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November 1994

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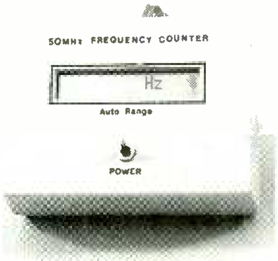
CONSTRUCTION

FEATURES



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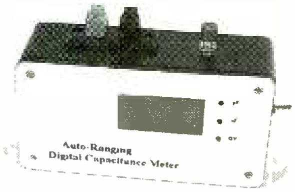

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ABC AUDITED

EDITORIAL

TEST GEAR FOR YOUR WORKBENCH

This month, **Popular Electronics** turns its attention to a topic that is at the top of most hobbyists' lists-test gear. Without adequate, properly operating test equipment, it is often impossible to troubleshoot or even align our projects and circuits.

Of course, you can go out and buy virtually anything you need, especially if you are relatively well-off. On the other hand, we are hobbyists, which means that most of us like to build whatever we can, whenever we can. That's why you are sure to love this month's lineup,because it presents several pieces of test gear that should be welcome on every builder's bench.

For starters, there's our *Autoranging Digital Capacitance Meter*. It takes the guess work out of selecting capacitors. No more deciphering cryptic markings. No more wondering about the true value of a component. It does its work in seconds and displays the value in an easy-to-read format. The story begins on page 62.

Then there's our *Autoranging Digital Frequency Counter*. Easy-to-build, easy-to-use, it gives a fast, accurate readout of the input frequency. With a range of up to 50 MHz, it is suitable for most hobbyist applications. It can also be used as a frequency readout for your older, non-digital radio equipment. The story begins on page 33.

Speaking of radio; in days gone by, no ham or radio shack would be complete without a grid-dip meter. That vacuum-tube-based unit was indispensable for getting a readout on the resonant frequency of any tuned circuit, including the antenna. While grid-dip meters may be harder to come by these days, the function they perform is still important. This month, we present a modern, solid-state version of the grid-dip meter—*The "Gate-Dip" Meter*. The story begins on page 37.

Add to that our *Battery Amp-Hour Meter* on page 51 and you have a true builder's bonanza. Enjoy!

Carl Laron
Editor

LETTERS

WHY 110 VOLTS?

In the article, "AC or DC" (**Popular Electronics**, September 1994), I think that I might have found the answer to a minor-league question about electricity that has been bugging me—and about which I have sought information from various sources, including the Westinghouse Company, without response.

As I have gone about my electronic tinkering, I began to wonder why the juice supplied to me in my various homes has been 110 volts. Why not 75, or 50, or 150? (Actually, it has varied between 112 and 120 volts, but one usually speaks of it as 110.)

The article stated that Edison had designed his light bulbs to work on 110 to 125 volts, which was the largest voltage that he considered could be used safely. (In view of his later generation of hoopla about the hazardous nature of AC, it is curious that he would consider safety in the usage of DC.) So I must assume that his domination of the bulb business resulted in the determination of the voltages put to use by any outfit entering the electric-illumination or power business.

It is interesting how some small things can have lasting effects on larger matters. We drive our cars on the right-hand side of the street because of the placement of the teamster's seat on the Conestoga wagon.

I enjoyed the article, which presented a welcome review of the history of electricity. It included some people who do not often get noticed—but I kept waiting for Tesla to turn up. Not a word. Or was he the person referred to in the first column on page 46, disguised as ". . . a man who had worked with Gaulard and Gibbs."?

F.G.H.
Redwood City, CA

LOOKING BACK

Thank you for bringing back **Popular Electronics**, the best electronics magazine of them all. I started reading **Popular Electronics** back in 1959, and continued until about 1984, when they began focusing on computers.

I was born in 1925, the same year as the Grand Old Opry in Nashville. I used to listen to it on my grandfather's old Zenith floor radio, with a wind charger on the roof. When the wind wasn't blowing, Grandpa would take the battery out of the old Willis-Overland. As I listened, I wondered how they made music in other parts of the world and I could hear it coming out of the speaker at home.

I first learned about electronics in **Popular Electronics**. I read the magazine, and started buying transistors and other parts and building projects. In 1960 I bought a CB and I began fixing antenna cables and microphones for myself and others.

Then a good friend urged me to go to electronics school. I was forty when I graduated second in my class. I went to work for RCA for ten years and then into medical electronics until I retired in 1988. That's when I finally got a computer—now I have to learn to program this wild machine.

Thanks again for teaching uneducated kids like me how to get started in electronics. Keep it going—I learn more all the time!

By the way, I have built several of Charles D. Rakes' circuits from *Circuit Circus*, and every one of them worked great!

A.G.
Fortville, IN

I need a schematic and manual for an Eico model 460 oscilloscope. I will gladly pay for any postage and copying costs. Thanks in advance.

ROBIN EVANS
622 Stevenson
Jacksonsville, AR 72076

I'm in desperate need of the schematic for a Motorola business-band transceiver. The outside front says "WPAR 223." The tag on the top is missing. A black stamp on the chassis says TUD2042AB. I will pay for the schematic.

DON GAGNON, KB7WGM
HCR-579-B
Payson, AR 85541
602-474-6526 (reverse charges)

I have an Intellivision video-game system, model 2609, manufactured by Mattel Electronics ten years ago (serial # 1554778). If anybody knows where I could find a schematic, or has one they could send me, I would be very grateful. I'd also like to find out how to program the cartridges, or at least what the programming language is.

I'll refund any postage charges, and even pay for the schematic if necessary. Thank you in advance.

ARISTARCO PALACIOS
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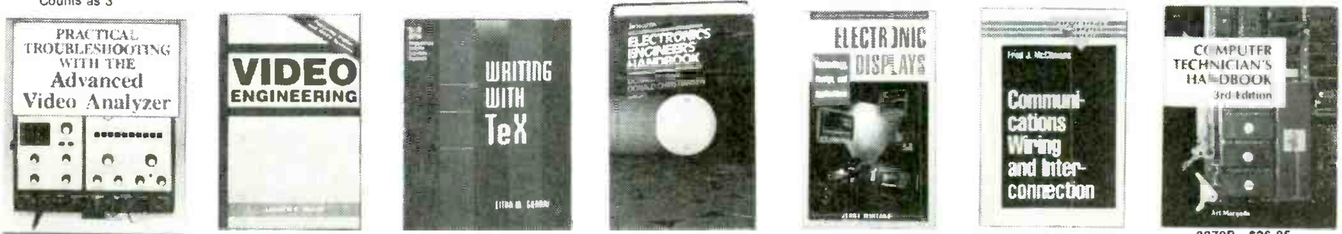

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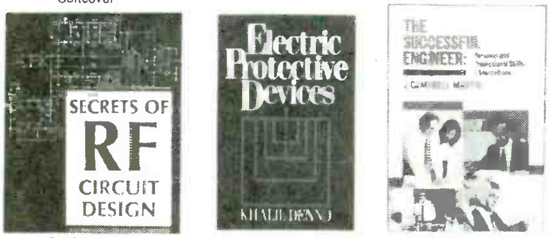

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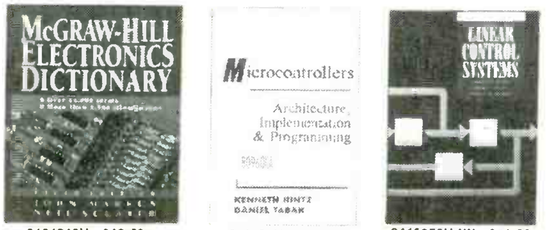

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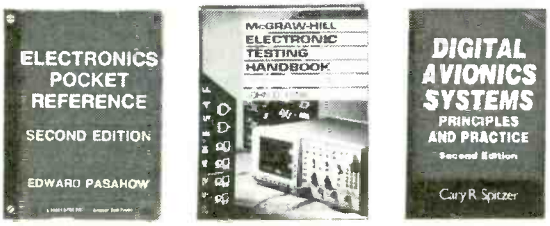

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MULTIMEDIA WATCH

By Marc Spiwak

PC Expo, and More!

I went to the PC Expo in New York this past week. As usual, it was a mob scene. Overall, I would say that some of the most interesting stuff I saw at the show was real-time video hardware and software. It seems that everyone wants to be able to display real-time video on their PC. Based on what I saw, I predict that within a year or two, we'll be able to play full-length movies from a single CD-ROM, and watch high-resolution real-time video on our monitors. Of course, the audio will be CD-quality, and we'll be able to edit and process the video to our heart's content.

These Yamaha YST-M10 speakers deliver surprisingly good sound considering their size and weight.

In addition, I think that MPEG, JPEG, AVI, QTW, and many other video formats and compression schemes, for both play and record, will be built into the average video card. After all, in the same way that we don't need a separate video card or monitor to handle CGA, EGA, VGA, SVGA, or whatever, we shouldn't have to use up an expansion slot to see real-time video. Anyway, at the rate that real-time video and PC's in general are evolving, I'm sure this stuff will be standard in a $2000 PC real soon.

I'll be reviewing some of the things that I saw at PC Expo in future columns. For this month, though, I have some interesting hardware and software. To begin with, I've installed a 3X CD-ROM upgrade in my PC and I really like it. It doesn't make CD-ROM's as fast as lightning, but with 2X drives being as slow as they are, I'd certainly prefer 3X any day.

MEDIA VISION PRO DELUXE

Before I talk about the hardware included with Media Vision's *Pro Deluxe Multimedia Kit*, I'd like to say that the thing I like best right off the bat about this package is that it's complete. The first upgrade package from Media Vision that I looked at didn't come with a microphone or speakers, and only included four or five discs—and none of them very exciting.

The Pro Deluxe comes with a microphone and a small pair of speakers, and plenty of neat discs to play with. An upgrade package as complete as this makes a great gift, because the new owner can jump right into multimedia as soon as the package is installed, without needing to buy discs for a while.

Software for the entire family is included in the Pro Deluxe package. To begin with, there's *Iron Helix*, a great game I looked at a couple of months back. This game sets the mood in a deserted spaceship that reminds me of the visuals from the movie "Alien." It's up to you to find DNA keys that reveal how to destroy a mechanical killer. (Spectrum Holobyte, 800-695-GAME).

Return To Zork is another great interactive fantasy game included with the Pro Deluxe. This game has real-time video and real-life digitized actors. I also just happened to receive the MPEG version of this game that runs on the *ReelMagic* card from Sigma Designs. MPEG allows full-screen video playback at 30 frames per second. MPEG Zork is the same game, but with much better video. The only problem is that you must have the ReelMagic card to play the MPEG version. Otherwise you have to buy the regular version. (Activision, 800-447-3650).

Mad Dog McCree is an arcade-type shoot-em-up game with good live-action video. You play the "Stranger" who just entered town and must save the town from Mad Dog and his men. (American Laser Games, 505-265-7215).

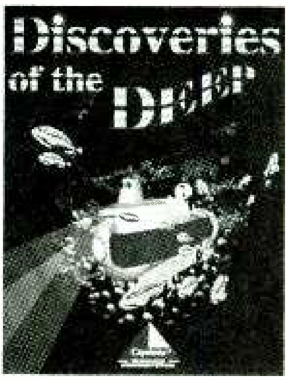
Mega Rock, Rap, & Roll lets anyone compose music in minutes. (Paramount Interactive, 415-813-8040). A copy of the very useful *Compton's Interactive Encyclopedia* is also included with the Pro Deluxe upgrade. (Compton's New Media, 800-929-2500). The *Home Survival Toolkit* (Books That Work) makes estimating time and materials easy, and the *Mayo Family Clinic Health Book* (Sony Electronic Publishing) is a complete home medical reference on CD-ROM.

Media Vision also bundles some of their own CD-ROM's with the package. *Critical Path, Quantum Gate*, and *Forever Growing Garden* are all included. A bunch of other children's discs are also thrown in. Overall, it's a nice assortment of software.

PRO DELUXE HARDWARE

The hardware included with the Pro Deluxe is just as impressive as the list of software. To begin with, the drive is a 3X, or triple-speed drive, which is 50% faster than a 2X. The drive is definitely snappier than my older 2X drive, but only for certain things. For example, the 3X drive has an access time of only 195 milliseconds, so it does look up and transfer data to my PC faster than my old drive. However, for things like real-time video played from a CD, the video is recorded so that owners of 2X drives will get the best possible performance, and so the added speed of a 3X drive for now does nothing to improve real-time video.

Another unusual piece of hardware included with the Pro Deluxe upgrade is Media Vision's new 3D sound card. This new card is similar to the older Pro Audio Spectrum, but it now includes built-in SRS circuitry. SRS, or the Sound Retrieval



Discoveries of the Deep from Capstone lets you explore the mysteries of the sea from the comfort of your PC.

System, was originally developed by the audio division of Hughes Aircraft Company.

The first time I saw SRS being demonstrated was at a Sony show a few years ago where SRS had been incorporated into a high-end Sony TV. The demonstration was amazing. With SRS turned on, a movie soundtrack sounded full and surround-sound-like from anywhere I stood in the gymnasium-sized room; as soon as the SRS was turned off, the sound was "sucked" back into the TV cabinet—a very impressive demonstration indeed.

SRS Labs now holds the keys to SRS, and I'll be playing with SRS Labs' stand-alone SRS decoder during the next few months. I'll let you know what I think. Anyway, the SRS built into the 3D sound card does the same thing for PC audio as it did to the movie soundtrack at the Sony demonstration. The effect is neat, so why not have it in your PC! The 3D sound card is not compatible with the Pro Audio Spectrum, but it is Sound Blaster-compatible, and I haven't had any incompatibility problems with it yet.

The Pro Deluxe Multimedia Kit has a list price of $799, and you can get it at street prices that are much lower than that. If you're in the market for a new upgrade, then you should seriously consider this one for its combination of performance and extensive software.

OTHER NEW HARDWARE

I've been testing another pair of multimedia speakers, this time from Yamaha. The *YST-M10* speakers deliver surprisingly good sound for their relatively small size and light weight. As any multimedia speakers should be, the YST-M10's are magnetically shielded so that they can be placed right next to a monitor.

The speakers must be used in left and right positions, accordingly. The right speaker contains a 10-watt amplifier that serves both speakers. The two speakers are connected by a cable. A DC adapter plugs into the right speaker, which has a power-indicator LED on its front panel above the power switch. Also housed on the front panel of the right speaker is a presence control, which adjusts the apparent separation of the sound, and a volume control.

The speakers have fabric grilles and come in gray or black. They look great and accent any multimedia system quite well. And like anything else, their list price of $99 can be reduced quite a bit by shopping around. I recommend the Yamaha YST-M10's to anyone looking for good mid-range multimedia speakers.

NEW STUFF

This month I've got some software that might be of particular interest to readers of this magazine. To start, there's *Get Wired* and *The Home Survival Toolkit*, both from Books That Work. Both of those Windows products are available on floppy disk only, but they are useful nonetheless. The Home Survival Toolkit is a $30 multimedia guide to home repair and remodeling. No home repair is left undone in this package. Get Wired is simply a subset of The Home Survival Toolkit that sells for under $20. Get Wired covers everything concerning home wiring, and presents it via multimedia.

Another product I thought readers of this magazine would find useful is the *1994 IC Master on CD-ROM*, published by Hearst Business Publishing. The IC Master for 1994 runs under DOS or Windows, and is a pleasure to use. Anyone who has used the book version of this product knows how cumbersome it can be, but only because of the vast information contained in it. The CD-ROM houses all the information on a single disc, and lets your computer do the searching for you. The disc can be had for the introductory price of $395.

I've been testing out a neat little stripped-down, inexpensive, and fast file-viewing utility from Inset Systems called *OOgler 1.0 for Windows*. (They're the same folks that publish *HiJaak Pro*.) OOgler lets you view nearly any conceivable file format, requires very little hard-disk space, and has a list price of only $37.50. You can't do any file conversion or printing with it, but nothing beats it for viewing.

On a more political note, *The Haldeman Diaries: Inside The Nixon White House*, is now available on CD-ROM from Sony Imagesoft. The disc contains the complete 22-page text from Haldeman's personal diaries plus 45 minutes of never-before-seen home movies shot by H.R. Haldeman, the Chief of Staff for former President Richard Nixon during the Watergate years. There's also 700 photographs and

Dinosaur mania comes to your PC courtesy of Jurassic Park The Screen Saver from Asymetrix.

2000 pages of additional text. The Haldeman Diaries has a suggested retail price of $69.95.

If you're interested in the invasion of Normandy, France, and are into multimedia, then you might be interested in *Normandy—The Invasions of France June 6, 1944* on CD-ROM from Quanta Press. All major events are covered in text, photos, audio, and video. The disc has a suggested retail price of $69.95.

The music industry is embracing multimedia faster than many others, and many artists have interactive multimedia discs already available. One such disc is from the artist who used to be known as Prince but now goes by an unpronounceable and, for us, unprintable, symbol. *(Symbol) Interactive* from Graphix Zone lets you navigate through a bizarre building solving mysteries, puzzles, and riddles as you go. You can also listen to music and watch videos, and I believe that if you unlock the "mystery" of the disc, you get to see a never-before-seen *(Symbol)* video.

Capstone sent me a bunch of their new CD-ROM's. The *CD Game Collection* includes five games on one disc: two *Trump Casino* simulators; *Bill and Ted's Excellent Adventure; Search for the Titanic*, where you get to see actual footage of the ship; and *Exotic Car*, which lets you check out 15 high-performance automobiles. *Terminator 2 Chess Wars* turns an ordinary game of chess into a futuristic battle zone of cyborgs, endoskeletons, and special effects. Finally, *Discoveries of the Deep* lets you explore the mysteries of the sea from your PC; the deep-sea missions can be quite involved.

If you can't get enough dinosaurs or Jurassic Park in your life, then you need *Jurassic Park The Screen Saver* for your PC from Asymetrix. This piece of software captures all of the excitement from the movie on your PC screen, and might even keep it from getting damaged.

Sam & Max Hit the Road from LucasArts is interactive cartoon fun for the entire family, although it might be too violent for some children. The detective comedy adventure also lets you play mini games such as Car Bomb, Sam and Max Dress Up, Highway Surfing, and others. Sam & Max has a suggested list price of $69.95.

Last but not least, *The Gospels, A Multimedia Guide to the Bible* from Cinerom, Inc., speaks for itself. Nearly one hour of video, one hour of audio, over 85 illustrations, and the complete text of both the Old and New Testament fill the disc. The disc sells for $49.95. ■

"Of course, you realize that the software is interactive?"

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A CHRONICLE OF CONSUMER ELECTRONICS

The Summer Consumer Electronics Show 1994

The end of a tradition, and the start of something new

The last Summer Consumer Electronics Show to be held in Chicago's lake-front McCormick Convention Center, was called, unofficially, the "Wake on the Lake." SCES 1994 was the end of a tradition that had lasted more than a quarter century. The mood wasn't funereal, but the show certainly was smaller and less upbeat than its predecessors.

Ironically, the last show in Chicago also marked the 50th CES. The Consumer Electronics Show began 27 years ago—in New York City, instead of Chicago, as had originally been intended. Unfortunately, a major fire at McCormick Place a few months before the scheduled show rendered the convention hall unusable. The show was moved to Chicago in 1971, and two years later a winter show was added. In 1978, the Winter CES was moved to Las Vegas, where the climate in January is more hospitable.

LOOKING BACK

The first Consumer Electronics Show covered 100,000 square feet in two major New York hotels, and lured some 15,000 attendees, many of whom already were in town for the North American Retail Dealers Association's (NARDA) trade show. Large exhibitors included the companies at the heart of the American television industry, including Westinghouse (the largest exhibitor), GE, RCA, Admiral, Motorola, Sylvania, Philco, and Magnavox. Also on hand were a handful of Japanese newcomers, such as Sharp, Sony, and Panasonic. The year was 1967, and the hot new products were color TV's and audio tape recorders.

Over the next quarter century, the Consumer Electronics Show was the chosen venue for dozens of new-product introductions. Just a bare sampling might include solid-state televisions in 1967, videocassette recorders and electronic calculators in 1972, CB radio in 1975, the Sony Walkman in 1979, camcorders in 1980, home computers in 1981, stereo television in 1984, multimedia CD-ROM systems in 1991, MiniDisc and Digital Compact Cassette in 1992, and widescreen TV in 1993. The summer shows, in particular, became known as the place for new technology introductions.

WHAT WENT WRONG?

After so many years of successful shows, why pull the plug on the Summer CES? Several factors contributed to the decline of the summer show, but the primary cause is the lack of support from the big players—the major manufacturers of traditional audio and video products on both sides of the Pacific.

In recent years, the consumer-electronics marketing schedule has shifted: Summer is no longer the prime selling season, and buyers had made their plans for the Christmas selling rush long before the Summer CES rolled around. Most manufacturers find it more efficient and

Thomson Consumer Electronics, one of the few traditional video manufacturers with an exhibit at SCES 94, was demonstrating a distinctly nontraditional system: DSS, or Digital Satellite System.

profitable to hold private "shows" for their buyers in the early spring, so setting up a huge exhibit a month or so later at SCES had become redundant—and expensive as well.

The general consensus is that the Winter Consumer Electronics Show, held each January in Las Vegas, along with those spring sales meetings, provides sufficient opportunity for manufacturers to do business with retailers.

Over the past several years, each successive summer show has seen more and more major manufacturers pulling out. At SCES '94, the major video manufacturers stayed away in droves, and the only audio products worth mentioning were the high-end items displayed in suites at the Chicago Hilton.

Despite its relatively small scale—only about 35,000 attendees over three days, compared to the 50,000 who came to last year's four-day show—SCES 94 was not a washout by any means. What was lacking in audio/video products was made up for in non-traditional, but fast-growing, consumer-electronic product categories. Those included "interactive multimedia," a catch-all phrase covering everything from video games to on-screen TV program guides; SOHO (small office/home office) products; PCC (personal communications and computers) gear; and accessories. There were a few traditional video manufacturers at the show—including Thomson and Philips—but they were there primarily to showcase some non-traditional items of their own. Let's take a look.

Gizmo is published by Gernsback Publications, Inc., 500-B Bi-County Blvd., Farmingdale, NY 11735. Senior Writers: Chris F. O'Brian and Teri Scaduto.

ON THE FLOOR AT SCES 94

Chicago's McCormick Place convention center is divided into two distinct sections: the East Hall and the North Hall, connected by a labyrinth of hallways and staircases. In past years, virtually the entire main level of the East Hall was devoted to the large exhibits set up by the big players in mainstream audio and video. Demo rooms on the lower level of both halls were used by smaller companies—or those seeking to restrict visitors to invited guests—to showcase new products. The North Hall, in recent years, was home to small-office products, computers and software, multimedia, and games.

This year, however, a small number of A/V exhibits shared the East Hall with the PCC "show," SOHO products, furniture displays, and the Innovations exhibit (which previously was in the North Hall's lower level). There was still plenty of room to spare. The North Hall was the exclusive province of video games, including multimedia software and hardware.

LET THE GAMES BEGIN

With so much of the show—perhaps half or even more—devoted to gaming, it's not surprising that the keynote address was given by Howard Lincoln of Nintendo. Lauding the video game as the "first true form of interactive multimedia," Lincoln predicted that gaming is no passing fad, and that it will remain a lucrative business for years to come. He went on to address the challenges faced by those in the video-game business, citing the call for censorship of games, the consolidation of small firms into large conglomerates, the introduction of new technologies, and the heightened competition between purveyors of old and new types of game systems.

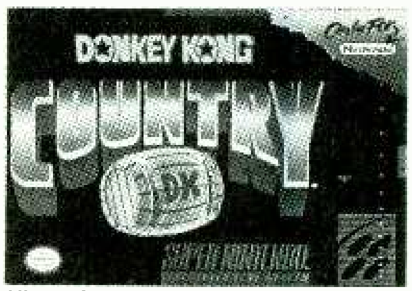
Comparing the situation to that faced in the 1920's by the budding motion-picture industry, Lincoln said that a "golden age of video games" is in the near future—*if* the video-game industry learns from the early Hollywood experience. Speaking for Nintendo, he cited the need for a "video game rating system . . . that's independent and honest and . . . that applies to all forms of digital entertainment software, whether played on Nintendo or Sega . . . or on IBM PC's or Apple computers."

Lincoln stressed that new technology won't change things overnight. Instead, after the introduction of a new technology, consumer acceptance follows a "predictable learning curve." Taking the position that "the first technology to market does not necessarily win," Lincoln, noting that movie-goers are drawn to theaters by content—not screen size or sound systems—said that "only hit games will get you customers."

He went on to introduce what Nintendo hopes will be the next huge video-game hit—*Donkey Kong Country*. Expected to be released in November, the game will be played on 16-bit Super NES. (The jungle theme of Nintendo's huge booth at the show, which dominated the North Hall, was inspired by Donkey Kong Country.)

Nintendo isn't sticking its head in the sand and hiding from new technology, however. The company claims to be on schedule with the fall 1995 release of its 64-bit system called "Nintendo Ultra 64." The first title for the new system will be *Turok: Dinosaur Hunter*, from Acclaim Entertainment.

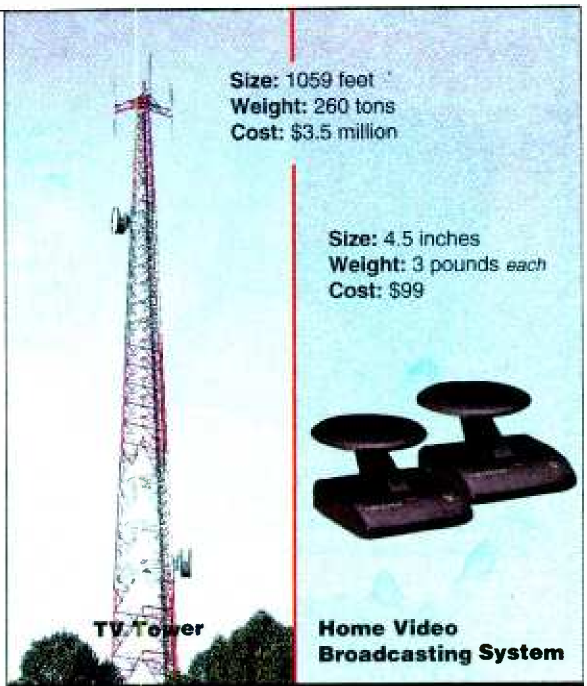
Meanwhile, Nintendo's chief competitor, Sega, was noticeably absent from the SCES floor. Instead, the company held private meetings at a lower-level demo suite, at which the focus was on the *32X* 32-bit adaptor for the Genesis, and a wealth of new software for Sega's Genesis, Game Gear, CD/CDX, and 32X products. Sega also introduced a line of children's toys, including early discovery learning games for young children and electronic entertainment for older kids. One of the first introductions will be *Pico*, "The Computer that Thinks It's A Toy," a combination of an interactive storybook and paint/animation program designed to look



Nintendo hopes to have the next smash video-game hit with the release of Donkey Kong Country for Super NES.

Your own TV station for less than $100?

Recoton's engineering breakthrough transmits cable, TV, VCR and satellite programs throughout your home...without wires!



TV broadcasting comes to the home.

By Charles Anton

Today television choices are virtually unlimited. With cable, satellite TV, videos and network programing to choose from, it's a full-time job just trying to keep up with everything. And it promises to get worse from here. Newly developed fiber optic technology will bring more than 500 TV channels to your home.

Home broadcasting breakthrough. The only problem with all this technology is the expense. Now, a newly developed wireless video broadcasting system gives you the power to utilize this technology, without the hassle and expense of wiring your entire home.

Recoton's research and development team brings you the next generation in wireless broadcasting. The wireless video broadcaster enables you to transmit (re-broadcast) cable, TV, VCR or satellite programs to any other TV in your home, without wires!

Wave of the future. Never again will you have to drag your VCR from room to room, or have to buy more than one. With the wireless video system you can broadcast videos to any other TV in your home.

You won't have to worry about running cable wire all over the place either. Besides, who could afford to install cable in every room anyway? With the wireless video system, you won't have to. You can even watch one program on your main TV and watch a different program or video on the other. It's like having a personal broadcasting system in your own home– and it's legal in every state.

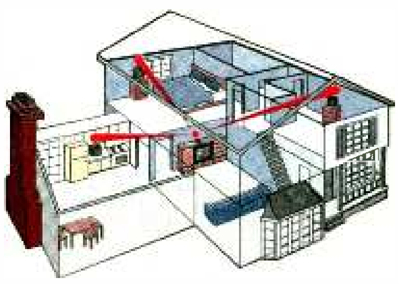
Hi-tech home broadcast. Recently, the *Federal Communications Commission* allocated a band of radio frequencies specifically for wireless, in-home product applications. Recoton's research and development group took advantage of the 1989 FCC ruling by creating and introducing wireless home transmission equipment that could transmit pictures and sound in the prescribed frequency over distances of 150 feet or more.

One transmitter, unlimited receivers. One transmitter operates an unlimited number of receivers. That means one transmitter in the den can send signals to the TVs in the bedrooms, kitchen and wherever else. Put your favorite programs in the places you want them most.

Wireless Video Breakthrough...

watch what you want, where you want

- **Cable.** *Broadcast cable channels to the other TVs in your home that aren't wired for cable... even premium channels.*
- **Videos.** *Transmit VCR signals to rooms that have no VCRs. Watch videos in any room of the house, even if someone's watching TV in the room with the VCR.*
- **Satellite programs.** *Watch satellite programs throughout your home without stringing cable everywhere.*
- **Network programing.** *If you have a house full of TVs but only one is hooked up to an antennae, you can broadcast the clear signal from that TV to all the others.*
- **Live video.** *Watch your home videos as you film them. Or turn your camcorder into a security camera.*



Even more choices. Since the system utilizes the latest 900 MHz frequency signals, no time-consuming or complicated wiring is required. The receiver can be moved from one TV to another as your needs change. Or the transmitter can broadcast to multiple receivers, so that you can watch the same program on many TVs simultaneously. The transmitter simply connects to the source TV; the receivers connect to the others.

Easy-to-use. With state-of-the-art resonator quality, both the transmitter and the receiver provide users with a small, easy-to-install product that does not require the adjustments that competitor's models do.

This latest version incorporating space-age styling with the latest miniaturized design circuitry, enables the transmitter and receiver to be substantially smaller than previous models.

Exclusive direct offer. With this breakthrough in home video broadcasting technology, you can have the convenience of your own personal wireless broadcasting system for a fraction of the cost of owning your own TV station. For a limited time, we are offering the Recoton wireless video broadcasting system direct-to-the-public for only $99. Remember, one transmitter will operate an unlimited number of receivers, you can order additional receivers for other TVs for only $59. So order now and put a personal broadcasting system in your home.

Risk-free offer. We are so confident that you will love the wireless video broadcaster that we back it up with our "No Questions Asked" 30 day money-back guarantee. If you are not completely satisfied for any reason, just return it within 30 days for a full refund. It also comes with a one year manufacturer's limited warranty.

Video Broadcasting
Cost: $99

Cable and VCRs for every room **Cost:** $799

Video Broadcasting System............**$99** $9 S&H
Includes one transmitter and one receiver.

Additional Receiver..............................**$59** $7 S&H

To receive this special pricing, you must mention promotional code **172-PL1101.**

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800-992-2966

To order by mail send check or money order for the total amount including S&H (VA residents add 4.5% sales tax). Or charge it to your credit card by enclosing your account number and exp. date.

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2820 Waterford Lake Drive Suite 106
Midlothian, Virginia 23113

Sega's new line of toys includes Pico, "the computer that thinks its a toy." Pico combines a book reader and a paint program for young children.

The CyberMaxx headset from VictorMaxx Technologies was one of the many virtual-reality accessories showcased at SCES.

like a colorful laptop computer. Other introductions will be *PODS*, a sound-and-light game that tests the player's memory, and *Beamers*, which are colorful electronic organizers that allow users to send messages across the room to a friend who also has a Beamer.

Virtual-reality systems for the home were also seen around the floor at CES. That product category, still in its infancy, is one of the "emerging technologies" that will be a primary focus of future summer shows. The lines of people awaiting an opportunity to don a virtual-reality headset were long, even on the last day of the show when many booths had a difficult time attracting a crowd.

A formidable presence on the North-Hall floor was Philips Interactive Media, which introduced new CD-i (Compact Disc-Interactive) titles in each of its four publishing categories: Games, Family Entertainment, Home Entertainment, and Video CD. New CD-i game titles include *Burn:Cycle*, a cyberpunk action/adventure game (with Macintosh and PC CD-ROM versions to follow); *Lit'l Divil* a humorous adventure game (also available on PC CD-ROM and PC floppy); *Mutant Rampage (a.k.a. Body Slam)*, an action-packed, arcade-style fighting game; and *International Tennis Open (2 Player)*, which allows two players to compete in tournament simulations (also on PC CD-ROM).

New CD-i titles from the Family Entertainment division include *Surf City, Crayon Factory, Max Magic's Electronic Magic Kit, The Joker's Wild Jr.*, and *Muzzy in Gondoland*. The Family Entertainment label has also begun releasing several CD-ROM titles.

Under its Home Entertainment label, Philips Media introduced *Time-Life Astrology*, an interactive excursion into the world of astrology; *Joy of Sex*, an interactive version of the best-selling book; and *Titanic*, in which *Star Trek TNG's* Patrick Stewart narrates a multimedia exploration of the famous shipwreck.

The Video CD group announced the availability of a set of "value-added features" that can be incorporated into any movie releases on the platform. The viewer can use an on-screen control bar to tap into information about the movie: its cast, the history of the period, and more. Also, the control bar can also provide access to a display of any available movie-related merchandise.

For example, we saw a demonstration of a Video CD of the film *Posse*. With a couple of cursor clicks we were able to call up information about African-Americans in the Old West, actor and film-maker biographies, wild-west photographs, and an on-screen "General Store." Those features can be accessed at any time during viewing. *Star Trek VI: The Undiscovered Country* will offer similar features, including access to "Trekkie" trivia and a behind-the-scenes "featurette."

Thanks to Philips' agreements with major motion-picture studios such as Paramount and MGM/UA, some big-draw attractions will be coming soon on Video CD. *Wayne's World, Addams Family Values, A Fish Called Wanda, Trading Places*, and *Moonstruck* are all due in the stores this summer. Fall releases will include *Dances with Wolves, Rainman. Thelma & Louise, Silence of the Lambs, Apocalypse Now*, and *Raging Bull*.

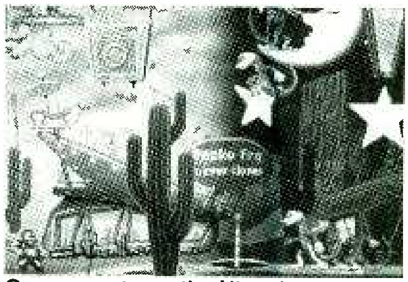
The Magnavox CDI450 Compact Disc-Interactive (CD-i) player easily accommodates an add-on full-motion video cartridge for watching Video CD's.

Throughout the second half of the year, several collectors' series will also be released, including James Bond, Star Trek, and Naked Gun.

The software introductions from Philips Interactive Media coincided with several hardware announcements from Philips, whose booth was back in the East Hall. Let's cross back over and see what was displayed on what used to be the "main floor" of SCES.

GO EAST, YOUNG MAN

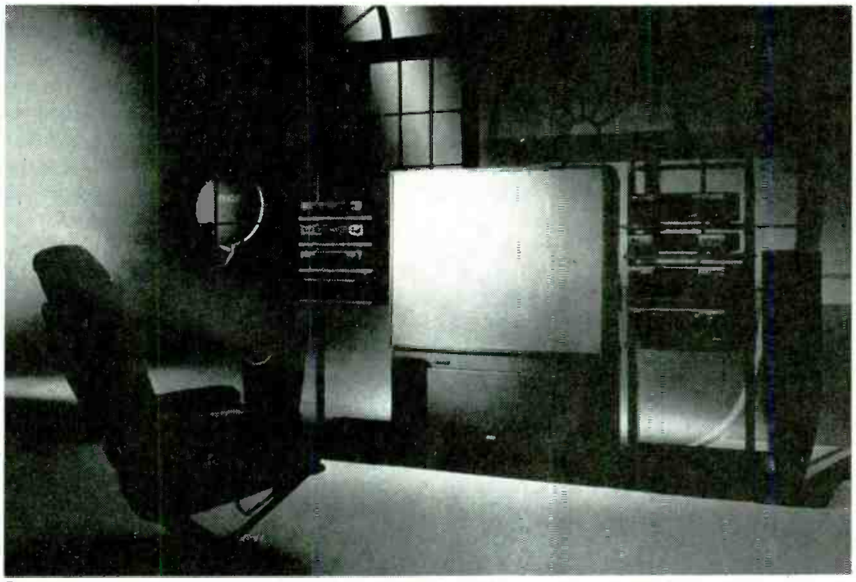
Philips Consumer Electronics introduced two new CD-i players, and previewed several "future" models that combined CD-i with audio, video, and computer products. Marketed under the Magnavox label, the *CDI450* and *CDI550* players offer all the functions of the original CD-i player, but, at 11.75 × 7.5 × 2.6 inches, are about a quarter of the size. The *CDI450* will go on the market this summer for just $299 including copies of *International Tennis Open (2-Player)* and *Compton's Interactive Encyclopedia*. The unit is designed to easily accept the second-generation Digital Video Cartridge ($249.95), which will allow it to play advanced video games and Video CD's. The *CDI550*, available this fall, will come with the Digital Video Cartridge installed, as well as the encyclopedia and the CD-i version of *Space Age*. Each model accepts the *CD-i Touchpad* video-game controller ($24.95) and splitter ($12.95) for two-player capability.



Gex, a smart-mouthed lizard, battles bad movies and TV shows in the 3DO game named after him.

Tetragon's Gridders is one of the new crop of games for 3DO.

Prototypes on display included a combination TV/CD-i, which will be introduced this year in Europe; no plans for U.S. marketing have been announced to



Consumer acceptance of small-dish digital satellite services is likely to drive sales of high-end home-theater gear, such as the RCA 52-inch rear-projection TV, VCR, tower speakers, and storage cabinet, shown here with the DSS satellite-receiving system.

date. We also saw a CD-i plug-in PC card that would give a multimedia PC full CD-i capability and a stereo mini system that incorporated a CD-i changer. Again, marketing plans are not yet announced.

Philips also was showing its latest Digital Compact Cassette (DCC) products, including its first portable recorder/player, the *DCC170*. A new DCC home deck, the second-generation *DCC951* recorder, adds four new features: Turbo Drive, which provides direct-access track search at three times the previous speed; User Text Recording, which allows owners to input up to 40 alphanumeric characters for each track recorded from a digital source; microphone inputs; and 18-bit digital-to-analog conversion. Both are scheduled for fall delivery, at as-yet-unannounced prices. Finally, Philips Car Systems introduced the second-generation DCC aftermarket car stereo. The *DCC 821*, which features a built-in CD-changer control to operate a Philips six-disc changer, has a suggested retail price of $999.99.

Not far from the Philips booth, its competitor, 3DO, was attracting the usual crowds, lured by new and upcoming software introductions. Our personal favorite was Crystal Dynamics' *Gex*, a wise-cracking, three-dimensional video lizard who must battle his way out of the Media Dimension (a retirement haven for B-movies and bad TV shows), armed with his suction-cup paws, regenerative limbs, thrashing tail, and smart mouth. Gex will be available in November.

More than 25 new 3DO titles were shown at the 3DO booth. They included *Shock Wave*, *Road Rash* and *FIFA International Soccer* from Electronic Arts; *Demolition Man* from Virgin Interactive Entertainment; *Way of the Warrior* from

Large crowds turned out for the introduction of DSS at participating dealers in Jackson, Mississippi, including Cowboy Maloney's.

Universal Interactive Studios; *Gridders* from Tetragon; and *Mathemagics: An Interactive Learning Cube* from L3 Interactive. Of course, one of the most popular games being showcased was Universal Interactive Studio's *Jurassic Park Interactive*, which was included, along with *Crash 'N Burn*, with Panasonic's *FZ-1 REAL 3DO Interactive Multiplayers* purchased between July 1 and August 31. The price of the FZ-1 was reduced last spring from $699.95 from $499.95.

Also on the hardware side of 3DO, Goldstar announced during the show its plans to expand the availability of its licensed Interactive Multiplayer in the United States and Korea. Exact pricing and availability dates were not released as we go to press, but Goldstar plans to market its 3DO machine through mass merchandisers and toy stores. And a relatively new 3DO licensee, Creative Technology, announced plans to develop a 3DO-compatible PC card.

VIDEO VISIONARIES

What about those of us who use our TV's not to play games or otherwise interact, but simply to watch programs? Never fear: Despite the small number of video exhibitors, there was plenty of gear at SCES to keep the couch potato happy for years to come.

The biggest news at Summer CES was the recent national roll-out of Primestar, and the initial launch of DSS. Both of the digital direct-broadcast satellite (DBS) systems enable homeowners to use small satellite dishes to directly receive dozens of stations of programming, with far better video and audio quality than that offered by cable companies.

PRIMESTAR

Primestar Partners is a joint venture of the subsidiaries of six national cable-television companies and G.E. American Communications, a subsidiary of General Electric, which owns the Satcom K-1 Ku-band satellite used by Primestar.

Although the first generation of Primestar systems was introduced four years ago and has a customer base of close to 70,000 subscribers, Primestar is in the process of upgrading all subscribers with digital receivers. The digital system will allow Primestar to increase its channel

Zenith introduced a line of eight TV's equipped with the StarSight interactive on-screen program guide, including this 27-inch model.

Cobra's radar/laser detector picks up all types of speed-monitoring signals and features a digital data display that graphically depicts all functions and signals.

The Personal Communications and Computing Show occupied a few aisles on the main floor of SCES.

lineup to more than 70 channels in 1994 and more than 150 in 1996.

Primestar's program lineup includes CNN, Headline News, TBS, The Cartoon Network, TNT, The Discovery Channel, The Learning Channel, C-Span, 15 regional sports networks, USA Network, The Family Channel, two Disney Channels, Arts and Entertainment, The Sci-Fi Channel, Turner Classic Movies, Encore, The Nashville Network, Country Music Television, three HBO channels, two Cinemax channels, and TV Japan (in English and Japanese). In addition, ABC, NBC, CBS, Fox, and PBS will be available to viewers who cannot get them over-the-air in their local areas. Six audio channels and ten "PrimeCinema" pay-per-view channels are also available to subscribers.

To receive Primestar broadcasts, the consumer must rent a 36- to 39-inch satellite dish and a set-top receiver (which is currently being manufactured by General Instruments.) Of course, viewers must also subscribe to programming.

The price? "Local Primestar distributors set prices for their area based on competition, customer preferences, and the cost of doing business." (Those local Primestar distributors are cable companies.) Basic service, including equipment rental, starts at about $1 a day. The one-time installation charge ranges from $150 to $300, also depending upon location.

Primestar offers more channels and better reception than that provided by standard cable TV. But little else differentiates it from the cable-monster we all love to hate. Viewers are still required to lease their equipment from the same company that's supplying the programming. And that company is the sole provider of programming.

Of course, the largely rural viewers who are not currently served by cable TV—the primary initial target customers of both Primestar and DSS—will be glad for any opportunity to have better programming selection and quality than their cable-equipped urban and suburban counterparts. And rental equipment—with "worry-free service," no maintenance costs, and free upgrades to digital service—is certainly appealing.

DSS

Thomson Consumer Electronics, DirecTV, and USSB are taking a somewhat different tack with the RCA DSS Digital Satellite System, which was all-digital from the start. Consumers will have to make an initial investment of about $700 to buy an 18-inch dish and a remote-controlled set-top receiver. Maintenance and upgrades are the owner's responsibility.

The flip side to those drawbacks is choice in both hardware and programming. Early adopters will be able to opt for the standard or high-end RCA system. And, in 18 months (or after the first million RCA units have been sold), other DSS licensees will begin to sell compatible receivers under their own brand names. (Sony is the first licensee.) Competition should result in lower prices for the hardware.

Positive Communications hopes to attract teens—and anyone else who doesn't have a credit card—with their cash-voucher programs for pager service.

Similarly, DSS offers a choice of two program suppliers. A total of about 75 channels are currently available, but by the time you read this, the second DSS satellite should be in operation, bringing the channel capacity to about 150.

DirecTV offers a host of popular cable networks, including CNN, ESPN, The Disney Channel, The Discovery Channel, A&E, and USA Network, along with a wide selection of pay-per-view movies, sports, and special events. USSB offers a similar selection of "standard" cable channels, as well as premium services, including multi-channel versions of HBO, Showtime, Flix and The Movie Channel. DSS programming is structured to be more flexible than cable; viewers can select various packages from one or both providers. Subscription rates for DirecTV range from $5.95 to $21.95 a month, pay-per-view movies cost $2.99, and sports and special events "will be competitively priced." USSB subscription rates range from $7.95 to $34.95 per month.

The big DSS news at the Summer Consumer Electronics Show was the highly successful opening weekend of RCA DSS sales at stores in Jackson, Mississippi and Shreveport, LA; all available units were sold out. The June 17th retail launch was timed, not coincidentally, to precede SCES 94 by a few days. The next few markets will include Little Rock, Tulsa, and Albuquerque; nationwide availability is scheduled for the fourth quarter of this year.

Of the opening weekend sell-out, DirecTV president Eddy Hartenstein remarked, "Results in these initial markets attest to our belief that not only are people ready for better TV technology, they are eager for more programming options."

STARS IN THEIR EYES

Those of you who already are overwhelmed with programming choices will be glad to hear that Zenith announced during SCES its nationwide launch of StarSight-equipped "interactive televisions." StarSight Telecast Inc. provides an on-screen programming guide that offers viewers seven days of continually updated program schedule information that can be used for direct tuning by title, theme, and channel number. It also allows one-touch time-shifted VCR programming of any show listed in the guide.

Zenith will be including the StarSight

Motorola's Land Mobile Products Sector introduced the Lingo line of wireless devices that connect users to voice dispatch, wireless phone, Message Mail, and data services that are available on Motorola's MIRS network.

900 MHz breakthrough!

New technology launches wireless speaker revolution...

Recoton develops breakthrough technology which transmits stereo sound through walls, ceilings and floors up to 150 feet.

Breakthrough wireless speaker design blankets your home with music.

By Charles Anton

If you had to name just one new product "the most innovative of the year," what would you choose? Well, at the recent *International Consumer Electronics Show*, critics gave Recoton's new wireless stereo speaker system the *Design and Engineering Award* for being the "most innovative and outstanding new product."

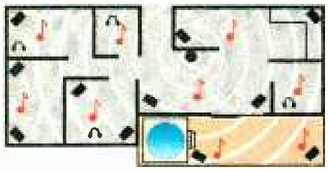
Recoton was able to introduce this whole new generation of powerful wireless speakers due to the advent of 900 MHz technology. This newly approved breakthrough enables Recoton's wireless speakers to rival the sound of expensive wired speakers.

Recently approved technology. In June of 1989, the *Federal Communications Commission* allocated a band of radio frequencies stretching from 902 to 928 MHz for wireless, in-home product applications. Recoton, one of the world's leading wireless speaker manufacturers, took advantage of the FCC ruling by creating and introducing a new speaker system that utilizes the recently approved frequency band to transmit clearer, stronger stereo signals throughout your home.

