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CIRCLE 78 ON FREE INFORMATION CARD
41 LOW-COST SOFTWARE FOR CIRCUIT SIMULATION

The solderless breadboard is not dead yet, but its days might be numbered. Today, the preferred method for proving new circuit design is not to build it from actual components, but rather to build a virtual circuit in using circuit-simulation software. This month, we look at eight software packages that handle both analog and mixed-mode (analog and digital) circuits. All of the packages are priced at less than $300, and many interface with schematic-capture and printed-circuit board design software. Before you buy, check our reviews. Then download demo packages so you can sample them. — TJ Byers

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Electronics Now

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July 1996
Reversible optical switch

Researchers at the Georgia Institute of Technology, in a program sponsored by the National Science Foundation, are developing a light-activated optical switch that eventually could be the basis for a new type of rewritable three-dimensional data storage system. By using a small number of “trigger molecules” to induce a phase transition in liquid crystal materials, the system would write, read, and erase information using different forms of polarized and unpolarized light.

Dr. Gary B. Schuster, professor of chemistry at Georgia Tech, “You can read, write, and erase information in liquid crystal materials using this system.”

Schuster and his co-workers use “chiral” molecules to trigger changes in the liquid crystal. Chiral molecules exist in right-handed and left-handed forms. Each form is affected differently by circularly-polarized light, which also exists in right- and left-handed versions. For example, when right-handed chiral molecules are struck by left-handed light, they may be converted preferentially to left-handed molecules. If the chiral molecules are dissolved in a liquid crystal material, that structural change can be used to prompt a phase transition in the crystal.

The phase transition changes the optical properties of the liquid-crystal material. One way that change can be detected, or read, is by passing linearly-polarized light through the crystals. Because the linearly-polarized light can be at a wavelength that does not affect the chiral molecules, reading the stored information would not alter it.

Multiple phase transition “switches” could be used together to store digital information. That information could later be erased by shining unpolarized light through it, reversing the phase changes originally made by the circularly-polarized light. Because the molecules would be returned to their original state, the system would be truly rewritable.

The Georgia Tech team is developing trigger molecules made up of bi-cyclic ketones substituted with a styrene group. Those materials, which exhibit the greatest response to circularly-polarized light, satisfy most criteria needed for a two-dimensional switch.

However, the switches must be converted from two-dimensional layers to a true three-dimensional system before they become useful for optical data storage. “Furthermore, that would be useful only if you don’t have to write information a bit at a time, which means writing it holographically,” said Dr. Schuster. “If you could write three-dimensional holograms optically and read them, you would really have something worthwhile.”
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Small, Low-Cost, Atomic Clock

A cesium atomic clock now under development is smaller, consumes less power, and will cost less than existing commercial atomic clocks. The clock, invented at Westinghouse Electric Corporation's Science & Technology Center in Pittsburgh, is intended for precision timing in certain military and commercial systems where it is expected to replace the best crystal oscillators now available.

The Westinghouse clock is in a matchbox-size package containing a small cell filled with cesium vapor within a microwave cavity. A diode laser, which emits in the near infrared region at about 852 nanometers, raises the cesium atoms to a higher energy level. A microwave oscillator creates an electromagnetic field within the microwave cavity that excites the electrons in the cesium vapor.

The magnetic field partially returns the atoms to their base energy level, altering the transmission of infrared energy through the cell but only when the circuit's frequency precisely matches the resonant frequency of the cesium atoms. This occurs at about 9.192 gigahertz for a cesium atom.

The microwave oscillator is locked to 9.192 GHz by a feedback signal from a photodetector and an oscillator control circuit. The microwave oscillator, in turn, stabilizes the internal quartz crystal that provides a stable frequency output of 10 megahertz, to better than 0.0001 hertz.

Westinghouse researchers believe the cesium atomic clock has a place in systems that can benefit from more precise and stable timing than offered from the best crystal oscillators today. They do not see crystal oscillators that are now performing satisfactorily in computers and communications systems.

For example, the clock could become an important component in the aircraft location systems based on the Global Positioning System (GPS) that are being developed. They would replace other existing position-location systems. Military applications might include all-weather landing systems for aircraft and covert identification friend or foe (IFF) systems that would prevent accidental "friendly fire" on friendly aircraft, vehicles, ships, and troops.

Each of the 24 GPS satellites now contains an atomic clock, so it is believed that replacing the crystal oscillators in some GPS receivers with the atomic clocks would greatly enhance their accuracy. According to Westinghouse, the clocks would help to overcome the blocking of satellite signals due to nearby as well as interference from other radio frequency sources.

CES/COMDEX mega-show

In response to the accelerating con-vergence of computer and consumer-electronic technologies in the retail marketplace, the Consumer Electronics Manufacturers Association (CEMA) and SOFTBANK COMDEX Inc. have formed a strategic partnership. As part of the new initiative, COMDEX/Spring '97 and the Spring Consumer Electronics Show (CES) will run at the same time, from June 2–5, 1997, in Atlanta, Georgia.

The two organizations also announced the creation of a new trade show and conference specifically developed to address the convergent marketplace. The as-yet-unnamed venture will be held alongside the combined COMDEX/ CES event in Atlanta.

continued on page 10
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"TV/PC" standard sought

Thomson Consumer Electronics, which plans to test a TV set with major computer features in 100 consumer homes later this year, has called for talks between TV and PC manufacturers looking toward standards on picture tubes, processing power, and other features of such hybrids. The call met with mixed response, some competitors claiming that Thomson was merely trying to create a market for its fine-pitch 36-inch picture tubes. Thomson, however, said that it hopes the industry will "determine what the consumers really want and then position that product accordingly."

Thomson officials said that the company's test of "Genius Theater" will probably use its new fine-pitch 36-inch tube and include a digital VCR, a 100-disc DVD-ROM changer, a 28.8 modem, and a receiver box that can both handle Digital Satellite System (DSS) feeds and provide access to the Internet. The tests could result in a product next year selling at about $5000, according to Thomson.

Other TV manufacturers—including Mitsubishi and Toshiba—are also introducing TV sets with some computer capability. As reported here, direct-market computer manufacturer Gateway 2000 has started sales of its Destination system, consisting of a computer and TV combination with a 31-inch screen for living room use. Other computer makers have announced or are preparing "network computers"—low-cost systems designed to access the Internet using the home TV as a display. And, of course, video and TV cards are readily available for installation in PCs. Whether a "standard" is necessary or desirable is still a subject of controversy.

HDTV station on the way

Construction of America's first high-definition TV station soon will be under way, with the transmitter and compression encoder due to be installed before this year is over and local program production equipment in place early next year. The station will be built in Washington, D.C., by broadcasters and equipment makers and will be used for demonstrations to important decision makers, in addition to serving as a testing ground for equipment and program production. The three-year project is expected to cost $6,000,000 and will piggyback on an existing Washington TV station, which has not yet been selected. It's expected to broadcast in HDTV virtually full time. One Washington station—PBS affiliate WETA-TV—has already announced independently that it plans to broadcast in HDTV, and it could be a candidate for the experimental station project.

Meanwhile, the Advanced TV Test Center in Alexandria, Virginia, site of the system's tests, will be rechristened the Advanced TV Technology Center to better reflect its revised purpose—helping broadcast and TV-receiver industries make the transition form analog to digital television. That also will be financed by broadcasters and equipment makers and will serve as a test bed for RF and systems development for digital broadcasting. At our press time, the non-profit center was backed by CBS, PBS, and Pioneer Electronics, with other sponsors expected to join soon.

DVD timetable snagged

Whether the new DVD system will be ready in time for its scheduled fall debut is still unknown, but the barriers continue to arise one after another. Technically, that introduction date appears to be feasible, but there are still problems in the path of this high-density optical system, which is expected to revolutionize video and audio recording as well as computer storage.

Some progress has been made on one of the stickiest problems—the issue of protecting copyrights in the video version. Movie companies generally have been reluctant to commit to recording their recent films on the new medium because its digital nature makes it possible to bootleg almost perfect copies. The movie industry, represented by the Motion Picture Association of America (MPAA), and the EIA's Consumer Electronics Manufacturers Association (CEMA) have agreed on an anti-copy system and hope to propose it to Congress for legislation. However, computer manufacturers were barely consulted—or even informed of the progress of the talks. In some cases their interests are completely different from those of the film companies—copying is desired, or even required, for computer programs.

At press time, this dispute was nowhere near a resolution, although talks with the computer industry have started. And even if there is an agreement, there is no assurance that Congress will pass
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the bill requiring anti-copy protection during this Presidential election year. Even if it is passed, another question is whether it will be passed in time for manufacturers to modify the specifications for the products and still get them on the market this year. And it's not known whether movie companies will release their product on DVD if there is no law by the planned introduction time.

In addition, the movie companies are demanding a “regional coding” system for DVDs to make up for the fact that any DVD can be played on any DVD player, regardless of the television system in use in the country where it's played. As we’ve reported before, the movie makers want an encoding system to make it impossible for a viewer in England, for example, to play an American movie before it’s introduced in British theaters or while it's still on its first run. The most recent proposals envision encoding for five different regions worldwide. While this apparently is no great technical problem, it could mean another time-consuming change in the specifications.

**MPEG-1 push for PCs**

Even though DVD promises to produce better video pictures—on PCs as well as TV sets—four major companies have launched a joint effort to support the use of MPEG-1-based Video CD in personal computers. The companies are JVC, Matsushita (Panasonic), Philips (Magnavox), and Sony. They are urging computer program developers to incorporate “White Book” video in their programs, arguing that the population of MPEG-compatible computers already exceeds 5,000,000 in the United States and will pass 10,000,000 by the end of this year. The companies argue that whatever the shortcomings of MPEG-1, the White Book specifications are the first step toward MPEG-2, which will be available later via the DVD-ROM.

**WHAT'S NEWS**

*continued from page 6*

“As the crossover between the consumer electronics and computer industries has increasingly grown, so has the industry’s need for one consolidated Spring event which will serve both industries,” said CEMA president Gary Shapiro.

Jason Chudnowsky, president and CEO of SOFTBANK COMDEX, added, “By bringing together the power of COMDEX and CES, we will better service a global industry whose needs have become more diverse because of emerging technologies and merging channels of distribution. Clearly, by joining these two events, and creating this new show, we present the ideal venue by which to market and address the requirements of the consumer electronics, computer, and communications industries, collectively.”

CES and COMDEX each will continue to market and sell their respective events, while the new trade show and conference will be marketed and sold jointly by both organizations. Operational aspects for all three events will be handled by SOFTBANK COMDEX.

Each of the three trade shows represented in this “mega-event” will maintain its individual focus while enhancing the others and providing exhibitors and attendees with new business opportunities. Attendees to any one of the trade shows will gain the full benefit of the combines events at no additional cost.

**DVD copyright legislation sought**

Representatives of the consumer-electronics and motion-picture industries have agreed to seek legislation concerning digital video recorders that would protect both intellectual property and consumers rights. The Motion Picture Association of America (MPAA) and the Consumer Electronics Manufacturers Association (CEMA) plan to submit to Congress a recommendation that will allow the marketing of digital video recorders that provide VCR-like features—such as the ability to time-shift TV programs for later viewing—while giving copyright proprietors additional control over some types of recording in the age of “pristine” digital copies.

