery soldering iron is ideal for transistor or IC circuits. Make good soldered connections, but do not leave the iron on the pin terminals too long. Check each pin for a good connection with a magnifying glass. Inspect for excessive solder between two or more pin terminals. Remove excess solder with solder wick and iron. Check each pin terminal to the same PC wiring with the low ohm range of DMM. Sometimes the foil will lift up or pull off when the IC is removed, breaking the foil connection. Clean off wax and rosin flux with a general purpose electronic cleaner/degreaser spray. ■

ABBREVIATIONS

CDS—Complementary symmetry device
MOS—Metal-oxide semiconductor or Metal-oxide silicon
CMOS—Complementary Metal-oxide semiconductor
PMOS—P-channel Metal-oxide semiconductor
DTL—Diode-transistor logic
TTL—Transistor-transistor logic

The abbreviations of various transistor and IC components.

CIRCUIT FRAGMENTS



STABILIZING RF OSCILLATOR DRIFT

The quality of any RF based device (receiver, transmitter or signal generator) can be defined by how stable the frequency of oscillation is. RF oscillators operating in the higher frequency region (ten's of megahertz and upwards) will drift in frequency under some worst case construction/layout conditions. At low frequencies, this drift in frequency might be tolerable, but for reliable long term operation, high frequency-operation drift is a no-no! The popular low power license free FM transmitter design using a single transistor will operate around 100MHz. Even a 1% drift of 1MHz either way is quite considerable. There are several basic 'good' construction layout techniques to follow to minimize and control frequency drift.

1. One of the most critical influences on frequency stability is temperature, particularly high temperatures and temperature variations. Therefore, physically locate the oscillator away from any component that is generating excessive heat, such as regulators and power transistors that consume high current.

2. Use an IC voltage regulator that supplies only the oscillator, so that its supply line is not affected by any of the other circuits components. A circuit block such as a power amplifier feeding into a low impedance load, will cause the supply current, hence supply voltage, to fluctuate as the load current changes. This change, if allowed to 'interfere' with the oscillator, will cause a frequency drift.

3. Keep the frequency controlling components firmly mounted. In the simple FM transmitter design, the frequency associated components are a capacitor and inductor. The capacitor is generally a small trimmer and is not much of a problem. The inductor, generally a small hand wound coil, will cause a change in frequency if the turns are allowed to move relative to each other. Make sure the construction is firm—use epoxy if required to keep turns in place and make sure the coil cannot move especially if the project is a portable device.

4. Insulate the RF oscillator with a 'box' made from a polystyrene sheet. Polystyrene is an excellent heat insulator. The sheets can be cut easily to shape with a hobby knife and glued together with contact cement. The heat shielding properties with a 'poly' cover are quite considerable. ■

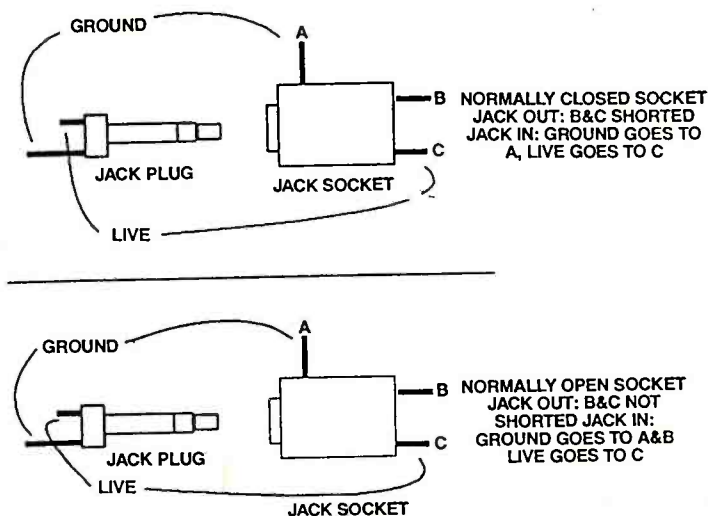
JACK SOCKET TUTORIAL

Miniature jack sockets ($\frac{1}{8}$ " size) are commonly used to couple an audio amplifier to headphones. For the beginner, it is very likely that some confusion can arise when buying/using these apparently simple jack sockets. First of all, there are two different types, called 'normally closed' and 'normally open'. For both types there are three connections, and when viewed from the side, they as shown in the illustration. The upper terminal ('a') always goes to ground and the lowest terminal ('c') always goes to 'live'. But here's where the two types differ! With the 'normally closed' type, pins 'b' & 'c' are shorted only when the jack plug is out. With the 'normally open' type, the ground goes to both 'a' & 'b' when the jack plug is in.

So, which type should you use? If you only want a regular ground and live connection, then either type will

do—ground goes to 'a' and live goes to 'c'. Ignore pin 'b'. Radios, having earphone jack socket, that automatically disconnects the speaker when the earphone is in use, utilize the 'normally closed' type. Pin 'a' goes to ground, 'b' goes to the internal speaker and 'c' comes from the amplifier output. As we've said earlier, 'b' and 'c' are connected when there is no earphone connected. When you insert the earphone, 'c' is disconnected from 'b' and the live feed now goes from 'c' (coming from the amplifier output), through the jack plug to the earphone. Take time to follow this through and you shouldn't go wrong.

Nothing beats actually seeing for yourself, the differences between these components. All you need are two jack sockets (one of each type, $\frac{1}{8}$ "), a jack plug ($\frac{1}{8}$ ") and a regular ohmmeter.

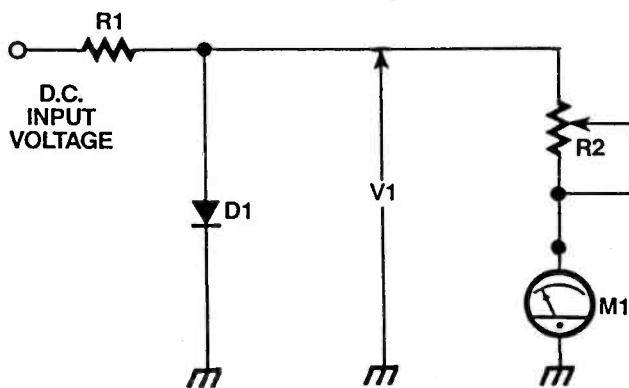


METER OVERLOAD PROTECTOR

D.C. analog meters can be very easily ruined, by applying too high an input voltage. To protect your meter during circuit adjustments, use the circuit shown here. The D.C. input voltage to be monitored is fed to resistor (R1), a current limiter for silicon diode (D1). The output is taken to your meter, (M1), through R2, a sensitivity control. For low input voltages the signal is fed through R1 and R2 to the meter. If a high overload occurs, diode D1 conducts, limiting voltage, (V1), to about 0.6 volts, thus protecting M1.

PARTS LIST FOR THE METER OVERLOAD PROTECTOR

- R1 — 1K resistor
- R2 — 10K potentiometer
- D1 — silicon diode 1N914
- M1 — D.C. voltmeter



METER OVERLOAD PROTECTOR

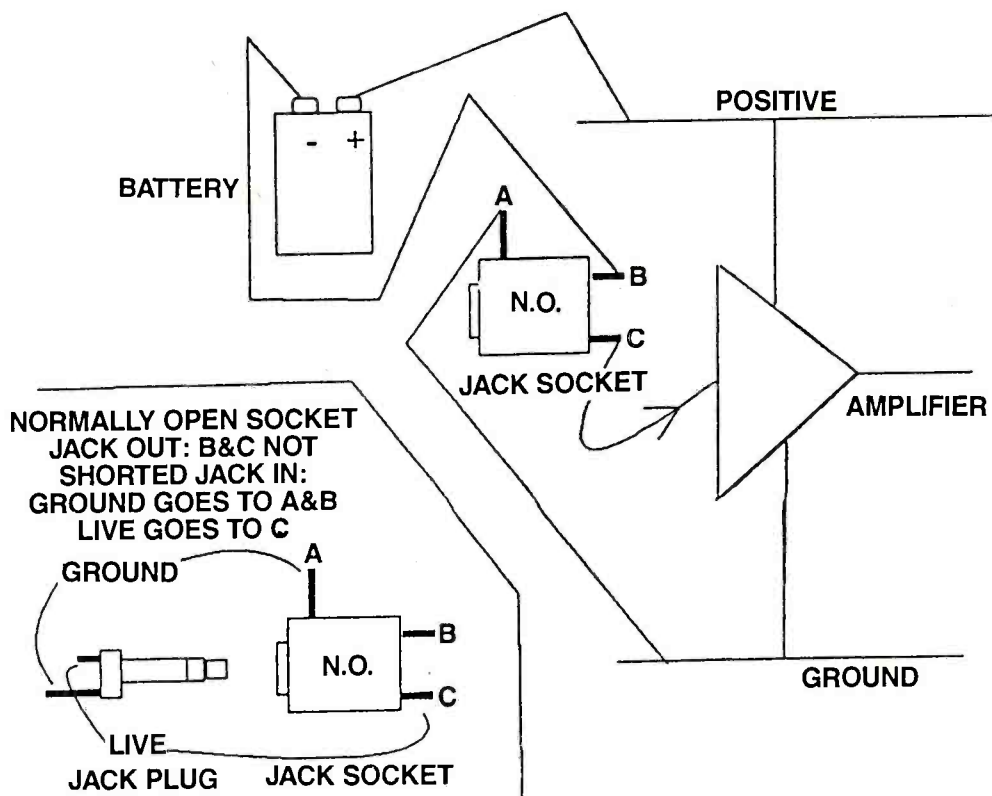
DOUBLE DUTY JACK-SOCKET POWER SWITCH

There's nothing as neat as making a component do double duty and getting something for nothing! Here, we'll see how to get a jack socket to act both as a feed source into an amplifier and to also switch the power at the same time. By pulling out the jack plug you not only disconnect the signal source but you also shut off the supply power — clever! This'll only work with what is called a 'normally open' type of jack socket. This is a $\frac{1}{8}$ " three terminal jack socket. The input signal from the jack plug goes to pin 'c' and into the amplifier when the jack plug is inserted. The remaining two pins, 'a' and 'b' are separated when the jack plug is **not** in. The normal ground connection goes to pin 'a', made when the jack plug is inserted. But, in addition, pin 'b' is also connected to 'a'.

So we make use of this feature by, connecting the

negative terminal of the battery to pin 'b'. Hence, the only time a connection to the negative (or ground) terminal of the battery is made, is when the jack plug is inserted. Thus, we save having to use a separate switch. Where space is a premium, this tip could come in useful sometime. The illustration shows the 'normally open' jack socket connections and how it is used in the way described here.

You can also use the same trick with the larger $\frac{1}{4}$ " jack socket/plug combo, as found with guitar amplifiers. These components are actually much easier to examine, being physically much bigger. Although shown, connected to the input of an amplifier, the jack socket can equally be connected to the output end. Just couple pin 'c' to the output as opposed to the input. The rest of the pins stay the same.



CAPACITANCE METER

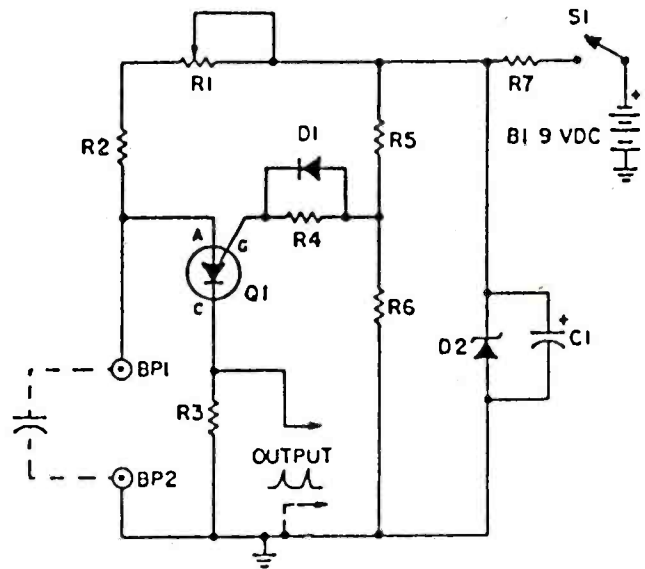
If you own a triggered-sweep oscilloscope or a frequency counter capable of making frequency measurements, you can use this PUT (programmable unijunction transistor) oscillator to measure capacitance. The practical range of measurement extends from 100-pF to about 10uF—wide enough to cover most of your measurement needs.

With an unknown capacitor connected across the binding posts, measure the time interval between

output pulses on your scope or frequency counter. To convert time to capacitance, use the relationship: CAPACITANCE (uF) = 10 × TIME. For instance, a reading of 100-micro-seconds (.0001-sec.) indicates a capacitance of 0.001-uF (or 100-pF). (NOTE: 1-uF = 1,000,000-pF). To calibrate the oscillator, hook a 1000-pF polystyrene capacitor across the binding posts, and adjust R1 until the time between out-put pulses is exactly 100-microseconds.

PARTS LIST FOR CAPACITANCE METER

- B1**—9-volt transistor battery
- BP1, BP2**—binding posts
- C1**—100-uF, 10-VDC electrolytic capacitor
- D1**—1N914 diode
- D2**—1N752A, 5.6-volt, ½-watt zener diode
- Q1**—2N6027 programmable unijunction transistor
- Note:** All resistors rated 5% tolerance
- R1**—200,000-ohm trimmer potentiometer
- R2**—390,000-ohms resistor
- R3**—22-ohms resistor
- R4**—1 megohm resistor
- R5, R6**—2,200-ohms resistor
- R7**—560-ohms resistor
- S1**—SPST toggle switch

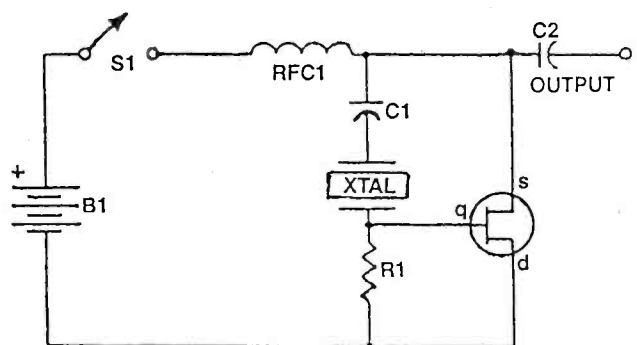


CRYSTAL OSCILLATOR

This JFET Pierce oscillator is very stable, very simple, and can prove very useful. With a suitable crystal, this oscillator can be the clock of a microprocessor, a digital timepiece or a calculator. With a probe attached at the output, it can be used as a precise injection oscillator for troubleshooting. You can attach a small length of wire at the output to act as an antenna and use this circuit as a micropower transmitter. With suitable crystals it can then provide reference marker frequencies for short wave listening, receiver tuneup, tv repairs and more. Transistor Q1 can be a Siliconix 2N5458, a Motorola MPF102 or similar.

PARTS LIST FOR CRYSTAL OSCILLATOR

- B1**—6-15 VDC battery
- C1**—.001-.01-uF capacitor
- C2**—100-pF, 0.01-uF capacitor
- Q1**—N-channel JFET (Junction Field Effect Transistor) (2N5458 or equiv.)
- R1**—1-2.2 Megohm resistor, ½-watt
- RFC1**—Radio frequency choke, 2.5-mH
- S1**—SPST switch
- XTAL**—Crystal

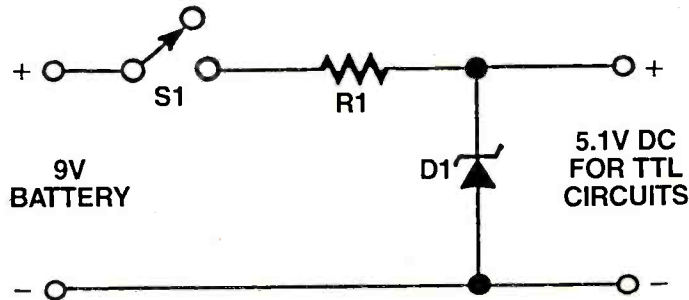


9V TO 5V POWER SUPPLY

The common 9V battery, useful for powering most transistor circuits, is too high for TTL logic. To power TTL logic, the 9V D.C. source can be lowered to a convenient 5.1 volts, using just two components. The positive 9V battery terminal is connected via switch S1, to resistor R1. R1 acts as a current limiter for reversed biased zener diode, (D1). When S1 is closed, D1 stabilizes to a useful voltage of 5.1V—just what is needed to power TTL logic. ■

PARTS LIST FOR THE 9V TO 5V POWER SUPPLY

- S1 — SPDT Switch
- R1 — 100 ohm Resistor
- D1 — 5.1V Zener diode (1N4733)



RC INTEGRATOR/DIFFERENTIATOR

The 555 timer is a nice, easy to use, source for generating square waves when connected in the free running astable mode. There are two very simple ways to 'modify' the stock square wave shape to produce what is called the 'integrated' wave and the 'differentiated' wave—the terms come from maths calculus text originally, but for electronics purposes, the end result is more of use than the calculus association. Begin with a stock audio frequency 10kHz square wave signal. The duty cycle does not have to be exactly 50%, i.e. the 'off' to 'on' periods are approximately the same, as seen in the diagram.

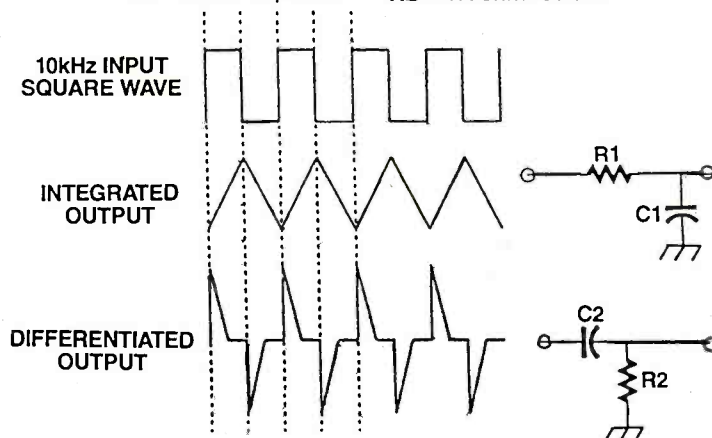
For the integrator circuit, the square wave feeds into a resistor, R1 and then a capacitor, C1. The values are chosen to 'match' the 10kHz signal. The output signal from the integrator resembles a sawtooth waveform

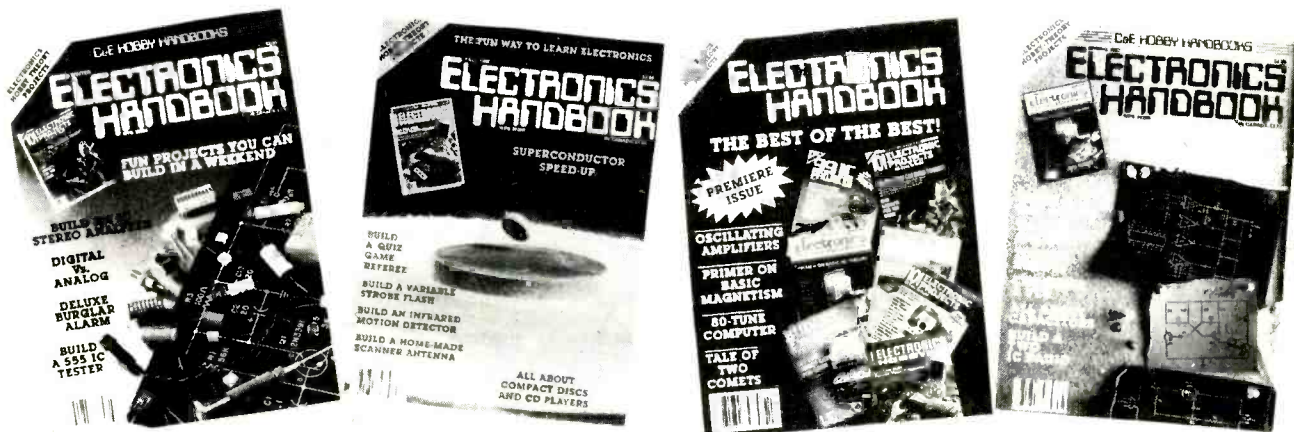
and has several uses, either as a less harsh audio version of the square wave for use as a test signal generator or as a ramp type signal (this is more useful when the source signal is dropped down to the few Hz region), to monitor for threshold changes in comparator circuits.

The differentiator has the components reversed. The input signal is fed to capacitor, C2, followed by the load resistor, R2. The wave form here is totally different as seen. At each point where the input voltage changes state, a pulse spike is produced from the differentiator, first with one polarity then the opposite. These pulses can be used as trigger pulses or timing pulses and by using a rectifier diode either polarity spike can be selected. Experiment with the values to see what the changes do to the output. ■

PARTS LIST FOR THE RC INTEGRATOR/DIFFERENTIATOR

- R1 — 1K ohm resistor
- C1 — 0.1uF capacitor
- C2 — 0.001uF capacitor
- R2 — 1K ohm resistor





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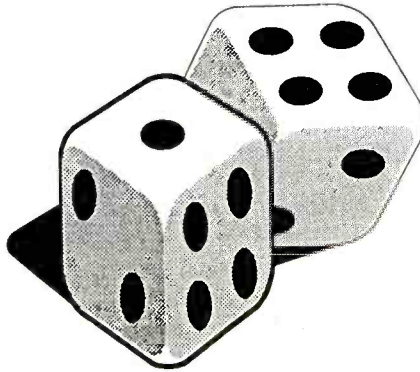
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V18

ELECTRONIC DICE

By Michael R. Ditz



Here is an interesting project for the hobbyist with a gambling spirit which, in varying degrees, probably applies to most of us.

The author has constructed an "Electronic Dice" that can be built in your workshop and be the source of much enjoyment for the hobbyist and friends. The applications are innumerable and limited only by your imagination.

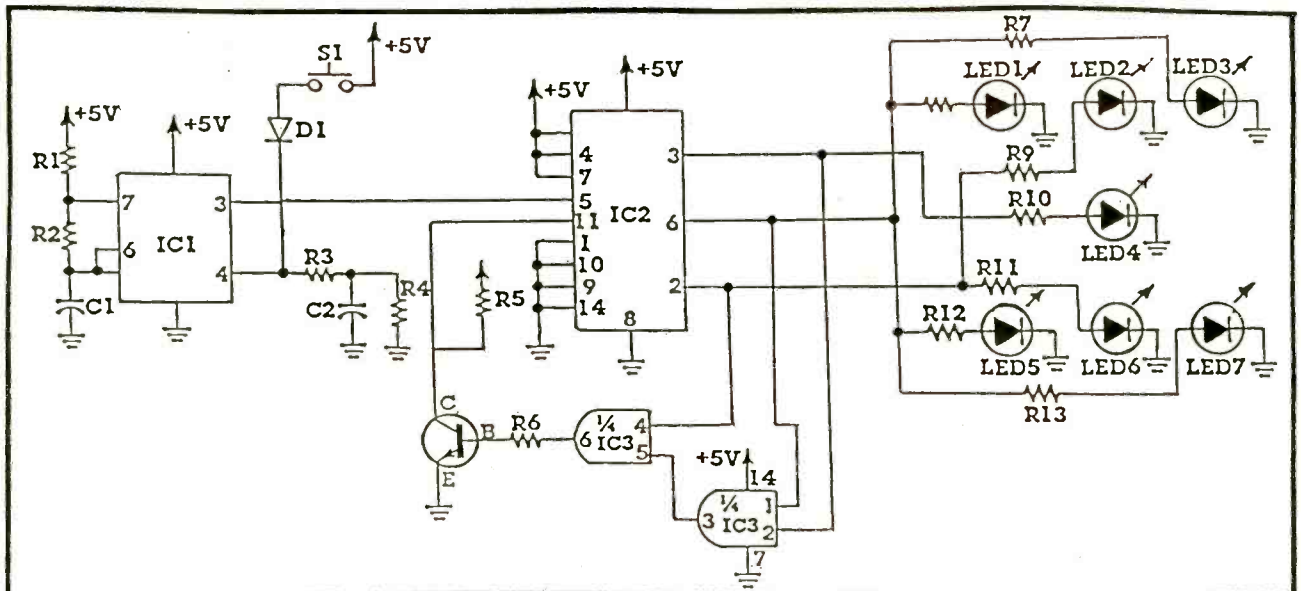
"ELECTRONIC DICE" is easy to operate. In order to roll the dice, just press S1. The dice will continue to "roll" for a couple of seconds before it locks in on a specific face.

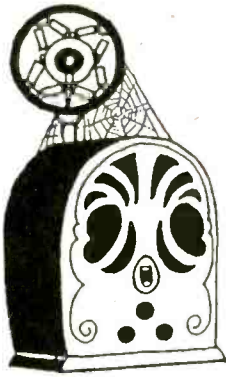
The operation behind this circuit is very simple. IC1, a 555 timer chip, sends a series of pulses to the counter IC once S1 is pressed. As indicated earlier, the pulses will continue for a specified length of time after the button is released. When S1 is pressed, C2 charges thru R3, enabling IC1. The chip will remain enabled until C2 is done discharging thru R4. These pulses cause IC2 to progress with counting. Whenever IC2 reaches a count of seven, the AND gates in IC3 cause IC2 to reset to its presettable value of one. The transistor acts as a simple inverter to pull the parallel-load input on IC2 to low. From the

counter, the BCD outputs go directly to the seven LEDs to form the pictures of dice. Because no decoding chips were used to make perfect representations of the dice, a result of two or three will be different than on normal dice. But for all practical purposes, and to save chips, the resulting display is fine.

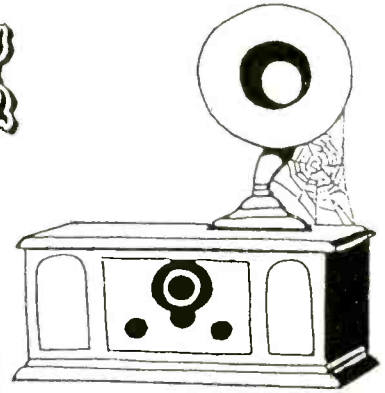
PARTS LIST FOR ELECTRONIC DICE

- R1—22K-ohm resistor
 - R2, R5, R6—10K ohm resistor
 - R3—4.7K ohm resistor
 - R4—150K ohm resistor
 - R7-R13—330 ohm resistor
 - C1—1 uf, 16 VDC capacitor
 - C2—4.7uf, 16 VDC capacitor
 - IC1—555 timer integrated circuit
 - IC2—74LS192 4-bit counter integrated circuit
 - IC3—74LS08 AND gate integrated circuit
 - Q1—2N3904 NPN transistor
 - LED1-LED7—light emitting diode
 - D1—1N4148 diode
 - S1—SPST normally open pushbutton switch
- All resistors are 1/2 watt, 10%





ANTIQUE RADIO CORNER



RESTORATION OF AN ALL-AMERICAN FIVE-TUBE AC-DC SUPERHET RADIO

By Lance Borden, WB5REX

When radio broadcasting began in 1919 with station KDKA in Pittsburgh, Pennsylvania, very few people had any idea of how great an impact it would eventually have on the life of every person on this planet. In the early 1920's, as radio stations began to appear all over the United States, many different manufacturers started making and selling radio receivers for the general public. These radios were usually very expensive because it was a new technology. Standard circuits and parts had to be developed and the cost was passed on to the consumer.

On the cheaper end, crystal sets and simple tube sets were available that cost from \$5.00 to \$50.00, which was still a lot of money when you consider that a good wage back then was about \$20.00 a week! These cheaper sets also lacked selectivity, sensitivity, and would not drive a loud speaker, so they required the listener to use headphones. This made it difficult for more than one person to listen. The higher-end sets, that had higher performance and allowed the whole family to listen with a speaker, were **very** expensive. It was not unusual for a high quality set to cost \$250.00 or more. A new Model 'T' Ford cost about \$450.00 in those days. This shows just how expensive those radios were!

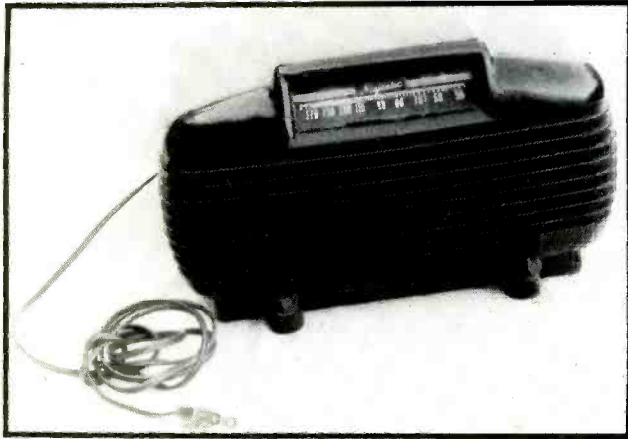


Photo #1. The Majestic Model 5T10 before restoration.

By the mid 1920's the technology had progressed to the point that radios were becoming more affordable and sales started to increase dramatically because everyone wanted a radio. Tubes, components, and circuits were becoming more standardized and, because of this, prices began to drop.

The standard tube radio circuits, in those days, were the regenerative, the reflex, the TRF (tuned radio frequency) and the superheterodyne. The inexpensive regenerative and reflex circuits were ingenious devices that forced one or two tubes to perform double duty by amplifying both the R.F. (radio frequency) and the A.F. (audio frequency) signals. These sets performed fairly

well but had a tendency to "squeal" and "howl" when not adjusted properly.

The more expensive TRF sets employed five or six tubes to amplify the R.F., and then detect and amplify the resulting A.F. signal, to drive a loudspeaker. This circuit eliminated the annoying howls and squeals of the regenerative and reflex sets, but was still very difficult to adjust because the three R.F. amplifier stages had to each be tuned to the same station with three separate knobs.

The superheterodyne circuit was the most expensive circuit employed in the late 1920s, but its performance far exceeded its peers. The superheterodyne was invented by Major Edwin Armstrong, of the U.S. Army Signal Corps, in the late 'teens for use in military communications. Armstrong was a phenomenal electronics genius who was also credited with inventing the regenerative circuit and F.M. (frequency modulation.) The superheterodyne circuit, which is shown in **Figure 1**, mixed the incoming R.F. signal with the output of an oscillator, to produce a lower I.F. (intermediate frequency) signal that was then amplified by I.F. amplifiers. The I.F. signal was then detected and the resulting audio was amplified and passed on to the loudspeaker. These sets were very sensitive, selective, and loud. They were

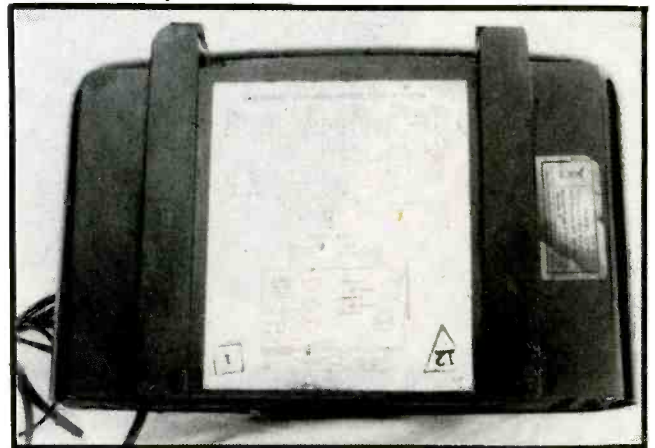


Photo #2. Bottom view of the radio showing schematic diagram and tube layout.

also easy to tune, and didn't squeal. Very few people could afford the superheterodyne because of its complexity, which resulted in a very high price tag.

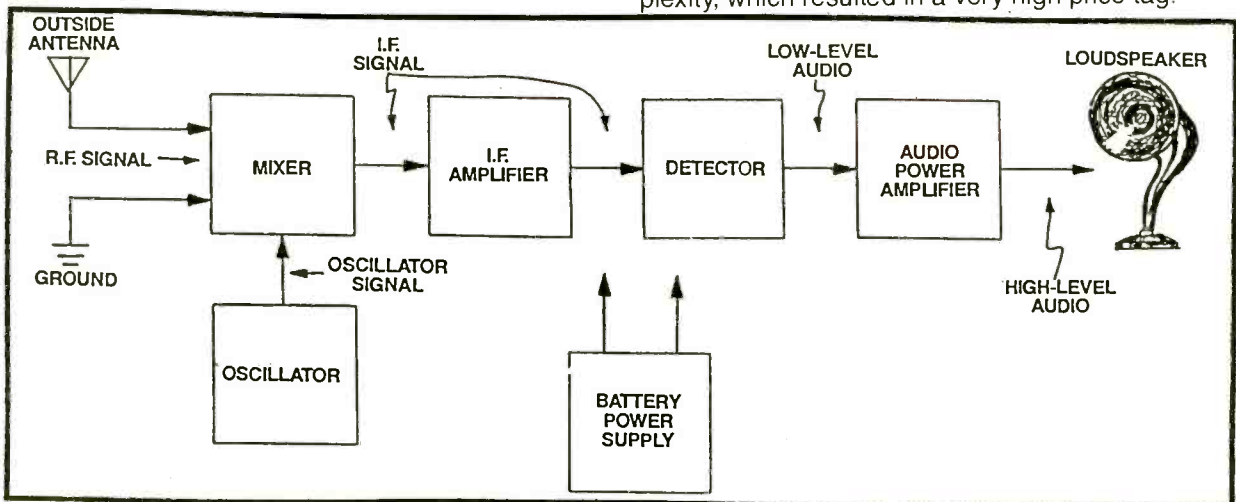


Figure 1. Armstrong's Superheterodyne Circuit of the 1920s

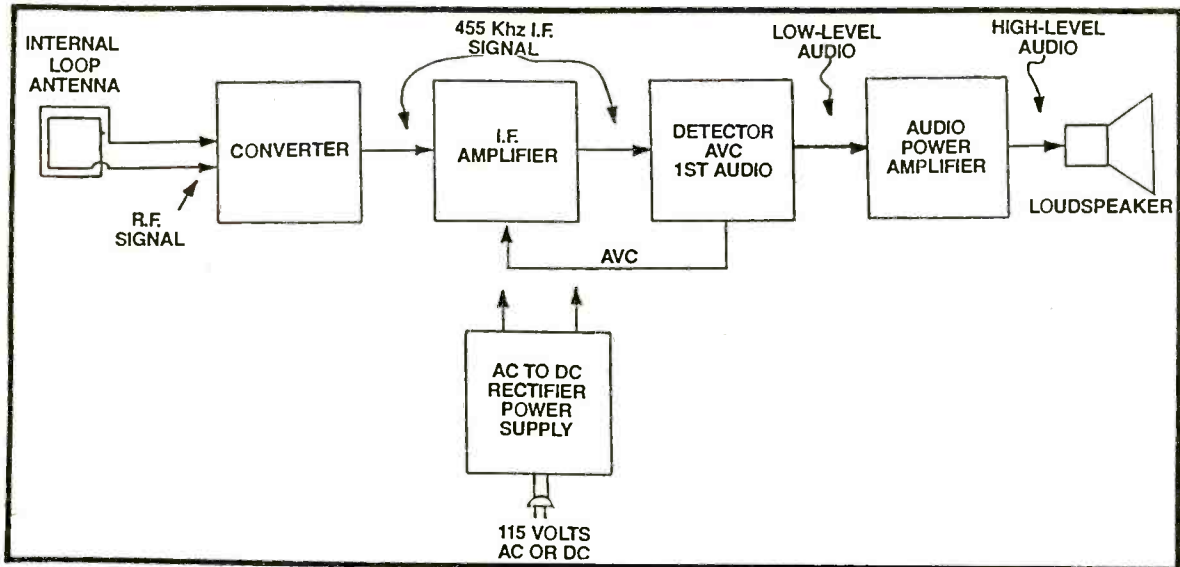


Figure 2. The Five Tube AC/DC Superhet Circuit

Another serious drawback of the 1920s radios was that they were nearly all powered by batteries! These batteries were expensive to buy and required frequent replacement. The reason for the batteries was that radios required, (and still do), pure D.C. (direct current) in order to operate. Practical power supplies that could convert the 110 volt 60Hz house lighting power to pure D.C. weren't developed until the late 20s.