150 foot range through walls!

Recoton gives you the freedom to listen to music wherever you want. Your music is no longer limited to the room your stereo is in. With the wireless headphones you can listen to your TV, stereo or CD player while you move freely between rooms, exercise or do other activities. And unlike infrared headphones, you don't have to be in a line-of-sight with the transmitter, giving you a full 150 foot range.

The headphones and speakers have their own built-in receiver, so no wires are needed between you and your stereo. One transmitter operates an unlimited number of speakers and headphones.



Recoton's transmitter sends music through walls to wireless speakers over a 75,000 square foot area.

Crisp sound throughout your home. Just imagine being able to listen to your stereo, TV, VCR or CD player in any room of your home without having to run miles of speaker wire. Plus, you'll never have to worry about range because the new 900 MHz technology allows stereo signals to travel over distances of 150 feet or more through walls, ceilings and floors without losing sound quality.

One transmitter, unlimited receivers. The powerful transmitter plugs into a headphone, audio-out or tape-out jack on your stereo or TV component, transmitting music wirelessly to your speakers or headphones. The speakers plug into an outlet. The one transmitter can broadcast to an unlimited number of stereo speakers and headphones. And since each speaker contains its own built in receiver/amplifier, there are no wires running from the stereo to the speakers.

Full dynamic range. The speaker, mounted in a bookshelf-sized acoustically constructed cabinet, provides a two-way bass reflex design for individual bass boost control. Full dynamic range is achieved by the use of a 2" tweeter and 4" woofer. Plus, automatic digital lock-in tuning guarantees optimum reception and eliminates drift. The new technology provides static-free, interference-free sound in virtually any environment. These speakers are also self-amplified; they can't be blown out no matter what your stereo's wattage.

Stereo or hi-fi, you decide. These speakers have the option of either stereo or hi-fi sound. You can use two speakers, one set on right channel and the other on left, for full stereo separation. Or, if you just want an extra speaker in another room, set it on mono and listen to both channels on one speaker. Mono combines both left and right channels for hi-fi sound. This option lets you put a pair of speakers in the den and get full stereo separation or put one speaker in the kitchen and get complete hi-fi sound.

These wireless stereo headphones have a built-in receiver.

Factory direct savings. Our commitment to quality and factory direct pricing allows us to sell more wireless speakers than anyone! For this reason, you can get these speakers far below retail with our 30 day *"Dare to Compare"* money-back guarantee and full one year manufacturer's warranty. For a limited time, the Recoton transmitter is only $69. It will operate an unlimited number of wireless speakers priced at $89 and wireless headphones at $59 each. Your order will be processed in 72 hours and shipped UPS.

AWARD WINNING WIRELESS SPEAKER

Built-in receiver and amplifier:

The wireless speaker and headphones both contain a built-in receiver and amplifier. Signals are picked up and transmitted as far as 150 feet away through walls without the use of wires.

Don't take our word for it. Try it yourself. We're so sure you'll love the new award-winning Recoton wireless speaker system that we offer you the **Dare to Compare Speaker Challenge.** Compare Recoton's rich sound quality to that of any $200 wired speaker. If you're not completely convinced that these wireless speakers offer the same outstanding sound quality as wired speakers, simply return them within 30 days for a full "No Questions Asked" refund.

Recoton's Design and Engineering Award

Recoton Transmitter (you must have a transmitter to operate speakers and headphones)............**$69** $7 S&H

Wireless products compatible with the Recoton transmitter:

Recoton Wireless Speaker................**$89** $9 S&H

Recoton Wireless Headphones......**$69** $6 S&H

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You'll be able to dial directly into the "information superhighway" without a PC, using the multi-service PhonePlus.

Move over, Dick Tracy! The TELEwatch is a full-featured cordless telephone and personal intercom packaged in a wrist-watch.

circuitry in eight top-of-the-line models in its Advanced Video Imaging (AVI) line. The sets, which were slated to hit the stores in July, include two 27-, two 32-, and two 35-inch direct-view sets as well as 52- and 60-inch rear-projection models. The StarSight-equipped sets will send an infrared code to any VCR to instruct it to record single programs, daily series, or weekly programs, with a single command. Zenith expects the StarSight feature to command about a $50 retail price premium over comparable models without the electronic programming guide. Suggested list prices will start at $799.

Built-in StarSight capability is also offered in some models of cable boxes from Jerrold, satellite IRD's from Uniden, and StarSight Telecast's own stand-alone receiver. Philips Consumer Electronics has announced plans to incorporate the technology into Magnavox and Philips VCR's and color TV's beginning in 1995.

ELSEWHERE AT THE SHOW

While traditional consumer-electronics companies were few and far between at SCES 94, Cobra was a notable exception. Positioning itself for added consumer appeal, the company is boasting a new name (Cobra Electronics replaces Cobra Dynascan), a new line of clothing featuring the well-recognized snake logo, and a host of new products with an emphasis on safety.

Cobra's *RDL-712SW* "Intelligent Radar Detector", for instance, not only alerts drivers to the presence of police equipped with X- and K-band radar, SuperWide Ka, Stalker, and PhotoCop Ka-band systems, but will also be able to warn them of potentially dangerous moving emergency vehicles and stationary roadside hazards, such as construction sites. "Cobra has initiated

NAMES AND ADDRESSES

ACCLAIM ENTERTAINMENT, INC.
71 Audrey Avenue
Oyster Bay, NY 11771
516-624-8888

COBRA ELECTRONICS
6500 West Cortland Street
Chicago, IL 60635
312-889-8870

COMPTON'S NEW MEDIA, INC.
2320 Camino Vida Roble
Carlsbad, CA 92009
619-929-2500

CRYSTAL DYNAMICS
87 Encina Avenue
Palo Alto, CA 94301
415-473-4192

DIRECTV
2230 East Imperial Highway
El Segundo, CA 90245
310-535-5113

ECONOLOGIC TECHNOLOGIES, INC.
2370 Watson Court
Palo Alto, CA 94303
415-843-6800

ELECTRONIC ARTS
1450 Fashion Island Blvd.
San Mateo, CA 94404-2064
415-571-7171

GOLDSTAR ELECTRONICS INTERNATIONAL, INC.
1000 Sylvan Avenue
Englewood Cliffs, NJ 07632

INGENIOUS IDEAS INC.
7373 East Doubletree Ranch Road
Scottsdale, AZ 85258
602-922-9250

MICROTALK TECHNOLOGIES INC.
10001 Wayzata Blvd., Suite 210
Minnetonka, MN 55305
612-545-2627

MOTOROLA
Land Mobile Products Sector
1301 East Algonquin Road
Shaumburg, IL 60196
708-576-1000

NINTENDO OF AMERICA, INC.
Consumer Products Division
4820 150th Avenue N.E.
Redmond, WA 98052

NORRIS COMMUNICATIONS CORPORATION
12725 Stowe Drive
Poway, CA 92064
619-679-1504

PANASONIC COMPANY
One Panasonic Way
Secaucus, NJ 07094
201-393-6415

PHILIPS CONSUMER ELECTRONICS
One Philips Drive
Knoxville, TN 37914-1810
615-521-4316

PHILIPS INTERACTIVE MEDIA
11111 Santa Monica Blvd. #400
Los Angeles, CA 90025
310-444-6600

POSITIVE COMMUNICATIONS, INC.
5753 West Las Positas Blvd.
Pleasanton, CA 94588
510-416-8686

PRIMESTAR PARTNERS
100 North Presidential Blvd.
Bala Cynwyd, PA 19004
215-660-6100

SEGA OF AMERICA, INC.
255 Shoreline Drive, #200
Redwood City, CA 94065
415-802-3653

STARSIGHT TELECAST
39650 Liberty Street, 3rd Floor
Fremont, CA 94538
510-657-9620

TETRAGON, INC.
296 West Renner Parkway, #200
Richardson, TX 75080-9604
214-680-8101

THOMSON CONSUMER ELECTRONICS
10330 North Meridian
Indianapolis, IN 46290
317-267-5000

THE 3DO COMPANY
600 Galveston Drive
Redwood City, CA 94063
415-261-3000

US ORDER
13873 Park Center Road
Suite 230
Herndon, VA 22071
703-834-9480

UNITED STATES SATELLITE BROADCASTING COMPANY INC. (USSB)
3415 University Avenue
St. Paul/Minneapolis, MN 55114
612-645-4500

VICTORMAXX TECHNOLOGIES
510 Lake Cook Road
Suite 100
Deerfield, IL 60015
708-267-0007

VIRGIN INTERACTIVE ENTERTAINMENT
18061 Fitch Avenue
Irvine, CA 92714
714-833-8710

ZENITH ELECTRONICS CORPORATION
1000 Milwaukee Avenue
Glenview, IL 60025
708-391-8181

an effort to employ radar detection technology for accident prevention," said Doug Marrison, vice president of marketing and sales. "We have developed an Emergency Vehicle/Road Hazard Alert Transmitter for use by public safety agencies and highway departments. The transmitter will emit a signal that can be received and interpreted by the new Intelligent Detector."

The detector's alphanumeric digital data display indicates whether the signal is standard K-band or an emergency vehicle or road hazard. The display also lets the driver know what frequency is being detected, its strength, and its place on the frequency spectrum. The Intelligent Radar Detector will be available in September at a suggested retail price of $219.95.

Cobra was also exhibiting new models of CB radios, marketing some traditionally—as truckers' companions—and others as family communications tools. Aimed at professional drivers, the "Classic" line now includes an integrated Weather Alert receiver with automatic activation to warn users of severe weather conditions. Family CB radios include emergency communications kits to be stored in the trunk of cars, and portable units that allow busy family members to stay in touch—or groups of teens to "power shop" by splitting up to search out the best merchandise at the local mall, and calling their friends by radio to fill them in on their finds.

THE PCC SHOW

Staying in touch seemed to be the theme of the Personal Communications and Computer "Show"—actually a couple of aisles on the main floor of CES, identifiable only by a large banner. (Most PCC activity took place off the show floor, in a series of workshops on emerging technology, converging technologies, and marketing strategies.) Computer exhibitors were in the minority; most PCC exhibitors were showing pagers and cellular phones.

Teens were being targeted by several companies offering pagers and accessories in bright neon colors. Positive Communications has also initiated a voucher payment program with teen appeal. The program allows customers who don't have credit cards to pay cash for paging services. Two types of vouchers are available through retailers. Existing owners of Positive Communications pagers can buy a voucher to cover one month of basic service. First-time buyers can buy a voucher that includes a one-time activation fee and the first month of basic service. After purchasing the voucher, the customer dials a tool-free number and enters the code found on the voucher; the account is instantly credited.

If you don't like the show that's on, shoot it off the air with the trigger channel changer on this Gunverter universal remote control.

The Flashback is a digital replacement for magnetic tape-based voice recorders.

One of the largest PCC exhibitors was Motorola, which introduced its *Lingo* line of multi-service portable phones. Combining voice and data capabilities into one compact device, Lingo phones provide users with access to the Motorola Integrated Radio System, or MIRS.

MIRS allows service providers around the world to offer customers two-way radio, phone, paging, and data capability in a single compact device. A menu-driven, three-line display guides the user through the available features and services. In North America, service providers will include Nextel Communications, OneComm, DialCall, and Clearnet. The equipment is designed to operate in the 800-MHz trunked radio band. Motorola's top-of-the-line model offers all four services, while lower priced models allow consumers to pay only for what they need.

Another telephone device displayed on the PCC side of SCES was *PhonePlus*, from US Order. According to the company's vice president, Scott Corzine, "PhonePlus delivers 'information superhighway' services two to three years earlier than consumers expect them"—and does so with no intimidating computer interface. The PhonePlus allows consumers to pay bills, shop from any catalog, and conduct ATM transactions without leaving their homes. The speaker phone features a 32-bit Motorola 68000 CPU, 256K memory, a full alphanumeric keyboard, a four-line by 20-character display, one-touch visual access to advanced telephone services such as Call Forward and Three Way Calling, built-in Caller ID, and an encrypted credit-card and ATM reader. Later this year, EmailPlus, FaxPlus, and InfoPlus will be added, allowing consumers to send e-mail messages over the Internet and to transmit faxes without using a PC or fax machine. InfoPlus will provide one-button access to sports scores, weather reports, stock quotes, and news. The phone itself costs less than $200, and the services (including BankPlus and ShopPlus) are available with a small one-time activation charge and monthly fee of less than $12.

ODDS & ENDS

CES always provides a showcase for some off-beat new items, and SCES 94 was no exception.

MicroTalk Technologies, for instance, was demonstrating a prototype of a miniature cordless telephone/wristwatch, *a la* Dick Tracy. The *TeleWatch* measures only $2.2 \times 1.6 \times 0.25$ inches, yet offers some features not found in all full-sized cordless phones. Those include a scrambler circuit for privacy, speed-dial, a hold function, and an intercom feature that allows users to communicate with one another through their TeleWatches. In addition, the wrist communicator eliminates the problem of misplaced handsets—at least while it's strapped to your wrist.

Anyone who relates to Bruce Springsteen's "57 channels and nothing on" lament has probably had the urge to toss the offending TV out a window, or take a shot at it. The latter can now be done safely, with the *Gunvertor* remote control from Ingenious Ideas. Don't like what's on? Simply aim at the TV and pull the trigger to change channels. Shaped like a handgun, the Gunvertor also features a 25-button keypad used to control all major functions of a TV, VCR, and cable box. Despite the national call for handgun control, the company expects them to fly off the shelves at the suggested retail price of $69.95.

What can you do if you can't bear to miss your favorite shows and haven't figured out how to program your VCR? You could try Econologic's *TELEmate*, a radio accessory for receiving TV audio signals. You won't get the picture, but the device is wireless, inexpensive, easy to use, and works with every radio that you already own, including the one in your car. When placed within 12 feet of any AM/FM radio, the TELEmate allows the radio to pick up the audio portion of on-air television signals. Up to five TV channels can be stored as favorite stations. The device is expected to retail for less than $60.

Keep track of your brilliant ideas with the *Flashback* digital voice recorder from Norris Communications. The palm-sized device, which weighs only three ounces, is intended to replace the microcassette recorder—if the company's steamrolling of a pile of such recorders at a press event is any indication. The Flashback allows for up to 30 or 60 minutes of recording on removable flash-memory cards called "SoundClips." Because the recording is digital, it's possible to insert a "thought within a thought" anywhere on the recording. Playback can be done in regular, slow, or fast speed without changing the voice's pitch. A PCMCIA interface will allow users to download recorded messages to a PC or PDA. Flashback will be available later this year at a suggested retail price of $249.95, including a 30-minute SoundClip, batteries, and accessories.

LOOKING AHEAD

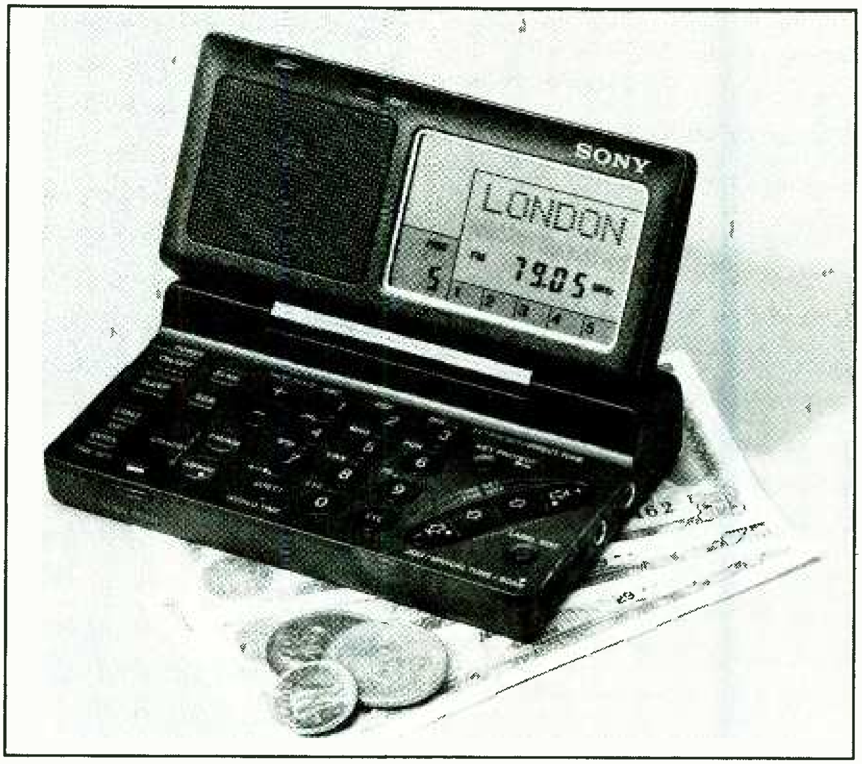
SCES '94 was smaller than previous shows, and—with the exception of the DSS launch—it lacked the excitement of major new technology introductions. (Some of the products that won Innovations awards for design excellence are highlighted in the Wish List section that appears at the end of **Gizmo**.) The show also represented the death of a consumer-electronics tradition—the annual summer showcase for audio and video gear. But it also foreshadowed the birth of what might prove to be another tradition—a late spring show dedicated to interactive consumer products.

Out of the ashes a new show is rising. Next year we'll be reporting all the action from Philadelphia, the site selected for the first "CES Interactive." ■

Tuning in the World

SONY ICF-SW100S WORLD-BAND RADIO RECEIVER. From: Sony Corp., 1 Sony Drive, Park Ridge, NJ 07656. Tel: 201-930-1000. Price: $449.95.

We have always enjoyed shortwave (or world-band) listening. Back when we first got involved in the hobby, hearing a broadcast from half-way around the world was exhilarating. During the Cold War days, the alternative opinions presented on world-band radio helped us keep the propaganda in perspective.



These days, when satellite communications has made the world an even smaller place, world-band radio can sometimes seem almost quaint. But world-band radio still has its place. Turn off the ABC commentators and listen to the World Cup games on the BBC, for instance, and you'll know what we mean.

Shortwave radio listening has gone through booms and busts in popularity. In the 1940's, for example, shortwave coverage was a common feature for a radio receiver. Here in the U.S., the latest surge in interest was brought about by the Gulf War—even though Americans saw the war start on their living room TV's and were provided almost 24-hour-a-day coverage on CNN and other networks.

One reason that world-band radio isn't as popular as it could be is that many people who gave it a chance in the past were turned off because they purchased a poor performing receiver. Although there are still plenty of junkers on the market, it's not as much of a problem today as it used to be. If there is any exception to that general rule, it is with portable receivers, which have often been poor performers.

Sony's new *ICF-SW100*, however, is an incredible receiver, especially when its size is taken into consideration; the receiver measures only $4\frac{3}{8} \times 2\frac{7}{8} \cdot \frac{15}{16}$ inches, which is small enough to fit comfortably in a shirt pocket. It weighs just under eight ounces, so it makes an ideal travel companion.

The receiver is designed something like a tiny notebook computer. The top cover contains a small ($1\frac{5}{8}$-inch) speaker and an LCD that measures about $1\frac{1}{4} \times 2$ inches. The top cover folds back to an angle that is ideal for use on a desktop—something that makes it different from other shirt-pocket-portables. The bottom half of the receiver contains a 28-button keyboard. On each side edge of the bottom half are a handful of switches and jacks. The receiver doesn't have to remain opened when you are listening to it, thanks to speaker vents in the top cover and a headphone jack.

The receiver tunes continuously from 140 kHz (longwave) to 29,999 kHz. It also tunes the FM band from 76 MHz (the beginning of Japan's FM band) to 108 MHz. The frequency coverage is broken into 16 bands: longwave, medium wave (standard AM broadcast), FM, and 13 shortwave bands (120, 90, 75, 60, 49, 41, 31, 25, 22, 19, 16, 13, and 11 meters). The SW100 is, however, a general-coverage receiver, so the frequencies outside the bands can also be tuned. The separate band designations are provided on the SW100 for several reasons. First, they allow novice users to immediately find where the international broadcasters are. Second, they allow the band of interest to be scanned. They also allow users to switch quickly between frequencies.

There are several ways to tune the ICF-SW100. One way is to enter the desired frequency directly on the keyboard. For example, to tune to 11,730 kHz, you could press DIRECT-1-1-7-3-0-EXE. Alternatively, you could use the tuning buttons.

A diagonal row of four tuning buttons is located on the right side of the keyboard. The buttons have several operating modes. The outer two buttons allow the frequency to be increased or decreased in relatively coarse 5-kHz increments. The inner two buttons allow tuning in 1-kHz increments. On the AM band, the outer buttons provice 10-kHz tuning increments, and the inner ones provide 1-kHz increments. Because the spacing of AM stations in much of the world is 9 kHz, it is also possible to configure the SW100 to tune in 9-kHz increments. Finally, in the SSB-receiving mode, the outer buttons are used to tune in 1-kHz and the inner ones in 0.1-kHz increments. However, the display cannot show the 0.1-kHz steps.

The tuning buttons can also switch the SW100 between shortwave bands. When the AM BAND button is held down, the outer tuning buttons become band-changing controls. So, to tune to the same 11,730-kHz frequency of our previous example, you would first tune to the 25-meter band and then use the outer tuning buttons to reach the frequency.

A third way to tune 11,730 kHz would be to choose it from a memory location in which it was stored. The receiver offers 50 memories, organized as ten "pages" of five locations each. That memory organization is particularly sensible for world-band listeners because many international broadcasters transmit on multiple frequencies. Storing multiple frequencies for a single station would allow that station to be tuned in at any time of day, as propagation conditions change. For example, we stored five frequencies for Radio Moscow in one page. During the day, we could listen to Radio Moscow on the 19-meter band. Frequencies in the 25-, 31-, 41-, and 49-meter bands were more useful as the evening approached and the propagation in the lower-frequency bands improved.

The radio comes pre-programmed with 30 frequencies for the BBC, Voice of America, and Radio Japan, but those memories can be reprogrammed easily. A six-character label can be stored with each memory location. After the LABEL EDIT button is pressed, the numeric keys become alphanumeric keys. For example, the 1 key, can input either an A, B, C, or 1 on subsequent pushes. The tuning mode is also stored in each memory.

There is yet another way to tune the SW100: by scanning. The receiver enters its scan mode when either of the outer tuning buttons is held down for about two seconds. The receiver will scan in either direction until a station is detected. Then it will stop for about three seconds. Scanning will continue unless one of the tuning buttons is pressed. When the top of a band is reached, the scanning will resume at the bottom of the band.

One of the few complaints we have about the SW100 is with the scanning. We would have preferred to see separate scan buttons. Instead, because the tuning buttons must be held down before the scan mode is entered, we often found ourselves tuning past stations as we were trying to initiate the scan mode. We also would have preferred to have an option of scanning past the edges of the band instead of always returning to the beginning of the band being scanned. A DX/LOCAL slide switch on the right edge of the receiver allows the scanning sensitivity to be set.

One of the high-tech features that makes the SW100 special in its size class is a synchronous detector. One of the biggest problems with shortwave reception is signal fading. Synchronous detection reduces the problem by replacing the carrier of the received signal with a perfectly synchronized, stable carrier generated by the receiver itself.

Another problem that plagues reception is interference from adjacent stations. However, the synchronous detector circuit locks onto only the upper or lower sideband of the station. So if an interfering adjacent station is higher in frequency, you would want to lock on to the lower sideband. Conversely, if the interfering station was lower in frequency, you would want to lock on to the higher sideband.

The receiver's USB and LSB/CW modes allow single-sideband and continuous-wave (Morse-code) signals to be received. Single-sideband and CW transmissions are commonly used by amateur radio operators (hams).

The receiver's display is side-lit by two green LED's. When the radio is being powered by two AA batteries, the light stays on for about 30 seconds. When powered by the supplied AC adapter, the light is always on when the radio is on. Because the light button is the only control located on the cover, it's easy to find in the dark—when you need it most.

Audio Technica's ATH-P5 headphones allowed us to listen and DX for hours in comfort.

The tiny front-panel speaker is surprisingly adequate for casual listening. However, it certainly doesn't provide high-fidelity, and it distorts at high volumes. A headphone jack is provided on the right edge of the receiver. Although small "ear bud" headphones are provided with the receiver, we found them uncomfortable. Most of our listening was done with the superbly comfortable *ATH-P5* headphones from *Audio-Technica* (1221 Commerce Drive, Stow, Ohio 44224). FM-stereo broadcasts are received in stereo through the headphone jack. The audio quality is pleasant enough for casual listening. It is, however, lacking in bass output. No tone controls are available for FM broadcasts. A NEWS/MUSIC tone control is provided for AM reception. The same switch acts as a STEREO/MONO selector in the FM mode.

The built-in 26-1/2 inch telescopic whip antenna performs well for casual listening, as does the built-in loopstick antenna for AM-band and longwave reception. For better results on the shortwave bands, a Sony AN-100 active (amplified) antenna is provided with the receiver. The active antenna receives its power from the SW100 ACTIVE ANT jack. Because that jack always supplies 3 volts DC when the radio is on, it cannot be used to attach other external antennas to the receiver.

For listening to mainstream world-band broadcasts, the active antenna, with its 26-1/2 inch whip hardly performs better than the receiver's built-in telescopic whip. The active antenna can help pull weaker signals out of the mud, however. The connecting cable is almost twelve feet long, and stores on a reel inside the AN-100. The AN-100 has four bandpass settings: Wide (0.15–30 MHz), Low (0.15–5.5 MHz), Mid (5.5–11 MHz), and High (11–30 MHz.)

The SW100 contains a built-in 24-hour clock. Unfortunately, the clock cannot be set—or even seen—when the radio is turned on. Thus, it can't be set with the help of WWV, WWVH, or other standard time-and-frequency stations. The clock is set by using the inner tuning buttons in conjunction with the TIME SET button to change the radio to indicate the proper local time zone (as identified by the name of a city in each zone). The outer tuning buttons adjust the time.

Coordinated universal time can be called up with the touch of a button (again, only when the radio is off). Another button lets you automatically compensate for daylight savings time. The tuning increment in the AM band (9 or 10 kHz) is determined by the time-zone setting.

A standby function allows two stations to be stored in timer memories. At the appropriate time, the radio will come on to the stored frequency. If the radio is already on, it will switch to the stored frequency. If only a time is stored in memory without a frequency, the SW-100 will act as a simple alarm clock, and beep at the stored times.

The receiver offers a line-level output jack for connecting the receiver to tape recorders, an audio amplifier, or other equipment. The output could also, for example, provide an input for a radioteletype decoder.

The SW100 is an incredible radio. Although it's somewhat expensive, it has something for everyone. Because it's easy to use and performs so well, first-time listeners won't be frustrated trying to find something to listen to. With its diminutive size and time/alarm functions, the receiver makes an ideal travel companion for shortwave enthusiasts.

The receiver does have what we think are a couple of minor problems. As mentioned earlier, you can't see the clock when the radio is on. Also, it lacks a signal-strength meter (although it does have a TUNE indicator). Also, the AM band tunes only to 1630 kHz—only a drawback when in the scanning mode. None of those problems is significant enough to take away from the best portable shortwave receiver we've ever tried. ■

Team Player

TEAM MONITOR AND TEAM BASS SUBWOOFER SPEAKERS. From Rock Solid Sounds of America, 54 Concord Street, North Reading, MA 01864-0008. Tel: 508-664-3406. Price: $199/pair (Team Monitor), $250 (Team Bass Subwoofer).

Of all the products that come through Gizmo for evaluation, speakers are the most difficult to review. Laboratory measurements tell precious little about how a speaker will sound in real listening situations. In fact, speaker placement and room acoustics have a more dramatic influence on speaker performance than virtually any other factor.

Instead of putting our speakers in an anechoic chamber with test generators and microphones, we generally put speakers to the test with our ears in a variety of listening areas, with a variety of program sources. What those tests have showed us is that *Rock Solid Sounds of America* has created an incredibly versatile speaker system with its *Team Monitor* speakers and the *Team Bass* subwoofer. Together or separately, they are ideal for a variety of listening applications and environments.

The Team (Total Entertainment Audio Monitor) Monitor is housed in an attractive cabinet that measures about 8 × 5½ × 5¼ inches. Built-in hanging brackets allow the speakers to be placed on a wall with a minimum amount of fuss—they can easily be mounted at ear level. Although the speakers are rather small, they nonetheless boast a power-handling capability of 75 watts.

The Team Monitors are two-way bass-reflex speakers. They have a rated frequency response of 80 Hz to 20 kHz (±3 dB) and a rated sensitivity of 87 dB (1 watt, 1 meter). Their nominal impedance is 8 ohms.

The Team Monitor speakers by themselves would be a good choice for rooms where space is at a premium but accurate speaker performance is equally important. They would be a sensible choice for one zone of a multi-room audio system, for instance. They also would be an excellent choice to serve as speakers for a video system—they are magnetically shielded so that they won't distort the monitor's display. The Team Monitors would also be a good selection for use as surround speakers because of their convenient mounting brackets.

Another example of the speakers' versatility is that they can be mounted outdoors. They do have to be somewhat sheltered, however, as they cannot withstand direct rainfall or immersion. They should be able to withstand the environment of a steamy bathroom or a kitchen without any problem. To show how serious Rock Solid Sounds is about outdoor mounting, the company includes a "bug plug" with the speakers. The small, round, metal screen is intended to be installed in the speaker's port to keep insects—perhaps even small birds—from calling the Team Monitors their home when they are used outdoors.

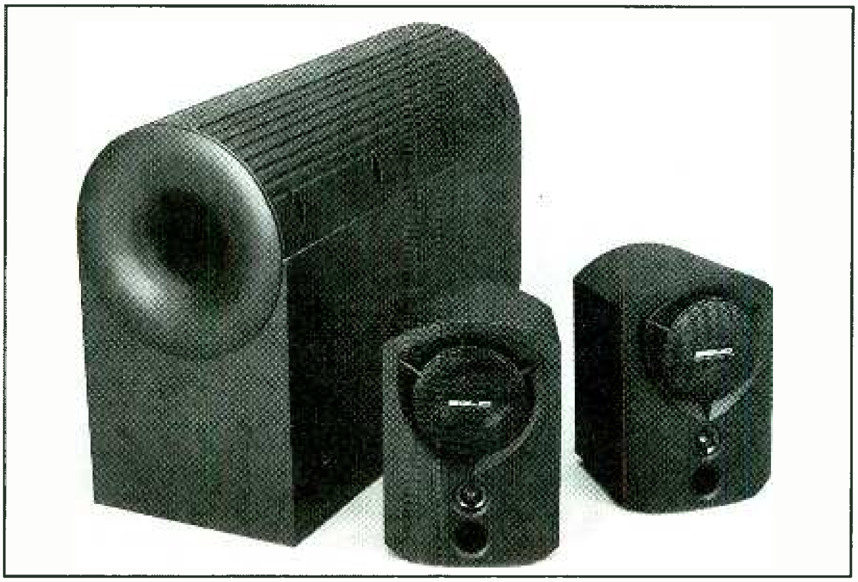
The Team Monitors can also more than meet the demands of being placed in the main listening room when they are teamed up with the Team Bass Subwoofer. Such a setup, in effect, becomes a top-notch three-speaker, subwoofer/satellite combination.

The subwoofer, with a frequency response of 45 Hz to 180 Hz (±3 dB), accepts the left- and right-channel outputs from a stereo amplifier. Outputs are available to drive the Team Monitor speakers. In this configuration, the power-handling capability of the system is boosted to better than 100 watts.

Unlike most subwoofers that incorporate a dual voice-coil, the Team Bass subwoofer incorporates two 5-inch drivers. They fire up from a rectangular base into the tubular top of the subwoofer cabinet. (Actually, "base" and "top" are subjective terms. The subwoofer can be mounted in virtually any position.)

As with any subwoofer—or any speaker—its performance is greatly influenced by placement. The placement is especially critical for subwoofers, because bass response is greatly affected by a speaker's proximity to walls and corners. Also, the wavelengths of the signals that the subwoofer handle are of the same order as room dimensions, so standing waves can be set up in the listening room, affecting how the subwoofer sounds at different listening positions.

The combination of the Team Monitor and Team Bass subwoofer yields a high-performance loudspeaker system. The highs were crisp (but not excessively so) and well-defined. The bass was free of boominess, and the stereo imaging was excellent. The transition from bass to treble frequencies was seamless—the component speakers were truly designed as a team. As good as the Team Monitor speakers are, the addition of a Team Bass subwoofer makes a combination that is tough to beat. ■



TECHNOLOGY UPDATE

How to get surround sound without buying the theater...

Chase Technologies brings you an amazing new surround sound decoder that turns your stereo into a multi-channel home theater.

By Charles Anton

As much as I love renting videos, it's just not the same as seeing a movie in a theater. I remember the first time I saw *Jurrasic Park*. I nearly jumped out of my seat when the dinosaurs roared. One of the reasons movies seem so real is because surround sound makes it seem like you're actually there when events are happening. Now there's an incredible new device that lets you use a stereo receiver to get that same surround sound in your home.

It takes more than four speakers to get surround sound; there needs to be a way of separating the signals. The new Chase Technologies HTS-1 decoder does just that, and in a revolutionary way that rivals the best Dolby Pro-Logic and THX systems.

Wins over critics. Gary Reber, editor and publisher of the most authoritative magazine on home theater systems, *Widescreen Review*, stated, "...passive matrix decoders such as the new Chase HTS-1 work great as Dolby Surround™ extractors, and sound exceptionally natural when used for soundtracks and music."

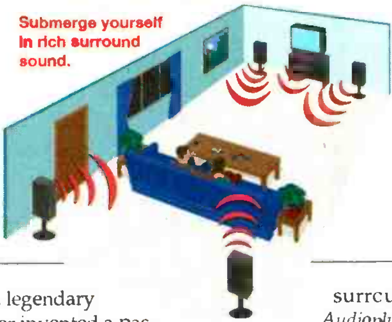
Passive circuit. In 1972, legendary audio pioneer David Hafler invented a passive circuit to extract the "L minus R" difference signals in stereo soundtracks. Because the circuit was patented, it was only available on expensive Hafler products. Now that the patent has expired, Chase can make this amazing decoding system available at a fraction of the cost of other systems!

The secret of surround sound

Surround sound has become the rage of the 90's because it adds depth and realism to stereo sound, giving you the home theater experience. It makes you feel like you're actually at a concert or theater. To "fill a room" with surround sound, you need more than two channels. The HTS-1 provides four channels of sound from any two-channel stereo source.

Free center channel. By connecting your VCR or laserdisc player to your TV, you get sound from your TV speaker; this acts as the fifth or "center channel." Adjusting your TV's volume gives you as much or as little "center channel" localization as you desire, without extra speakers or amps. There are also no extra costs with the "fifth" channel. When used with the HTS-1, you'll have a true state-of-the-art five-channel system.

Submerge yourself in rich surround sound.



Breakthrough. The HTS-1 is able to decode the Dolby Surround™ signal in a videotape or laserdisc because the spatial and depth cues have been matrixed into the "L minus R" portion of the two-channel stereo soundtrack. By decoding passively, the HTS-1 avoids costly and noisy signal processing. Plus you don't need any additional amps! Just connect the HTS-1 to your existing stereo system, add two speakers for the rear, and you'll experience the magic of home theater at a fraction of the cost.

Concert sound. The HTS-1 also decodes the ambience found in all music recordings. This sense of space, or "concert hall acoustics," is present in all CDs and cassettes, especially live recordings. John Sunier, the leading authority on surround sound and producer of *Audiophile Audition*, a nationally syndicated radio program for audio enthusiasts, says, "...the new Chase HTS-1, when used to decode the hidden ambience in all musical recordings, definitely outperforms all the Dolby and THX processors (which could cost you up to $3,000)... I am impressed!"

Easy installation. Hooking up the HTS-1 is easy. Simply connect the speaker outputs of your receiver or amp to the HTS-1, then connect speaker wire to the front and rear speakers. The rear channel speakers don't have to be big. In fact, we recommend the Chase ELF-1 in either black or white finish to match your decor. They can be mounted with enclosed color-matched mounting brackets or can be flush mounted on the wall. They are also water and weatherproof; they can be used indoors or out.

The ELF-1 rear channel speakers integrate perfectly with the HTS-1.

Risk-free home trial. Let's face it— the best way to evaluate surround sound is in your home, not in a showroom. That's why we're offering this risk-free home trial. We're so sure you'll be delighted with the quality of these products and the surround sound experience that we are giving you 30 days to try them for yourself. If they're not everything we say, return them for a complete "No Questions Asked" refund.

HTS-1 Home Theater Decoder............ **$79** $9 S&H

Speakers designed by Chase for the HTS-1:

ELF-1 Rear Channel Speakers .... **$99** $10 S&H

Please mention promotional code 165-PL1102.

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ELECTRONICS WISH LIST

Bogen Cordless Friday

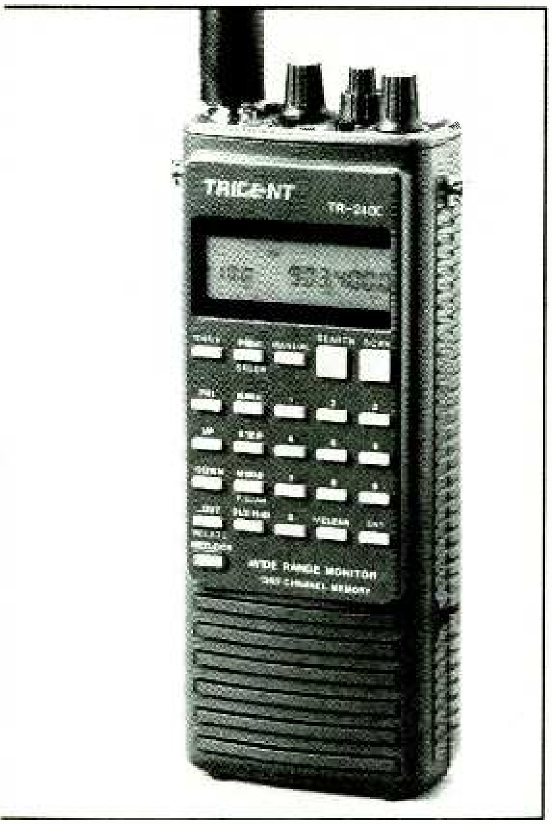
Cordless Friday

Friday, the electronic "Personal/Office Receptionist" from *Bogen Communications, Inc.* (50 Spring Street, P. O. Box 575, Ramsey, NJ 07446) is now available as *Cordless Friday*, an integrated, pocket-sized, cordless telephone and digital answering system. Cordless Friday offers home-office workers and members of busy households the freedom of a cordless phone and the electronic-receptionist features of the original Friday. Those include call forwarding, pager notification, fax switching, and digital voice mail. The small, 10-channel cordless handset fits conveniently in a shirt pocket and boasts a transmission range of up to 1000 feet. The messaging unit allows users to selectively skip, save, and delete messages, and provides eight mailboxes for greater control of business and personal communications. Voice and visual prompting simplify setup and on-going use. A dataport allows Cordless Friday to be connected to a fax machine or PC to allow remote access to the computer. Price: N/A.

Samsung A/V Disc Player with CD-OK

Multi-Format A/V Disc Player

Aimed squarely at the Asian-American market, the *KDC-1* disc player is the first product to incorporate *Samsung Electronics America's* (106 Challenger Road, Ridgefield Park, NJ 07660-0511) CD-OK format. CD-OK discs store the musical information as MIDI data, and high-resolution video images are stored as MPEG-compressed data. A proprietary graphics system displays lyrics and cuing information. The format allows Samsung to "exponentially improve both capacity and functionality over older laserdisc and CD + G systems"—in other words, to create karaoke discs that contain up to 3000 songs and 4000 images. The multi-format, five-CD carousel is compatible with audio CD's and CD + G discs in addition to the CD-OK format. The first CD-OK releases will feature Chinese, Korean, and other Asian songs; the copyright problems—and costs—inherent in producing a 3000-song disc could delay the release of any American CD-OK discs, perhaps indefinitely. Price: $1199.



Ace Trident Receiver

Full-Spectrum Receiver

The *Trident TR2400* handheld receiver from *Ace Communications* (6975 Hills dale Court, Indianapolis, IN 46250) can receive virtually any legal broadcast frequency. (Cellular frequencies are disabled to conform with current FCC regulations.) With a frequency range from 100 kHz to 2.060 GHz, it covers the radio frequency spectrum from below AM broadcast to above the new Personal Communications services in the microwave range. Users can tune in to nearly every kind of voice broadcast from all over the world. The TR2400's demodulation modes are AM (for broadcast and world-band radio plus civil and military aviation), narrow FM (for police, fire, and emergency transmissions), Wide FM (for radio and TV-audio broadcasts), and single sideband (for transoceanic-aircraft, ships-at-sea, and ham-radio communications). Tuning increments are selectable in steps as low as 1 kHz. The receiver offers 1000 permanent memory locations for storing active channels. Up to ten different search ranges can be set and entered into the unit's memory. Memorized frequencies are scanned at up to 25 channels-per-second, and the radio will lock on active calls to receive the broadcast. The TR2400 comes with a 12-volt adapter, an AC battery charger, four "AA" batteries, an earphone, a built-in speaker, a belt clip, a flexible antenna, mounting hardware, operating instructions, and a listing of allocated uses for all the frequencies covered. Price: $799.

ELECTRONICS WISH LIST

Tornado Warning

Dorothy sure could have used *KBA Inc.'s* (256 Commerce Drive, Suite 471, Peachtree City, GA 30269) *Final Alert*. The device warns homeowners in both urban and rural areas that a tornado is very near and approaching, and is particularly useful in rural areas where coverage by a central warning system is not available. Similar in size and appearance to a smoke detector, Final Alert is installed unobtrusively on the southwest eaves of a home. It works by detecting the characteristic audio frequencies produced by tornadoes. An individual household is alerted to the presence of a tornado in ample time to take immediate action to prevent injury or loss of life—or unplanned trips to Oz. Price: $139.

KBA's Final Alert

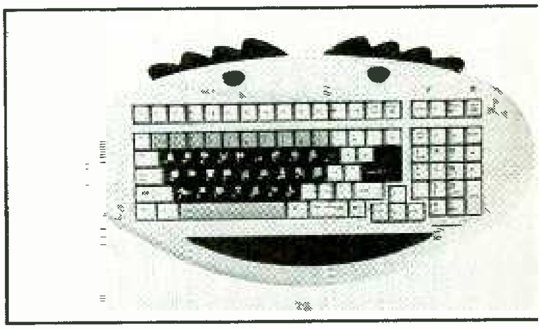
No-Skip CD Player

Fisher Audio/Video (21350 Lassen Street, Chatsworth, CA 91311-2329) has introduced a personal CD player with the upgraded "Opti-Trac II" anti-skip system. The *PCD-60* contains a buffer memory that keeps the music playing even during the bumps and shakes associated with portable listening. The Opti-Trac II system resists interruption by storing CD music data in a memory chip with the capacity to store 10-seconds of audio data. (The original Opti-Trac system had only a three-second buffer.) Using a fast-read multi-trace (FMT) system, musical data is read at twice the normal speed and stored in memory before digital-to-analog conversion. If the player is jarred and mistracking occurs, the memory plays on as the pickup moves back to its original position. Other features include a line-out jack that allows the personal player to be used with an existing home or portable audio system; and a three-position (rock, jazz, and classical) electronic equalization system. Price: $219.95.

Fisher Anti-Skip CD Player

Kid-Style Keyboard

You don't have to know how to read to use a computer—ask any preschooler. There's plenty of kid-oriented software out there, and now there's some hardware, as well. The *kidBoard* from *KidBoard, Inc.* (6545 France Avenue South, Suite 376, Edina, MN 55435) is a computer keyboard specifically designed for kids aged three to eight. It combines the capability of standard "grownup" keyboards with kid-friendly features such as bright primary colors, clever icons on the alphabet keys (an apple for A, etc.), a cartoon-like face incorporated into the housing, and fun software to help children become more comfortable using a computer. Its creators compare the kidBoard to "a set of training wheels for young computer users." The industry-standard, 101-key keyboard resembles a large yellow face, complete with blue hair, blue button eyes, and a "smiling blue chin" that serves as a hand rest for small hands. The keys are color-coded to differentiate groups of keys. The Board Games software package includes three programs to help kids become more familiar with the alphabet, the keyboard, and computer operations. Price: n/a.



kidBoard Children's Keyboard

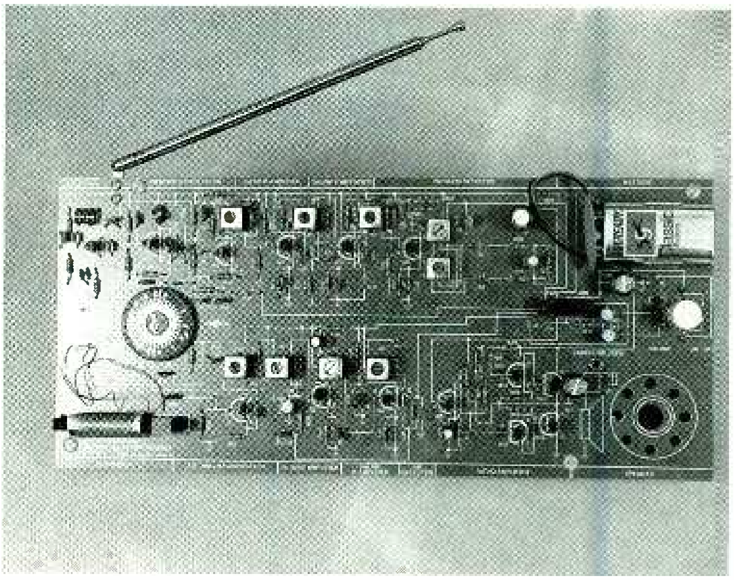
CB Emergency Kit

Cobra Electronics (6500 West Cortland Street, Chicago, IL 60635) dubbed its *Model 10 SOS* citizen's band radio an "Emergency Kit," emphasizing its potential role in calling for roadside assistance, and positioning it as an affordable alternative to a cellular phone. The 10 SOS Kit contains an ultra-compact, 40-channel CB radio, a microphone, a magnetic-mount antenna, and an emergency "Help" flag. The radio is packaged in a durable storage carton, which can be kept in the glove compartment, under a seat, or in the trunk until needed. When the radio is needed, it can be powered through a 12-volt cigarette lighter plug. The radio offers one-touch tuning of channel 9, the universal emergency channel on the citizen-band frequency. Price: $69.95.

Cobra CB Emergency Kit

A Hands-on Electronics® REPORT

ELENCO ELECTRONICS AM/FM RADIO KIT



CIRCLE 119 ON FREE INFORMATION CARD

A great project for the beginning or intermediate builder.

We know that many of the readers of this magazine enjoy building kits and projects. We know that because building is a large part of what this magazine is all about. Whether you like the comfort and convenience of building from a kit or the challenge of building a project from scratch is largely a matter of personal preference. The bottom line is that you like to build.

That said, there are quite a few advantages to working with a kit, especially for less experienced builders. For one thing, buying a kit is sometimes cheaper than gathering individual parts together. For another, there's the convenience of having everything in one package, including the etched PC board or boards, ready to go. What's more, going the kit route should in no way limit what you can build. There are hundreds, if not thousands, of interesting kits available through advertisers in this magazine and elsewhere. But with so many kits around, you may wonder what kit offers that something special that makes building it a worthwhile endeavor, and just *what* is that special something?