The recommendation would assure consumers’ unimpeded ability to make home video recordings of anything shown over broadcast or basic cable television, and allow consumers to make at least one copy of subscription or other “pay-cable” programming. Digital copies of that copy, however, may be prevented. And copyright holders would be allowed to prohibit consumers from copying from pay-per-view, video-on-demand programming and from pre-recorded media. Those provisions would apply only to digital recording devices and recordings made from digital sources with conventional analog VCRs. No royalties on recorders or blank media would be called for.

The recommendation also includes technical standards that assure compliance with the system. Manufacturers of recording and other devices involved in the transmission and playback of video programming would be required to comply with those standards. Finally, the recommendation includes a proposal of updating the system to take advantage of new technology.

**Semiconductor Orders Exceed Shipments**

The Semiconductor Industry Association (SIA) San Jose, Calif., reported a book-to-bill ratio of 1.18 in October, up from September’s 1.15 but below July’s record of 1.23. The book-to-bill ratio compares orders with shipments and is a bellwether of industry health. A number of more than one indicates positive growth, and a ratio of 1.18 indicates that for every $100 of devices shipped $118 of devices were ordered.

SIA also forecast that the North American market would grow 40.2% to $47.1 billion by the end of 1995. One reason for the gain, according to SIA, is continued strength in personal computer sales, but data communications, telecommunications, consumer electronics, and automotive are also doing very well.
Electronics Paperback Books

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- **WA6E**—How to Use OpAmps...
- **BP61**—Beginners Guide to Digital Techniques...
- **BP62**—Beginners Guide to Modern Electronics Components...
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- **BP254**—From Atoms to Amperees...
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- **PCP11**—Electronic Test Equipment Handbook...
- **BP17**—Introduction to Computer Communications...
- **BP177**—Introduction to Computer Communications...
- **BP179**—Electronic Board Games...
- **BP350**—Electronic Board Games...
- **BP390**—PCP111—Everyday Electronics Data Book...
- **BP310**—Electronic Power Supply Handbook...
- **BP311**—Electronic Power Supply Handbook...
- **BP315**—Introduction to the Electro-magnetic Wave...
- **BP322**—Essential Theory for the Hobbyist...

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**Negative resistance**

Q When working with parallel circuits, I was taught that the total resistance is always less than the smallest of the resistances in parallel. However, I recently ran across a reference that said this is not true if one of the resistances is negative in an active circuit. What is meant by this?—K.S., Brooklyn, NY

A As you surmise, there is no such thing as a negative resistor—that is, there is no component which, without an external power source, will “help electrons along” and undo the effect of a positive resistance. Even a battery doesn’t have negative resistance in this sense, because it produces a constant voltage rather than a voltage proportional to current.

Negative resistance in electronic theory refers to either of two things. First, some components have a negative dynamic resistance. That is, under some conditions, the component suddenly “breaks down” and begins to conduct heavily, so that the voltage across it can decrease while the conduction is increasing—the opposite of what happens in a resistor. Another way of looking at negative dynamic resistance is to say that the component’s (real, positive) resistance suddenly drops when a particular voltage is reached. The familiar neon lamp oscillator (Fig. 1) is an example.

Second, some op-amp circuits are set up so that the current in a particular place is the exact opposite of what it would have been if a simple resistor or capacitor had been there. Circuits of this type are called negative-impedance converters (NICs). They are useful because they make capacitors act like inductors, eliminating the need for coils in filter circuits.

**Remote Sensing of Driveway Gates**

Q I have a 200-foot driveway with electric gates at the end of it. I cannot see the gates from the house and cannot tell if they are open or closed. My thought is to install a magnetic reed switch on one gate and a magnet on the other, but I need a circuit that uses low power and will light a bulb that will not get hot if the gates are left open several hours. The wiring is already installed from the gates to the house. For a power source, I would like to use a doorbell transformer (24 volts AC) that is used for my gate doorbell/intercom. Could you come up with a circuit for me?—G. Holst, Los Gatos, CA

A Figure 3 shows the circuit that you need. Light emitting diodes (LEDs) run cool and last practically forever. With an AC power source, you’ll need two LEDs wired back-to-back as shown in the diagram; each LED protects the other one from reverse voltage. You can use red, yellow, green, or blue LEDs; you can even get a bi-color LED (red and green) mounted together in the same lump of plastic, and when they’re both lit, the combina-
Where to Take Audio Output

Q I'm thinking of increasing the power output of my integrated amplifier by adding a separate power amplifier. However, my integrated amplifier does not have preamp-output terminals. Can I connect the power amp to the integrated amplifier's headphone jack? — E. A. C., Calgary, Alberta.

A Yes. The signal at a headphone output is equivalent to line-level (i.e., about 1 volt peak to peak); the main difference is that headphone outputs can drive heavier loads than ordinary line-level outputs.

However, any noise or distortion originating in the final stages of the integrated amplifier will be present in the headphone signal. An amplifier with pre-out terminals would let you bypass the final stages and get somewhat higher quality. The difference may or may not be significant depending on whether your main need is for higher fidelity or just more sound (to fill a large room or overcome background noise).

AM receiver sensitivity

Q After much research on automobile radios I have determined that the performance of all recent radios is specified only for FM reception. As far as AM is concerned, "you get what you get" and it is

E. A. S., Lambertville, N.J.

A The car radios that we've used lately have excellent sensitivity on AM, at least as good as their counterparts of 30 years ago. The reason sensitivity isn't specified is that all good AM radios are sensitive enough to pick up atmospheric noise, and there's no point in adding more sensitivity beyond that point.

You might want to compare the car radio to a good line-powered radio at the same location. If the car radio is

HOW TO GET INFORMATION ABOUT ELECTRONICS

Books: Several good introductory electronics books, including Building Power Supplies, are available at Radio Shack.

Our favorite general electronics textbook is The Art of Electronics, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 1-800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is The ARRL Handbook for Radio Amateurs, comprising 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham radio equipment dealers.

Copies of past articles in Electronics Now, Radio-Electronics, Popular Electronics, and Hands-On Electronics are available from our Reprint Bookstore, 500-B Bi-County Road, Farmingdale, NY 11735 (1-516-293-3000).

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Service manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214 (1-800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, Box 637, Spanaway, WA 98387.

Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including Radio Shack on special order). The ECG, NTE, and SK lines contain just a few hundred parts which substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations can be located by writing to the American Radio Relay League (Newington, CT 06111). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts both amateur and professional.

Writing to Q&A: We welcome your questions. The most interesting ones are answered in print, usually within 9 months. Please be sure to include plenty of background information (we'll shorten your letter for publication). If you are asking about a circuit, please include a complete diagram. We regret that we cannot give personal replies.
disappointing, there are two obvious opportunities for improvement. One is to reduce engine noise by using standard techniques (see the ARRL Handbook for Radio Amateurs). The other is to install a longer antenna. Almost all car radio antennas nowadays are 30-inch whips tuned for optimum FM performance. Older-style, 5-foot antennas pick up AM noticeably better.

Of course, if the radio has an AM antenna trimmer, it should be adjusted for best performance at the frequency of most interest to you. This is typically a screwdriver adjustment which you access by pulling off a knob, as described in the radio's instruction book. Not all radios have them, however.

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**Care and feeding of lead-acid battery**

Q I have replaced my camcorder's aging and pesky nickel-cadmium battery with a 12-volt, 2-ampere-hour sealed lead-acid battery, together with some circuitry to reduce the voltage to about 6.3 V. What is the correct float charge voltage for the battery, and should the charger be connected to it through two paralleled 12-volt 1-amp light bulbs? — W. A. E., North York, Ont., Canada.

A The correct float charge voltage for a 12-volt lead-acid battery is about 14.1 volts. Whether you need light bulbs or other current limiting components depends entirely on the design of your charger; the two light bulbs, as you suggest, will do fine if you are charging from a regulated power supply that can deliver 2 amps. If you want to limit the charging current to a maximum of 1 amp, use just one light bulb.

Since you need 6.3 volts, it might be simpler to use a 6-volt lead-acid battery, which will give exactly 6.3 volts under normal conditions.

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**Complicated timer/controller**

Q I am trying to design and build a timer/controller with a programmable timer to allow it to activate at 4 or more selected times of day. I would also like the controller to respond to light (sunrise and sunset), and I'd like to remotely activate it from a distance of 300 yards. Can you recommend a set of ICs and a schematic that will produce these results? — D. R., Houston, Tex.

A You don’t need a circuit, you need a computer. That is, the way to build your timer/controller is to write a suitable program for a microcontroller.

Once programmed, the microcontroller runs on battery power with just a few support components. Many microcontrollers include analog-to-digital converters (to which you could connect a photocell); all of them have digital output ports that can be used to control relays, motors, and the like.
The easiest microcontroller to get started with is probably the Parallax "BASIC Stamp," described in Don Lancaster's column in this magazine in several recent issues (starting May 1995). It costs $29 and is programmed in BASIC. The manufacturer is Parallax, Inc., 3805 Atherton Road, Rocklin, CA 95765. If you can handle assembly language, you may prefer a Microchip PIC or Philips 87C750, each of which costs only a few dollars.

Your 500-yard remote-control requirement is tougher. Can you use a long cable? If so, an RS-232 link to a PC, at a low baud rate, should work fine. Radio control is not so easy; nobody has come up with cheap and easy homebrew radio modems yet.

TRANSISTOR DATA BOOKS

Q Can you recommend the most up-to-date books or manuals that contain the operating curves and characteristics of most all transistors (domestic and foreign)?—A. Wiegand, Helena, MT

Unfortunately, there is no comprehensive book of that type, as far as we know. Fortunately, it isn't necessary. Unlike a tube, a transistor doesn't have a well-defined set of characteristic curves; two transistors of the same type may differ in gain by a factor of 10 or more. The only characteristics of a transistor that you can rely on are the polarity (PNP vs. NPN), material (usually silicon), packaging, pinout, and maximum ratings.

The simplest way to find out about a transistor is to look it up in the ECG or NTE substitution directory, and read off the characteristics of the corresponding ECG or NTE substitute. The maximum ratings for the original transistor might be slightly lower than those of the substitute.

Many popular industrial transistors are described in books published by Motorola, National Semiconductor, and Philips. You can get directories of Japanese transistors from MCM Electronics (call 1-800-543-4330 and ask for a catalog).
THE FUTURE IS NOW

Magnetically-propelled trains operating on conventional rails ("What's News," Electronics Now, January 1996) are not new. Such a system has been operating here for the past 10 years. SkyTrain, as it is called, operates on a 28-kilometer, mostly elevated guideway serving the cities of Surrey, New Westminster, Burnaby, and Vancouver.

On-board linear induction motors push against a central reaction rail, consisting of a series of aluminum plates located on the side of the guideway. The cars are driverless, controlled by on-board computers linked to a control center. The top speed is about 80 kilometers per hour, or 50 miles per hour. That does not seem particularly fast, but it appears quite rapid compared to the snail-paced, grid-locked automobile traffic over which it passes. The route, including 20 station stops, is covered in 39 minutes. Trains run every five minutes.

Just because the cars are driverless does not mean the system is unmanned. On-board personnel check tickets and maintain order. As a result, the system is virtually graffiti-free and as safe, or safer, than any similar conventional system. Most of the public complaints about SkyTrain come from those who are not served by it and would like to see the system extended to their areas.