Radio manufacturers realized that the superheterodyne, with its superior performance and ease of tuning, should become the standard circuit for broadcast receivers. They also realized that batteries were undesirable for use in the home and that their new designs should operate on A.C. About the same time that these facts became apparent to the manufacturers, another event occurred that significantly influenced their de-

same thing) radios that could be sold cheaply. The most popular of these was the Philco Model 90 table superhet of 1931 that had a rounded top and Gothic styling that resembled an old cathedral. Because of this styling, these sets became known as "cathedral" radios. Philco simply called them "midget" radios because they were smaller than the more expensive floor models they produced.

People really liked the cathedral styling so Philco and other companies built radios with this type of cabinet throughout the 1930s. At the same time, radios in rectangular cabinets and larger floor models were also produced. The midget radios of the early 1930s were actually based on the circuits for more expensive console (floor) models but were cheaper because they had small speakers and smaller table-top type cabinets. These sets were still not all that cheap because they used complex power supplies with heavy, expensive power transformers.

As the depression deepened, it became apparent

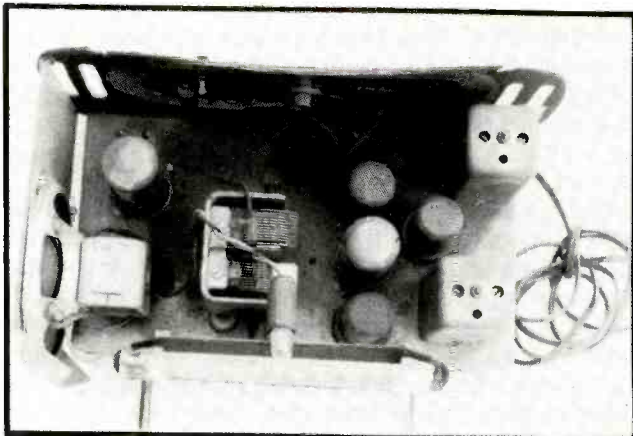


Photo #3. Top view of radio before cleaning.

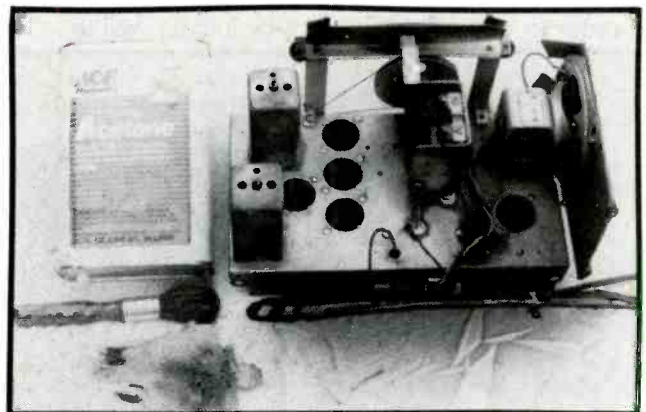


Photo #4. Cleaning the chassis with dust brush and acetone solvent.

signs and marketing strategies; the Stock Market crashed in October of 1929, which ushered in the Great Economic Depression of the 1930s.

In order for radio manufacturers to survive, they had to be able to produce A.C.-powered superheterodyne receivers in mass quantities that the general public could afford to buy. Philco was one of the first manufacturers to use automated assembly lines to make quality superhet (superheterodyne is kind of a long word, so the word "superhet" caught on long ago to mean the

that the manufacturers would have to come up with an even cheaper alternative if they were going to be able to stay in business. The solution to the problem was to design tubes that could be used in a superhet circuit that would operate without the expensive power transformer. The way this was done was to create a set of

tubes for a superhet circuit that had filament voltages and current requirements that would allow them to be connected in-series in order to drop the 110 volt house power without a transformer. The tubes would also have to work efficiently with a lower high-voltage supply than their predecessors, which often required 250 or



Photo #5. Cleaning the radio tubes with Armor-All.

more volts, because there would be no power transformer to step up the voltage for their plate circuits.

The earliest sets to use series-connected tubes began to appear in late 1932. These radios were ingenious compromises of design that employed a combination of tubes and dropping resistors to allow them to work without power transformers. Most of these early transformerless sets had only four tubes and required an external antenna because they were not very sensitive. By the mid 1930s efficient five-tube sets were being made, but they still required hot dropping resistors to reduce the house power voltage to a level that could be used by their tube filaments. The dropping resistors were often built into the radios' power cords, which got warm to the touch when they were operating! These radios were called "AC/DC" sets because they did not have a power transformer, which requires A.C. in order to work. They would play just as well on 110

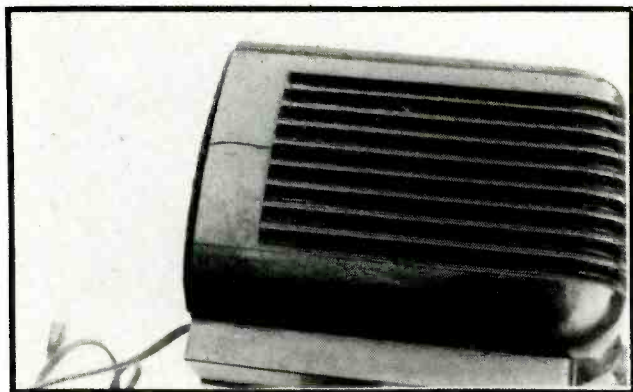


Photo #6. View of a crack in bakelite cabinet of the radio. volts D.C. as they would on 110 volts A.C. Until the 1940s, many areas of the country had 110 volts D.C. house power!

In the late 1930s a five-tube compliment of eight-pin (or "octal") tubes was designed that would work to-

gether in an efficient superhet circuit without the need for dropping resistors or external antennas. (There were also some other compliments of tubes designed for this purpose, such as the "Locktal" variety. These functioned the same as the octal types, but were less common. For the sake of brevity, we will only cover the more common octal tubes at this time.) The rectifier tube even had a tapped filament that was designed to provide 6 volts to operate a pilot light. This set of tubes consisted of (see **Figure 2**): the 12SA7 converter, which acted as a combination oscillator and mixer for converting the incoming R.F. signal to an I.F. signal; the 12SK7 I.F. amplifier that increased the level of the I.F. signal from the 12SA7; the 12SQ7 detector/audio amplifier that detected (or rectified) the I.F. signal to extract its audio and then amplified the audio to drive the next

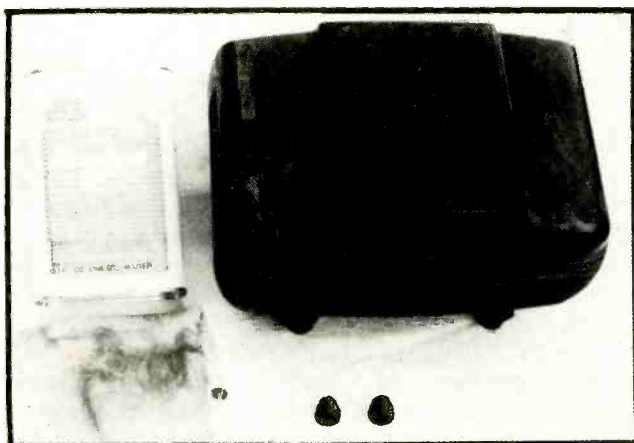


Photo #7. Cleaning the cabinet and knobs with acetone.

stage (this tube also produced a negative voltage that corresponded with the signal level that was used to control the volume on strong stations and was known as "automatic volume control" or AVC); the 50L6 audio power amplifier that was used to amplify the audio to a level that would drive a loud speaker with plenty of volume; and the 35Z5 power rectifier that rectified, or changed, the A.C. house power into D.C. to power the plate circuits of the rest of the tubes, as well as providing 6 volts A.C. for the pilot lamp from its tapped filament.

This compliment of tubes became the standard for most American-made five-tube AC/DC superhets built between the late 1930s until the late 1940s. In the late 1940s an equivalent compliment of tubes was introduced with 7-pin miniature envelopes. They were the 12BE6 converter, 12BA6 I.F. amplifier, 12AV6 detector/AVC/audio amplifier, 50C5 audio power amplifier, and 35W4 rectifier. These tubes were electrically the same as the octal types, just smaller. Five-tube AC/DC superhets built between the late 1940s and into the 1960s used these tubes.

These little radios were built by the millions by many different manufacturers during the 1930s, 40s, 50s, and 60s, until transistors took over the market. Because of their low price, they brought news, music, comedy, drama, sports, weather, and market reports to homes and farms all over America. Because of their immense popularity, they became known as the "All-American Five-Tube AC/DC Superhets." These radios represent a significant part of our American radio heri-

tage, and because of this they have become highly collectible. Among radio collectors, they have become affectionately known as "Acky-Dacs."

You can still find these radios in flea markets, antique shops, garage sales, and Grandmas' attics all over the country. Their prices range from \$2.00 to several hundred dollars for especially rare ones with catalin plastic cabinets. The usual price is around \$35.00 for a nice one, in good, unrestored, condition.

A well-restored, working, Acky-Dac makes a nice addition to the decor of any home. You see them being used in movies and on TV as props all the time. Many A.M. radio stations are now re-broadcasting old radio shows on Saturday and Sunday nights. It is really a fun, nostalgic, experience to spend an evening listening to vintage radio shows on a real vintage radio that came from the time when those shows were originally broadcast. No solid-state radio from the present can produce the warm glow of the tubes and pilot light or exude the aroma (yes, these radios give off a faint, pleasant odor when they warm up!) of a vintage Acky-Dac.

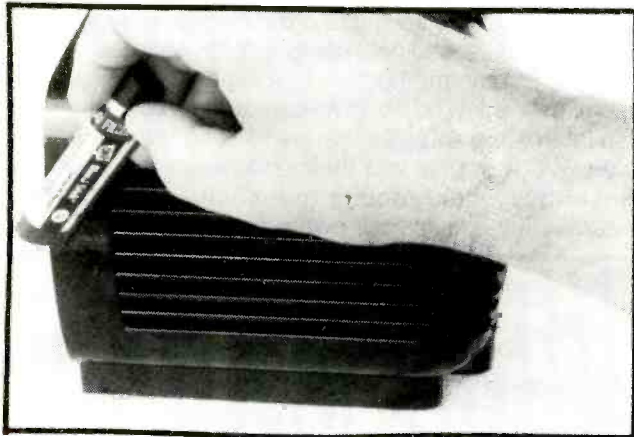


Photo #8. Filling the crack with Dap Blend Stick after repairing it with Super-glue.

The subject of this article is to describe how to restore a vintage Acky-Dac using simple techniques and tools, and without the need for sophisticated test equipment or know-how. The radio used as an example for this article is a 1942 Majestic Model 5T10. If the radio you chose is in fairly good condition to begin with, and has not been "butchered" by someone before you get it, you should be able to use this method to return it to its original appearance and operating condition in a couple of evenings work.

WARNING!!!

THE RESTORATION OF THESE RADIOS INVOLVES POSSIBLE CONTACT WITH DANGEROUSLY HIGH VOLTAGES. EXTREME CARE MUST BE USED WHEN TESTING THESE RADIOS WITH POWER APPLIED TO PREVENT ELECTROCUTION!!

CAUTION!!

NEVER TRY TO PLAY AN OLD RADIO BEFORE REPLACING THE POWER CORD AND FILTER CAPACITORS. DAMAGE TO THE SET AND RISK OF ELECTRICAL SHOCK CAN RESULT FROM THIS PRACTICE!!

CLEANING THE CHASSIS

The condition in which we find these old "Acky-Dacs" varies a lot. The original owners may have kept the exteriors clean and dusted, but they would have never thought of removing the chassis and cleaning it. Sometimes these radios can be found after they have been carefully stored away for many years in a box or covered with a cloth. These sets are usually not too dirty, but they will still require some cleaning because the insides will have accumulated some dust and grime, even though they were well cared for when they were used. The hot, electrically-charged chassis acted like a "dust magnet" and could collect an amazing amount of crud over several years of use. Radios that were used in kitchens are the worst because they will not only have a lot of dust, it will be cemented to the chassis with a thick greasy film.

Often we find a set that was used in a dirty environment, such as a garage, and was never kept clean when it was in use. These sets can be a real challenge to clean up. The condition of most of the radios we find is somewhere in between these two extremes. The Majestic radio shown in this article is typical of what we find (see photo #3). It was probably used in, or near, a kitchen, because its chassis had a moderate coating of dust, that was held in place by a waxy film. The following is a description of how to clean up a chassis, using the Majestic as an example:



Photo #9. Polishing out scratches with rubbing compound.

STEP 1.

Begin the clean-up by removing the chassis from the cabinet. Save the mounting screws and knobs in a small dish or plastic bag, so they won't get lost. Remove the tubes and draw a sketch of their locations, if you don't have a tube layout drawing on the cabinet.

STEP 2.

(See photo #4) Remove most of the dust and dirt from the chassis top with a brush. Dust the underside of the chassis, being careful not to disturb the components or to bend any wiring. An unused paint brush works well for this purpose, or you can employ a dust brush like the one in the photo. This brush was designed for "detailing" car interiors and was purchased at an auto parts store. Solvent is then used, on a rag,

(the blue paper shop towels sold in hardware stores work well) to remove the greasy scum from the chassis. If the build-up isn't too bad, a mild solvent, such as denatured alcohol, can be used for this purpose. The coating on the Majestic chassis is resistant to the mild solvent, so a stronger solvent was needed.

Acetone easily removed these deposits from the metal surfaces. Be very careful if you use acetone and follow the manufacturer's instructions and warnings printed on the container. Acetone is very flammable, has dangerous fumes, and will dissolve paint and many plastic parts. Unpainted bakelite is not affected by this solvent.



Photo #10. Restoring the beautiful original finish with paste wax.

STEP 3.

(See Photo #5) Clean the tubes with Armor-All. If the glass parts of the tubes are loose in their bases, then glue them with super-glue. A coating of Armor-All on the chassis will help preserve its finish. This modern cleaner and protectant will leave a dust-resistant coating on these parts.

STEP 4.

Spray tuner cleaner on the tube socket contacts while wiggling a tube in the sockets to remove deposits. The volume control potentiometer should then be cleaned by spraying tuner cleaner into the area where the connection lugs emerge from the case. Turn the volume control through its range while spraying the cleaner. This will remove deposits from the internal parts and will eliminate "scratchiness" in the audio when the volume control is turned while the set is operating. Repeat this operation on the tuning capacitor for the same reason.

STEP 5.

The finishing touches of the chassis clean-up will vary from radio to radio, but the approach is basically the same for all sets. Look the chassis over and correct any minor defects that you can. Sometimes you will have to use your imagination to come up with a clever, creative solution for these types of problems. Spots of rust can be touched up with silver colored Testors model paint. Loose parts can be secured with super glue and cracks in the speaker cone can be repaired with radio service cement. The dial pointer on the Majestic was faded badly and was re-painted with white Testors enamel. The dial glass was cleaned with Armor-All and

a missing dial glass securing clip was replaced with a clamp-type paper clip. (see photo #17)

CLEANING, REPAIRING, AND POLISHING THE CABINET

Acky-Dacs were produced with many types of cabinets. Cabinet materials included wood, metal, and various types of plastics. One of the most common cabinet materials used for these sets was a form of urea plastic known as bakelite. The cabinet and knobs of the Majestic radio described in this article are made from bakelite. This is a durable plastic that has the characteristics of being a good electrical insulator, able to withstand high temperatures, and is easily molded into various shapes. Bakelite has a pleasing appearance when it is cleaned and polished. It isn't used much any more and because of this, items made from it are becoming very collectible. The single major drawback of bakelite is its brittleness. Most radios with bakelite cabinets have at least one or two cracks. These cracks are easy to repair with super glue, but it is usually very difficult to hide the repairs. The following is a description of how to restore a bakelite cabinet, using the Majestic as an example. A simple method of disguising a crack repair is also explained. Wood and metal cabinet restoration are also interesting subjects that we may cover in future articles. We won't go into their restoration this time because they would require too much space and are separate subjects in their own rights.

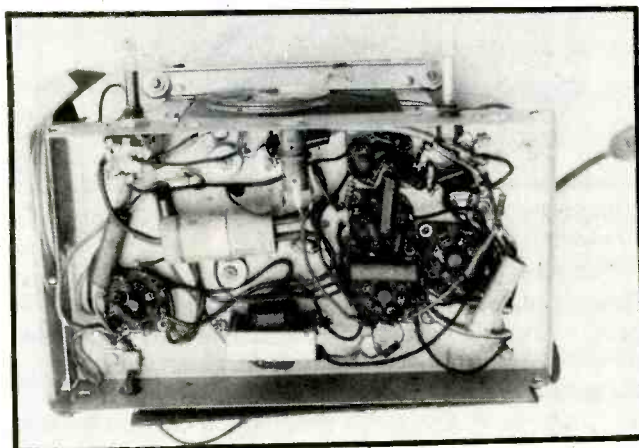


Photo #11. Underside view of chassis before restoration.

STEP 1.

Most old bakelite radios are dirty and can be easily cleaned with a rag and hand cleaner, such as GoJo or Goop. After cleaning they should be polished with rubbing compound and then waxed as described in Steps 3 and 4.

Photo #1 shows the Majestic before restoration began. Some well-intentioned person had applied a varnish, probably tung oil, to the cabinet, sometime in the past. These radios never had this type of extra-shiny finish when they were made and in order to restore the set to its original subdued luster, it was necessary to remove the varnish with acetone (see Photo #7.)

Sometimes, these sets are found with various, non-original, finishes on them. These range from varnish, such as this one, to paint and shellac. Acetone will remove these finishes without damaging the bakelite. Be

careful if you use acetone and follow the manufacturer's cautions and warnings. This is quite a bit of work, but will be worth the effort. Some bakelites did have original painted finishes and if your set is one of these, it is easy to sand them down with fine steel wool and re-paint them with Krylon spray enamel. Krylon is available in many colors at hardware stores.



Photo #12. Tools and supplies used for the electrical restoration.

STEP 2.

After the cabinet is cleaned, it will be necessary to repair cracks, if there are any, with super glue. **Photo #6** shows one such crack in the Majestic's cabinet. Allow the super glue to harden for about fifteen minutes and then scrape off any excess with a razor blade or Exacto knife. Step 4 explains a method for disguising the crack repair after the cabinet has been polished.

STEP 3.

Now that the cabinet is clean, and cracks, if any, have been repaired, it is time to polish out the dullness and scratches with automotive rubbing compound. Rubbing compound comes as a liquid or as a paste, and is available at auto parts stores, etc. It is a fine-textured abrasive mixture that is designed for polishing away fine scratches and oxidation from car finishes. Fortunately for us, it can do the same thing for our old bakelite radio cabinets. **Photo #9** shows the Majestic's cabinet in the process of being polished using this method.

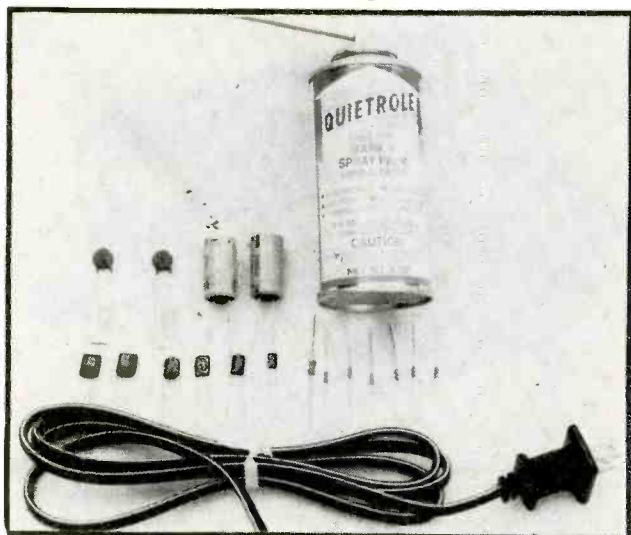


Photo #13. Parts needed for the electrical restoration.

The dull appearance of the unpolished bakelite is caused by thousands of tiny cracks and scratches. Rubbing the cabinet with the abrasive rubbing compound will "grind" these anomalies away and will expose a "new" smoother surface that can be waxed and polished to a beautiful luster.

The way to perform this is to use a damp cloth to apply the rubbing compound and rub the cabinet surface with a firm, but not hard, pressure. The amount of rubbing required will depend on how badly scratched the cabinet is. Sometimes, for a particularly badly scratched cabinet, it can take a lot of rubbing in order for the fine grit in the rubbing compound to remove all of the defects. Rub the entire cabinet so that it is evenly polished. If you concentrate in one area, it will end up having a different appearance from the rest of the surface. Extremely deep gouges and scratches cannot be removed in this manner and will have to be filled with a furniture scratch stick as described in step 4 for disguising a crack repair.

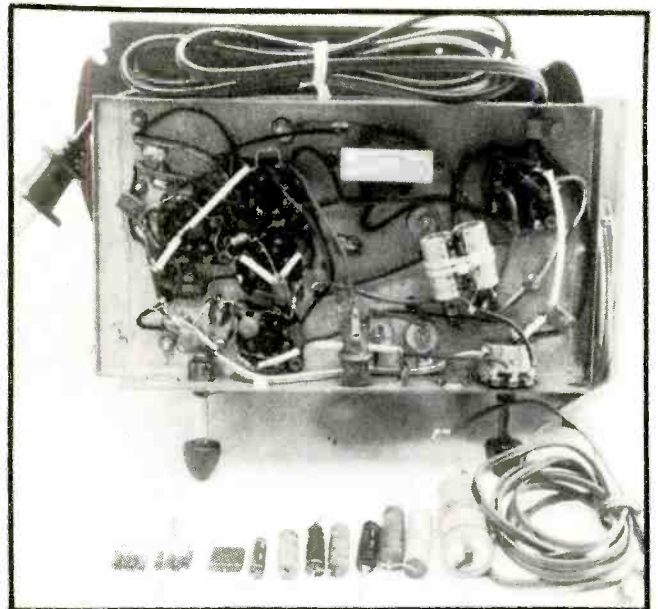


Photo #14. Underside view of electrically restored chassis, showing old parts that were removed.

STEP 4.

Photo #8 shows a Dap Blend Stick being used to fill in and cover the crack after it was repaired with super glue. Dap Blend Sticks are a wax and pigment mixture and are intended for filling in scratches in wood furniture. They come in many colors and shades and are available in hardware stores.

Purchase a blend Stick in a shade that is quite a bit darker than the bakelite you intend to repair. Apply the material by rubbing it over the defective area and then heat it with a Bic lighter or match to begin to smooth it out. Finish the smoothing process by rubbing the repair spot with your finger until it tapers smoothly to the level of the surrounding bakelite. A black or brown felt pen can then be used to give the repaired spot the same "marbleized" appearance of the original bakelite. Don't worry if your first attempt fails because the wax will not harden and can be scraped off with a razor blade if it doesn't look right. It may take some practice to get the

appearance that you desire. Once you are satisfied with the repair, apply just enough clear acrylic spray lacquer (Krylon Brand clear acrylic spray lacquer is sold in hardware stores) to lightly cover the wax. This is necessary because the Blend Stick wax is fairly soft and will never fully harden. The clear acrylic will protect the repair from damage and will provide a hard surface for the paste wax that will be applied in the next step.

STEP 5.

The last step in restoring the cabinet is to apply a fine automotive paste wax, such as Simonize, and then to polish it to the beautiful subdued luster it had when it was new. Simonize is a formulation of carnauba wax which comes from a form of tropical palm tree. It is the hardest natural wax in existence and is used by classic car restorers. **Photo #10** shows the cabinet being polished in this way.

Begin by applying the wax with a soft cloth using a circular motion. Before the wax dries, buff it well with a shoe brush. Then, polish the wax to a hard shine with a soft dry cloth. The wax will fill in the fine scratches that the rubbing compound did not remove and will leave a hard protective coating on the bakelite.



Photo #15. Testing a tube with a multimeter and clip-leads

ELECTRICALLY RESTORING THE CHASSIS

The approach to electrically restoring the chassis is similar to the method used today in modern TV, VCR, and computer repair shops where troubleshooting is only taken down to the circuit board level. Once the defective circuit is found, the whole board is replaced and the old one is discarded. The reason for this is that it is cheaper to buy a new board than it is to spend expensive troubleshooting time to find the defective component.

The "old-timers" called this approach the "shotgun" method of repair. With this procedure, the technician would check for physical damage, such as burned or broken components, test all of the tubes, fuses and bulbs, and then, if the trouble wasn't found, he would try to narrow down the problem to the most likely circuit. He would then replace **all** of the capacitors, resistors,

diodes, etc., in that part of the set. After that he would power it up and see if it worked. This is why this method is called the "shotgun" approach, because you "shoot" an area with several new parts, instead of targeting the individual component that failed.

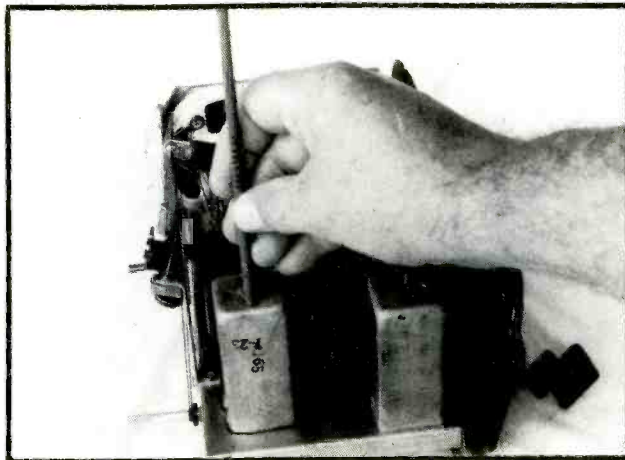


Photo #16. Adjusting an I.F. transformer using an Insulated tuning tool.

If the first attempt didn't fix the set, then the technician "shotgunned" the next most-likely area. Eventually the bad part, or parts, would be replaced and the unit would function correctly. At first, this method may seem wasteful, but the cost of a few capacitors and resistors, etc., is cheap in comparison to the time it would take to locate the failure using conventional troubleshooting.

The "shotgun" method, when used with old radios, has several advantages. The first advantage is that **everything** in the old radio is **old** and because of this, if it hasn't failed yet, it eventually **will fail**. The second reason is that the old sets often have multiple failures, and even if you replace a part and get the set working, it won't perform as good as when it was new and will probably quit in a short period of time because something else will fail. A third advantage is that "shotgunning" an old radio will protect expensive parts, such as I.F. and audio transformers, coils, speakers, and tubes from damage caused by shorted capacitors or resistors being out-of-tolerance.

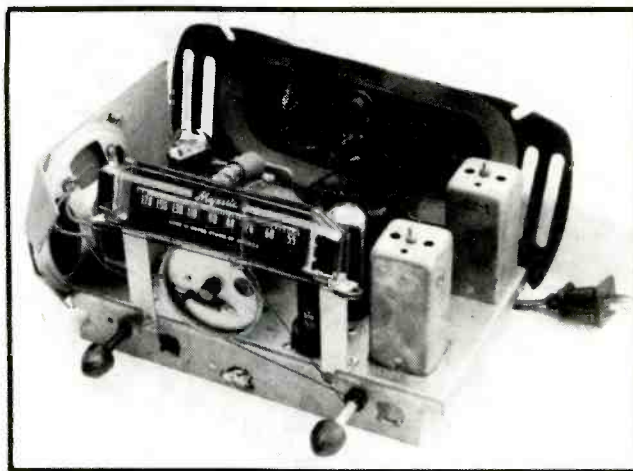


Photo #17. View of the completely restored chassis.

The parts that usually need "shotgunning" are capacitors, resistors, power cords, and some intercon-

necting wiring. Sometimes, terminal strips may become carbonized, or other parts, such as switches and volume pots may be bad. These are not usually replaced unless it has been determined that they are bad after testing the set.

As for capacitors, you should replace **all** electrolytic, tubular, ceramic disc, and other capacitors in the **Microfarad** range. The electrolytics are chemical capacitors that eventually will fail because of the electrolyte leaking or drying out, or by causing corrosion. An open electrolytic filter capacitor will cause the set to have excessive A.C. hum. A shorted filter can cause resistors, speaker field windings, and rectifiers to burn out. Electrolytic capacitors are limited-life items and should **always** be replaced if they are old. The tubular and ceramic disc capacitors also age and become electrically "leaky". These should also be replaced to ensure optimum performance. Mica or ceramic capacitors in the **Micromicrofarad** (Picofarad) range don't usually need replacing because they have extremely long life-spans and seldom fail, unless they have been exposed to severe conditions. Only replace these if the radio fails to operate properly after replacing the other, higher failure-rate, components.

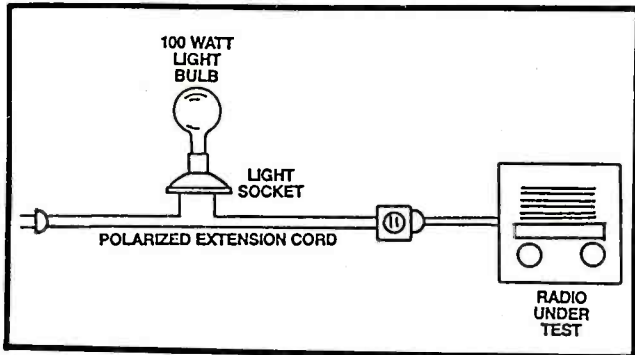


Figure 3. 100 Watt Light Bulb Test Set-up

Old carbon resistors with values above about 10K ohms will often be out-of-tolerance in the high direction. The higher the original resistance, the higher the out-of-tolerance condition will be. Very often 100K ohm resistors will measure in the megohms, and megohm resistors will read infinity. The most probable cause of this is that the binders in the carbon composition dry out and separate from age and heat, thus raising the resistance.

Many of the high resistance value resistors are used to set bias voltages for the tubes. If these resistors are out-of-tolerance, and are left in the set, they will cause the tubes to operate out of the desired portion of their characteristic curves. This will result in poor sensitivity, distorted audio, inoperative oscillators, and sometimes overheating of certain tubes caused by over-conduction. You should replace **all** resistors above about 10K ohms without even testing them. They are very cheap and this "shotgun" replacement saves troubleshooting time and will extend the life of the set.

After all of the above components have been "shotgunned", power up the set with a 100 watt light bulb in series with the power cord and ensure that there aren't any shorts (see Figure 3). If the radio contains any significant shorts, the lamp will burn brightly and will pro-

tect the circuit. If the bulb burns dimly, or not at all, then there aren't any major shorts. Once the receiver passes this test, remove the bulb and apply full power.

At this point most radios will play. If the set doesn't play, then go into more intensive troubleshooting. This is usually fairly easy because most of the high-failure items have been replaced. This leaves only a few components, such as I.F. and audio transformers, potentiometers, and coils to check. Once the radio is playing, align the R.F. section, oscillators, and I.F. amplifiers.

The following is a description of the electrical restoration of the Majestic Acky-Dac that is the subject of this article. Your Acky-Dac will probably differ somewhat in layout from this one, but the circuitry in all of them is basically the same, with a few minor differences. You should be able to restore your radio by following these steps, taking into consideration any differences.

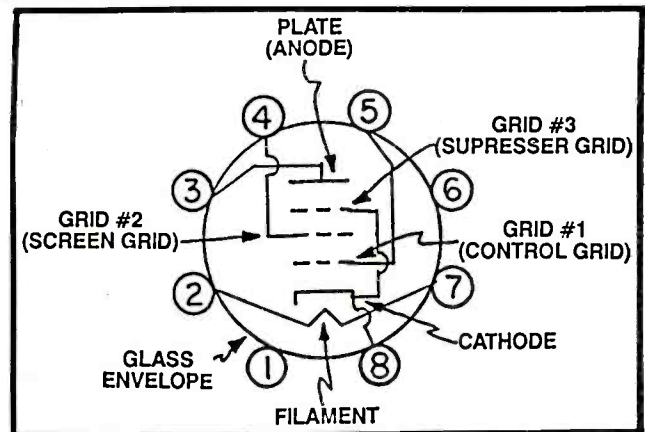


Figure 4. A Typical Vacuum Tube (50L6)

Parts, supplies, and schematic diagrams for most radios built from the 1920s until the 1950s are available from the sources listed at the end of this article. **Photo #2** shows the schematic diagram and tube layout that came attached to the bottom of the Majestic, many radios will have these diagrams, but in a lot of cases they will be missing or unreadable. Diagrams aren't really necessary unless you run into difficulty after doing all of the normal restoration steps described below.

Photo #11 shows the underside of the chassis before restoration. It is a good idea to draw a sketch of where all of the capacitors and resistors are connected before removing any of them. **Photo #12** shows the tools and supplies used for the electrical restoration. Solder "wick" is used to "suck" up the old solder when removing old components. "spaghetti" tubing is used to insulate the leads of components in areas where they can come in contact with other parts of the circuit. Hook-up wire is used on components to extend their lead length in cases where they are too short. The radio service cement is used to repair cracked speaker cones. The Testors white enamel was used to touch-up the dial pointer. "Tie-wraps" are used to secure the new electrolytic capacitors in place. Super-glue is used wherever necessary. **Photo #13** shows the new components before installation. The new capacitors and resistors look a lot different than the old ones, but are of the same (or near the same) values. **Photo #14** shows the underside of the radio with all of the new parts installed.