A Kit Classic. For this reviewer, one type of kit that offers something special, especially for a beginner, is a radio kit. That's because radio kits were among the very first kits around, and the emergence of radio was what largely started the electronics hobby that we all enjoy so much. Where would we as a group of hobbyists be today if it weren't for those early radio pioneers?

Nothing makes you feel more like an electronics hobbyist than powering up a radio you built yourself for the first time. And even though you've heard radio a million times before, there's nothing that matches the thrill you get when you hear a radio signal for the first time on that receiver.

One kit that can give you all of that excitement and fun, and help you learn more about electronics in the bargain, is the AM/FM-108 Radio Kit from Elenco Electronics Inc. (150 W. Carpenter Ave., Wheeling, IL 60090 Tel. 708-541-3800). That kit lets you build a superheterodyne AM/FM radio from the PC board up. The radio is built on a single-sided PC board that's about 5 by 11 inches. It features 14 transistors and 5 diodes, built-in antennas for both AM and FM, a speaker and earphone jack (with an included earphone), and it's powered from a 9-volt battery. A "classic" kit like this deserves a classic battery, and an "Eveready Classic" 9-volt is included with the kit. A roll of solder is also included. The price of this kit is very easy to swallow, as it will cost you only $29.95.

An added bonus with this kit is what you can learn about radio. The instruction manual contains over 50 pages, and most of it is filled with technical information on radio theory. The manual begins with a block diagram of the receiver and briefly explains what each section does.

More in-depth information is offered as the radio is built. During assembly, each section is explained, built, and tested before going on to the next. The AM portion is fully functional before a single FM part is installed. That method of construction gives the builder a thorough understanding of how each section works, and also eliminates problems along the way—while they're easy to track down and repair—so it's unlikely that you'll have any trouble getting the radio to work. Optional quizzes to see how much you have learned are also presented.

One unusual feature of this kit is how the actual schematic of the circuit is silk-screened right on the PC board.

The parts fit on the board right over their symbols, making this quite a conversation piece for anyone into electronics. Not only does that enhance the builder's familiarity with radio circuitry, it also reduces the chance of incorrectly installing components, as the resistors go down on resistors, capacitors on capacitors, and so on.

Testing and Alignment. Two methods of testing are possible with this kit. If you have access to such test equipment as audio generators, variable power supplies, oscilloscopes, and the like, the manual includes detailed information on how to use that equipment to align the radio to tight specifications.

However, because most people who would want to build this kit would not have access to most of that test equipment, the manual also includes information on how to test and align the circuitry with only a multimeter and your ears. As a last resort, you can even align the radio entirely by ear.

Even though we do have access to the required equipment, we wanted to make sure that anyone could build and align the radio, so we did our alignment using the second method (multimeter and ears). We found that it was very easy to get the radio to work without any fancy equipment.

We kept ourselves busy for two nights building the radio kit, which makes it a good entertainment value. Its unusual PC board also makes it one of my favorite display items and an interesting conversation piece.

For more information on the AM/FM-108 kit, contact Elenco directly, or circle No. 119 on the Free Information Card. ■

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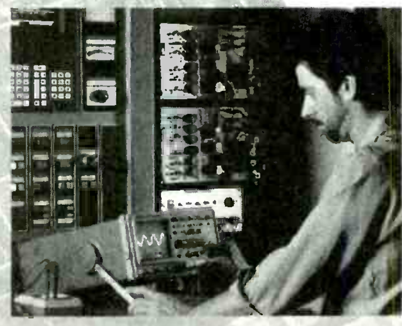

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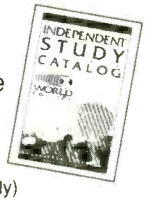

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THINK TANK

By John J. Yacono,
Technical Editor,
Windows Magazine

Some Shop Circuits

Last month I began a tutorial in basic electronics. I described electrons, nuclei, and the electrostatic force. This month I'll continue the discussion of that sub-microscopic world, and then we'll turn our attention to some circuits for the workbench. I hope the mix will make both experienced and beginning hobbyists happy.

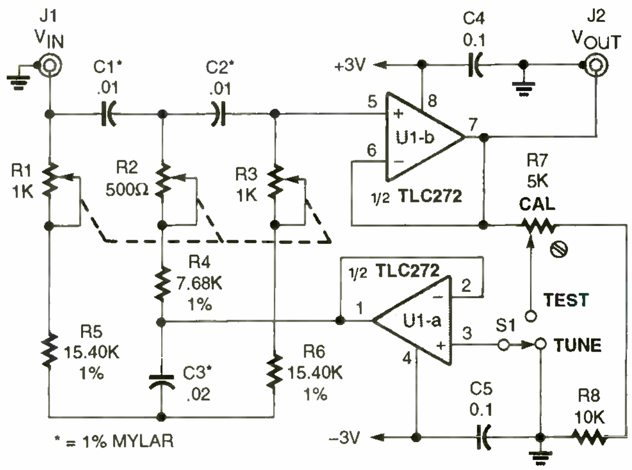

Fig. 1. Need a nice THD analyzer but haven't got thousands of dollars to spend? Try adding this to your multimeter and pocket the difference.

CONDUCTORS AND CURRENT

As I mentioned last time, electrons orbit nuclei. More times than not, more than one electron orbits the same nucleus. How many depends on how positively charged a nucleus is. Elements we typically call metals have very positive nuclei, so they tend to have a large number of electrons. So many in fact, that the outer most ones are only loosely held in orbit. It doesn't take much energy for one electron to go wandering off unmissed.

Another property of metals is something called "metallic bonding" (which has nothing to do with atoms playing sports together). Atoms in a metallic bond share their outer electrons so that for every positive charge in the nucleus, there is a full complement of electrons in orbit at least part of the time. Generally, a metal atom will form metallic bonds with each of its neighbors. Effectively, that means that the outer electrons in a metal are fairly free to migrate from one atom to the next, and they do. If electrons can move freely through a substance, we can call it a "conductor."

Now let's say we take blocks of two different metals and metalically bond them together. If we dip the assembly in a puddle of the right acid, both will have a tendency to dissolve. That is, the nuclei of each will tend to move into the acid, leaving their outer electrons behind. That will continue until the acid becomes saturated with nuclei because (being all positively charged) they don't like being crowded together. Also, the electrons saturate the blocks, so the blocks become a more attractive place for the positively charged nuclei to stay than the acid.

Since the metals are dissimilar, one will have a greater tendency to move into the acid than the other. So the metal with the greater tendency to dissolve will start "pushing" the nuclei of the other metal (let's call it metal A) back onto the block forcing it to accept some foundling electrons. The electrons will migrate through both blocks toward the adoptive nuclei. The flow of electrons is called "current."

If we disconnect the two blocks from one another before all the nuclei of metal A are re-attached to the block, the assembly (sloppy as it is) could be called an "acid battery." Any conductor attached between the blocks will experience a flow of current (electrons). That flow can be made to do work, as we'll see next time.

We'll that's enough to absorb this time. Let's dissolve into some shop gear!

THD ADAPTER

One of the most important criteria of audio-amplifier performance is the harmonic distortion it introduces to a signal. This simple circuit (see Fig. 1) lets you accurately measure the total harmonic distortion (THD) using your true-RMS voltmeter. All the parts are available from Mouser Electronics (800-346-6873).

This THD circuit is somewhat different from the usual types: it can operate at the standard frequency of 1000 Hz, but is also tunable from 970 Hz to 1030 Hz, and has an adjustable "Q" factor of 0.3 to over 50. That makes the circuit much easier to use than standard units and allows very accurate results. Op-amp U1, a TLC272 CMOS unit, contains the two voltage-followers required to buffer the input to the bootstrapped twin-T notch filter. The power supply is made of two CR2032 Lithium coin cells, and if you want to maximize their shelf-life, you can substitute a TLC27M2 for U1.

Tuning is accomplished by R1, R2, and R3, which are standard linear-taper slide pots "ganged" together by mounting them side-by-side and gluing their sliders together. The only other important construction hint is to use twisted pair at the circuit's input and output.

To calibrate the circuit, input a 1.000-volt RMS signal at 2000 Hz, set S1 to TEST, and adjust R7 for a reading of 0.99-volts RMS on a true-RMS voltmeter at the output. That sets the Q of the filter so it can pass all of the harmonics, but reject the fundamental, or first harmonic, at 1000 Hz.

To use the circuit, set S1 to TUNE, input a 1000-Hz sine-wave signal to the amplifier under test, and set the amplifier's output for less than 1.50-volts RMS (1.000-volt RMS is convenient). Connect the amplifier's output to the THD Adapter and tune R1/R2/R3 for the lowest output signal. Then set S1 to TEST and read the RMS voltage. To calculate the percent THD use:

$$THD = (V_{out}/V_{in}) \times 100$$

—Skip Campisi, South Bound Brook, NJ

Of course if the input signal is 1-volt RMS, the reading at the output will be the THD as a decimal percent, so just shift the decimal point two places to the right. That's as simple as measuring THD can get!

You always seem to come out with the neatest stuff, Skip. Your circuits are usually easy to build and do interesting things. (Forgive me if I'm slow to include them in the column; that's one of the pitfalls of trying to compose a planned column.) In fact, this circuit I actually have a use for. We'll be quality-testing computer sound cards where I work, so this one might end up in the test lab until we buy a manufactured unit.

METER ADAPTER

I am enclosing a simple circuit that recently solved a problem for me. I had an appliance motor that would run for a few seconds, then trip the overload. I wanted to measure the current draw, to determine if the problem was in the motor, or an overload that tripped too soon. I did not have a clamp-type AC ammeter, and the current maximum for my digital meters is 10-amps AC. If the motor was bad, it would draw over 10 amps, as its rated current was 6.8 amps.

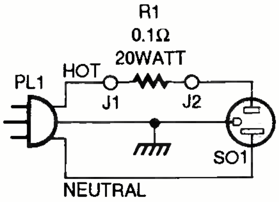

Fig. 2. Testing heavy-load devices with a ten-amp maximum meter can be accomplished with this straight-forward meter add-on. If done right, it could be made from a high-current extension cord.

As a solution, I came up with the enclosed circuit (see Fig. 2), which I put in a plastic project box. Jacks J1 and J2 are **well-insulated** pin units that accept my meter's probe tips. I did not have a 0.1-ohm 20-watt resistor, but I had two 0.2-ohm resistors, which I connected in parallel. Plugging the test leads from my digital VOM into the jacks, I read 1.4 volts AC during the few seconds before the overload tripped, indicating a current of 14 amps! The problem turned out to be sticking contacts on the starting relay for the motor.

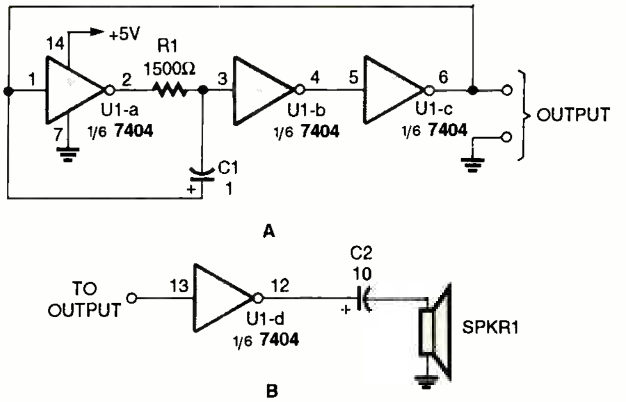

Fig. 3. Thought TTL-based audio oscillators would be impossible to build? Try the one shown in A, and if you need an annunciator, connect the circuit in B to its output.

—Bill Stiles, Hillsboro, MO

Just a couple of weeks ago I was checking the current draw of an amplifier that had a discrete power supply. I naturally blew the meter's fuse during turn on, so I convinced myself the test wouldn't be too important. Well, now I want to add another amplifier to the set up and need to determine if the power supply can handle it. You can bet I'll be using your circuit to find out! Thanks.

TTL AUDIO OSCILLATOR

Many inverting-type TTL integrated circuits will oscillate if three gates are cascaded, with the output of the third connected back to the input of the first. But the frequency will be high—many megahertz in fact—and attempts to use resistors and capacitors to slow it down to the audio range can prove frustrating for the experimenter who wants a simple audio-frequency source.

Using either a 7404 hex inverter or a 7400 quad 2-input NAND IC with the inputs of each gate tied together, the circuit of Fig. 3A seems to be nearly foolproof. The circuit will positively oscillate nicely at an audible frequency. You can change the resistor value to get the frequency you want, or use a 2000-ohm potentiometer in place of the fixed resistor to vary the frequency from a low growl to beyond the highest audible pitch. If the capacitor used is an electrolytic type, keep tolerance in mind; its actual capacitance could vary by a considerable amount.

—C.C. Stalder, Waynesville, NC

Short, sweet, and compact: If you use surface-mount parts and a potentiometer for R1, the whole circuit could be built on the back of the potentiometer. I like your optional output circuit in Fig. 3B as it doesn't require an extra IC.

SHORT-CIRCUIT PROTECTOR

Do you need a short-circuit protector for your regulated-DC power supply? Well, the circuit in Fig. 4 is very versatile, inexpensive, and rugged. All the components are easy to get at any electronics-supply store. When S1 is pressed, the coil of K1 is energized, closing its normally open contacts. If the regulated DC input is between 1 and 24 volts, that voltage feeds the base of Q1 through R1, turning on the transistor and latching the relay. When that occurs, LED2 glows indicating that all is okay.

(Continued on page 91)

special project

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Are you interested in helping us make this magazine as good for you as it can be? Then be one of the first to join the 1994 *Popular Electronics Reader Council.* Twice a year you'll be asked to complete a detailed questionnaire. It will tell us about the things in this magazine that are important to you and give us the information we need to make this your best possible reading.

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Thank you, and I am looking forward to hearing from you!

Larry Steckler,
Editor-in-Chief

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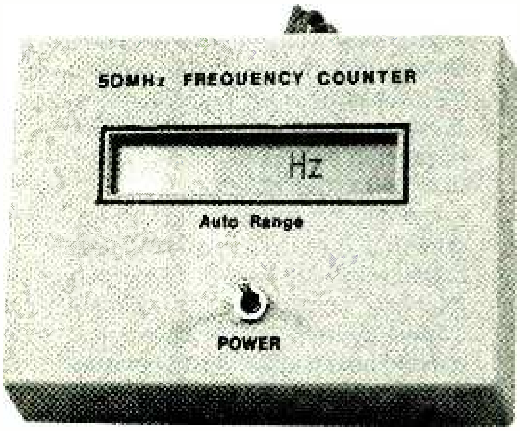


50-MHz Frequency Counter

Add this auto-ranging, digital, frequency counter to your troubleshooting arsenal!

BY TERRY WEEDER

Test equipment can really take a huge bite out of the experimenters' budget. For example, a typical basic frequency counter can run anywhere from a hundred to several hundred dollars. However, with a little effort, you can put together a very inexpensive 7-digit, 50-MHz frequency counter, based on the new PIC16C5x series of microcontrollers manufactured by Microchip.

The microcontroller provides an auto-ranging, direct-display feature—*i.e.*, the frequency is displayed with the actual suitable suffix (Hz, kHz or MHz) and with floating decimal point, instead of the old "number as an exponent" method. That makes for a substantial improvement in the readability of the displayed frequency. In addition, the gate time automatically changes from 0.1 second to 1 second at the low end of the frequency range to produce measurements with a resolution extending down to 1 Hz. All that is made possible using just a couple IC's and a couple transistors linked to a display module.

About the Circuit. A schematic diagram of the *50-MHz Frequency Counter* is shown in Fig. 1. The signal in question is coupled through C1 to a resistor network comprised of R1 and R2, which is used to set the input impedance to greater than 1 megohm. Capacitor C2 improves signal gain at the higher frequencies, while D1 and D2 clip signals greater than 1-volt peak-to-peak (p-p). After that, the signal is applied to the gate of Q1 (an MPF102 N-channel JFET), which is configured as a common-source amplifier that is self-biased by its source resistor, R4.

The output of Q1 (taken from its drain) is direct-coupled to the base of Q2 (a 2N4403 PNP transistor), which is configured as a common-emitter amplifier and whose output is negatively fed back to the source of Q1 through Q2's collector resistor, R5. That negative feedback helps to flatten the frequency response throughout the 50-MHz bandwidth. A 500-ohm trimmer potentiometer (R3) sets the bias of both Q1 and Q2, while a decoupling capacitor (C4) further improves gain at the higher frequencies.

Note that this input-amplifying stage (Q1, Q2) is powered by 9 volts as opposed to the 5 volts used by the remaining circuitry. That allows the counter's front-end to have greater overall gain than would otherwise be possible. The circuit's sensitivity is about 100 mV rms at frequencies from 100 Hz to 2 MHz, decreasing to about 800 mV rms at 50 MHz.

The output of the Q1/Q2 amplifying stage is coupled through C5 to a Schmitt trigger NAND gate (U2), which, in turn, converts the signal to a 5-volt, square-wave signal that can then be processed by the microcontroller. A voltage-divider network (consisting of R6 and R7) holds the input level at pin 1 of U2-a to the midway point between its high and low triggering thresholds. The function of the four NAND gates in U2 will be explained in a moment.

Microcontroller. At the heart of the circuit is U1—a PIC16C54 EPROM-based 8-bit CMOS microcontroller manufactured by Microchip—which has one 8-bit I/O port and one 4-bit I/O port, whose pins can be individually configured as either inputs or outputs at different times during the execution of its program. The program is stored in 512 × 12 bits of internal EPROM. The chip also contains 32 × 8 bits of RAM that is used as a general-purpose register in the execution of its program.

An RTCC (Real Time Clock/Counter) input pin is available on the chip together with its own asynchronous ripple-counter/prescaler. The prescaler is completely independent of the microcontroller's operating speed and is what makes it possible to count the pulses of a signal being tested even though it may be at a much higher frequency than that of the microcontroller's clock.

The clock is set by a 4-MHz crystal (XTAL1), and trimmer capacitor (C12) is used for final calibration. The PIC16C5x's instruction time is equal to four clock pulses, so with a 4-MHz clock, one instruction is executed every microsecond. That makes it easy to get the exact gate times of 0.1 and 1 second.

The microcontroller starts the count of the test signal by driving bit 3 of port A (pin 2 of U1) high, which enables U2-a. In addition, that logic level is inverted by U2-d, and then applied to U2-c, which disables it (explained later). The output of U2-a passes through U2-b and is placed on the RTCC input (pin 3) of the microcontroller. The internal prescaler assigned to the RTCC pin counts the pulses and automatically increments the RTCC's main register every time the prescaler reaches a full count of 256. The microcontroller's program is designed to watch the RTCC register and increment an additional register every time the RTCC register rolls over. So, in effect you have three 8-bit PIC16C54 registers in which to store the count—the maximum count being 16,777,215, or over 167 MHz when using a 0.1-second gate. That's more then adequate for our 50-MHz counter.

The programming loop that the microcontroller goes into when performing the count function terminates after an exact, predetermined time that's equal to the gate time (0.1 or 1 second), after which, bit 3 of port A is driven low, preventing any additional input-signal pulses from being applied to U1 pin 3 (RTCC).

A flowchart of U1's operating program is shown in Fig. 2. Among other things, that chart shows which of the two gate times is used at any particular moment and which suffix is added to the end of the count when displayed.

After accumulating the count for the duration of the gate time, the RTCC's prescaler holds the least-significant 8 bits of that number. To retrieve that number, the microcontroller must toggle the RTCC input externally while keeping a count of the cycles required to force a rollover of the prescaler, which is detected by an increment of the main RTCC register. The actual number is then derived by using the two's complement.

As mentioned earlier, while the microcontroller was in the count mode, U2-c was disabled by the low-going output of U2-d. At the end of the gate time, however, bit 3 of port A was driven low, causing a high at the output of U2-d, which enables U2-c. The microcontroller can then toggle bit 2 of port A, passing that pulse through U2-c and U2-b to the RTCC input.

The count (representing the frequency of the signal under test) contained within the three 8-bit registers must now be converted to a binary-coded-decimal (BCD) number in order to be displayed. That is done via a complex subroutine that stores the results in seven different 8-bit registers, one for each digit in decimal notation. The most-significant four bits of each register is set to 3 hexadecimal, creating the actual ASCII equivalent, which can then be sent to the display module.

Note: For those who have the equipment and wish to program their own microcontroller, the source and object code files for the PIC16C54 are available on the **Popular Electronics** bulletin board (516-293-2283). Alternatively, you can obtain a pre-programed chip from the source mentioned in the Parts List.

LCD Display Module. The display (DISP1) is a DMC16117 1-line, 16-character LCD module. That unit, which accepts standard ASCII code equivalent on its 8-bit port, has a built-in controller and is designed to display both numbers and letters. Data, including the ASCII codes, are sent to the display via port B of U1. The first three bits of U1, port A, are used as control lines for the display (Data/Instruction, Read/Write, and Enable).

Writing a character to the display consists of first placing the 8-bit address (location for the character on the display) on port B, setting the correct status on the control lines, and strobing the enable line. Then the actual ASCII character code is placed on port B, and the process is repeat-

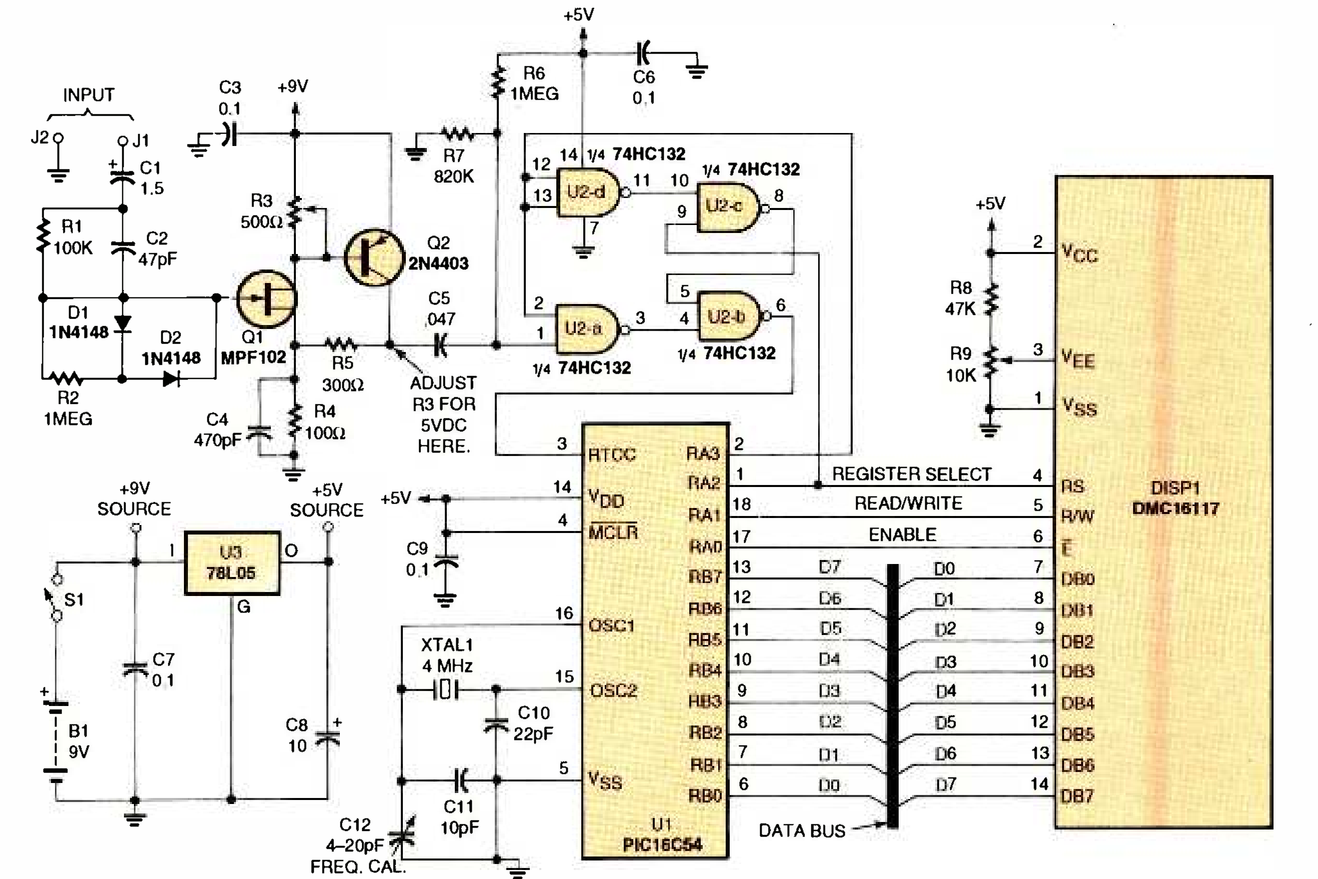


Fig. 1. The counter's input signal is amplified by Q1 and Q2, and clocked into U1 through its RTCC input where the count is accumulated. Then the 7-digit ASCII equivalent is sent to and displayed on the 16-character LCD (DISP1).

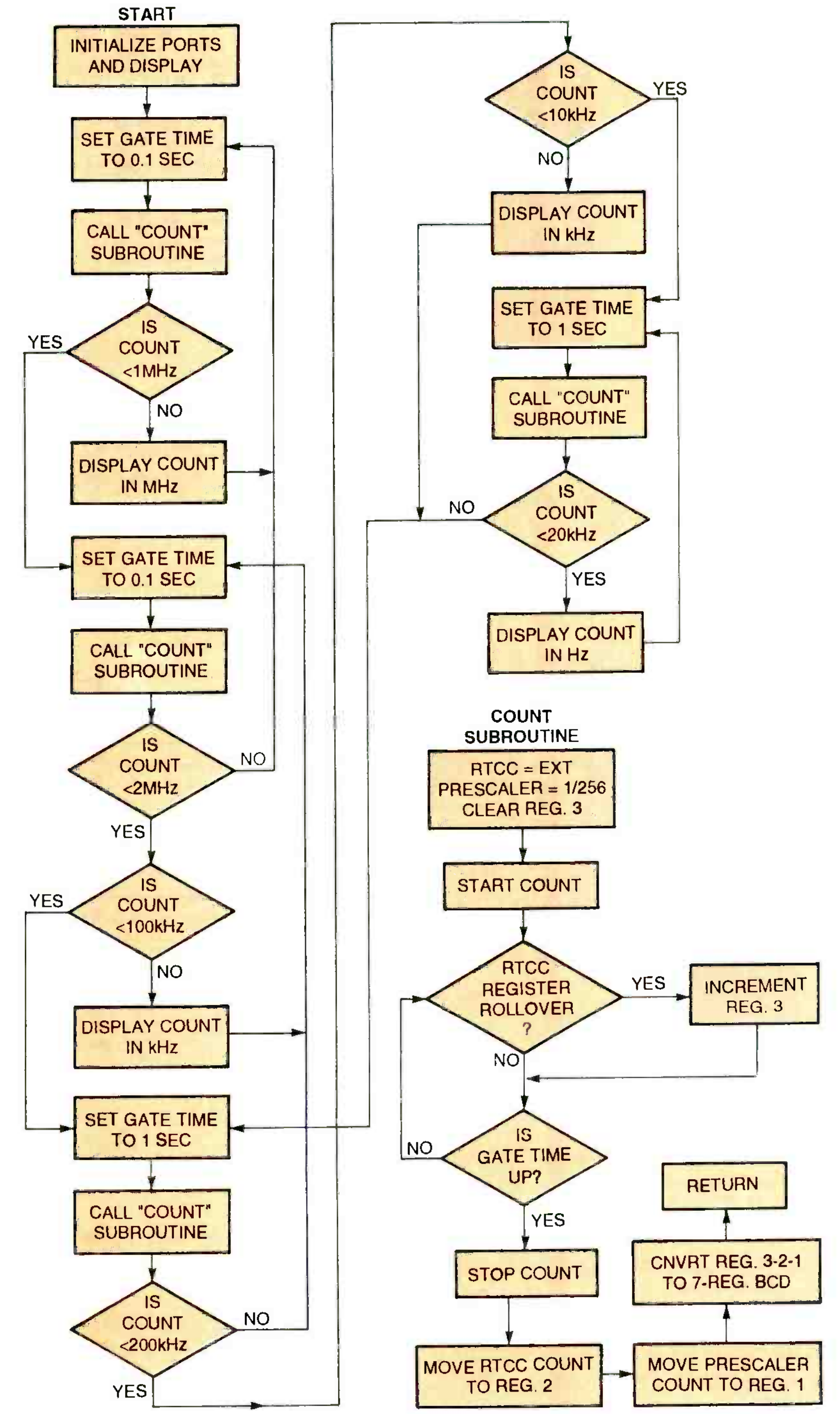


Fig. 2. This flowchart shows the operating program stored in the microcontroller (U1). Note the conditions that change the gate time and/or the suffix (Hz, kHz, or MHz).

ed. The microcontroller (U1) then changes port B to an input, setting the status lines to read the busy flag from DISP1, as U1 strobes the enable line until the busy flag indicates DISP1's internal operation has finished writing the character to the screen. That all takes less than 100 µs.

Depending on the range of the count (see Fig. 2) that was stored in U1's seven ASCII registers earlier, the count together with its appropriate suffix (Hz, kHz, or MHz) with the correct positioning of the decimal point are sent to the display module. Microcontroller U1 then jumps back to the beginning of the program and captures another frequency count.

Construction. The author's prototype unit was assembled on a double-sided printed-circuit board measuring about 2⅛ by 1¹⁵⁄₁₆ inches. A full-size template of the foil side of the board is shown in Fig. 3, while the component side is shown in Fig. 4. If you wish, you can fabricate your own board using the artwork provided, or you can purchase a pre-fabricated board from the source mentioned in the Parts List.

After you've obtained all the necessary parts for the project, assemble the unit guided by the parts-placement diagram shown in Fig. 5. Note: Because the circuit may be used to test relatively high frequencies, it's recommended that you follow the layout procedures closely—especially where the input stage (Q1 and Q2) is concerned.

Start by mounting IC sockets for U1 and U2 on the component side of the board. Next, mount the resistors and the diodes, paying attention to the diodes' orientation. The trimmer potentiometers (R3 and R9) can be soldered in next along with the trimmer capacitor (C12). Avoid excessive heating when installing the trimmer capacitor. Install the rest of the capacitors, making sure that the polarized capacitors (C1 and C8) are properly oriented.

Follow that by mounting the regulator (U3) and the transistors (Q1 and Q2), again paying particular attention to their orientation. The crystal (XTAL1) should be mounted with a small gap between the bottom of its case and the circuit board. There is a chance that the crystal's metal case could short the circuit-board pads if it were pushed all the way down onto the board when soldering.

After soldering all the components to the board, carefully check for cold solder joints (indicated by dull blobs of solder) and solder bridges between pads and/or traces. Re-solder any areas that appear suspect.

Cut two pieces of 22-gauge, stranded, hookup wire to about 6 inches long and twist them together. Strip about ¼ inch of the insulation from both ends of both wires. Then tin each end and use the wires to connect S1 to the appropriate circuit-board terminals. Solder a battery clip to the appropriate circuit pads, as indicated in Fig. 5 (with the red lead

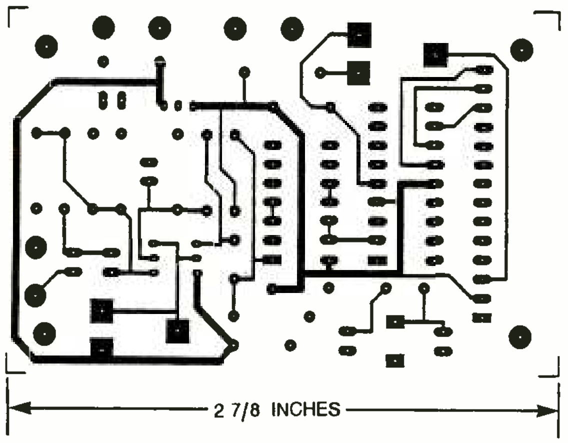


Fig. 3. The author's prototype was assembled on a double-sided printed circuit board, measuring about 2⅞ by 1¹⁵⁄₁₆ inches. Shown here is a full-size template of the foil side of the board.

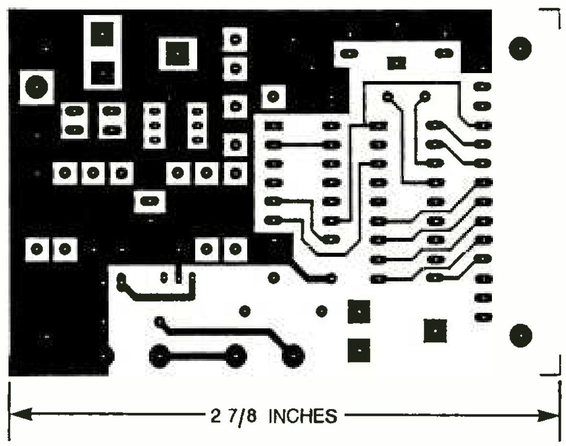


Fig. 4. The component side of the author's double-sided layout is shown here full size. You can fabricate your own board using the artwork provided, or you can purchase a prefabricated board from the source mentioned in the Parts List.

going to the "+" side and the black lead going to the "–" side).

In the author's prototype, the input to the circuit is handled by a couple of test leads soldered directly to the circuit board. For a test lead, a piece of shielded cable (such as Radio Shack's cat. no. 278-512) is ideal. Solder the cable's center conductor to the J1 position, and solder the shield to the J2 position. Tie a knot (which will be used as a strain relief) in the test lead about 4 inches from the board. There are a number of different clips that can be soldered to the end of your test lead. The author used an alligator clip on the shield, and a micro-hook clip on the center conductor.

A length of 14-conductor ribbon cable was used to connect the display (DISP1) to the circuit board; either 25-conductor ribbon cable (Radio Shack cat. no. 278-772) or a 36-conductor (cat. no. 278-774) will work fine. Simply peel off and discard the unused wires. Strip about ¼ inch of insulation from each conductor, then tin and begin soldering the individual wires to the board and the display module. Pin 1 on the board is indicated by a rectangular pad as opposed to an oval one. Be sure to match that pad with the pad labeled "1" (V_{SS}) on the display module.

The author's unit was housed in a 3- × 4- × 2-inch plastic enclosure (Digi-Key cat. no. SR232G-ND); however, any enclosure will do, provided it has the space for the circuit board, display, battery, and any part of the switch (S1) that protrudes into the enclosure. Avoid using metal stand-offs.

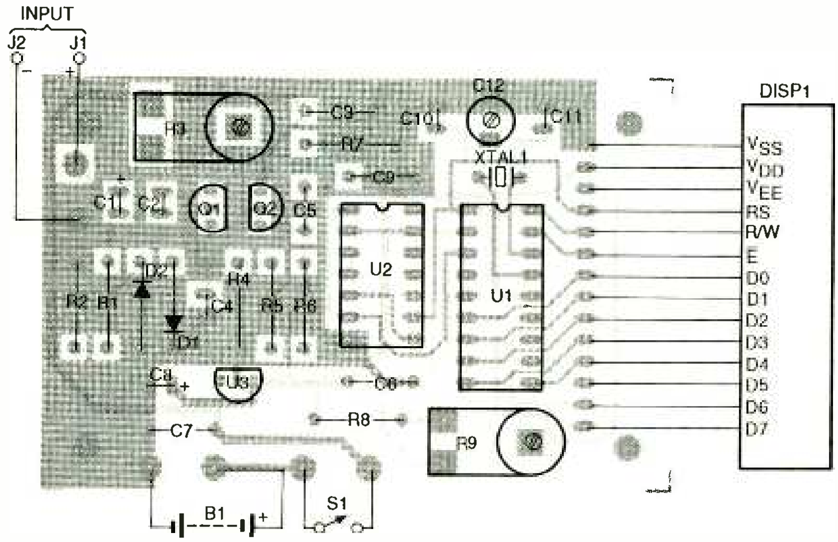


Fig. 5. Once you've obtained all the parts, assemble the unit guided by this parts-placement diagram.

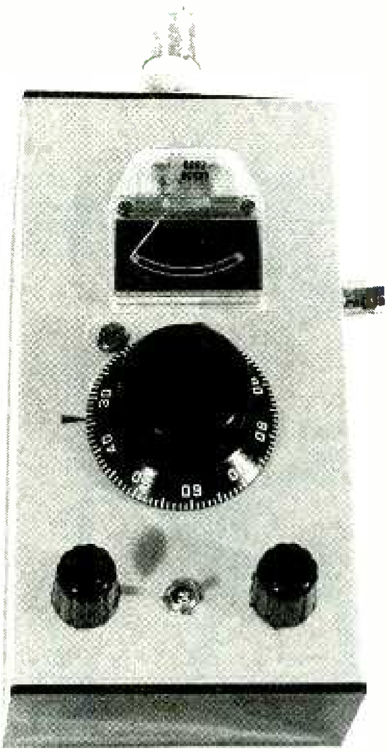
They could short traces on the underside of the board to the ground plane on the top of the board. Cut a rectangular hole in the top of the enclosure for the display to show through and a hole below that for the switch.

Label the enclosure using dry-transfer lettering, and then cover the front-panel labeling with a thin coat of clear enamel for protection. Give the enamel plenty of time to dry, then mount and hook up the toggle switch. The display should be mounted to the inside of the enclosure and positioned so that all characters can be seen through the rectangular opening in the case. The author used RTV silicon adhesive to hold the display in place. Finish by cutting a slot in the back of the bottom half of the enclosure for the test lead to exit; then mount the board in its enclosure.

Testing. Before installing the U1 and U2, connect a fresh 9-volt alkaline battery to the circuit, turn on S1, and check for 5-volts at pins 4 and 14 of U1, and pin 14 of U2. If there is no voltage at those points, try the opposite position of S1. If there is still no reading, check the orientation of U3 (the regulator) and C8. If the voltage is less than 4.5 volts and U3 begins to heat up, remove power and check for a short (such as a solder bridge) somewhere on the board; be sure to check both the top (the component side) and bottom (the foil side) of the board.

(Continued on page 94)

BUILD A



"GATE-DIP" METER

Check the resonant frequency of tuned circuits and antennas, or use it as an RF-generator or an absorption wavemeter!

BY FABIO VERONESE

Genuine radio enthusiasts often daydream about sophisticated and costly test equipment like wideband oscilloscopes or professional-quality spectrum analyzers. Perhaps you can afford such equipment, then again maybe you can not. Fortunately, the average radio hobbyist rarely if ever needs such equipment for his/her radio activity. As to the test gear most often used by radio hobbyists, much of it is relatively inexpensive to buy or build. One such instrument is the *Gate-Dip Meter* described in this article. But what is a Gate-Dip Meter?

A Little Background. The Gate-Dip Meter is a MOSFET version of the tried-and-true grid-dip meter (also known as a GDM)—a simple circuit built around a triode tube that was once extremely popular among radio amateurs and experimenters. Basically, a GDM is a very stable RF oscillator that can be tuned over a wide range of frequencies, usually by means of a series of interchangeable tuning coils. The tuning coils were connected to the GDM through a plug in the top of its enclosure (as shown in Fig. 1A), which also allows the coils to easily be coupled to external circuits.

Figure 1B shows a simple block diagram of the GDM's basic subassemblies. Note: the connected interchangeable tuning coil is part of the RF oscillator. The RF output of the oscillator is fed to a diode detector that, in turn, is used to drive a meter through a DC amplifier stage (not shown).

When the oscillator is working, and the coil is not coupled to an external circuit, the oscillator generates an RF signal whose total energy is applied to the diode, producing a maximum reading on the meter. However, if the tuning coil is brought near a tuned circuit that is resonating at the exact same frequency as the oscillator, it absorbs a good portion of the RF signal, making the meter reading fall (dip) almost to zero (see Fig. 1C). The frequency at which the dip occurs (which is the resonant frequency of external tuned circuit) can then easily be determined using a digital frequency meter or a radio receiver.

A GDM can also be used to measure the resonant frequency of an antenna by simply coupling the GDM's tuning coil to the coaxial feed line using an insulated wire, as illustrated in Fig. 1D. Because a GDM contains a variable-frequency oscillator (VFO), it can be used as an RF signal generator, or as a local oscillator for simple conversion receivers, or whenever a stable RF signal is needed.

In most GDM circuits, the oscillator can be temporarily shut down and the GDM's tuned circuit connected directly to its the detector stage, allowing the GDM to be used as an absorption wavemeter or a field-strength meter.

Circuit Description. A schematic diagram of the Gate-Dip Meter is shown in Fig. 2. At the heart of the circuit is a Colpitts oscillator that is built around Q1 (an ECG222 dual-gate MOSFET). The Colpitts oscillating frequency is determined by the circuit's tuning section, which is comprised of C1 (the tuning capacitor), C2, and C3 in conjunction with the interchangeable coils (designated L1 in Fig. 2). The tuning-section components are connected to gate 1 of Q1 through C4. AC feedback for the oscillator is applied to the junction of C2/C3 (which are in parallel with C1 and L1). From the C2/C3 junction, the feedback signal travels through C4, returning to gate 1 of Q1.

Potentiometer R3 is used to vary the DC bias applied to gate 2 of Q1, allowing the frequencies of oscillation to be set over a wide range. Resistor R5 serves as a load for the drain of Q1, which is RF-bypassed via C6. When S1 is in the DET position, the drain of Q1 is isolated from the positive supply. That switches off the oscillator and directly connects the gate-1 tuning circuit (L1 and C1) to the detector.

The DC content of the RF signal generated by the oscillator, appearing at the source of Q1, is shunted to ground via L2. The remaining RF signal component of the output then divides along two paths. In one path, a small amount of the output signal is fed through C8 to J1, where it can be applied to a digital frequency counter. In the other path, the RF signal is applied to D1, a Germanium diode that serves as the detector. The output of D1 is filtered by C7, and then used to drive a common-base amplifier (comprised of Q2), which, in turn, controls the amount of current through M1. Potentiometer R8 allows M1 to be adjusted for a full-scale reading on all frequency ranges.

Building the Gate-dip Meter. The GDM's layout requirements are non-critical and the circuit could be built on a small section of perfboard. If you decide to go that route, however, be sure that the oscillator leads are kept as short and direct as possible. The author's prototype, on the other hand, was assembled on a small printed-

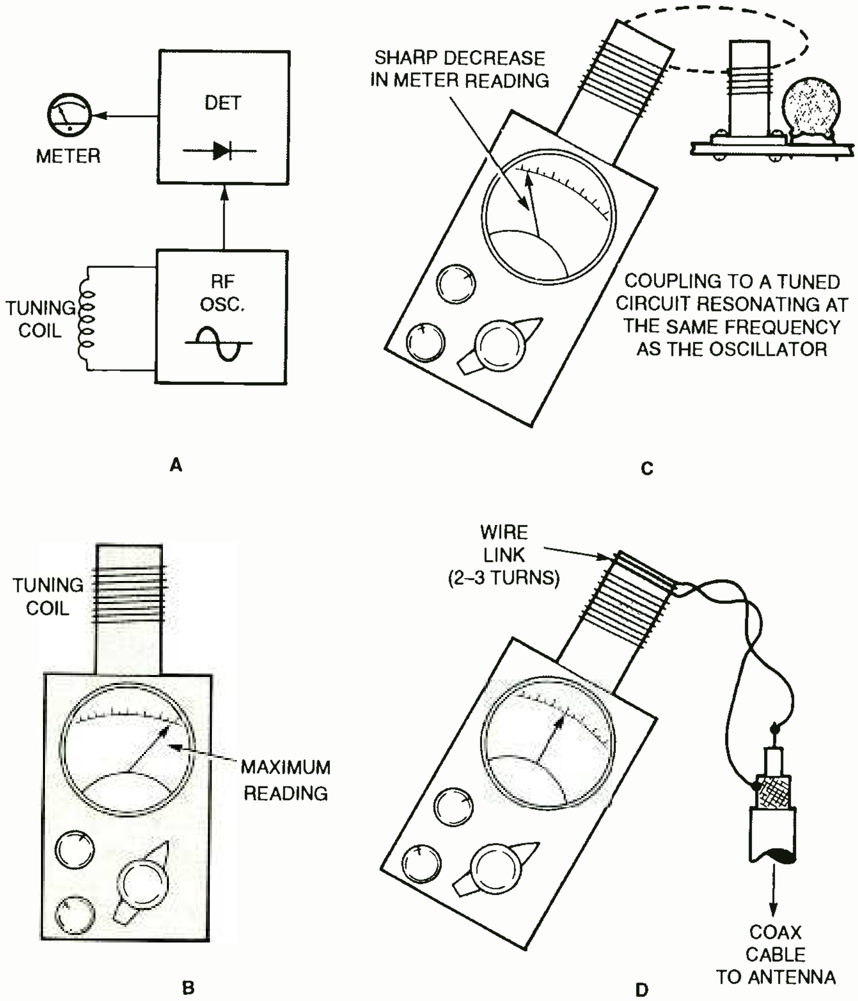


Fig. 1. The typical dip meter is comprised of a tuning coil, RF oscillator, a detector, and a meter as shown in A. When the meter's tuning coil is in free space, the meter gives a full-scale reading (B). When the coil is coupled to a tuned circuit resonating at the same frequency as the GDM, the reading dips (C). The GDM's tuning coil can be coupled to the coaxial feed line of an antenna through a few (perhaps 2–3) turns of wire, and used to determine the antenna's resonant frequency (D).

PARTS LIST FOR THE GATE-DIP METER

SEMICONDUCTORS

Q1—ECG222, 40673, BF961, or 3N204 dual-gate, N-channel, enhancement MOSFET
Q2—2N2222, 2N2904, or BC548 general-purpose NPN silicon transistor
D1—AA117 (or any other) germanium diode

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—220,000-ohm
R2—27,000-ohm
R3—47,000-ohm linear potentiometer
R4—39,000-ohm
R5—270-ohm
R6—56,000-ohm
R7—1000-ohm
R8—4700-ohm linear potentiometer
R9—12,000-ohm

CAPACITORS

C1—50-pF, air-variable tuning
C2—12-pF, ceramic-disc
C3—47-pF, ceramic-disc
C4—8.2-pF, ceramic-disc
C5—0.01-μF, ceramic-disc
C6—0.0047-μF, ceramic-disc
C7—0.0033-μF, ceramic-disc
C8—10-pF, ceramic-disc
C9—0.1-μF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

L1—See text
L2—100—μH, RF choke
M1—1-mA panel-mount milliammeter
S1—SPDT toggle switch
J1—Panel mount BNC connector (see text)
Printed-circuit materials, metal enclosure, knobs, ½-inch plastic tubing, plugs and panel-mount jack, enamelled wire, 9–12-volt power source, wire, solder, hardware, etc.

TABLE 1—COIL WINDING DATA

Band (MHz)	Turns	Wire Size/Type
3.5 6.5	45	32-enameled
6.5 11	32	26-enameled
11 19	14	20-enameled
15 24	10	20-enameled
21 36	7	insulated connection wire
32 56	4	insulated connection wire
60 110	U-shaped*	16 enameled

*1.8-inches long

circuit board, measuring about 1⅞ × 3³⁄₁₆ inches. A template for that printed-circuit layout is shown in Fig. 3.