Similar, smaller systems using the same technology operate around downtown Detroit and also in the Toronto suburb of Scarborough.

DAVE ELEY
Surrey, British Columbia, Canada

KUDOS FOR THE ATV TRANSMITTER

I just finished reading "Amateur TV Transmitter" in the May issue, and would like to thank you for publishing William Sheets and Rudolf Graf, who write the most interesting articles in Electronics Now.

I look forward to the upcoming article on the downconverter, and, I hope, a few more details on the corner reflector and other antennas used on this project. Perhaps expanding on the few alluring references to airborne remote-control models would make for another interesting series of articles ... which would, in turn, more than justify my subscription for another year or two!

JAMES M. FOSTER, KD6GEJ
Cardiff by the Sea, CA

Check out page 57 in this issue to discover the complete plans for a matching UHF corner-reflector antenna for the ATV transmitter and downconverter projects.

In the August, 1996 issue we'll present plans for a UHF discone antenna that's easy to build and functions perfectly.

NO MORE MAC ATTACKS!

Randy Jones' letter titled "Sorry, Mac" (Electronics Now, May 1996) was a hoot! Those poor Mac users out there! They can't find any software at the local Walmart; they can't go down to the gas station and get a new fan belt for their "Daimler Benz" Macs; and, worst of all, they can't call Microsoft and hark in the superb tech support for Windows. What a joke! He even trotted out the tired old Betamax analogy (never heard that one before).

The fact is that people have been using those lame arguments to predict the imminent demise of the Mac ever since it was first rolled out in 1984. And, like the Energizer bunny (to use another tired analogy), they keep going, and going, and going. My advice to Mr. Jones is to get out of the "break rooms" and obtain some first-hand information.

I receive about a dozen different Mac-only mail-order catalogs each week. Last week, after researching the products in three different Mac magazines, I called one of the companies at 7 PM and ordered a third-party Mac peripheral. I received the
merchandise at 9 AM the next day (at no extra charge).

Here is what happened next: I opened the box, attached the power cord and SCSI cable to my Mac, turned it on, and began using it immediately! Sorry, I can't tell you how good the tech support was because I didn't need any. In fact, I haven't called any tech support hot lines since I stopped using Microsoft QuickBasic and switched to FutureBasic. I do miss the Microsoft DJ though! "Average hold time in the Windows group is 47 minutes. Now back to the hits!" Ha, ha, ha!

"You can't get any software for the Mac," is the oft-heard argument, yet the average Mac user has (and uses productively) more applications than the average PC user. Installing new applications is no big deal on the Mac, and neither is learning how to use them. Maybe there are only 5000 Mac software products out there, instead of 20,000 (I don't know the real numbers), but the only ones that really matter are the ones you actually use productively.

The real question is why the PC world feels so threatened by the Mac, and why is it so obsessed with stamping it out? I read PC magazines, too (including Jeff Holtzman's column in Electronics Now), and it is always Mac this, Mac that. Yet the Wintel platform is rarely mentioned in the Mac publications.

The truth is, we don't care, we go happily about our business, immune from the multitude of hassles faced by the average Wintel user. Does the PC community really think their interests will be served if the Mac goes away and personal computing really becomes a Bill Gates monopoly? Actually, I think Bill has bigger fish to fry—watch out Unix!

NEAL DUNCAN
Washington, DC.

ERRATA SHEETS AVAILABLE

A full-page ad for our books, "Communications Licensing and Certification Examinations," and "Practice Tests for Communications Licensing and Certification Examinations" recently appeared in Electronics Now. We regret, however, that some errors were published in the books.

We are offering errata sheets to anyone who has purchased one or both books. Those wishing to receive the errata sheets should send a stamped, self-addressed envelope to the address that follows.

SAM WILSON AND JOE RISSE
P. O. Box 2077
Melbourne, FL 32902-2077
The Ramsey Electronics FM-25 kit lets you build a FM stereo broadcaster and put your signal anywhere on the FM band. Why would you want to do that? Well, the reasons are numerous. How about using it as a kind of whole-house audio system? With the FM-25, you could listen to your CD changer anywhere in the house where you had an FM receiver. Better yet, you could listen to it outside with a portable radio. We find that it's a great way to enjoy commercial-free music when we have some friends over.

We also find the FM-25 a great way to let us listen to our favorite radio station on a personal portable when we're outside doing yard work. It just so happens that our favorite station has a low-power transmitter operating from a university about 30 miles away. We have no problem picking up the signal with a rooftop antenna, but we have almost no luck on a portable. Now, we can feed the output of our stereo receiver into the FM-25, and then re-broadcast it to our portable.

Building the transmitter
The FM-25 kit is relatively easy to build. All of the components are mounted on a single-sided printed-circuit board. The component side of the board is silk-screened with the location of all parts. The solder side of the board features a solder mask that help to reduce the chance of creating an inadvertent solder bridge across adjacent pads. An experienced builder should be able to assemble the kit in one evening; a beginner will probably require twice that to complete the 265 solder points.

The heart of the circuit consists of three integrated circuits: a Rohm BA1404 stereo transmitter IC, a Motorola MC145170 phase-locked loop (PLL) frequency synthesizer with serial interface, and a 68HC705 8-bit microcontroller.

The Rohm chip was originally designed for use in automotive CD systems, where it would allow signals from the CD player to be fed to the existing audio system throughout the antenna input. As it turns out, of course, the BA1404 also makes an excellent stereo broadcaster.

One potential problem with FM transmitters comes into play when a digital tuner is used to receive them. If the transmitted signal isn't exactly on frequency, the receiver won't be able to receive it. Analog radios, of course, can tune in an off-frequency signal without problems. A digital receiver, with its discrete tuning steps, cannot. The MC145170 PLL and the 68HC705 8-bit microcontroller ensure good on-frequency performance.

The microcontroller looks at the settings of three DIP switches to determine the frequency of operation. Each DIP switch has four positions, and they allow the frequency to be entered in binary-coded decimal format. For example, to set the transmitter to a frequency of 89.9 MHz, the switches would be set, in binary, to 8, 9, and 9 respectively. For frequencies above 100 MHz, the first switch would be set to a value of 10.

The microcontroller is smart enough to disallow any illegal frequencies. For example, only the first DIP switch can be set to a value of 10. Any other switch setting greater than 9 will be read as a zero. Also, and out-of-band frequencies will not be allowed, and the transmitter will default to a frequency of 88.1 MHz.

After the microcontroller reads the switches, it sends the 16 bits of frequency information to the PLL frequency synthesizer serially. An additional 32 control bits of control information are also sent.

The PLL IC operates with a 4-MHz crystal. Under control of the microprocessor, it divides the 4-MHz clock by 40 to obtain a stable reference frequency of 100 kHz. The PLL also examines the output of the BA1404 FM transmitter chip and divides it by N, where N is the desired frequency in megahertz times 10.

Using the example frequency of 89.9 MHz, the PLL would divide the output of the transmitter chip by 899, and compare it with the 100-kHz reference frequency. It uses this information to increase or decrease the voltage across a varactor diode.

A varactor diode is a specially
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July, 1996 Electronics Now
INTEGRATED PDA SOLUTION

PHILIPS SEMICONDUCTORS' PR31100 and UCB1100 with software fax/modem represent a two-chip solution for personal digital assistants (PDAs), personal intelligent communicators (PICs), and other smart communication products. The chipset offers size, cost, and power-consumption improvements, and, according to Philips, "will bring device prices low enough to change the way people think about PDAs."

Because the chipset provides virtually all the functionality needed for a PDA or PIC in just two ICs, most such devices will require only the addition of memory. Competing solutions require a processor and other off-the-shelf chips in addition to one or more custom chips. That approach makes PDA/PICs large and expensive, shortens battery life, lengthens the hardware design cycle, and requires customized software.

In contrast, the PR31100 and UCB1100 allow designers to create various types of wired or wireless PDAs, PICs, screen phones (which allow users to handle phone-related information and over-the-line data on a computer-like display), or Internet access terminals (low-cost, plug-and-play devices that use a TV as a display), simply by taking advantage of different chipset functions. Those applications share the common feature set of LCD display, input via touchscreen and optional keyboard, and communication via telephone lines.

To support those applications, the PR31100 contains an MIPS R3000 RISC core with 4 Kbytes of instruction cache and 1 Kbyte of data cache, plus a hardware multiply/accumulate unit to perform DSP functions. Those computing resources allow the PR31100 to run routines such as the V.32bis (14.4 Kbps) software fax/modem, voice recognition of about 100 words, echo cancellation for high-quality speakerphone performance, and handwriting recognition. Working with a 14-bit telecom codec in the UCB1100, the Philips-licensed software fax/modem eliminates the need for an external modem chipset, which would cost about $30—almost as much as the chipset and software combined. The PR31100's other features include a complete video controller for both color and monochrome LCDs, along with several industry-standard communications channels.

In addition to the telecom codec, the mixed-signal UCB1100 provides a 12-bit audio codec, a touchscreen interface, four general-purpose analog-to-digital converter inputs (battery voltage measurement), and 10 programmable I/O lines. All of those resources are designed to minimize or eliminate external components. Philips supplies low-level software drivers and reference designs for the main PR31100/UCB1100 applications. Complete development support is available. The PR31100/UCB1100 chipset and the software fax/modem license costs $38 in 100,000-unit quantities.

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HC PROTEK'S MODEL D-980 is a highly accurate, 3-3/4-digit multimeter that meets UL standard 1244 specifications. It comes with a protective holster to guard against mishandling, and features an LCD readout and a 3200-count analog bar graph.

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The Model D-980 costs $69.

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contact arrangement, and is also available in a dual-coil latching type. The R72 relays offer coil voltages of 5, 6, 12, and 24 volts DC. The DC operating temperature range is −40°C to +70°C. Dielectric strength is 1000 volts AC between coil and contacts, 250 volts AC (latching) between set and reset coils, 750 volts AC between contacts of the same polarity, and 1000 volts AC between contacts of different polarity. Resistance is 50 megohms maximum.

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**8×2 AUDIO MIXER-ON-A-CHIP**

ANALOG DEVICES’ SSM2163 IS A functionally complete 8-input audio mixer-on-a-chip. It accepts eight audio channels, provides user-friendly control of volume in 63-dB steps, and can mix individual channels to either the right, the left, or both outputs. It is well-suited for automating many computer audio systems, from high-end multimedia workstations to low-cost PC soundcards. Other applications include professional audio mixing consoles, broadcast equipment, intercom and paging systems, and musical instruments.

The device replaces expensive multichip solutions and improves audio fidelity in computer audio systems. With its industry-standard three-wire serial interface and one data output terminal multiple SSM2163s can be easily daisy-chained for high-end multi-track audio systems. A single mute pin, when driven by a microprocessor reset signal, will silence all eight audio channels simultaneously. No additional external components are needed for fully specified operation.

The SSM2163 is a companion to Analog Devices’ family of stereo codecs. It signal-to-noise ratio is −82 dBu (0 dBu = 0.775 volts rms), with an additional 10 dBu of headroom, resulting in a total harmonic dynamic range of 92 dBu. Total harmonic distortion plus noise is a low 0.007% at 1 kHz with all levels set for unity gain. The mixer-in-a-chip can be powered by a single (±5- to ±14-volt) supply or dual (±4- to ±14-volt) supplies and is available in 28-pin plastic DIP and SOIC packages.