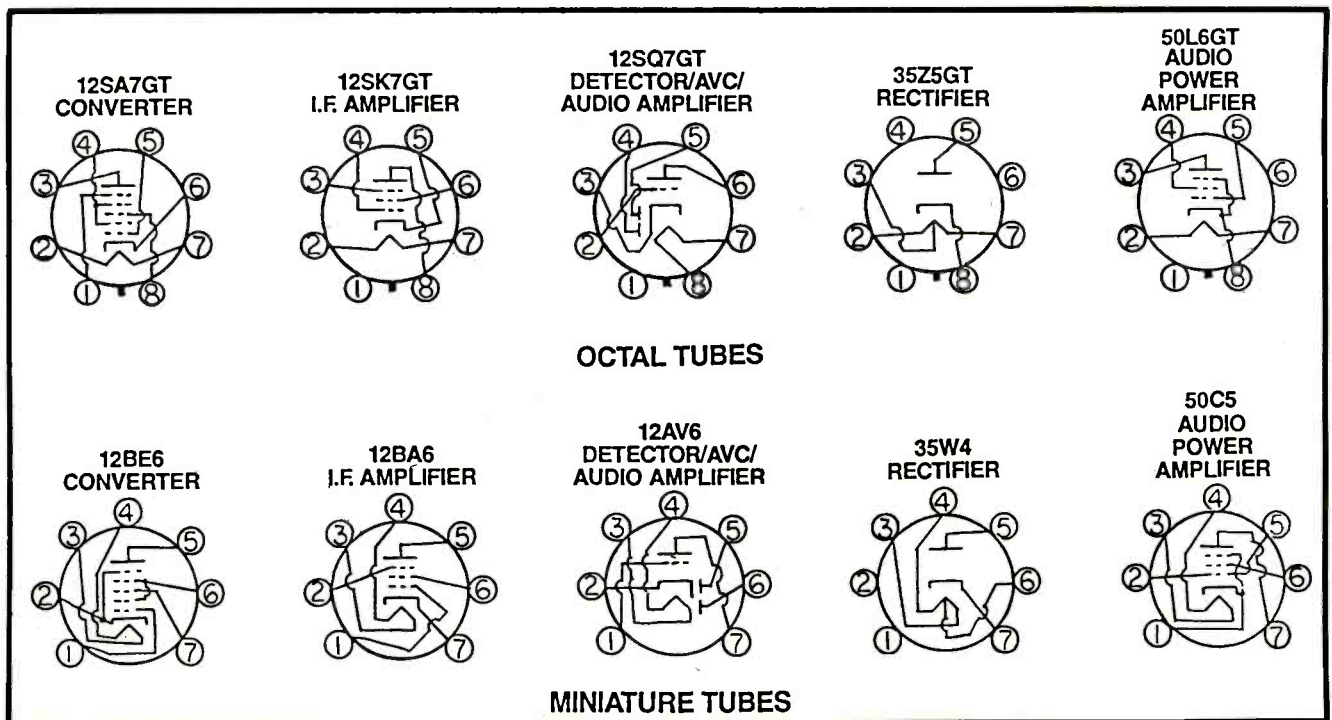


Figure 5. Common Tubes Used in AC/DC Superhet Radios

STEP 1.

Begin the electrical restoration by replacing the power cord. Use a cord with a **polarized plug** as a safety precaution, because these radios have one side of the power line connected to chassis ground, either directly or indirectly via a large capacitor. Most of these sets have the on-off switch in the ground side of the circuit. Connect the power cord lead that goes to the big pin on the polarized plug to the connection in the circuit where the old cord went to chassis ground (usually through the switch.) Connect the other new lead to where the other old lead went. Connecting the power cord in this manner ensures that the low side (big pin) of the house power will be connected to the chassis of the radio and will prevent it from being electrically "hot" in respect to other grounded objects.

STEP 2.

Replace the filter capacitors.

The electrolytic filter capacitors in most of these old radios will be in a combination unit that will have two, or more capacitors built into one container. Exact replacements for these are hard to find. It is usually necessary to replace the old filters with individual capacitors. The values of these are not critical as long as you are careful to replace the capacitors with ones that have at least the voltage rating of the old ones. It is also a good idea to install new filters that are the same capacitance, or more than the old capacitors. In the case of the Majestic, the original filter had a 20 Mfd and a 40 Mfd capacitor, both rated at 150 volts, in the same case. These were replaced with two 40 Mfd, 160 volt capacitors. It is not usually recommended to replace filter capacitors with new values larger than about 150% of the original ones because of the extra current they draw when the set is first turned on. Tie-wraps are used to hold the new filter capacitors in place.

STEP 3.

Replace the remaining capacitors and resistors.

As previously mentioned, it is not usually necessary to replace mica or ceramic capacitors in the Micromicrofarad (Picofarad) range, or resistors below about 10K ohms, unless they are burned. It is best to replace these components one-at-a-time, if possible, to preclude connecting them up to the wrong place. Use hook-up wire and spaghetti where necessary. Capacitor values are generally not extremely critical as long as you replace them with ones that have at least the voltage rating of the old capacitors. For example, in this set a .008 Mfd 400 WV (Working Voltage) tubular paper capacitor was replaced with a .01 Mfd 600WV Mylar capacitor. The modern Mylar capacitors are far superior to the old paper ones and should last for many years in this application. Resistors used in these radios usually have a tolerance of 20%. What this means is that they could be within plus or minus 20% of the specified value. You can use this as a guide when replacing resistors, as long as you replace them with ones that have at least the wattage rating of the originals. Most resistors in these radios were rated at $\frac{1}{4}$ to $\frac{1}{2}$ watt. Resistor values and sometimes capacitor values are marked with color bands that conform to a standard color code. **Figure 7** shows how to read the color codes for resistors and capacitors. Most of these sets have the capacitor values printed on the tubular paper capacitors and don't use color codes for these components. Some later models do have color coded tubular paper capacitors (the "paper" is the internal insulation, the external insulation is usually plastic.) The capacitor color code shown is the most common one used in these radios, if the capacitors are color coded. Other, less common capacitor color codes can be found in the books referenced at the end of this article. Resistors and capacitors are available from the parts sources

listed at the end of this article.

STEP 4.

Test the tubes and pilot lamp and insert them in their sockets. It is common to find that all of the tubes in an old radio are still good, even after many years of storage. It is also common to find that a radio works perfectly with tubes that indicate "weak" on a tube tester. Tube testers are rare items these days, and if you don't have one, you can still perform a couple of simple tests on your tubes with a multimeter that will make you 99% sure whether they will work or not. **Figure 4** shows the internal connections for a typical octal tube, the 50L6 audio power amplifier. Pins 2 and 7 are connected to the filament, which should read only a few ohms if it is good. As the drawing shows, the filament should not show any continuity with any of the other elements. The Plate (or anode) is connected to pin 3 and grids (grids control the electron flow in the tube) one and two are connected to pins 5 and 4, respectively. Grid number three is internally connected to the cathode which is then hooked to pin 8. None of these other pins should show continuity to each other. If they show continuity, then the tube is shorted and is bad. **Figure 5** shows the diagrams of the most common tubes used in Acky-Dacs. The diagrams are shown with the tubes upside-down, looking at the bottoms. **Figure 6** shows how the pins are numbered, one-through-eight for octal tubes, and one-through-seven for miniature tubes, counting clockwise with pin number one being just clockwise of the guide "key" on octal tubes and on miniature tubes it is the first pin clockwise of the space in the pins. Some octal tubes will have missing pins and in this case you count their empty positions as pins. First, check the continuity of the filament using clip-leads to connect your multimeter to the filament pins. **Photo #15** shows this being done. Filaments should read just a few ohms. If the filament is open it will read infinity.

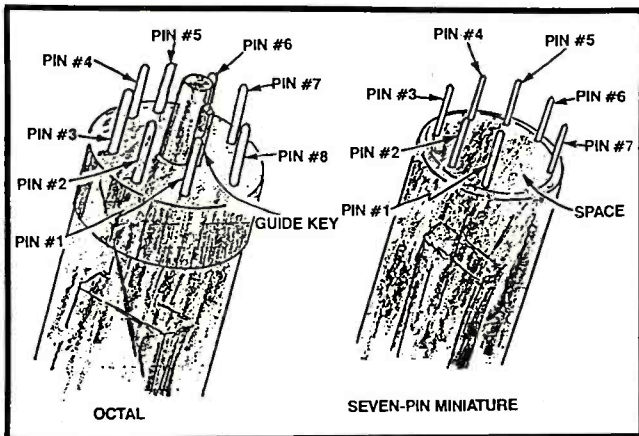


Figure 6. Octal and Seven-Pin Miniature Tube Bases

Next, check the tube for shorts by setting your multimeter to its highest ohms scale and connecting it between the various grids, plates, cathodes and filaments to make sure that none of these, that aren't supposed to be connected, are reading any continuity. Some of the elements are supposed to be connected together in some tubes, as shown in the tube diagrams. If your tubes are not cracked or broken and pass these two simple tests they will almost assuredly work in your ra-

dio. Next check the pilot lamp bulb for continuity. It should read only a few ohms. If it is bad, it will read infinity. Sources for tubes and bulbs are listed at the end of this article, in case you find a bad one. These companies sell "new-old-stock" (NOS) tubes at very reasonable prices.

STEP 5.

WARNING!!

Be extremely careful not to touch the metal chassis of an AC/DC receiver while it is plugged in. The chassis is connected to one side of the power line and can cause dangerous electrical shocks!

Power your radio up using a 100 watt lamp in-series with the power cord to ensure that there aren't any significant shorts.

Figure 3 shows how this is done. If the 100 watt bulb burns brightly, then a short circuit exists in your set. Go back and check your work to find where the short is located. If the bulb burns dimly, or not at all, then you don't have any shorts and it is safe to plug the radio in directly. If your radio was in good shape to begin with, and there aren't any unexpected failed components, it should play at this point, after warming up. If the set doesn't play, then further troubleshooting is necessary. Check your work to be sure you got everything hooked up correctly. Most problems at this stage are human induced. If the set still doesn't play, then you will need help from the experts. A couple of good books on radio electrical restoration are listed at the end of this article. Sources for ordering these books are also listed. Also, the author would be glad to answer any questions you may have regarding antique radios. Just write C/O The Editor, **ELECTRONICS HANDBOOK**, at the address listed in the front of this magazine.

STEP 6.

Align the I.F. transformers. (**See Photo #16**)

If your radio plays after performing all of the preceding steps, then you can perform a minor, "touch-up" alignment without the need of expensive test equipment.

The first step is to adjust the I.F. transformers. These come in two basic versions. Version one is found on the older radios. There will be access holes on the top, and sometimes, the bottom of the I.F. transformer cans. Trimmer capacitors will be under these holes that can be adjusted using an **insulated** alignment tool. An insulated tool is necessary because these screws may have high voltages on them that can be shorted to the I.F. can, which is grounded, causing damage to the radio and possibly electrical shock to **YOU!** The second version found on newer radios, will have ferrite slugs inside the I.F. transformer coil forms. These slugs should be adjusted with a plastic alignment tool designed for this purpose. Never use a metal tool, such as an Allen wrench, because it will not only affect your adjustment, it can break the fragile ferrite slugs.

Begin the alignment by tuning to a very weak station. This is necessary because a strong station will activate the AVC and make it difficult to find the point where the I.F. transformers "Peak." Adjust the I.F. transformers for a point where there is an increase in volume, followed by a decrease. Leave the adjustment at the point where

the signal is the loudest. This point is called the "Peak." Sometimes the peak won't be very distinct and this is O.K. as long as it is there. If peaks can't be found in less than two turns, then there is something else wrong that will require further attention, and possibly, help from the experts.

you can get between the two ends of the dial. Remember to use a plastic tool for this alignment, because a metal tool will affect the oscillator's tuning.

NEWER RESISTORS

OLDER RESISTORS

TUBULAR PAPER CAPACITOR COLOR CODE

COLOR	1ST DIGIT	2ND DIGIT	MULTIPLIER	TOLERANCE	VOLTAGE RATING, VDC
BLACK	0	0	1	+/- 20%	—
BROWN	1	1	10	—	100
RED	2	2	100	—	200
ORANGE	3	3	1,000	+/- 30%	300
YELLOW	4	4	10,000	—	400
GREEN	5	5	—	—	500
BLUE	6	6	—	—	600
VIOLET	7	7	—	—	700
GRAY	8	8	—	—	800
WHITE	9	9	—	—	900
GOLD	—	—	—	—	1,000
SILVER	—	—	—	+/- 10%	—

CAPACITANCE IS IN PICO FARADS (Pf OR Mmf)
 1 Mfd = 1,000,000 Pf OR Mmf
 EXAMPLE: YELLOW/VIOLET/ORANGE/YELLOW =
 4 / 7 / 1,000 / =
 47 X 1,000 = 47,000 PICO FARADS =
 47,000 ÷ 1,000,000 =
 .047 MICROFARADS @ 400 VOLTS DC

RESISTOR COLOR CODE

COLOR	1ST DIGIT	2ND DIGIT	MULTIPLIER	TOLERANCE
BLACK	0	0	1	—
BROWN	1	1	10	—
RED	2	2	100	—
ORANGE	3	3	1,000	—
YELLOW	4	4	10,000	—
GREEN	5	5	100,000	—
BLUE	6	6	1,000,000	—
VIOLET	7	7	10,000,000	—
GRAY	8	8	100,000,000	—
WHITE	9	9	—	—
GOLD	—	—	0.1	+/- 5%
SILVER	—	—	—	+/- 10%
NONE	—	—	—	+/- 20%

EXAMPLE: YELLOW/VIOLET/YELLOW =
 4 / 7 / 10,000 =
 47 X 10,000 = 470,000 OHMS
 OR 470K OHMS

Figure 7. Resistor and Tubular Paper Capacitor Color Codes

STEP 7.

Adjust the oscillator.
 The oscillator determines the frequency that the radio receives. The adjustment for the oscillator is a small trimmer capacitor that is on the side of the small section of the tuning capacitor.

To adjust the oscillator, tune to a known local station at the high frequency end of the dial and check to see if the dial reads the correct frequency. If it reads correctly then check a known station at the low frequency end of the dial. If it also reads correctly, then the oscillator doesn't need adjusting. If either station reads incorrectly, then alternately tune to the higher station and then the lower station while taking out as much error as possible with the oscillator adjustment. It may not be possible to get both ends of the dial to read exactly, and if this is the case, then adjust for the best compromise

Figure 7. Resistor and Tubular Paper Capacitor Color Codes

STEP 8.

Adjust the R.F. section.
 The adjustment for the R.F. section is a small trimmer capacitor that is on the side of the large section of the tuning capacitor.

To adjust the R.F., tune to a weak station at the high frequency end of the dial and adjust the trimmer for a peak in the signal level.

STEP 9.

This completes the alignment of the radio. If everything has gone well for you, then your set should be operating as good as new. If you have had problems, then you may need help, as mentioned earlier. If your set works well, then reinstall it in its cabinet and enjoy it for years to come!

CONCLUSION

In conclusion, you can apply this simple method to restore your radios and bring them back to like-new operating condition. Remember to clean the set first and to use a good contact cleaner to spray the potentiometers, switches, and tube sockets to remove films and oxidation. The next step is to test all of the tubes and lamps, and then to replace the power cord and any other wiring that is frayed, brittle, or cracked. After this is complete, you should replace the capacitors and resistors as already mentioned. The last step is to align

the set to bring it back to optimum performance.

Remember that your radio was inoperative because one or more of the parts failed, at least partially, because they were **OLD!** Now that you have replaced all of the **OLD** high-failure parts with **NEW** modern parts, your set should operate as good as new for many years to come. ■



Photo #18. The completely restored Majestic model 5T10.

REFERENCES

OLD TIME RADIOS! RESTORATION AND REPAIR

Copyright 1991

By Joseph J. Carr

Published by TAB BOOKS

Blue Ridge Summit, PA 17294-0850

ISBN 0-8306-7342-3

Available from Antique Electronics Supply (See parts/source list for address)

ANTIQUE RADIOS — RESTORATION AND PRICE GUIDE

Copyright 1982

By David and Betty Johnson

Published by Wallace-Homestead Book Company

1912 Grand Avenue

Des Moines, Iowa 50305

Available from Antique Electronics Supply and Antique Radio Classified (See parts/source list for address)

PARTS AND SOURCE LIST FOR RESTORING AN ALL-AMERICAN FIVE-TUBE AC/DC SUPERHET RADIO

ITEM

Capacitors, resistors, spaghetti, hook-up wire, polarized power cords, vacuum tubes, pilot light bulbs, tuner spray, alignment tools, solder wick, radio service cement. AES also sells books on antique radio restoration and collecting.

SOURCE

Antique Electronic Supply

6221 S. Maple Avenue

Tempe, AZ 85283

(602) 820-5411

Ask for their catalog.

ITEM

Capacitors, resistors, polarized power cords, vacuum tubes, pilot light bulbs.

SOURCE

Frankenstine's Radio Laboratory

4010 Fairmont Parkway

Pasadena, TX 77504

(713) 998-0130

Ask for their catalog.

ITEM

Resistors, spaghetti, hook-up wire, polarized power cords, pilot light bulbs, tuner spray, alignment tools, solder wick, tie-wraps. Radio Shack does not carry the higher voltage capacitors needed for vacuum tube equipment.

SOURCE

Radio Shack or other electronics supply

ITEM

Krylon spray paint, Dap Blend Sticks, Armor-All, acetone, super glue, Testors model paint, 100 watt light bulb, lamp socket, polarized extension cord.

SOURCE

Local Hardware Store

ITEM

Rubbing compound, Auto paste wax, Armor-All, car detailing brush.

SOURCE

Local Auto Parts Store

ITEM

Antique Radio Classified is a monthly publication for radio collectors that has articles on the hobby and many ads from collectors, clubs, and dealers on all aspects of antique radio. They also sell books on antique radio. A.R.C. is a must for anyone interested in antique radio. Subscription is \$34.95 a year by second class mail or ask for free sample copy.

SOURCE

Antique Radio Classified

P.O. Box 2

Carlisle, MA 01741

(508) 371-0512

ITEM

Schematic diagrams for antique radios.

SOURCE

Antique Radio Schematic Service

13911 Kensington Place

Houston, TX 77034

Copies of schematics for most radios built from the 1920s to the 1950s. Send make & model needed and business size self-addressed stamped (32 cent for USA) envelope with \$2.00. If schematic is unavailable, money will be refunded.

NOTE TO READERS

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

ROAD TESTING THE NEW SINGMIN PCB

By Tony Lee

Let's face it! There's nothing more annoying than when you connect the battery to your project in excited anticipation — and nothing happens! And although faults can often be traced to poor solder joints and minor wiring errors, many problems are exacerbated by the shortcomings of commercially available circuit boards. And unless you enjoy making your own custom designed printed circuit boards, and handling messy etching solutions, etc., it hardly seems worth the effort for that one-off project.

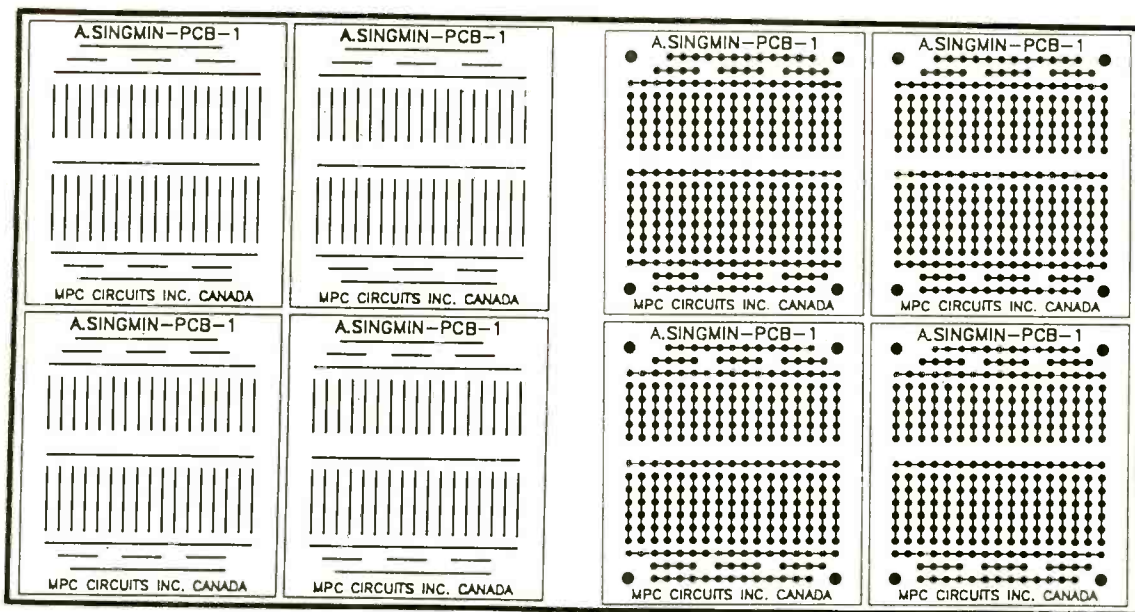


Figure 1. A new concept in circuit board design — The SINGMIN PCB. The Singmin PCB. View at left shows track markings on front of board. At right, the under-side of board showing the solder-track pattern.

Of course, there will never be a universal board on the market that is perfectly suited to the thousand and one circuits that interest us as hobbyists, but if you've ever used an experimental plug-in breadboard to try out projects before building them, you might wish there was something like it in solder boards.

Well, now there is — the Singmin PCB, shown in Fig. 1. You will see that the track pattern **does** resemble the breadboard shown in Photo 1. In fact, the components plugged into the breadboard (which took all of two minutes to assemble) are in a similar location to those in the layout on the Singmin board shown in Fig. 7.

This brings us back to those annoying projects that fail when the power is switched on. If, however, the circuit board used for the project facilitates assembly, there is less likelihood of error. An initial examination of the Singmin PCB appears to do just that. You can see at a glance the location of components and what they are connected to.

But, before evaluating its degree of effectiveness, it might be a good idea to review briefly, some of the better known assembly systems available to the hobbyist. A once popular method of assembly for small, simple circuits was to mount the components on a tag strip, as illustrated in Fig. 2. This, of course, was okay before

the advent of integrated circuits (chips), but it can still be resorted to for jobs involving half-a-dozen discrete components.

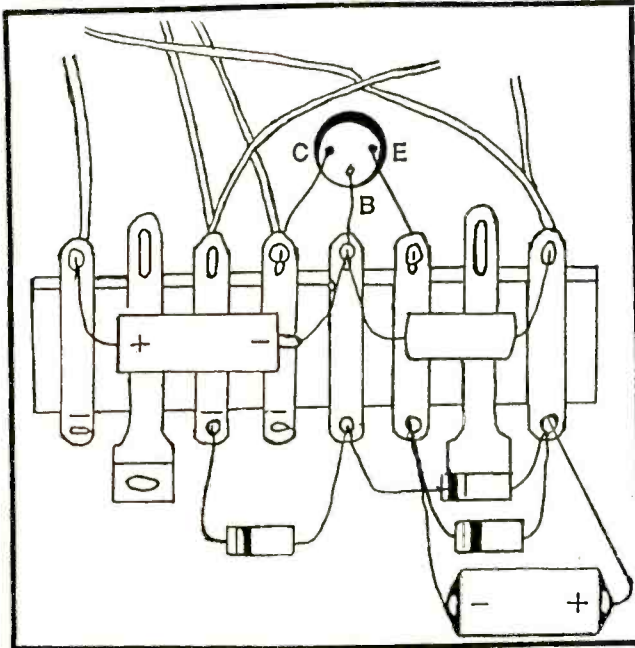


Figure 2. Simple Tag Strip assembly.

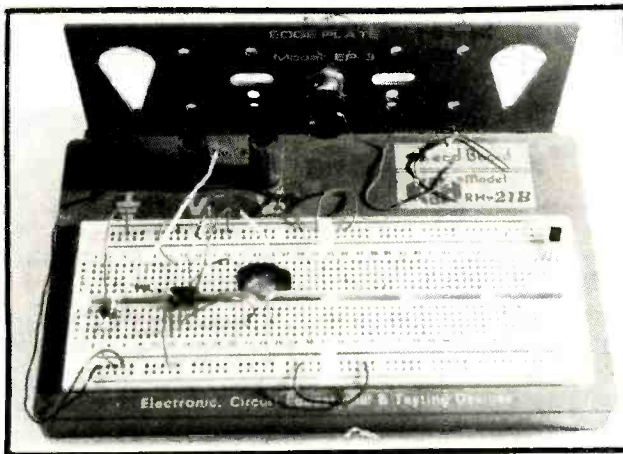


Photo 1. Breadboarding the 555 Sensor Switch. The practical Singmin PCB track pattern resembles the breadboard system.

The most basic of all boards with pre-punched holes spaced in a grid-like pattern to take ICs and discrete components, is the well-known Perfboard marketed by Radio Shack and which may be described as matrix board by other stockists. It is a tough phenolic material and ideal for simple proto-typing, but being a plain non-printed board, the components are only held in place by soldering them to each other under the board. The IC socket seen in **Photo 2** is held in position by the leads of the other components connected to its pins—not a workmanlike procedure for the serious constructor.

A far more practical board, popular in Europe and downunder, but perhaps not so well known in the U.S. is the printed strip board, consisting of continuous, parallel copper tracks as shown in **Fig. 3**. All components are mounted vertically as indicated by the arrow. However, although a very flexible system, the tracks need to

be 'broken' in places where continuity cannot be tolerated, for example, between the inline pins of an 8-pin IC, as indicated in the illustration. The breaks are made with a small drill bit, and although not difficult, does call for some care in its execution and in selecting the correct locations.

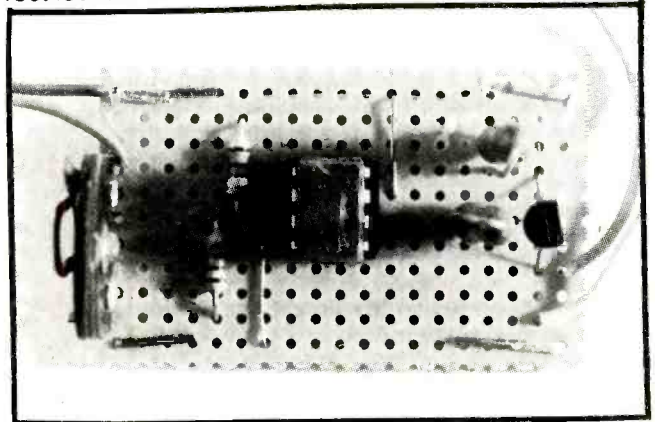


Photo 2. The Op-Amp Sensor Switch mounted on Perfboard. Components are anchored by soldering them to each other under the board.

Another type of printed circuit board has all the pre-punched holes encircled with unconnected donut-shaped or square copper pads, which the writer has tried but with very limited success.

Finally, small dedicated PCBs are available to take one or two ICs only. Tracks run from each pin to wide solder lands around the edge of the board for connection to off-board components. Useful in some applications.

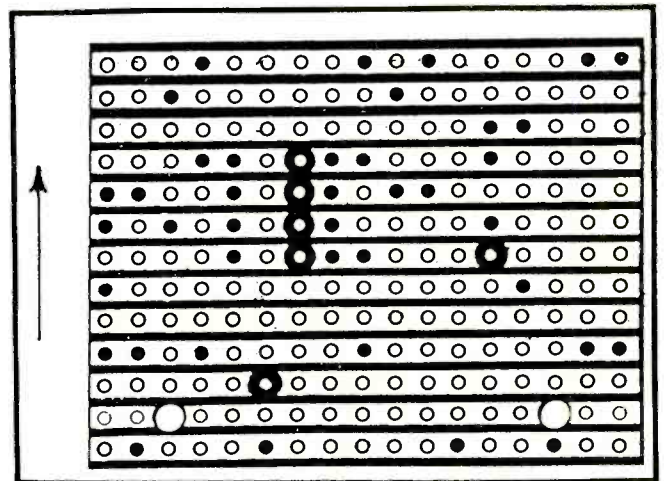


Figure 3. Strip Board showing "Breaks" in solder tracks.

Evaluating the Singmin PCB

Volume XVI of the Electronics Handbook featured a new concept in circuit board construction—the Singmin PCB. The article focused particular attention on its suitability for op-amp circuitry in which a split voltage is often needed to allow for positive and negative voltage swings. This involves a dual supply, either two batteries or preferably, a voltage divider network which is adequately catered for on the Singmin board.

But what of those countless circuits that don't use op-amps or, for that matter, any ICs at all? The only way of determining the adaptability of the Singmin board

would be to assemble circuits on it of totally different configuration and weigh up the advantages and disadvantages.

To give added impetus to what might be a workaday lab report, it was decided to choose an interesting project that could be built in totally different ways and with totally different components—the popular Sensor Switch. This practical device can warn of fire or frost, or rain or flooding, or switch on a porch light or serve as a light beam detector, or...the applications are endless and only limited by the constructor's imagination. The only feature in common with all the sensor switch circuits discussed below is the voltage divider, which comprises the sensor and a variable resistor (trimpot). Otherwise, each circuit works on an entirely different principle.

The first thing the writer did was draw one section of the Singmin board twice full size for the purpose of pre-planning the layout. This was considered essential. The layout drawing can be used over and over by laying a piece of tracing paper over it using adhesive tape and sketching the components in various locations until an acceptable arrangement is achieved. The layouts chosen for this lab report are functional and representative. Remember, as they say in the classics, there's more than one way of killing a cat!

One of the objectives was to design a layout with the minimum number of connecting links—it being considered an important measure of performance of a printed circuit board. The first discovery was, contrary to the advice given in Andrew Singmin's article on how to separate the four sections of the board (with a small hacksaw), the four quadrants could be easily separated by scoring along the scribe holes on **both** sides using a steel rule and a hobby knife, and snapping them apart with the aid of long-nose pliers aligned with the scribe line. The sections snapped apart cleanly and without fuss.

Only brief mention will be made of the circuit theory for a basic understanding, the object of this article being the evaluation of a new product.

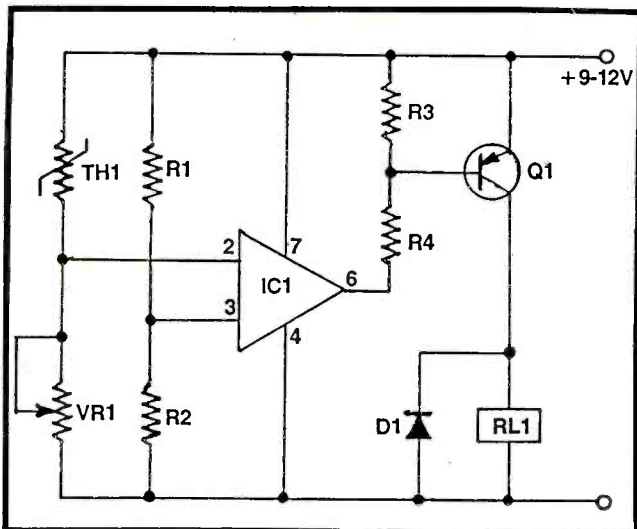


Figure 4. Op-Amp sensor switch circuit.

The Op-Amp Sensor Switch

The first sensor switch to be discussed, which high-

lights the fact that not **all** op-amp circuits require a dual power supply, is shown in **Fig. 4**. This simplifies the layout. Readers will recognize a conventional bridge at the input, comprising R1, R2, VR1 and the thermistor, TH1, which, while in balance, produces no output at pin six. In the circuit shown, an increase in temperature will turn on the transistor and operate the relay. TH1 and VR1 can be easily transposed to work in the opposite mode, i.e., a drop in temperature will again energize the relay. The thermistor can be exchanged for a photo cell (light dependent resistor) or any other sensing device. These comments apply to all the sensor switch circuits discussed in this article.

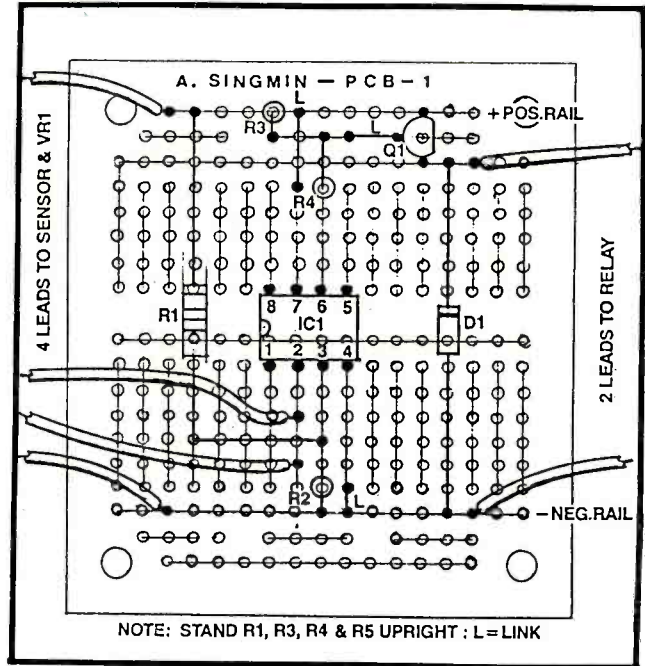


Figure 5. Op-Amp layout of sensor switch.

And now we turn to the layout shown in **Fig. 5** and **Photo 3**. The first requirement was to establish the positive and negative rails, and this wasn't difficult to do with the continuous tracks at the top and bottom of the board. Reference to the layout will identify these rails.

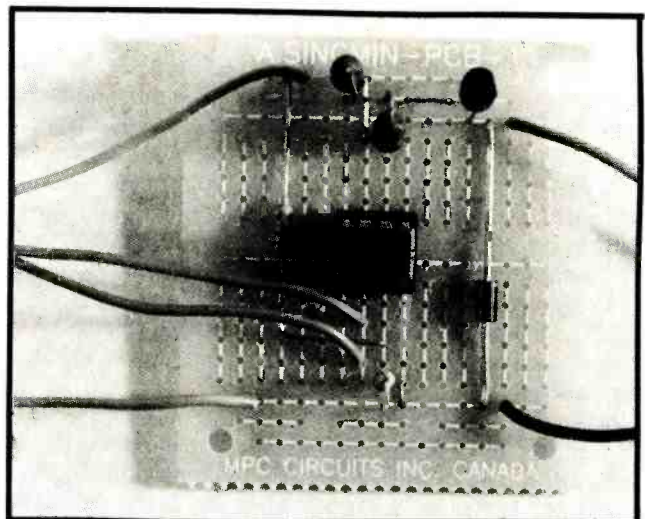


Photo 3. The Singmin PCB-mounted Op-Amp Sensor Switch.

Initially, some concern was felt at the emphasis placed on making provision for dual supply components for op-amps in Andrew Singmin's article which might lead one to conclude that the board design was largely influenced by this requirement. The writer, however, was pleased to discover the top section of the board used for his biasing components was well suited for other arrangements, as an alternative to the higher priority area surrounding the IC.

You will observe that the Perfboard op-amp sensor switch in **Photo 2** has a trimpot (VR1) mounted on the left hand edge of the board. This was not possible on the Singmin board owing to the smallness of the holes and solder lands. Leads, therefore, had to be soldered to it for connection to an off-board trimpot. Care must be taken when soldering joints that the soldering iron is held at 45 degrees to avoid clogging other holes with solder. This can easily happen to the less experienced constructor, particularly, if a very fine soldering tip is not being used.

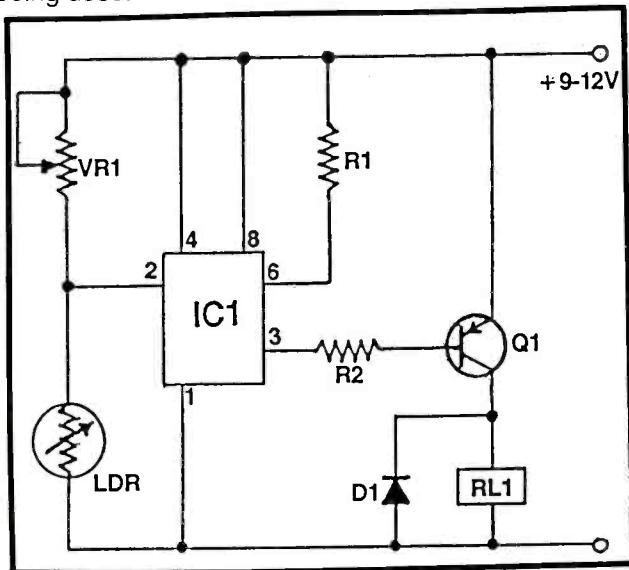


Figure 6. 555 Timer sensor switch circuit.

Care must also be taken not to inadvertently turn the board upside down during assembly or testing which can easily occur due to its symmetrical shape. Seasoned constructors may scoff, but the writer can vouch for it being a common occurrence with beginning students. It's a good plan to mark the top of the board with a red fiber-tip pen to denote the positive rail.

In passing, a very useful tool for assembly work of this nature is a pair of jeweler's tweezers which work in reverse to normal tweezers (they open when you squeeze them). They hold a component firmly in position during soldering and also act as a heat sink.