After etching the board and obtaining the necessary parts (see the Parts List), begin construction using Fig. 4 as a guide. It's recommended that construction begin with the small, non-polarized parts (fixed resistors and ceramic capacitors). Once that is done, install L2, D1, and Q2, making sure that they are correctly oriented. Following that, install Q1.

Installing the variable capacitor (C1) on the board may require a little ingenuity, since the physical dimensions and structure of such units vary widely from one manufacturer to another. Because of that, extra room has been provided on the board for C1. The chassis of C1 should be electrically connected to the large grounding area of the printed circuit by a couple of screws, which will also block it in place on the board. Once C1 is mounted to the board, connect the stator lug of C1 to the point indicated on board using a very short length of bare-copper wire.

Afterward, connect all off-board components to the points shown in Fig. 4 using 3- to 4-inch lengths of insu-

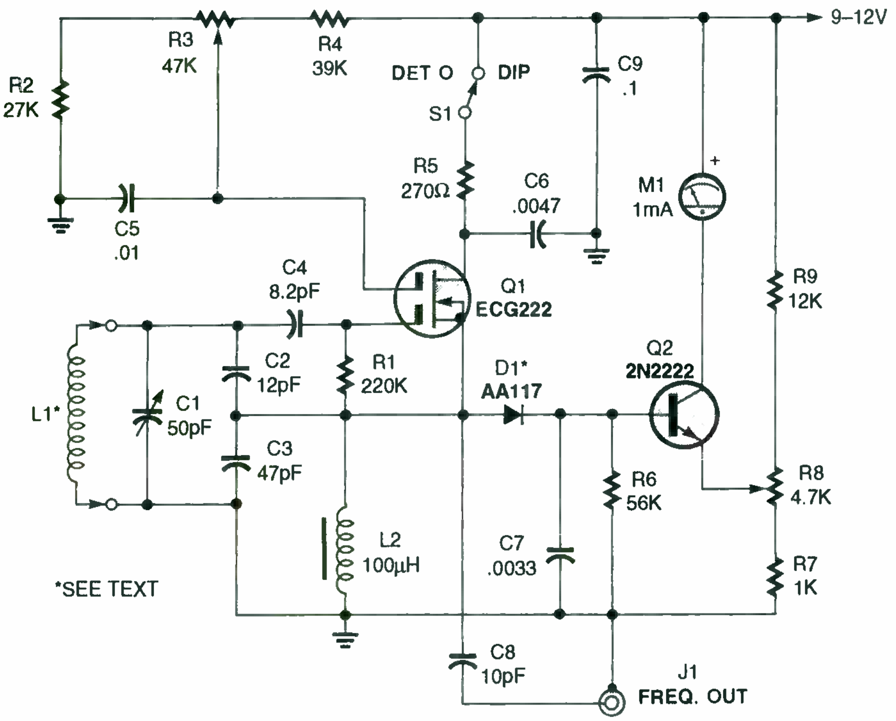


Fig. 2. The Gate-Dip Meter (a variation of its tube predecessor) is built around a dual-gate MOSFET (Q1) which is configured as a Colpitts oscillator.

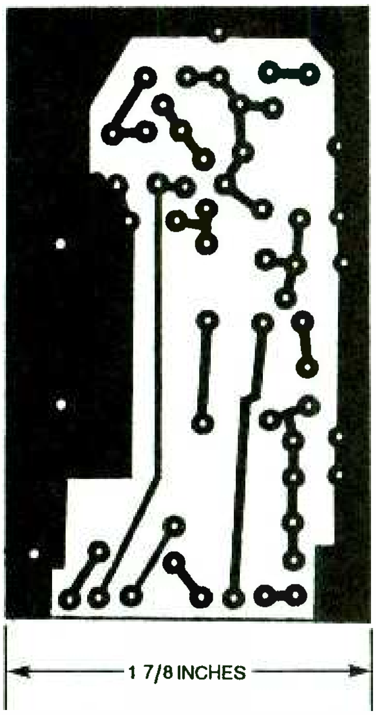


Fig. 3. The author's prototype of the Gate-Dip Meter was assembled on a small printed-circuit board, measuring about 1⅞ × 3³⁄₁₆ inches.

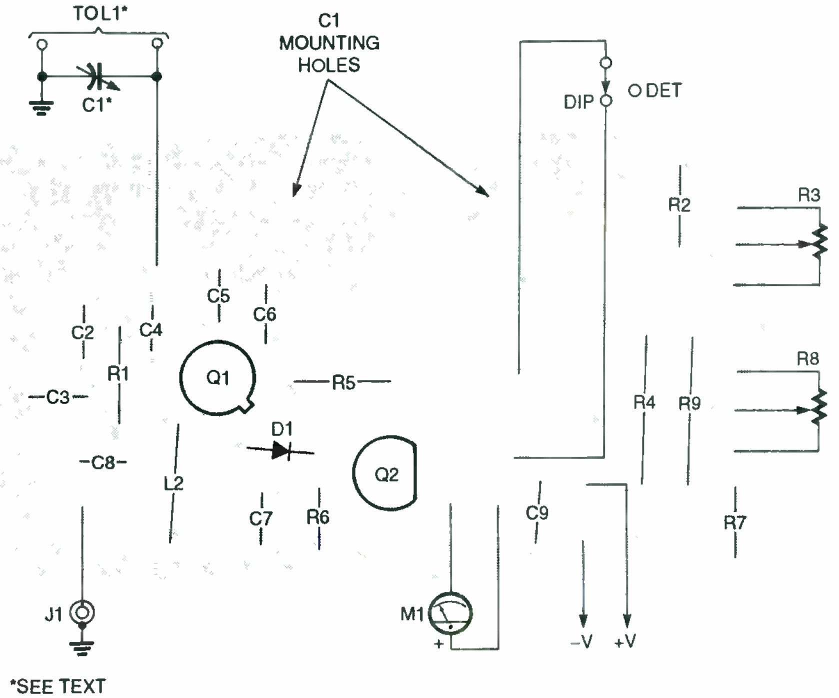


Fig. 4. Begin construction by installing the fixed resistors and ceramic capacitors, followed by the RF choke and semiconductors. Take special care to avoiding overheating Q1.

lated wire. Once that is done, momentarily set the board to one side, and get ready to wind the coils.

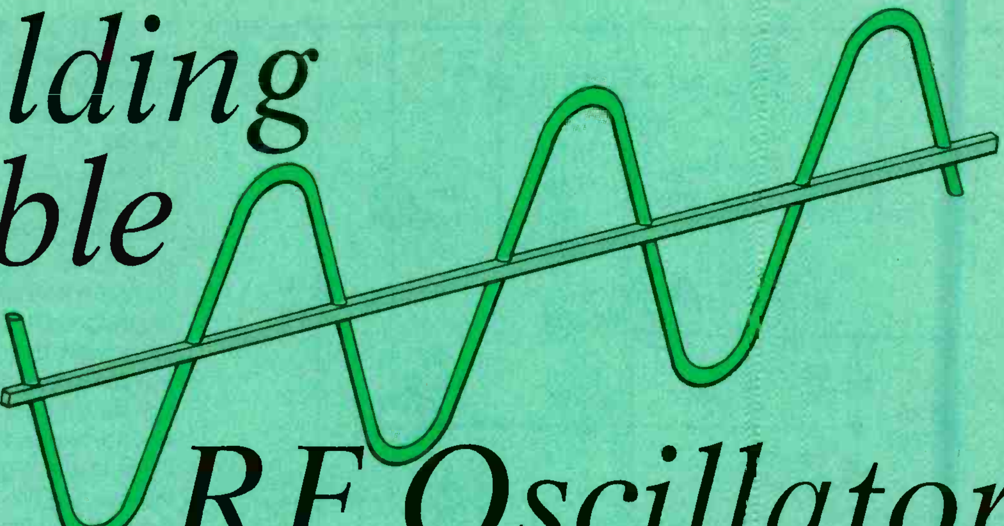
Winding the Coils. For his unit, the author wound a set of seven interchangeable coils, allowing the GDM to be tuned from approximately 3.5 to 110 MHz. All of the coils—except for one (the 60–110-MHz coil, which is self-supporting)—were wound on 2½-inch long cylinders made of ½-inch diameter plastic tubing. Table 1 gives the winding data for the complete set of seven coils used in the author's prototype.

Before winding your coils, consider the type of plug that will be connected to the coil leads to allow for easy coil swapping; the type used is up to the builder. Just remember that the plug that is used for the coils must mate with the jack that will be installed on the top of the project's enclosure. When all the coils have been wound, solder the leads of each of them to the lugs of a suitable plug, then secure the windings in place at the bottom of the coil form using epoxy. Once the coils are complete (plugs and all), prepare the enclosure that will house your GDM.

The GDM should be housed in a metal enclosure to prevent the RF generated by the oscillator from leaking out and raising havoc with other nearby devices. Provisions will have to be made in the enclosure for R3, R8, C1, J1, S1, and M1; and don't forget to make an appropriate-sized hole for the coil jack that you select. Once all the openings have been made, mount the off-board components

(Continued on page 92)

Building Stable



RF Oscillators

Learn how to ensure the stability of your signal-generating circuits with these easy-to-apply design techniques.

BY JOSEPH J. CARR

Radio-frequency-oscillator stabilty is always important in radio circuits. In both CW and (especially) single-sideband circuits, it is down-right critical. Frequency stability is one of the principal specifications that defines the quality of radio receivers and transmitters, as well as signal generators and other RF devices.

Frequency stability generally refers to freedom from frequency changes (or drift) over a relatively short period of time (*e.g.*, from a few seconds to dozens of minutes). That problem is different from drift due to component aging, which takes place over relatively long periods of time (say a hertz per year).

Several factors can upset oscillator stability. We'll review them in this article along with guidelines for reducing their effects. If the guidelines are followed, it will result in stable oscillator operation. For the most part, the information provided applies to both crystal oscillators and LC-tuned oscillators, such as variable-frequency oscillators, or VFO's. When that is not the case, the oscillator type will be indicated in the text.

Temperature. Excessive temperatures and temperature variation have a tremendous effect on oscillator stability, so an oscillator should be constructed to prevent temperature variation. At one time, it was common practice to use a constant-temperature oven for crystal oscillators. The oven kept the piezoelectric resonator at a constant temperature of 75 or 80°C. I've only seen one, now very obsolete, piece of equipment that housed an LC VFO resonating circuit in an oven environment. In some equipment today, the internal temperature is allowed to build up to a certain level and then remain stable as long as there are no air currents circulating through it, achieving an oven-like effect. In your own designs, just avoid locating an oscillator circuit near any source of heat within equipment. In other words, keep it away from power transistors, IC's, rectifiers, lamps, etc.

If you have preassembled equipment suffering from heat-induced drift, you can insulate its oscillator. There was one tube-type ham SSB-transceiver kit (not a Heathkit by the way) that drifted terribly because the VFO circuit was located only two inches or so from the IF-amplifier's vacuum tubes. (The heat involved was tremendous.) Using a bit of insulation to cover the VFO housing noticeably reduced the drift of that rig. In fact, I saw more than a few radios come into a shop where I once worked that had ¼-inch sheets of Styrofoam glued over all surfaces of the VFO housing (see Fig. 1). In those days, the "Styrofoam job" was nearly always a mess because only salvaged coffee cups and ¾-inch builder's Styrofoam were easily available.

Today, however, art-supply stores sell a kind of posterboard that makes the job really neat and easy. The poster board is glued to a backing of Styrofoam to give it support. It is easy to cut using a hobby or razor knife (I used a scalpel in some experiments). You just cut the pieces to size and glue them to the metal surface of the oscillator cabinet using any cement that will cause metal and paper to adhere to one another.

Also, operate the oscillator at as low a power level as can be tolerated to prevent self-heating of the main active device and its associated components. It is generally agreed that a power level on the order of 10 mW is sufficient. If more power is needed, then a buffer amplifier can be used (which is a good idea for other reasons that we'll discuss shortly).

Oscillator Operation. In general, VFO's should not be operated at frequencies above about 12 MHz. Above that, it is better to heterodyne a lower frequency VFO against a crystal oscillator to produce the needed frequency. For example, to make a 20-

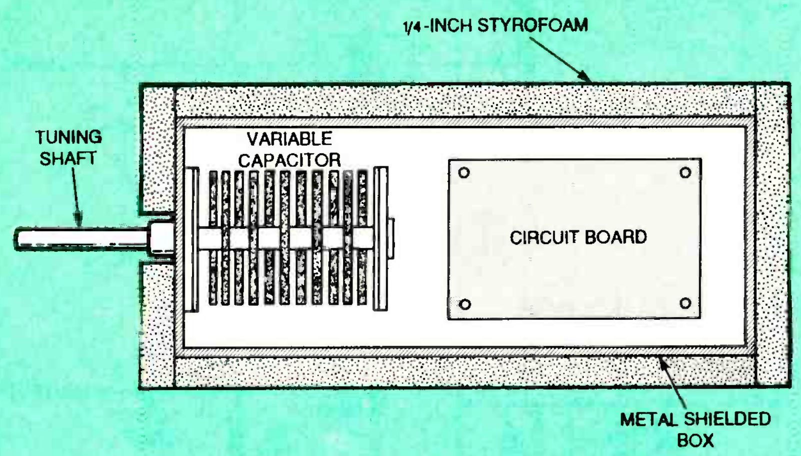


Fig. 1. A VFO should be thermally isolated by using insulation around the shielded enclosure housing the oscillator circuitry.

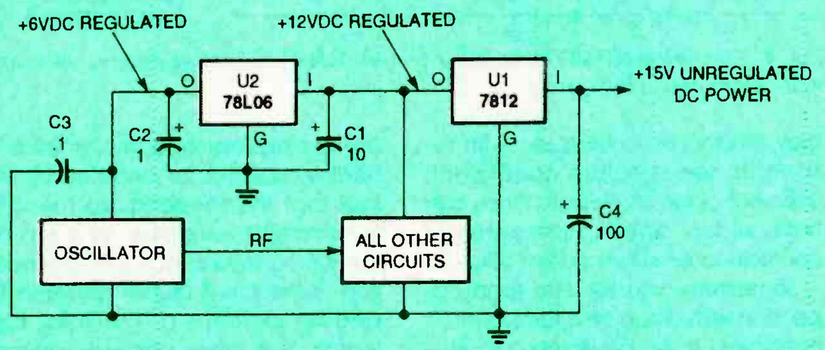


Fig. 2. A DC power-distribution system for a stable oscillator should use a separate voltage regulator just for the oscillator circuit.

meter VFO, you could beat a 5- to 5.5-MHz VFO against a 9-MHz crystal to get 14- to 14.5-MHz operation.

Also, allow just enough feedback in the oscillator to quickly start it when turned on (or keyed in the case of a CW transmitter), but not so much as to "pull" the frequency when the load impedance changes. In some designs, that is accomplished by placing a 2- to 3-pF NPO ceramic-disc capacitor between the LC tank and the gate or base of the active device. It lightly loads the tuned circuit to prevent drift. However, for best stability in your own designs, use a 2–12-pF air-dielectric trimmer capacitor and adjust it for the minimum value that ensures good starting and frequency stability under varying load conditions.

A buffer amplifier, even if it is a unity-gain emitter follower, is also highly recommended. It will permit building up the oscillator signal power, if that is needed, without loading the oscillator, and isolates the oscillator from variations in the output load.

The Power Supply. Power-supply voltage variations have a tendency to frequency-modulate the oscillator signal. Because dynamic circuit conditions often result in a momentary transient drop in the supply voltage, and because line-voltage variations can cause both transient drops and peaks, it is a good idea to use a voltage-regulated DC power supply for the oscillator.

It is also a very good idea to use a voltage regulator to serve only the oscillator, even if a voltage regulator is already present for the other circuits (see Fig. 2). Although this double-regulator approach may have been a significant cost burden in times long ago, it is now reasonable to do. For most low-powered oscillators, a simple low-power "L-series" (*e.g.*, 78L06) three-terminal voltage regulator is sufficient (see U2 in Fig. 2) as they can provide up to 100 mA of current.

Capacitors on both the input and output sides of the voltage regulator (C1 and C2 in Fig. 2) add further protection from noise and transients. The values of those capacitors should be selected according to the amount of current drawn. The idea is to have a local supply of "stored" current to temporarily handle sudden demand changes or to allow time for a transient to pass.

A requirement for varactor-based oscillator circuits is a clean, noise free, separately regulated DC power supply for the tuning voltage itself. In most cases, one can use a low-powered three-terminal IC fixed-voltage regulator for that purpose, or alternatively an LM317 programmed for the specific voltage.

Inductors. The frequency-setting components of an oscillator can also affect its stability. For that reason, inductors should be rigidly mounted to prevent vibration. While that requirement means different things for different coil styles, it is nonetheless important.

Air-core coils are generally superior to those with either ferrite or powdered-iron cores because the magnetic properties of an air core are hardly affected by temperature variation. Of all the coils with material cores, slug-tuned units are said to be best because they can be operated with only a small amount of the core inside the coil windings, reducing the vulnerability to temperature effects. Still, toroidal cores have a certain endearing charm, and can be used wherever the ambient temperature is relatively constant. The type-SF material is said to be the best in this regard, and it is easily available as Amidon Associates (P.O. Box 956, Torrance, CA 90508) type-6 material.

One source recommends tightly winding the coil wire onto the toroidal core, and then annealing the assembly. That means placing it in boiling

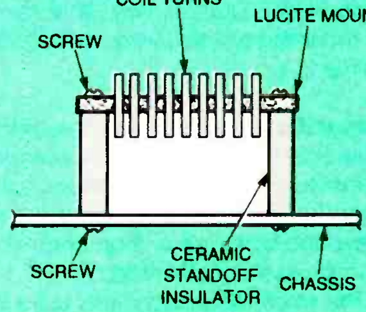


Fig. 3. This is an example mounting for Barker and Williamson Pi-Dux coils used in VFO circuits. Note how stable it looks.

water for several minutes, and then allowing it to cool in ambient air while sitting on an insulated pad. I haven't personally tried it, but the source did and reported remarkable freedom from inductor-caused thermal drift.

For most applications, especially where the temperature is relatively stable, a coil with a core can be wound using enameled wire (No. 20 to No. 32 wire is usually specified), but for best stability it is recommended that Litz wire be used. Although a bit hard to get in small quantities, Litz wire offers superior performance over relatively wide changes in temperature. Be aware that this nickel-based wire is difficult to solder properly, so be prepared for a bit of frustration.

For air-core coils, use No. 22 or larger bare wire. It is probably best to use the Barker & Williamson (10 Canal Street, Bristol, PA, 19007; Tel. 215-788-5581) pre-wound air-core coils for that. They make a wide range of air-core inductors under the Airdux, Miniductor, and Pi-Dux brand names. The Pi-Dux coils are especially suited to use in VFO's—even though intended for transmitter pi-network applications because they have an easy-to-use plastic mounting plate.

Recently I bought a length of their type-816A Pi-Dux product for a VFO circuit. It is 3³⁄₁₆ inches long, and has sixteen turns-per-inch (16 tpi) of No. 18 AWG bare wire on a one-inch diameter form. The total inductance is about 17 µH, so with taps it can be used to accommodate almost any frequency within the HF spectrum. Figure 3 shows how the Pi-Dux coil was mounted in my project. A pair of one-inch insulated stand-offs provided adequate clearance for the coil, and held it rigidly to the chassis. The Lucite mount, shown in Fig. 3, is integral to the type-816A Pi-Dux coil. Any other form of mounting will also work, as long as it's rigid.

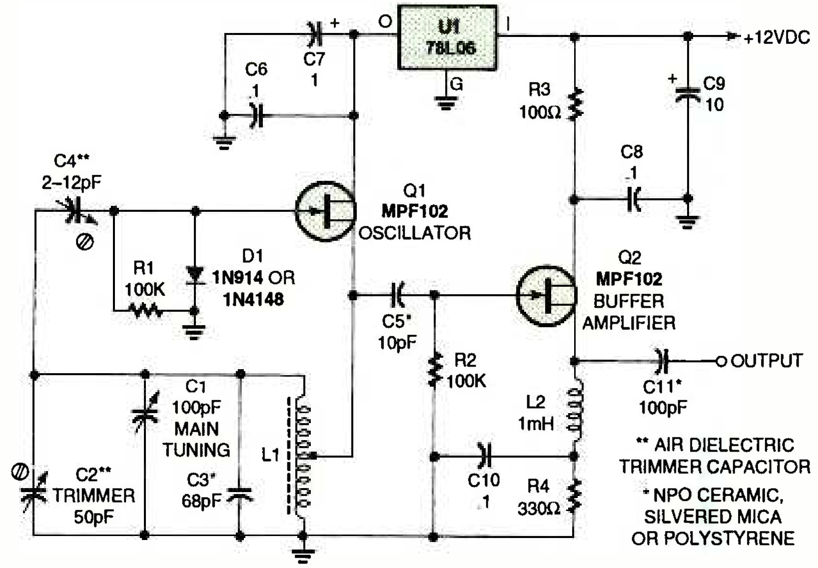


Fig. 4. This typical HF VFO circuit has several stability-enhancing features, including well-chosen capacitor types.

Capacitors. Since solid dielectrics cause drift with age and temperature changes, the trimmer capacitors used in an oscillator should be air-dielectric types rather than ceramic- or mica-dielectric trimmers.

The small fixed capacitors used in an oscillator should be either NPO ceramic discs (*i.e.*, zero temperature coefficient), or polystyrene types. Silvered-mica units can also be used but they tend to be a bit quirky with respect to temperature coefficient; even out of the same batch they can have widely differing temperature coefficients on either side of zero.

Sometimes, you will find fixed capacitors with a non-zero temperature coefficient in an oscillator's frequency-determining circuit. They are used to make temperature-compensated oscillators. The temperature coefficients of the capacitors are selected to create a counter drift that cancels out the natural drift of the circuit.

The variable main-tuning air capacitor should be an old-fashioned double-bearing type (*i.e.*, with a bearing surface on each end-plate) made with either brass or iron stator and rotor plates (not aluminum). The capacitor should be rugged. If possible, use surplus military-grade VFO capacitors for that. An excellent choice, where still available, are the tuning capacitors from the World War II AN/ARC-5 series of airborne transmitters and receivers.

Today, voltage-variable-capacitance diodes (varactors) are often used instead of mechanical main tuning capacitors. In such cases, it becomes critical to control the temperature of the oscillator's environment. It seems that temperature variations will result in changes in the diode's PN-junction capacitance, and that contributes much to thermal drift.

An Example. Figure 4 shows a sample VFO circuit with several stability-enhancing features. This circuit is a Hartley oscillator, as identified by the fact that the feedback to the JFET transistor(Q1) is supplied by a tap on the tuning inductance (L1). The position of the tap is usually between 10 and 35 percent of the total coil length. The exact position is sometimes a trade-off between stability and power output. Always opt for the stability unless it is absolutely impossible to provide a power boost (as needed) with a buffer amplifier. A buffer/amplifier is included in the Fig. 4 circuit, and it provides two basic functions: it boosts the low output power from the oscillator to a higher level, and it isolates the oscillator from changing load impedances.

The capacitors in Fig. 4 are selected according to the criteria discussed above. The main tuning capacitor (C1) is a 100-pF air-dielectric variable unit of heavy-duty double-bearing construction. The trimmer (C2) is used to set the exact frequency, especially when using a dial that must be calibrated. Note several of the fixed capacitors are indicated as NPO ceramic-disc, polystyrene, or silvered-mica (in order of preference).

Note also that there is a voltage regulator that serves the oscillator, but not the buffer92 packages, and generate very little heat. Nonetheless, it is still a good idea to mount the regulator (U1) away from the actual oscillator circuit.

The small trimmer capacitors (C2

(Continued on page 92)

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AN INTRODUCTION TO SCHEMATIC SYMBOLS

Schematic symbols are a form of electronic shorthand; once you've uncovered their meaning, analyzing a schematic diagram is no more difficult than reading text!

BY ROBERT A. YOUNG

Anyone entering the electronics field, whether for fun or for profit, is immediately overwhelmed with the many symbols used in schematic diagrams (sort of an electronics blueprint). But it doesn't end there; once you are able to recognize individual symbols, you must further dedicate yourself to understanding how the various components interact within a given circuit. The ability to analyze a circuit through a knowledge of the operation of its components will greatly enhance your ability to troubleshoot and repair most electronics equipment.

The aim of this article is to familiarize you with the more-common symbols that you are likely to encounter in both hobby- and commercial-grade electronics circuits.

Starting From Scratch. Figure 1 shows many of the schematic symbols that you are likely to encounter in an electronics diagram (they are not the only ones, but merely the more common ones). The symbols shown are standard for this publication.

The component symbols are broken down into families: some families can be broken down into subsets; the transistor family, for instance, consists of bipolar, FET, and MOSFET types. Regardless of the breakdown of the individual families, each member of that family is capable of performing essentially the same functions. For example, transistors are commonly used in amplifiers or buffer applications, but can also be used as electronic switches.

Another example is the optoelectronics family: optoisolators/couplers are often used as isolation-type interfaces between two dissimilar circuits (analog and digital, in many cases). However, a light-emitting diode (LED) paired with a photodiode or phototransistor, for instance, might be used to perform the same function as an optocoupler.

While different members of a given family may perform a particular function, they often do it in slightly different ways. To illustrate, take the switch family: compare the toggle switches to the relay switches. If you were to compare the action of a single-pole, single-throw (SPST) toggle switch to a reed relay, you'd find that they perform the same function: the former manually and the latter electrically. And if you compare the operation of a single-pole double-throw (SPDT) toggle switch to that of the relay pictured in the switch section of Fig. 1, you'd find that they both perform the same function (again the former, manually and the latter electronically).

As another example, there are also components—known as thyristors—similar in composition to transistors—that are intended to function as switches. The most common member of that family is the silicon-controlled rectifier (SCR), which can be looked upon as a rectifying one-way switch; if an AC signal is fed to an SCR that has been gated on, the result is a half-wave rectified DC output. The SCR, once turned on, (like any diode) only conducts during half of the AC cycle.

Its switch characteristics differ from a conventional mechanical switch in that when the current through the SCR drops below a specific level (called the holding current, I_H), the SCR cuts off and conduction can only be re-establish by feeding a trigger voltage to the gate of the SCR.

Family Portraits. Now let's take a closer look at the various families and their members. Transistors are among the most commonly used components in electronics. And while they can be used as switches, they are more widely configured for amplifier operation.

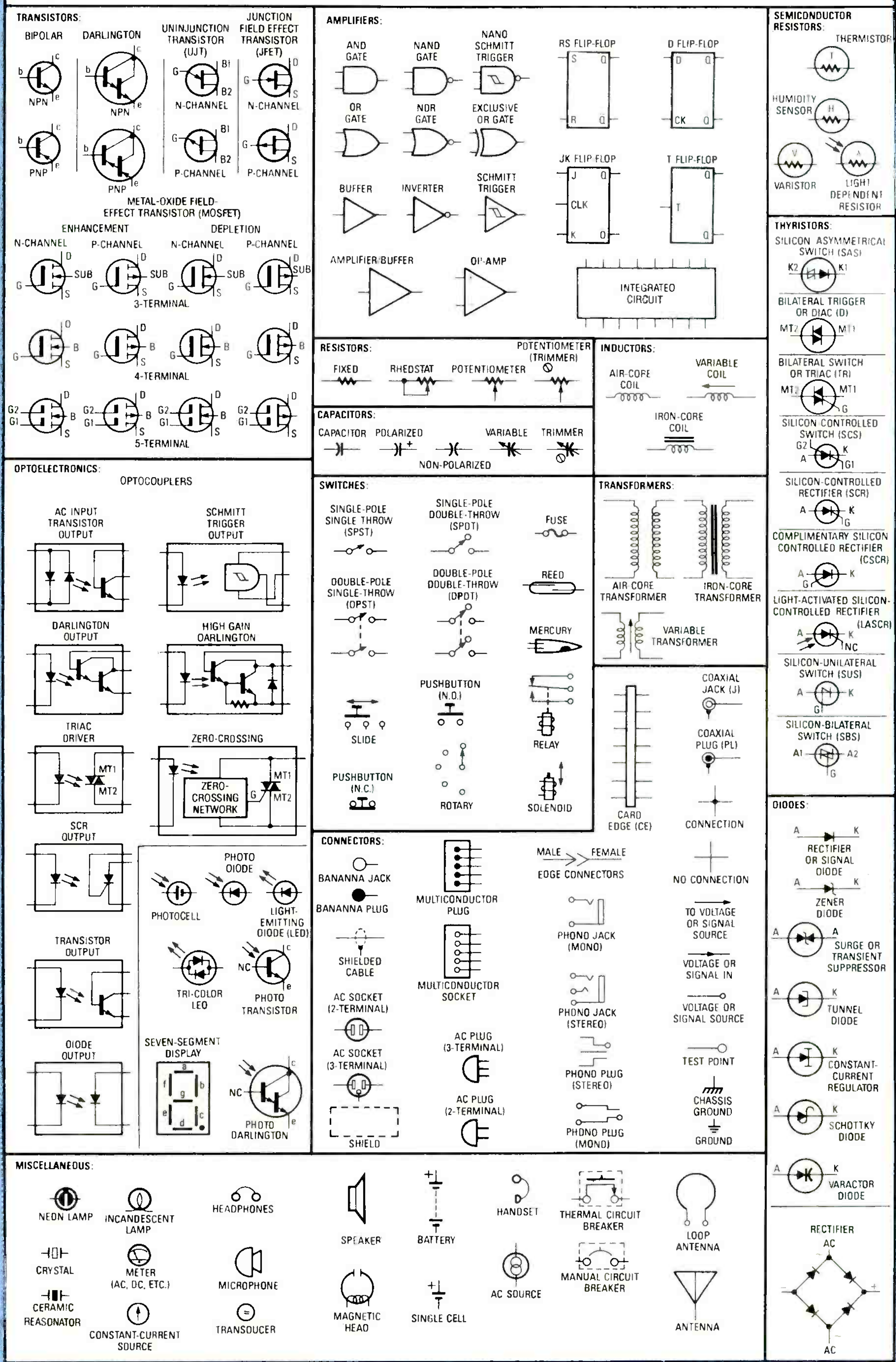
An amplifier is a circuit that draws power from a source other than the input signal and produces an output that's *usually* an enlarged reproduction of the input signal. We say usually because not all amplifiers are used to magnify the input signal. Buffers are one type of amplifier not designed to magnify the input signal.

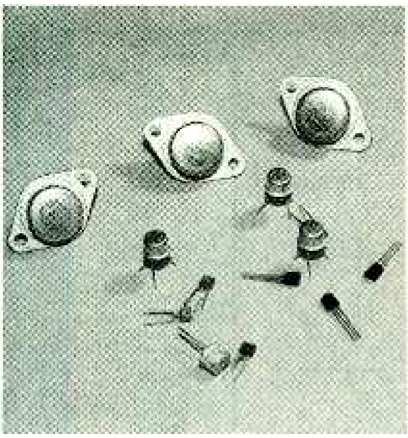
When operated as a buffer, the transistor is used to isolate the signal source from the next stage of the circuit. A buffer is said to have *unity* gain: there is no increase in signal level. Buffers are often referred to as unity-gain amplifiers. If a 10-millivolt (mV) signal is applied to the input of a unity-gain amplifier, the signal is output at a 10-mV level.

In a Class-A amplifier—which is the least efficient, but offers the least distortion—the transistor is biased so that its operating point is in the mid-linear region. Because of that, output current flows for the full input cycle, and the entire input signal is output at some higher level with minimum distortion. Such amplifiers are well suited to audio applications.

Fig. 1. The schematic symbols shown in this chart are standard for this publication, and make up many of the symbols that you are likely to encounter in an electronic diagram. They are not the only ones, but merely the more common ones.

ELECTRONICS SYMBOLS CHART





Transistors are among the most commonly used components in electronics. Most are three-terminal devices, but there are some special types that have four or more terminals.

In Class-B operation, the transistor is biased so that output current flows during only half the input cycle. It is used where high efficiency and low distortion is required—for instance, in audio-output amplifiers.

In Class-C operation—which has the highest efficiency, but offers the greatest distortion—the transistor is biased beyond the cutoff region. Because of that, the output current flows during less than half (about a third) of the input cycle, making it unsuitable for amplifying signals of varying amplitude (like audio). It is usually used to amplify a signal of fixed amplitude. The efficiency and distortion characteristics of the Class-B amplifier lie between that of Class-A and Class-C amplifiers.

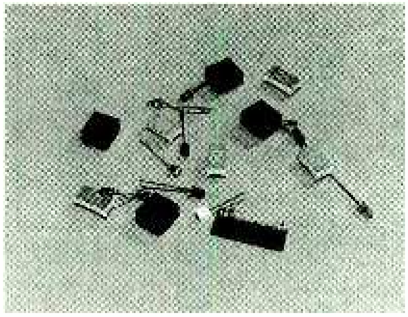
Optoelectronics. This family of components is a rather diverse one, which includes optocouplers, light-activated diodes and transistors, light-emitting diodes (LED's), and seven-segment displays. There are others, such as the light-activated SCR (LASCR), which is shown in Fig. 1 under the thyristor heading.

The optocoupler has two main functions; to provide isolation and serve as an interface between two dissimilar circuits (for example, digital control of analog circuits). Photocells have been used in many applications; including light-activated switching circuits, where the switch is triggered by an increase in light intensity.

The LED can be used as an indicator lamp or, in its infrared (IR) form, in remote-control applications, coupled with a phototransistor (which serves as the remote-control receiver's detector element). As mentioned earlier, they are occasionally combined (by hobbyists) with LED's to form optocouplers.

The tri-color LED (which shares its schematic symbol with the bi-color LED) can take the place of three indicator lamps. Its internal make-up is such that the application of a DC voltage in one direction produces a green glow; in the other direction it produces a red glow; and an AC voltage produces a yellow glow.

Seven-segment displays come in two "flavors:" the liquid-crystal display (LCD) and the LED types, which are available in either common-anode or common-cathode configurations. Common anode means that the anode of the seven LED's (segments) that make up the display are tied together; for common-cathode types, all cathodes are tied together. The type required (common anode or common cathode) depends on the display driver used in the circuit.



Here are some the principle players in the optoelectronics family of components.

Amplifiers. It may seem strange to see logic gates and flip-flops under the amplifier heading, but consider this: logic gates consist of networks of transistor-based buffer amplifiers, and a flip-flop is nothing more than some combination of basic logic gates. In fact, the basic logic gates, in various circuit configurations, make up the entire logic family.

Logic gates have many sub-divisions—DTL, RTL, TTL, CMOS, etc.—TTL and CMOS being the most popular, with each having branches of its own. The TTL type (based on bipolar technology) is limited to +5-volt operation, therefore the high and low output states of TTL devices are rigidly defined. CMOS logic (based on MOSFET technology), on the other hand, can be safely operated from supply voltages ranging between +3 and +15 volts, so the high and low output states of such devices are defined as a percentage of the supply voltage.

The amplifier/buffer, like the single transistor type, is used to isolate one stage from the next and is used to schematically indicate a buffer stage or gain block. The integrated-circuit package outline is used to schematically represent specific integrated sub-assemblies (or blocks) of a circuit; for instance, counter IC's, display driver IC's, etc.

Semiconductor Resistors. The semiconductor-resistor family is a special breed of resistive elements fabricated from semiconductor material. Such devices are widely used as sensors. For example, a thermistor is a heat-sensitive resistive semiconductor element that's designed to vary the voltage across it in accordance with the surrounding thermal condition. Therefore, it is well suited to applications where temperature must be taken into consideration: in an electronic thermometer or perhaps a thermal shutdown circuit.

A humidity sensor is a semiconductor device that is designed to vary its resistance in proportion to the amount of moisture sensed. Such devices have found application in equipment where high moisture levels can do great harm; VCR dew-sensors, for example. Other applications might include flood alarms, and automatic flood-pump devices.

The varistor is a semiconductor device designed to alter its resistance in accordance with the applied voltage. Some applications for such devices might be to automatically limit current to the succeeding circuitry or to shunt excessive voltage spikes.

The light-dependent resistor (LDR) is a semiconductor device whose resistance varies with light intensity. Because of that characteristic, it has found widespread use in circuits where light is a factor; automatic porch-light systems that turn on at dusk and off at dawn, for example.

Thyristors. The thyristor (its name derived from THYRatron-transISTOR) family of devices includes the SCR (Silicon-Controlled Rectifier), widely used in power-control applications: CSCR (Complementary, Silicon Controlled Rectifier), a negatively-triggered SCR; Triac (also called a bilateral switch); SCS (Silicon Controlled Switch); SAS (Silicon Asymmetrical Switch); SUS (Silicon Unilateral Switch) and SBS (Silicon Bilateral Switch, not to be confused with the Triac), commonly used as gate-trigger devices for power-control elements.

And that's not all there is to this family: There are a few other devices (some shown in Fig. 1 and some not) that can be used as solid-state switches, in variable power-control circuits, and for low-voltage control of high-power circuits.

The SCR—the first developed, and probably the most common member of the thyristor family—is essentially a gate-triggered rectifier; a four-layer diode with a gate connected to the P-section nearest its cathode. When sufficient trigger current is applied to its gate, the SCR conducts. Removing the trigger does not cause it to turn-off; instead, current through the device must fall below the holding level to turn the device off.

The Light-Activated Silicon Controlled Rectifier (LASCR) can be triggered by either a beam of light or an electrical pulse applied to its gate. Its applications include power switching and control in optical sensing, phase control, computers, and related digital-electronic control systems.

The Triac—the name of which was derived from TRIode AC semiconductor—can be triggered by positive or negative gate signals, and is used to control AC current in either direction. Precise Triac control is often achieved by using a special trigger-control device, the diac. The diac—sometimes referred to as a bidirectional diode—is used extensively as a trigger device for the Triac in AC-control circuits such as lamp dimmers, heating controls, motor-speed controls, etc.

The silicon controlled switch (SCS) is a dual-gate switch that's primarily used in low-power switching applications. Either gate can be used to turn on or turn off the main current through the device. The SCS may be used in applications where a low-level SCR with gate turn-on/turn-off capability is required.

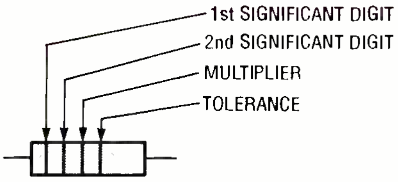
The silicon unilateral switch (SUS) and the silicon bilateral switch (SBS) are actually small integrated circuits containing transistors, Zener diodes, and resistors. The SBS is simply two SUS's in a single package connected for bilateral current transfer. Both are designed for high-speed signal-switching applications and are capable of producing fast-rising, high-current trigger signals for power thyristors such as SCR's and Triacs. They are also used in digital circuits involving frequency dividers, ring counters, bistable memory circuits, and pulse generators, and for voltage sensing in electronic crowbars (overvoltage protection for DC power-supply circuits).

Diodes. The symbol for the standard diode is a triangle with a bar across one corner, as shown in the lower right corner of Fig. 1. The diode is designed to conduct current in one direction and one direction only, and only when forward biased. Because of the diode's opposition to a change in direction of current flow, it is often used for rectification—the process by which AC is converted to DC.

A single diode can be used to half-wave rectify an AC voltage, producing a pulsating DC (a voltage that swings between some minimum and maximum level, but does not pass from positive to negative, or *vice versa*). A pair of diodes can be used to form what's termed a full-wave rectifier, one version of which—the full-wave bridge—is shown in the lower right corner of Fig. 1. The other version, which is less efficient than the bridge type, but more efficient than the half-wave type, is fabricated from two individual diodes.

There are also special diodes, like the Zener. What makes this diode special is that it is designed to be operated reverse biased—its cathode tied positive with respect to its anode—and regulates the voltage across it at some predetermined level. Therefore Zener diodes are offered according to voltage and power (which indicates the maximum safe-operating current of the device) ratings. When a Zener is forward biased (its cathode negative with respect to its anode), it behaves like any other diode.

The surge (transient) suppressor, as its name implies, is used to lessen the effects of sudden power fluctuations.



RESISTOR COLOR CODE		
1st & 2nd BANDS	3rd BAND MULTIPLIER	
	COLOR	MULTIPLIER
0 = BLACK	BLACK	1
1 = BROWN	BROWN	10
2 = RED	RED	100
3 = ORANGE	ORANGE	1000
4 = YELLOW	YELLOW	10,000
5 = GREEN	GREEN	100,000
6 = BLUE	BLUE	1,000,000
7 = VIOLET	SILVER	0.01
8 = GRAY	GOLD	0.1
9 = WHITE		
4th BAND		
TOLERANCE		
NO BAND +/– 20%		
SILVER +/– 10%		
GOLD +/– 5%		

Fig. 2. Color-coded bands on the resistor body are used to indicate the resistor value and tolerance. The illustration shows what each band represents.

(You might think of such a device as the electronic equivalent of a shock absorber.) The Schottky diode is designed for unilateral, or half-wave operation, and is often used in SCR trigger circuits.

Passive Components. The resistor, often set up in various series and/or parallel combinations, is probably the oldest regulating electronics device in existence. One of its major uses is in voltage-divider networks—series-connected strings of resistors, which play a major role in VOM's, DVM's, DMM's, etc. The resistor family consists of many types: carbon composition, carbon film, metal film, wire wound, wire-wound ceramics, etc. Resistors are available in various wattage ratings, from less than a ¼ watt to well over 250 watts. The type and wattage used in a circuit is dictated by the type of circuit and expected peak power through it.

A resistor's value is usually indicated by colored bands around the resistor body. The first band represents the first

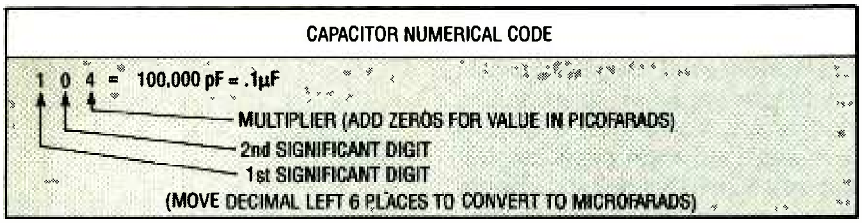


Fig. 3. Unlike resistors, a special numerical code is used on a capacitor's body indicate its value. The illustration shows what each digit in the code represents.

digit of the resistor value; the second is the second digit of the value. The third digit is the multiplier; and the forth is the tolerance band (which indicates the percent error in the parts marked value). Figure 2 gives the values represented by the various colors used in the resistor color code, and shows how the color bands are read.

The first band represents the most-significant digit of the resistor's value; the second digit represents the second-most-significant digit; and the third represents the multiplier (the number by which the first two digits are multiplied to the give the resistor value). The forth band (if there is one) gives the resistor's tolerance, which is the percentage by which the unit can deviate from its coded value.

For example, say that a resistor is coded brown-red-green-gold; the first band (brown) represents a value of one (1), the second (red) represents a value of two (2), the third color band (green) tells you to multiply the first two digits by 100,000, giving a resistance of 1,200,000 or 1.2 megohms (the prefix "meg" means million). Finally, the gold tolerance band tells us that the value can deviate from the 1.2-megohm rating by 5%, meaning that the resistor's actual value can fall between 1,080,000 ohms (1.08 megohms) and 1,320,000 ohms (1.32 megohms).

Capacitors, because of their willingness to pass AC while blocking DC, are often used in audio coupling applications—where it is desirable to block DC and pass AC. They exhibit a high resistance (called capacitive reactance) to DC. But for AC, as frequency increases, opposition to current flow (capacitive reactance) in the capacitor diminishes. Another useful characteristic of capacitors is their ability to store a charge, much like a battery stores a charge. Because of that, they are useful in filter applications.

Electrolytic capacitors (such as aluminum and tantalum units), have their values printed right on the body of the unit. Those capacitors—which usually range in value from 0.1 microfarad (denoted 0.1 µF) to 1 farad (1 F)—can be polarized or non-polarized; polarized units will have either the positive or negative lead indicated on the capacitor body. Smaller-value capacitors use a three-digit numerical code to indicate their value, as shown in Fig. 3., and may or may not have its rated voltage printed on its body.

Inductors (or retardation coils) are simply coils of wire wound on various core materials: paper, iron, etc. They are found almost exclusively in circuits where varying signals are present: audio, video, RF, etc. An inductor exhibits some resistance (opposition) to a change in the direction of current flow. The amount of electrical resistance (known as inductive reactance, and measured in ohms) depends upon the frequency of the applied signal. The higher the frequency, the greater the reactance, and *vice versa*; thus, an inductor offers no opposition to DC current flow (other than the characteristic resistance of the wire from which it is formed).

Transformers, which are simply two inductors placed in close proximity to each other, are used in many applications; for example, isolation, coupling, voltage step-up/step-down, etc. Transformers can be thought of as "magnetic-transfer" devices. Placing the two coils in close proximity to each other allows current flowing in one coil to induce current to flow in the other coil. That is, if an alternating signal is fed through one coil of the transformer, a signal of the same shape is created in the other coil. The magnitude of the induced signal depends on the turns ratio of the two coils.

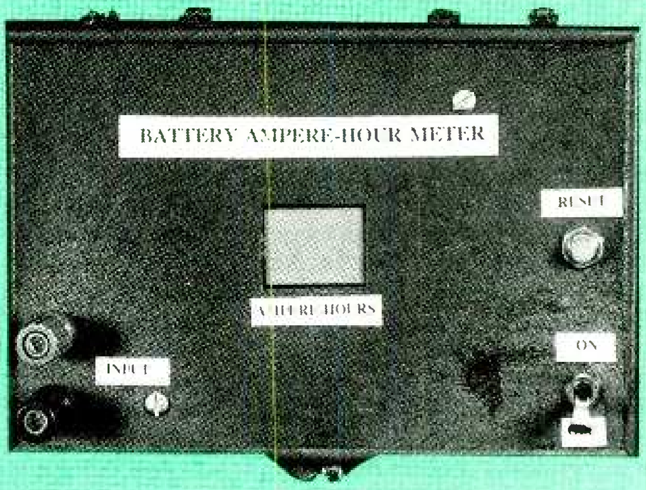
Other Items. Switches are devices (mechanical or electromechanical) that either pass or prevent the flow of current by opening or closing a circuit path. Switches are available in many configurations: slide, toggle, pushbutton (both normally-open and normally-closed types); there are also electromechanical types like mercury switches, relays, and reed relays and switches. Some switches—such as relays—are designed to activate upon the application of a signal of sufficient magnitude to energize a coil; others react to other trigger mechanisms. For instance, the mercury switch (which is composed of two electrodes and a blob of mercury encapsulated in a glass envelope) responds to movement; that is, when held in one position, the blob of mercury does not bridge the two electrodes and no current flows. However, when the switch is tilted so that the blob of mercury bridges the electrodes, electrical contact is established, and current flow is permitted.

Connectors come in many forms, and vary nearly as widely as the applications in which they are used. Regardless of the configuration, they all do one thing: provide an electrical connection between devices. Banana jacks, for instance, are a mainstay of test instruments, but are also used with other equipment where quick connect/disconnect capability (signal patching) is desirable. Other connectors are designed for specific applications; coaxial jacks, for example, are used in high-frequency applications, where transmission losses can greatly affect circuit operation. Such applications require shielding to help minimize signal loss.