The SSM2163 costs $8 each in quantities of 100.

**ANALOG DEVICES, INC.**

Ray Stratton Technology Center
804 Woburn Street
Wilmington, MA 01887
Phone: 617-937-1428
Fax: 617-821-4273

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**BREAK’R TRAC’R CIRCUIT TRACER**

AMPROBE’S BREAK’R TRAC’R BT-100 circuit tracer allows the user to quickly and easily determine the 120-volt AC circuit breaker or fuse that supplies a receptacle or lighting fixture. Well-suited for residential applications, the BT-100 saves time by eliminating trial-and-error troubleshooting and allows breakers to be identified without shutting off power. The two-piece set consists of a small handheld receiver, the BT-100R, which emits an audible tone and displays and LED when the signal, pro-

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**LINEAR AMPLIFIERS**

AMERITRON’S AL-800 AND AL-800H AMPLIFIERS PROVIDE ALL-BAND OPERATION: 160–15 meters, including the WARC bands. They can be modified by the user for 12 and 10 meters. The AL-800H uses two Genuine Eimac 3CX800A7s tubes and boasts 1500 watts “plus.” The AL-800 uses one 3CX800A7 tube and powers up to 1250 watts.

Both amplifiers feature an adjustable slug tuned input circuit and a Pi/(Pi-L) output network, providing smooth tuning and a wide matching range. The amplifiers’ grid current limits circuits and protects the tubes. Both display an adjustable front panel and true ALC control. Vernier reduction drives tune and load and make adjustments smooth and easy. A user-modifiable, 32-pound, grain-oriented, silicone steel-core transformer is supplied with high-capacitance computer-grade filter capacitors. Both amplifiers come with dual illuminated cross-needle meters that read peak forward power, reflected power, SWORE high voltage, grid current, and plate current. Other features include multi-voltage operation and air-cooled ventilation systems.

The AL-800H amplifier costs $2295.

**AMERITRON**

116 Willow Road
Starkville, MS 39759
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providing the transmitter (BT-100T), is sensed on the appropriate circuit breaker or fuse. Adjustable sensitivity on the receiver enables the appropriate breaker or fuse to be identified.

The Break'r Trac'r BT-100 carries a trade price of $39.85.

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**NOTEBOOK-COMPUTER CASE**

THE CURTIS CASE FROM Rolodex is a cleverly designed carrying case for notebook computers. It features moveable, self-grip accessories that allow users to customize the case to suit their work habits. The case also features built-in wiring ports, allowing users to run cables through the bag and connect directly into an optional retractable-cord surge protector, in effect creating a portable workstation. The case comes with a key-chain, pen holder, and disk holder. Other self-grip accessories, including a note holder, an eyeglass holder, a cellular-phone holder, all-purpose pockets, accessory pouches and a disk wallet, are available separately.

The lightweight Curtis Case features a protective shell over a frame constructed of durable polypropylene for extra strength. An internal flexible strap and shock-absorbing corners secure the notebook PC firmly inside the bag. The reinforced handle is fastened directly through the frame.

The Curtis Case costs $149 in black leather, or $119 in black vinyl. The retractable-cord surge protector, which fits neatly into the case's pocket, provides protection on the AC line and modem/fax lines, and includes a six-foot telephone cord, costs $9.95 with the purchase of the bag. Additional accessories have suggested retail prices of $4.00 each.

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High-quality computer graphics can be used to create virtual rooms for architects or guided tours of human cells for students and doctors.

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Principles of Digital Audio
Third Edition
by Ken C. Pohlmann
McGraw-Hill Book Company
11 West 19th Street
New York, NY 10011
Phone: 1-800-2-MCGRAW
$44.95

This comprehensive introduction to digital audio, now in its third edition, has been updated and expanded to introduce both audio and computer users to the many new technologies that are transforming the field. Aimed at both professional designers and engineering students, the book provides complete details on advances in such areas as optical disc reading, interfacing and networking, perceptual coding theory and applications, and digital audio broadcasting.

The book combines digital audio theory with examples of applications and provides an in-depth database of valuable digital audio information. It includes coverage of digital audio fundamentals, recording and reproduction, error correction, magnetic tape storage, optical storage and transmission, compact disc formats, satellite broadcasting, MPEG coding, digital audio workstations, and digital signal processing. The book reveals all the exciting breakthroughs in digital audio technology for the multimedia age.

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This catalog features test accessories intended to enhance test equipment from leading manufacturers. Leading off the newest products are complete “take-it-with-you” test kits in carrying cases designed specifically for use with Fluke, Hewlett-Packard, or Tektronix meters and oscilloscopes. The Test Companion kits also include high-quality Pomona test leads, probes, grabbers, and clips, all organized in lightweight, durable carrying cases. The catalog also features DMM test accessories and kits, oscilloscope probes, test clips, cable assemblies, coaxial adapters and kits, banana plugs, enclosures, and IC test clips for popular two- and four-sided devices including new solder-on adapters.
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This 112-page catalog covers equipment for amateur, shortwave, and scanner enthusiasts, and also features an impressive selection of antennas, head-phones, books, and accessories. Several new items premiering in this catalog include the Kenwood TS-870S transceiver, the Sangean ATS-909 portable receiver, the Lowe HF-250 receiver, the AOR AR5000 receiver, the Grundig Traveller II digital receiver, and the Sony ICF-SW1000T receiver/recorder. Many new antennas and accessories are also introduced. In addition, the catalog provides answers to frequently asked questions in comprehensive, one-page introductions to shortwave, radioteletype, and amateur radio.

NetLaw: Your Rights in the Online World
by Lance Rose
Osborne McGraw-Hill
2600 Tenth Street
Berkeley, CA 94710
Phone: 1-800-822-8158
$19.95

In the brave new world of cyberspace, online legal rights are continuously evolving. Issues like privacy, copyrights, and freedom of speech don’t necessarily work the same way in a digital environment, and rights to which you may be accustomed in print or broadcast media might not apply. System operators and BBS users alike need to know their rights, as well as the legal risks involved in online communications.

This book provides an introduction to the world of online law, explaining how everyday online behavior is protected or prohibited under the law. Using fascinating case studies, it covers the hottest and most widely debated topics affecting system users and operators, including commercial relationships, ownership of information, searches and seizures, and sexually explicit materials. The book discusses the potential demise of the copyright on the Internet, the legal risks faced by corporations online, how the First Amendment protects online systems and users, how to make an online contract, and how obscenity is defined and which laws apply to it.

45 Simple Electronic Terminal Block Projects
by R. Bebbington
Electronics Technology Today Inc.
P.O. Box 240
Massapequa Park, NY 11762-0240
$6.25 (plus $3 shipping and handling)

When soldering is off-limits (for absolute beginners in electronics, particularly youngsters), simple terminal block projects offer a safe introduction to the hobby. The 45 projects presented in this book not only do not require soldering, but also are powered by nothing more dangerous than a small battery. They meet the most stringent safety standards.

All of the projects can be constructed by complete newcomers to electronics, on terminal blocks using only a screwdriver and other simple

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July 1996, Electronics Now
hand tools. By following the layout diagrams, most of the projects can be finished in a matter of minutes. And they can be readily unscrewed, if desired, to make new circuits using the same parts. A theoretical circuit diagram is included with each project to help broaden the hobbyist's experience and knowledge.

The projects cover a wide range of interests. They fall under the chapter headings: Connections and Components, Sound and Music, Entertainment, Security Devices, Communication, and Test and Measuring.

**1996 Power Supply Catalog**

Lambda Electronics Inc.
515 Broad Hollow Road
Melville, NY 11747
Phone: 516-694-4200

Free

This 192-page catalog contains detailed specifications, mechanical drawings, and prices of more than 1000 power supplies, DC-DC converters, power systems, and accessories.

The catalog features more than 200 new products. Listed for the first time is the SV Series of low-cost, single- and multiple-output, power supplies from 100 to 300 watts; the PM Series of low-profile, low-cost 10-watt to 30-watt converters, specifically designed for telecommunications, computer, and data-communications applications; the Ultraflex Series of standard, modular power supplies for 400- and 600-watt applications with 1 to 10 outputs; and the FE Series of high-density distributed power front ends for 24- and 48-volt DC converters, intended for computer and telecommunications uses. The RM Series 12-watt to 100-watt DC-DC converters, which offer 90% efficiency and do not require a heatsink, are well-suited for telecommunications applications such as broad-band distribution, ATM exchanges, LANs, and multimedia systems.

**FRAMM Technology Overview**

Dynamem Inc.
22 Manchester Road
Derry, NH 03038
Phone: 603-432-1200
Fax: 603-432-0361

Free

Dynamem's patented Foldable Rigid Assembly Memory Module (FRAMM) technology, which can increase PC and workstation working memory by as much as 200 percent, is described in this four-page brochure.

The memory increase is achieved through the folding of the module's flexible, multi-layered circuit board, on which the memory chips are mounted. The resulting surface area and memory capability of the module are at least twice that of a standard module of the same dimensions. The brochure outlines additional benefits of FRAMM technology, including ease of installation and cost-effectiveness. (Please use a company letterhead when requesting the brochure.)

**1996 Test & Measurement Products Catalog**

LeCroy
Customer Care Center
700 Chestnut Ridge Road
Chestnut Ridge, NY 10977-6499
Phone: 1-800-5-LECREY
Fax: 914-578-5985

Free

This 194-page catalog features LeCroy's complete lines of test and measurement products, including the 9300 Series portable digital oscilloscopes, software and hardware options, probes and accessories, waveform generators, and programmable pulse generators. In addition, the catalog provides a wealth of technical information, including in-depth tutorials on the fundamentals of digital storage scopes and creating waveforms.

Application notes cover digital storage oscilloscope (DSO) applications in high-speed electronics, finding intermittent faults in electronic signals, the benefits of long memory in digital scopes, new tools for wireless design, and the benefits of DSOs in communications and power-supply design and testing. A comprehensive glossary of technical and test-instruments terms is also included.

**Semiconductor Essentials for Hobbyists, Technicians & Engineers**

by Stephen Kamickich
Prompt Publications
2647 Waterfront Parkway, East Drive
Indianapolis, IN 46214-2012
Phone: 800-428-7267 or 317-298-5710
Fax: 317-298-5604

$16.95

This book represents the first course in electronics at the technical and engineering levels. The information it offers will help readers gain hands-on knowledge of semiconductor diodes and transistors. The book covers semiconductor and diode chemistry, rectifier diodes, Zener diodes, transistor chemistry, transistor DC and AC analysis, transistor biasing, and it details transistor and rectifier diode circuits.

Each chapter is a lesson in electronics, with problems at the end of the chapter to test the reader's understanding of the material presented. The generously illustrated book serves as a useful instructional tool for the student and hobbyist, as well as a practical review for professional technicians and engineers.
Delta-wye transforms, and building your own Tesla coil

ONE OF OUR RECENT TINAJA QUEST WINNERS WAS D.C. COX FROM RESONANCE RESEARCH. THIS FIRM IS THE LEADING SUPPLIER FOR THE BIGGER TESLA COILS AND VAN DE GRAFF GENERATORS YOU FIND IN SCIENCE.