The track markings on the front of the board proved invaluable, enabling the insertion of component leads, etc. in their correct locations without the need to turn the board over to check their position. Mistakes are virtually impossible.

The three connecting links were pre-formed with eyebrow tweezers in the shape of a staple. Their size is easy to estimate after a little practice. Soldering was a joy! Joints took no longer than two seconds to solder, and the solder flowed readily around the protruding pin

or lead. Beginners, though should beware of excessive heat. It will lift the solder lands off the board, although it is more likely to happen if you have to remove a component for some reason.

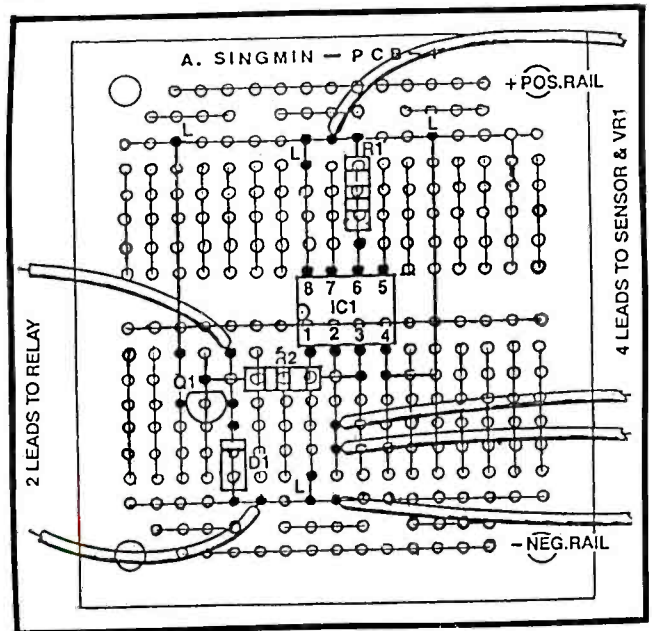


Figure 7. 555 Timer layout of sensor switch.

555 Timer Sensor Switch

Let's look at the next Sensor Switch circuit shown in **Fig. 6**. Again we use an 8-pin IC, much cherished by hobbyists, but it couldn't be more dissimilar in the way it works. It is the 555 Timer IC, so-called because its main function is as a timing device or an oscillator, but constructors have found many other uses for it, the Sensor Switch being a case in point.

It requires fewer components than the op-amp circuit, in fact, even the output transistor and its base resistor are hardly necessary for most applications, but in this case, a spare pair of contacts in the relay, were used to latch on the circuit after being activated, by wiring them across the transistor. We'll be looking at latching methods a little later.

The way the circuit in **Fig. 6** has been drawn, it operates as a dark-activated switch. While sufficient light falls on the photo cell (LDR), trigger pin 2 is held at or below $\frac{1}{3}$ of the supply voltage, which holds off transistor Q1. As the light intensity reduces, at a certain level the voltage will rise above $\frac{1}{3}$ and change the state of an internal comparator. This enables output pin 3 to sink a current and turn on the transistor. The output current of the 555 can source or sink up to 200mA in its own right. The unused threshold pin 6 is tied high with R1.

The layout shown in **Fig. 7** and **Photo 4** hardly needs comment. The location of the transistor and its associated components in the central section is an alternative to the peripheral tracks at the top and bottom of the board when there is adequate room for them. The only criticism — if it warrants so strong a term — is the need at times to bend component leads and connecting links at right angles to connect to the positive and negative rails. It was found necessary in this and the previous layout. More will be said of this in the summing up of the board's overall performance.

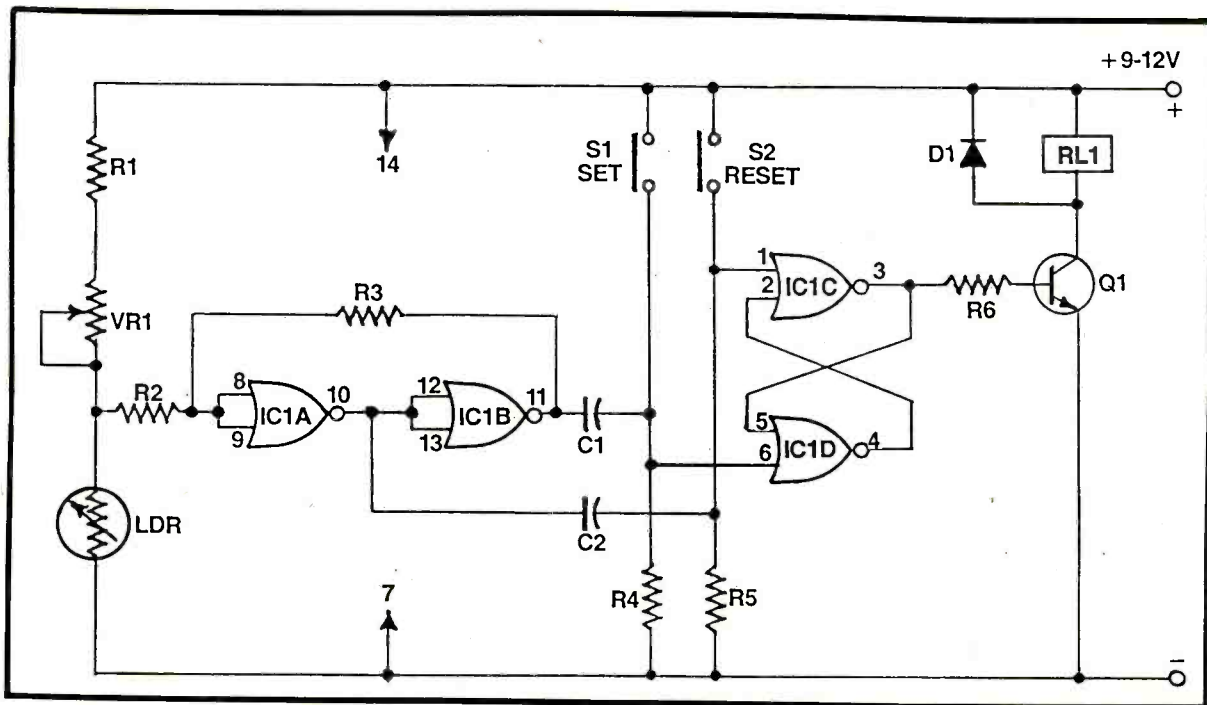


Figure 8. Quad NOR Gate sensor switch circuit.

Quad Nor-Gate Sensor Switch

So far, we have been dealing with simple circuits involving linear ICs and a few other components, for which the Singmin PCB is ideal. How will it perform with a digital logic IC, and more discrete components and links crowding the board?

The circuit shown in **Fig. 8**, apart from its many other applications, is drawn for use as an automatic light (or other appliance) which switches on at dusk and switches off at daybreak. It also has provision for manual push-button operation which does not interfere with the automatic feature. The previous two circuits do not lend themselves to this added benefit, although anything's possible.

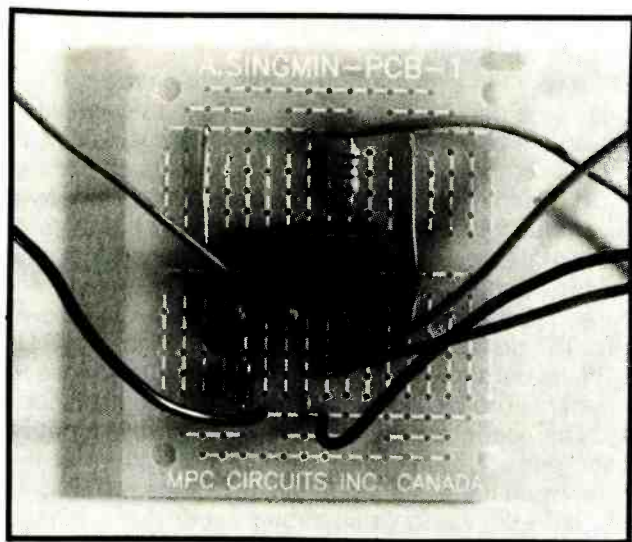


Photo 4. The Singmin PCB-mounted 555 Sensor Switch.

The circuit is economical in that it utilizes all four NOR gates in the one IC Package. For those not too familiar with digital circuitry, a basic OR gate will pro-

duce an output (high) when either or both input pins receive an input voltage (we talk in 'highs' and 'lows'). Conversely, a NOR gate output will go **low** when one or both input pins goes high. This is the effect needed for this circuit. A NOR Gate is denoted by a bubble (not) at its output as shown in the gate symbols.

During daylight, there is a low at both inputs of IC1a and a high at its output. And consequently, a high at the inputs of IC1b and a low at its output. As light fades, the increase in resistance of the LDR causes the input at IC1a to go high, thereby inverting the two gates and producing a high at the output, pin 11. Resistor R3 is necessary to obtain the Schmitt effect and maintain the gates in their new state, regardless of small changes in light level.

The Schmitt trigger circuit is connected to a flip-flop circuit via capacitors C1 and C2. The flip-flop is made up of the two remaining NOR gates, IC1c and IC1d, the logic of which is as follows: pins 1 and 6 are held low by R4 and R5. Output pin 4 and input pin 2 are, therefore, high, thereby putting a low on output pin 3 and holding the transistor off.

Now, here's the interesting part: When pin 6 goes high, either by pressing S1 or when pin 11 goes high, pin 4 goes low and, of course, so does pin 2. Now, both input pins 1 and 2 are **low**, thus producing a high at pin 3 and switching on the transistor. Pin 5, as a consequence, goes high, too, thus keeping pin 4 low and locking the flip-flop in that state. Only by pressing reset button S2 or the Schmitt trigger reverting to its former state at daybreak, will the flip-flop change state and switch off the transistor and the relay.

For the layout, shown in **Fig. 9** and **Photo 5**, the oversize drawing of the circuit board and its tracing overlay proved invaluable. Pre-planning **is** essential. Few problems were encountered in placing the ten discrete components on the board, and it would appear that one section of the Singmin PCB is comfortable

with up to a dozen small components, plus the IC.

The number of connecting links, though, was time consuming and thought to be excessive. This aspect again will be dealt with in the summary. All in all, it is a neat symmetrical layout, with adequate room for the eight connecting leads to off-board components.

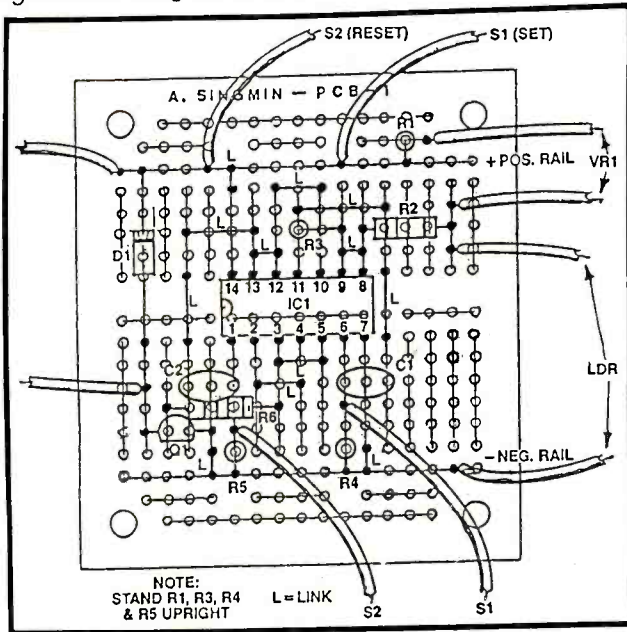


Figure 9. NOR Gate layout of sensor switch.

Transistorised Sensor Switch

Now we are on the home stretch. The final test is to determine how adaptable the Singmin board is for circuits comprised of discrete components only. But first, a description of the circuit shown in **Fig. 10**.

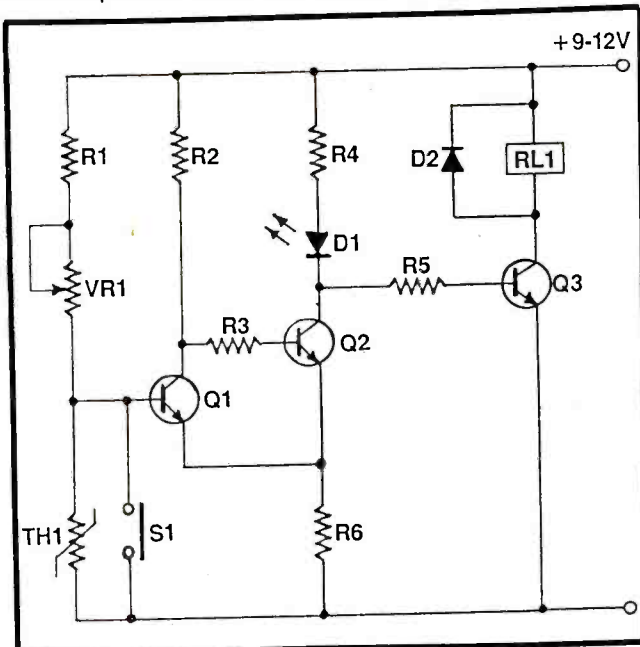


Figure 10. Transistorized sensor switch circuit.

It is drawn in the 'frost' mode, but like the previous circuits, the potential divider network at the left of the diagram can be transposed to obtain a 'fire' mode. We will assume that the thermistor we are using is the more

popular negative temperature coefficient (NTC) type, that is, its resistance falls as the temperature rises, and vice versa.

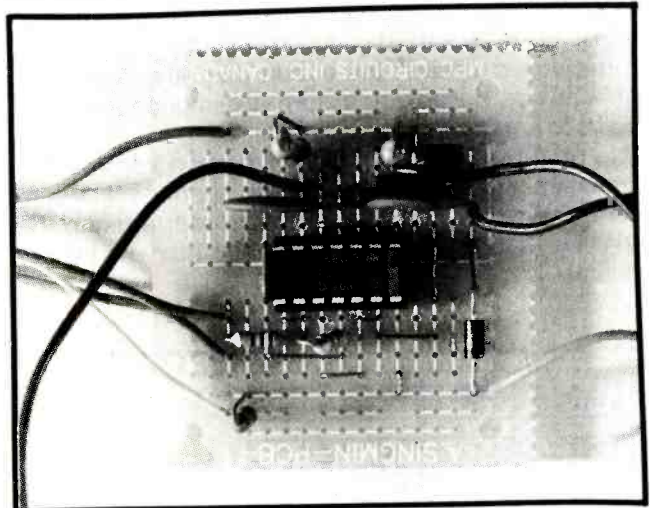


Photo 5. The Singmin PCB-mounted Quad Nor-gate Sensor Switch.

During normal conditions, Q1 is off and Q2 is on as will be indicated by the illuminated LED, D1. As the temperature falls, so the resistance of the thermister rises until it reaches the critical level as determined by the setting of VR1. At that point, Q1 snaps on, depriving the base of Q2 of current. D1 switches off. Now that current can no longer flow through Q2, it takes the alternative path and switches on Q3 via R4 and R5, thus energizing the relay. Once again, we have the Schmitt effect which is achieved with R6 in the emitter line of Q1 and Q2. The circuit is, therefore, prevented from reverting to its original state by any small increase in temperature. This circuit, in other words, is an electronic latch. The latch can be reset with push-button S1.

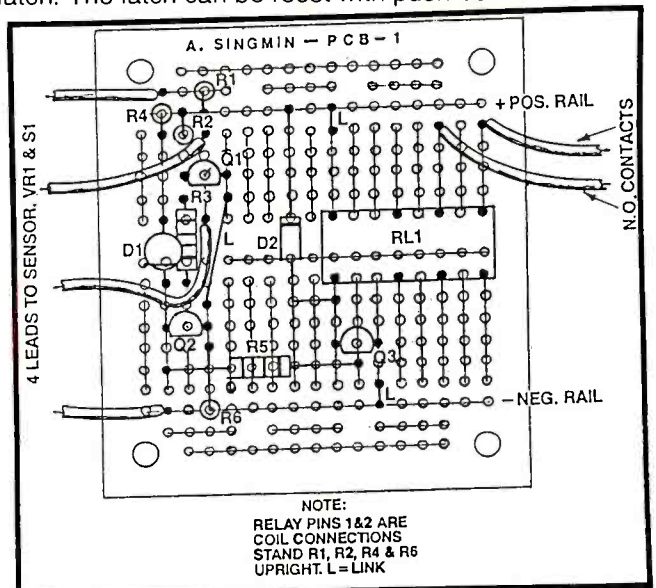


Figure 11. Transistorized layout of sensor switch.

It was decided to make better use of the board by installing a PCB type relay on it as shown in **Fig. 11** and **Photo 6**. This created a problem. Unlike ICs, other components could not be placed around the relay, and the relay commandeered half the board. But apart from

that, because the positive and negative rails are at the top and bottom of the board, it necessitated positioning the components from top to bottom rather than the preferred left to right as you would read a well-drawn schematic. This makes it difficult to identify the components on the board against the circuit diagram. And once again, it was necessary to turn a component at right angles to connect it to the positive rail.

No doubt the layout could have been improved to some extent if more time had been spent on it. Meanwhile, the writer can see little advantage using the Singmin PCB for transistorised circuitry over other systems.

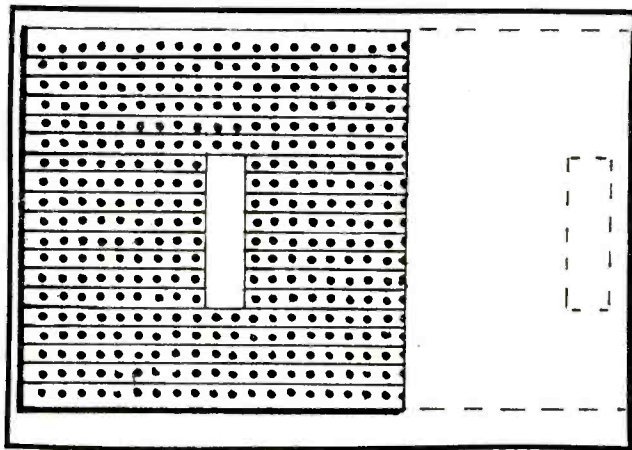


Figure 12. The "perfect" composite Circuit Board.

Summing up

It can be stated, without hesitation, that a segment of the Singmin PCB is superior to most other systems when used for circuitry comprising one or two 8-pin ICs, or one 14 or 16 pin IC, and up to a dozen small discrete components (not large electrolytic capacitors).

Furthermore, it is ideal for beginners or those enthusiasts with an elementary knowledge of electronics and limited experience in circuit board assembly. They should find the assembly of any of the foregoing projects enjoyable, and the Sensor Switches very useful.

As previously observed, there will never be a universal circuit board system free of all criticism. Each system has its good points and its drawbacks.

But what if we could take the best features of each and incorporate them in one circuit board?

An attempt to do this resulted in the circuit board shown in Fig. 12. It is 2 inches wide by 8 inches long. It has wide, continuous solder tracks similar to strip board that won't lift off with excessive heat when you want to remove a component. It has large pre-punched holes (say .040" dia.) like Perfboard that will accept trimpots and other components with thick pins, leads and multi-strand wiring which obviates the need for connecting leads to off-board components. The large-size holes are almost impossible to clog with solder. Provision is made for an IC at two inch intervals and the board can be split to any length simply by scoring along the appropriate vertical row of holes in the manner previously explained. The board can, therefore, be left in its entirety or split into a number of sections as

required. No mounting holes are provided, it being left to the constructor to choose his/her own by drilling out any of the pre-punched holes.

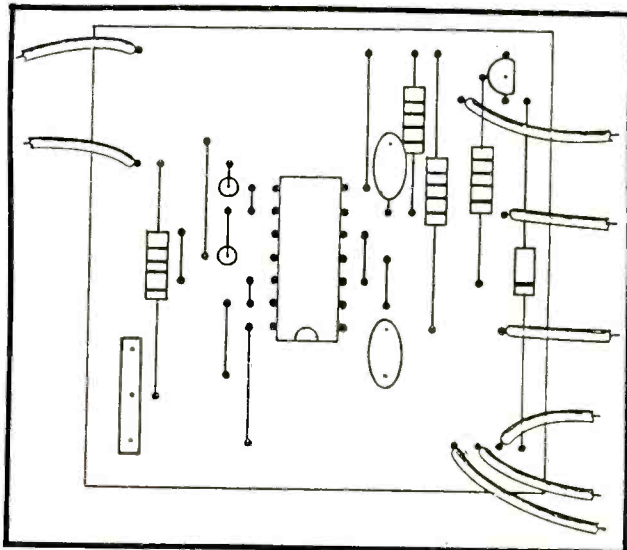


Figure 13. Assembly of the NOR Gate sensor switch on the composite circuit board.

Positive and negative rails can be located at the top and bottom of the board, thus avoiding the need to bend component leads at right angles. There is more opportunity to lie resistors horizontally and in contact with the board for better heat dissipation. Also, assembly can be completed with fewer connecting links. And finally, there are sufficient tracks above and below the IC to avoid breaking continuity as for strip board.

The circuit board in Fig. 12 shows the solder track pattern on the underside of the board. Guide marks on the front of the board may be helpful, but not essential.

Using the above concepts, a layout was drawn for the NOR gate Sensor Switch circuit as shown in Fig. 13. All components are fitted vertically, including the IC. The trimpot is mounted at the top r/h corner of the board. Assembly was achieved with four fewer connecting links and two less connecting leads. A straight-edge may be placed horizontally on the layout to find out what connects to which.

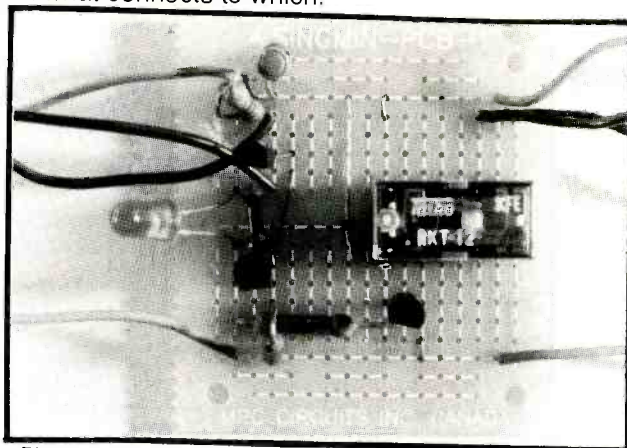


Photo 6. The Singmin PCB-mounted Transistorized Sensor Switch.

But to the writer's knowledge, this circuit board doesn't exist and in the meantime, he commends the use of the Singmin PCB wholeheartedly for hobby projects.

ROAD TESTING THE NEW SINGMIN PCB

PARTS LIST FOR THE OP-AMP SENSOR SWITCH

R1, R2 — 15K resistor
R3, R4 — 1.5K resistor
VR1 — 47K nominal variable resistor (see note below)
IC1 — 741 OP Amp IC
Q1 — BC548 NPN transistor, or similar
D1 — 1N4002 diode, or similar
TH1 — NTC thermister or other sensing device
RL1 — 9-12V relay with adequate contact rating

PARTS LIST FOR THE 555 TIMER SENSOR SWITCH

R1 — 10K resistor
R2 — 4.7K resistor
VR1 — 47K nominal variable resistor (see note below)
IC1 — 555 timer IC
Q1 — BC558 PNP transistor, or similar
D1 — 1N4002 diode, or similar
LDR — light dependent resistor or other sensing device
RL1 — 9-12V relay with adequate contact rating

PARTS LIST FOR THE QUAD NOR GATE SENSOR SWITCH

R1 — 270 Ohm resistor
R2 — 1Meg resistor
R3 — 3.3Meg resistor
R4, R5 — 100K resistor
R6 — 4.7 K resistor
C1, C2 — 0.1 capacitors
VR1 — 47K nominal variable resistor (see note below)
IC1 — 4001B quad NOR gate IC
Q1 — BC548 NPN transistor, or similar
D1 — 1N4002 diode, or similar
LDR — light dependent resistor or other sensing device
RL1 — 9-12V relay with adequate contact rating
S1, S2 — push-button N.O. switches

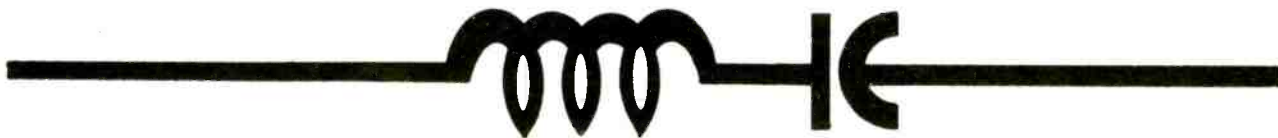
PARTS LIST FOR TRANSISTORISED SENSOR SWITCH

R1 — 1K resistor
R2 — 10K resistor
R3 — 4.7K resistor
R4 — 470 Ohm resistor
R5 — 100K resistor
R6 — 100 Ohm resistor
VR1 — 47K nominal variable resistor (see note below)
Q1, Q2, Q3 — BC548 NPN transistor, or similar
D1 — red light emitting diode (LED)
D2 — 1N4002 diode, or similar
TH1 — NTC thermister or other sensing device
RL1 — 9-12V PCB relay or off-board type relay as required
S1 — push-button N.O. switch

NOTE

The resistance of VR1 must be sufficient to balance the sensing device used which may vary from 10K to 100K. However, VR1 resistance should not be unnecessarily excessive as to diminish sensitivity adjustment. 47K may be found suitable for most situations.

WORKBENCH PROJECTS



By Darren Yates

If you're looking to get started in electronics but don't want to spend up big, then why not have a look at these simple but useful circuits. They use easy-to-get and cheap transistors and can be built in next to no time.

There's nothing like turning lumps of plastic, silicon and carbon into living and breathing electronic projects. The only problem these days is that many of these lumps of plastic can be rather expensive, fragile and difficult to replace.

Transistors on the other hand are about the most common component you can get. If you walk into your favorite parts store, you'll probably even find them in discount "grab" bags as well. There are many thousands of circuits that use one or more of these little guys to do many useful things.

To get you started, we've come up with a selection of circuits that are cheap, fun and interesting to build. You'll even learn a bit about the components along the way.

How you build these projects is up to you. We suggest that you use some perfboard or European style Veroboard or even one of our Singmin PCBs, advertised elsewhere in this issue. All that you have to do is make sure that all the connections are soldered neatly and that you don't have any dry joints that can cause problems.

All of these projects use low voltage power supplies, which can come from most power pack (transformer style) sources.

6V TO 12VDC CONVERTER

This next circuit is a little more complicated and uses quite a few more components. Its job is to convert a 6V into 12V. One place where a circuit such as this could be used is to drive a 12V car radio from a 6V Volkswagen.

Looking at the circuit, transistors Q1 and Q2 form an astable multivibrator or square wave oscillator. The diode, D2, improves the rise time of the waveform (or, more simply, makes sure that the jump from a low voltage to a high voltage level is as quick as possible). The output is taken from the collector of transistor, Q2, and fed via a 1.5K Ω resistor to Q3. This is a Darlington NPN type. If you don't have a BD679 handy or can't happen to locate one, you could use just about any Darlington NPN type so long as it can withstand around 20W of power and 4 amps of current. It also has to have a Vce (maximum collector-emitter voltage) rating of around 80V.

This transistor is used to switch the coil L1 in and out of the circuit. The job of the coil is to act as an inductor. Inductors are strange circuit components in that when they are charged up, and the charging current is interrupted, they try to maintain the level of energy stored by increasing the voltage.

What you end up getting is a high voltage spike at the collector of Q3 when it is switched off. This spike can go as high as 40 or 50V but only for a very minute length of time. Diode D3 is a special type of diode known as a fast recovery diode. It is designed for this type of work where it can handle very fast switching currents. This diode ensures that the high voltage pulse is dumped into the 470uF reservoir capacitor C3.

To ensure that the voltage doesn't rise above 12V, a 12V zener diode is connected to the output of the circuit. Once the voltage reaches 12V, the diode begins to conduct and switches on transistor Q4. This pulls the base of Q3 to ground, making sure that it can't switch on.

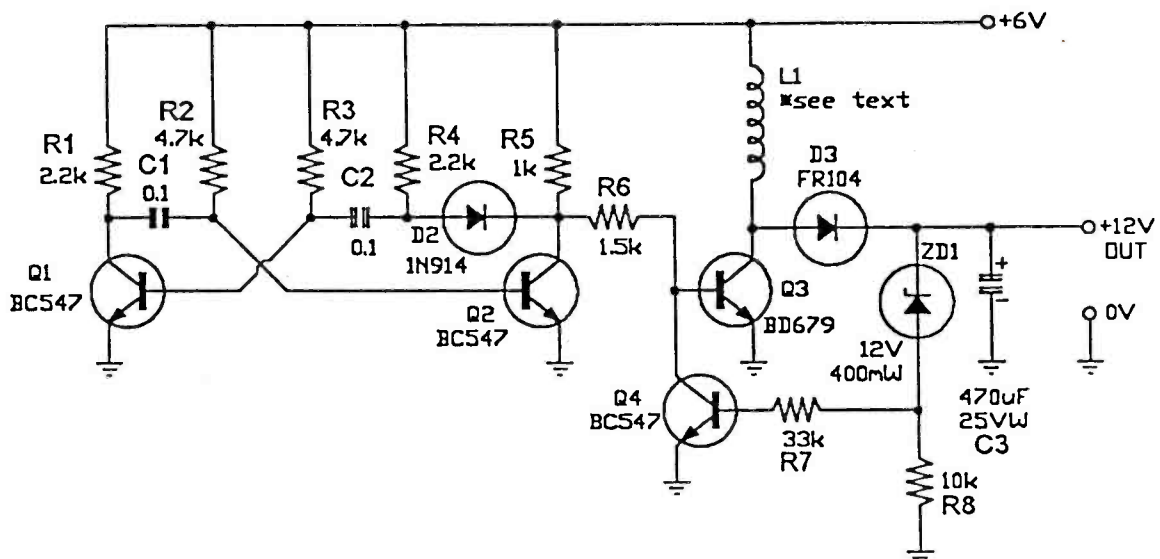
The coil L1 is made up of about 80 turns of 0.5mm diameter enamelled copper wire wound around a toroidal ring core (40mm outside diameter).

The important thing to remember about this circuit is that it doesn't just generate voltage from thin air but rather converts current into voltage. Because we are doubling the voltage, the current from your 6V power supply will be more than double that consumed by your 12V gismo. If this circuit was perfect, it would be exactly double but because it is not perfectly efficient, the current will be around 2.5 times more than the 12V gismo is using. What it loses in efficiency, it more than makes up for in rugged reliability.

This circuit can provide up to around 800mA max. to your circuit and you'll need to use heavy duty hook up wire for the high current paths, (ie: from your 6V power supply to the inductor L1, to diode D3 and from D3 to the output connection). A heatsink for Q3 wouldn't go astray either. ■

PARTS LIST FOR THE 6V TO 12VDC CONVERTER

- C1, 2—0.1uF mylar capacitor
- C3—470uF 25VW, electrolytic capacitor
- L1—see text
- ZD1 (D1)—12V, 400mW, zener diode
- D2—FR104, 1 amp, fast-recovery diode
- D3—1N914 signal diode
- Q1, 2, 4—BC547, NPN, transistor (or equivalent)
- Q3—BD679, NPN, Darlington transistor
- R1, 4—2.2K ohm, 0.25W, 5% resistors
- R2, 3—4.7K ohm, 0.25W, 5% resistors
- R5—1K ohm, 0.25W, 5% resistors
- R6—1.5K ohm, 0.25W, 5% resistor
- R7—33K ohm, 0.25W, 5% resistor
- R8—10K ohm, 0.25W, 5% resistor
- Extras—6V battery or power supply



SINEWAVE OSCILLATOR

If you've been tinkering around for a little while with electronics, you'll probably by now have found lots of references to sinewave oscillators. A sine wave is the most pure waveform you can generate. While it doesn't sound particularly interesting to listen to, it is used in just about every piece of test equipment to measure the performance of CD players, tape decks and audio amplifiers.

This little circuit could form the basis of your own low-cost test equipment. It produces a very clean sinewave (with less than 0.05% distortion) at a frequency of around 130Hz. What's more, you can use just about any NPN small-signal transistor here (just about anything lying around in your junk box will do the trick) and its quite easy to get going.

Looking at the circuit, two 10K Ω resistors set up the DC voltage bias for the circuit as well as the emitter voltage of transistor Q1 to around 3.3V. The three 1.5K Ω resistors and 0.1 μ F capacitor form a phase-shift network which has a small amount of voltage gain at the frequency of resonance (ie: around 130Hz). This voltage gain is roughly 1.12V.

The transistor is running in emitter-follower mode which means that it has a voltage gain of around 0.99. When you multiply 1.12×0.99 you get an overall close-loop gain of more than 1, which is what we need to make the circuit oscillate.

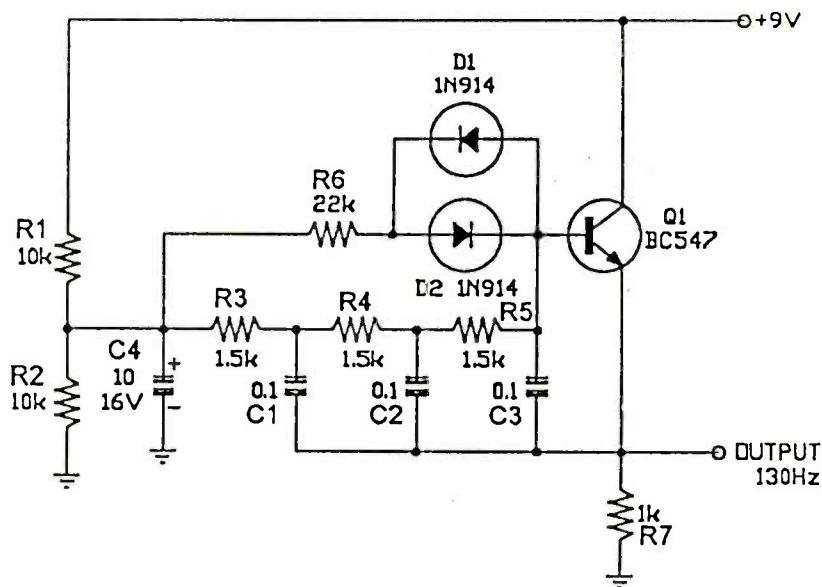
The two back-to-back diodes and the 22K Ω resistor provide some crude but useful amplitude stabilization. Without this, the signal would continue to amplify until it was so large that it ran into both the positive supply and the ground. These three components ensure that once the amplitude gets to a certain level, the diodes begin to turn on and reduce the amplitude.

The 10 μ F capacitor joined to the junction of the two 10K Ω bias resistors ensures that the bias point is free from noise and allows the circuit to produce a very clean signal.

Since this circuit doesn't use very much current, you could quite easily run it from a 9V transistor radio battery or some penlights. To test that the circuit is working, you can connect the output directly to a small loud-speaker amplifier. Make sure it has a volume control, otherwise the tone will be deafening! ■

PARTS LIST FOR THE ONE-TRANSISTOR SINEWAVE OSCILLATOR

- C1, C3—0.1 μ F mylar capacitors
- C4—10 μ F 16VW electrolytic
- D1, D2—1N914 signal diodes
- R1, R2—10K ohm, 0.25W 5% resistors
- R3-R5—1.5K ohm, 0.25W 5% resistors
- R6—22K ohm, 0.25W 5% resistor
- R7—1K ohm, 0.25W 5% resistor
- Q1—BC547 NPN, small signal transistor (or equivalent)
- Extras—9V battery or power supply



QUICK EMERGENCY FLASHER

There is nothing worse than getting a flat tire when you're on the freeway except getting one at night. It can be quite dangerous if you're unable to pull off the side of the road. What you need in this situation is to have an emergency flasher/beacon further back up the road to warn other drivers of problems ahead and get them to slow down.