Under the miscellaneous heading are components that don't quite fit into the other families. Among those components are the neon lamp and incandescent lamp; batteries; meters; antennas; and transducers, including speakers, headphones, microphones, and more.

Conclusion. Schematic diagrams are like electronics road maps. But what good are they if you've never learned to read the signs? Being able to recognize schematic symbols and equate a specific function to that device will greatly improve your ability to interpret schematic diagrams. That translates into time saved in the repair of any electronic equipment. ■

Build a Battery Amp-Hour Meter



Know the true state of your rechargeable batteries with this handy test accessory.

BY ANTHONY J. CARISTI

Rechargeable batteries do not last forever, and begin to lose capacity from day one. However, if being absolutely sure of reliable battery operation is important to you, the project described in this article can make an excellent addition to your arsenal of test gear. The Battery Ampere-Hour Meter can be used with all batteries to measure and display continuously the cumulative number of ampere-hours that are being delivered by the battery into a load. It can also be used in reverse, to provide a continuous display of the total number of ampere-hours delivered to a battery during recharging.

The Battery Ampere-Hour Meter is a small, lightweight, portable device that can be built and used as a stand-alone instrument. It can also be permanently wired into equipment that is battery powered and used as a dedicated battery-monitoring system. Another use would be to build it into a battery charger, which in effect will make that charger the "smartest one on the block."

The Ampere-Hour Meter contains a two-digit LCD display and has a resolution of 0.1 Ah. With it you will be able to monitor the total amount of energy delivered by the battery, and know when it is near exhaustion. That can help avoid situations such as losing vital data in your laptop computer should the battery suddenly go dead.

Circuit options allow the display of the total number of ampere-hours (from zero) used, or the remaining battery capacity in ampere-hours. Alternatively, the display can show battery-charge time remaining with a resolution of 1⁄10 hour. The maximum display in ampere-hours or real-time hours is 9.9.

The circuit is powered by a standard 9-volt transistor-radio battery, which provides many hours of use. Even when the unit is turned off, the Ampere-Hour Meter will retain the accumulated total. A switch is provided to reset the display at any time and to start the measurement process from the beginning. When used with batteries or power sources that deliver between 7- and 15-volts DC, a circuit option allows the instrument to operate without the built-in 9-volt battery.

Battery Fundamentals. The electrical capacity of rechargeable batteries, such as NiCd's or lead-acid cells, is rated in ampere-hours. For example, a typical camcorder rechargeable battery may have a rating of 1.5 ampere-hours, which is sometimes specified as 1500 milliampere-hours. The terminal voltage of the battery is not a factor in the ampere-hour rating, and measuring a battery's terminal voltage is a very poor method of determining its remaining charge.

What does all that mean? The ampere-hour rating of a NiCd battery is usually specified using the 10-hour discharge rate. Other types of rechargeable batteries, such as lead-acid, may be rated at a different discharge rate. In the case of the NiCd camcorder battery mentioned above, that battery is able to deliver 0.15 amperes (150 milliamperes) into a load for a period of 10 hours. Thus 0.15 amperes times 10 hours equals 1.5 ampere-hours.

The battery is, of course, able to deliver currents far in excess of its ampere-hour rating (1.5 Ah in the above example). Such a battery can deliver possibly 50 amperes into a short circuit! However, at higher discharge rates, the ampere-hour capacity of the battery can be significantly less than its rating.

As an example, a typical camcorder current draw might be 0.5 amperes. That could easily lead one to assume that the operating time of a camcorder with a fully charged 1.5-Ah battery is 3 hours. That is not so, since at that current level, the discharge rate is more like a 3-hour rate rather than the standard 10-hour rate. As a result, the total battery capacity is less, and might be as little as ⅔ of the rated capacity. That's why the fully charged 1.5 Ah camcorder battery under a load of 0.5 amperes may last only 2 hours.

There are other factors that can affect the capacity of the battery. For one, there is some permanent deterioration of the battery as it charged and recharged many times. Thus, total battery capacity is continuously decreasing due to wear and tear, and when it is reduced to a low amount over a period of time, it has no effective service life and must be replaced. Also, there is the inherent "self discharge" characteristic that slowly depletes battery charge during idle time and makes periodic recharging to restore full capacity necessary. Self discharge increases dramatically at higher ambient storage temperatures.

The Battery Ampere-Hour Meter can provide a meaningful measurement to determine if there is indeed some deterioration of battery capacity due to aging. It can also be used to determine the true ampere-hour capacity at the discharge rate that the battery normally sees. That, as you can see from the above, is vital information that is just not otherwise available to the consumer!

About the Circuit. The Battery Ampere-Hour Meter consists of six major sections. Those are a current-to-voltage converter, a voltage-to-frequency converter, a binary divider, a binary-coded-decimal (BCD) counter, a liquid-crystal display system, and two regulated power supplies.

Refer to Fig. 1 as we proceed. Power to operate the circuit is provided by a 9-volt battery that drives a fixed 5-volt regulator chip, U1. A voltage-converter chip, U2, contains all the necessary passive components, except C3 and C4, to convert the positive 5-volt supply to −5 volts. The regulated output of U1 feeds the entire circuit, while U2 is used to provide a negative supply for U3 and U4.

The battery current that is to be monitored is passed to U3, which, in conjunction with R1, forms a current-to-voltage converter with a gain of 10 as determined by the resistance ratio of R2 and R3. The output voltage at pin 1 of U3 is equal to the number of amperes flowing through R1. Over a range of 0 to 5 amperes, the voltage at pin 1 will be 0 to 5 volts. That voltage is a true representation of the current flowing out of (or into) the battery under test.

We have established one parameter of the ampere-hour equation: current. The other, time, must also be taken into account. That is the function of U4, a linear voltage-to-frequency converter that is the heart of the Battery Ampere-Hour Meter.

In order to measure ampere-hours in digital form with a resolution of 0.1 Ah, it is necessary to produce 1-pulse-per-hour for a battery current of 0.1 ampere. That translates to a frequency of 1-pulse/3600-seconds or about 0.000278 Hz. Additionally, the frequency must be a linear function of current.

The TC9402TCPD, U4, connected as a voltage-to-frequency converter, fills that requirement ideally. It generates an output pulse at pin 8 whose repetition rate is a function of the current flowing into pin 3, a reference voltage fed to pin 7, and the value of the capacitor connected between pins 3 and 5. Additionally, a square-wave output waveform at one-half the generated frequency is available at pin 10.

For reasons that soon will become evident, the output frequency at pin 10 of U4 is adjusted to 5825 Hz when the voltage present at pin 1 of U3 is 1.0 volt. Since the voltage-to-frequency

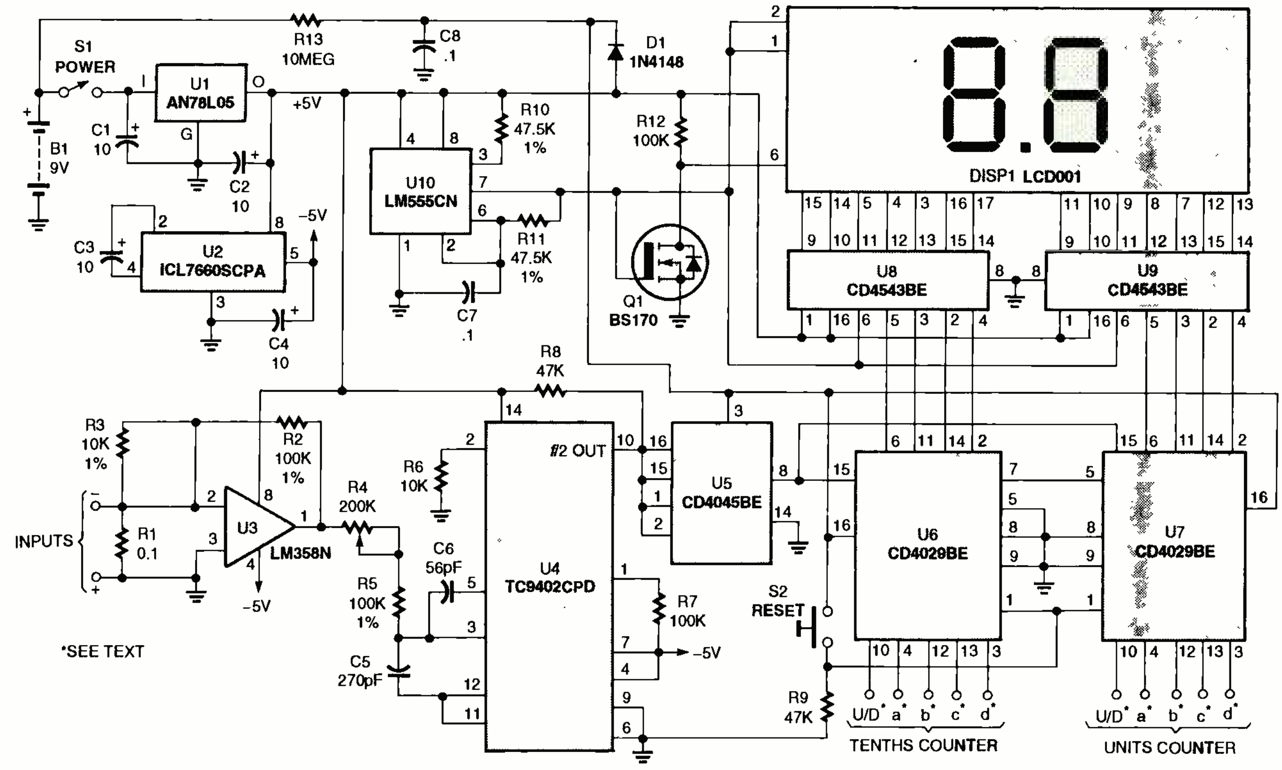


Fig. 1. Here's the schematic diagram of the Battery Ampere-Hour Meter. The circuit can be operated in three different modes, depending on the configuration of the two counter IC's, U6 and U7.

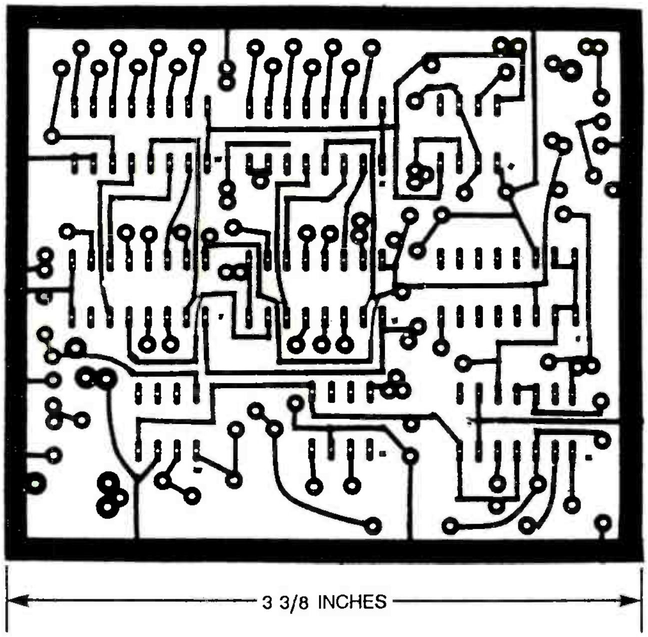


Fig 2. Use this foil pattern to etch the main circuit board. The pattern is shown here full size.

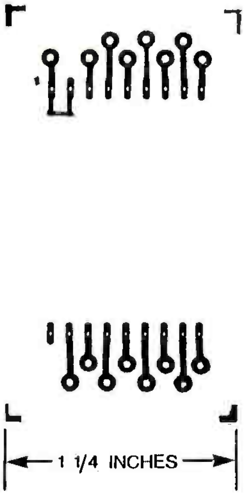


Fig. 3. The LCD display is mounted on its own board. The pattern for that board is shown here full size.

relationship is linear, when pin 1 of U3 is 0.1 volt, the frequency output at pin 10 will be 582.5 Hz. The output frequency of U4 is adjusted by placing a variable resistance in the path between U3 pin 1 and U4 pin 3 to control the IC's input current. Potentiometer R4 can therefore be used as a calibration adjustment to set the operating frequency of U4.

The pin-10 output of U4 is fed to the clock input, pin 15, of U5, a CD4045BE 21-stage binary divider. The division ratio of U5, 2 raised to the 21st power, is 2,097,152. When the frequency output at pin 10 of U4 is 582.5 Hz (with 0.1 ampere of current flowing through R1), the output frequency of U5, at pin 8, is 582.5/2,097,152 or 0.000278 Hz. That is equal to 1 pulse-per-hour, which is what is needed to produce a digital increment of 0.1 each hour for 0.1 amperes of battery current.

Two CD4029BE programmable binary/decade up/down counter chips, U6 and U7, are cascaded and are operated in their decade mode to produce a BCD count of the number of pulses appearing at the clock input terminals (pin 15) of each chip. The up/down-count input terminal, pin 10, is hard wired to V_{dd} to count up, or to ground to count down in accordance with the three available circuit options as earlier described. The operating range of the counter is 0.0 to 9.9, or vice versa.

Preset BCD data is hard wired to input terminals 4, 12, 13, and 3 of each chip, called a, b, c, and d respectively. These are the BCD 1, 2, 4, and 8 preset inputs. For applications requiring counting up from zero, all eight input-data terminals are grounded. To count down from a preset number, the input terminals are hard wired to V_{dd} and ground in accordance with the desired BCD number. Hard-wired preset data is entered into the counters when the load input, pin 1, is taken high by means of reset switch S2.

The BCD output of the cascaded counters appears at pins 6, 11, 14, and 2 of each chip. That data is fed to the BCD input of the LCD decoder/driver chips, U8 and U9.

A 10-megohm resistor, R9, is connected between the positive battery terminal and the V_{dd} supply terminals of U5, U6, and U7. That provides a "keep alive" trickle current of less than 1 microampere, which preserves the memory of the chips when the instrument is not in use. That ensures that the total accumulated ampere-hour

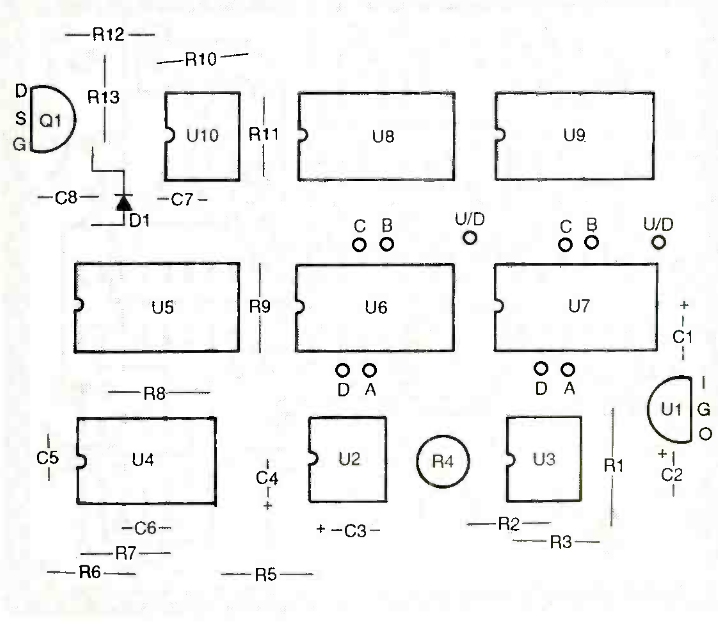


Fig. 4. Use this parts-placement diagram when installing the board-mounted components on the main circuit board.

count is retained until the instrument is reactivated.

A CMOS 555 timer chip, U10, which operates as a 130-Hz square-wave generator, supplies the required backplane drive for the LCD readout. The backplane signal is also fed to pin 6 of each decoder/driver chip, which inverts the signal fed to each segment of the particular LCD digit that must be activated. The segments that must be extinguished are driven by the unchanged backplane signal.

A TMOS field-effect transistor, Q1, is used to invert the backplane signal for the decimal point. That is fed to pin 6 of the display to activate the decimal point.

Construction. Building the Battery Ampere-Hour Meter consists of stuffing the main-circuit board, which contains the bulk of the circuitry, mounting the LCD module onto the other board, and making 16 hardwire connections between the two boards. The circuit also may be hard wired on a section of perfboard if good wiring techniques are used.

Figures 2 and 3 are the printed-circuit layouts of the two boards, shown full size. Etched and drilled PC boards are also available from the source given in the Parts List if you do not care to etch and drill your own.

The component layout of the main circuit board is shown in Fig. 4, which also serves to identify the proper orientation of all polarized components such as IC's, the transistor, electrolytic capacitors, and the diode. It is important that these components be placed onto the board correctly to avoid possible component damage and a non-operating circuit.

Note that the board contains a number of jumper wires. The locations of those wires are listed in Table 1, and, along with the off-board connections, are shown in Fig. 5. The outlines of the DIP IC's are also shown in that figure to help locate the proper connection points. To prevent breakage, use stranded wire for the jumpers.

Be sure to use sockets for all DIP integrated circuits. That will allow ease of troubleshooting and servicing should it become necessary. It is extremely difficult to remove a multi-pin IC that has been soldered directly onto a printed-circuit board without damage to the board or the chip.

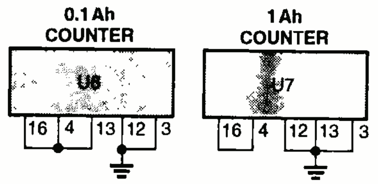


Fig. 6. For options 2 and 3, U6 and U7 must be pre-programmed as described in text. This example shows how to preprogram the chips for a starting value of 1.5 Ah.

The 0.1-ohm wirewound resistor, R1, is commercially available as specified in the Parts List. Alternatively, it can easily be fabricated by taking 29½ inches of #26 enameled magnet wire and winding it on an ordinary ½-watt carbon resistor of any value. To check the value of your home-made resistor, pass 1.0 ampere DC from a power supply through it and measure the voltage drop across the resistor with a digital voltmeter. (A 5-ohm 5-watt resistor can be connected in series with the power supply to make adjusting the current easier.) In accordance with Ohm's law, if R1 is of the correct value, the voltage reading across it should be 0.1-volts DC. Bear in mind that if several amperes of current (the maximum allowable is 5 amps) are to be monitored, choose a heavier gauge wire to wind the resistor. Additionally, a large heating effect due to power dissipation should be avoided, since the resistance of copper wire will increase slightly with temperature.

To complete the circuit, the builder must select one of the following options and wire the circuit accordingly:

1. Display total accumulated ampere-hours, starting from 0.0, and count up.

2. Display the remaining number of ampere-hours left in the discharging battery, from a pre-programmed value (up to 9.9), and count down.

3. Display the operating time left in the discharging battery, counting down from a pre-programmed value of up to 9.9 hours.

For option 1 (count up), pin 10 of U6 and U7 must be hard wired to pin 16 (V_{dd}) of each chip and pins 3, 4, 12,

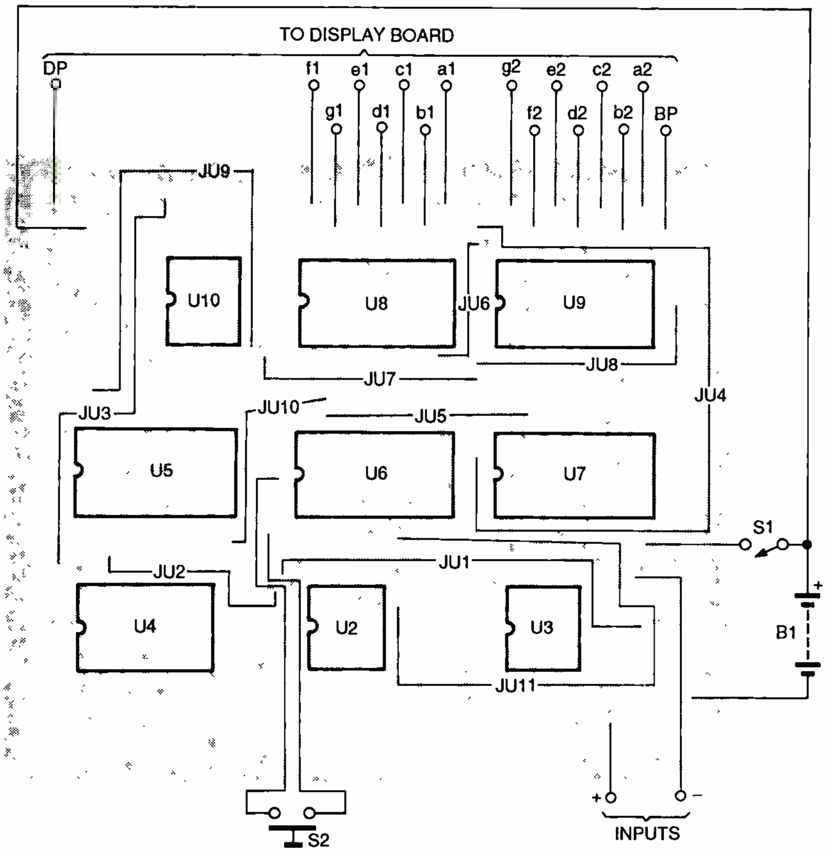


Fig. 5. The locations of the numerous jumpers and the connections to the off-board components are shown here. The outlines of the DIP IC's are also shown as reference points to aid the builder.

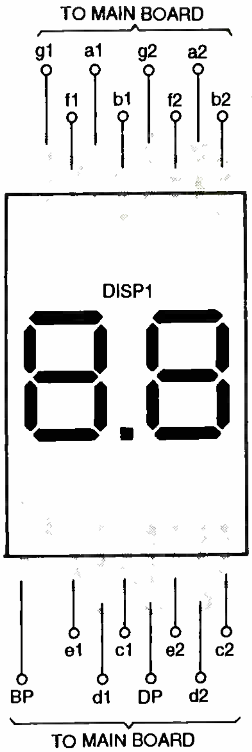


Fig. 7. Here is the parts-placement pattern for the LCD-display board.

and 13 of each chip must be grounded for a preset BCD number of 0.0.

For option 2 (count down) pin 10 of each counter chip (U6 and U7) must be grounded. Pins 3, 4, 12, and 13 of those IC's must be hard wired for the battery's nominal ampere-hour capacity, up to 9.9, in BCD format. Counter U6 is the tenths counter, and U7 is the units counter. Pin 4 ("a") of each chip is the least-significant bit in the 4-bit BCD code; pin 3 ("d") is the most-significant bit.

As an example, to pre-program 1.5 Ah, follow the wiring shown in Fig. 6. That shows 0.5 Ah preprogrammed into U6 and 1 Ah into U7 for a value of 1.5 Ah (in BCD).

For option 3 (count down) pin 10 of each counter chip must be grounded. The pre-programmed number must be calculated using the following relationship:

Preprogrammed Number In Hours = Battery Capacity In Ah/Actual Load Current In Amperes

The calculated number, not greater than 9.9 hours, must be hard-wired into the preset BCD input terminals of the two counter chips as described under option 2 above.

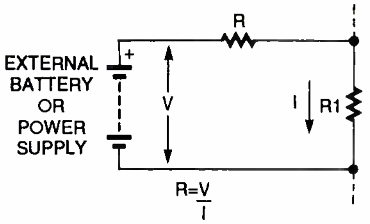


Fig. 8. A calibrated current source is required to check out the meter. Use the circuit shown here.

Additionally for option 3, the value of R2 must be changed so that the voltage at pin 1 of U3 is 1.0 volt when the actual load current that will be delivered by the battery is flowing through R1. That is easily calculated by the relationship:

R2 In Ohms = 100,000/Actual Load Current In Amperes

Use a 1% metal film resistor for stability.

Figure 7 is the parts-placement diagram for the LCD board. Note that the LCD has an indentation marked in the border, similar to that found on many DIP IC's, to identify the location of pin 1.

The LCD is made of glass and is very fragile; handle it carefully and do not place excessive strain on it during installation. It may be soldered directly onto the printed-circuit board, or, at the builder's option, a socket can be fabricated by cutting an 18 pin IC socket in half lengthwise.

Use small gauge stranded wire to make the connections between the two boards, following Figs. 5 and 7. Again, use stranded wire for that.

The entire assembly of two boards makes a low profile package that can be placed into a small enclosure. The two boards may be stacked, or placed next to each other. Cut a suitable-size rectangular opening in the enclosure to allow the readout to show through.

The input terminals can be brought out to binding posts on the exterior of the enclosure. Be sure to use at least #20 wire for those connections.

Mount S1 and S2 on the enclosure and wire them to the appropriate points on the circuit board. Finally, connect a 9-volt battery clip to the appropriate points as shown in Fig. 4 and you are done.

When the assembly and wiring of the circuit is complete, examine the circuit board very carefully for any possible opens, shorts, or cold-solder joints, which can appear as rough, dull blobs of solder. Re-do any joint that is suspect. It is far easier to correct assembly problems at this time rather than later on if you discover that the project does not work.

Test and Calibration. The best way to check out the circuit is to do it in stages, rather than trying to operate everything at once. A DC voltmeter or VOM will be required; an oscilloscope and/or frequency counter will be needed to calibrate the oscillating frequency of U4.

A calibrated current source is also required. That can be as simple as a battery and an external load resistor that will draw 1 ampere (or any other desired value) of current. See Fig. 8.

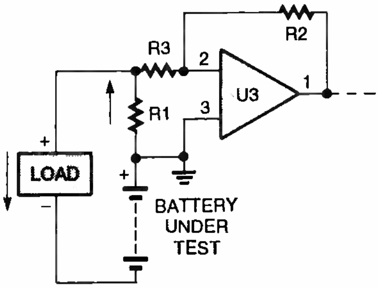


Fig. 9. This diagram shows how a load and a power source (the battery under test) are connected to the meter.

Use Ohm's law to calculate the resistor value:

External Resistance in ohms = Battery Voltage Under Load/Load Current

Be sure to use a resistor that can safely dissipate the heat generated by the current.

Alternatively, the device that is to be driven by the battery can also serve as the load. Figure 9 shows the proper connections if you choose to go that route. Note that this is the same set up that will be used during operation of the instrument. Also, note that you will have to determine the actual current being drawn by the load. To do that, a DC ammeter must be connected in series with one of the battery leads to measure the current. The measured value will be what you will use in the tests that follow.

Procedure. First check out the regulated power supplies by removing all chips from the board except U1 and

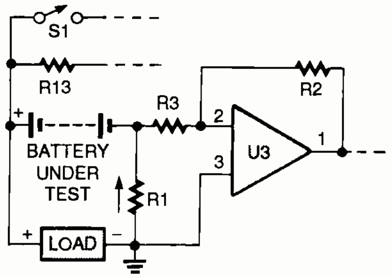


Fig. 10. The internal battery can be omitted when the battery-under-test delivers 7 to 15 volts. The wiring for that option is shown here.

PARTS LIST FOR THE BATTERY AMP-HOUR METER

SEMICONDUCTORS

U1—AN78L05 5-volt regulator, integrated circuit
U2—ICL7660SCPA voltage converter, integrated circuit (Harris)
U3—LM358N op-amp, integrated circuit
U4—TC9402CPD voltage-to-frequency converter, integrated circuit (Teledyne)
U5—CD4045BE 21-stage binary divider, integrated circuit
U6, U7—CD4029BE binary/decade up/down counter, integrated circuit
U8, U9—CD4543BE decoder/driver, integrated circuit
U10—LMC555CN CMOS timer, integrated circuit
Q1—BS170 TMOS field-effect transistor
DISP1—2-digit, liquid-crystal display, Digi-Key LCD001 or equivalent
D1—1N4148 general-purpose silicon diode

RESISTORS

(All fixed resistors ¼-watt 5% units unless otherwise specified.)
R1—0.1-ohm, 3-watt wirewound, Dale CW-2B or equivalent (see text)
R2, R5—100,000-ohm 1% metal-film
R3—10,000-ohm 1% metal-film
R4—200,000-ohm cermet potentiometer, PC mount
R6—10,000-ohm
R7, R12—100,000-ohm
R8, R9—47,000-ohm
R10, R11—47,500-ohm 1% metal-film
R13—10-megohm

CAPACITORS

C1–C4—10-µF, 25-WVDC, radial electrolytic
C5—270-pF NPO ceramic-disc
C6—56-pF NPO ceramic-disc
C7, C8—0.1-µF ceramic-disc

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery
S1—SPST toggle or slide switch
S2—SPST normally-open pushbutton switch
PC Board, battery clip, enclosure, IC sockets, binding posts, hardware, solder, wire, etc.

Note: The following parts are available from A. Caristi, 69 White Pond Road, Waldwick NJ 07463: Set of 2 printed circuit boards, \$29.95; U1, \$2.25; U2, \$7.25; U3, \$2.25; U4, \$8.75; U5, \$2.75; U6, \$2.75; U7, \$2.75; U8, \$2.75; U9, \$2.75; U10, \$2.75; set of five 1% metal-film resistors, \$2.95. Please add \$5.00 postage/handling. NJ residents must add appropriate sales tax.

U2. Install a fresh 9-volt battery and turn power on. Verify that U1 is delivering 4.75 to 5.25 volts (with respect to the circuit common) to the positive side of C2. Measure the voltage at the negative side of C4. That should be a negative voltage of the same magnitude as the positive supply.

Do not proceed with the checkout if you do not obtain the correct readings. Troubleshoot the circuit by checking the orientation of U1, U2, and C1–C4. Measure the battery voltage under load and verify that it is connected to the circuit with the correct polarity and that it is delivering at least 7 volts to the circuit. The normal current draw of the instrument is about 8 milliamperes. Check for short circuits between the regulated output lines and ground.

Insert U3 in its socket. Be sure to orient it properly as illustrated in Fig. 4. Connect the calibrated current source, or the load and the battery, and set S1 to the ON position. Be sure that the load current through R1 flows in the correct direction as indicated in Figs. 8 or 9 (depending on the set up you are using). It is assumed that the builder has verified the level of load current if the actual load is used. Measure the voltage appearing at pin 1 of U3. The voltage reading should be the same as the level of load current (1 volt-per-ampere within the tolerance of R1).

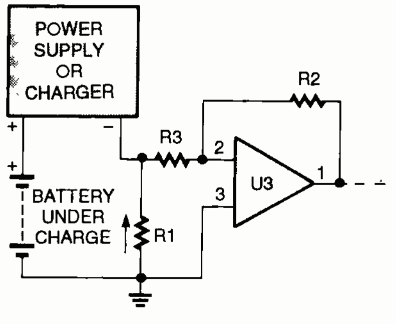


Fig. 11. To modify a battery charger so that it will display the ampere-hours delivered into a rechargeable battery, configure the circuit as described in option 1 and wire it to the charger as shown here.

Failure to obtain the correct reading can be caused by incorrect resistance values at R1, R2, and/or R3, or a defective or improperly oriented U3. Check also the power-supply voltage to pins 8 and 4, which should be about +9 and −5 volts, respectively.

Next we have to set the frequency of U4. For options 1 and 2 described earlier, use the following procedure: With power off, insert U4 into its socket. Reapply the load current and battery power, and check pin 10 of U4 for the presence of a squarewave. Adjust R4 for a frequency of 5825 Hz (172-µs period) if the calibrated load current is 1.0 ampere. For any other load-current value, set the frequency in accordance with the following relationship:

$$\text{Frequency} = 5825 \times \text{Current}$$

For option 3, with a modified value for R2 as described earlier, adjust the R1 current to obtain 1.0-volt DC at pin 1 of U3. Then set U4's output frequency (at pin 10) to 5825 Hz by adjusting R4.

If no square wave is evident at pin 10 of U4, carefully check all components associated with that chip. Also, be sure that the IC is properly oriented in the circuit as shown in Fig. 4. If possible, try a new chip.

If the frequency cannot be set as directed, check the voltage at pin 1 of U3 to verify that it is 1 volt-per-ampere of load current. The maximum allowable load current is 5 amperes. Check the values of C5 and C6.

If all is well to this point, turn off all power and insert all remaining IC's into their respective sockets. Be very

(Continued on page 92)

All About Crash Protection

Learn how researchers are making it possible to survive even severe automobile crashes through the use of air bags, automatic roll bars, and more.

BY WILLIAM D. SIURU, JR.

Antilock braking systems (ABS) now, and collision-avoidance systems in the future can help you avoid an accident. However, if a collision is unavoidable, air bags and seat belts are your first line of defense in surviving the crash.

Statistics from the Insurance Institute for Highway Safety and the National Highway Transportation Safety Administration show the effectiveness of air bags. With air bags, the likelihood that you will receive moderate to severe injuries is reduced by 25% to 29%. The chances of going to the hospital are reduced by 24% if the crash occurs in a vehicle equipped with air bags compared with one with only seat belts. Between 1985 to 1991, there were 28% fewer fatalities in frontal crashes with cars equipped with air bags compared to those with seat belts alone. Seat belts are now worn by about 65% of U.S. drivers. This is up from only about 10% in 1986.

It is getting harder to find a new car, truck, van, or sport/utility vehicle without at least a driver-side air bag. Air bags for front-seat passengers are also becoming common in cars and some minivans. By the 1997 model year, Federal law will require that all new cars sold in the U.S. have dual air bags. That will extend to light trucks and vans in 1998.

Air Bags for Older Vehicles. People who have vehicles they love but that lack air bags can install aftermarket air-bag systems that are starting to appear on the market. Breed Technologies, a company that is a major supplier of air-bag systems and crash sensors, is offering its SRS-40 Supplemental Restraint System. The SRS-40 is now available for over sixty American car and truck models, and the list is growing. Currently available are units for most of the 1987 and after GM passenger cars that did not originally come with driver-side air bags. Also available are units for most Chevrolet and GMC pickups, Suburbans, vans, and Blazers/Jimmys, plus Jeep Cherokees.

The SRS-40 is not a full-sized air bag, nor does it have knee bolsters like factory-installed air bags sold in the U.S., and it does not meet all the Federal standards. Therefore, it must be used with seat belts. Then again, all air bags are Supplemental Restraint Systems (SRS) and must be used with seat belts to be fully effective. However, the SRS-40 is virtually identical to the air bags installed in Europe and Asia, where virtually everyone fastens up. In any event, the SRS-40 can definitely reduce face and head injuries.

The SRS-40 costs just under $600 installed, and installation must be done by a trained specialist; this is not a do-it-yourself operation. On the plus side, however, installing it might even save you some money; check your insurance carrier to see if you qualify for a discount by installing this retrofit system.

The SRS-40 including the air bag, inflator, logic circuitry, and crash sensor are all contained within the steering wheel itself. The installation requires replacement of the steering wheel so, obviously, one size does not fit all cars. The system has to interface with vehicles that have different controls on the steering wheel. The SRS-40 is distributed by Applied Safety, Inc. of Ventnor, NJ (Tel: 800-723-3611) or Wynn's Climate Systems, Inc. of Ft. Worth, TX (Tel: 800-347-3883). Nationwide distribution will follow shortly through car dealers as well as auto-service chains.

While not a full-sized air bag like those installed in new cars and trucks, the aftermarket SRS-40 from Breed Technologies can provide air bag protection if seat belts are worn.

Air-Bag Technology. Today, most air-bag systems are decentralized in that the components are found in various locations on the vehicle. For instance, crash sensors are located at the front of the car, while the microprocessor is located under the instrument panel. The air bags themselves are in the steering wheel, and in front of the passenger when dual air bags are installed. However, the trend is towards single-point sensing systems with the sensors, and in some cases the logic circuitry as well, located with the air bag.

Few things in life are as reliable as air bags. In 1200 investigations of air-bags crashes, there were no situations where air bags failed to inflate. On the other hand, air bags should deploy only in a severe crash when you must be protected from injury, or worse. They should not deploy if you hit a curb or a pothole. A deployed air bag could even cause a collision if it impairs the view out the windshield. Preventing unneeded deployment, such as during parking-lot fender-benders, is important since replacing an air bag is expensive, with costs starting at $600. Incidentally, because of their value, thieves are now breaking into vehicles to steal the air bags, leaving expensive sound systems behind.

Putting air bags on trucks and sport/utility vehicles represents an additional challenge. They have to deploy in a crash, but not when pushing a snowplow or offroading over rugged territory. Engineers have been able to design crash sensors that can reliably

What Happens In A Crash With Air Bags

- Crash sensors sense that a crash is starting to happen.
- Crash sensors are triggered to send impulses to an electronic control module.
- The module evaluates the situation, and if air-bag deployment is needed, triggers an impulse. The module usually includes a sensor that prevents false deployments of the air bag.
- The impulse causes a central igniter or squib to fire.
- The igniter burns, penetrating the propellant chamber.
- The propellant ignites, producing and expelling hot, yet harmless, nitrogen gas (we normally breathe 78% nitrogen). The "smoke" produced is a harmless powder used to lubricate the air bag so it will deploy easier.
- The gas passes through a filter and enters the nylon air bag through inflator ports.
- The pressurized bag inflates, emerging from the center of the steering wheel, or in the case of dual air bags, through the dashboard panel.
- Once deployed, the bag cushions the occupant's impact using pneumatic damping effects from the air cushion vents.
- Immediately afterwards, the bag's vents release the remaining pressure, deflating the bag.

All this happens in 40 to 50 milliseconds for front air bags, and much faster for side-impact air bags. Depending on the manufacturer, air bags are deployed in sudden stops from speeds above 10 to 15 mph. ■

tell the difference between a crash and "normal" bumps and jolts.

One example is the deer/car encounters that occur over 300,000 times a year in this country. A while back, GM demonstrated the sensitivity of its air bags with tests using Styrofoam and sand bags to simulate a deer. The sophisticated sensors and triggering logic in the air-bag system was quite able to discern when the collision with the "deer" was severe enough to deploy the air bag or not deploy the bag, which was most of time.

The Robert Bosch Corp. has developed a seat-occupancy sensor to detect whether a passenger-side seat is occupied and then commands air-bag deployment accordingly. The sensor prevents air-bag deployment if the seat is detected as unoccupied, even if the seat contains a rear facing child-safety seat or heavy objects, both occasions when air-bag deployment is not desirable.

The sensor uses a capacitive measuring principle, rather than mass-sensitive sensors to determine seat occupancy. The sensor is easily integrated into the seat, has no mechanical switches, and works with heated seats. Bosch will introduce the technology in Europe this year.

By mounting the bag in the seat rather than the door, the Volvo side-impact air bag is always in the same, optimum position relative to the person in the seat, no matter how the seat is adjusted.

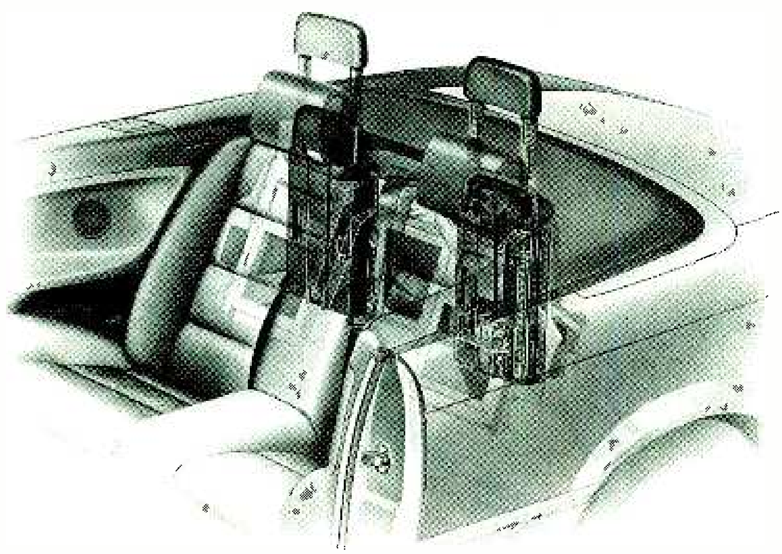
Air Bags and Children. Unfortunately, a new danger is surfacing as vehicles are being equipped with air bags for front-seat passengers While air bags are unquestionably saving adult lives, that may not be the case for infants. A deploying air bag can transmit sufficient forces to a rear-facing infant safety seat to severely injure or even kill a baby. Air bags literally explode at speeds of 100 to 200 mph in about 0.05 seconds. In the process, forces equivalent to over 300 G's can occur because the child's head is so close to the air bag in a rear-facing seat. The current solution, of course, is to place the safety seat on the back seat. The National Highway Traffic Safety Administration recently announced requirements that new rear-facing child-safety seats have labels warning that deployment of passenger-side air bags pose risks to children. Occupancy sensors like the one from Bosch will also prevent that dangerous problem.

Some pregnant women believe that they should not wear lap belts because of possible harm to the unborn child. GM and the University of Michigan Medical School are now doing research to improve the safety of pregnant women in vehicle crashes. In future crash tests, measurements will include acceleration of the fetus' head and pressure applied to the mother's abdomen. The information will identify the relative safety of different restraint designs.

While the results of the study are not yet in, the experts say that the benefits of wearing safety belts far outweigh the risks of not wearing them. Pregnant women should wear lap belts under the bulge in the tummy and over the pelvic bones. The shoulder belt should fit between the breasts and over the shoulder. Indeed, everyone should wear the shoulder belt over the shoulder, not under it.

Side Air Bags. After frontal collisions, side impacts are the next most dangerous. The statistics show that about a third of all car deaths and serious injuries occur during side-impact accidents; that is about 8,000 fatalities and 24,000 serious injuries. The immediate, but not complete, solution is the "side-impact reinforcements" that are appearing on cars now and will be required on all cars by 1997. The ultimate solution may be side-impact air bags. The air bags may be located in seats, backrests, doors, or pillars.

However, transferring the already well-developed air-bag technology for frontal collisions to side air bags is not simple and represents a real engi-



In BMW's Rollover Protection System, if a sensor detects an impending rollover, rollbars located in the seats are released and extend 10 inches above the headrests.

neering challenge. First, the space between the door and occupant is considerably less than the space between the occupant and the steering wheel or dashboard. That means there is far less time for the sensors to detect a side impact, for the system logic to determine if air-bag deployment is needed, and to deploy the bag. Toward that end, TRW, Inc. has developed an ultra-fast electronic crash sensor that can detect a side impact and deliver a deployment signal in 4 milliseconds.

Another problem that must be overcome is that the system must have a very low false-alarm rate so the air bag does not go off when someone carelessly opens a door into yours, a child on a bicycle rides into the door, or you accidentally open the door into a pole or another obstruction. However, it must detect and discern when there is a real side-impact collision.

Work is proceeding on that problem as well. Morton International, a leading supplier of air-bag components, has developed side air-bag modules that deploy within 10-12 milliseconds after receiving the trigger command from the electronic control unit. Prototype testing shows promising results using accelerometers located at the pillars or in the doors. Those sensors, located behind the outer panel of the vehicle, detect accelerations due to side impacts. The electronics are able to discern the difference between simple blows and life-threatening side-impact collisions through the distinct increase in accelerations caused by the latter. The side-mounted accelerometers are connected with the central sensing unit that also triggers the driver's and passenger's frontal-collision air bags. The final trigger decision and command is made in this single electronic control unit

Safety-pioneer Volvo plans to introduce a seat-mounted air bag system on its 1995 850 sedans and station wagons. The Volvo SIPS (Side Impact Protection System) BAG is located in the outer edge of the back of both the driver and front-passenger seats. There it acts as a cushion, helping prevent contact between the chest and the door. As a secondary benefit, the SIPS BAG helps reduce head injury by holding the occupants away from the door, pillar, and side window. The SIPS BAG is mechanically triggered, requiring no electrical hook-up and the entire system is contained in the seat. The SIPS BAG uses a sensor built into the two front-seat frames and two gas generators in the seat back to inflate each air bag. If the side-impact force hitting the door exceeds a pre-set threshold, the inner door panel will strike the sensor with sufficient force to trigger the system to fire the pyrotechnic charge activating the twin gas generators and expanding the bag. The bag deploys through a seam in the upholstery. The bag inflates within 4-6 milliseconds and the total time to activate from first contact to full inflation is less than 12 milliseconds. The deployed bag is about a foot long and 5 inches in diameter.

Safer Convertibles. Convertibles are very popular in Germany, but because of the Germans' concern for safety, most offer more protection than convertibles built in other parts of the world. German automakers like Opel, Porsche, and Volkswagen provide rollover protection with fixed rollbars. BMW and Mercedes-Benz use sophisticated automatically-activated systems that offer closed-car rollover protection without sacrificing any openness.

Mercedes-Benz uses an "Automatic Roll Bar" in its two-seat 300SL/500SL/600SL roadsters and the four-passenger 300CE Cabriolet. Sensors on the rear axle sense when the car is in a potential rollover situation as determined by the car exceeding a specified roll angle and one wheel lifting to the point where it is about to lose contact with the road. The rollbar will also pop up if accelerometers that measure lateral and longitudinal deceleration show that a threshold has been exceeded, indicating a front-end, rear-end or side impact. The rollbar is spring-loaded, so it can deploy in about a third of a second. Not only does the rollbar pop up, but seat belts lock automatically and the doors, if locked, are unlocked (but still latched) to make it easier for rescuers to gain entry.

The driver can raise and lower the rollbar hydraulically via a console switch in about three to four seconds. With the rollbar in place, air drafts are reduced for more comfort in chilly weather. If a crash situation occurs during these brief seconds, the automatic system will take over and the rollbar will spring into action much faster.

BMW's Rollover Protection System (RPS), offered as an option on its 318i and 325i convertibles, has twin modules behind the rear headrests. Each module is fitted with a mechanically actuated rollbar. If the sensor located in one of the modules senses an impending rollover, the rollbars, which are normally held in their retracted position, are released, deployed up-

(Continued on page 94)

BY MARK EMERY BOLLES

Build an Auto-Ranging Digital Capacitance Meter

An easy-to-build, easy-to-use addition to your workbench that performs as well as commercial units but at a fraction of their cost.

I had never considered a capacitance meter as an essential piece of test equipment for the electronics hobbyist, even though such units could help to take the guesswork out of selecting capacitors, particularly in those instances where matched pairs are required. Still, being able to test capacitors before placing them in a circuit under development or in a circuit that you are trying to repair does have its appeal. But after seeing how much a decent meter can cost, I figured that it was not one of my more pressing needs.

However, since building the *Digital Capacitance Meter* described in this article, I wonder how I ever got along without one. The Digital Capacitance Meter, whose performance rivals that of commercial units costing hundreds of dollars, can read capacitor values from 1 pF to 1000 μF with surprising accuracy (plus or minus 1 pF in the lowest range). It is compact, lightweight, portable (powered from a 9-volt transistor-radio battery), and best of all, it can be put together for under $50.

Circuit Operation. Figure 1 is a schematic diagram of the Digital Capacitance Meter. In that circuit, U1 (a 555 oscillator/timer configured for astable operation and serving as the "System Clock") feeds a 5-Hz square-wave signal to "Test Sequencer" U3's clock input at pin 14. Integrated circuit U2 (a 4017 counter/divider) serves as a "Range Sequencer," automatically kicking the meter circuit into the next higher range when the value of capacitor-under-test is too large to be measured on the present range. That's done by activating the appropriate relay (either K1 or K2).

Because the 4017 is incapable of providing sufficient current to trigger the relays, each relay is driven by a 2N3904 general-purpose NPN transistor (either Q2 or Q3). A trio of 15-turn trimmer potentiometers (R1–R3) are used to provide the proper resistances for the three different ranges. Note that R1 is always in the circuit, and that each relay has a reverse-biased diode connected across its coil to protect the circuit from electromagnetic kick-back.