Three phase power consists of a triad of voltages spread by 120 electrical degrees. Advantages for higher energy users include a constant and a more efficient power flow, lower vibration machinery that starts and reverses easily, and rectifiers that are more economically filtered...

Two methods of connecting loads to a three phase system are the Delta and the Wye. Each has advantages and limitations. Note that currents in a Delta load are higher for a given input voltage...

For any Delta load, there is an equivalent set of Wye impedances, and vice versa. Here are the classic Delta-Wye transform pairs...

\[ Z_{ab} = \frac{Z_a Z_b + Z_b Z_c + Z_c Z_a}{Z_c} \]
\[ Z_a = \frac{Z_a Z_c}{Z_a Z_b + Z_b Z_c + Z_c Z_a} \]
\[ Z_{bc} = \frac{Z_b Z_c + Z_c Z_a + Z_a Z_b}{Z_a} \]
\[ Z_b = \frac{Z_a Z_c}{Z_a Z_b + Z_b Z_c + Z_c Z_a} \]
\[ Z_{ca} = \frac{Z_c Z_a + Z_a Z_b + Z_b Z_c}{Z_c} \]
\[ Z_c = \frac{Z_a Z_c}{Z_a Z_b + Z_b Z_c + Z_c Z_a} \]

Fig. 1— SOME FUNDAMENTALS of three phase power.

centers, museums, and planetariums. He is also newly offering his free do-it-yourself reprint on building up your own smaller Tesla coil.

A Tesla coil is nothing but a huge, resonant transformer that is intended to deliver high-voltage, high-frequency electricity—otherwise known as "lots of sparks." Sparks which literally can stand your hair on end, or light up an unconnected fluorescent tube you are holding in your hand.

The key secret to Tesla coil design is a high-Q air-core transformer with precisely the right amount of input source coupling. The resonance buildup produces a "Q-multiplier" effect to generate the high voltage.

The ultra high voltages are usually safe because they are high-frequency alternating current. Thus, they exhibit the skin effect, a property of high-frequency AC currents which causes them to travel only on the outside of conductors. The higher the frequency, the smaller the skin effect depth. The output from a Tesla coil can often be routed along a person (or a chain of people) without significant shock hazards.

Amazingly, most of the Resonance Research machines still use a spark gap for their input switching. Above a certain power level, spark gaps still have compelling advantages over tubes or solid-state devices.

Needless to say, a Tesla coil is one really horridous generator of radio frequency interference or...
A three phase delta load is normally driven by three “half bridge” drivers. These usually require a total of six power switching devices...

When using digitally switched unipolar inputs, there are only eight possible bipolar motor winding current results...

Just as there are delta-wye transforms, we can list these eight pairs of unipolar delta input to bipolar motor coil forward and reverse transforms...

Further analysis easily proves that any motor winding magic sinewave bit sequence which has a zero third harmonic will end up fully delta friendly.

RFI. These can be a most blatant violator of FCC Part 15 regulations and therefore illegal!

There are several persistent urban lore type myths that Tesla coils are in some manner a “suppressed” or “lost” source of “free energy.” The original myth can be traced to one of two sources: Either Tesla’s really bad misunderstanding of differences between resonance stored energy and source converted energy. Or as something between too much hype and an outright scam to get lab funding.

Research carefully and objectively, and you will discover there is not one shred of either actual or theoretical evidence that this sort of hogwash is even remotely possible.

Tesla coils are closely related to TV flyback transformers and to all the UHV ultra high voltage power line transmission research. In spite of countless hours of formal research in these fields, not the least hint of any over-unity energy has emerged.

Another good source for hands-on Tesla stuff is Lindsay Publications. The Tesla Bookstore is another useful resource. But you’ll be way better off limiting your readings to those books and the reprints by Tesla, rather than
errant ramblings about him.

If you really want to get into all of the free energy Tesla hogwash, check High Energy Enterprises, or else the International Association for New Science, the International Guild of Advanced Science, or Borderlands. Check out the KeelyNet BBS for a mesmerizingly outrageous source for late-breaking pseudoscience information.

And, of course, for a back-to-earth reality check, be certain to read the Skeptical Inquirer instead.

I’ve been thinking about gathering all my pseudoscience info into a new book. Give me a call if you have any interest in this.

Watch that Q!

A recent caller had a brilliant but flawed idea on how to simplify his Tesla coil. He wanted to use a Slinky for his main coil, eliminating most of those messy winding hassles.

The only tiny oint in the flyment is that Tesla coils must have a high Q and nearly lossless. A steel Slinky won’t hack it. But a gold plated one or a beryllium copper version might work.

In another time, long ago and far away, a student came to me hours before his Theremin project was due for a course final show-and-tell. The bright silver colored coils sure were pretty. It seems that the story he was copying clearly said to use #30 wire in his oscillators coils. While he found lots of No. 28 and No.34 copper wire, the only No. 30 he could find seemed to be made from Nichrome.

Three-phase power basics

Most of your utility electricity is generated as three-phase power. Pretty near all larger industrial and agricultural motors are three-phase. Ever wonder why?

Figure 1 shows a three-phase waveform. Three windings are spaced out 120 degrees around a generator’s stator, thus producing three identical sinewave waveforms whose electrical phase is also 120 degrees.

Your first great advantage of three phase is that all three phase power is continuous. Go through the math, and you’ll find that the instantaneous sum of the power on all three phases will always add to the same value.

In a single-phase system, there are times when very little power is being delivered to you. Other times, much more than average is delivered. Thus, three phase power is more efficient and has lower line losses.

Three phase motors also start a lot easier than single phase ones. Most of them are easily reversed, simply by swapping phases. Because of the continuous power, most vibration and noise ends up a lot lower.

Three-phase power sources can be easily rectified for DC. Its ripple is much lower and its ripple frequency is way higher. That’s one of many reasons why a car alternator is a three-phase AC generator.

---

**Fig. 3** — OF THE 281,474,976,710,656 possible 192-bit quadrant symmetric magic sinewaves, a scant 43,046,721 end up three-phase "delta friendly". Here are three of the more interesting examples

<table>
<thead>
<tr>
<th>Hexadecimal:</th>
<th>$812B36F7EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental Amplitude:</td>
<td>0.866208</td>
</tr>
<tr>
<td>Distortion 3-17:</td>
<td>0.0739%</td>
</tr>
<tr>
<td>Relative Harmonics 3 through 17:</td>
<td>0.000167379</td>
</tr>
<tr>
<td>0.0</td>
<td>0.000051363</td>
</tr>
<tr>
<td>0.0</td>
<td>0.000024485</td>
</tr>
<tr>
<td>0.0</td>
<td>-0.000021694</td>
</tr>
</tbody>
</table>

**Fig. 4** — CORRECTED VERSION of the PIC time delay generator.
It turns out there are two standard ways of connecting a transformer or motor or whatever to any three-phase power line. With a delta connection, one winding goes between phases $a$ and $b$. A second goes between phases $b$ and $c$ and the last one routes from phases $c$ and $a$.

In the wye connection, one end of each motor winding is connected together and usually brought out to a fourth line called a safety neutral. The free end of each winding is connected to phase $a$, $b$, or $c$.

Under balanced loading, you have a safety neutral current of zero. Even with some major unbalance, the safety neutral current still stays low.

Delta and wye each feature unique advantages and disadvantages. Note that voltages are $1.732$ times higher in wyes and the currents are $1.732$ times higher in deltas. $(1.732 = \sqrt{3})$. Thus, you could easily overload or underpower any load by making an incorrect choice of delta or wye—but that’s what power engineering is all about in the first place.

It is simple to show that any delta has a wye equivalent and vice versa. This is called a delta-wye transform or else a wye-delta transform. I have also shown these in Fig. 1.

The major disadvantage of three phase power is that three times the wiring is needed, combined with far more expensive switches. Plus, you need three times as many transformers. Thus, single phase is used for home, shop, and other “low power” uses, while the advantages of three phase power are reserved for industrial and agricultural users.

Much more information on three phase is available in any college power textbook, such as my utterly ancient favorites of Skilling's Electrical Engineering Circuits or Fitzgerald and Kingsley’s Electrical Machinery.

### Three-phase magic sinewaves

As regular readers already know, I have been doing a lot of unique new magic sinewave research. Magic sinewaves are rather carefully chosen and ultra long sequences of repeating ones and zeros—sinewaves of precisely controlled amplitude and amazingly low distortion.

Compared to classic pulse-width modulation (PWM), these brand new magic sinewaves can offer elegant simplicity along with superb efficiency for such diverse applications as induction motor speed controls, solar-panel inverters, electric auto drives, power factor correctors, home energy-efficiency improvers, or for reliable uninterruptible power supplies.

A participant at one of our magic sinewave seminars did ask me a very embarrassing question, though, a real scary back-to-the-drawing-board one: “How can magic sinewaves be used with three-phase loads that use only three half bridge drivers?”

The original magic sinewaves used individual “H-bridge” drivers. These needed access to both ends of each winding phase. For the three winding currents of $(+)$, $(0)$, or $(-)$.

All of which is just fine for single and two-phase users. But in the real world of big time three-phase power, we rarely have access to both ends of each winding. Especially doing some upgrade or retrofit. And we’d sure like to get by using a mere six active power devices. Instead of the twelve the full H-bridge route needs.

Well, for openers, the length of our magic sinewave sequence should be a multiple of three. Such that our three phases happen on bit boundaries. For simplicity and compact files, we’d also want a multiple of four. For that way, we’ll need only work with and store one of four quadrants.

Next for something a tad subtle: Another factor of eight sure would be handy. This lets each one of the three sinewaves work out of the same bit position of each 8-bit stored quadrant.
sequence. And, last time I checked, $3 \times 4 \times 8 = 96$.

Thus, to be three-phase friendly, a magic sinewave's length should be a multiple of 96 bits. And several very interesting libraries of 384- and 768-bit magic sinewaves already exist.

What do we have to do beyond this to also become what I will call being delta friendly?

The delta-friendly sinewave needs only three leads. And each of those leads need only be connected to a positive supply or ground. Figure 2 should get us started.

With simple SPDT or "half bridge" drivers on each line, there are only eight possibilities here. Namely, the binary combinations of 000, 001, 010, 011, 100, 101, 110, and 111. We might define a "clockwise" winding current as (+) and "counterclockwise" as (−).

We immediately see that the eight combinations can give us our choice of (+), (0), or (−) currents.

Now for the tricky part: For all of your possible input combinations, the winding currents always must sum to zero! You could have zero current on all three windings (cases 000 or 111). Or have zero current on one winding, positive current on one, and negative current on one (as in cases 001, 010, 011, 100, 101, and 110).

Next, think about this really hairy concept: Not only do winding states $a$, $b$, and $c$ have to occur together, but state $b$ will occur in data stream $a$ at one third of the way through the time sequence, and state $c$ also happens in data stream $a$ at two thirds of the way through the time sequence.

We already do know that our three states must sum to zero. But this also newly tells us that the three states are bits that are separated by one-third of their cycle distance in each sinewave sequence. Thus, the one-third spaced bits must also sum to zero.

Which tells us that a delta-friendly magic sinewave must have a forced zero third harmonic!