This circuit uses just two transistors, three resistors and a capacitor. Looking at the circuit, the 10uF capacitor, C1 provides the impetus for the circuit to start. Initially when the power is first switched on, C1 is discharged but it now begins to charge up slowly via the current flow through the globe GL1, the 4.7KΩ resistor and the 150KΩ resistor.

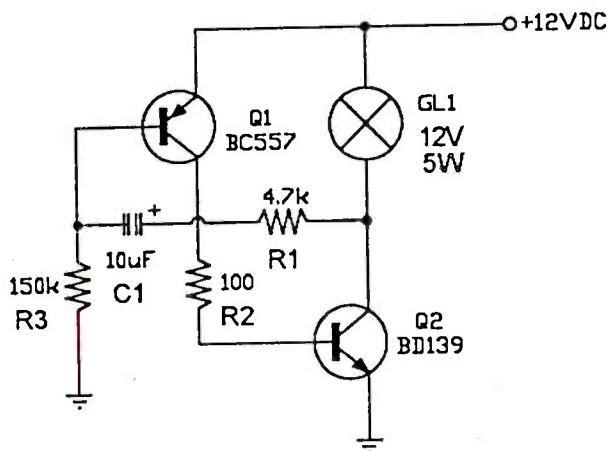
Eventually, the current causes the capacitor to charge to a point where Q1 begins to switch on. At this stage, Q1 turns on, which turns on Q2 and lights the globe. With transistor Q2 turning on, the capacitor now begins to discharge, as the current flows from C1 through the 4.7KΩ resistor and through Q2.

This causes Q1 to switch off which in turn switches off Q2 and the globe. Once this stage is reached, the capacitor begins to charge up again and the process continues indefinitely.

This flasher is ideal to run from a lantern battery or even from your car battery itself. There are a number of low-voltage lamp assemblies on the market and the circuit is small enough to build inside one of these to make a self-contained unit. ■

PARTS LIST FOR THE EMERGENCY FLASHER

- C1 — 10uF, 16VW, electrolytic capacitor
- R1 — 4.7K ohm, 0.25W, 5% resistor
- R2 — 100 ohm, 0.5W, 5% resistor
- R3 — 150K ohm, 0.25W, 5% resistor
- Q1 — BC557, PNP, transistor (or equivalent)
- Q2 — BD139, NPN, power transistor (or equivalent)
- GL1 — 12V, 5W, globe
- Extras — 12V battery or power supply



TRANSISTORIZED SCHMITT TRIGGER

This circuit is for those who have had some experience in electronics. It's a transistor equivalent of the famous Schmitt trigger circuit which is often used in logic ICs. The only problem with these ICs is that they come in packs of six which isn't always useful, particularly if you only need one.

Looking at the circuit, when the input signal is low, transistor Q1 is switched off. This enables Q2 to be switched on via the current flowing through resistors R1, R2 and R3. The collector output of Q2 is at around 1.3V.

If we now start to increase the input voltage, Q1 begins to turn on, which robs current from the base of Q2. Because the two emitters of these transistors are connected together, as we increase the input voltage further there is a sudden snap action which takes the output from low to high. This 'high' level is 5V.

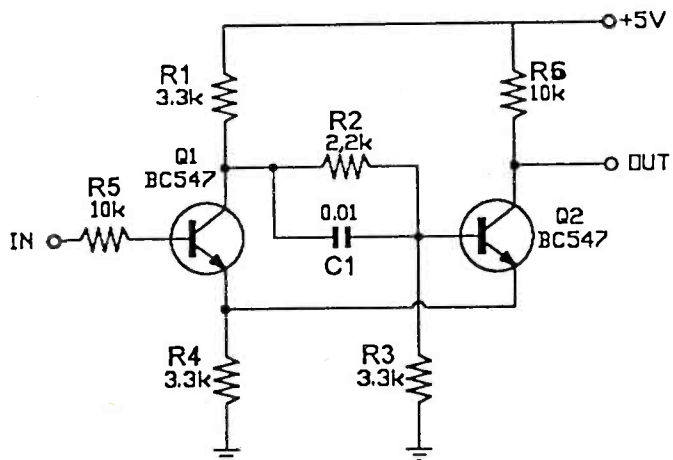
Bringing the input voltage back down again provides a similar result except at a different voltage threshold which is set up by the 2.2KΩ resistor R2 and the 3.3KΩ emitter resistor R4.

PARTS LIST FOR THE SCHMITT TRIGGER

- C1 — 0.01uF, mylar capacitor
- Q1, 2 — BC547, NPN, transistor (or equivalent)
- R1, 3, 4 — 3.3K ohm, 0.25W, 5% resistors
- R2 — 2.2K ohm, 0.25W, 5% resistor
- R5, 6 — 10K ohm, 0.25W, 5% resistors
- Extras — 5V, power supply

The difference between these two voltage thresholds is known as the hysteresis level. This makes the circuit particularly useful in removing noise of digital signals, or more accurately, removing the ability of the circuit to switch at input voltages within the hysteresis area.

Again, you can experiment with this circuit and adjust the supply voltage and the hysteresis threshold voltages by changing the resistor values. ■



SOUND TO LIGHT MODULATOR

Have you been to parties where there's been a strobe or disco light that flashes in time with the music? Well, it's a pretty simple task to build a low-cost version of your own using this circuit.

It simply takes the sound from your audio amplifier or personal stereo, converts it into a DC voltage which then drives a globe to switch on and off.

Looking at the circuit more closely, transistor Q1 is connected up as a simple audio buffer. It provides a bit of protection for your personal stereo from being overloaded. From the emitter of Q1, the signal is then passed onto Q2, a PNP transistor. The 10KΩ pot, VR1, is used to adjust the intensity of the flash and can be adjusted from fully on to fully off. At just the right spot, the light will flash at the same rate as the drum beat of the music.

What we're technically doing is trying to get the transistor Q2 to be just short of turning on. At that point, the music itself turns the transistor on, providing small voltage bursts to diode D2 and the SCR. This last component is known as a silicon-controlled rectifier and is basically a controllable diode.

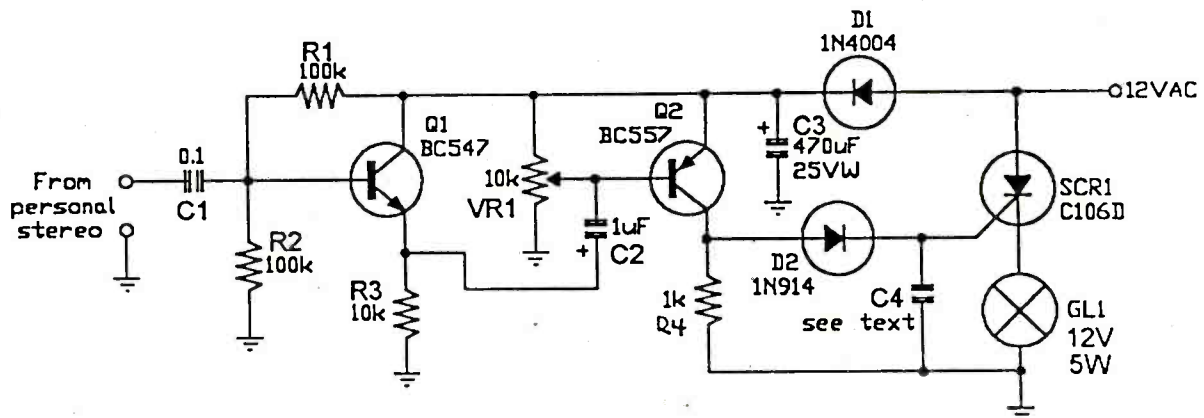
When a voltage pulse is applied to the gate via diode D2, the SCR turns on and lights up the globe. The only way to turn the globe off is to interrupt the power to the SCR. By using an AC power supply, this happens automatically 60 times a second.

DC for the rest of the circuit comes via diode D1 and the 470uF filtering capacitor C3. Capacitor C4 will also make the flashes more intense as well.

The important thing to remember with this circuit is not to use it near people who suffer from migraines or epilepsy, as it can bring on attacks to both sufferers. The globe used in this circuit is a 12V 5W type however it could be a 12W type provided your AC power supply can deliver the current required. Remember to make sure that the wire carrying the current to the globe is heavy duty, otherwise it may melt under the strain. ■

PARTS LIST FOR THE SOUND TO LIGHT MODULATOR

- C1 — 0.1uF, mylar capacitor
- C2 — 1uF, 25VW, electrolytic capacitor
- C3 — 470uF, 25VW, electrolytic capacitor
- C4 — see text
- D1 — 1N4004, rectifier diode
- D2 — 1N914, signal diode
- Q1 — BC547, NPN transistor (or equivalent)
- Q2 — BC557, PNP transistor (or equivalent)
- GL1 — 12V, 5W, globe
- SCR1 — C106D, silicon-controlled rectifier
- VR1 — 10K ohm linear pot
- R1, 2 — 100K ohm, 0.25W, 5% resistors
- R3 — 10K ohm, 0.25W, 5% resistor
- R4 — 1K ohm, 0.25W, 5% resistor
- Extras — 12VAC power supply



SIMPLE TREASURE LOCATOR

If you dream of striking it rich, like most people, then this circuit will probably interest you. It's a simple metal or treasure locator. But this is only half of the project — the other half is a common AM broadcast-band radio.

Actually, it's unlikely that you're ever going to strike it rich with this circuit but it will detect large iron-based objects under the ground and can even be used to find nails in walls etc.

The circuit, shown, is actually an RF (radio frequency) oscillator which is tuned to the same frequency as a weak radio station on your AM radio. You'll know when it's tuned in because you'll, all of a sudden, hear a whistle come from your radio which will change

hear a whistle come from your radio which will change pitch when you vary the tuning capacitor, VC1.

Here's how the circuit works. What this oscillator does is mix or beat with the signal that's coming from the long-distance radio station. Your radio converts this or demodulates the RF signals to produce the audible whistle in your radio.

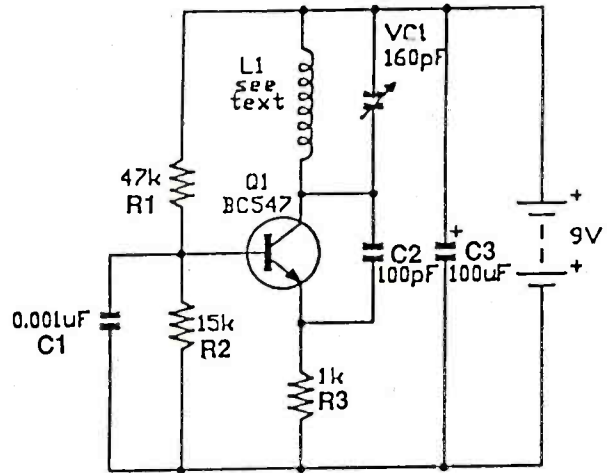
L1 is the search coil which is made up of 20 turns of 0.3mm enamelled copper wire wound around a 10cm plastic former (You can use a sturdy plastic plate for this.)

When the coil is brought near an iron-based metal, it changes its inductance fractionally but enough to

change the frequency of the oscillator. The radio picks up this change and changes the tone of the whistle coming from your radio.

Try it first with a few 4-inch nails just lying on your work bench and run the search coil over the top of them. You'll soon see how far away you can get from them before the oscillator no longer detects them. With a circuit as simple as this, the bigger the object you wish to detect the better. It will detect smaller objects so long as they are closer to the search coil.

This circuit is ideally run from a 9V transistor battery which should last about 40 hours or so—try it out the next time you're at the beach. Who knows what you might find. ■



PARTS LIST FOR THE LOW-COST TREASURE LOCATOR

- C1—0.001uF, ceramic, capacitor
- C2—100pf, ceramic, capacitor
- C3—100uF, 16VW, electrolytic capacitor
- VC1—160pF, tuning capacitor
- Q1—BC547 NPN transistor (or equivalent)
- R1—47K ohm 0.25W 5% resistor
- R2—15K ohm 0.25W 5% resistor
- R3—1K ohm 0.25W 5% resistor
- Extras—9V battery

BLOWN FUSE INDICATOR

This last circuit could save you quite a bit of hassle when you're trying to figure out just what happened to that favorite project. It's a simple circuit but has proven itself very useful many times over.

Looking at the circuit, this simple "Blown Fuse Indicator" uses just a transistor and a resistor as the main detection elements—the rest of the circuit is used to flash the LED on and off to indicate that the fuse has blown.

The emitter of Q1 is connected to the power supply side of the fuse while the base is connected to the other side of the fuse via a 4.7KΩ resistor R1. While the fuse is in working order, it appears as a short circuit, ensuring that Q1 remains off. Since Q1 is supplying the power to the flasher circuit of Q2 and Q3, if Q1 is off, so is the rest of the circuit.

When the fuse blows, the base of Q1 is now pulled to ground by the remainder of the circuit, even though there is no main current flowing and for all intents and purposes appears as though it's off. Q1 now turns on and supplies current to the flashing circuit of Q2 and Q3.

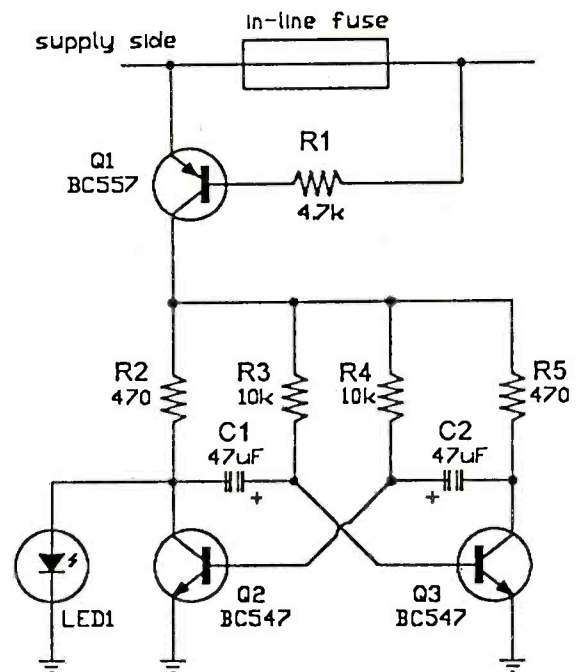
These transistors work in a simple oscillator mode, with Q2 used to shunt the current away from the LED. The frequency, or rate of flashing, is set by the 47uF capacitors and 10KΩ resistors. By varying either or any of these components, you vary the flash rate.

Again, this is a simple circuit which could be incorporated into just about any existing DC-powered project, provided that it normally pulls at least 10mA.

I hope that gives you plenty to think about as well as spurring you onto some project ideas of your own. Next time, we'll take a look at some more useful and simple electronic circuits. ■

PARTS LIST FOR THE BLOWN FUSE INDICATOR

- LED1—5mm, red LED
- C1, 2—47uF, 16VW, electrolytic capacitor
- R1—4.7K ohm, resistor
- R2, 5—470 ohm, 0.25W, 5% resistors
- R3, 4—10K ohm, 0.25W, 5% resistors
- Q1—BC557, PNP, transistor (or equivalent)
- Q2, 3—BC547, NPN, transistors (or equivalent)
- Extras—existing circuit with current usage of 10mA or more



SIMPLE NICAD CHARGER

The first project although being very simple, could save you lots of money. Think about how many dry cells you use in a year and then think how much you could save with a single set of Nicad batteries. The Nicad battery charger uses a single PNP transistor to produce a constant current source—exactly what Nicads need to recharge correctly.

Looking at the circuit, diodes D1 and D2 provide a constant voltage drop of 1.2V between the base of transistor Q1 and the positive supply. Since the V_{be} voltage drop between the base and emitter is a fixed 0.6V, we know that we have a constant 0.6V across the 10Ω emitter resistor. Thanks to Ohm's Law, we know that we're left with a constant current of 60mA by simply dividing the voltage across the resistor by its resistance.

The output is then a constant 60mA regardless of the load connected to it. This circuit can be easily used to charge up a bank of up to four 'AA' size cells in series. Most engineers recommend that you charge each cell on its own (ie: building four of these circuits, one for each cell) but if money is a bit tight, you can easily do quite well with just the one circuit.

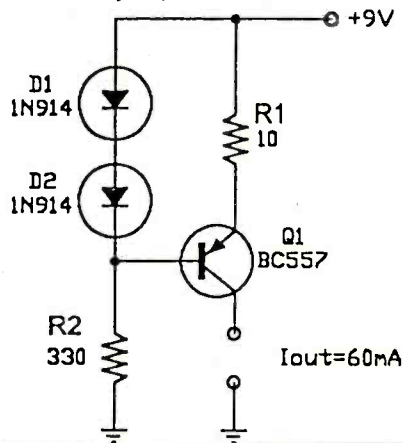
For higher currents drop the 330Ω resistor down to 220Ω and drop the 10Ω emitter resistor down to 6Ω for a 100mA current flow. At this current, you'll need to change the transistor as well to just about any PNP

type that can handle around 500mA of current and dissipate about 2W—oh! a heatsink would be a good idea too.

The circuit as is will charge a set of 'AA' cells in around 14 hours and can be run from your car battery or from a power pack as we mentioned earlier. ■

PARTS LIST FOR THE NICAD BATTERY CHARGER

- D1, D2—1N914 signal diodes
- R1—10 ohm, 0.25W, 5% resistor
- R2—330 ohms, 0.25W, 5% resistors
- Q1—BC557 PNP transistor (or equivalent)
- Extras—9V battery or power supply



CARRIER OPERATED RELAY

Scanner/CB radio enthusiasts usually have a number of receivers operating simultaneously, monitoring emergency, law enforcement, amateur etc. traffic. When a CB radio (4W to 10W range) is keyed i.e. running in the transmit mode, the interaction can cause havoc through acoustic feedback. A simple single transistor carrier operated relay can serve as a very useful controller for attenuating or shutting down your monitors during the transmit period. Using the COR is left up to your ingenuity. The circuit operation is described below.

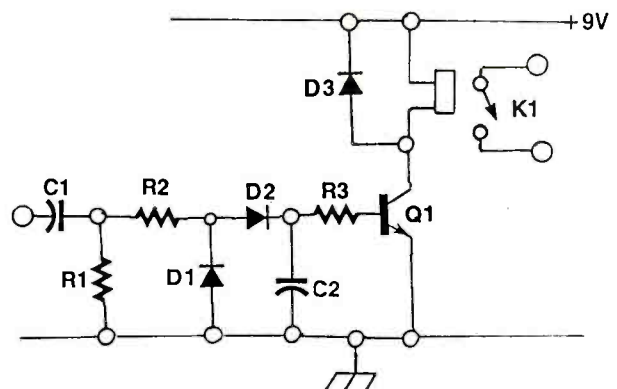
The CB radio output (normally coupled to the antenna) is routed through a T-splitter connector (typically a SO-239 type of connector) thus providing a drive signal to the COR. Input capacitor C1 is fed with this signal, which then goes to resistors R1 and R2, providing loading impedance and current limiting & isolation features respectively. Silicon diodes D1, D2 and capacitor C2, form a voltage doubler rectifying circuit, converting the carrier AC to a DC signal. Resistor R3 limits current to the base input of switching transistor Q1. A suitable relay, K1, in the collector lead can be used to attenuate or silence a monitor receiver. Diode D3 serves as a protection device for the transistor when the relay is de-energized.

Every time the CB is keyed, the relay is turned on and the contacts can thus be used as a trigger signal. The supply voltage is a 9v battery. Values are not criti-

cal, C1 can vary from 10pF to 1000pF—experiment with different values. ■

PARTS LIST FOR THE CARRIER OPERATED RELAY

- Resistors are 1/4 watt, 5%
- Electrolytics are 25-WVDC
- C1—100pF ceramic capacitor
- C2—10uF electrolytic capacitor
- R1—5.6K resistor
- R2—4.7K resistor
- R3—1K resistor
- D1—1N914 silicon diode
- D2—1N914 silicon diode
- D3—1N914 silicon diode
- Q1—general purpose NPN switching transistor, 2N2222
- K1—9v, 2A SPDT mini relay (500 ohm), RS 275-005



VARIABLE FREQUENCY AUDIO TEST SIGNAL GENERATOR USING THE SINGMIN PCB

By Andrew Singmin

USE THIS VERSATILE AUDIO TEST SOURCE FOR VERIFICATION OF THE CORRECT OPERATION OF AN UNLIMITED NUMBER OF AUDIO FREQUENCY DEVICES, RANGING FROM SIMPLE (SPEAKERS) TO COMPLEX (AUDIO SOUND SYSTEMS)!



This is the third project in a set of three using the *SINGMIN PCB*, and together they offer a formidable array of test gear units. By now, readers following the previous two articles ('Audio preamp', Vol. #16 & 'Audio power amp', Vol. #17 of the *Electronics Handbook*) will have a pretty good idea on what to expect here. If you've started to use the *SINGMIN PCB*, and judging from the orders received, some of you are already doing this, then you'll know what the 'flavor' of this project will be like. In keeping with the philosophy of using only readily available components and keeping designs as simple as possible we present this very useful audio test signal generator project. This particular project will be more comprehensive than the previous two and will include controls for varying the frequency and the amplitude of the output signal.

The familiar 555 timer IC (integrated circuit) is used here. This device, when configured in what is called the 'astable' or free-running mode, produces a nice clean looking square wave. To get you in the mood for firing up that soldering iron, let's see what types of tests can be carried out with all three project

units. By connecting them individually or in conjunction with each other, we can test a huge, almost endless number of audio devices, for example, speakers, record players or phonographs, recorders, radios and so on). Just three of the many possible situations are shown in Fig. 1, 2, 3. In the text, the following abbrevi-

ations are used:

- **APR: Audio Pre-Amp** (from Vol. 16)
- **APO: Audio Power Amp** (from Vol. 17)
- **ASG: Audio Signal Generator** (Vol. 18)

By using an assortment of 1/8" mono miniature jack plugs and sockets, together with several of Radio Shack's plastic project boxes, you should be able to build up an impressive array of test units, that can be easily connected into each other. If you are going to do this, the plug/socket requirements are as follows:

- **APR: 1x input socket, 1x output socket**
- **APO: 1x input socket, 1x output socket**
- **ASG: 1x output socket**

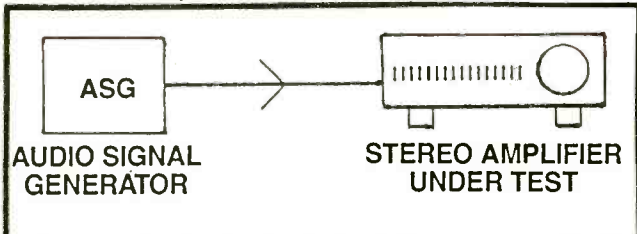


Figure 1. Inject low level test signal into stereo amplifier to check for defective channel or input.

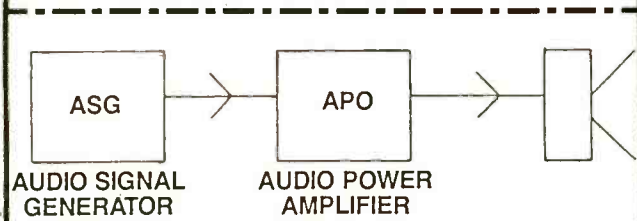


Figure 2. Speaker testing with audio generator and power amplifier.

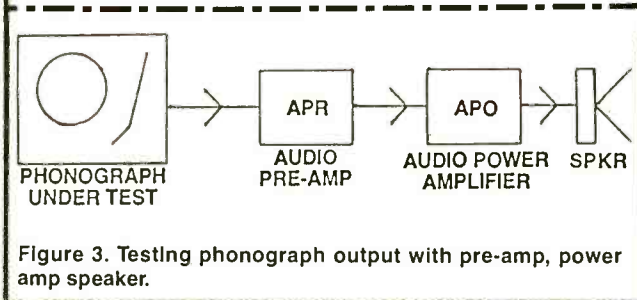


Figure 3. Testing phonograph output with pre-amp, power amp speaker.

The interconnecting patch cords can be short lengths (e.g. about 6" to 12") of twin flexible small diameter lamp cord wire, terminated with jack sockets at each end. There are no high frequencies involved so you don't really need the expense of shielded cable, but if you already have the shielded cable by all means use it. Many of my own units are made up like this. An additional interface cord for the APO is to make up a similar length with miniature crocodile clips on the ends to make connections to speakers, when testing. Miniature crocodile clips are much easier to use, especially when attempting to make connections to the tiny terminals on the back of small transistor radio replacement type speakers. As is common with this series of design projects, only a single 9 volt battery is used for the power requirements, thus conserving valuable space in the project cases.

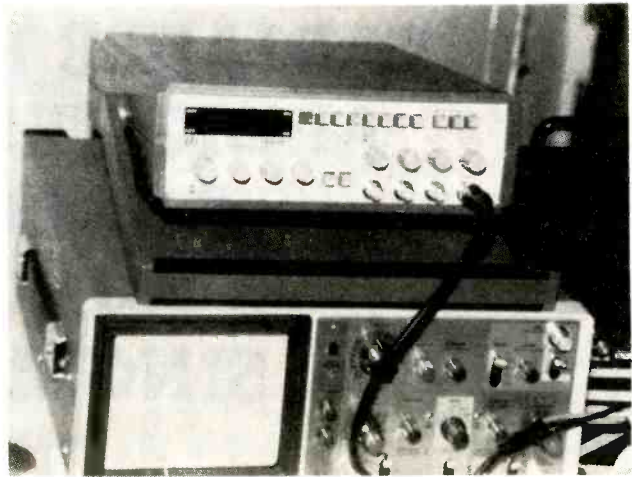


Photo 1. A signal generator and oscilloscope, similar to the type seen here are certainly useful to have and are necessary for critical measurements and signal analysis—but the high cost is a drawback. There could be little change left from a \$1000 bill! By building this project, you'll have fun, learn quite a bit about electronics and have plenty of change left and best of all have one of the most versatile test instruments ever!

Design Philosophy

As with any design there are always compromises to be made when one first starts to list the most important features needed. In general, adding more features means making the circuit more complex, and with added complexity we have more components. With more components the chances of error increases and the risk of having a hobbyist beginner holding a 'useless' PCB is too great! Personally, I prefer building circuits that can be completed in an evening, having no more than a handful of components and with a pretty good chance of working the first time I switch on. Having said all that lets look at the factors influencing this design.

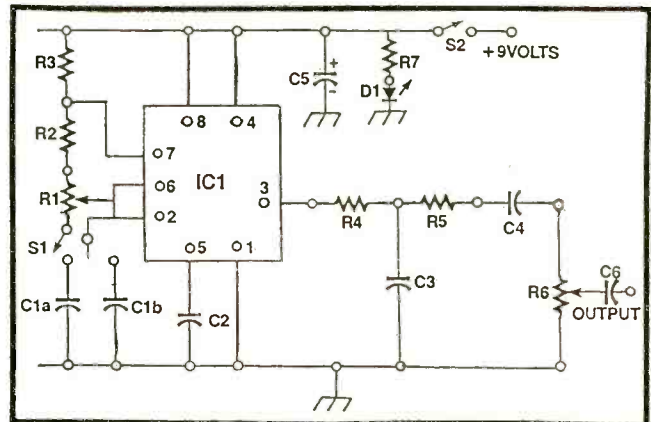


Figure 4. Audio Signal Generator schematic.

1. The ever popular 555 timer used is the workhorse integrated circuit. It has some limitations though, such as the duty cycle (which is the ratio of 'on' period to 'total cycle' period for a square wave) varying when the frequency is varied. This is not a serious issue and in any case the design can be tailored to have a reasonably symmetrical shape, by selecting an appropriate value of resistor connected to pin #7. In order to see the wave shape symmetry, you have to have an oscil-

oscope available. For the applications described here though, it is not a matter of great concern.

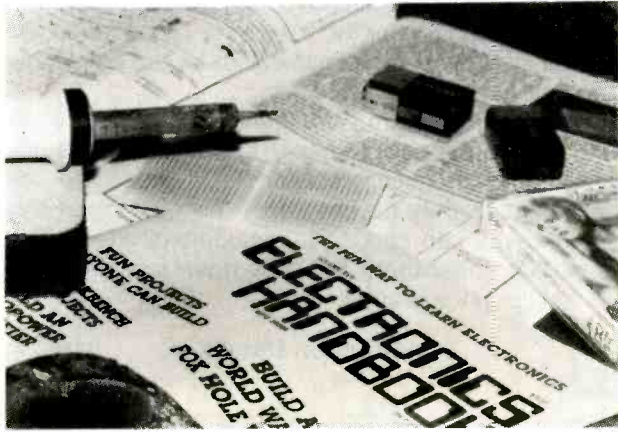


Photo 2. Collect a bunch of your favorite electronics hobby magazines (ours naturally), clean up that soldering iron, stick in your favorite country tape (Lorrie Morgan, Tanya Tucker, Patty Loveless, Pam Tillis...), crank up the volume and let's begin!

2. The normal output (pin #3) from the 555 is a square wave. For audio testing applications a less harsh signal is preferable and this is done by converting the square wave into a triangular wave for a smoother sound. A very basic resistor/capacitor network is used and for our purposes this is quite satisfactory. The amplitude of the converted signal will however increase or decrease as the original signal decreases or increases. The advantage of only needing a simple two component convertor outweighs this anomaly. The voltage amplitude is attenuated by the addition of the convertor network but again this is not an issue as we, in any case, only need low amplitude signals for test purposes.

3. The output signal amplitude can be varied through use of a potentiometer. Since the absolute signal amplitude is dependant on the frequency, there is no point in calibrating the amplitude knob.

4. Frequency can be varied over the most useful part of the audio frequency band, about 64Hz to 6kHz. This frequency range is determined purely by the choice of two timing components (a resistor and a capacitor) for the 555 (pins #2, 6). My preference is to use (where possible) components with 'regular' values e.g. values of 1K, 10K, 100K for resistors and 0.01uF, 0.1uF for capacitors, since these are most readily obtainable. That is how we land up with the above frequency band.

5. Since the 555 timer is spec'd to work down to 5 volts (supply voltage) and the design has been simplified to **not** have calibrated controls, we can, therefore, increase the operating life-time of the battery, by not having a voltage regulator in the supply line. This means that as the battery voltage decreases, so too will the output signal level. It is unlikely that this will be much of a concern.

ELECTRONICS HANDBOOK will always be aimed at helping the beginner in electronics to learn and successfully build these and other hobby projects, and, therefore, my projects design philosophy will always be to place 'simplicity of design' before 'performance'.

Audio Frequency Signal Generator (ASG)

Specifications:

Signal Amplitude: Variable from 0 to 'several' volts (approximately, depending on frequency selected)

Signal Frequency: 580Hz to 6kHz and 64Hz to 680Hz (approximately)

Signal Waveform: Triangular (approximately)

Signal Amplitude

The ASG has a potentiometer control to adjust the level of the output signal from millivolts to volts. Since there are many different factors (most notably frequency and supply voltage) affecting the absolute voltage level, the control knob is not calibrated and in any case for simple applications it is of no major importance. Rotate the potentiometer clockwise for the maximum signal output. Although the maximum signal level is only a few volts, this is more than sufficient for testing purposes.

Signal Frequency

The frequency of the output signal is adjusted with a potentiometer and in conjunction with a two way selector switch, a 'low' and 'high' band of frequencies can be obtained.

The 'high' range extends from about 580Hz to 6kHz and the 'low' band from 64Hz to 680Hz. The change in frequency band is simply done by changing the value of the timing capacitor (C1a or b) for the 555. The capacitors used are 0.01uF (for the 'high' band) and 0.1uF (for the 'low' band). Since the capacitors vary by a factor of '10' so too will the frequency band. By using different capacitor ratios, different frequency bands can be obtained, as seen below.



Photo 3. The **SINGMIN PCB** measures a mere 2" x 2.25" for one of the mini sections and although only about half the size of a regular cassette, it still can accommodate four 8 pin DIL integrated circuits—more than enough space for any of the beginner projects you'll see featured here.

Using a timing resistor of 100K:

a. With timing capacitor = 0.01uF: High Frequency Band = 580Hz to 6kHz.

b. With timing capacitor = 0.1uF: Low Frequency Band = 64Hz to 680Hz.

R1 and R2 in total make up the timing resistor and C1a or b is the timing capacitor.

Signal Waveform

The original signal from the 555 is a square wave but for audio applications a smoother sound is preferable. Where, for example, you are testing loudspeakers, it is important to use a sound source that itself is not distorted. A sine wave would be ideal but a triangular wave is nevertheless a good compromise. Hence we have converted the square wave here into a triangular wave to eliminate some of the harsher sounding harmonics. A very simple resistor-capacitor network is all that is needed to accomplish the conversion.

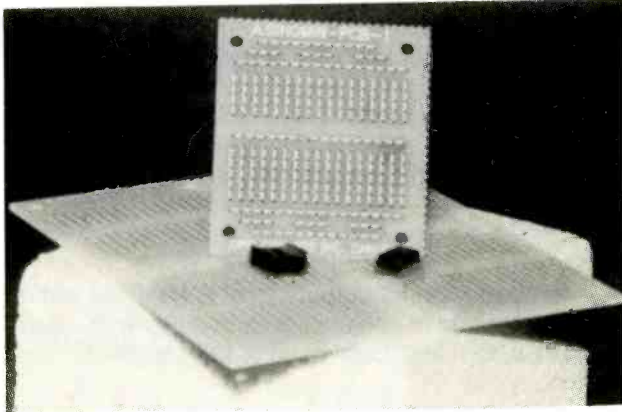


Photo 4. As you can see the IC socket (on the left) and the integrated circuit occupy a very small amount of space and the clear board markings make component positioning easy. Once you start using the *SINGMIN PCB*, perfboard will seem like going back to the dark ages!

Circuit Description

The circuit schematic for the audio signal generator is shown in **Figure 4**. IC1 is the 555 timer integrated circuit. Pins #4, #8 go to the supply line (9 volts) and pin #1 is the ground connection. The output is taken from pin #3. Capacitor C1a, b and resistor R1 (100K potentiometer) are the frequency controlling components. Capacitor C1a or C1b is selected with a two way switch (S1) and allows either a 'high' or 'low' frequency band to be available. If either of these components are reduced, the frequency increases and vice versa. Resistor R2 is added to prevent the resistance from pin #6 to pin #7 going to zero. The duty cycle, which is the ratio of 'on' to 'on + off' period, is set to approximately 50% by the value for resistor R3. With these component values, the output from pin #3, is a square wave with voltage amplitude that is close to the supply voltage value.

The next two components, resistor R4 and capacitor C3, act together as an integrator and convert the square wave into a triangular wave. The triangular wave is reasonably close to a sine wave in shape, thus sounds smoother than the harsher square wave. A potentiometer, R6, is used to vary the output voltage. Further components, resistor R5 and capacitor C4, are needed to buffer the triangular output from the potentiometer R6. A final capacitor, C6, takes the feed signal from the center tap of the potentiometer.

Capacitor C2 is needed for decoupling the 555. The supply voltage is obtained from a regular 9 volt battery and since the 555 device is spec'd to work down to 5

volts, there should be plenty of 'life' even from a fairly run down battery. The mechanical components used here are a 100K potentiometer (R1) for the frequency control, a switch (S1) for the frequency range selection and another 100K potentiometer (R6) for the amplitude control and a supply switch S2.