Integrated circuit U4 (a 556 dual oscillator/timer) serves as the "Capacitance Tester." Half of U4, in conjunction with the resistance switched into the circuit (via the relays) and the unknown value of the capacitor-under-test, generates an output whose duration depends on the values of the connected resistor/capacitor combination. The other half of the chip produces an output whose duration depends on the values of R8 and R11.

Those two outputs are NANDed together via U7-a (¼th of a 74HC00 high-speed CMOS quad 2-input NAND gate) and inverted by U8-e (⅙th of a 74HC04 high-speed CMOS hex inverter), and then fed to the enable input of U6 (a 74C947 4-digit CMOS up-down counter/latch/decoder/driver), which is used to produce the appropriate display on a 4-digit LCD readout (DISP1). Integrated circuit U5 (a PXO-1000 programmable pulse generator that is used as the "Count Clock") feeds the clock input of U6.

Incidentally, the PXO-1000 offers several advantages over traditional clock-oscillator circuits. That 16-pin DIP contains a 1-MHz laser-trimmed crystal and internal logic and dividers that allow you to get 57 different frequencies depending on the logic levels at its program pins. Additionally, the chip has good temperature stability, doesn't suffer from the start-up problems that standard crystal oscillators

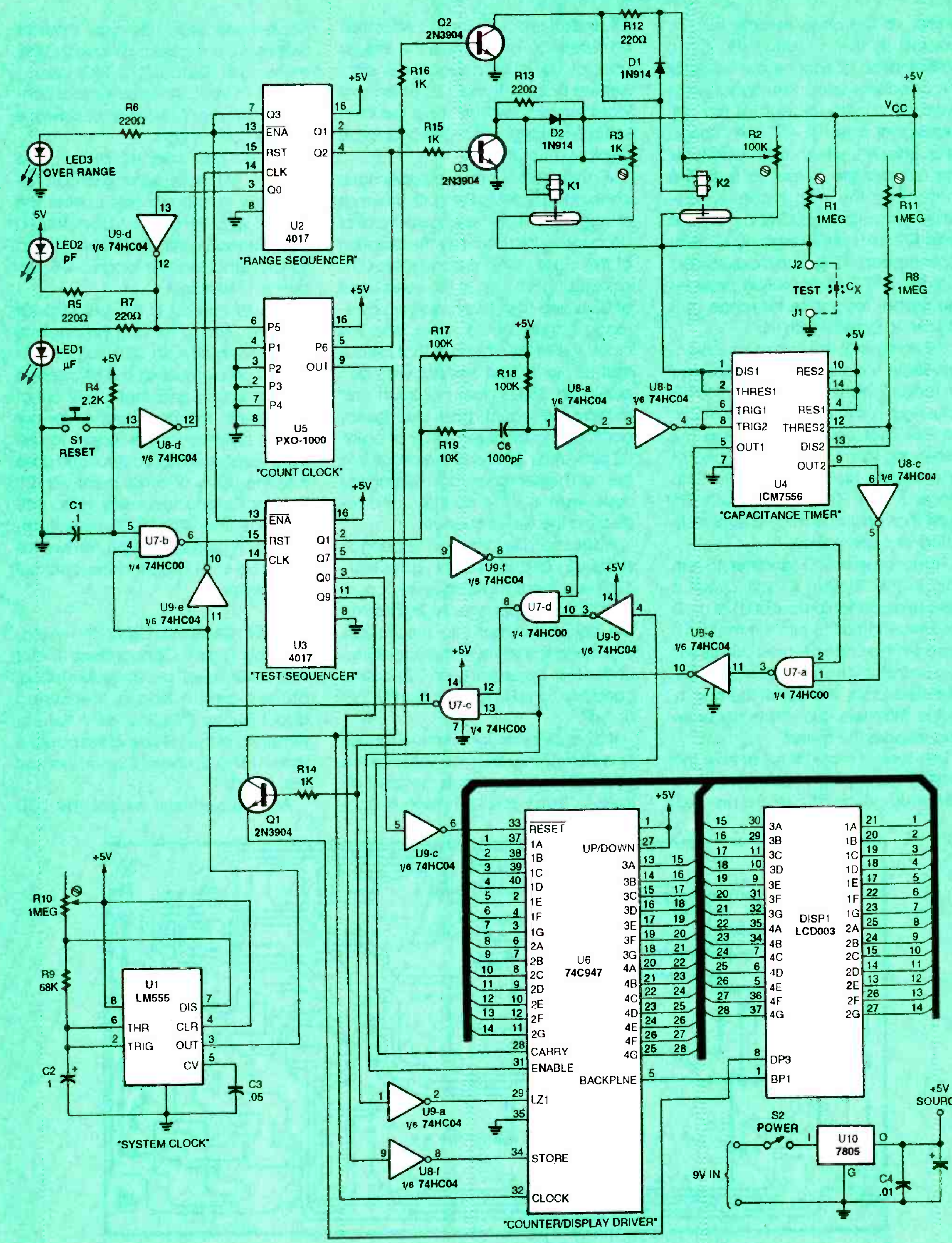


Fig. 1. Here's the schematic diagram for the Auto-Ranging Digital Capacitance Meter. It can be built for under $50 but can outperform instruments costing many times more.

sometimes do, and draws only about 700-µA of current. Using that chip lets us get the frequencies we need for our meter with a minimum of fuss.

When the meter is in the lowest range (range 1), neither relay is energized, so the only resistance connected in the circuit is R1. If the combination of R1 and the value of the capacitor-under-test cause U6 to produce a carry output (at pin 25), that signal is fed to U2 (the "Range Sequencer"), which then activates the appropriate output to push the meter into the next higher range. When the output of U2 at pin 2 goes high, Q2 turns on, energizing K2. With K2 energized, R2 (which is adjusted so that the R1/R2 combination provides the proper resistance for range 2) is placed in parallel with R1.

If the value of the capacitance-under-test is too large to be measured on range 2, another pulse is sent to U2, causing pin 4 to go high and pin 2 to go low. That causes K2 to drop out (removing R2 from the circuit) and K1 to energize, placing the meter into range 3 and R3 in parallel with R1. Note that only one relay is ever activated at a given time.

Potentiometer R10 (another 15-turn unit) in the "System Clock" circuit is used to adjust the output of U1 at pin 3 for 5 Hz. Another 15-turn trimmer (R11) is used in the capacitor-less 555 circuit to subtract circuit capacitance. Needless to say, the better the quality of the trimmers, the more accurate and reliable the meter.

Let's look in more detail at how the range-sequencing circuitry works. At power-up or when S1 (RESET) is pressed, C1 and R4 reset U2 and U3. After that, U3 resets U6 and pulses the trigger lines of U4. If no capacitor is connected across J1 and J2, U6's enable input remains low, inhibiting the chip, so no counting takes place and zero is displayed on DISP1.

If, on the other hand, a capacitor is connected across J1 and J2, U4 sends a trigger pulse to the enable input of U6, causing it to count for the duration of the trigger. One second later, U3's Q7 output goes high. If the ENABLE input of U3 is also high (indicating an over-range condition), U3 resets, and the clock line of U2 is pulsed. That means that U3's Q9 output has not yet been activated. So U6 does not latch and display the count, and the display continues to read zero. At that point, U2 activates K2, kicking the circuit into the next higher range, and U3 starts all over, resetting the counter, and repeating the test sequence.

A second after the new sequence starts, U3's Q7 output again goes high. If its ENABLE input is low, no reset occurs, and U3's Q9 output goes high, latching the counter output into the display, indicating the value of the capacitor-under-test. Depending on U2's output condition, an LED lights to signify "pF" or "µF."

If U2 cycles through all three ranges and determines that the value of the capacitor-under-test is beyond all ranges, its Q3 output (which is connected directly to U3's ENABLE input as well as its own), goes high, causing the meter to freeze and LED3 (OVER RANGE) to light. The circuit remains in that condition until manually reset or power is toggled off and on.

As you can see, U2 performs a number of functions in the circuit. Additionally, its outputs also control the output of U5. For range 1, U5 outputs a 1-MHz signal; for range 2, U5 outputs a 10-kHz signal; and for range 3, U5 outputs a 1-kHz signal.

Also of interest is the unorthodox scheme used to turn on the decimal point. Normally, an LCD segment is turned on by feeding the segment a square-wave signal that is 180° out of phase with the back plane. For our circuit, however, it was easier to use the pulse generator's output and gate it to the LCD's decimal point via Q1. The back-plane frequency is about 60 Hz; since the PXO-1000's output frequency in range 2 is 10 kHz, the two will never be in phase, and the decimal point lights.

Circuit Construction. The Auto-Ranging Digital Capacitance Meter was assembled on a double-sided, printed-circuit board measuring about 5½ by 2¹³⁄₁₆ inches. A full-size template of the foil side of the board is shown in Fig. 2, and of the componant side in Fig. 3.

All components, except the LCD

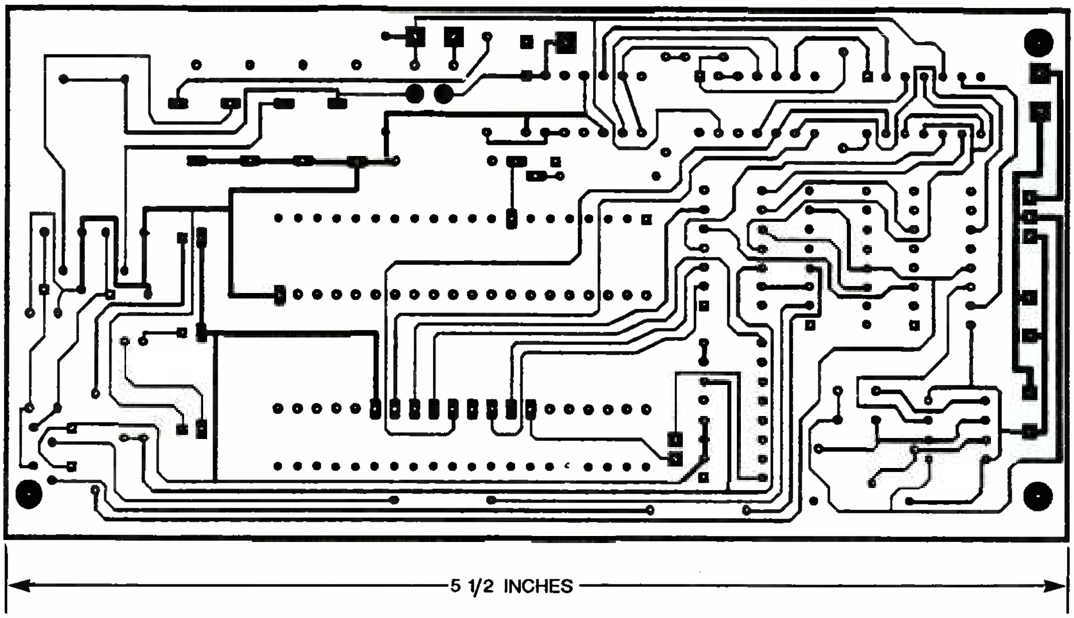


Fig. 2. The Auto-Ranging Digital Capacitance Meter was assembled on a double-sided, printed-circuit board measuring about 5½ by 2¹³⁄₁₆ inches. A full-size template of the foil side of the board is shown here.

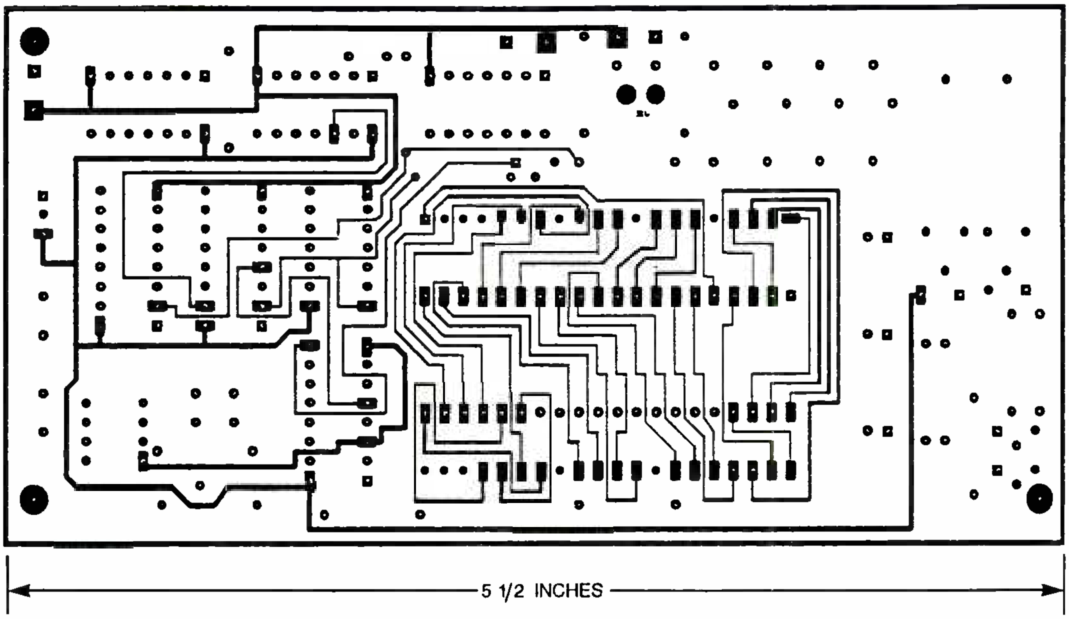


Fig. 3. Here is a full-size template of the component side of the board.

readout and LED indicator, were mounted to the component side of the board; the others were mounted on the foil side. The board was then mounted in a cabinet with the LCD facing front. That prevents having to run a bunch of wires to a second board for the LCD, but it also makes construction a little trickier.

Using the artwork provided, etch and drill the board as you would any other. After etching, use a continuity tester and check all of the traces for shorts and opens. When you are sure that you have a good board, begin installing the IC's where indicated in Fig. 4. It is recommended that sockets be used for all DIP components.

Since most of the power and ground connections for the IC's are located on the component side of the board, it will be necessary to first solder the power- and ground-pin connections of each IC socket on that side of the board. Next, solder the rest of the pins that are on the component side of the board; all of those have an extra-large pad to make identification and soldering easier. As you solder, use a continuity tester to make sure that you have a good connection from the trace to the pin, and also make sure that you haven't created any solder bridges between pins or traces. When all of the pads that need to be soldered on the component side of the board are done, turn the board over and solder the pads on the bottom (foil) side. Note that some IC pins (as well as the leads for some discrete components) are soldered on both sides of the board.

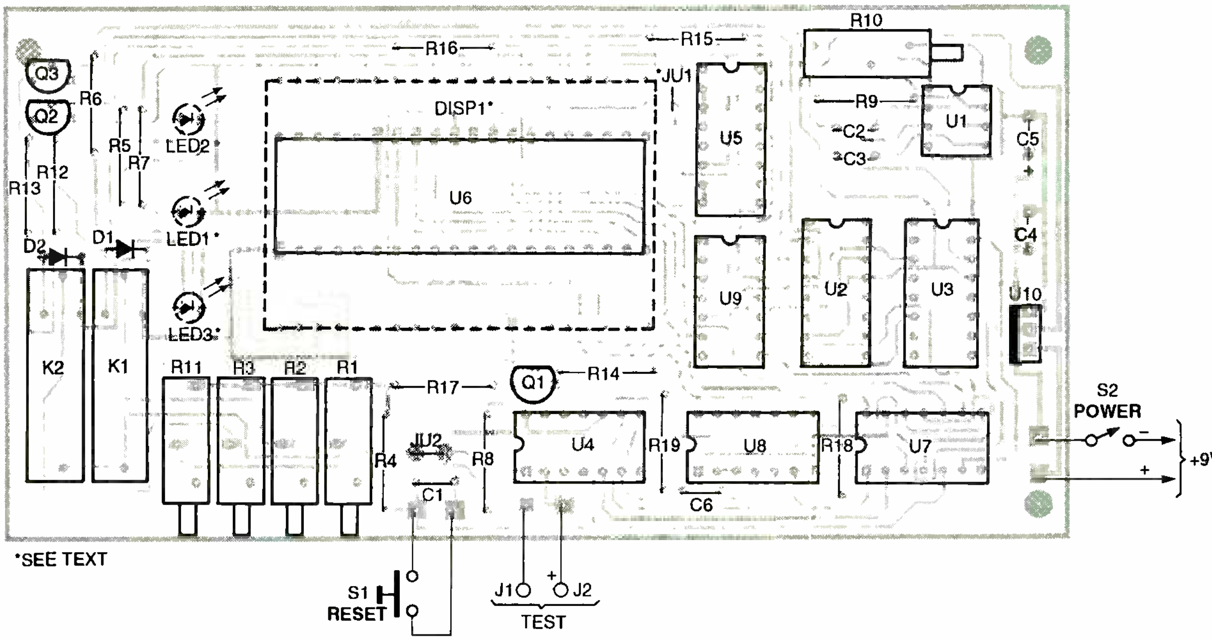


Fig. 4. All components, except the LCD readout and LED's, mount on the component side of the board.

PARTS LIST FOR THE CAPACITANCE METER

SEMICONDUCTORS

U1—ICM7555IPA or LM555 oscillator/timer, integrated circuit
U2, U3—CD4017 decade counter/divider, integrated circuit
U4—ICM7556IPD dual CMOS oscillator/timer, integrated circuit
U5—PXO-1000 or SE3102 programmable standard pulse generator, integrated circuit (see text)
U6—74C947, 74C946, or ICM7224 4-digit CMOS up-down counter/latch/decoder/driver, integrated circuit (see text)
U7—74HC00 high-speed CMOS quad 2-input NAND gate, integrated circuit
U8, U9—74HC04 high-speed CMOS hex inverter, integrated circuit
U10—7805T 5-volt 1-amp voltage regulator, integrated circuit
Q1-Q3—2N3904 general-purpose NPN silicon transistor
D1, D2—1N914 silicon diode
DISP1—LCD003 4-digit liquid crystal display
LED1, LED2—Green 0.125-inch, 50-mA, diffused light-emitting diode
LED3—Red 0.125-inch, 50-mA, diffused light-emitting diode

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1, R10, R11—1-megohm 15-turn trimmer potentiometer (Bourns 3006P or similar)
R2—100,000-ohm 15-turn trimmer potentiometer
R3—1000-ohm, 15-turn trimmer potentiometer
R4—2200-ohm
R5-R7, R12, R13—220-ohm
R8—1-megohm
R9—68,000-ohm
R14-R16—1000-ohm
R17, R18—100,000-ohm
R19—10,000-ohm

CAPACITORS

C1—0.1-µF, 35-WVDC, tantalum
C2, C5—1-µF, 35-WVDC, tantalum
C3—0.05-µF, Mylar
C4—0.01-µF, Mylar
C6—1000-pF mica

ADDITIONAL PARTS AND MATERIALS

K1, K2—SPST 5-volt reed relay (Radio Shack 275-232 or similar)
S1—Normally-open SPST momentary pushbutton switch
S2—Miniature SPST toggle switch
J1, J2—See text
Printed-circuit materials, enclosure, IC sockets, 9-volt transistor-radio battery and holder, wire, solder, etc.

Next, mount the LCD (indicated in Fig. 4 with dashed lines) on the foil side of the board, and solder it in place. All of its pads are soldered on the board's component side. Once the LCD is soldered in place, you will not have access to the pins of U6 (the 74C947), so make extra sure that all of its pins are correctly soldered before the LCD is mounted.

Next, mount all discrete components and solder them in place. A few of them need to be soldered on both sides of the board. Be careful not to miss any. When installing any polarized unit, be sure that it is properly oriented before being anchored in place.

The board is designed to accommodate either a 74C947 (as in the author's unit) or, if you can't find one of those, a 74C946 or ICM7224 at U6. Assuming that you have been successful at finding 74C947, install a jumper wire at JU1. If you use the 74C946 or the ICM7224 omit JU1; including that jumper when either of the latter two chips are used could result in "fried silicon." Do not install jumper JU2 yet. Instead, mount LED1–LED3 on the same side of the board as DISP1. They should be mounted so that they hover about ¼ to ⅜ inch above the board.

Now take time to closely inspect everything again. Double check for shorts, opens, solder bridges, missed solder joints, etc. When you are satisfied that all is well, prepare the cabinet you have selected and mount the off-board components. When that is done, connect the off-board components to the appropriate points on the board. Those include switches S1 and S2, and test jacks J1 and J2. Also connect a 9-volt battery clip (but do not install the battery as of yet) where indicated. Then mount the board to the front panel of the cabinet with the display and the LED's facing outward.

Incidentally, the author used color-coded, spring-loaded, speaker terminals for J1 (black) and J2 (red). You can use your imagination when it comes to the capacitor test socket. For instance, you might consider using a 10-terminal SIP socket, soldering 5 terminals to each side. That allows you to test various sizes of capacitors hands-free. If you get a better idea, great, but make sure that whatever you use does not have a whole lot of its own capacitance, and be sure that at least one side is marked to make testing polarized electrolytics simple.

Calibration. Without a battery connected to the circuit, connect an ohmmeter (a DVM is best) between U10's (the regulator) output and U4, pin 1. Adjust R1 until you get a reading as close to 909.09k as possible. Place a jumper across the contacts of relay K2. Without changing the setting of R1, adjust R2 until you get a reading as close to 90.909k as possible. Remove the jumper from K2, and install it across the contacts of relay K1. Then adjust R3 until your meter reads 909 ohms. Remove the jumper and your DVM and install jumper JU2.

Connect a fresh 9-volt battery to the clip, and turn the power on. The PF indicator (LED2) should light and the display should glow (probably displaying zero or a low value). If nothing lights up, check all power and ground connections to the ICs to make sure everything is working. If that isn't it, you have a short or open somewhere, and you'll have to trace it down.

Once everything appears to be okay, check the output of U1 at pin 3, using an oscilloscope or a frequency counter, for a 5-Hz square-wave output. If neither instrument is available, place an LED connected in series with a 330-ohm resistor between V_{CC} and pin 12 (the carry out) of U3. That pin should output a square wave at 1/10th the clock frequency. Adjust R10 until the LED blinks on for one second and off for one second, over and over. You can use your watch to time the alternations. Note that the meter will generally work all right if U1's output is slower than 5 Hz, but if it's faster, it will tend to advance to the next range prematurely.

Lastly, without a capacitor connected across J1 and J2, press S1 (RESET), and adjust R11 until the display reads more than zero, and then back it off until it just reads a stable zero. You must be in range 1 for this to work correctly.

With that complete, try some capacitors of known value and accuracy for each range. You may need to do a little tweaking of the trimmer potentiometers, but experience has shown that unless the values are way off, you should trust the meter first, and

(Continued on page 93)

HOW TO START YOUR OWN PROFITABLE DESKTOP PUBLISHING BUSINESS.

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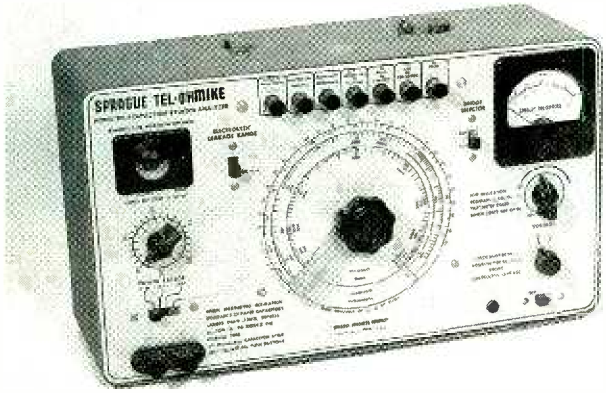
By Marc Ellis

Resurrecting a Capacitor Analyzer

I've gotten along without a capacitor analyzer in my workshop for quite a few years. But I've certainly wished for one on many occasions. Not only will analyzers measure the value of unknown capacitors (that's very handy when selecting vintage parts for use in making repairs or building replicas of old equipment), most can also check for leakage under actual working-voltage conditions. That is much more reliable and positive than an ohmmeter check.

Such leakage testing is a valuable trouble-shooting tool. It's also invaluable for checking replacement capacitors (which, even if unused, may very well be old stock) prior to installing them in a radio. Capacitor analyzers usually measure resistance, too, and often also assess something called the *power factor* (to be discussed later) of electrolytic capacitors.



The Sprague TO-4 as received. Its physical condition was good, except for the pushed-in glass window on the meter at the upper right.

I took steps to correct the lack of an analyzer in my workshop when I picked up a *Sprague Model TO-4 Tel-Ohmike* at the AWA Rochester conference last September. Let's go through this piece of equipment together and, I hope, put it in good working order. Most capacitor analyzers have similar features (though circuitry details will certainly vary), and you should find this experience helpful in selecting and restoring a unit of your own.

FINDING THE EQUIPMENT

Before we get into *my* unit, here are some suggestions on acquiring your own. Capacitor analyzers are not hard to locate. Look on and under the tables at the next hamfest or antique-radio meet you attend, and you're almost certain to spot at least one. Most have a prominent knob attached to a large plastic cursor that sweeps over several concentric resistance and capacitance scales. Another standard feature is a "tuning-eye" tube, the use of which will be described a bit later.

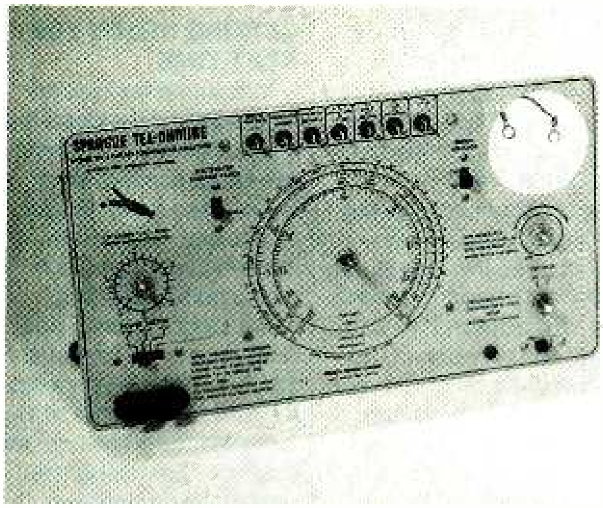
Most hobby-kit makers of a few decades (or more) ago—Heathkit, Knight, and Eico, for example—had capacitor analyzers in their lines. Today, those units can often be picked up for under ten dollars (which is less, in fact, than you would have to pay a tube dealer for the 6E5 tuning eye that many of them contain). But I'd suggest that you hold out for one of the units manufactured for the radio/TV-service trade.

The professional units typically sell for just a bit more (in the $20–$30 range) than the hobbyist-grade kits. Though, as you might expect, design and construction are much more sophisticated, and you get more features for your money. Those units were generally offered by the major capacitor manufacturers. Solar, for one, had quite a few models on the market, as did Aerovox and Sprague.

Of course, you might also consider a modern digital capacitance or capacitance-inductance meter. Some digital volt-ohm meters offer capacitance and/or inductance scales as well. Such equipment has become very affordable in recent years, but it's unlikely that these meters (especially the portable hand-held versions) would be able to check leakage under working-voltage conditions. Since the digital meters generally operate from a couple of "AA" cells or a 9-volt battery, the necessary high voltage simply wouldn't be available.

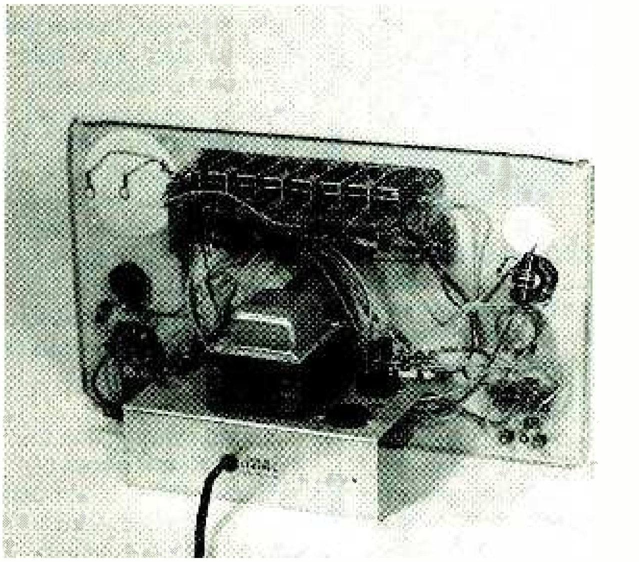
EXPLORING THE TO-4

I've included a shot of the TO-4 as it looked when I found it. As you can see, it came to me in pretty good shape. For the most part, there were no scratches, bumps, or other signs of rough treatment. Apart from the deteriorated and mostly missing leather carrying handle, the only physical problem seemed to be the pushed-in and loose viewing window (not visible in photo) on the leakage meter (upper right-hand corner of panel).



The front panel as stripped for cleaning. The eye tube, meter, control knobs, and buttons have been removed.

At that point, I wasn't concerned with the operation of the meter or the functioning of its various controls. What I wanted to do was open up the unit so that I could continue my physical inspection of the various components. I was able to do so quite easily after removing the few retaining screws located on the front edge and rear of the cabinet. A gentle push on the rear apron of the unit's electronic chassis (which was accessible through the line-cord opening in the cabinet back) released the front panel from its friction fit in the cabinet. I was then able to slide the cabinet away from the front-panel and chassis, exposing the interior to view.



The rear view of the TO-4 with its case removed. The assembly at the top of the panel is the pushbutton-switch unit.

Let me now digress just a bit to stress the importance of securing an instruction manual to go with your newly-acquired piece of test equipment. It will be invaluable in helping you not only identify and correct any problems that exist, but also (it goes without saying) understand and properly use all the features that have been built into the unit.

If you didn't get the instruction book along with your capacitor analyzer, one of the most reliable ways of obtaining one is through Hi-Manuals, Box L-802, Council Bluffs, IA 51501. To do business with Hi-Manuals, you must first order their current catalog at a cost of $2.00 postpaid ($3.00 outside USA). The catalog will provide you with a listing of all manuals in stock, along with price and ordering information. I ordered one for the TO-4 immediately after purchasing it, so the manual was already waiting in my file when I was ready to give the unit some attention.

With the cabinet removed, I immediately began examining the wiring behind the panel and under the chassis for signs of tampering or tragedy. Most of us have experienced that sinking feeling when, on first opening up an exciting flea-market find, we discover tell-tale signs that a failed component has caused a chain reaction of burn-out and destruction or that an unskilled dabbler has preceded us—upsetting factory calibrations, making difficult-to-reverse changes, and generally destroying the integrity of the piece. However, so far as I can tell right now, nothing like that has happened to this instrument!

FIRST MOVES

With the initial inspection completed, I immediately removed the leakage meter so that I could turn my attention to the loose viewing window. It took only a moment to release the three retaining screws so that I could slide the Bakelite housing off the meter movement. I was concerned that the pushed-in glass might have bent the meter pointer or otherwise damaged the movement.

Fortunately, I needn't have worried: The pointer was undistorted and still swung freely on its bearings. Not only that, but the loose glass was a snap to correct; its spring-loaded retaining ring had merely been pushed back a bit—a situation that was easily restored with a little gentle screwdriver pressure. After cleaning both sides of the glass, I quickly reassemblea the meter case and put it aside for reinstallation at the appropriate time.

Next I removed and tested the three tubes: the 1619 beam-power tube used as a rectifier (to be discussed later), the 12J5 that serves as a meter amplifier during insulation-resistance tests, and the 1629 tuning-indicator tube. All of those tubes bore military "VT" numbers, by the way, suggesting that Sprague made some advantageous surplus buys when purchasing parts and materials to produce this instrument sometime in the early 1950's.

The 1619 tested quite weak, giving an indicator reading of less than half that specified for a good tube. The 12J5 was fine, though, as was the 1629—which lit up brightly in the checker and produced a strong shadow. I was a bit dubious about the 1619's low reading; for one thing, I've never seen a tube test quite as low as that one did without being completely burned out. For another, the black paint on that metal tube still looks fresh and shiny—not at all like the dull, oxidized finish I have learned to associate with metal tubes that have seen extensive use. However, my military TV-7 tube checker has always been quite reliable, so I plan to have a new 1619 tube on hand in time for next month.

With the tubes still out of their sockets, I plugged in the line cord and tried to switch the analyzer on so that I could check the secondaries of the power transformer. The slide switch used for "power" moved to the "on" position only with great difficulty and could be switched off again only through the use of brute force. So before proceeding to the transformer testing, I decided to try some contact cleaner/lubricant spray.

The spray nozzle slipped neatly through a hole in the switch housing, and a light touch on the button saturated the space within with the magic preparation. Working the switch back and forth a few times took care of the problem, and the control now slides quite easily. While I was at it, I gave all of the other switch and pushbutton contacts in the instrument a similar treatment.

Turning my attention to the transformer again, I switched on the power and got out the VOM so that I could check out the secondaries. There were several of them, but it was easy to tell which was which because the lugs on the transformer are numbered to match corresponding points on the schematic diagram. All of the secondaries checked out okay, and the main high-voltage winding astonished me by reading almost 800 volts. It was the first time in a long while that I've found it necessary to switch the VOM to a 1-kV range. But when I remembered that the instrument was designed to check capacitors at DC working voltages of up to 600, the 800-volt secondary made more sense.

GETTING READY FOR NEXT TIME

To finish off this month's work session, I removed the knobs, buttons, and tuning-eye bezel from the front panel, then gave the panel, cabinet, and all the removed knobs and buttons a good soap-and-water cleaning. Brillo pads (well-moistened to prevent scratching) were very helpful in removing some of the more serious grime from the cabinet. After drying, the panel and cabinet certainly looked a good deal brighter and trimmer.

The layer of dust covering the chassis and some of the assemblies in back of the front panel was removed next, with cloths and Q-Tips. As a final step, the meter, tuning eye, and all the knobs and buttons were reassembled on the panel in preparation for next month's work session.

Next month, the new 1619 will be on hand, and I'll also have a couple of fresh electrolytic capacitors to replace the pair of 12-µF units used in the filter circuit. I don't know that the originals are bad, but 40-year-old electrolytics certainly have to be a bit suspect. I'd just as soon have new ones in place before putting the analyzer into service again.

As for the other capacitors in the instrument, most of which are molded paper, I'm leaving them in and keeping my fingers crossed. Many of them are used as standards for capacitance measurement or used for calibration purposes. I'll just have to assume that Sprague installed some of its best-quality capacitors in those spots and that they're probably still okay.

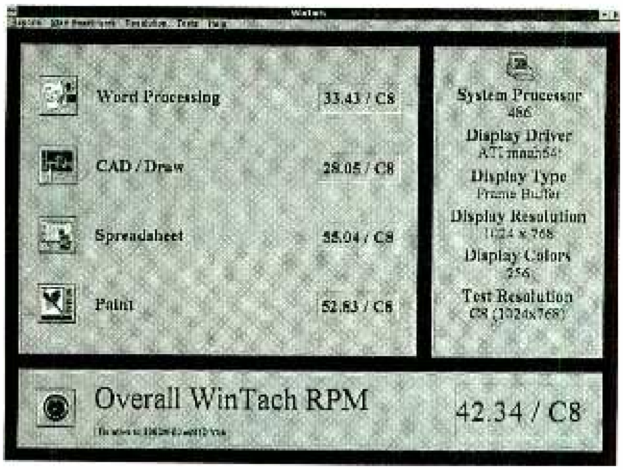
We'll be back on this project next month, at which time we'll begin to check out the various features of the instrument. ■

COMPUTER BITS

By Jeff Holtzman

Va Va Va Video

If you're running Windows with an older non-accelerated video card, you're in luck. Do not walk, but run to your nearest computer outlet and snatch up an ATI Graphics Pro Turbo. It's a 64-bit accelerated video card that gives new meaning to the word speed. I've gone through a series of system upgrades throughout 1994 (more on those next time), but the ATI card gave by far the most noticeable improvement.



ATI's new Graphics Pro Turbo is one of the new breed of 64-bit graphics accelerator cards. As this benchmark test shows, it redefines the meaning of speed under Windows.

In case you're wondering about the concept of 64 bits, no, you don't need some fancy new expansion bus; 64 refers to the card's internal data pathway. ATI sells versions of the card for the standard 16-bit ISA bus, and for the 32-bit VESA and PCI local buses. I tested the VLB version, and it's a screamer. I would expect comparable results on the PCI version, but somewhat less on the ISA version.

The card comes with either two or four megabytes of RAM; two-MEG cards are upgradeable to four. The amount of RAM determines the maximum resolution and color depth that the card can handle. The 4-MB card supports 24-bit color at the following resolutions: 640 × 480, 800 × 600, 1024 × 768, 1152 × 864, and 1280 × 1024. You'll need a fast monitor (110 MHz) to handle 24-bit color at the highest resolution.

The Graphics Pro Turbo can run in a variety of color levels: 8, 15, 16, and 24 bits-per-pixel (bpp). The 24-bit mode provides what graphics professionals call "true color." The board can also run in a 32-bit per pixel mode, which gives a performance boost, because the CPU's natural word size is 32 bits anyway. The trade-off is memory usage, but with a 4-MB card running at 1024 × 768 (my test configuration), memory usage was not a problem.

SPEED TESTS

I ran the card through three sets of benchmark tests (WinTach 1.0, published by Texas Instruments; Windsock 3.02, by Technical Pixies of Australia; and WinBench 3.11, published by PC Magazine). Naturally, I got contradictory results from the tests. But, in general, at my test resolution, the 8-bit color mode ran almost twice as fast as the 32-bpp mode. In addition, the 32-bpp mode ran about 50% faster than the 24-bpp mode.

I ran the same set of tests on my old video card, a coprocessor-based Hercules Graphics Station, which in its heyday was no slouch. Depending on the test, the ATI card showed improvements of anywhere from 3 to 30 times.

Given the moderately inconclusive test results, let me give you my subjective opinion: Strap yourself in before running this card! It's probably not ten times as fast as my old Hercules, but windows snap up on screen in a wholly new and totally pleasurable way. Scrolling through a word-processor document happens instantaneously; there is no evidence of a wave of pixel writes moving down the screen. It's just like DOS text mode; press the page-down key and you're there. It's totally addictive.

SOFTWARE GOODIES

The card comes with drivers for several operating systems, including Windows 3.x, OS/2 2.1, and Windows NT; and drivers for DOS versions of AutoCAD, Word, and WordPerfect. I tested it under Windows for Workgroups 3.11.

Several Windows-based utility programs round out the package. One allows you to vary screen resolution, color depth, and other factors. Another allows hot-key video mode switching. The mode switcher, however, was buggy. First, switching modes invariably fouled up the color palette, yielding a sickly green background color. Second, the mode switcher did not reliably detect when the hot keys were pressed. Third, the hot-key and mode-edit screen had bugs.

One interesting feature of the card is its ability to define a "desktop" that is larger than your physical screen. When the mouse pointer moves to the edge of the screen, the display pans to show the off-screen portion of the image. This is nice when dealing with large bitmaps—for example, an image from a Photo CD.

Another useful feature is a color correction utility. Professional graphics artists need precise matching between screen colors and printed output, and the supplied utility can help. I found it useful because my monitor, an old 19-inch NEC MultiSync XL, has a rather dim display. The contrast and brightness knobs help somewhat, but the ATI color correction utility really does the trick.

I had some trepidation before installing the card, as past ATI cards have had a reputation for belonging to the "driver-of-the-week" club—*i.e.*, buggy, with continual revisions fixing some bugs but introducing others. In this case, I'm happy to report that ATI seems to have cleaned up its act. In several weeks of use, I've had no problems (other than mode switching, which I don't often use anyway) running any Windows or DOS applications.

So if you're in the market for a system upgrade or contemplating the purchase of a new system, check out ATI's Graphics Pro Turbo. Just strap yourself in tightly before taking off. ■

Vendor Information

ATI Graphics Pro Turbo
ATI TECHNOLOGIES, INC.
33 Commerce Valley Drive East
Thornhill, Ontario, Canada
L3T 7N6
(905) 882-2600

CIRCUIT CIRCUS

By Charles D. Rakes

Making Waves

Building and playing with waveform-generator circuits can be a lot of fun. If you look at the circuitry in your TV, VCR, camcorder, or computer monitor you'll find one or more waveform generators working there. If you take a look at some of the more popular pieces of test equipment, you'll find even more waveform-generator circuits. So, considering the many ways that waveform generators are used, it is highly possible that one of the circuits discussed here just might fit into a future project. Besides, playing with waveform-generator circuits is fun, so take the plunge and check one out.

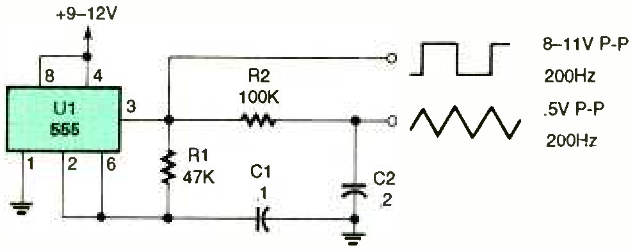


Fig. 1. This triangle waveform generator was designed to give good results with as few parts as possible.

TRIANGLE WAVEFORM GENERATOR

The first circuit, in Fig. 1, is a triangle waveform-generator circuit that uses as few parts as possible. A 555 timer IC, two resistors, and two capacitors make the triangle waveform. The IC is connected in a 50% duty cycle astable square-wave oscillator circuit. The square-wave output is fed from pin 3 of the IC to an RC shaping circuit.

When the 555's square-wave output goes high, C2 begins to charge through R2 and the voltage across C2 increases as long as the output remain high. When the IC's output goes low again, C2 begins to discharge through R2 reducing the voltage across C2 as long as the output remains low. The resulting waveform across C2 takes the shape of a triangle. The best waveform linearity is obtained when R2 and C2 are made as large as possible. With the component values shown, the peak-to-peak output is 0.5 volts at a frequency of about 200 Hz.

The oscillator's frequency may be varied by changing the values of R1 and C1. Increasing the value of either component will lower the frequency, and decreasing the value will increase the frequency. To maintain the peak-to-peak output level, the values of R2 and C2 will need to be adjusted as the frequency changes. As the oscillator's frequency goes up, the value of C2 will need to decrease in value. The output voltage may then be fine-tuned using R2.

PARTS LIST FOR THE TRIANGLE WAVEFORM GENERATOR (Fig. 1)

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1—47,000-ohm
R2—100,000-ohm

CAPACITORS
C1—0.1-µF, Mylar
C2—0.2-µF, Mylar

ADDITIONAL PARTS AND MATERIALS
U1—555 oscillator/timer, integrated circuit
IC socket, wire, solder, etc.

SAWTOOTH GENERATOR

A sawtooth waveform generator circuit using the same 555 IC is shown in Fig. 2. The IC is connected in an astable oscillator circuit with the majority of the output contained in the positive portion of the cycle. The negative output is a very brief pulse.

Capacitor C2 charges through R3 in a positive direction during the time that the IC's output (at pin 3) is high. When the output goes negative, C2 is rapidly discharged through D1 and the IC's output.

The peak-to-peak sawtooth output is about 1

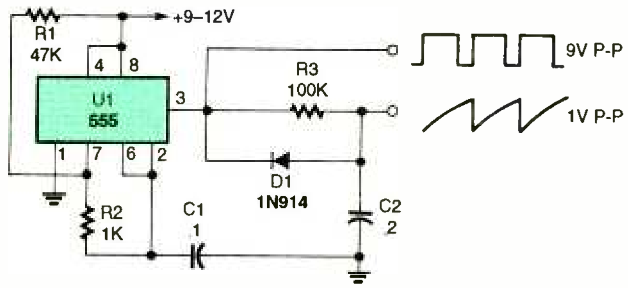


Fig. 2. This sawtooth generator is built around a 555 configured as an astable multivibrator.

PARTS LIST FOR THE SAWTOOTH GENERATOR (Fig. 2)

SEMICONDUCTORS
U1—555 oscillator/timer, integrated circuit
D1—1N914 silicon diode

RESISTORS
(All fixed value resistors are ¼-watt, 5% units.)
R1—47,000-ohm
R2—1,000-ohm
R3—100,000-ohm

CAPACITORS
C1—0.1-µF, Mylar
C2—0.2-µF, Mylar

ADDITIONAL PARTS AND MATERIALS
IC socket, wire, solder, etc.

volt. The linearity of this circuit, like the last, is best when R3 is as large as possible. The oscillator's frequency is about 200 Hz and may be increased by lowering either the value of R1 or C1; to decrease the frequency, increase the values of those components.

IMPROVED SAWTOOTH GENERATOR

Neither of the two 555-based waveform generator circuits presented thus far offer a high-level output or perfect linearity, but, for their simplicity, each can perform well in many circuit applications.

The output linearity may be greatly improved by going to a constant-current capacitor charging circuit. That will also produce a much greater peak-to-peak output level. Take a look at the sawtooth generator circuit in Fig. 3 and you will see that Q1 is connected in a simple constant-current generator circuit. The value of Q1's emitter resistor sets the constant-current level flowing from the transistor's collector to the charging capacitor, C1.

One op-amp of a LM324 quad op-amp IC, U1-a, is connected in a voltage-follower circuit. The input impedance of the voltage follower is very high and offers little or no load on the charging circuit. The follower's output is connected to the input of U1-b, which is configured as a voltage comparator. The comparator's other input is tied to a voltage divider setting the input level to about 8 volts.

The output of U1-b at pin

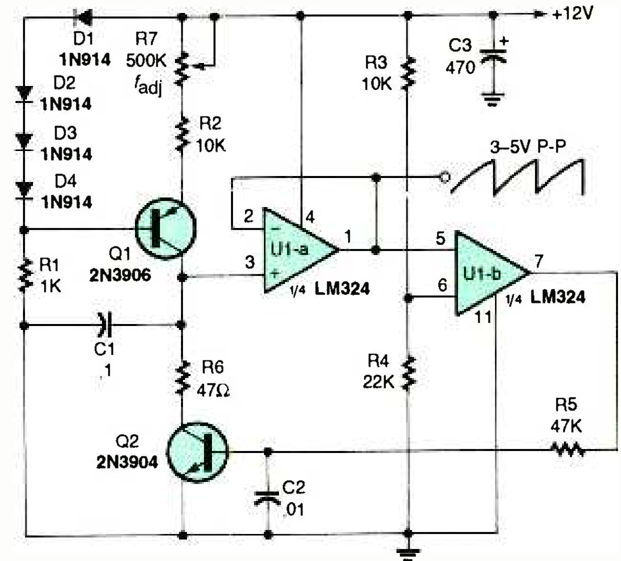


Fig. 3. Transistor Q3 is connected in a simple constant-current generator circuit in this improved sawtooth generator. This circuit offers improved linearity and a higher output.

PARTS LIST FOR THE IMPROVED SAWTOOTH GENERATOR (Fig. 3)

SEMICONDUCTORS
U1—LM324 quad-op-amp, integrated circuit
Q1—2N3906 PNP transistor
Q2—2N3904 NPN transistor
D1–D4—1N914 silicon diode

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1—1000-ohms
R2, R3—10,000-ohm
R4—22,000-ohm
R5—47,000-ohm
R6—47-ohm
R7—500,000-ohm, potentiometer

CAPACITORS
C1—0.1-µF, Mylar
C2—0.01-µF, Mylar
C3—470-µF, 16 WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
IC socket, wire, solder, hardware, etc.