And that is all there is to it. To be both three-phase friendly and delta-friendly, just select 96-bit multiple magic sinewaves that have their third harmonic forced to zero.

Most power books also tell us that there can be no third harmonic line current on any delta connected three phase load—sort of an independent check on what we've discovered. Several examples of 192-bit delta friendly magic sinewaves are shown in Fig. 3.

You will find vastly more magic sinewaves than there are particles in the galaxy. Untold zillions versus a mere 1070. So finding the good ones gets real tricky. Indeed, there are lots and lots of highly useful and delta-friendly magic sinewaves. But magic sinewaves that are not delta friendly might perform better.

Just as there are delta-to-wye and wye-to-delta transforms, there's also simple math which gets you from the "positive-ground-negative" winding currents to the "positive-ground" line currents. I've also shown these back in Fig. 2.

When you want zero current on all three windings at once, you'll have your choice of using 000 or 111 input states. At first glance, either would work just fine. But it turns out one or the other might be more efficient and needs fewer transitions.

For instance, if your previous state was 000 and your next state was 010, use of a 000 would require only one transition. But use of 111 would need five transitions instead.

Obviously, you pick the one with the fewest transitions, because fewer switchings certainly means less high-frequency losses, and usually means higher efficiency. Sometimes a 000 is clearly better. Other times, 111 is the only way to go. Other times (such as a previous 010 and a following 101), it doesn't matter at all.

The bottom line: Magic sinewaves work just fine with half-bridge delta drives as long as you use only those which include (A) a forced zero third harmonic, and (B) bit lengths that are an integer multiple of 96.

As you may have guessed, this is a billion dollar new opportunity that is
very much up for grabs. I'll be happy to send you a free tutorial on magic sinewaves when you call or write. You can also ask me for a formal proposal that explains in detail our seminars, PIC source code, and the new partners programs. Both reprint and proposal are also available at www.tinaja.com

Time-delay correction

The neat PIC time-delay utility I showed you a few columns back had one bug in it. A PIC spends one cycle if a skip is not taken, and two cycles if an instruction skip is taken.

The corrected version is shown in figure four. Sorry about that.

Professional Audio Resources

I have just picked up a free new subscription to Pro Audio Review. A trade publication that more or less reports what its name implies. It has detailed reviews of high-end amplifiers, mixers, and microphones for TV, video, CD, and radio.

For this month's resource sidebar, I've tried to gather together some of the other pro audio resources.

A second major magazine is Mix, which also operates an outstanding Mix Bookskef where you will find just about any book on audio.

The leading technical audio organization is the Audio Engineering Society. The finest audio publication in the world seems to be the British Studio Sound and Broadcast Engineering.

Let me know if I've missed any of your favorites here. A free Incredible Secret Money Machine II if you tell me about any pro audio resource I don't already know about.

New Tech Lit

A real fine new collection of PIC-related data books is now offered by Microchip Technology. These include the PIC 16/17 Microcontroller Data Book; the PIC 16CXX Data Book; PIC 14000 Data Book; a PIC 16C7x Data Book; the PIC 16C62X Data Book; ECHV Update I; the MPASM Assembler Guide, Third Party Guide 1996; the Non-Volatile Memory Products Data; Embedded Controller Handbook; Serial EPROM Tutorial Series I-III; the Development Systems Ordering Guide; BBS System User's Guide; MPSIM Users Guide; and the HCS300 Data Book.

Their PIC, of course, is the finest microcontroller. Nothing else comes remotely close. Other PIC resources include Scott Edwards Electronics, and the superb Basic Stamp products offered by Parallax.

A unique collection of PC-related books is offered by Coriolis Books.

A new CD ROMs in Print 1996 is freshly offered by Gale Research. It reviews over 9000 titles.

Free beta copies of Acrobat Amber can be downloaded from www.adobe.com This wonderment lets you view full technical reprints on line. Part of it plugs into Netscape Gold. Which you can find at netscape.com

I often like to check out the hobby and craft catalogs. These can be a great source for products and ideas. One example is the Source Place for Creative Living “owner’s manual” by Loose Ends. Mostly on unusual hand made papers. Another is the Wood Parts Catalog from Lin-Wood. Who do make a bewildering array of small wooden items.

Or, just because it is there I guess, you should get your hands on the neat free Things You Never Knew Existed catalog from Johnson Smith.

For typical individuals and small-scale startups most of the time, any involvement whatsoever with patents is absolutely certain to turn into a net loss of your time, energy, money, and sanity. You find out why in my Case Against Patents package. It includes proven real world alternatives.

See my nearby Synergetics ad for more details. I've also got some great deals on Tektronix 1230A logic analyzers left over from my school buy-out.

I'm still building my web site at www.tinaja.com Eventually, globally searchable reprints for my previous columns should be available here.

As usual, a no-charge tech helpline and online access is available per the Need Help box. Most of the resources mentioned in this column appear in our Names and Numbers or Pro Audio sidebars.
Just like these Fully Trained Electronics Professionals

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"I loved the flexibility CIE offered. It was the only way I could continue both school and my demanding job."  
Britt A. Hanks Director of Engineering Petroleum Helicopters, Inc.

"I liked the way the school was set up with laboratory assignments to enforce conceptual learning. The thing which impressed me the most about CIE's curriculum is the way they show application for all the theory that is presented."  
Daniel N. Parkman Missile Electro-Mechanical Technician U.S. Air Force

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Making Time Measurements with a DSO

The oscilloscope is the time-honored tool of choice for measuring voltage changes over time because the waveforms on its screen are graphical representations of those changes. This article will show you how to use your digital storage oscilloscope (DSO) to your advantage when you need to make highly accurate time measurements.

Time is measured on the oscilloscope's horizontal or X axis. You can adjust the time axis by using the scope's horizontal scale or time-per-division control. In this article, we will be discussing some of the more frequently made time measurements. A similar discussion of voltage measurements was presented last month.

Common time measurements include the waveform period, frequency, pulse risetime, and pulse width. A period is the time it takes a repetitive waveform to complete one cycle or move through a series of amplitude values until the values begin to repeat. The frequency in Hertz is one divided by the period, or the period's reciprocal.

Pulse waveforms are encountered frequently. All pulses have a rising edge, a width, and a falling edge. The *risetime* is the time it takes the pulse to go from a low amplitude (voltage) to a high one. (See Fig. 1.) Risetime is usually measured from the 10% to the 90% point on the rising edge (Figure 1). Fall time is measured on the falling edge from the 90% point back to the 10% point. Pulse width is the width "at the waist line," that is, at the 50% point.

Another common time measurement is delay, sometimes called propagation delay. Propagation delay is the time it takes a waveform to travel from one point in a circuit to another, such as from the input to the output of an amplifier.

Delay measurements are made by using two channels of your oscilloscope. If a pulse at an amplifier input is applied to one channel, and the output is applied to another, you can measure the time from an edge on the first channel to the same edge on the second channel. This is the propagation delay through the amplifier, that is, the time it takes the signal to propagate from the input to the output.

Phase shift is a special kind of propagation delay measurement, usually using sine waves and measuring the delay in terms of the sine wave period. If the sine wave period is expressed as 360 degrees, the phase shift is 360 times the delay, expressed as a fraction of the period. If the delay is half the period, for example, the phase shift is 180 degrees.

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Maximizing accuracy

Many variables can affect the accuracy of time measurements, including the measurement method, the oscilloscope's vertical and horizontal resolution, its sample rate, trigger jitter and noise. The most important factor is the oscilloscope's horizontal resolution. Fortunately, that is also the factor that is most under your control.

In addition to the horizontal time-base/time-per-division control, many DSOs also have a record-length control. Record length is the number of data points taken or "acquired" on a waveform each time the oscilloscope is triggered. Both the horizontal time-base and record-length controls can be used to maximize the horizontal resolution on a time measurement. Use the longest record length available, then adjust the timebase control to use as much of this record length as possible. This will provide the maximum number of data points.

You may choose from three methods for time measurements (Figure 2). The easiest way, and, often the most accurate, is to let the oscilloscope perform the measurement. Most DSOs have automatic measurement functions that you can select from a menu. The DSO automatically calculates and displays the measurement result for each acquired waveform.

The second method is to use measurement cursors—movable horizontal and vertical lines—to manually make the measurement. You can individually control and align each cursor with the appropriate waveform feature in order to make time and voltage measurements. Cursors are often used when the automatic measurement definitions are not easy to set, or where you wish to make several closely related measurements. Your accuracy will depend on how well you set the cursors.

The third method is to "eyeball" the measurement, that is, to align the waveform features with the internal graticule markings and counting divisions of the display. This is the method you use when just looking at the waveform. With closer observation and using the "minor division" graticule markings on the display (located on the central vertical and horizontal graticule lines), you can be considerably more precise.

For time measurements beyond the normal record length, use the delayed-sweep feature of your oscilloscope to improve horizontal resolution. Follow the procedure as outlined below and as illustrated in Figure 3:

1. Set the first measurement point with the main sweep at the center ver-

FIG. 2—THREE MEASUREMENT METHODS are illustrated here. First, the oscilloscope is making the risetime measurement. The warning message indicates that the 100% point may be doubtful because it is represented by just a few points. Second, the cursors are measuring the time from the peak value, 1.63 volts, to the point where the voltage returns to zero. This is 17.9 nanoseconds. Finally, from the graticule, you can see that the voltage is above 1 volt for about 14.5 nanoseconds, 2.9 divisions at 5 nanoseconds per division.

FIG. 3—IN A DELAYED SWEEP MEASUREMENT, the measurement is made from the center vertical graticule line on the main sweep display to the same line on this delayed sweep display. The delay is 12.9195 microseconds. To this delay, add 7.1 ns, the additional time from the center of the time jitter to the center graticule line. The total time is thus 12.9266 microseconds, plus or minus about 1.5 nanoseconds, the width of the jitter band.
tical graticule line by using the triggering and the horizontal position controls.
2. Select the delayed-sweep mode, then set the Delayed-Runs time to align the second time point to the same center graticule line.
3. Start with a delayed sweep speed only slightly faster than the main sweep, and then advance the delayed sweep for a more precise setting.
4. If the feature can’t be aligned exactly with the center graticule line, read any difference from the graticule and correct the Delayed Runs readout.

Reducing noise

Noise can interfere with time measurements by blurring the waveform data at the time-measurement points. There are numerous ways to reduce noise. On repetitive waveforms, you can use the signal averaging capability of your digital scope to reduce random noise. At slower sweep speeds, a HiRes mode, available on some DSOs, will reduce high-frequency noise. A scope’s bandwidth-limit feature also will help eliminate noise above the bandwidth limit.

Of course, you can learn to live with the noise and try to work around it. Set the measurement cursors to the center of a noise band to measure an average value. Your scope’s persistence display feature can help in visualizing the noise-band center.

Another common problem is edge aliasing, often produced by high sweep speeds, fast risetimes and sample-rate limitations. Edge aliasing is identified by false overshoot, ringing, and a jittering edge position. This condition can happen in single-shot measurements or when Digital Real-Time (DRT) oscilloscopes treat all acquisitions as if they were single-shot. Edge aliasing may also occur if less than two samples are acquired during edge risetime.