There are three optional components: Capacitor (C5) placed across the power supply, LED (D1) and its associated current limiting resistor (R7). These are optional because they do not affect the working of the circuit and you can choose to include/omit them. The schematics show them but they have **not** been included in the photographs.

Construction Details

Stage 1

The circuit will be constructed in two stages. We will first build the basic 555 timer circuit to produce a square wave. Once that has been checked to be working, the rest of the circuit will be built. In that way if an error does occur with construction, we have fewer components to deal with. In the course of building numerous projects, I have found that the most common construction errors are always due to:

- Connections going to the wrong point
- Missed connections
- Solder splashes between adjacent pins (because of using too much solder)

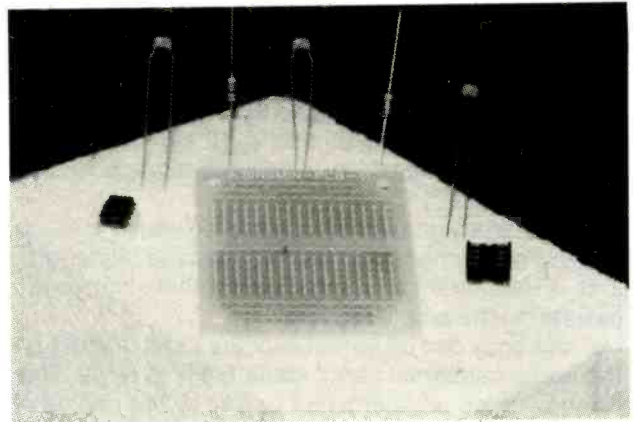


Photo 5. Yes, that's true! Most of what you need to get the first part of the circuit working is seen here. Going from left to right, there's the 8 pin integrated circuit, capacitors, resistor, capacitor, resistor, capacitor and IC socket.

Circuit malfunctions because of defective components has never occurred!

Begin by preparing one of the mini circuit boards (**Singmin PCB**). Firmly grasp the large 4-section **Singmin PCB** and break it into two and then once more into a single piece. The printed circuit board is very robust and can be easily broken by hand.

Smooth over the sharp edges with emery paper or a smooth file. The edges will smooth over very easily. Position the board as shown in **Figure 5** with the 'A.Singmin PCB-1' legend at the top and place the 8 pin IC socket as shown, approximately in the center. Note: If you do make an error and it is not exactly as shown — don't worry. There is a lot of space on the board and components can be placed anywhere around the positions shown. Do make sure, however, that the 'notch'

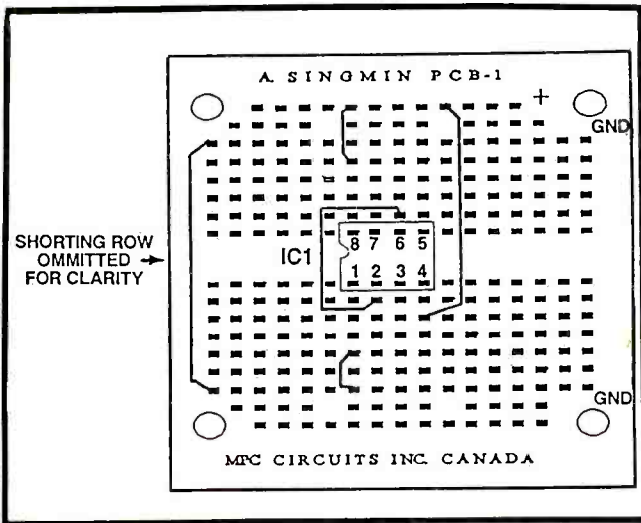


Figure 5. Start with the IC socket and shorting wire links.

on the IC socket faces to the left as shown. This is important, as by convention, pin 1 of the IC is always the pin closest to the notch, on the 'bottom' of the socket — **when the 'notch' faces left**. I find that a small piece of masking tape placed over the top of the IC socket will firmly hold it in place. Have your soldering iron warmed up before hand and with a clean tip, apply the iron to pin #1, heat, add solder, remove the iron and allow to cool without moving the socket. Turn the board over and look at the socket. It should be straight (preferably) and flush with the board. If it appears to be sitting up in the air, re-heat the joint **while pressing firmly on the top of the socket**. You should feel the socket move towards the board. Hold firmly in place while the solder cools. The socket should now be flush.

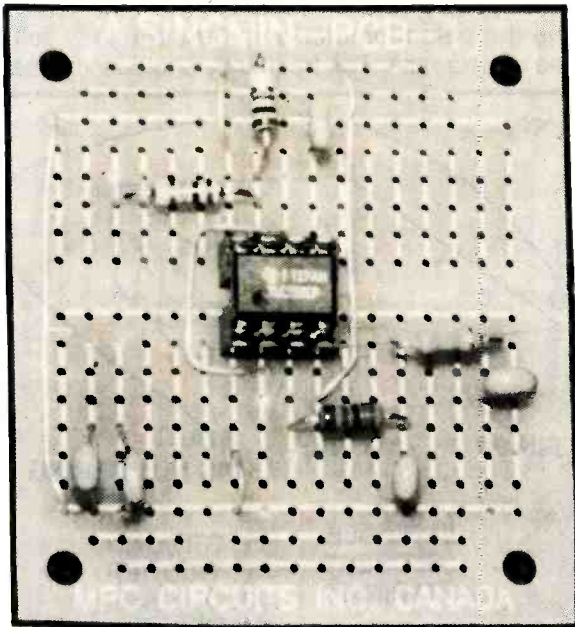


Photo 6. The fully populated SINGMIN PCB test signal generator. Notice how there is plenty of space between components, so that you can really make sure everything's going to the correct location. What could be simpler to use?

Go across to pin #5 and solder as before. The time to correct any errors is before this pin is soldered. If more than one pin has been soldered, it can be a con-

siderable chore to remove the solder and start again! Pin #5 is chosen so that the four corners of the socket are done in sequence. Repeat as before with Pins #8 and #4. After that, the rest of the pins can be done in any order. When you have finished, remove the masking tape and examine all the solder joints very carefully with a magnifier. Check that each hole in the board has been covered in solder and there are no solder splashes or bridges between pins. It is infinitely more advisable to examine solder joints as you go along, rather than wait till the very end. The chances of missing a joint are very high (I speak from experience!)

It is a good idea also to mark the board (use a pencil) as shown in **Figure 5** with the '+' and 'ground' rails at the top and bottom of the board. It is again very easy to make a solder connection to the wrong rail if there are no polarity marks made.

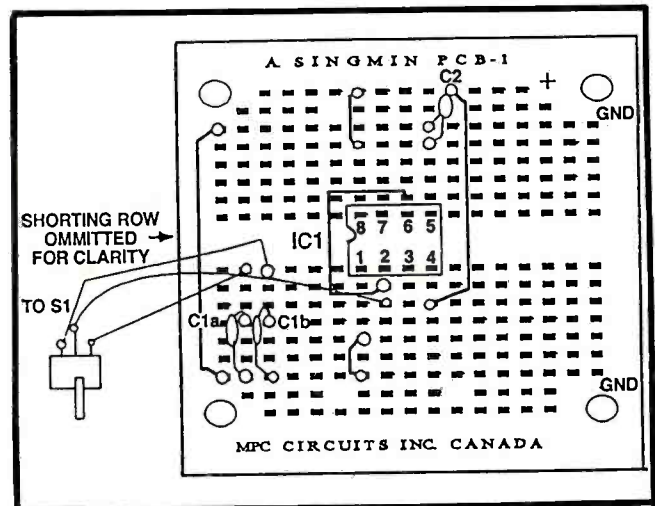


Figure 6. First set of capacitors installed.

For the next stage, add the solid wire links running from pins #8, #4 to the + line and pin #1 to the ground line. For this part of the work, use solid hook up wire with the insulation removed. Any gauge will do, preferably lightweight, so long as it goes through the holes in the board. If it resembles the lead from a 1/2W or 1/4W resistor in thickness, that's fine. You can add the wires in one of two ways. Either solder one end first, allow to cool and then bend the length to fit the second hole of solder, and bend to length first, insert both ends and solder in turn. Use whichever is easier for you. Add the linking wire next, joining pin #2 to pin #6. Finally, add the ground linking wire running from top to bottom as shown in **Figure 5**. We will need this connection since it is easier to have a ground rail at both ends of the board, for soldering purposes. Excess wire from the underside can be cut off. Allow just a tiny length (about 1/10th inch) of wire to protrude rather than cutting flush with the board, so as not to damage the solder joint.

Capacitors

Locate capacitor C2 (0.01uF), a disc ceramic type, and place it from pin #5 to ground as shown in **Figure 6**. Solder in place, allow to cool and cut off the excess leads. Verify that components are in the right place (before cutting) in case you need to remove it to the correct

spot. Incidentally, components can be removed with either a solder sucker or solder braid. The solder sucker works by sucking up the molten solder through a spring loaded piston arrangement, whereas the solder braid works by soaking up the excess molten solder. I usually use a combination of the two depending on how much space is available.

The next capacitors to be inserted are C1a (0.01uF) and C1b (0.1uF), both disc ceramics. They both go to ground and 'free' node points. The selector switch (S1) will later couple either of these capacitors to pin #2. There are three connections needed for the selector switch and hence three flying leads come off the board as shown. For these three leads use any form of flexible stranded wire (smallest gauge possible). With care the stripped, flexible wire ends can be twisted together and threaded through the board holes. Wire lengths of around 6" to 12" can be used for initial testing and later trimmed to size for the final layout.

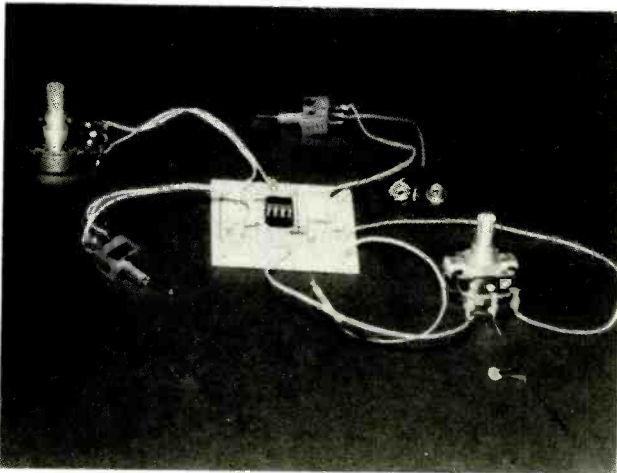


Photo 7. The rest of the mechanical components (2 switches, battery clip and 2 potentiometers) complete your project. Note the capacitor coming from the wiper terminal of the amplitude control potentiometer. That's a bona fide signal generator you see in front of you—pop in a 9v battery and it's ready to roll!

Resistors

Resistor R3 (1K) can easily be inserted between pin #7 and +9V and soldered. Next, resistor R2 (10K) goes from pin #7 to an isolated node point to which a flying flexible lead is connected. This will be one of the connections to potentiometer R1 (100K). The other connection to R1 comes from pin #6. Potentiometer R1 has the center terminal soldered to one of the end terminals (see Figure 7). The resistance decreases between pins #1 & #2 as the control is rotated clockwise. Finally bring out a wire from pin #3 for the output signal. Solder a 9 volt battery terminal clip in place—the black/negative end goes to the ground rail and the red/positive end goes to switch S2. The other end of S2 goes to the '+' rail on the board.

Gently insert the 555 IC into the socket making sure that it goes in as shown in Figure 8. There is a dot on the IC itself positioned closest to pin #1. When looking at the IC socket with the notch facing the left, the 555 IC should have the dot positioned to the lower left hand side. Often the leads to the IC will appear wider than the IC socket. Gently bend the rows of leads inwards so

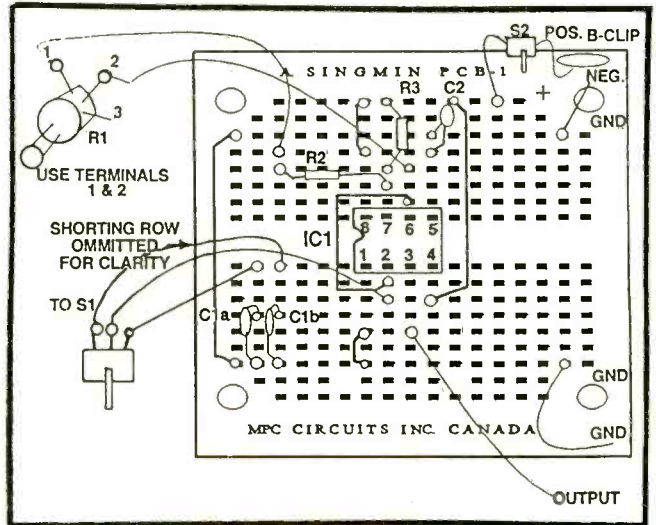


Figure 7. Install resistors, battery clip and switch.

the IC fits more easily into the socket. Check that all the IC pins have entered the socket correctly. Do a final test for correct connections on the top side and error free solder joints on the underside. For testing purposes you only need a small speaker. Couple the output from pin #3 to the speaker input using a length of wire through a 1K. The 1K resistor is used to increase the usual 8 ohm speaker load value presented to the 555 IC output. The exact value is not critical and can be anywhere from a 100R to 1K. The ground return wire goes to the ground rail on the board. Figure 9 shows you exactly how this is done.

Set the potentiometer R1 midway. Connect a fresh 9 volt battery (alkaline preferably) and switch on. All being well you should hear an audio tone (very low volume because of the 1K resistor) from the speaker. Rotate the potentiometer and the frequency will increase or decrease. The frequency should increase as

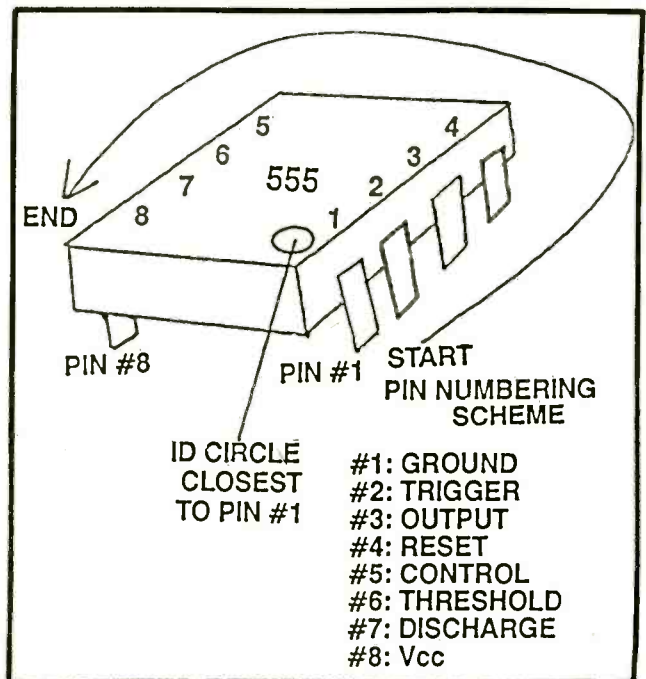


Figure 8. Connections for the 555 IC.

the potentiometer is rotated clockwise. If this is not the case, switch off the power and solder the wire from resistor R2 to the other outer terminal of the potentiometer.

If there is no sound, then switch off and check thoroughly for errors. The most common cause for the circuit not working could be:

- Is the 555 IC in the correct way?
- Are all the components going to the correct locations?
- Is the solder side free from shorts?
- Is the battery clip connected properly?
- Are all the leads intact?

If all is well, switch off and let's move on to stage 2 of the construction.

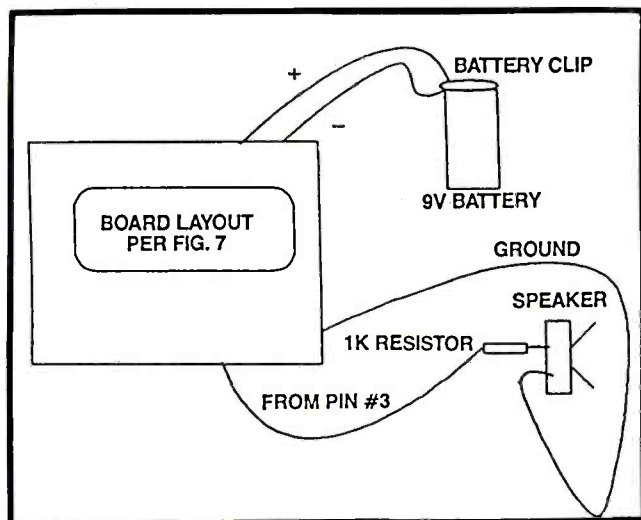


Figure 9. First test set-up. Check that the sound output changes in frequency as R1 and S1 are checked.

Stage 2

What we have done so far is to construct a variable audio frequency square wave source. The next stage

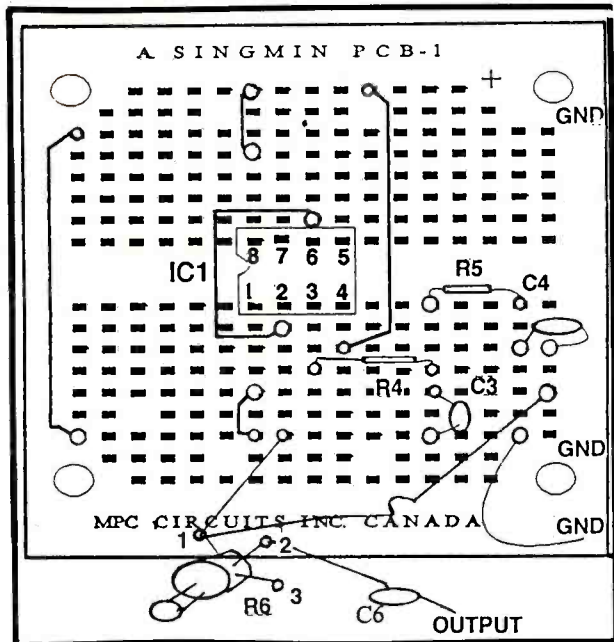


Figure 10. Only new components are shown for clarity.

will be to convert the square wave to a triangular wave (for a cleaner sounding signal) and add a means of controlling the signal amplitude (or volume). Add the two components, R4 and C3 as shown in **Figure 10**. These go to pin #3 of the 555 IC. Next add the resistor R5 and capacitor C4 as shown. Resistor R4's 'odd' value of 15K is needed to get the cleanest looking triangular wave. Resistor R5 is used as a buffer to isolate the signal from the load of the following components. C4 blocks any DC signal. The final component is potentiometer R6 which is our volume control. The terminal connections are also shown in the same figure. The output signal comes from the center tap or wiper terminal through another DC blocking capacitor, C6 that is soldered directly onto the center terminal. Since the potentiometer will be mounted in a project case, connection to the **Singmin PCB** is made with three flexible lengths of connecting wire.

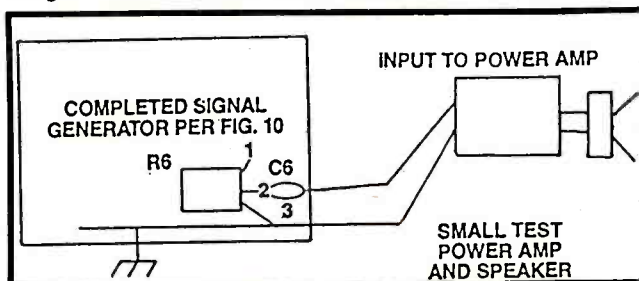


Figure 11. Connections for testing the signal generator with the audio power amplifier.

If you have already built the 'power amplifier' from **Vol. #17 of the Electronics Handbook**, then this will be an ideal time to use it. Alternatively, any suitable power amplifier will do. The hook up connection is shown in **Figure 11**. You will need a small speaker to couple to the output of the power amplifier. Connect a suitable lead to the input of the amplifier and couple the other end to C6. Make sure that the ground lead is also connected between the two units. Turn R6 fully anticlockwise i.e. to the minimum setting. R1 is set to about halfway and switch S1 can be in either position. Switch on the power amplifier first, with its volume control turned about a quarter way up, then switch on the signal generator. Turn the volume (R6) up slowly. You should hear a tone coming from the speaker. Adjust the volume controls of both units to suit and vary the frequency control (R1). The tone will change up or down in frequency. Switch S1 to the other position. Again you should get a different frequency range as R1 is rotated.

Troubleshooting guide

If you're not getting the right signal, go back carefully and check that the components are going to the correct points. If your amplifier input cable is terminated with a pair of crocodile clips you can check the following test points. Keep the ground end connected to the ground line of the signal generator. Keep the amplifier volume control about a quarter way up. Switch on the amplifier and switch on the signal generator. Momentarily touch the flying end of the crocodile clip to pin #3 of IC1. The output amplitude is **very high** so be ready to turn the volume control down quickly! If there is too little space, use a small length of solid hook up wire as a wire probe

(coupled to the crocodile clip). There should be a loud signal (though probably discordant, as it is a high level square wave) as we have already verified in stage 1, that everything works up to this point. Move the probe now to the junction of R4 and C3. The sound should be much clearer and softer. Adjust the power amplifier volume to suit. If there is no sound then the problem lies around R4 and C3. If all is OK, move to the junction of R5 and C4. Again there should be an audible signal here. Continue doing so to the next junction of C4 and R6. What you have been doing here is called signal tracing, i.e. tracing back along the circuit to see where the faulty area lies.

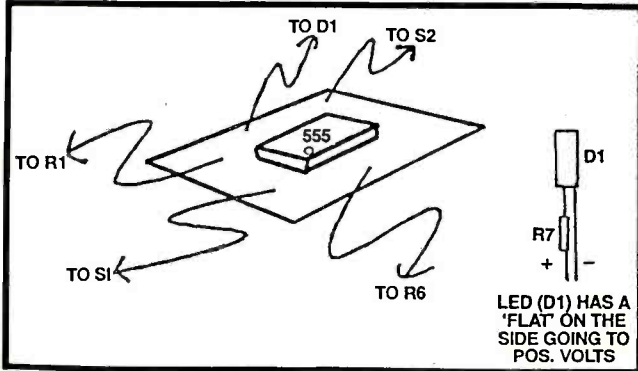


Figure 12. Overall layout of major components.

I will assume that at some stage all is well and everything works. Your Singmin PCB should look something like that shown in **Figure 12**. There are three flexible wires coming off and leading to R1, three more flexible wires leading to R6, two flexible wires going to S1 and one to S2 (the other end of S2 goes to the positive end of the battery terminal). Two wires also go off to the indicator LED, D1. Be aware that current will be drawn by the LED. IF you are going to use it, then connect the resistor R7 to the end of the LED that has **not** got a flat edge closest to it. The flat edge is used by the manufacturer to identify the end of the LED that goes to the negative supply. If you're not sure, then use this simple trick. Solder R7 to either of the leads. Place the flying end of the resistor and the unsoldered end of D1 onto a 9 volt battery. Then reverse the connections. With one way, the LED will light up. Make a note of which end goes to the positive and negative terminals respectively. When you solder the LED later to the board, the identified positive end can go to any spare solder hole in the positive rail and the identified negative end can go to any spare solder hole in the ground rail. For a brighter light, reduce the resistor to 1K but remember that more current is drawn and the battery will run down quicker. Go to a higher value resistor to conserve battery life further e.g. towards 10K.

Choosing a project case

Here are some tips for mounting your signal generator in a case. Plastic is a good choice as it is much easier to work with than metal. Choose a size that gives you plenty of space to work with (larger is always better I find, than trying to cram everything in a tiny case). Don't forget that the 9-volt battery takes up a fair amount of space. Most probably, your case will not have a special 9-volt battery compartment (as these are difficult to find) so four case screws have to be re-

moved for changing the battery. I like to mount input sockets to the left and output sockets to the right. The **Singmin PCB** can be mounted with nuts, screws and spacers so it looks nice and neat. The lid can of course have the two potentiometers, the two switches and the LED mounted on it as another alternative. The options are endless. Check as you go along to make sure that wires or components have not been mechanically damaged. Allow generous wire lengths initially, to check out the signal generator during final testing. Eventually, you can trim the wires down to size for a neater look.

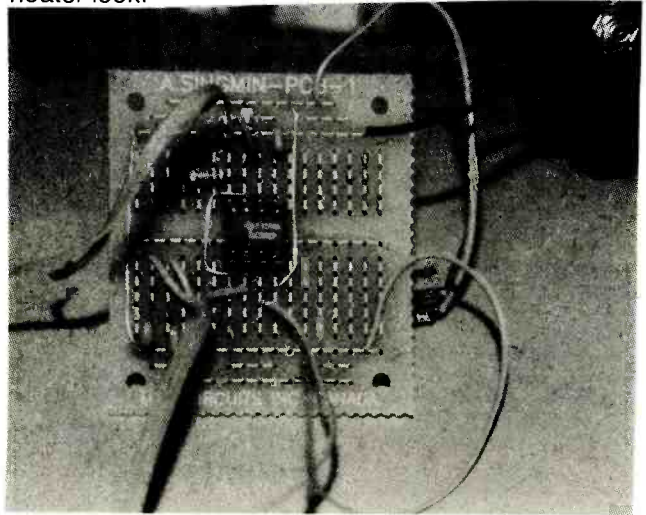


Photo 8. The final shot, with real life messy wires coming off the board. Use flexible wires (thin gauge) for the interconnections to the board. Finally trim to length when you've chosen a project case to your liking.

PARTS LIST FOR THE VARIABLE FREQUENCY AUDIO TEST SIGNAL GENERATOR

All resistors are 5%, 1/4W, electrolytic capacitors, 25V rating.

- IC1 — LM 555 timer IC
- R1 — 100K potentiometer
- R2 — 10K resistor
- R3 — 1K resistor
- R4 — 15K resistor
- R5 — 47K resistor
- R6 — 100K potentiometer
- R7 — 4.7K resistor (optional)
- C1a — 0.1uF disc ceramic capacitor
- C1b — 0.01uF disc ceramic capacitor
- C2 — 0.01uF disc ceramic capacitor
- C3 — 0.1uF disc ceramic capacitor
- C4 — 0.1uF disc ceramic capacitor
- C5 — 100uF electrolytic capacitor (optional)
- C6 — 0.1uF disc ceramic capacitor
- D1 — Light emitting diode (optional)
- S1 — single pole double throw miniature switch
- S2 — single pole double throw miniature switch

Miscellaneous:

- Singmin PCB (1/4 mini section)
- 9 volt battery clip
- 8 pin IC dual in line IC socket
- mounting hardware (nuts, screws, spacers)
- 1/8" miniature jack socket
- control knobs
- 9 volt alkaline battery
- project case

VARIABLE FREQUENCY AUDIO TEST SIGNAL GENERATOR USING THE SINGMIN PCB

The potentiometers will need their shafts cut down to size and knobs attached. Measure, before hand, the length of shaft needed for the knobs chosen before cutting the excess length off. The battery can be mounted with double sided tape to keep it from rattling around.

A series of photographs show the construction of the Singmin PCB at various stages of progression. You

can use these in conjunction with the figures to help with identifying the solder points. Hobby projects are meant to be enjoyable and constructive, so take your time with each stage, checking as you go along and in that way you'll improve your chances of having an error free board. The Singmin PCB is available through C&E Hobby Handbooks. Look for the advertisement in this issue. ■

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THE UBIQUITOUS DIODE

By Darren Yates

PART I

Ounce for ounce and for the relative low cost, diodes are probably the most useful component ever produced and they can certainly do more than just make your power supply function.

If you visit your local electronics supply store and invest the pocket change necessary to purchase a 1N4004 or whatever diode, you're buying a lot more than just a rectifier diode. Diodes have been used for years as power rectifiers for power supply but they can also be made to do other jobs including voltage multiplying, digital logic functions, amplitude modulation and detection, audio signal expansion and compression and a few other things we'll observe along the way.

Ok, so where do we start? Perhaps it would be a good idea to take a close look at this tiny two-lead device and see what makes it tick.

A diode has two leads, just like a resistor and often looks like that shown in figure 1. The biggest difference between the diode and the resistor, however, is that a diode will only allow current to flow in one direction.

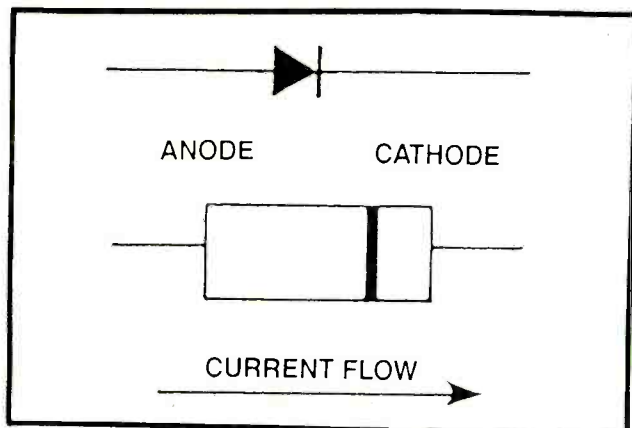


FIGURE 1: PHYSICAL APPEARANCE OF A DIODE

Unlike a resistor, there has to be some way to identify which end of a diode is which, otherwise we'll end up with all sorts of problems. As you can see in figure 1,

near one end of the diode there is a single colored bar that runs around it. The end furthest from this is called the ANODE and the end closest is called the CATHODE.

Current always flows only from the anode to the cathode. An easy way to remember this is that "A" (for anode) comes before "C" (for cathode) in the alphabet and current always hits the anode before the cathode as it flows through the diode.

Above the physical diagram in figure 1 is the graphical symbol for a diode, which is a triangle pointing in one direction, with a bar at the end of it. This symbolises that the current flow is in the direction of the arrow but that it doesn't flow back the other way.

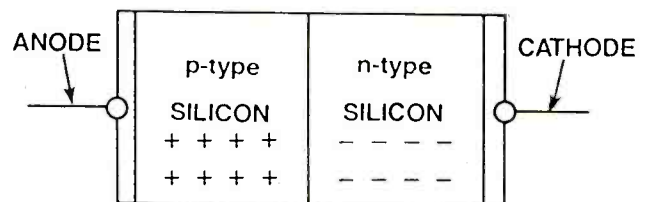


FIGURE 2: PHYSICAL STRUCTURE OF A SILICON DIODE

A diode, however, is more than just a one-way piece of wire. It is the simplest semiconductor junction that

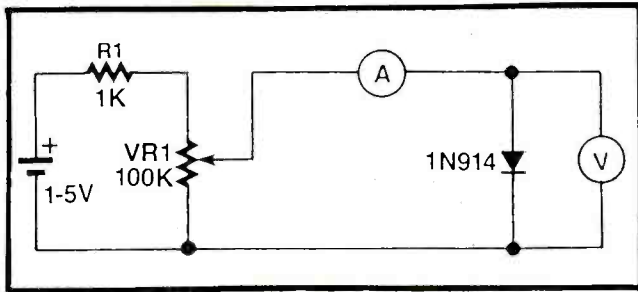


FIGURE 3: BASIC CIRCUIT TO TEST HOW A DIODE WORKS

can be produced, and is called a "pn junction". If you take a look at figure 2, you'll see the reason why.

Back in the early days of semiconductors, diodes and transistors used to be made from a poisonous substance called Germanium, but now they are all made out of the much safer, silicon.

Without going into unnecessary detail, the n-type silicon is a thin wafer of silicon material which has an excess of electrons and the p-type silicon has an excess of what we can call "holes". These are really gaps in microscopic atoms where electrons would normally be.

These holes are produced by a method called "doping" (seriously!), which is the controlled addition of impurities into the silicon. The most important thing here, practically-speaking is that the amount of current flow between the two silicon regions, from the positive region to the negative region, is determined by the voltage across the two regions.

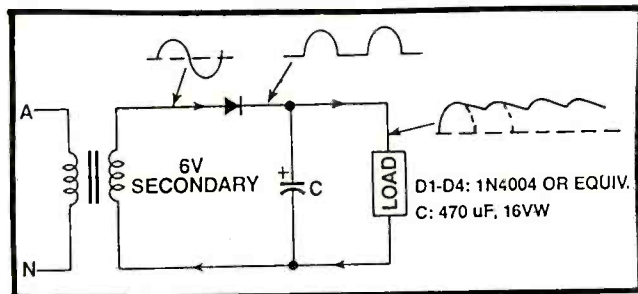


FIGURE 4: HALF WAVE RECTIFIER

This may sound a bit confusing but we'll explain it by giving an example. If you look at the circuit in figure 3, we've made a little test jug so you can have a go yourself and see what happens.

If you can get hold of two multimeters (they don't need to be digital ones and it would probably be better if they weren't), select one of them on the 0-2mA range (or similar) and the other on the 0-1V range.

Connect the mA multimeter in the circuit as shown and connect the volt multimeter across the diode. Now if you connect up the 1.5V battery, we're ready to go.

Start with the variable resistor so that there is maximum current flowing through the diode. You should find that there is about 0.8mA of current flowing through the multimeter and that there is about 0.6 or 0.7V or so across the diode. Now if you rotate the variable resistor, the current should start to drop but when the voltage across the diode drops below 0.5V or so, you should see the current start to drop off dramatically.

The current will drop anyway when you start to turn the variable resistor around, but it's when the diode

voltage begins to drop that is most important.

The reason for this is that the diode must have a voltage across it before it will conduct a current, but as it approaches about 0.6V, the current flowing through it will increase enormously for very little change in the voltage across it. This is because the voltage acts like a "step" to lift up the energy level of the p-type region so that current flows.

OK. So we've established that a diode only conducts in one direction, namely, from the anode to the cathode and that there is a "voltage drop" of about 600mV (or 0.6V) across the diode when it is conducting.

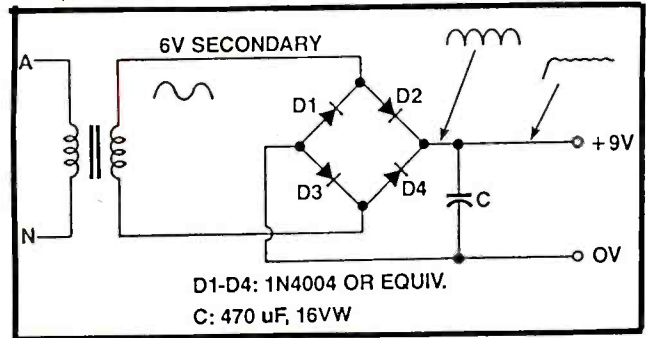


FIGURE 5: FULL WAVE RECTIFIER CIRCUITS....

That's enough of the boring stuff! Let's see how we can make the diode do different things!

HALF-WAVE RECTIFIER

Figure 4 shows the most common and basic circuit for a diode. This is a simple half-wave rectifier, a "bread and butter" circuit for the diode.

The idea of the circuit is to turn the AC power coming from your wall outlet into DC that your Walkman, video recorder, CD and thousands of other items can use.

AC power is a sinewave with a frequency of 60Hz and has a voltage of 115V (in Australia, the frequency is 50Hz and the voltage is 240V). Your Walkman only requires about 3VDC so we must change the type of voltage as well as drop it down a long way.

To drop the voltage down, we use a device called a transformer, which as its name suggests, transforms the voltage to another value. Transformers can be made to make the voltage higher (called a "step-up transformer") or lower (called a "step-down transformer"). What we need for our job is a step-down transformer. You won't be able to see the difference between the two from the outside.