PARTS LIST FOR ANOTHER SAWTOOTH GENERATOR (Fig. 4)

SEMICONDUCTORS
U1—LM324 quad-op-amp, integrated circuit
U2—555 oscillator/timer, integrated circuit
D1-D4—1N914 silicon diode
Q1—2N3906 PNP transistor
Q2—2N3904 NPN transistor

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1—1,000-ohm
R2-R5—10,000-ohm
R6, R7—22,000-ohm
R8—47-ohm
R9—500,000-ohm, potentiometer

CAPACITORS
C1—0.2-µF, Mylar
C2—0.1-µF, Mylar
C3—0.02-µF, Mylar
C4—470-µF, 16 WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
IC sockets, wire, solder, hardware, etc.

PARTS LIST FOR THE STEPPED TRIANGLE GENERATOR (Fig. 5)

SEMICONDUCTORS
U1—4011 quad two-input NAND gate, integrated circuit
U2—4017 decade counter/divider, integrated circuit
D1-D10—1N914 silicon diode

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1—1-megohm
R2—100,000-ohm
R3, R4—1,000-ohm
R5—2,200-ohm
R6—3,300-ohm
R7—4,700-ohm
R8—6,800-ohm

CAPACITORS
C1—0.01-µF, Mylar
C2—680-pf, ceramic-disc
C3—470-µF, 16 WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
IC sockets, perfboard, hardware, solder, wire, etc.

7 switches high when the voltage at its positive input, pin 5, goes above 8 volts. That turns on Q2, discharging C1. The sawtooth cycle is repeated over and over as long as power is applied to the circuit.

The sawtooth's frequency is determined by the value of C1 and the charging current supplied to that capacitor. As the charging current increases, the frequency also increases, and *vice versa*. To increase the generator's frequency range, decrease the value of C1, and to lower the frequency, increase the value of C1. The output is about 3-5 volts.

ANOTHER SAWTOOTH GENERATOR

Our next sawtooth-generator circuit, shown in Fig. 4, is reset at the end of each cycle. The result is a constant peak-to-peak output throughout the circuit's frequency range.

The constant-current generator circuit, the voltage-follower circuit, and (Continued on page 91)

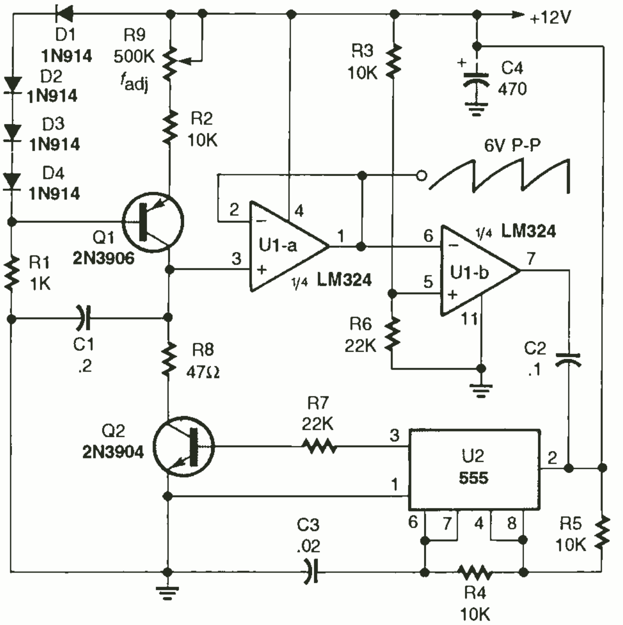


Fig. 4. Offering a different approach to improved linearity, this sawtooth generator is reset at the end of each cycle, resulting in a constant peak-to-peak output throughout its frequency range.

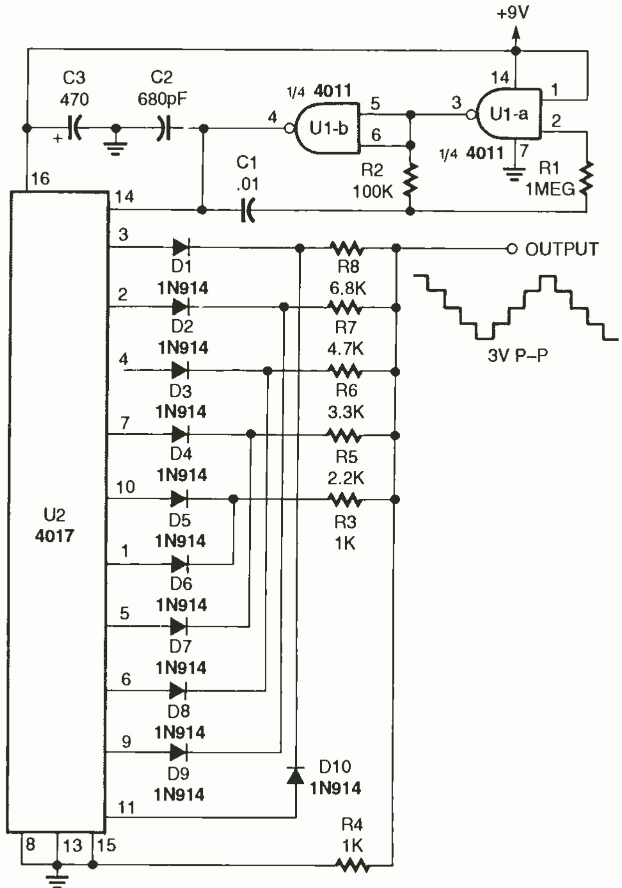


Fig. 5. This stepped triangle waveform generator is an experimenter's delight as different output arrangements can produce a variety of waveforms.

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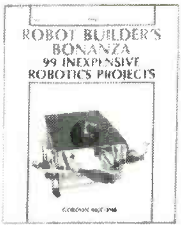

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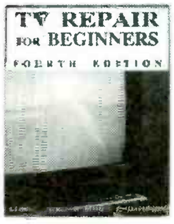

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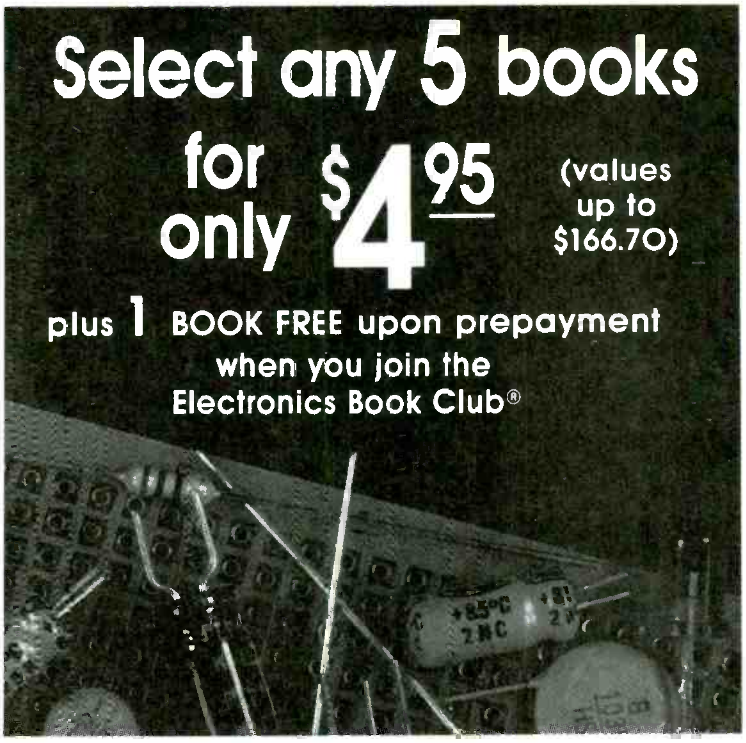

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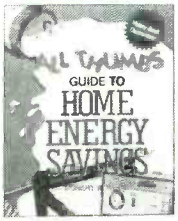

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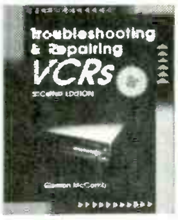

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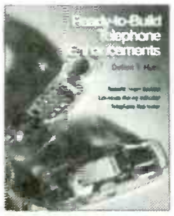

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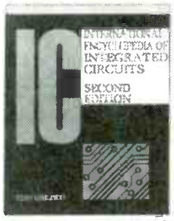

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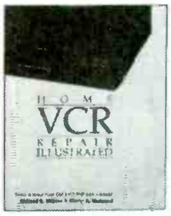

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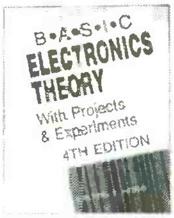

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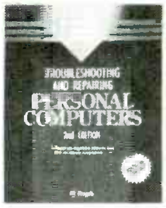

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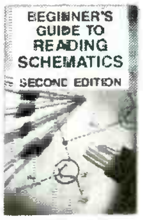

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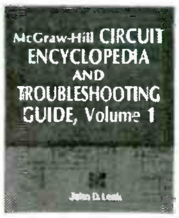

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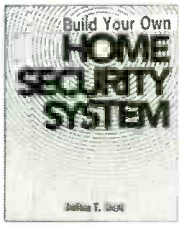

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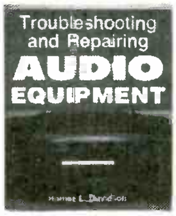

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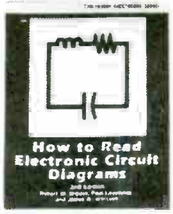

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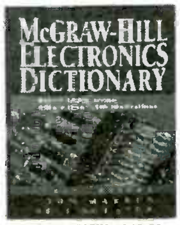

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DX LISTENING

By Don Jensen

Radio Jamming in the 1990's

Every couple of years, it seems, we hear news reports that jamming has ended, only to later learn that the obituary was premature. When the Cold War era ended and the Soviet Union collapsed, we thought there no longer was a reason for jamming another country's shortwave broadcasts. We were wrong, of course. There still are countries in the world that are afraid to let their citizens freely listen to broadcasts from outside their borders.

Bart Gribnau, interim managing director of Radio Netherlands, says that changes are coming to that popular SW broadcaster.

The end of the Soviet communist era did make a big difference, though. No longer do we experience anything like the level of jamming that plagued past decades, when every evening, dozens of frequencies and huge chunks of the international SW bands were blocked by raucous noise transmissions.

But jamming does continue on shortwave and one of the culprits has been China. A few months ago, however, a senior U.S. official told reporters that China had agreed to a visit by a team of American technicians to talk about halting its jamming of Voice of America radio broadcasts. That was considered significant, since ending the jamming of foreign radio broadcasts has been one of seven human rights demands set by President Bill Clinton.

When China halts its jamming of foreign SW broadcasts, it will be another step in the right direction. However, we'd be foolish to believe that it will mark the end of jamming. A number of others countries will continue to do so, and probably will for years to come.

A considerable amount of information about the USSR's more than 40-year jamming campaign against Western SW broadcast has been revealed in the past couple of years. Powerful transmitters with antenna arrays on towers in many locations throughout the former USSR made it a tremendously costly operation for the Soviets. It is estimated that operating a jamming system to try to prevent listeners in a specific territory from hearing a broadcast is seven times more costly than broadcasting that program.

Over the years, stations like *Radio Free Europe* and *Radio Liberty*, aimed at listeners in eastern Europe and in the Soviet Union itself, developed techniques to fool the jammers. However, the USSR did have substantial success and their systems were becoming more sophisticated.

According to reports, the USSR used two types of jammers. One was a short-range groundwave sort that blanketed a big area of the Soviet homeland with radio noise. The other involved long-range jamming using highly directional antennas.

As late as the mid-1980's, when the radio Cold War supposedly was relatively quiet, some 95 percent of *Voice of America* broadcasts to audiences in the USSR suffered some jamming. At the same time, 98 to 100 percent of Radio Liberty and RFE broadcasts were jammed to some degree.

In Lithuania, for instance, there were up to five jammer sites, each with 10 to 15 separate 5,000-watt transmitters. Located near major population centers, each site could pump radio noise into a nearby area, up to 40 kilometers in diameter. Besides that, long-range jamming signals were bounced into the same area by skywave from 50- to 500-kilowatt stations, 500 to 3,000 kilometers away.

It was, of course, not foolproof. Many persistent listeners in the USSR found ways to escape the jamming. By careful monitoring of the many frequencies of, say, the Russian language Radio Liberty, it was possible to find holes in this blanket of jamming.

Listeners were helped by tricks developed by the stations they were trying to hear. A recent article in *World Broadcast News* says that Radio Liberty, for instance, used to pause for two or three minutes on the hour, knowing that the Soviet jammers typically checked the bands for offending signals at that time.

Finding a channel unoccupied by Radio Liberty, they might leave it unlocked for an entire hour, during which time, Radio Liberty resumed its broadcasting without interference. The Soviet jammers at times could be even more lax in their efforts, sometimes "wasting" their noise transmissions on random SW frequencies just to use up their monthly electric-power allotment.

In the late 1970's, a new type of jamming was invented. The Soviets called it *rechepodobyn*, or voice-like signal. It consisted, mostly, of tapes of *Radio Moscow's* own programs, played backwards. Its advantage was that the resulting noise conformed to the timbre of the human voice, making it effective in muffling voice broadcasts such as newscasts. A later jamming technique involved retransmitting an electronically distorted version of the incoming signal, making it seem, for example, as though Radio Liberty somehow was blocking its own programming.

When the USSR broke up, many of these jamming transmitters were dismantled. Others were acquired by many of the small, private commercial stations that have sprung up in Russia and the other new republics. In once-again independent Lithuania, for example, *Radio Centras*, sometime heard on shortwave these days by North American DX'ers, uses one of the former jamming transmitters for its programs.

CREDITS: Brian Alexander, PA; Jerry Berg, MA; Julianna Bickus, VA; Rufus Jordan, PA; Marie Lamb, NY; Ernest Lawrence, NY; Ken McHarg, ECUADOR; Don Moore, IA; North American SW Association (45 Wildflower Road, Levittown, PA 19057)

CHANGES COMING

"Programming will always be at the heart of our operation," says Bart Gribnau, interim managing director of *Radio Netherlands*. "But the way we get those programs to listeners is changing much faster than anyone could have predicted."

The Radio Netherlands board of directors has been busy redefining the role of Holland's external broadcasting service for the rest of the decade and beyond. The international broadcaster's publication, *On Target*, reported that Radio Netherlands will be undergoing some changes to "ensure that we can improve the quality of the programs and maintain a competitive edge against other international broadcasters."

Gribnau says Radio Netherlands needs to consider how programs will change as a result of more local stations outside Holland rebroadcasting its satellite-fed signals, and the future introduction of digital audio broadcasting. The result, he suggests, will be that Radio Netherlands will have to choose between serving some targets well, or not at all. "There has been a lot of theory put forward at recent broadcasting conferences. Now we're going to put some of it into practice."

We hope that this doesn't mean that Radio Netherlands intends to focus its future on satellite, rather than supposedly "old fashioned" shortwave. But it might! One positive point, though, is that Radio Netherlands does pay attention to what its listeners are saying. *On Target* cites a recent survey of 2,000 listeners to its English language programs. Yvonne van den Brand of the research department notes that the survey showed that "people are listening considerably longer to our programs than during the last survey, often more than an hour a day" and that the station's documentaries are especially popular with North American listeners.

So, more than ever, SWL's who want to continue to hear Radio Netherlands' programming on shortwave for a long time to come would be wise to drop a line to the station. Tell them that satellite relays to local FM rebroadcasters may be okay, but don't short change shortwave!

DOWN THE DIAL

Let's take a look at what's being heard on the shortwave bands these days:

AUSTRALIA—6,150 kHz. *Radio Australia* is logged here in English at 2050 UTC. It is also in parallel on 11,695 and 11,880 kHz at the same time.

BRAZIL—15,445 kHz. *Radio Nacional Brasilia* is noted in English, with Brazilian pops, at around 1250 UTC.

INDIA—11,445 kHz. *All India Radio* is noted here from shortly after 1800 UTC, with English programming, news and sports, commentary, and a music.

MONACO—7,385 kHz. *Trans World Radio* was heard here earlier than its normal time, at 0650 UTC, with an English language religious broadcast, "Hour of Freedom."

SOLOMON ISLANDS—5,020 kHz. *The Solomon Islands Broadcasting Corp.* at Honiara is a real DX-listening target, especially when it features the exotic island music of the Pacific. Try this one around 1100 UTC. ■

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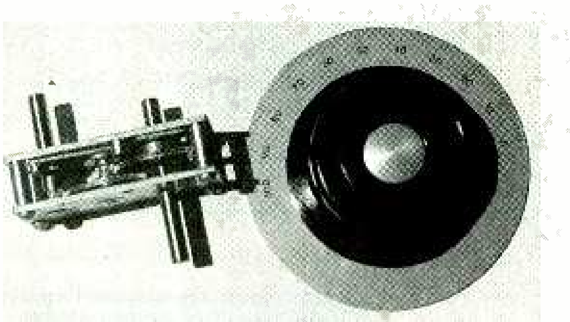
HAM RADIO

By Joseph J. Carr, K4IPV

Mechanical Things For Builders

One of the laments of electronic hobbyists and ham-radio builders is the difficulty in obtaining parts. That is one reason why **Popular Electronics** authors are encouraged to either offer critical parts kits themselves or arrange for someone else to offer the kits for the projects that appear in the magazine. My



These two mechanical assemblies available from Jackson Brothers of England are just not commonly available from U.S. sources.

own policy is to offer kits or individual parts whenever I discuss a hard-to-get part. For example, I received complaints from a few readers when I covered the delightful MAR-1 IC, which serves as a preamplifier for near-DC to 1000 MHz. Readers could obtain the device and its printed-circuit board from me for a nominal cost of $10. That price, by the way, is very near the cost of obtaining and mailing the parts, with only a small profit—less pay-per-hour filling orders than I make writing.

Some vendors make it possible to obtain parts that are of particular interest to amateur-radio builders. For example, Ocean State Electronics—P.O. Box 1458, 6 Industrial Drive, Westerly, RI, 02891; Tel. 401-596-3080 (voice), 800-866-6626 (orders only), and 401-596-3590 (FAX)—offers toroids, B&W Mini-Ductor and Air-Dux air-core coil stock, and variable capacitors from small trimmers to large Cardwell and Johnson transmitting-type variable capacitors. Their catalog should be on the bench of every ham-radio builder, simply because they offer stuff we have a hard time getting anywhere but at a hamfest—and even there only used.

One of the hardest classes of components to come by are the mechanical bits and pieces. Although stand-offs (both insulated and metallic) and ground lugs are easy to find, dials and drives are a bit harder. Indeed, sometimes they are impossible to locate except in Europe.

Over the past several years, I have made it my custom to buy things that are not easily obtained in the U.S. or Canada from sources in Great Britain. There are several mail-order suppliers of ham and electronic-hobbyist parts in the United Kingdom. Two that I have used are *Maplin Electronics* (P.O. Box 3, Rayleigh, Essex, England, SS6 8LR) and *CirKit Distribution Ltd* (Park Lane, Broxbourne, Hertfordshire, England, EN10 7NQ).

This is easier to do than you might think, as two of the most frequently expressed problems in dealing with European firms are basically unfounded. First, the issue of the currency conversion. The currency in the UK is the pound sterling rather than the dollar. Today, as I write this column, 1 pound sterling = $1.51, but the conversion rate varies daily (and in some hotels twice daily). When dealing with these firms one has to be aware of the approximate cost through the conversion rate found in your newspaper.

There are several alternatives to currency conversion. For large purchases, banks that have foreign-exchange departments can offer money orders or cashier's checks drawn on foreign banks in local currency. However, the $10 to $25 fee they charge makes that reasonable only for large purchases. American Express offices can also offer the service. But the best way is to use a credit card. European firms routinely accept Visa, MasterCard, and American Express cards. They charge the account in pounds sterling, the credit-card company performs the conversion at the rate in effect at the time when the charge is posted, and bills you in U.S. dollars. Using that technique, I've experienced no difficulties in five years of dealing with UK firms.

The second problem is in getting the stuff into the country through customs. That is also a non-problem. Although the customs officials can charge import-duty tax on anything sent in, small purchases for personal use or gifts are usually not taxed. I've not been taxed on items costing as much as $200 sent to me from the UK. Even if a tax is charged, it is not the big hassle (other than the cost) that it is made out to be;

the post office letter carrier or the clerk at your local post office will collect it and take care of any paperwork.

JACKSON BROTHERS MECHANICAL PARTS

The main theme of this article is parts, but not just any parts: mechanical parts. When I was a Novice, it was possible to buy vernier-dial drives and couplings from Millen, National, and the British Eddystone company (which sold in this country). In 1961, I worked for a parts distributor that stocked, that's right stocked, dial drives for amateur and professional builders. (Yes, they really did!) Today, you often must strip old projects or surplus equipment to get the mechanical dial parts. Unless, of course, you know about *Jackson Brothers (London) Ltd.* (Kingsway, Waddon, Croydon, England, CR9 4DG).

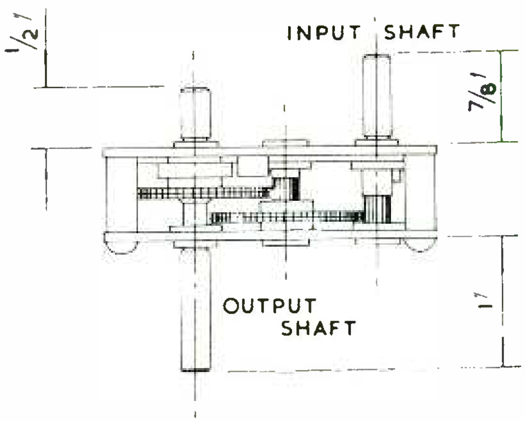
One of their products that I like the most is the ball-drive dial, catalog number 4489/C. One of the luxuries of that dial is that it is 4 inches in diameter, with a knob that is 2.25 inches in diameter. If you've tried to tune a homebrew receiver, VFO, or signal generator with the tiny little knobs sold by local distributors today, you'll understand immediately why I use the term "luxurious" to describe the feel of the Jackson 4489/C.

The outer rim of the 4-inch 4489/C dial has a 0–100 logging scale spread over 180 degrees of rotation. However, the dial can be reversed to allow either a blank outer rim, or an engraving of your own.

The dial has a quarter-inch shaft coupling, so it will fit almost all commonly available potentiometers and variable capacitors. The Jackson 4489/C provides a 6:1 turns ratio: *i.e.*, the knob turns six times for every one turn of the 0.25-inch shaft. A small plastic cursor is packaged with the knob to permit a precise reading from the logging scale.

Another Jackson Brothers product is the Type G10 gear-drive mechanism. That device is an offset gear drive with turns ratios of 25:1 (p/n 12000/3), 20:1 (p/n 12000/2) or 12:1 (p/n 12000/1). With the 12000/1 model, 10 turns of the main drive shaft results in a 300-degree rotation of the output shaft; with the 12000/2 model, 10 turns of the main shaft rotates the output shaft 180 degrees; and with the 12000/3, 10 turns rotates the output shaft 144 degrees.

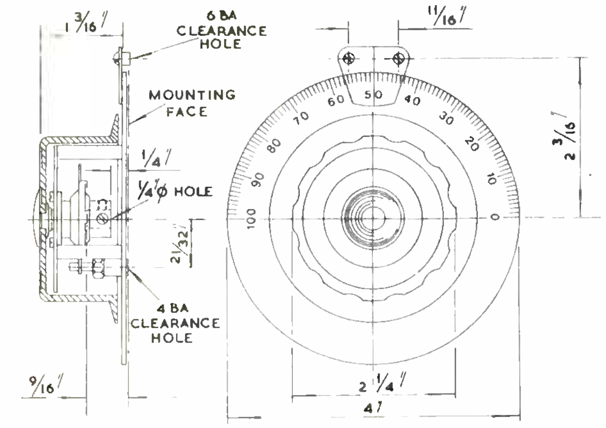
Also in the Jackson Brothers catalogs (there are several) are variable capacitors, many of which are also sold by CirKit and Maplin, as well as shaft couplings, vernier drives without dials, 0.25-inch drive shafts, dial-cord shafts, and other hard-to-find mechanical parts.



The Jackson Brothers G-10 gear box/drive mechanism is available in three models with different turns ratios.

ANTLERS FOR WINDOWS 2.0

It has surprised me how well the Antlers for Windows antenna calculator software has been received. The comments of reviewers and users are most gratifying. If you would like to get a copy of Antlers, the price is $30 postpaid, and it can be ordered from me at P.O. Box 1099, Falls Church, VA 22041. ■



Here's a detailed sketch of the Jackson Brothers 4489/C dial drive. The mechanism offers a 6:1 turns ratio.

SCANNER SCENE

By Marc Saxon

Exploring New Horizons

Uniden Bearcat's *BC-890* continuous-band scanner is a sophisticated desktop and mobile unit for the serious monitoring enthusiast. With its 200 memory channels arranged in 10 banks, its frequency coverage runs from 29 through 956 MHz. There are gaps in the coverage from 54–108 MHz and 174–216 MHz (TV and FM broadcast channels), and from 512–806 MHz (most of the UHF TV channels). The cellular bands are also locked out.

Uniden's sophisticated BC-890 continuous band scanner is meant for the serious monitoring enthusiast.

The BC-890 has some particularly interesting features. There are 10 priority channels, one in each memory bank. A frequency-transfer feature allows you to instantly enter a stored frequency in another bank's open channel. The search mode automatically stores discovered frequencies at any available open memory location. The BC-890 offers keyboard programming, but also has a front-panel rotary tuning knob that allows the radio to be manually tuned.

A variable-speed key permits scanning at different speeds between 16 and 100 channels per second. A counting feature indicates the number of times the scanner has stopped on a channel during its operating period. The BC-890 scans all NOAA weather channels, and features a weather-alert signal. An auxiliary tape output is provided.

Optional accessories include a mobile mounting bracket, a cigarette-lighter power cord, and a user-installable CTCSS PL tone decoder board.

As you can see, the Uniden Bearcat BC-890 is hardly a run-of-the-mill scanner. It is a receiver that incorporates many excellent features. It is available from Uniden's large network of dealers.

A FORGOTTEN BAND?

Many scanners cover the 118–136-MHz (VHF aeronautic) band and the 144–148-MHz two-meter amateur-radio band. Both are favorites with monitoring enthusiasts. Crunched between those two bands is a piece of spectrum, 8-MHz in width, that is usually ignored by scanner owners. It might be worth your time to pop in there to take a listen.

Although there are satellite transmissions between 136 and 138 MHz, the rest of the band (138–144 MHz) is used for military communications. One peculiarity of the band to take note of is that *most* of the activity is in AM (rather than FM) mode. Set your scanner to AM mode here, but other than that, your two-meter ham, VHF aero-band, or VHF high-band scanner antenna will bring in stations well.

You might want to try searching the band; channel separation is 25 kHz there. I have found quite a bit of USAF tactical aircraft communications taking place on 138.30, 138.425, 139.70, and 139.825 MHz. Those frequencies should be active nationally. In addition, other frequencies worth watching for tactical activity include 139.575, 139.70, 139.775, 139.875, 139.95, 141.80, 141.85, 141.90, and 143.70 MHz. Note that 148.975 MHz is a MARS frequency. FM-mode transmissions on 143.28 MHz are U.S. Coast Guard Auxiliary stations, while FM on 143.75 MHz is from Civil Air Patrol stations.

Just because you might not have monitored there previously, and the band isn't your usual stomping ground, don't be put off. You want to get the most from your hobby and your equipment, to take every possible opportunity to thoroughly explore each nook and cranny of the spectrum provided by your scanner. Open up new horizons!

WIND PROFILES

This column gets frequent requests from readers asking about tuning in on satellite beacons in the 137-MHz range. If it's scientific signals that are of interest, here are some to try for. The NOAA Wind Profiler Demonstration Network (WPDN) operates from 31 cites in the center of the nation between Wisconsin and Texas.

WPDN is part of the National Weather Service data-collection effort. Tests are underway to evaluate its use in updating and improving short-term weather forecasts and warnings. WPDN monitors wind profiles near the surface to the stratosphere by using the Doppler shift of signals scattered from ever-present atmospheric turbulence. They take measurements over large areas.

Present wind-profiler equipment is being developed by Radian Corporation (Boulder CO). Scanner owners can try for these signals on 915 MHz. Radian is also building a 449-MHz system.

DIS & DATA

Attention scanner owners in the areas of Toledo, Columbus, Cleveland, Akron, and Canton, Ohio, and Youngstown, Erie, and Pittsburgh, Pennsylvania: If you are interested in participating in one of several regional scanner notification networks, you might be in luck. If the net is formed, it will use alphanumeric pagers to provide information on major incidents and severe-weather warnings. For more information, contact R.E. Christian, P.O. Box 12763, Pittsburgh, PA 15241-0763. Please enclose a stamped, self-addressed envelope. Via the Internet, send a message to recons!pagenet@telerama.pgh.pa.us and a reply will be sent.

A reader passed along a copy of the *HASMC Herald*, the newsletter of the Houston Area Scanner and Monitoring Club (909 Michael Street, Alvin, TX 77511-2513). It's quite an attractive paper, although no other information was received. You might want to check it out if you live in the Houston area.

Reader Tony S. Patti is a scanner buff who is interested in cryptosystems (secret codes) as they relate to communications. He publishes the *Cryptosystems Journal*, and makes our readers a fine offer. Tony writes that he has two free cryptosystems that he would be happy to provide to any *Scanner Scene* reader. If you're interested, send him a formatted IBM PC diskette and a return self-addressed, *stamped*, disk mailer. His address is 485 Middle Holland Road, Holland, PA 18966.

Tony tells us that these are fully function programs that he wrote. He provides complete source code in Pascal and C. The programs give good insight into today's mathematically intensive, secure secret codes.

HIGH SECURITY

B.R.J. of New York writes that he had occasion to visit the Computer Associates building in Islandia, New York. He reports that it is a high-security facility with guard booths and a large and highly visible uniformed private security force in and around the building. Since they were using radios, he wonders if the frequency can be ascertained. Try monitoring 471.7375 MHz and see what you can hear.

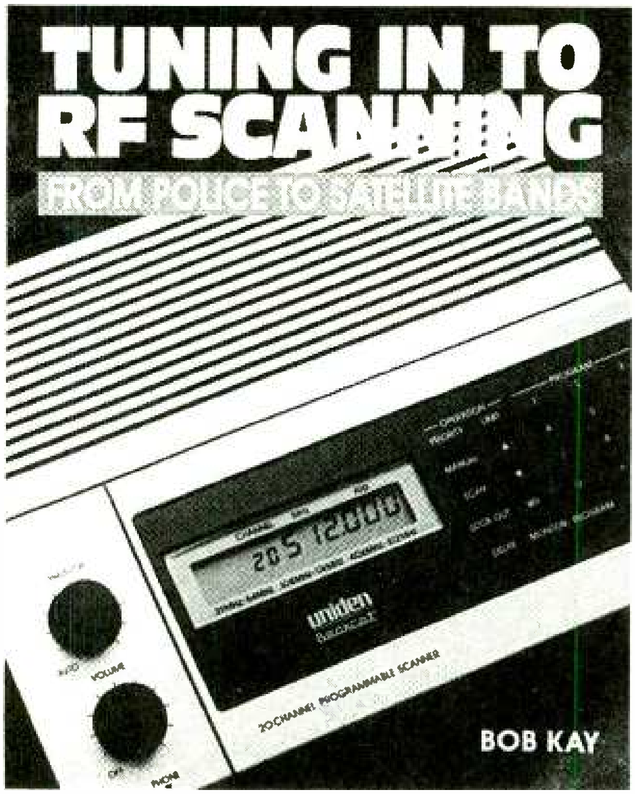
That's all for now. Until next time, write to us with your frequencies, questions, and ideas. We're at *Scanner Scene*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

ELECTRONICS LIBRARY

Tuning in to RF Scanning from Police to Satellite Bands

by Bob Kay

All across the country, scanning enthusiasts tune in to police, fire, and ambulance calls. This eye-opening book tells how to monitor hundreds of largely untapped, but fascinating frequencies, including FBI, Secret Service, and NASA. The non-technical guide will appeal to beginners to the hobby as well as experienced scanners. It offers valuable advice, tips, and ideas drawn from the experience of the author, a recognized



scanning authority. The book begins with advice on choosing a scanner and an antenna, as well as buying and installing accessories. It moves on to cover the fundamental rules of scanning and the laws governing third-party listening.

With the basics covered, the book concentrates on how to use a scanner to monitor cordless telephones, baby monitors, sports and entertainment frequencies, military aircraft and ground maneuvers, and more. It explains the 100 top national frequencies and includes a chart listing hundreds of more obscure frequencies that can be explored by scanners. It also provides information on scanning clubs and publications and how to establish a listening post.

Tuning in to RF Scanning from Police to Satellite Bands costs $14.95 and is published by Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 800-233-1128.

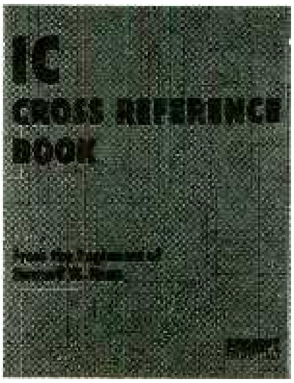
CIRCLE 98 ON FREE INFORMATION CARD

IC CROSS REFERENCE BOOK

from the Engineers of Howard W. Sams

The Sams engineering staff assembled this comprehensive guide to help professionals and hobbyists find replacements or substitutions for more than 35,000 IC's or modules. The book was compiled from manufacturers' data and from the analysis of consumer-electronics devices for PHOTOFACT service data, which has been used since 1946 by service technicians worldwide.

The book is divided into two sections. The first, "Original IC or Module Part or Type Numbers," lists devices in alphanumeric order by manufacturer's part number, type number, or other identification. Next to the part number is a replacement code/block number that is used to look up compatible replacements in the second section. The "Replacements" section provides substitutes and replacements for the IC's and modules listed in the first section.



The IC Cross Reference Book costs $19.95 and is published by Prompt Publications, 2647 Waterfront Parkway, East Drive, Indianapolis, IN 46214-2012; Tel. 800-428-7267 or 317-298-5710; Fax: 317-298-5604.

CIRCLE 97 ON FREE INFORMATION CARD

THE RADIO COLLECTOR

from Radio Collector Publications

Marc Ellis, **Popular Electronics'** *Antique Radio* columnist, founded this new monthly publication to fill a specific niche in the radio-collecting community: The eight-page, newsletter-style journal is aimed at relative newcomers to the hobby, who need the most basic information on radio history, theory, and restoration practice. Every issue of *The Radio Collector* includes a feature article that covers some fundamental aspect of radio collecting, as well as monthly columns on vintage-radio restoration, history, and reference material. The newsletter also offers free classified ads for subscribers and free publicity for radio-club functions. Reader response to the open question-and-answer forum indicates that experienced antique-radio hobbyists enjoy sharing their knowledge—and reading *The Radio Collector.*

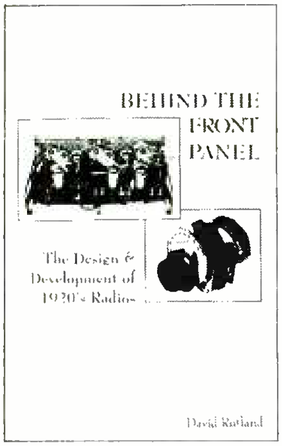
The Radio Collector costs $20 for an annual subscription within the United States; $21 (U.S. funds) in Canada, and $35 (U.S. funds) via air to other countries, from Radio Collector Publications, P. O. Box 1306, Evanston, IL 60204-1306.

CIRCLE 96 ON FREE INFORMATION CARD

BEHIND THE FRONT PANEL: The Design & Development of 1920's Radio

by David Rutland

Aimed primarily at vintage-radio collectors and enthusiasts, the combination of history and technology that it presents will interest a larger audience. The book explains the technology that made the first radios possible, and introduces the people who struggled to bring radio to life. It relates the dreams and motives of the famous and not-so-famous men—including Fleming, DeForest, Armstrong, Marconi, Alexanderson, and Hazeltine—who brought radio to the public.



The book's main focus, however, is on the inner workings of those early radios, from the simplest crystal set to six-tube superheterodyne receivers. Using simplified descriptions, the book provides a readable explanation of what goes inside old radios. The basic, down-to-earth components—the tubes, variometers, variocouplers, and more—that were used in the first radios are described, and their functions explained. Design examples are taken from more than 45 actual radios manufactured during the decade that saw broadcast radio start out as a national pastime, and turn into an integral part of life in America. Photographs of 25 actual radios and components provide examples of early radio construction.

Behind the Front Panel: The Design & Development of 1920's Radio costs $18.95 and is published by Wren Publishers, P. O. Box 1084, Philomath, OR 97370; Tel. 502-929-4498.

CIRCLE 85 ON FREE INFORMATION CARD

SONY STYLE

from Sony

If you like to keep informed of the latest offerings in the world of consumer electronics, this quarterly magazine can be of some help. The print-media version of an infomercial, the magazine is essentially a collection of detailed advertisements for Sony's entire product line. Its glossy pages contain articles explaining new technologies, such as MiniDisc and digital audio tape, as well as old standbys. Product categories include camcorders, personal and portable stereos, autosound, home entertainment, home audio, televisions, VCR's and laserdisc players, My First Sony, videogames, telephones, clock radios, navigation systems, world-band receivers, information products, and business products. Within each section, product guides provide details, features, and suggested retail price for each item.

The magazine presents several shopping incentives including mail-in offers for free merchandise: Buy a Video Walkman and receive a free carrying case and five 8mm movies, for instance. To further simplify your Sony shopping, pull-out bookmarks are provided, each printed with "This is the perfect Sony gift for . . ." followed by a choice of gift-giving occasions and holidays.

Sony Style is available quarterly for $4.95 per issue on the newsstand or can be ordered from Sony Style, P. O. Box 9500, Cranbury, NJ 08512-9929; Tel. 800-848-7669. Add $1.50 for shipping and handling.

CIRCLE 84 ON FREE INFORMATION CARD

CONSUMER ELECTRONICS PRODUCT TERMINOLOGY DICTIONARY

from the EIA/CEG

It's commonly accepted that education is an important selling tool—if a consumer understands a new technology or feature behind a new product, he's more likely to purchase it. This book was written to help consumers, retailers, and others to understand the terms commonly used in the consumer-electronics industry. It was developed by the manufacturers that participate in the Product Education Committee of the Electronic Industries Association's Consumer Electronics Group (EIA/CEG). By using the same generic terms for generic features, industry members hope to alleviate much of the confusion and "technophobia" that can dampen consumer excitement over sophisticated electronics. The dictionary contains terms and definitions used in several major product categories, including accessories, camcorders, computers, home audio products, fax products, mobile electronics, telecommunications products, TV's, and VCR's and laserdisc players. An index lists every term, making it easy to find a word even when unsure of its category.

The Consumer Electronics Product Terminology Dictionary is available for a 6X9-inch self-addressed, stamped envelope with $1.44 in postage. It is published by the Electronic Industries Association/Consumer Electronics Group, 2001 Pennsylvania Avenue, N.W., Washington, DC 20006-1813; Tel. 202-457-8700; Fax: 202-457-4901.

CIRCLE 83 ON FREE INFORMATION CARD

DOS 6 COMPLETE

by Manfred Tornsdorf and Helmut Tornsdorf
Software by Marten Grumpel

This book-and-disk set is a practical guide to learning and using MS-DOS 6 (all versions to 6.2). Providing an encyclopedia of knowledge for ordinary users as well as for computer whizzes, the book is loaded with helpful hints for outfitting any computer with DOS. Using easy-to-follow examples, the book explains everything from installing the operating system to using the new file, directory, and storage-maintenance features. It fully explains AUTOEXEC.BAT and CONFIG.SYS files in a friendly style that won't scare off beginners. A complete DOS command reference is also included.

The companion disk contains Tempest, a graphical shell that makes it easier to use DOS by clicking on icons with a mouse. It also provides dozens of powerful batch files, detailed explanations, and useful tips and tricks to help readers get the most out of DOS 6.2.

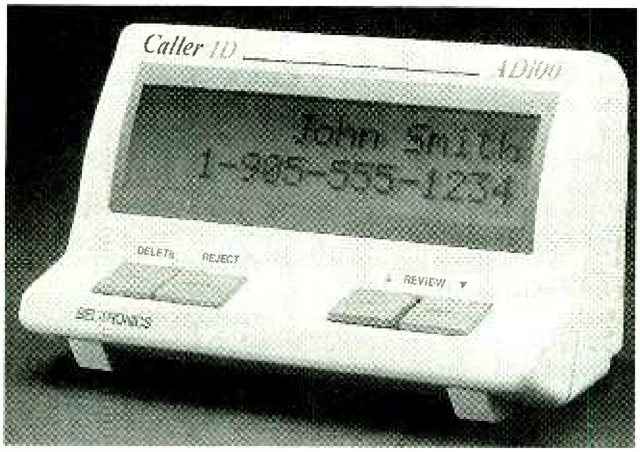
DOS 6 Complete costs $39.95 and is published by Abacus, 5370 52nd Street SE, Grand Rapids, MI 49512; Tel. 800-451-4319. ■

CIRCLE 82 ON FREE INFORMATION CARD

NEW PRODUCTS

Bilingual Caller-ID System

BEL-Tronics' AD100 caller-identification system offers a bilingual name display, along with two features to help users take action against nuisance calls: Call Reject and Block Buster. The device displays both the callers' name and phone number, with name-display prompts in English or Spanish. It provides a record of the last 100 phone calls. Call Reject memorizes the originating number of any unwanted phone call. When that number calls you again, Call Reject answers your phone with a pre-recorded digital message intended to deter further calls.



Block Buster intercepts calls from those who have deliberately blocked the identity of their originating phone number. A pre-recorded message tells the caller that you don't accept anonymous calls and requests that the identity block be removed before attempting the call again. Block Buster eliminates the need for the anonymous-call reject services provided by many local phone companies for a monthly fee. Both outgoing messages are available in English and Spanish versions.

The AD100 bilingual Caller-ID system has a suggested retail price of $109.95. For further information, contact BEL-Tronics Limited, 8100 Sagl Parkway, Covington, GA 30209; Tel. 800-341-1401.

CIRCLE 100 ON FREE INFORMATION CARD

NI-CD BATTERY EXTENDER

According to *Wings West*, its *Deep Cycler 5000* will dramatically extend the life of your Ni-Cd batteries. The device slowly steps down the battery, then jolts the battery and applies a precision stand-off or deep-cycle circuit to the battery. That

completely eliminates the Ni-Cd memory effect and restores the battery to its original full-charging capacity. The Deep Cycler 5000 is easy to use: Just connect the leads to the battery, red to positive and black to negative, and switch on the device. The patented Deep Cycler 5000 does not require outside power, but uses the battery's power for the deep cycling process, so it can't damage the battery. A single unit works on Ni-Cd batteries from "AAA" to 15 volts, eliminating the need for multiple chargers.

The Deep Cycler 5000 costs $79.95. For additional information, contact Wings West, 7166 Crown Point Road, Coos Bay, OR 97420; Tel. 503-888-2849.

CIRCLE 101 ON FREE INFORMATION CARD

BUBBLEJET PRINTERS/ NOTEBOOK COMPUTERS

A new series of integrated notebook computer and BubbleJet printer units from *Canon*, the *NoteJet 486* and the *NoteJet II* lines, feature accelerated performance at affordable prices. The NoteJet 486, with an Intel 486SX/33MHz microprocessor, features a 9-inch monochrome display, while the NoteJet 486C offers a 9.5-inch dual-scan color

LCD. Each includes a handheld, two-button trackball. The NoteJet II 486C uses an IBM 486SLC/50MHz processor, features a 10.3-inch dual-scan color display, and includes an integrated joystick pointing device. Consumers can choose between 130-, 200-, or 260-MB hard-drive options. With a Windows accelerator and 1 MB of video RAM included in the new NoteJets, fast Windows and graphics redraw performance is achieved.

Each model allows users to create and print out high-resolution, 360-dots-per-inch, letter and legal-sized documents, and transparencies at 116 characters-per-second. For convenience, the NoteJets each offer a 10-sheet, letter-size, automatic paper feeder.

The NoteJets weigh 8.8 pounds, including Ni-Cd battery, and measure 12.2 × 10 × 2.5 inches. All models include a built-in BubbleJet printer; 4 MB of memory (expandable to 12 MB), a 3.5-inch, 1.44-MB external floppy drive; pre-loaded MS.DOS 6.2 and Windows 3.11; two PCMCIA Type II slots or one PCMCIA Type III slot; and a one-year warranty.

Prices for the NoteJet line range from $2299 for the 33-MHz 486 monochrome model with 120-MB hard drive to $3699 for the 50-MHz NoteJet II 486C with 260-MB hard drive and color graphics display (pictured above). For more information, contact Canon Computer Systems, Inc., 2995 Redhill Avenue, Costa Mesa, CA 92626; Tel. 800-848-4123; Fax: 714-438-3317. ■

CIRCLE 102 ON FREE INFORMATION CARD

THINK TANK

(Continued from page 31)

If there is a short to ground at the circuit's output (*i.e.*, in the device being powered), the voltage that feeds the base of Q1 goes to zero, turning off the transistor. Then LED1 glows because K1 is de-energized to indicate the short circuit.

Heck, we all build power supplies from time to time and this is a really nice addition. I like how it would interface with the key structures of a supply (the filtered bridge circuit and the output). That makes it easy to add to just about any standard design.

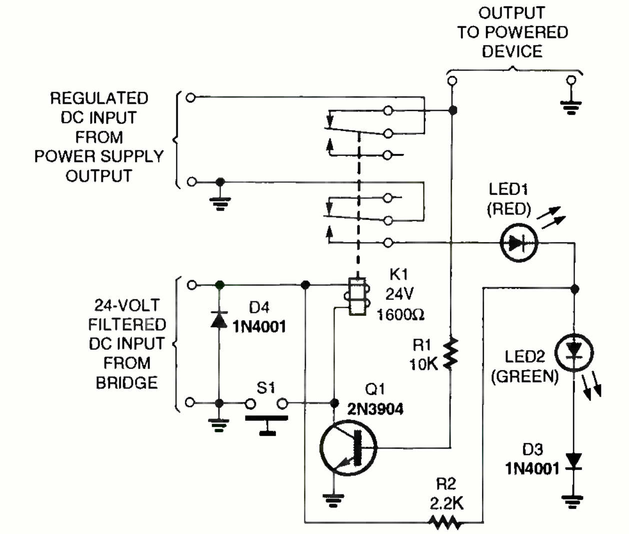


Fig. 4. Power-supplies are useful projects. You can make yours better by adding this short-circuit shut-down circuit that protects the powered equipment.

Diode D4 protects the 24-volt power-supply circuit from K1's coil kickback. I used a +24-volt DPDT relay with a coil resistance of 1600 ohms. If you use another relay, pay special attention to the specification of the collector and base saturation currents of Q1.

—*Joaquin Diaz A., Nogales, Mexico*

ELECTROSCOPE

Winter is a good time of year for high-voltage electrostatic experiments thanks to the low indoor humidity. I get a "charge" out of making simple electrostatic generators, but sometimes confusion reigns as to what is getting charged with what polarity, if at all, and roughly how much. Here is a very simple circuit that will help demystify any electrostatic generator.