There are several ways to correct edge aliasing. If the delay or period is being measured, risetime is not a factor, and bandwidth limiting will stabilize the measurement. In addition, some high performance DSOs have 100-MHz and 250-MHz bandwidth limits that can be limit risetime and stabilize very fast edges.

Trigger jitter can impact time measurements on repetitive waveforms. In this case, slow risetimes are the problem. Trigger jitter happens because the oscilloscope trigger cannot determine exactly when a slower moving signal passes through the trigger level. Fast edges have the least trigger jitter. By simply expanding the signal amplitude on the display, you can decrease trigger jitter. This is because the signal speed is increased through the trigger-level point.

Your DSO lets you “see” electrical signals that occur in a split second. By using your oscilloscope’s features to “expand” that split second as much as possible, and then letting the scope make the measurements automatically, you’ll have the highest degree of accuracy in time measurements. When automatic measurements are not available or appropriate, use the helpful tips provided above to ensure a higher degree of accuracy.
If you’ve been following this series on low-cost software for electronics, you know how your PC can ease the chores of drawing a schematic and designing a printed-circuit board. Did you know that it can also expedite the process of debugging a circuit design!

TJ BYERS

WE’RE SURE THAT SOME OF YOU REMEMBER BUILDING EXPERIMENTAL radios on old kitchen breadboards using nails and bare wire. As time passed, Grandma’s breadboard gave way to phenolic terminal strips, which eventually evolved into today’s solderless breadboards.

We all have fond memories of breadboarding simple circuits using a slab of plastic embedded with metal strips. But those days are shrinking into the past, too. Today’s circuit designs are far more complex, run faster, and require a lot more than a plastic and metal breadboard to make them work. Now we do all of our circuit-design work using a PC-based software simulator—which is what this article is all about.

There are several different kinds of software circuit-simulators, each with its own purpose. The most popular is the analog simulator, used for wringing out linear designs such as audio amplifiers and filters. Digital circuits, on the other hand, have special needs that require a different set of rules that don’t always coincide with those of analog circuits. Consequently, there’s a separate category of digital-only simulators. However, because today’s designs are often a mixture of digital processing linked with an analog interface, the trend is toward mixed simulators that do both. On the cutting edge is the burgeoning wireless telephone communications market, where frequencies range from 500 MHz to 5 GHz. These designs require special RF software simulators where every solder connection enters into the formula.

HOW CIRCUIT SIMULATION WORKS

Circuit-simulator programs are software applications that let you test your electronic devices on a top PC. At the core of the circuit simulator is a number-crunching engine that reads a netlist file that contains a list of the circuit’s components, their various voltage and current parameters, and how the components react when these values are changed.

Device models. Circuit simulation is done by applying mathematical equations, called algorithms, to a model of an electrical device such as a transistor, then solving the equation with different sets of numbers that you plug into the formula. For example, one of the formulas used in bipolar transistor simulation is

$$I_C = I_{FE} (e^{v_{BE}} - 1) + I_{RE} (e^{v_{CE}} - 1)$$

which describes the current flow through the emitter of a common-base amplifier.

Thankfully, you don’t have to take a refresher course in advanced algebra or electrical engineering to use circuit-simulation software. Any company worth its salt has done the homework for you, and rendered the many formulas into compact code. All you need to supply are such variables as operating voltage or current.

As explained above, the simulator engine works from a netlist. Generally, the netlist is in ASCII format, which means that all you need to create a simulation netlist is a text editor. However, it’s much faster and more accurate to extract the information from a schematic-capture program in much the same way PC-board layout programs convert schematics into solid pads and copper traces. Very often the simulation package includes a schematic capture front end.

Test instruments. Once the circuit parameters have been defined and loaded into the simulator, the design is stepped through its paces using a function generator. Sometimes the input is a simple sine wave, while other times it can be as complex as a frequency-modulated modulated modem carrier signal or a word generator. The signal source depends on the design and what results you’re looking for.

Of course, you need a monitoring device that tells you what’s happening as you wring out the design with various inputs. Generally that’s done...
using a software-simulated multi-trace oscilloscope. From what we've seen in the simulation software in this review, many of these simulated instruments far outpace their commercial counterparts, displaying transient activity that you'd never catch on the screen of a scope no matter how quick you are on the trigger. Most analog simulators also include a bode plotter that's used to study the frequency response of a circuit. And no simulator would be complete without a multimeter.

Digital circuits need specialized test instruments, like a pulse stepper, propagation delay viewer, breakpoint analyzer, and event counter. You're also likely to find a logic analyzer that shows the state of all the nodes in the circuit and their relative timing, and sometimes a logic converter that can convert between gate, truth table, and Boolean logic.

That said, let's begin our tour of the software packages that threaten to make your soldering iron obsolete. Before we begin, let me explain that we'll be looking at some of the same programs that appeared in the October 1995 issue of Electronics Now, which highlighted schematic-capture software. However, some of the features and prices have changed since the last time you and I looked at them. For example, some have been upgraded to 32-bit programming to make them compatible with Windows 95. Consequently, you may find brief comments on the new features in the text as we review the following eight programs.

**Analog Simulators**

Do you want to build a circuit that measures room temperature, ambient light, or which way the wind blows? If so, you need an analog simulator to test it. Analog simulators are used to check out any circuit that deals with voltages and currents that have analog values instead of digits. Typical analog applications include filters, oscillators, amplifiers, linear power supplies, and transmission lines.

![Diagram of a circuit](image)

**FIG. 1—EACH OF THE EE WORKS MODULES has its own canned schematic drawing. In addition to running a simulation using component values you plug into the circuit, EE Works can do the reverse and calculate component values for you when you enter the design parameters, like above.**

Although it's possible to digitize some of these applications, any digital processor still has to talk to an analog world via input sensors such as a thermistor or photocell, and output transducers, including motors and loudspeakers. Even your computer's monitor, which you might think is digital, is basically an analog device—both inside and out. Hence, there will always be a need for analog designs, regardless of where the digital future may take us.

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<th>Product: EE Works</th>
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<td>Platform: DOS</td>
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<td>Publisher: Geoban Engineering</td>
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Before you begin using EE Works, you'd better dust off your old engineering reference books, because you'll need them. EE Works is the most exhaustive of any of the simulation programs tested, giving you answers to questions you didn't even think to ask—and the results are given in engineering language, not hobbyist jargon.

Unlike the other simulators in this review, which are integrated and work from a common schematic. EE Works is a collection of several DOS programs, each designed to do one thing, and one thing only. For example, there's a simulator module that tests your design for linear transient analysis, and another that does nothing but linear AC/DC analysis. Each simulation comes equipped with a canned "schematic" (Fig. 1) that electrically represents the design under test, such as an active filter. Unfortunately, the individual simulator modules aren't interactive. Each simulation runs on its own, and the results are exclusive of any other simulation. In other words, every time you start a different simulation, you have to restate your circuit's parameters.

You must be very precise—immaculate, in fact—when defining component and circuit parameters. For example, if you choose the power supply simulation routine—a power supply design/simulation program that's unique to EE Works—you even have to enter the permeability of the inductor and the capacitor's ESR value. If you skip any step, hoping the simulator will default to a standard value, you are thrown back to the main menu where you have to start the simulation all over again. It's the same with transistors, op-amps, and even resistors, where you have to specify the resistor's tolerance. So you better have those vendor specs in hand before you begin—or be a good guesser.

*Continued on page 65*
CONVERTING AN OBSOLETE computer printer into a strip-chart recorder is both easy and inexpensive. With about $40 in parts, construction of a simple circuit, and some minor mechanical fabrication, you can have a functioning chart recorder. We built the prototype as a weather station to record air temperature, but it could be used for any number of things ranging from seismography to radio astronomy.

The chart recorder works by comparing the voltage on a potentiometer to the voltage on a temperature-sensing thermistor. The potentiometer is mechanically connected to the printer carriage. A marking pen is also connected to the printer carriage. Any difference in the voltages on the potentiometer and the temperature sensor causes an op-amp to attempt to bring the voltages back in balance. In so doing, the print-head carriage moves left or right, thereby causing a mark on the paper. We drive the platen (i.e., pull the paper through the device) using a standard household timer.

How it works
Figure 1 shows the complete circuit. We use a standard 741 op-amp as a comparator. The comparator monitors the voltages at the junctions, marked TP1 and TP2 in Fig. 1, of two voltage-divider networks. The op-amp compares the voltages from the two networks at its inputs (pins 2 and 3). When the voltages are identical, the op-amp's output (pin 6) is zero, so neither driver tran-

sistor (Q1 and Q2) turns on, and therefore the motor does not turn.

But if thermistor R2's resistance changes because of a change in air temperature, a new voltage occurs at the op-amp's inverting input (pin 2). For example, assume the value of R2 decreases. The pin-2 voltage then increases, so the op-amp's output swings negative, thereby biasing Q2 on. That in turn starts the motor, which moves the carriage left or right.

Potentiometer R5 is also coupled to the carriage, so, as the carriage moves, R5's wiper moves, thereby varying the voltage on the non-inverting input of IC1. When the op-amp's input voltages become equal, the output goes to zero, both transistors turn off, and so does the motor. Now the circuit remains quiescent until the temperature changes again.

The potentiometer is a precision, 10-turn type with a value of 20K. A 50K device would provide a wider range, but with reduced resolution. You should be able to buy a surplus 10-turn unit from an electronics supplier for $1-5.

For temperature sensing, we used a common thermistor available from Radio Shack. (Internally, each device actually consists of two separate thermistors.) A thermistor is a device whose resistance changes with temperature. The thermistor is not linear; its resistance increases disproportionately fast at cooler temperatures. That nonlinearity restricts the range of the recorder. Also, the resistance range of your probe, be it a thermistor or some-
thing else, must not exceed the range of the potentiometer, or the pen will try to run off the side of the chart.

We use precision resistor R3 in conjunction with S1-a and S1-b to calibrate the circuit. When R3 is in the circuit, the carriage will move to where the value of R5, the 10-turn potentiometer, equals the value of R3. That provides a reference point for the chart printouts.

By switching in either one or two temperature sensors, switch S1 allows the choice of two ranges. Position 1 of the switch is for calibration; only R3 is connected. Position 2 connects R2, for a range of 20–108 °F; and Position 3 connects both R1 and R2, for a range of –6–76 °F.

For the prototype, we picked up a derelict daisy-wheel printer at a local second-hand store for $5. Note that a dot-matrix printer would work just as well. If you live near a university, check whether it has an equipment-disposal unit, typically a warehouse with old, broken, and outdated equipment. Another potential source is a printer repair shop.

For marking the chart paper, we simply installed a pencil, using a rubber band to maintain tension against the platen, as shown in Fig. 2. We used several different colors of soft lead drawing pencils to track temperatures for several days on a single chart. You could even glue the chart into a multi-day loop if you wish.

**Construction**

To prepare the printer, first gut it, removing PC boards, the daisy-wheel mechanism from the carriage, the wiring harnesses, the fan, etc. Don't be too quick to dispose of the gutted parts; you may be able to use some of them, particularly the cables and connectors. You should end up with the frame, the platen, and a carriage and drive mechanism.

In most printers the carriage-drive motor has several wires attached. By trial and error you can determine which wires operate the motor. In our case, there were two red and black wires. We merely tried one red and one black wire and got the motor to turn. The motor should operate on a low DC voltage—the prototype begins to turn at about 2–3 volts—but you may want to determine low-voltage DC operation for certain before you buy.