Underneath the layers of tape you can see, are two fairly large coils, which are just windings of wire. The amount of voltage you get at the output depends on the ratio of turns between the two coils.

For example, for our simple circuit, we'll have 115Vrms (we'll explain the "rms" a little later) on the input and we'll need 3VDC at the output. Jumping ahead a little, using our single diode power supply circuit, the output in DC voltage is about half the RMS voltage.

Since we need 3VDC, that means we need about 6Vrms at the output end of the transformer. Remember that a transformer just changes the voltage level: it doesn't turn AC power into DC! So, for our transformer, we need 115V going in and 6V going out. Now remem-

ber how we said that the voltage depended upon the number of turns in each winding, well, the ratio of the number of turns of the "primary winding" (that's where the 115V goes) and the "secondary winding" (that's where the 6V comes out of) needs to be 115/6 which is nearly 20:1.

A "turn" is simply a complete circle of wire, usually enamelled, around the transformer.

That means any transformer with either 40 turns on the primary winding and 2 turns on the secondary or any multiple (up to a point) of these will be suitable.

OK, we've got off the track a little but it is important to know how everything works otherwise you'll miss out on the important bits.

Now that we have our 6V coming out of the transformer, we still have the problem of turning it into DC. Since it is still AC at the moment, the voltage keeps changing polarity. If we look back to figure 4, let's consider what's happening at both sides of the diode. Half the time, the anode voltage will be positive and the cathode end will be negative, but the other half of the time, it swaps around!

If you connected this changing voltage to your Walkman, it would give up and die in a second! Now you can probably see the reason for the diode. Remember we said that a diode will only conduct current one-way? We also said that this only happens when the anode end is positive with respect to the cathode end.

What simply happens in our circuit is that for half the time the anode is positive, the diode allows a current to pass through, and when it is negative, it stops the flow. If you were to look at the waveform of the power coming out of the diode, it would look that drawn in figure 4. Even though it does look a little sick, the current flow is only in one direction, i.e. we have DC. If you measure it with a voltmeter, it would be around 3VDC even though we have 6Vrms coming out of the transformer.

"RMS" stands for Root-Mean-Squared which is a way of describing the absolute voltage level of an AC power line. Since our diode chops off the negative half of the sinewave, we only end up with half the voltage, hence the 3V.

The DC we end up with coming out of the diode is still pretty awful, so we add a filter capacitor which smoothes the waveform a bit more. Now we have a quite acceptable power supply!

The filter capacitor also boosts the voltage up to about 6VDC. This is because the capacitor acts like a storage cell, provided the load current is not too large, to provide a more constant level of voltage. As the load current increases, the voltage will drop down. This is because the load current is being taken down from the capacitor continuously, but the capacitor itself, is only being topped up for half the time i.e. when there is a positive current flow.

FULL-WAVE RECTIFIER

Although the half-wave rectifier is simple, it wastes half the power we could use if we had the right circuit, and as we've just shown it cannot consistently supply a constant voltage under heavy load currents.

Figure 5 shows a full-wave rectifier. It's so named because it turns both halves of the wave so that the current continually flows in the one direction.

The four diodes are connected so that they form a diamond shape with each diode pointing from left to right. This configuration is called a "diode bridge". Every point on the bridge has two diodes connected to it. Notice that there are two points on the bridge where a diode is pointing to it and another diode pointing away from it. The secondary winding of the transformer is connected to the points. The other two points have both diodes pointing away from it or pointing to it.

Our DC voltage is taken from these points: the point where both diodes are pointing away from it is zero volts or ground and the other end is the positive end.

The operation of this type of rectifier is not obvious so we'll explain it in detail.

Remember how we said before that the voltage across the secondary winding changes polarity, one minute one is positive and then next, the other end is? This voltage is applied to the bridge, which works like this:

Looking at figure 6, if we assume to start with, that the end of the transformer connected to diodes D1 and D2 is positive and the other side of the transformer is negative, then current flows through D2, out through the load you have connected to the circuit, then back through the ground line, through diode D3 and to the transformer.

At this stage, no current flows through diodes D1 and D4 because they are reversed biased i.e. the cathode

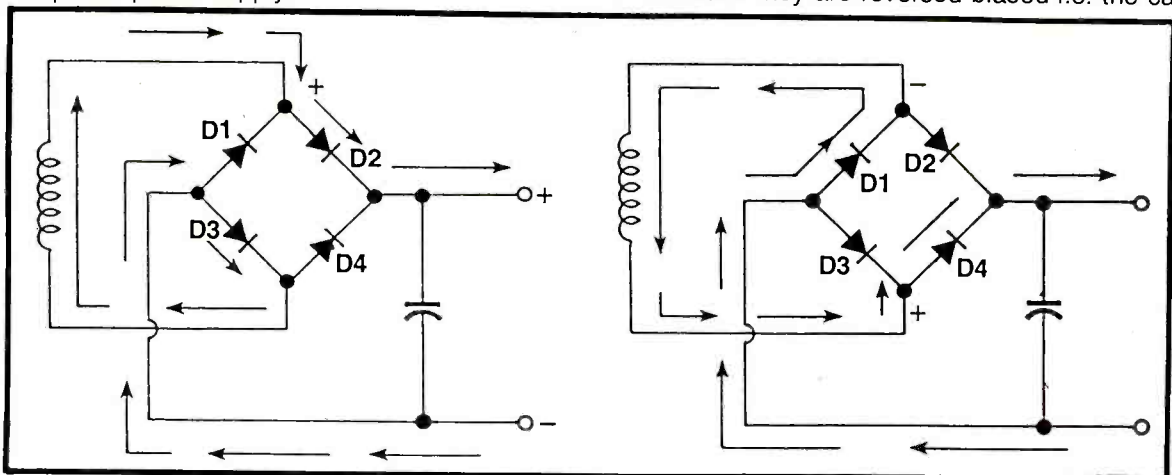


FIGURE 6: CURRENT FLOW DURING BOTH HALVES OF THE SINEWAVE

ends are at a higher voltage than the anode ends of both diodes.

Now, when the voltage across the transformer changes polarity, the point connected to diodes D3 and D4 is now more positive than the point connected to diodes D1 and D2.

This time, current flows through D4 to the load, then back through the ground line and then to the transformer via diode D1. Also, diodes D2 and D3 are now reversed biased so no current flows through them.

The filter capacitor at the output shown in figure 5 does the same job as that shown in the half-wave rectifier circuit, but in this case the capacitor is being topped up by every half cycle instead of every second one. This means that it can supply a much larger current to the load while still maintaining its output voltage.

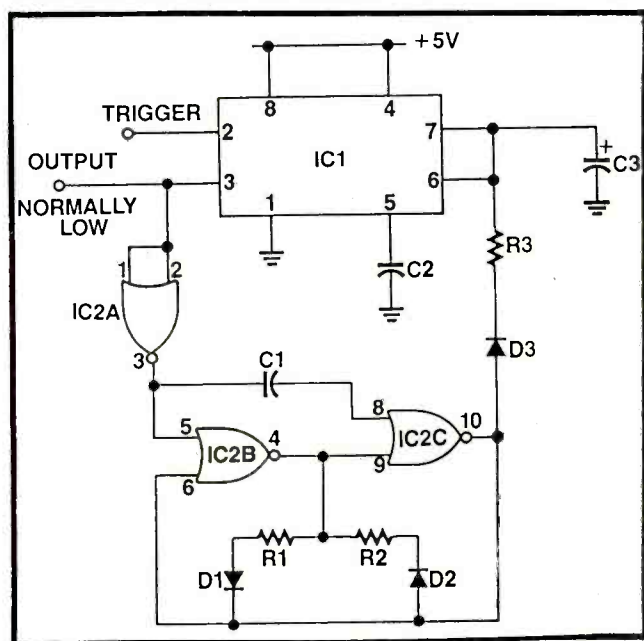


FIGURE 7: LONG DELAY TIMER CIRCUIT

LONG DELAY TIMER

Let's depart from power supply circuits for a while and look at a different use for the diode.

Most of you would probably know how a 555 timer IC works, in fact, you probably have one or two lying around on your bench or in your "junkbox."

They are a very useful IC, particularly as a "one shot" or monostable. This is where the IC is triggered by a negative-going pulse, which produces a high output for a particular length of time, determined by an external resistor and capacitor.

The problem occurs, however when trying to create delays of 10 seconds or more. The equation for the time delay is as follows:

$$T = 1.1 \times R \times C, \text{ where } R \text{ is in ohms and } C \text{ in farads.}$$

If we wanted to generate a 20 second delay, we would need a 1M resistor and 22uF electrolytic capacitor (or thereabouts). That's OK in theory, but in practice, electrolytic capacitors are renowned for their high leakage current. This results in the time delay being inaccurate, depending on how much leakage current there is.

The circuit in figure 7 fixes this problem and also enables the generation of time delays up to about 40 minutes with a high degree of accuracy.

Furthermore, it uses diodes to do two totally different things, both of which are vital for the circuit's operation.

The operation of the 555 is as usual except that when the trigger is applied to IC1, the capacitor is no longer charged up from the power supply as in the usual way, but instead, from a pulsed output coming from IC2c.

Before we go any further, we should explain how this is possible.

Capacitor C3, diode D3 and resistor R3 form what is known as a "charge pump". Figure 8 shows how this works.

In figure 8a, the capacitor is charged up through the resistor and the diode by a DC voltage. In this circuit the diode doesn't do anything.

If we say this circuit has a time constant of $R \times C$, we mean that it takes $R \times C$ seconds to reach a certain point. It isn't important for the moment what that certain voltage is, since the capacitor charges up at a logarithmic rate. What is important is this rate or speed at which the capacitor charges.

If we now take a look at figure 8b, instead of feeding the charge pump with straight DC, we use a square wave. This is where the diode comes into action. A square wave as its name suggests—is high for half the time and low for the other half.

If we place a diode in series with the RC circuit, we stop the capacitor from discharging through the resistor when the input goes low again. Therefore, we get a series of positive pulses which charge up the capacitor, but because the pulses only occur for half the time, we get a DC voltage for only half the time.

This means that it takes twice as long for this circuit to charge the capacitor up to the same level it would if charged up with the circuit in figure 8a.

If we look at figure 8c, the input signal is a 10% duty cycle pulse. To explain this, "10% duty cycle" means that the positive pulse occurs for 10% of the time. Notice this is regardless of the frequency. If we consider DC as a 100% duty cycle then it should be clear that if we feed the charge pump in figure 8c with a 10% duty cycle that it must take 10 times longer to charge up the capacitor to the same level as that in figure 8a.

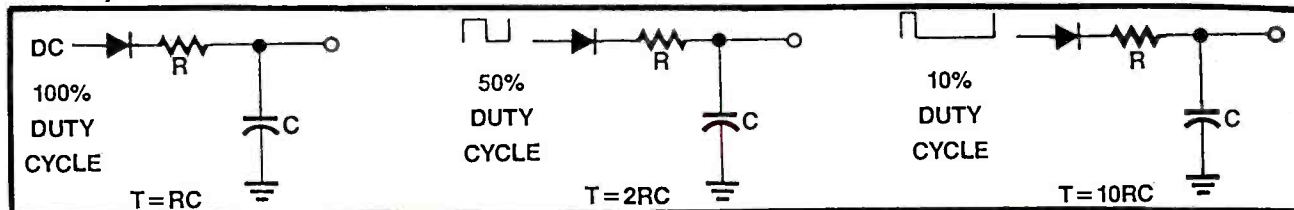


FIGURE 8: THE CONSTANT OF A CHARGE PUMP CAN BE VARIED BY USING A PULSE TO CHARGE THE CAPACITOR

The threshold input of the 555 is when the capacitor voltage is 2/3rds of the supply voltage. Thus by using pulses to charge up the capacitor rather than DC, we can vary the time it takes to reach this point.

OK. Now we have to find some way of producing the pulses when we want them.

When a negative trigger is applied to pin 2 of the 555 timer, the output at pin 3 goes high. We can use this to turn on an oscillator which can then be used to fill up our charge pump.

If you look back to the circuit in figure 7, IC2 is a CMOS 4001 quad 2-input NOR gate IC package. The first gate, IC2a, is connected as an inverter to the output of the 555 timer. The output of IC2a is then used to turn off and on, the pulse generator made up of IC2b and IC2c.

Before we go any further, we should explain a couple of things. The reason we used a 4001 is because when the pulse generator is turned off, we want the output to be held low. If it is held high, which is what would happen if we used a 4011 NAND pulse generator, the charge pump would fill up too fast as normal and defeat the purpose of the circuit.

To make a NOR pulse generator work, we must make the control input low and then make it high to stop it at the appropriate time.

Resistor R1 and R2, and diodes D1 and D2 determine the pulse width and hence the time delay.

The diagram in figure 9 will help explain how this works. Looking at the first half of the diagram, let's assume that the output of IC2c is high, and it's filling up the charge pump (D3, R3 and C3). This means that the output of IC2b is low, because it, too acts as an inverter, so capacitor C1 is charged up from the high output of IC2c, through diode D2 and resistor R2.

Looking now at the second half of the diagram, once the voltage across this capacitor reaches the threshold level of the input to IC2c, the output will drop low. Capacitor C1 will now discharge through resistor R1 and diode D1 to the low output.

The diodes make sure that the current flow is split into two paths depending on which way it's flowing. If the current is flowing from the output of IC2c, it passes through diode D2 and resistor R2, and if it's flowing back to the output, it passes through resistor R1 and diode D1.

If both resistors are made the same value, then the output of IC2c will be a square wave, but if we make one resistor bigger or smaller than the other, then the pulse width will depend on the ratio of the two resistors.

If we make R1 ten times as big as R2 then we'll get a 10% duty cycle (very narrow) pulse. If we make R2 ten times as big as R1 then we'll get a 90% duty cycle (very wide) pulse.

As an example, if we make R1 equal to 1Mohm and R2 equal to 1Kohm, then the circuit will give us an "on time" of approximately 37 minutes. You could use this circuit to turn your Walkman on, and then it will automatically turn itself off after that time has expired.

Or, if you're very careful, you could use this as a power appliance time, say for an iron, so that it turns itself off after the desired time interval. Anyway, the choices are only left up to your imagination!

Next time, we'll have a look at audio applications of diodes including signal compression and amplitude modulation. See you then! ■

PARTS LIST

- C1—0.01uF Mylar Capacitor
- C2—0.1uF Mylar Capacitor
- C3—2.2 uF, 25 VW Tantalum Capacitor
- D1-D3—1N4001 Diodes or similar
- IC1—LMC555 CMOS Timer
- IC2—4001 CMOS Quad 2-input NOR Gate
- R1, R2— See text
- R3—1M ohm, 0.25W Resistor

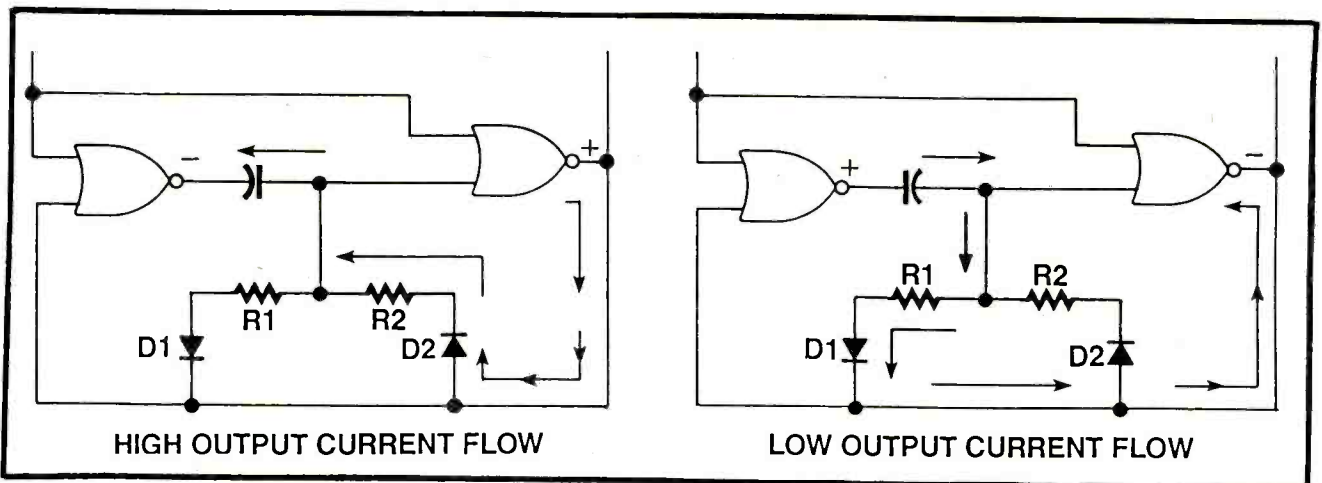
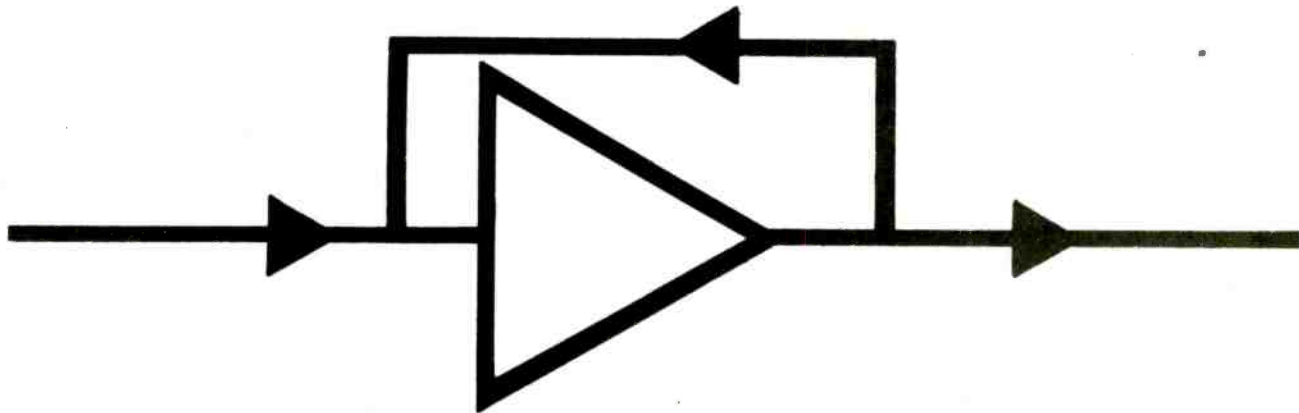


FIGURE 9: OPERATION OF A PULSE GENERATOR

IC TESTBENCH



HIGH FREQUENCY TRANSISTOR CHECKER

For experimenters into building single transistor VHF FM transmitter circuits, this circuit idea could save you wasting hours of time trying to debug an apparently dead circuit. Common general purpose NPN transistors are often specified as being suitable for FM transmitters in the 88 to 108 MHz region. Sometimes these transistors can be purchased in bulk with perhaps no identifying part number. Through trial and error it has been found that not all of these 'unmarked' devices will oscillate at around 100 MHz.

The circuit shown below checks transistors for noise emission, since it has been empirically found that devices which are good noise emitters also make good VHF oscillators. Devices which emit no noise at all, have been found not to oscillate at all. Although transistors can be DC checked, this might not be good enough to verify their 'oscillatory' capability.

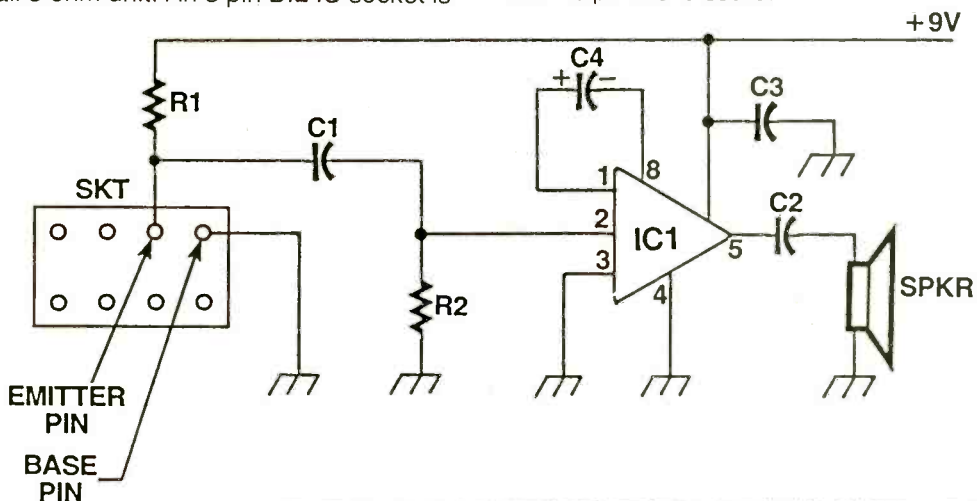
IC1 is an LM386 audio power amp, configured in a very basic mode, since it is only intended to amplify short term duration noise. There is no need, therefore, to waste time building a high quality audio amp. The speaker is a small 8 ohm unit. An 8 pin DIL IC socket is

used to allow transistors to be quickly and easily checked. Resistor (R1) biases the transistor under test (reverse) with capacitor (C1) coupling the noise signal out to the input pin #2 of the LM386. R2 is the signal load. Capacitor (C2) AC couples the output to the speaker. C3 is required for the LM386 to operate correctly. C4 boosts the IC's gain.

To use, plug a transistor into the test socket, taking care that the emitter and base are connected as shown. Use only NPN devices. Good transistors will generate a noise output, rejects are silent! ■

PARTS LIST FOR THE HIGH FREQUENCY TRANSISTOR CHECKER

- IC1 — LM386 audio power amp
- R1 — 1M resistor
- C1 — 0.01uF capacitor
- R2 — 100K resistor
- C2 — 10uF capacitor
- C3 — 100uF capacitor
- C4 — 10uF capacitor
- Spkr — 8 ohm mini-speaker
- Skt — 8 pin DIL IC socket



LOW FREQUENCY PULSER

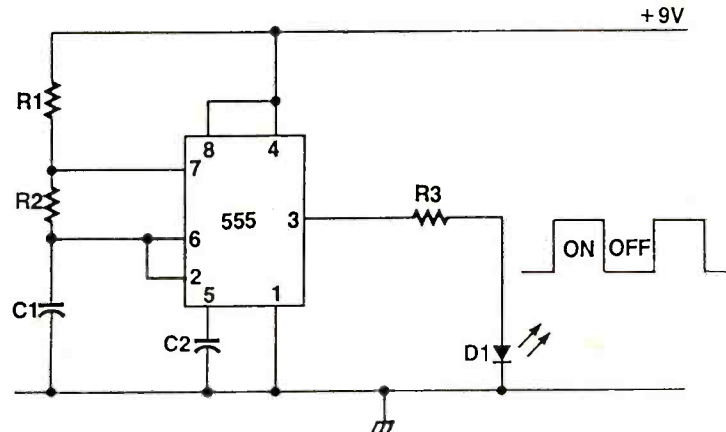


For the newcomer to digital electronics, a slow pulse train source, is a very useful circuit to build. The slow speed will allow you to easily watch the high to low transitions taking place. The 555 timer is shown in the astable mode. Approximately similar "on" and "off" periods are obtained with the values given. Duration in either the "on" or "off" state is a few seconds. The output LED (D1), fed through current limiter (R3), turns on when the output goes high. Timing components (R1, R2, & C1) control the pulse frequency and "on" to "off" periods. C3 is a standard required capacitor for correct

operation of the 555.

PARTS LIST FOR THE LOW FREQUENCY PULSER

- IC1 — 555 timer
- R1 — 10K resistor
- R2 — 100K resistor
- R3 — 1K resistor
- C1 — 22MFD capacitor
- C2 — 0.01MFD capacitor
- D1 — LED, (any type)



LOW FREQUENCY PULSER

CODE PRACTICE OSCILLATOR



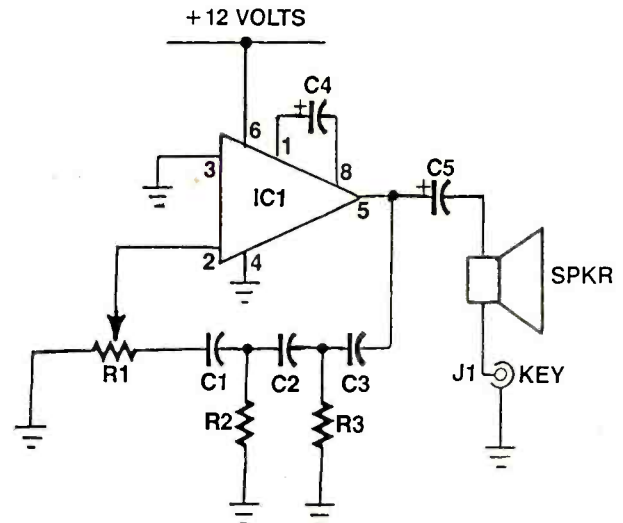
Here is a simple code practice oscillator you can build. It consists of an amplifier and a three stage RC feed back phase shift network R1, C1, R2, C2 and R3, C3 designed to produce an 180 degree phase shift at 655 Hz. This network couples the output of the amplifier to the inverting input of the amplifier integrated circuit. The gain of the amplifier is greater than the approximately 29 required for oscillation. Capacitor C4 increases the gain of IC1 from 20 to 200 which is greater than the required 29 to produce oscillation.

The frequency may be changed by solving the relationship $f = 1/(15.3 RC)$. The values computed are for one of the three stages of the network and apply to the other two stages as well. The output is coupled to a small speaker in series with the code key. Capacitor C5 adjusts the volume to a listening level less than the 400 milliwatts possible.

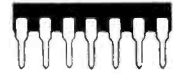
Adjust R1 for oscillation and good tone and keying characteristics. All of the components are available from Radio Shack.

PARTS LIST FOR THE CODE PRACTICE OSCILLATOR

- IC1 — Audio amplifier LM 386
- R1 — 10K potentiometer
- R2, R3 — 10K resistors
- C1, C2, C3 — 0.01 microfarad capacitors
- C4 — 4.7 microfarad capacitor
- C5 — 3.3 microfarad capacitor
- J1 — Phone jack
- SPKR — 8 ohm speaker



TWIN SCANNER MONITOR



Dedicated scanner radio enthusiasts are more likely to own more than one scanner (unlike the casual scanner listener). Late night monitoring through headphones limits you to one scanner only. Here's a neat circuit for monitoring, quietly and privately, through headphones, two scanners or a scanner and ham band radio. We use as the main integrated circuit, the LM 386 audio power amp. Since there is a ton of audio power available from the source scanners, the gain for the IC is set to x20 only. Two separate volume controls give you much more versatility. Current drawn is minimal (less than 10 mA) from a 9 volt battery.

IC1, is the audio power amplifier IC, driving a pair of headphones. The input from scanner #1 goes to vol-

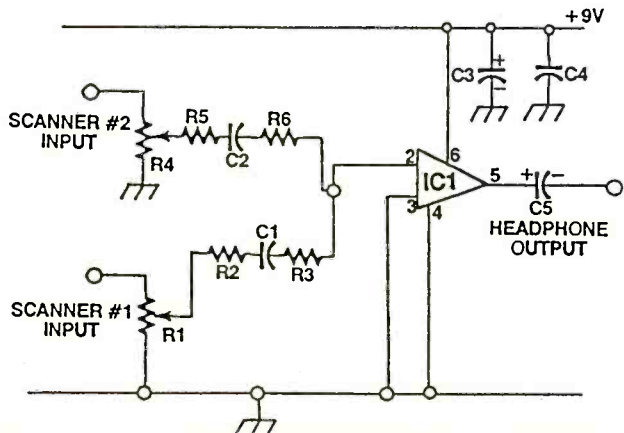
ume control R1. Buffer components, R2, C1, R3 coming off the wiper terminal feed into Pin #2 of IC1. The second scanner #2, feed, comes from potentiometer R4. Similar buffer components, R5, C2, R6 feed the signal also to pin #2. Capacitors C3 and C4 are needed across the supply line for the IC. Finally, capacitor, C5 ac couples the output to headphones. There's plenty of drive for regular 8 ohm or 32 ohm headphones.

Set both volume controls, R1 & R4, say 1/2 way up, and then adjust both scanner volumes to give about the same sound output. Now, both channels can be individually controlled, without having to go back to the scanners every time.

PARTS LIST FOR THE TWIN SCANNER MONITOR

Resistors are 5% 1/4 w and electrolytics are 25V rating

- IC1 — LM 386 audio IC
- R1 — 100K potentiometer
- R2 — 100K resistor
- R3 — 100K resistor
- R4 — 100K potentiometer
- R5 — 100K resistor
- R6 — 100K resistor
- C1 — 0.1uF ceramic disc capacitor
- C2 — 0.1uF ceramic disc capacitor
- C3 — 100uF electrolytic capacitor
- C4 — 0.1uF ceramic disc capacitor
- C5 — 100uF electrolytic capacitor



SYMMETRICAL SCHMITT OSCILLATOR

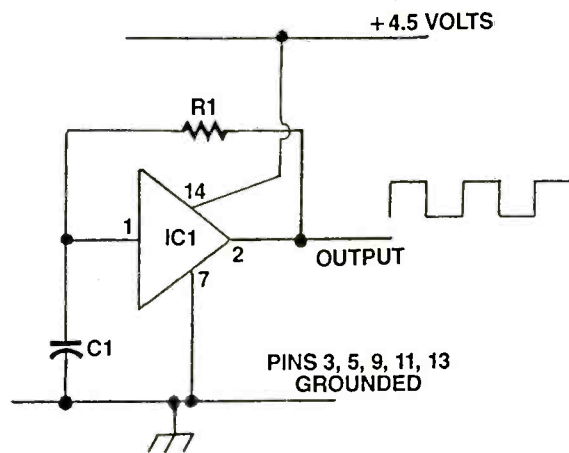


To get a pretty good approximation to a 50% duty cycle square wave oscillator, the Hex Schmitt Inverter will take some beating. Apart from the IC itself, there are only two other components! Even the ever popular 555 timer needs more than 2 components to do a similar task. The frequency is controlled by the component values for the resistor, R1 and the capacitor, C1 and the frequency set by $f = 1/CR$ (approximately). When you change the frequency, by varying either R or C, the duty cycle remains constant. This is a real advantage over the 555 which irritatingly (in spite of all its good points), changes its duty cycle as the frequency changes. Duty cycle is the ratio of either the 'on' or 'off' period to the total period.

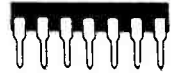
The supply voltage has to be kept to +4.5 volts. If you're using a stock 9 volt battery, then a simple potential divider will produce 4.5 volts (e.g. two 10K resistors across the supply line). There are 6 identical devices in this IC and all unused inputs must be grounded to keep the operation reliable. Leave the output pins as is. The device used here is the SN74HC14 and the pinouts refer to this IC. There are other hex Schmitt types, but check for pin compatibility and supply requirements before using an alternative. For the components values given, R1 = 10K and C1 = 0.01uF, the frequency is 10K with a duty cycle close to 50%. ■

PARTS LIST FOR THE SYMMETRICAL SCHMITT OSCILLATOR

- IC1 — SN74HC14 hex Schmitt inverter
- R1 — 10K resistor
- C1 — 0.01uF capacitor



GUITAR FUZZ EFFECT



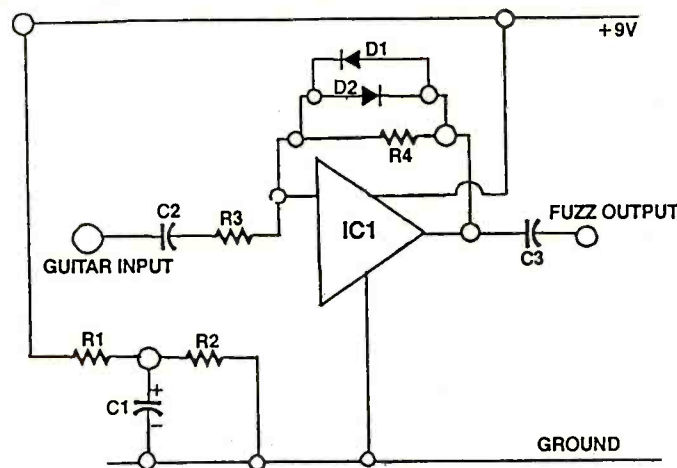
If you're a guitar player and electronics hobbyist at the same time, chances are you've most likely built a guitar amplifier, using something like the ever popular LM 386 audio power integrated circuit. To add some gusto to the basic sound, fuzz or distortion can be very easily achieved. Commercial guitar amplifiers always have a fuzz option, as guitar players consider this effect a 'must'. The Rolling Stones 'Satisfaction', is often named as one of the best examples of the first use of fuzz in the swinging mini-skirted 60's. The fuzz circuit produces heavy distortion by boosting the input signal by a huge amount. Typically a gain of 1000 will be sufficient to generate the desired distortion.

IC1 is a regular ac op-amp pre-amplifier, running off a single 9v battery, with a split resistor bias supply. R1 and R2 are equal in value, hence provide the $V_{cc}/2$ bias. Capacitor C1, decouples the ac signal path to ground. Regular coupling capacitors C2 and C3, appear at the input and output. Gain, for this non-inverting mode amplifier, is given by the ratio of $R4/R3$. R4 is the feedback resistor and is given a high value of 1M. The

input resistor has a low value, 1K, in order to produce a very high gain of 1000. Normally, of course if a clean sound was needed, the gain would be nowhere as high as this—more like around 10. The excessive gain of 1000 causes the signal to clip heavily. The balance of the fuzz effect is produced by the shunt silicon diodes, D1 and D2. These go across the feedback resistor, with opposite polarities and cause the output signal to clip at 0.6 volts in each direction.

PARTS LIST FOR THE GUITAR FUZZ EFFECT

- IC1—LM 741, op-amp
- R1—100K resistor
- R2—100K resistor
- R3—1K resistor
- R4—1M resistor
- C1—100uF electrolytic
- C2—0.47uF ceramic disc capacitor
- C3—0.47 ceramic disc capacitor
- D1—1N4148 silicon diode
- D2—1N4148 silicon diode



SIMPLE SWITCH DEBOUNCER



By C. R. Fischer

While the speed of digital electronics makes it possible to do things that the relatively slow human being can't touch, sometimes this quickness can be a problem. For example, if we were to hook up an everyday pushbutton to the clock input of a counting circuit, we would find that the counter would jump through random numbers rather than counting one step at a time as we would want.

The problem is not with our counter, but is actually within the switch itself. Whenever the switch is opened or closed, the contacts may make and break several times before coming to rest. This phenomenon is known as contact bounce, and it causes problems when digital circuitry interprets each bounce as a separate switch closure.

One simple and inexpensive solution is shown in

figure 1. To eliminate any bounce, we use a SPDT momentary switch to set or reset a flip-flop. Since the state of the flip-flop is set by the positive edge of the signal, any other noise is ignored. When the switch is depressed, the flip-flop is set high, and when the switch is released, the output goes low again (See Fig. 2).

Since the chip is a dual flip-flop, we can use the other half for a second switch, or for an alternating output by wiring it as shown. The top half is connected as a binary divider, which goes high and low on subsequent clock pulses. This allows us to use a momentary pushbutton as a regular on/off switch, with a minimum of hardware. By using the IC to drive a relay or SCR, we can control loads much greater than the small amount of current we would put through a small pushbutton.

This is a very simple circuit, and it can be powered

from DC supplies of 3 to 15 VDC. If the chip is not being used to drive an active part like an LED, it can be powered from batteries with very low power consumption. This would make the circuit attractive for remote controls and similar applications.