Like most other electroscope circuits I've seen, the heart of the circuit is an FET. The circuit is sort-of middle-of-the-road—it's not a super-duper, dual-FET, temperature-compensated-bridge monster, but it is not an oversimplified, drifting, monopolar device either. What the circuit does is detect a charged object at a respectable distance and display the polarity (positive, negative, or earth grounded) and relative-intensity.

In operation, C1 reduces AC noise but lowers the sensitivity a bit. The MPF102 and R1 form a voltage divider. When the FET's gate is earth-grounded, the divider's output will be about 4.5 volts giving a half-scale reading on M1, a 200-microamp meter. A positively charged object (like cotton-rubbed glass) will give a positive deflection from half-scale, and a negatively charged object (a plastic comb, for example) will give a negative meter deflection.

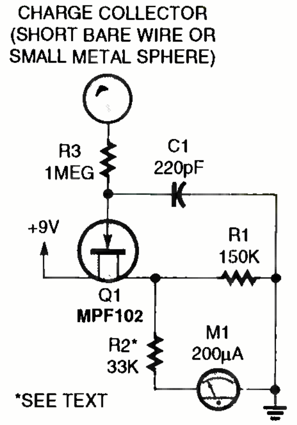


Fig. 5. If you're an amateur scientist or just want to hunt down charges around your workbench, this electroscope should give you a charge. It's also great for impressing your friends and family!

The whole circuit (including the 9-volt battery supply) should be in a metal enclosure, and a short piece of bare wire makes a fine charge collector, but use a small metal sphere to really worry family and friends!

—*Nick J. Cinquino, Schaumburg, IL*

I wonder if the unit is sensitive enough to help detect CMOS-damaging charge levels. If so, it would be even more useful around the work bench. (By the way, I like the sphere idea.)

I should conclude this one about here. If you would like to take part in our monthly meeting, write to *Think Tank*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

CIRCUIT CIRCUS

(Continued from page 76)

the comparator circuit are about the same as in the previous sawtooth-generator circuit. A 555 timer IC (U2) is configured as a one-shot multivibrator that's triggered by the comparator's negative output pulse.

Take a close look at the circuit diagram, and you will see that the inputs of the comparator circuit have been reversed to produce a negative output when the input voltage at pin 5 goes above 8 volts.

STEPPED TRIANGLE-WAVEFORM GENERATOR

Our last entry this visit, see Fig. 5, is a circuit that produces a stepped triangle waveform. Two gates of a 4011 quad two-input NAND gate (U1) are connected in a pulse generator circuit.

The squarewave output, at pin 4 of U1-b, connects to the clock input, pin 14, of a 4017 decade counter IC (U2). For each input clock pulse, the 4017 takes a single step. Since the 4017 counter is set up to count ten and then repeat the count, the stepped output frequency will only be one-tenth of the clock frequency. For a 100-Hz output, the clock generator must operate at 1 kHz.

The 4017's positive output pulses begin at pin 3 and progress to pin 11 in a serial manner. The first output pulse, at pin 3, passes through D1 and R8 and appears across R4 to produce the first step up the triangle. The second pulse is routed through D2 and R7 to produce the second step. The outputs at pins 10 and 1 form the top of the waveform, and outputs at pins 5,6,9, and 11 produce the down steps. ■

AMP-HOUR METER

(Continued from page 56)

careful to observe proper orientation.

Apply 9-volt power only. Momentarily operate the reset switch, S2. The display should indicate 0.0 or the pre-programmed value if option 2 or option 3 was chosen.

If the display is blank, be sure that operation of S2 applies V_{dd} to pin 1 of U6 and U7. Check pin 3 of U10 for the presence of the backplane drive signal. Normal indication is a 5-volt peak-to-peak square wave at a frequency of about 130 Hz. Check the orientation and wiring of U6, U7, U8, U9, and U10. Review Figs. 4 and 7 and verify that the LCD module is properly wired to the main circuit board.

If the digits are not properly formed, it is likely there is a miswire, open, or short on, or between, the two boards. If the decimal point is not illuminated, the cause may be Q1 or its associated components. Verify the orientation of Q1 or try a new transistor.

Activate the load-current source. If the calibrated current is 1 ampere, it will take 6 minutes for the ampere-hour display to increment each 0.1 ampere hour. For other current levels, the time required to increment the display will be a linear function of the current; higher levels of current will increment faster, lower levels slower. If the time option (option 3) has been implemented, the time required to increment the display 0.1 hours will obviously depend upon the level of current through R1 and the nominal ampere-hour rating of the battery.

When the display has incremented by 0.1 or more, turn off all power for about 5 minutes. Then turn S1 on. The display should retain the last reading before power was shut off. Press S2; the display should go to zero or to the pre-programmed number.

Circuit Options. For those applications that use batteries or power sources that deliver 7 to 15 volts, it is possible to delete the 9-volt battery and operate the circuit from the external power source. The schematic wiring for that option is shown in Fig. 10. **Caution:** When using this option, be absolutely sure that the voltage source never exceeds 15 volts under any circumstances.

To modify a battery charger so that it will display the ampere-hours delivered into a rechargeable battery, select option 1 and follow the wiring diagram of Fig. 11.

Using The Battery Ampere-Hour Meter. Probably the first thing that you will want to know is the true ampere-hour capacity of a rechargeable battery. To make that measurement, charge the battery fully in accordance with the manufacturer's instructions.

For NiCd's, proper recharging is accomplished by using a constant current source equal to $1/10$ the ampere-hour rating of the battery (A 1.5-Ah battery requires a 0.15-ampere recharge current). The charge time must be 14 to 16 hours to guarantee full recharge.

Once the battery has been charged, obtain a resistive load that will discharge the battery in 10 hours; that is the same current level that was used to charge the battery as described above.

To calculate the required load-resistance value, use the nominal terminal-voltage rating of the battery under load. For NiCd's, that voltage is 1.2 volts-per-cell. Lead acid batteries deliver 2.2 volts-per-cell.

Operate the Battery Ampere-Hour Meter until the terminal voltage of the battery falls to about 10% or 15% below nominal. The final reading of the display will be the true ampere-hour rating of the battery.

As an exercise, you may wish to check the ampere-hour rating using the actual load current that the battery must normally deliver. If that current is more than the 10-hour rate, the battery Ah capacity for that application will be less than that stated by the battery manufacturer. ■

"It's a software problem—you'll have to lose some."

RF OSCILLATORS

(Continued from page 42)

and C4) are air-dielectric types, rather than mica or ceramic. The purpose of C4 is to provide DC blocking to the transistor-gate circuit. It is such a small value because we want to lightly load the LC-tuned circuit. That trimmer is adjusted from a position of minimum capacitance (*i.e.*, with the rotor plates completely unmeshed from the stator plates), and is then advanced to a higher capacitance as the oscillator is turned on and off. The correct position is at the lowest value that allows the oscillator to start immediately every time power is applied.

Conclusion. Oscillator circuits should be stable for best operation. If you follow the guidelines we've presented, then it is likely that your circuits will be highly successful. While these techniques do not exhaust the possibilities for stable-oscillator construction, they are a good start. They represent a practical collection of weapons for your use. ■

GATE-DIP METER

(Continued from page 39)

and connect them to the points shown in Fig. 4. The coil jack should be connected to C1 and to ground through very short lengths of bare wire.

Testing. Check the component positioning and wiring of off-board parts with great care; correct any errors that you find. Once you are sure of the accuracy of your work, plug a coil into the coil jack, set S1 to the DIP position and turn both R3 and R8 to about mid-rotation. Apply power to the circuit. The meter (M1) should give a noticeable reading. Rotate R3 for a full-scale reading on M1. Should the meter's needle peak, adjust the meter's sensitivity by rotating R8.

Once that is done, connect a frequency counter to the RF output at J1 and check tuning range by rotating C1 to both extremes. Place a finger on the coil: RF energy absorption should cause a dip in the meter reading. Once you are satisfied, test all remaining coils in the same way. ■

CAPACITANCE METER

(Continued from page 66)

the capacitor markings second. Also, if you readjust R1, you must recalibrate R11 as described above. If you can't get the meter to read a small number and then zero out, you may have to use a different value for R8.

Using the Meter. Once calibrated, the meter is a cinch to use. Just turn it on, place a capacitor across J1 and J2, and read the value. Most capacitors settle in within two or three samples (a few seconds); larger units, say, more than 50 µF, may take a bit longer. Also, it's a good idea to always start a test by pressing S1.

The battery lasts longer when the meter is in range 1, so if you're going to leave the meter on for any length of time, press S1 to drop out the relays. In that state, the unit only draws about 27 mA.

Part Sources. The 74C947 is readily available from mail-order electronics suppliers, such as Digi-Key Corp. (800-344-4539). If you have any problems finding the 74C947, the circuit is set up so that it can also accommodate the 74C946 or the Intersil/Harris ICM7224 as described earlier. The ICM7224 is available from Mouser Electronics (Tel. 800-34-MOUSER).

If you can't find the PXO-1000 anywhere, Epson America makes a compatible unit that is available from Digi-Key as part SE3102. The 4-digit LCD display and the ICM7556 is also available from Digi-Key.

The relays are available from Radio Shack (part 275-232). You can use relays from other sources, but make sure, first of all, that they fit the circuit board, and also that they have low-current coils. The Radio Shack units draw 20 mA. The board was designed to fit into a Radio Shack project box (part 270-223), although the choice of cabinet is of course up to you.

Except as noted, the various discrete components can be standard 5% units; you won't get better accuracy by spending more for 1% devices. The one place you might splurge and go for precision units is with the 15-turn trimmer potentiometers for R1–R3. The meter's accuracy depends on those units. ■

FREQUENCY COUNTER

(Continued from page 60)

Once power has been verified, it is time to set the bias control (R3). Hold the positive probe of your volt meter to the side of R5 closest to U3, and adjust R3 for a reading of 5 volts. Be careful not to short R5 to the surrounding ground plane with your probe. If you are unable to adjust R3 for 5 volts, check the orientation of Q1 and Q2, and for solder bridges on those components. If you still have no luck, replace Q1.

Disconnect the battery, then carefully plug U1 and U2 into their sockets, making sure that they're properly oriented (as shown in Fig. 5) and seated. A very common problem in using IC sockets is that one or more pins of the IC may bend underneath the chip during installation. The insertion force required to seat the IC is sufficient to mask any feel of this occurring, and it is very difficult to detect such problems later without close examination. The best way to avoid that situation to push the chip half-way into its socket, then check all pins before seating the chip.

With R9 turned completely clockwise, reapply power to the circuit. With no signal input to the circuit, the display should briefly show ".00 kHz," then automatically switch ranges to read "Hz." Adjust R9 to change the contrast of the display to your liking.

Calibration. The frequency counter resolution is +/– the least-significant digit shown on the display (1 Hz with a 1 second gate or 10 Hz with a 0.1 second gate), plus the % error of the calibration source.

Hook your frequency counter's test lead to a stable reference source of known frequency (the higher in frequency the better). The output of a calibrated PLL synthesized transmitter (CB or ham radio) is a good starting point if no other source is available. Note, however, that the accuracy of your counter will be proportional to that of your calibration signal.

Your counter should display the frequency (within a small percentage) of your calibration signal. If the frequency counter initially jumps up to some number only to return to 0 Hz, your test signal does not have sufficient amplitude to trigger NAND gate U2. Once you obtain a stable reading, use a non-metallic screwdriver and adjust trimmer capacitor C12 to tweak the displayed frequency to that of your calibration signal.

Note: If the frequency displayed on the frequency counter is more than a few percent lower than the known calibration signal, chances are the amplitude of your calibration signal is at or close to the minimum triggering threshold, and low frequencies (60 Hz, for example) riding on the test leads are forcing that signal below the trigger level during part of the gate time, resulting in a lower than true count. Increase the amplitude of the calibration signal if that occurs. ■

PARTS LIST FOR THE 50-MHZ FREQUENCY COUNTER

SEMICONDUCTORS
U1—PIC16C54-XT/P (pre-programmed), microcontroller (Microchip), integrated circuit
U2—74HC132, quad 2-input, NAND Schmitt trigger, integrated circuit
U3—78L05 low-power 5-volt regulator, integrated circuit
DISP1—DMC16117 or equivalent, 16-character × 1-line LCD module
Q1—MPF102, N-channel VHF FET
Q2—2N4403, general-purpose PNP silicon transistor
D1, D2—1N4148 general-purpose silicon diode

RESISTORS
(All fixed resistors are ¼-watt, 10% units.)
R1—100,000-ohm
R2, R6—1-megohm
R3—500-ohm, trimmer potentiometer
R4—100-ohm
R5—300-ohm
R7—820,000-ohm
R8—47,000-ohm
R9—10,000-ohm, trimmer potentiometer

CAPACITORS
C1—1.5-µF, 16-WVDC, tantalum
C2—47-pF, ceramic-disc
C3, C6, C7, C9—0.1-uF, Mylar
C4—470-pF, ceramic-disc
C5—0.047-µF, ceramic-disc
C8—10-µF, 35-WVDC, electrolytic
C10—22-pF, ceramic-disc
C11—10-pF, ceramic-disc
C12—4-20-pF, trimmer capacitor

ADDITIONAL PARTS AND MATERIALS
XTAL1—4-MHz crystal
S1—SPST toggle switch
B1—9-volt alkaline battery
Printed-circuit materials, enclosure, battery holder and connector, IC sockets, ribbon cable, shielded cable, wire, solder, silicon adhesive, hardware, etc.

Note: The following items are available from Weeder Technologies, P.O. Box 421, Batavia, Ohio 45103: A double-sided, printed-circuit board with plated-through holes (WTCNT-B) for $8.50; a kit of all board-mounted components, including a pre-programmed PIC16C54, (WTCNT-C) for $19.50; a pre-programmed PIC16C54 only (PIC-CNT) for $16.00; a 16-character × 1-line LCD module for $18.50. All orders must include an additional $3.50 for shipping and handling. U.S. and Canadian orders only please. Ohio residents must add 6% sales tax.

CRASH PROTECTION

(Continued from page 60)

ward by powerful springs, and locked into place. That all takes just 3/10 second. Fully deployed, the rollover bars are extended about ten inches above the headrests.

Crash Protection for Tomorrow's Cars. While future collision-avoidance systems are aimed at avoiding collisions, they could also incorporate the ability to sense when a crash is unavoidable and trigger the deployment of an air bag. In contrast to current air-bag sensors that do not sense until the crash starts to happen, these advanced sensors would predict a crash and start deploying the air bags before any crunching of metal.

Safety advocates are encouraging manufacturers to develop belts that could continually monitor an occupant's head and body position. If they were outside of a "safe zone" where the belts would not give proper protection, the occupant would be warned of the hazard. ■

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November 1994

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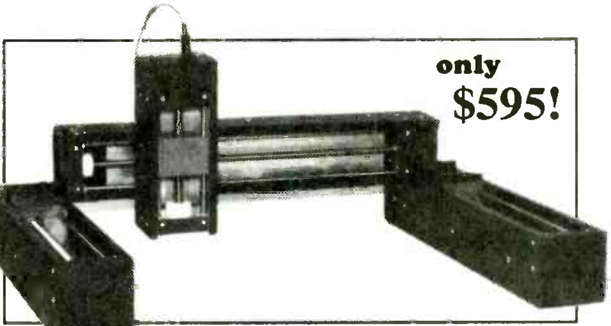

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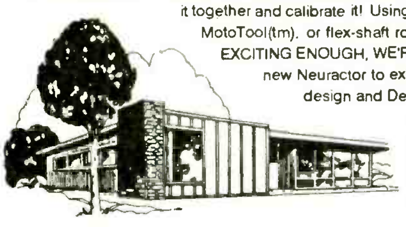

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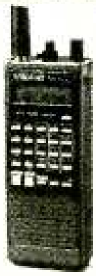

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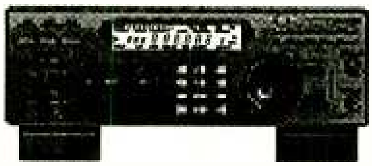

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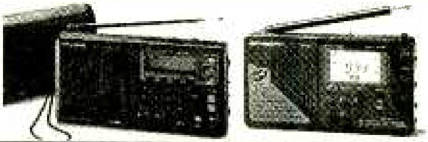

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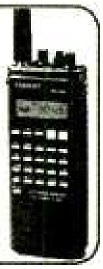

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5795	x10	1.2	10	15	100	3	600	10-60	35.00
4550A	x1-x10 Switchable	1.2	x1 x10 Same 10 as scope	x1 x10 55 16	x1 x10 15 100	x1 x10 35 3	600	10-60	43.00
5800	x1	1.2	Same as scope	45	30	10	600		41.00
5803	x10	1.2	10	15	200	1.8	600	10-60	45.00
5806	x1-x10 Switchable	1.2	x1 x10 same as as scope	x1 x10 55 15.5	x1 x10 20 200	x1 x10 10 1.8	600	10-60	49.00
5827	x100	1.2	100	6.5	200	1.6	1200	15-50	80.00

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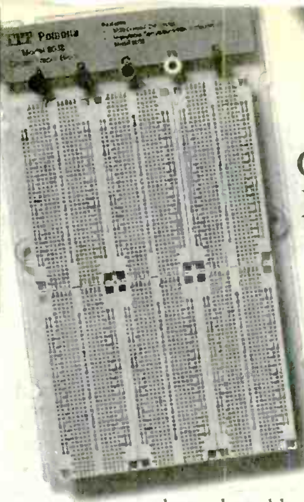

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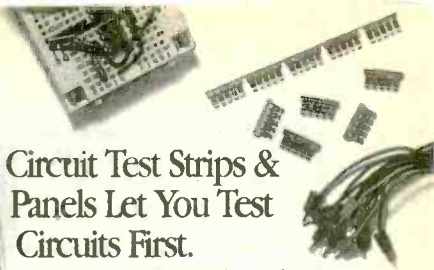
6037 Circuit Test Strip $ 9.50 ea.
6038 Circuit Test Panel $65.00
6039 Accessory Kit $15.00



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Electronics Lab Test Kit Switchable x1-x10 Oscilloscope Probe with Accessories, Multi-use kit for Electronics (5543A), Oscilloscope Ground Kit and Double Banana Plug to BNC (f).	6003	92.00
Multi-use Kit for Electronics 2 each: Probe Handles, Pop Jack Leads, one black & one red. 1 each: Medium Alligator, Spade Lug, Minigrabber® Lead & Extended Slide-on Tip.	5543A	34.90
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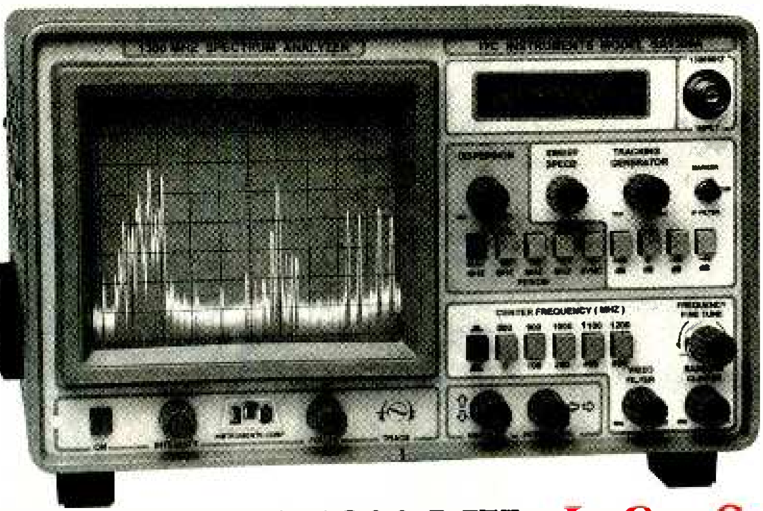

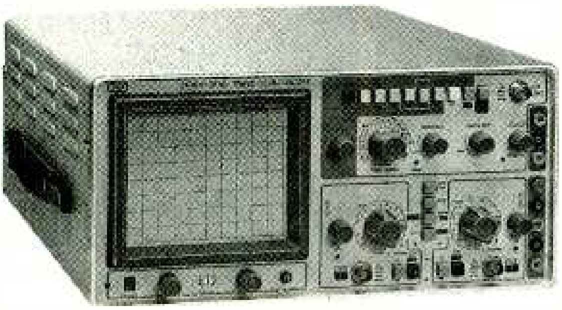

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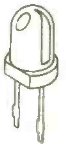

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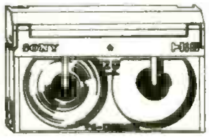

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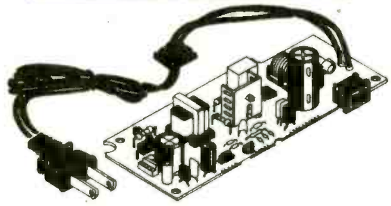

Working power supply, complete with power cord, fuse and on/off switch. Removed from Seikosha # SP-2400 dot matrix printer. We don't have the official specs on these, but they appear to have two outputs providing 5 and 24 vdc. Great for educational and experimental projects. The parts alone are well worth the price.
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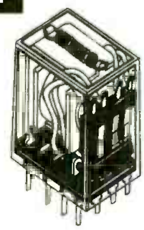

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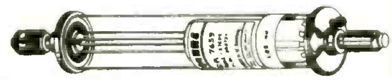

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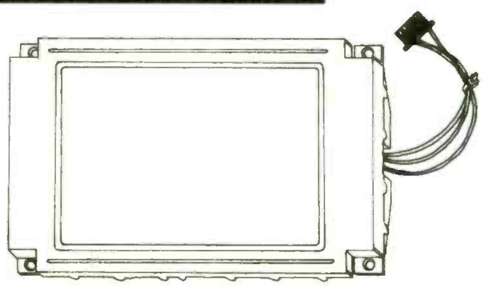

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Pulse:	Single, Burst, Neg. or Pos.
Pulsewidth Range:	200 s to 125 ns
Pulse width resolution:	5 sec to < 1 ns (consult factory)
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Square modes:	CW, Sweep and Burst
Triangle modes:	CW
Ramp modes:	CW, Positive and Negative
Burst modes:	
Max number of cycles per burst:	1 to 65535
Burst repetition rate range:	.01 Hz to 1 MHz

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frequency range:	1 Hz to 200 kHz
frequency resolution:	.005 Hz
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FM modulation deviation range:	1 Hz to 200 KHz
AM modulation depth:	1% to 99%
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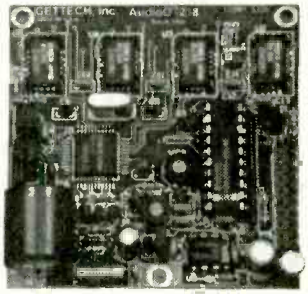

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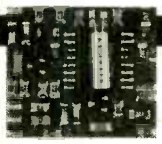

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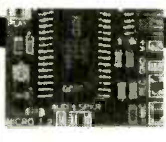

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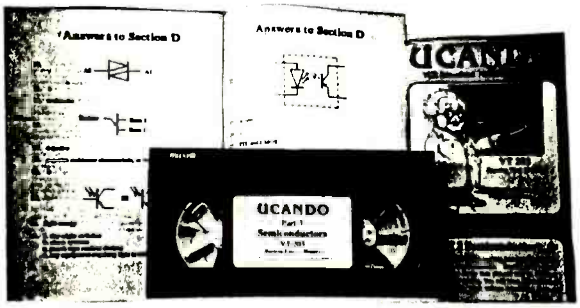

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INSTRUCTION FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or PRINT your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for the additional ads (a photocopy of this form works well). Choose a category from the list below and write that category number into the space at the top of the order form. If you do not specify a category, we will place your ad under Miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. Payment in full must accompany your order. We do permit repeat ad or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first two words of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $1.00per word. Minimum charge is $15.00 per ad per insertion (15 words). Any words that you want set in bold or caps are 20¢ each extra. Bold caps are 40¢ each extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged as all-caps words. State abbreviations must be Post Office 2-letter abbreviations. A phone number is one word.

CONTENT

All classified advertising in the **PE Market Center** is limited to electronics items only. All ads are subject to the publisher's approval. We reserve the right to reject or edit all ads.

DEADLINES

Ads received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March, 1995 issue that is on sale January 17. The PE Market Center is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

AD RATES: $1.00 per word, Minimum $15.00.

Send your ads with payment to:
Popular Electronics Market Center, 500-B Bi-County Blvd. Farmingdale, NY 11735

CATEGORIES

100 — Antique Electronics
130 — Audio-Video-Lasers
160 — Business Opportunities
190 — Cable TV
210 — CB-Scanners
240 — Components
270 — Computer Equipment Wanted
300 — Computer Hardware
330 — Computer Software
360 — Education
390 — FAX
420 — Ham Gear For Sale
450 — Ham Gear Wanted
480 — Miscellaneous Electronics For Sale
510 — Miscellaneous Electronics Wanted
540 — Music & Accessories
570 — Plans-Kits-Schematics
600 — Publications
630 — Repairs-Services
660 — Satellite Equipment
690 — Security
710 — Telephone
720 — Test Equipment

CLASSIFIED AD COPY ORDER FORM

Ad No. 1—Place this ad in Category # ______

1 - $15.00	2 - $15.00	3 - $15.00	4 - $15.00
5 - $15.00	6 - $15.00	7 - $15.00	8 - $15.00
9 - $15.00	10 - $15.00	11 - $15.00	12 - $15.00
13 - $15.00	14 - $15.00	15 - $15.00	16 - $16.00
17 - $17.00	18 - $18.00	19 - $19.00	20 - $20.00
21 - $21.00	22 - $22.00	23 - $23.00	24 - $24.00
25 - $25.00	26 - $26.00	27 - $27.00	28 - $28.00
29 - $29.00	30 - $30.00	31 - $31.00	32 - $32.00
33 - $33.00	34 - $34.00	35 - $35.00	36 - $36.00
37 - $37.00	38 - $38.00	39 - $39.00	40 - $40.00

Total classified ad Payment $ ______ enclosed.

[ ] Check [ ] MasterCharge [ ] Visa ($15.00 minimum credit card order)

Ad No 1—Total words ______ × $1.00 per word = $ ______

All Caps words ______ × .20 per word = $ ______

Bold words ______ × .20 per word = $ ______

Bold Cap words ______ × .40 per word = $ ______

TOTAL COST OF AD No. 1 $ ______

Card # __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

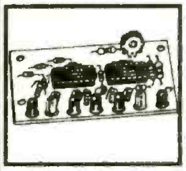
Expiration Date __ __ / __ __

Signature ______________________

Name ______________________ Phone ______________________

Address ______________________ City State Zip ______________________

RAINBOW KITS

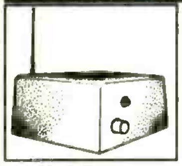


DC VOLTAGE MONITOR

If battery status is important, you need this kit. Build this kit to monitor 12v in 1v 1/2v, or 1/4v steps. Monitor 8v or 5v in 1/4v steps. Great for boats, motor homes, model planes or race car ni-cads. All parts and instructions are included. SIZE: 1/2"x 2.7".

VM-1 **$7.95**

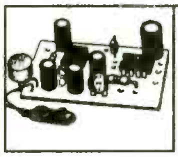
FM STEREO TRANSMITTER



Own your own FM radio station. Any stereo signal you plug into the FMST-100 will be transmitted to any FM radio tuneable from 76 to 108MHz FM. Transmit a wireless link through an auditorium, from your car to your camper, listen to your cd's while mowing the lawn,Play music on one channel sing on the other. Clarity is excellent, aprox. 40dB stereo separation. Length of antenna determines the distance of transmission. Complete with stereo input level controls , & crystal for stereo separation. 9v battery operation

FMST-100 $29.95
FMST Cabinet $8.95

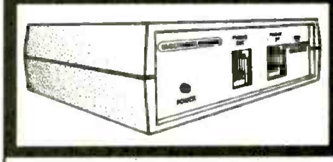
SUPER SNOOPER BIG EAR



Listen through walls, hear conversations across the room. Add a parabolic reflector and hear blocks away. The BIG EAR can be hidden about anywhere. Makes an ultra sensitive intercom. Can be used as a 1.5W AMP. We supply a mini-electret mike in the kit. SIZE: 1"x.75" 6 to 12vDC.

AA-1 **$10.95**

The Exciting New TELEPHONE MONITOR



Monitors your phone system, See how accurate your phone company really is!

1. **RECORDS OUTGOING CALLS :**
   - Date & time of each call.
   - Length of the call.
   - What number was dialed.
   - If you use a credit card it records the card number.
2. **RECORDS INCOMING CALLS :**
   - Date & time of call.
   - How many times phone rings.
   - If answered the length of call.
3. **RECORDS ANY DTMF TONE :**
   - Detects any tone on line sent by phone company or any other source.

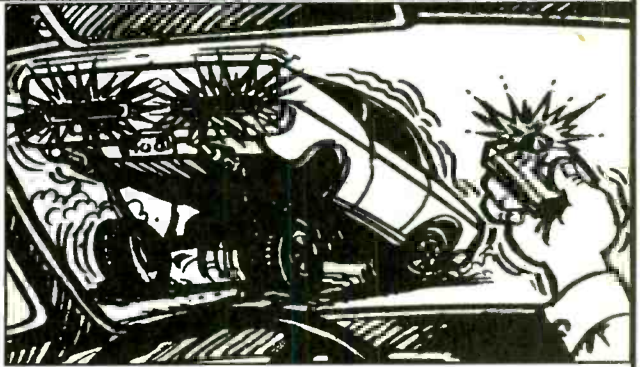
Records to Screen or Floppy Disk

EASY TO INSTALL
- Connects to parallel port
- Phone line in.
- Phone line out to telephone.

All software included!

TM-1 ONLY **$99.95** KIT

BUILT **$169.95**

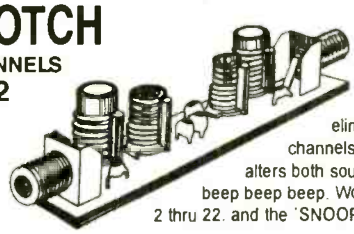


THE ZAPPER activates any radar detector within 3\4 of a mile. Check the brake lights of that sports car that just went by 90 miles an hour. Back off that 18 wheeler trying to eat your back bumper. Put the fun back in driving. THE ZAPPER is a 10GHz amateur transmitter the size of a cigarette pack, operates on a 9v battery, when the button is pushed, brake lights and radar detector light the skies. Complete with the rules of the new ROAD WARRIOR GAME...TROLLING FOR TAIL LIGHTS, Americas fastest growing highway participatory sport.

Built **$49.95**
Kit **$39.95**

TV NOTCH FILTERS

FOR CHANNELS 2 thru 22 ONLY

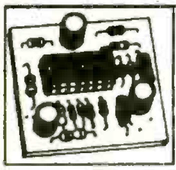


Our TV filters eliminate unwanted TV channels or interference that alters both sound and video with a beep beep beep. Works on cable channels 2 thru 22. and the 'SNOOPER & BULLET.

NOTE: All TV Filter Kits are sold for educational purposes only. You must obtain permission from your local cable company before using these filters on your cable system.

DF-222 Kit **$14.95**

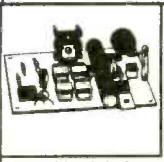
VOICE ACTIVATED SWITCH



This VOX circuit can be used to operate a tape recorder, ham radio, or CB radio, turn on an alarm. The VOX-1 kit has 100MA of output,that operates a relay, light, motor, ? What could you do with a sound activated switch? Size: .1.5"x1.3" 7.5 TO 18vDC.

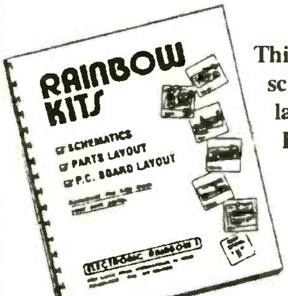
VOX-1 **$6.95**

STROBE LIGHT



If you need an attention getter, warning light, or flashing light for model airplanes, then this kit is for you. Use it as an emergency light for your auto, radio tower, even use it on your bicycle. Has a varible flash rate. Size 3.5"x1.8" operates on 6 or 12v DC only.

ST-1 **$9.95**

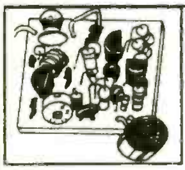


This Manual contains all schematics, parts lists & P.C. board layouts for all of the Rainbow Kits. Use your own parts to construct any of our kits.

KIT BOOK

$14.95 $9.95 with the purchase of any kit.

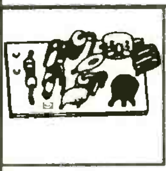
WIRELESS FM MICROPHONE



Small but mighty this little jewel will out perform most units many times its price. It really stomps out a signal. The WM-1 kit is a buffered wireless mike that operates from 80MHz to 120MHz FM , the frequency of any broadcast FM radio. Includes a mini-electret mike. SIZE: .8"x1" 6 to 12vDC

WM-1 **$14.95**

PHONE TRANSMITTER



Small but mighty, it fits anywhere. Phone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances. Variable tunes from 70MHz to 130MHz FM. You can also use it as a speaker phone. SIZE .5"x1".

TEL-B1 **$12.95**

4E

Please add sufficient postage First lb $5.00 Canada $7.00
Additional LB. Add $1.00 US FUNDS ONLY
We will accept telephone orders for Visa or Mastercard

MasterCard

To Order Call 317-291-7262

VISA

ELECTRONIC RAINBOW INC

6254 LaPas Trail • Indianapolis, IN 46268
FAX 317-291-7269

CIRCLE 140 ON FREE INFORMATION CARD

PE MARKET CENTER CLASSIFIEDS

MISCELLANEOUS ELECTRONICS FOR SALE

VIDEO GAME training videos for NES, Super NES and SEGA Genesis, tools, parts, schematics. Send SASE for free catalog. **Irata Systems**, 2562 East Glade Ave., Mesa, AZ 85204-6208.

THE CASE Against Patents. Thoroughly tested and proven alternatives that work in the real world. $28.50. **SYNERGETICS PRESS,** Box 809-C, Thatcher, AZ 85552. (602) 428-4073. Visa/MC.

TURBO CHARGE your amplifier. Guide to increase wattage of existing power amplifiers. Send $7.50 for complete book. JAM Electronics, 7391 St. Hwy 78, Gratiot, WI 53541.

EDUCATION

NEW! ADAPT-11 microcontroller module plugs vertically right into your solderless breadboard! No wire-wrapping or soldering required! Just breadboard your interface circuits and test-drive your 68HC11 designs instantly! Included software and serial cable make it a breeze to program with any PC! Re-useable thousands of times! Ideal for schools, students, hobbyists and experimenters! Also programs 68HC711 chips! Only $74.95! Quantity discounts available. TECHNOLOGICAL ARTS, Suite 102-418, 309 Aragona Boulevard, Virginia Beach, VA 23462.

FOR BEGINNERS, learn Elec. Tech. and or Computer Repair. You can order either Elec. Tech./Computer Repair 101 or Computer Repair 101. They come in a 4 tape set, each VHS tape is 2HRS. long. Taught at Occupational Center they cover some of the basics you need to know to start a career. To order send a check or money order of $49.95 (per set) to Mike Kolberg Productions, Box 791, Sun Valley, CA 91352.

Don't Despair...REPAIR!

Here's how to troubleshoot and repair your electronics successfully!

You Can Be Your Own Repair Expert!

For VCRs, camcorders, audio equipment, TV equipment, computer hardware, office equipment, home appliances, automobile electronics, and outdoor equipment.

- Pinpoint and analyze problems quickly.
- Successfully complete repairs with hands-on troubleshooting instructions.
- Become skilled understanding flowcharts and schematic diagrams.
- Confidently use test equipment such as oscilloscopes, frequency counters, and video analyzers.
- Keep your equipment in top condition with effective preventive maintenance techniques.

Continue to Broaden Your Repair Expertise!

You'll receive quarterly supplements, up to 160 pages, with new step-by-step repair and maintenance instructions, valuable schematics and new repair techniques. Learn how to repair a growing variety of appliances with hands-on repair projects that will keep you up-to-date with later models and technology. You'll be thrilled with your ability to repair a growing list of electronic equipment! Supplements may be returned or cancelled at any time.

One Source For All Your Repair Needs!

Better organized than a magazine, more current than a book.

- 900-page manual
- easy-to-follow, detailed instructions
- trouble analysis flowcharts
- safety precaution checklists
- comprehensive replacement parts list
- directory of manufacturers

Order your copy today!

SAVE $10

Call our toll-free number, pay by credit card, and mention this ad. We'll deduct $10! We'll also waive shipping and handling.

Order today for your 30-day, no-risk review of The Electronics Repair Manual.

For Faster Service Call TOLL-FREE

1-800-222-WEKA

Or Fax To: 1-203-622-4187

MONEYBACK GUARANTEE

There's no risk in trying the ELECTRONICS REPAIR MANUAL to see if it's right for you. If you are not delighted, simply return the manual after the 30-day trial period and receive a prompt refund.

97 Indian Field Rd.
Greenwich, CT 06830

☐ **YES!** Please rush me a copy of the new Electronics Repair Manual for only $59.95 + $5.50 shipping and handling. I understand that if I am not satisfied I may return the manual within 30 days for a complete refund. Supplements are sent quarterly for 25¢ per page (never more than $30) and may be returned or cancelled at any time.

☐ My payment is enclosed ☐ Bill me later

☐ Charge my ☐ Visa ☐ MasterCard

Acct. No.__________ Exp. Date______

Signature__________

Phone (   )__________ Signature and phone number are required for all orders.

Name__________

Address__________

City______ State____ Zip____

All payments must be in U.S. funds. Canada add $10. All other countries add $15. CT residents add 6% sales tax.

Mail to: WEKA Publishing, 97 Indian Field Rd., Greenwich, CT 06830

400094

PE MARKET CENTER CLASSIFIEDS

PLANS-KITS-SCHEMATICS

BUILD — FIVE-digit, ohms, capacitance, frequency, pulse, multimeter. Board and instructions $9.95. Bagnall Electronics, 179 May, Fairfield, CT 06430.

ALL-IN-ONE catalog. AM/FM/ham/spy, transmitters, amplifiers, receivers. Voice scramblers/disguisers, audio, TV, Tesla coils, plans, "secret" books, kits, imports, exports and more. Start your own licensed or unlicensed radio station, 60 full pages for $1.00. **PAN-COM INTERNATIONAL,** PO Box 130-H11, Paradise, CA 95967.

FM STEREO TRANSMITTER kit broadcasts any audio signal to FM stereo radios throughout your home. Uses unique BA1404 IC. Complete kit: PC board/components — $24.00. Visa/MC. **TENTRONIX,** 3605 Broken Arrow, Coeur d'Alene, ID 83814. (208) 664-2312.

ELECTRIC DOG DOOR, entrancing LED clock, CD scratch remover, awesome phones, plans, kits and more. Send $2.00 (refundable) for **cool stuff catalog. CAMPBELL ENTERPRISES,** 27955 Terrace PE11, North Olmsted, OH 44070-4962.

THE ONLY CATALOG NEEDED! Kits, plans, surveillance, test, radios, more! Part locating. Best prices! Send $1.50 (refundable) **NEUTRONICS,** 4 Croydon Ct., Englishtown, NJ 07726.

HOBBYIST CIRCUITS — Remote room monitor, tone decoder, long distance circuit control and more. Simple experiments for the beginner. **CATALOG** $2.00 — Garrett Plans, Box 155, Jamesburg, NJ 08831.

SURVEILLANCE TRANSMITTER kits. 65 to 305 MHz. **Quick & Easy.** Partially assembled units. Five minutes completion. 110-volt duplex receptacle, room battery types, and telephone. Countersurveillance. Catalog: $2.00. **SHEFFIELD ELECTRONICS,** PO Box 377940-B, Chicago, IL 60637-7940.

FASCINATING DEVICES! FREE plans with parts special! Super spy microphone $19.50! Super FM transmitter varactor tuned $22.50! Vocal truth detector $39.50! Bug detector 10 GHz bargraph, audible $47.50! Universal IC tester tests any IC $24.50! Hypersonic dazer defend yourself $34.50! Radar cloaker electronic shield $29.50! Laser jammer $39.50! PC Boards $10.00 each. Package of all 8 plans $25.00! S&H $5.00, catalog $4.00 (creditable) or included with order! **QUANTUM RESEARCH,** 17919 - 77th Avenue, Edmonton, Alberta, Canada T5T 2S1.

WAVEFORM VIEWER square sine other on monitor TV RF sweep applications filters circuits book $19.95, Waveform Viewer, PO Box 142042, Gainesville, FL 32614-2042.

SUPERIOR GUITAR EFFECT + FREE 3D. Wild-hot sound, also drives headphones, belt clip option, pre-amp ability. Build in one evening using Radio Shack parts! Plans $12.95 (+s/h). 24 hr sample/info (407) 727-0137. Visa/MC/Disc/AmEx.

WAVEFORM VIEWER uses TV monitor view audio sine square signals. RF applications build RF filters, sweep oscillators and detectors. $19.95 to Waveform Viewer, PO Box 142042, Gainesville, FL 32614-2040.

SATELLITE EQUIPMENT

SAVE $$$ TROUBLESHOOTING your satellite system yourself! Simplified manual $14.95: T. Dee, POB 858, Fleischmanns, NY 12430.

SATELLITE RADIO BOOK AND GUIDE. New book covers all audio services, SCPC, subcarriers, FM squared, facsimile, press services, weather services. Simple how-to-receive instructions. $16.95 plus $3.00 Priority Mail. UNIVERSAL ELECTRONICS, 4555 Groves Road, #12, Columbus, OH 43232. (614) 866-4605.

Countersurveillance

Never before has so much professional information on the art of detecting and eliminating electronic snooping devices—and how to defend against experienced information thieves—been placed in one VHS video. If you are a Fortune 500 CEO, an executive in any hi-tech industry, or a novice seeking entry into an honorable, rewarding field of work in countersurveillance, you must view this video presentation again and again.

CALL NOW!

1-516-293-3751

HAVE YOUR VISA or MC CARD AVAILABLE

Wake up! You may be the victim of stolen words—precious ideas that would have made you very wealthy! Yes, professionals, even rank amateurs, may be listening to your most private conversations.

Wake up! If you are not the victim, then you are surrounded by countless victims who need your help if you know how to discover telephone taps, locate bugs, or "sweep" a room clean.

There is a thriving professional service steeped in high-tech techniques that you can become a part of! But first, you must know and understand Countersurveilance Technology. Your very first insight into this highly rewarding field is made possible by a video VHS presentation that you cannot view on broadcast television, satellite, or cable. It presents an informative program prepared by professionals in the field who know their industry, its techniques, kinks and loopholes. Men who can tell you more in 45 minutes in a straightforward, exclusive talk than was ever attempted before.

Foiling Information Thieves

Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businnesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

CLAGGK INC. PE
P.O. Box 4099 • Farmingdale, NY 11735

Please rush my copy of the Countersurveillance Techniques Video VHS Cassette for a total cost of $53.95 each (which includes $4.00 postage and handling).

No. of Cassettes ordered ____________.
Amount of payment $____________.
Sales tax (N.Y.S. only) ____________.
Total enclosed ____________
Bill my ☐ VISA ☐ MasterCard
Card No. ____________
Expire Date _____ / _____
Signature ____________
Name ____________
Address ____________
City ____________ State ______ ZIP ________

All payments in U.S.A. funds. Canadians add $4.00 per VHS cassette. No foreign orders.

The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

The Dollars You Save

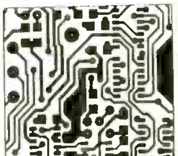
To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.

NEW EASY PC

BRITISH DESIGN AWARD

SCHEMATIC and PCB C.A.D

ONLY **$195**



Includes

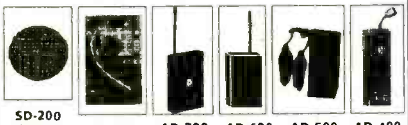
- MGA, CGA, EGA & VGA compatible.
- Design large multi layer boards.
- One level pull down menu and quick keys for fast layout.
- Dot matrix, laser, plotter, Gerber & N.C. drill output.
- 6 Month Free update Free Demo

OHIO AUTOMATION Inc.

7840 ANGEL RIDGE ROAD
ATHENS, OHIO 45701
(614) 592-1810
Visa & MasterCard Accepted

PROFESSIONAL SURVEILLANCE EQUIPMENT
Used By Law Enforcement Agencies

VHF-FM CRYSTAL CONTROLLED TRANSMITTERS
A - 139MHz, B - 139.970 MHz, C - 149 MHz, D - 149.450 MHz
All kits assemble in less than 5 mins.



SD-200	CX-102	AD-700	AD-600	AD-500	AD-400
Smoke Detector Camera w/Audio 400 lines .03 lux 10-14 VDC	Miniature Camera w/Audio 240 lines 2 lux 7-14 VDC	Mic Range: up to 5 Mile Power 750MW	Mic Range: up to .5 Mile Power 15MW	Tel. Range: up to .5 Mile Power 15MW	Mic Range: up to 2.5 Mile Power 400MW
$330	$235	$247	$125	$115	$155

We sell a variety of cameras, bug detectors, night vision equipment, video transmitters, time lapse recorders, remote video monitoring systems, and many more...

A&D ELECTRONICS
P.O. Box 601, Monsey, NY 10952
914-356-7541 • Fax 914-356-7505
Call for FREE catalog. Credit Cards accepted

Radiotelephone - Radiotelegraph

FCC Commercial License

Why Take Chances?

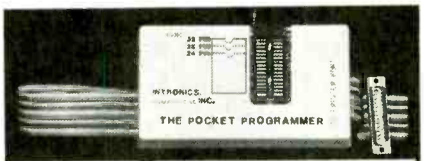
Discover how easy it is to pass the exams. Study with the most current materials available. Our **Homestudy** Guides, Audio, Video or PC "Q&A" pools make it so fast, easy and inexpensive. No college or experience needed. The new commercial FCC exams have been revised, covering updated Aviation, Marine, Radar, Microwave, New Rules & Regs, Digital Circuitry & more. We feature the Popular "Complete Electronic Career Guide" 1000's of satisfied customers **Guarantee** to pass or money back. Send for **FREE DETAILS** or call

1-800-800-7588

WPT Publications
7015 N.E. 61st Ave Dept. 10
Vancouver, WA 98661

Name_______________
Address_______________
City__________St._____Zip_______

1-800-800-7588



The Pocket Programmer

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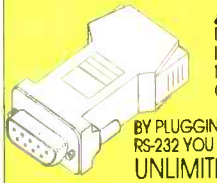

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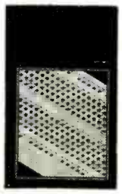

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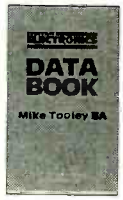

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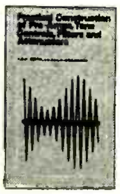

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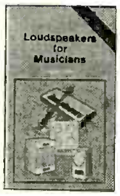

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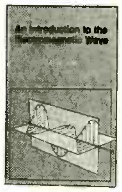

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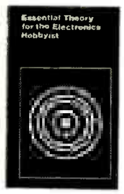

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