Finally, note that the IC is a CD 4013, and is a CMOS device. For this reason, be sure to use a socket and avoid handling the IC until the circuit is finished. For now, give it a try and see how many uses you can find for it!

PARTS LIST

- IC1**—CD 4013 Dual D Flip-Flop
- S1**—SPDT momentary switch
- R1, 2**—100k ¼W resistors
- Misc.**—14 pin socket or Molex Soldercons, breadboard or perfboard, hookup wire, Etc.

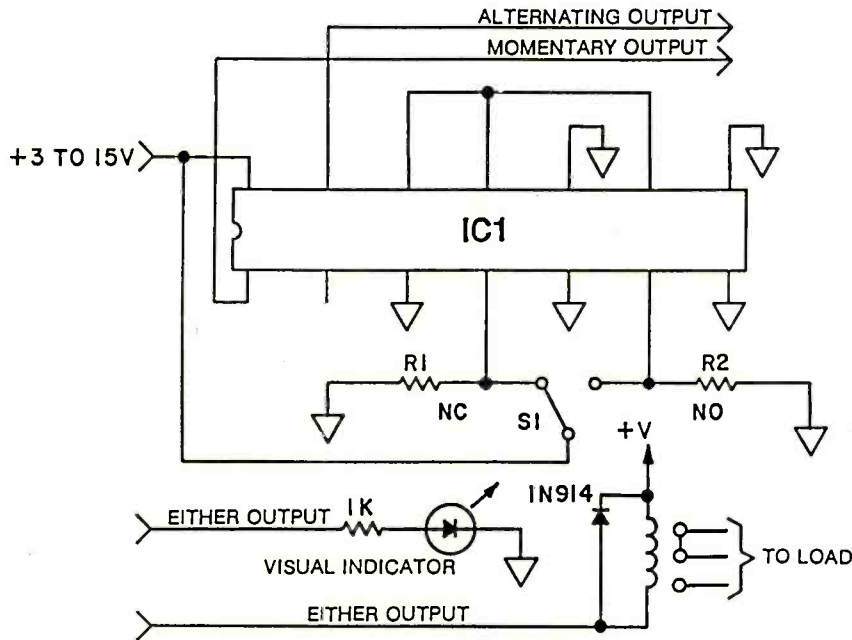


FIGURE 1) SCHEMATIC DIAGRAM FOR BOUNCELESS SWITCH.

RELAY DRIVER
(CHOOSE RELAY FOR SUPPLY VOLTAGE USED AND LOAD TO BE SWITCHED).

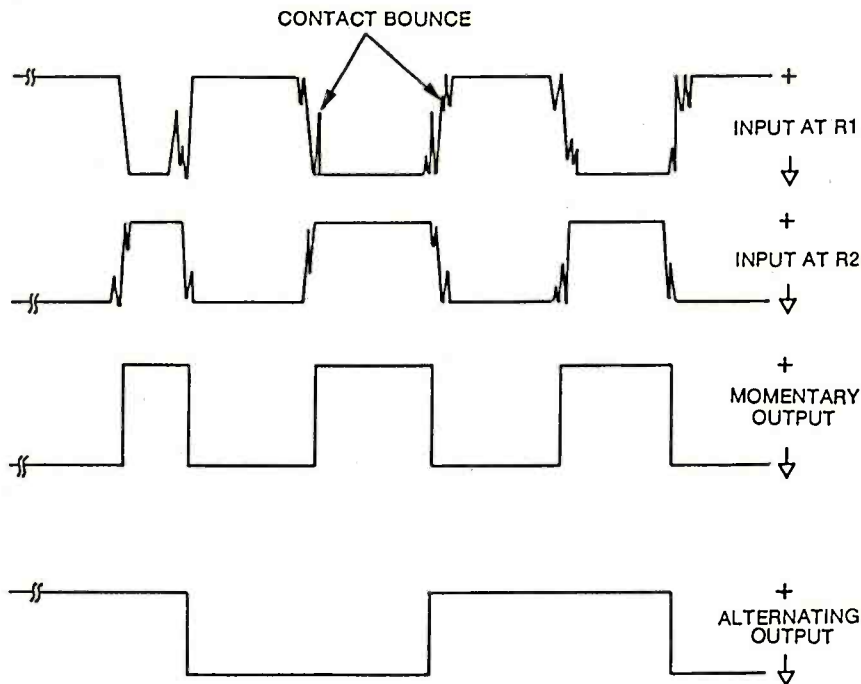
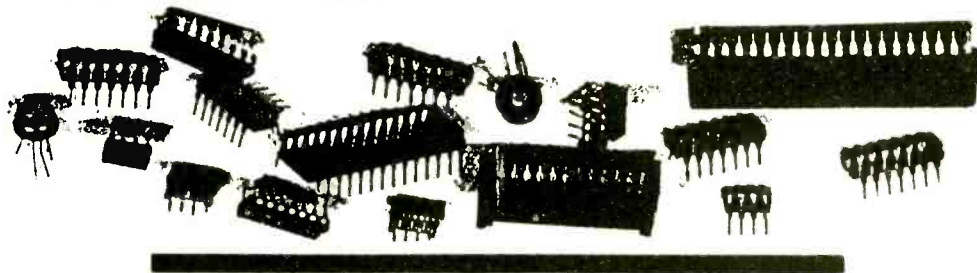


FIGURE 2—TIMING DIAGRAM FOR BOUNCELESS SWITCH

SOLID STATE UPDATE

Each month, the manufacturers of solid state components release literally hundreds of new devices. While we cannot report on all of these, we do intend to feature some of these devices that are most likely to interest our readers. For further information on any of these solid-state components, write directly to the manufacturers. They can provide you with data sheets and application notes at no charge.



1995 IC MASTER

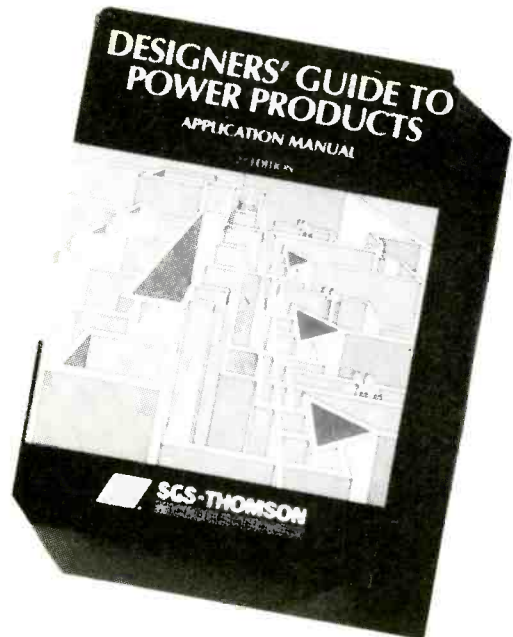
Hearst Business Publishing presents the 22nd annual edition of its **IC Master catalog**, a comprehensive source of information on all kinds of integrated circuits. IC Master contains data on over 108,000 commercially available ICs in a three-volume, 3,000-page set. Volume 1 includes Master Selection Guides that organize ICs by type, function, and key electrical parameters.

Volume 2 is devoted to part-number identification, military parts, and alternate sources. Included in Volume 3 are hundreds of data pages and a complete Manufacturers & Distributors Directory with contact information for all manufacturers, distributors and sales reps serving the IC industry. The cost of an annual subscription is \$185 plus tax plus \$10 shipping. To order, contact **Hearst Business Publishing/UTP Division**, 645 Stewart Ave., Garden City, NY, 11530. Telephone (516) 227-1314.



POWER PRODUCTS GUIDE

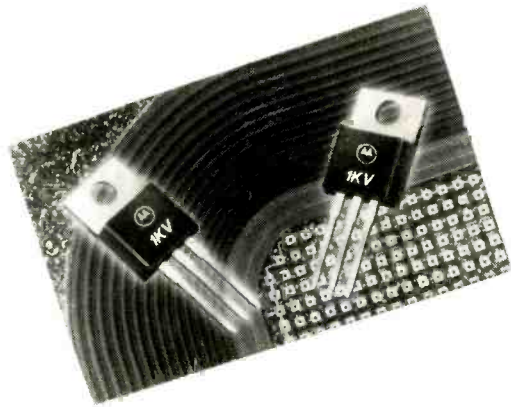
SGS-Thomson Microelectronics has compiled 1292 pages of application notes into its **Designer's Guide to Power Products**. In this case, power products include bipolar power transistors, power MOSFETs, and various integrated circuits capable of handling high voltage and/or high current. This handy guide concerns itself with both the theory of how these devices operate and the practical applications in which they can be used. The **Designer's Guide to Power Products** is, for the most part, organized according to application. Thus we have the following major divisions: technology and basics, smart power development system, stepper motors, DC and brushless motors, drivers and intelligent power switches, power supplies, power MOS and IGBTs, SCRs and triacs, monitors and TV circuits, and thermal management. Contact **SGS-Thomson Microelectronics, 1000 E. Bell Rd., Phoenix, AZ, 85022**.



MOTOROLA POWER MOSFETs

Motorola has announced the availability of a broad range of power MOSFETs using a patented high-voltage power technology. The key to this advanced design lies in multiple rings that provide proper shaping of the electrical field near the edges of the MOSFET die. This new design offers substantially enhanced voltage-blocking capability. Motorola's entire 400-600 volt line of power MOSFETs has been upgraded, and new 800- and 1000-volt devices using this technology have been added.

Designed for high-voltage, high-speed switching applications in power supplies, converters, and pulse-width-modulated (PWM) motor controls, these devices are particularly well-suited for bridge circuits, where switching speed and safe-operating area are critical concerns. Contact **Motorola Semiconductor Products, 5005 E. McDowell Rd., Phoenix, AZ, 85018**.



UNITRODE IC DATA BOOK

Unitrode Integrated Circuits manufactures a variety of specialized and general-purpose ICs, the specifications of which you'll find carefully documented in the company's **Product and Applications Handbook**.

The major divisions of the handbook (and some representative devices) are as follows: automotive products (high-side FET drivers, thermal monitors); power-supply circuits (linear and switchmode regulators); intelligent motion controls (step-motor drivers, brushless DC motor controllers); and interface circuits (solenoid drivers, Ethernet interfaces). Furthermore, for those who might be curious about how these integrated circuits can be used, Unitrode includes over 500 pages of detailed application notes.

For a copy, write to **Unitrode Integrated Circuits, 7 Continental Blvd., Merrimack, NH, 03054**.

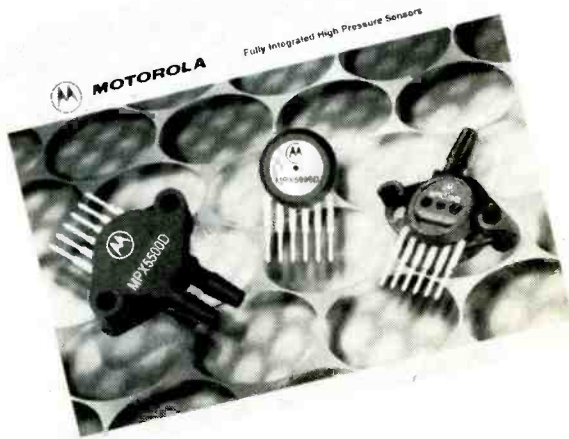


NEW MOTOROLA PUBLICATIONS

Motorola has released two new pieces of technical literature describing its RF products and technology. The annually issued RF Selector Guide and Cross Reference (SG46/D, Rev. 13) and a new RF Application Reports Handbook (HB215/D) are now available.

The RF Selector Guide and Cross Reference has been updated to reflect new and current products, including integrated circuits in the 1.8-2.4 GHz range. The brand new RF Application Reports Handbook contains 92 application notes, article reprints, and engineering bulletins authored by Motorola employees in various Motorola semiconductor product groups relating to the RF industry.

To obtain a free copy of either the RF Selector Guide and Cross Reference (SG46/D) or the RF Application Reports Handbook (HB215/D), write to **Motorola Inc., Literature Distribution Center, P.O. Box 20924, Phoenix, AZ, 85063.**

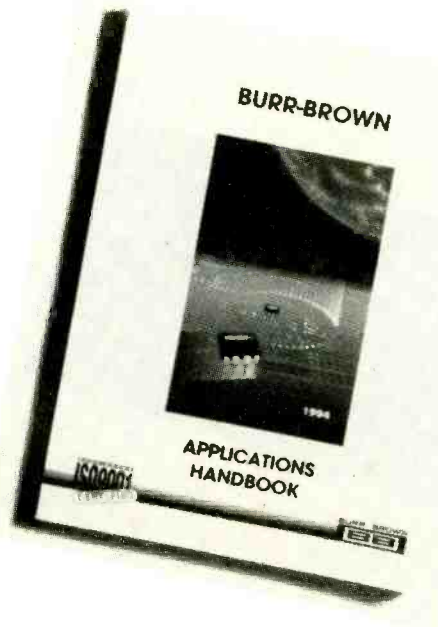


BURR-BROWN HANDBOOK

One of the best ways of acquiring knowledge about integrated circuits is by reading what their manufacturers have to say about them. These pronouncements are made in the form of application notes, which are usually available free of charge. Every once in a while, a manufacturer will gather up a batch of these application notes and publish them in book form. That's just what Burr-Brown has done. The Burr-Brown **Applications Handbook** contains 426 pages of valuable information on the company's broad line of products.

Topics covered include analog-to-digital converters, instrumentation amplifiers, isolation amplifiers, operational amplifiers, power op amps, multiplexers, references, special-function circuits, and voltage-to-frequency converters.

To obtain a copy, write to **Burr-Brown Inc., 6730 S. Tucson Blvd., Tucson, AZ, 85706.**



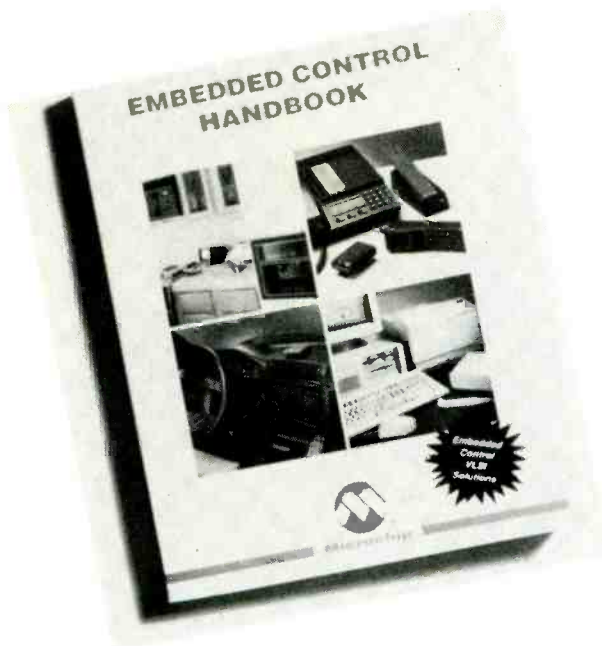
EMBEDDED CONTROL HANDBOOK

The PIC family of microcontrollers from Microchip Technology has enjoyed spectacular success. There are two reasons for this. First, these RISC-based microcontrollers are fast; second, they're cheap.

If you'd like to jump on the PIC bandwagon, you'll need the information contained in Microchip's **Embedded Control Handbook**, a compendium of detailed application notes that discuss hardware and software issues pertaining to PIC microcontrollers.

Covered are the PIC16C5X family and the PIC17C42. In addition, you'll find information on how to interface a PIC with a serial EEPROM, a description of the PIC development tools available from Microchip, and some article reprints (in German, French, and Japanese no less).

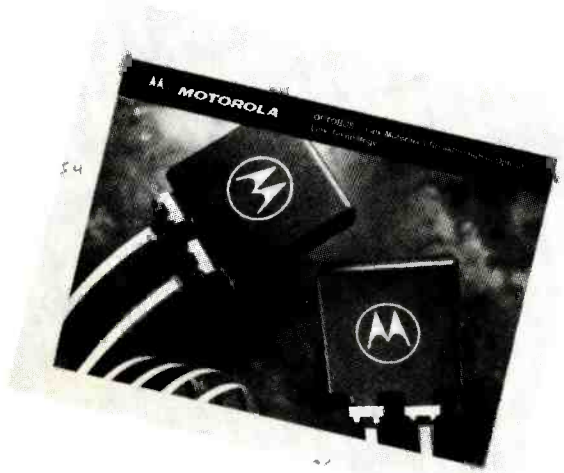
To obtain a copy of the **Embedded Control Handbook**, direct your inquiry to **Microchip Technology Inc., 2355 West Chandler Blvd., Chandler, AZ, 85224.**



FIBER OPTIC NETWORK

Engineers at Motorola have developed a new technology that allows an inexpensive fiber-optic assembly to link computer systems over distances of up to 30 meters, with data-transfer rates of 1.5 billion bits per second. This new **OPTOBUS technology** will provide low-cost solutions to the problem of transferring image, text, video, and voice data at ever-increasing rates.

Modular design makes the **OPTOBUS link** easy to use. The optical link assembly consists of two identical transceiver modules at the ends of a pair of 10-fiber ribbon cables. The designer, who needs no optoelectronic expertise, merely provides a suitable set of connectors and level-shifting circuitry at each end of the cable. **Contact Motorola Inc., 2200 W. Broadway, Mesa, AZ, 85202.**



MANIFOLD PRESSURE SENSOR

A new family of solid-state pressure sensors designed specifically for automotive applications has been developed by Motorola. The initial product offering in the MPXM4000 family is a manifold absolute pressure (MAP) sensor module. The device has a single-chip, temperature-compensated, amplified sensor and an o-ring sealed package. The single-chip sensor, combined with an internal EMI filter, makes this the smallest MAP sensor currently available. Devices have been fully characterized for EMI susceptibility at the 200 volt-per-meter level and found to be very resistant to ambient and cable-borne noise.

"This technology represents a new direction in automotive pressure sensor modules," said Jerry Curtis, VP and general manager of Motorola's Sensor Products Division. For more info, **contact Motorola Inc., 5005 E. McDowell Rd., Phoenix, AZ, 85008.**



PRESSURE SENSORS

Motorola has announced a new family of differential, integrated, high-pressure sensor devices ideally suited for microprocessor- or microcontroller-based applications with A/D inputs. These signal-conditioned, temperature-compensated, and calibrated devices combine advanced micromachining techniques, thin-film metallization, and bipolar semiconductor processing to provide an accurate, high-level analog output signal that is proportional to the applied pressure.

Available in epoxy-molded unibody elements, the new family of devices comprises the MPX5500D sensor, the MPX5700D (available in durable ported packages), and the MPX5999D. The maximum pressure that these devices can sustain is 150 psi. The unit price is \$10.00 in high-volume quantities. **Contact Motorola Inc., 5005 E. McDowell Rd., Phoenix, AZ, 85008.**



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SPACE ENERGY RECEIVERS — Power from the Wheelwork of Nature Send \$6.50 plus \$1.00 (P&H) to Simplified Tech. Service, P.O. Box 2140A, Champaign, IL 61825. Space energy receivers may be defined as a class of devices, which apparently collect electrical energy from the surrounding space without applied force, by some process other than chemical or mechanical action. This book describes eight inventors and their devices, covering the years 1901 to 1945.

LOOK INSIDE YOUR PROJECT! We sell used electronic equipment. (Oscilloscopes, 8Mhz, \$99.00) (Digital Volt Meters, \$35.00) Shipping and Handling is extra. **PRO-AM Electronics**, Rt. 6, Box 587, Guthrie, OK 73044 — (405) 282-8573 — CompuServ 71344-1440.

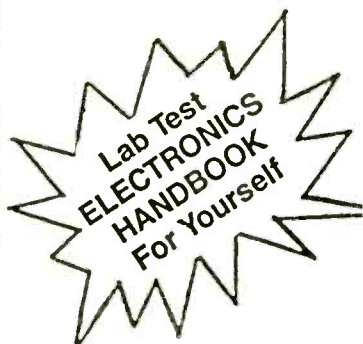
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ELECTRONICS HANDBOOK

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V18

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.

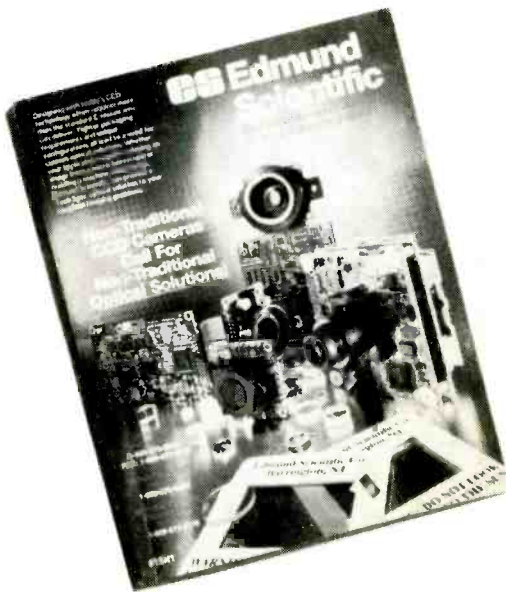
Following are several catalogs that we have recently received in the mail, with brief descriptions and comments. Most of these suppliers send out new catalogs every four to six months, with many of the items repeated and new ones added, plus some new "specials"...usually on the first couple pages and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

LNS TECHNOLOGIES

Kits are a great way to get started in electronics. You get all the parts you need together with an etched printed-circuit board and instructions. After a few hours' worth of work with a soldering iron and screwdriver, you end up with a working device that you can point to with pride and say, "I made that."

Lots of companies offer kits, but few have as interesting a lineup as that of LNS Technologies. Their new mini-catalog features a spy microphone disguised as a marker pen, a laser pointer, a secret voice disguiser, a solid-state laser and laser light show, a solid-state message recorder, a combustible-gas alarm, a talking clock, a talking IR motion detector, and various computer components. LNS charges \$1.00 for their catalog, but you get the buck back when you place an order. Sounds fair to us. Write to **LNS Technologies, 20993 Foothill Blvd., Suite 307, Hayward, CA, 94541.**





EDMUND SCIENTIFIC CO.

After forty years in business, the Edmund Scientific Co. is probably familiar to most people with an interest in science and technology. Edmund's latest general catalog is a 235-page treasure trove of all kinds of science-oriented products. Some of these items are intended for the professional, and are thus relatively expensive, but there is also a wealth of modest-cost equipment that will appeal to the student, hobbyist, and experimenter.

You can take your pick of lenses, microscopes, telescopes, binoculars, prisms, and other optical equipment. Edmund also has lasers, labware, magnets, and tools. There's more, too, and you can check it out for yourself because the catalog is free. Just write to **Edmund Scientific Co., 101 E. Gloucester Pike, Barrington, NJ 08007. Telephone (609) 573-6250.**

SPECIALIZED PRODUCTS CO.

If you build electronic projects, you need tools to cut, grind, drill, and file. You can find all the tools you need in the new 320-page full-color catalog from Specialized Products Co.

Their tool lineup includes such things as power drills, screwdrivers, wrenches, hammers, saws and files. A variety of pre-packaged tool kits is also available. Test gear goes hand-in-hand with tools, and Specialized Products offers a wide array of multimeters, 'scopes, power supplies, signal generators, EPROM programmers, and telecom testers.

The company stocks all the products it sells, and is thus able to offer next-day delivery of any order for a flat fee of \$9.95. Their catalog can be obtained by writing to **Specialized Products Co., 3131 Premier Dr., Irving, TX, 75063. Or call (800) 866-5353.**



OLD COLONY SOUND LABORATORY

If you're interested in building your own audio equipment, you'll want to get your hands on the latest catalog from Old Colony Sound Laboratory. What do they sell? Well, first and foremost they've got kits for such things as high-quality power amplifiers, preamplifiers, electronic crossovers, audio test microphones, audio filters, vacuum-tube amplifiers, and audio test gear. In addition to that, they've got a huge selection of audio-related books covering everything from psychoacoustics to amplifier and speaker design.

Want more? How about integrated circuits, transistors, vacuum tubes, audio-test CDs and cassettes, and speaker-design software. You'll be hard pressed to find such a collection of do-it-yourself audio products anywhere else, so if you'd like to try your hand at audio construction, write to **Old Colony Sound Laboratory, P.O. Box 243, Peterborough, NH, 03458.**



RAG ELECTRONICS

When buying an expensive item like a car, you have the option of buying either a new one or a used one. That's true of electronic test equipment as well. The latest catalog from RAG Electronics contains a mix of both the new and the used. The company carries power supplies, oscilloscopes, calibrators, signal generators, spectrum analyzers, multimeters and other common instruments. RAG also is a purveyor of some very uncommon equipment such as environmental test chambers, network protocol analyzers, RF impedance meters, and the like.

In case you're wondering, all of the used equipment is fully calibrated and certified, traceable to the NIST, and comes with all manuals, standard accessories, and a six-month warranty. Write to **RAG Electronics, 2450 Turquoise Circle, Newbury Park, CA, 91320. Telephone (800) 670-3457.**



HOME CONTROL CONCEPTS

Home automation seems to be all the rage these days, and not just among the rich. Home automation equipment is relatively inexpensive, but unless you live in a big city, chances are slim that you'll find much of a selection close to home. As usual, mailorder shopping is the answer. The latest catalog from the folks at Home Control Concepts contains a wide variety of products designed to put your homestead under electronic command.

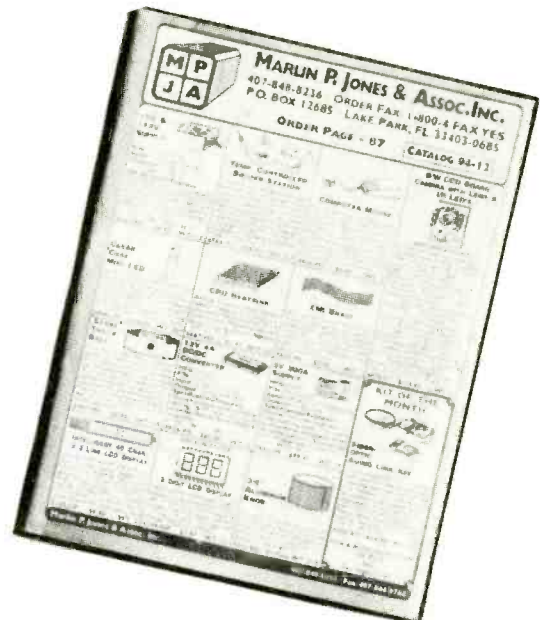
You'll find wireless controllers from X-10 and Leviton, as well as wireless security systems. Home Control Concepts also carries video equipment such as cameras, monitors, lenses, and distribution amplifiers. They've even got devices that will open and close your drapes automatically. You can get all the details by writing to **Home Control Concepts, 9520-108 Padgett St., San Diego, CA 92126. Or call (619) 693-8887.**

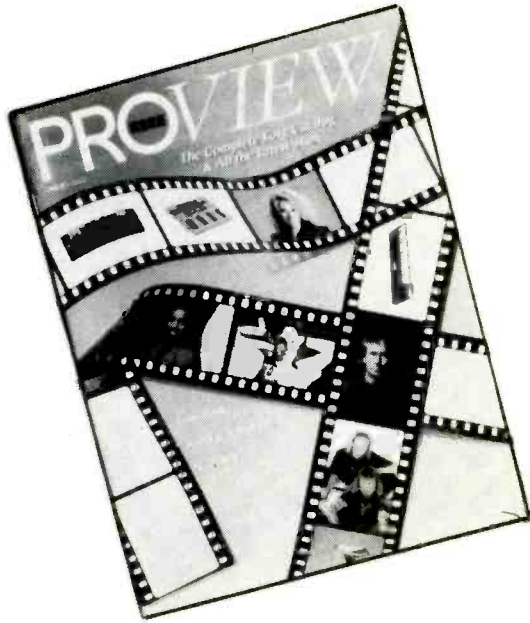
MARLIN P. JONES & ASSOCIATES

The name Marlin P. Jones & Associates sounds like it might belong to an accounting firm, but in fact MPJA is one of the better purveyors of surplus electronic goods. In addition to surplus, the company also carries a variety of brand-new electronic items, all reasonably priced.

Some highlights of the MPJA product lineup: video cameras and monitors, linear and switching power supplies, fans, switches, relays, motors, the Parallax "Basic Stamp" computer modules, pressure gages, electronic kits, speakers, cabinets, tools, meters, test gear, magnets, LCD displays, semiconductors, connectors, lenses, and lasers.

You can get a free copy of their 104-page catalog by writing to **Marlin P. Jones & Associates, P.O. Box 12685, Lake Park, FL, 33403. Or call (407) 848-8236.**





KORG PROVIEW

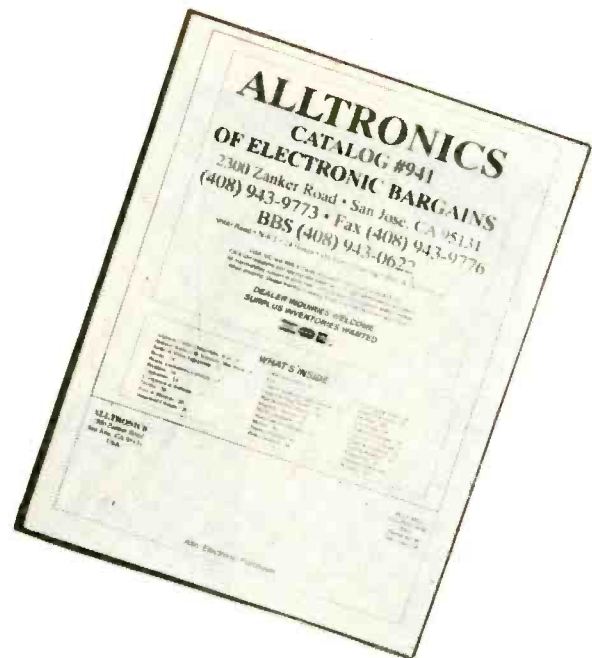
Korg, as many of you with a musical bent probably know, is one of the big names in the electronic music industry. Their publication **Korg Proview** is part catalog and part magazine. In it you'll find ads for the latest Korg products, such as keyboards, sound processors, distortion processors, music workstations, pianos, synthesizers, tuners, and multimedia equipment. All this equipment is digital; hence, you'll find the ads filled with familiar terms like RAM, ROM, hard drive, and the like.

In addition to the ads, **Korg Proview** features articles on such topics as famous musical artists, reviews of new musical equipment (all of it Korg's, naturally), and tutorials on how to get the most out of your musical gear. Those of you not afflicted with a tin ear may wish to subscribe to **Korg Proview** by writing to **Korg USA Inc., 89 Frost St., Westbury, NY, 11590.**

ALLTRONICS

Anyone who's read this column for a while knows we just love surplus electronics because of the bargains to be found. Case in point: I recently acquired some wire-wrap boards studded with thousands of goldplated pins. The current distributor's price for these items is over \$300, but I paid just \$20. Sure, the boards were a little dusty and probably spent the past decade in a warehouse, but at \$20 apiece, who cares?

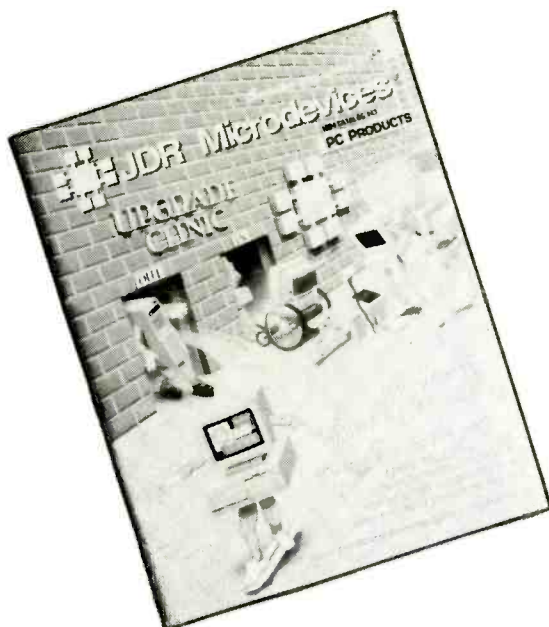
Bargains of all kinds can be found in the Alltronics catalog. With the exception of a few kits, all of the merchandise is surplus. They have motors, ICs, books, cabinets, switches, tools, toys, vacuum tubes, radios, lasers, lenses, fans, computers, connectors, wire, and lots of unique stuff that just can't be categorized. For a copy, contact **Alltronics, 2300 Zanker Rd., San Jose, CA, 95131. Telephone (408) 943-9773.**



JDR MICRODEVICES

JDR Microdevices used to offer two separate catalogs—one devoted to electronic components, the other to computers and computer accessories. I guess it finally dawned on them that the same people who buy electronic components also buy computers, because their latest catalog is a fusion of both the electronic component and computer offerings of the company.

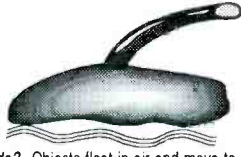
JDR's got an impressive lineup of integrated circuits and discrete semiconductors, augmented by such necessities as resistors, capacitors, pots, connectors, books, solder, tools, test instruments, and do-it-yourself kits. As for computers, they feature reasonably priced machines with '486 and Pentium processors, as well as computer boards, power supplies and cases. Contact **JDR Microdevices, 1850 S. 10th St., San Jose, CA, 95112. Phone (800) 538-5000.**



AMAZING

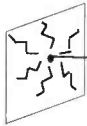
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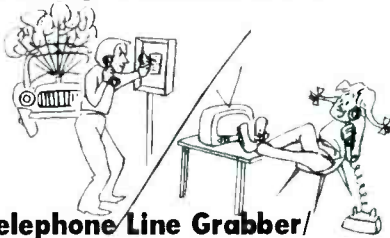
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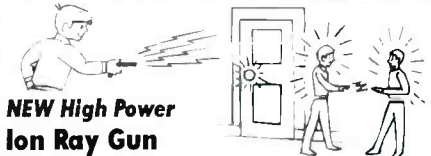
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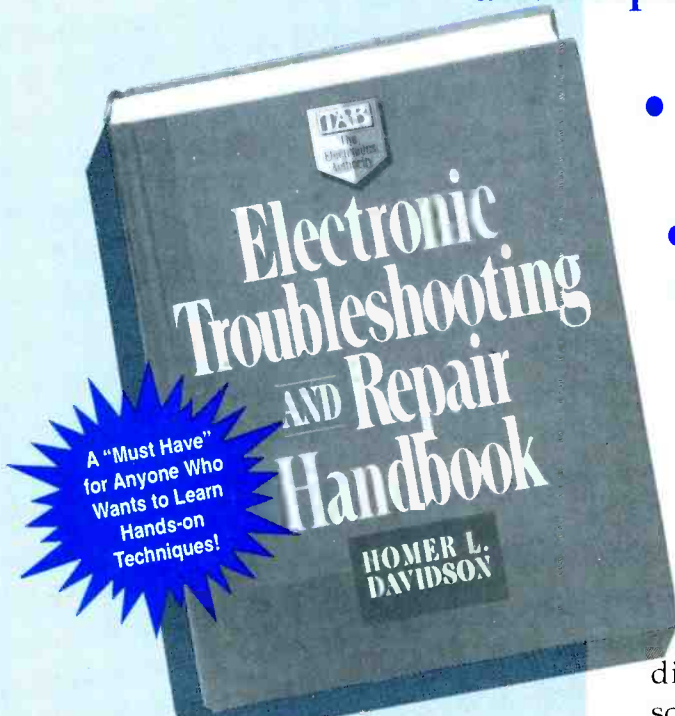
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