Now affix the potentiometer to the carriage. Some printers use a cable to move the carriage back and forth; others use a rubber belt. Our unit used a cable drive, but because the cable is greasy and hard to get at, we did not attach to the cable directly. Instead, as shown in Fig. 3, we fixed the potentiometer securely to the carriage and then strung a length of strong, coated twine from one side of the printer frame to the other. A small coil spring keeps the twine taut. The twine wraps once around a spindle attached to the potentiometer shaft. The diameter of the spindle should be such that the potentiometer turns ten rotations (or a little less than ten) over the length of the carriage movement.
To calculate the diameter of the spindle, simply measure the total distance the carriage moves from left to right, and divide that value by \((\pi \times 10)\). Anything that size or slightly larger will do. The spindle material is not critical; we used two hard rubber spacers bracketed by a couple of large washers, and brushed with paint to increase friction. You could also use a wooden spool, a small diameter pipe, or a stack of washers. Incidentally, the spindle must be wide enough to allow the string to worm its way across without jamming into the bracketing washers.

To drive the platen, we used a plug-in appliance timer, available at most hardware and variety stores. We glued the timer dial directly to the platen knob, giving a chart speed of about \(\frac{1}{6}\)-inch per hour, which is satisfactory for temperature recording.

That type of timer is not intended to drive anything, so you should keep a close eye on it until you are certain it can do the job without overheating. We tried three different brands, old and new, and they all worked. Be sure to minimize the drag on your platen by removing all drive gears, stepper motors, etc. Also, because of mechanical slack in the system, it may take up to an hour for the timer to begin turning the platen. If you desire a faster chart speed, other drive arrangements can be constructed, possibly using the built-in mechanics.

Your printer may have operable DC power supplies. Ours didn’t, so we bought two wall-mount DC adapters. Anything in the range of 12–15 volts DC at 500 mA should work, but check the current draw of your carriage drive motor to be safe.

**Calibration and testing**

Switch R3 into the circuit, let the carriage settle down, and then mark that point as a reference. You may want to slip the twine to move the carriage assembly to a convenient location.

The simplest way to calibrate

Continued on page 50
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The driver circuit

The driver circuit ionizes and sustains the illumination of neon or argon gas-filled tubes up to four feet long bent into any shape desired. The tube will remain illuminated as long as power is applied to the circuit. However, the driver circuit permits the tube’s illumination level to be adjusted to maximize brightness or reduce brightness to conserve power depending on which is more important.

Build this driver circuit to illuminate your car’s license plate, light up its underside for a glamorous “spaceship” look, or just create portable neon or argon light displays.

ROBERT IANNINI

A note of caution

It is illegal in all states to drive a car with an illuminated license plate frame that flashes while the vehicle is moving. However, the frame can serve as an attention-getting emergency beacon if the vehicle is stopped.

Also, it is illegal in at least one state to have an illuminated license plate frame on a car unless the gas tube is so masked that only the light reflecting from the plate is visible to the driver of any vehicle that is following behind the car with the lighted frame.

How the driver works

Refer to the schematic Fig. 1. An industry standard bipolar 555 timer, IC1, is configured as a duty cycle clock to control the on and off time of the circuit’s high-frequency oscillator. With C2 switched into the circuit by switch S1, the output at pin 3 of IC1 will be a square wave with a duty cycle or pulse rate that is fast enough to sustain continuous illumination of the gas-filled tube.

Adjusting trimmer potentiometer R1 changes the brightness of the gas tube by altering the on-to-off ratio or the duty cycle of the squarewave that appears at the output of pin 3 of IC1. The squarewave output of IC1 appears at the base of NPN transistor Q1, which functions as a buffer amplifier. The output of Q1 then appears at the base of grounded-emitter NPN transistor Q2, which functions as the feedback element in a free-
running oscillator circuit. Transistor Q1 acts as the switch to turn transistor Q2 on and off by clamping the transistor's base to ground.

The oscillator oscillates at a frequency of 25 to 30 kHz, and the output voltage at the top of the 1300-turn coil of T1 is approximately 2500 volts, peak-to-peak, sufficient to ionize the gas in the tube. The duty cycle pulse of IC1, as buffered by transistor Q1, controls the base of transistor Q2. The tank circuit that determines oscillator frequency consists of capacitor C6 and the 18-turn primary coil of transformer T1.

Changes in the duration of the “on” cycle change only the brightness of the gas tube but do not affect the frequency of the oscillator. High-voltage ceramic capacitors C8, C9, and C10 correct for differences in the length of the gas tube being driven.

If switch S1 is set to the flashing mode, capacitor C1 is placed in parallel with capacitor C2, and the sum of their capacitive values will shorten the repetition rate of the squarewaves appearing at pin 3 of IC1. This will cause the tube to flash on and off at a rate slow enough to be seen as flashing (less than 50 pulses per second). The flashing time rate can be changed to a visually comfortable level by adjusting trimmer potentiometer R1.

### Building the driver circuit

Whether you plan to operate the driver only from the battery pack or directly from an automotive 12- to 14-volt supply, it is recommended that provision be made to operate the circuit from the battery pack for testing.

If the illuminated frame is to be used on a vehicle (regardless of power source), attach a heatsink to the copper tab on the TO-220 case of transistor Q2. Omit capacitors C9 and C10 if you intend to install the system in a vehicle.

The driver circuit can be built on perforated board by point-to-point wiring method. Cut a \( 3\frac{3}{4} \times 1\frac{1}{2} \)-inch rectangle of punched circuit board (0.042-inch diameter holes) in a 0.1-inch grid. With the exception of the high-voltage capacitors C8, C9, and C10 and transformer T1, all components are readily available items.

If you do not want to wind your own miniature transformer, you can purchase one from the source given in the Parts List. The neon or argon frame and plate cover assembly referenced in this article is also available from the same source. Also the high-voltage capacitors C8, C9, and C10 are available in a kit.

Refer to Parts Placement diagram Fig. 2. Before starting assembly work, cut out a rectangular relief hole in the circuit, as shown by the dotted line, to make wiring slide switch S1 easier. If you intend to install the system in a car, attach a heatsink to the tab of transistor Q2 before inserting it.

Insert all components in the approximate positions shown on Fig. 2. Insert all components in the approximate positions shown. Insert all axial-leaded resistors and diodes marked with an asterisk vertically to conserve circuit board space. A snap-on heatsink suitable for a TO-220 package is, but a satisfactory substitute can be made by cutting and folding a piece of 0.062-inch thick sheet aluminum \( 1 \times 1\frac{1}{2} \) inches. Drill a small hole in its center for mounting.
it to the hole in the heat tab of transistor Q2 with a nut and bolt.

Carefully fold back one lead of all axial components shown as vertically mounted over the body of the component so that both leads can be inserted in holes spaced 0.10-inch apart. Observe the polarities of the diodes and electrolytic capacitors before inserting them and be sure that you have identified the pin functions of transistors Q1 and Q2 before inserting them in the board.

Insert and bend all leads first before doing any soldering so that extra lead lengths can be used to form the specified connections between components.

**PARTS LIST**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All resistors are 1/4-watt, 10%, unless otherwise specified</strong></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>25,000 ohms, trimmer potentiometer, PC board mounting, carbon film</td>
</tr>
<tr>
<td>R2, R3, R4</td>
<td>1000 ohms</td>
</tr>
<tr>
<td>R5</td>
<td>3900 ohms</td>
</tr>
<tr>
<td>R6, R7</td>
<td>220 ohms</td>
</tr>
<tr>
<td>R8</td>
<td>1 ohm, 1/2-watt</td>
</tr>
<tr>
<td><strong>Capacitors</strong></td>
<td></td>
</tr>
<tr>
<td>C1, C7</td>
<td>10 µF, 35 volts, aluminum electrolytic, radial-leaded</td>
</tr>
<tr>
<td>C2</td>
<td>0.47 µF, 50 volts, aluminum electrolytic, radial-leaded</td>
</tr>
<tr>
<td>C3</td>
<td>0.01 µF, 50 volts, ceramic disc</td>
</tr>
<tr>
<td>C4</td>
<td>0.1 µF, 50 volts, ceramic disc</td>
</tr>
<tr>
<td>C5</td>
<td>0.02 µF, 100 volts, polyester</td>
</tr>
<tr>
<td>C6</td>
<td>0.47 µF, 100 volts, polypropylene, radial-leaded</td>
</tr>
<tr>
<td>C8, C9, C10</td>
<td>100 pF, 3000 volts, ceramic multilayer, radial-leaded DIP (see text)</td>
</tr>
<tr>
<td>D1, D2</td>
<td>1N914 silicon diode</td>
</tr>
<tr>
<td>D3</td>
<td>1N4001 silicon diode</td>
</tr>
<tr>
<td><strong>Other components</strong></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>transformer with 10-, 18-, and 130-turn windings, (see text)</td>
</tr>
<tr>
<td>S1</td>
<td>slide switch, two-deck, three position (DP3T), PC mount, Mouser 10SL008 or equiv.</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td></td>
</tr>
<tr>
<td>neon or argon gas tube frame assembly (see text); circuit board, (see text); circuit case (optional); 9-volt battery clip; eight-cell battery pack (optional); eight alkaline AA cells; No. 24 AWG insulated hookup wire; TO-220 heatsink, spade connectors, nut and bolt, solder</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Completely assembled systems, kits of parts, and individual parts for the neon/argon license plate frame with variable brightness and emergency flashing, are available from Information Unlimited: Box 716, Amherst, NH 03031. Telephone 1-603-673-4730; Fax 603 672 5406. Include $4 for shipping & handling per order. The following options are offered:

- Driver circuit transformer, T1 (28K087) — $9.50
- Printed-circuit board PC1 — $4.50
- Kit of parts for system including all electronic components and PC board, but no gas tube or plastic frame (BATNEONK) — $19.50
- Ready-to-use aqua and purple neon tubes with plastic frames for flashing power supply (AQUA1) — $12.50; (PURP1) — $12.50
- Ready-to-install non-flashing purple license frame neon assembly (LICNPR) — $24.50
- Ready-to-install non-flashing green license-frame neon assembly (LICNGR) — $24.50
- High-brightness under-car neon assembly: Pink 4-tube kit (RG4K) — $124.50; Purple 4-tube kit (RG4L) — $124.50; Music driver for above kits (RG4M) — $39.50; Single tube kit (specify pink or purple) (RG1K) — $34.50

After soldering all components and trimming their leads, insert and solder the wires for the battery pack and vehicle's power system. Solder all the wires from transformer T1 to their specified terminal points. Connect and solder the hot and ground wires to the neon-tube frame assembly.

**System assembly**

Refer to assembly diagram Fig. 3. The neon or argon gas-filled tube has been bent to form a rectangle with an inside measurement of 11 x 5 1/4-inches so it can frame the license plates of all American and Canadian cars. The tube is embedded in RTV silicone within the lip around a transparent plastic cover that will protect the license plate.

Wires extend from both ends of the gas-filled tube for connection to the high-voltage output and ground wires of the driver circuit. Those wires can be soldered together or connected by soldering automotive spade-style connectors to their ends for more convenient connection and disconnection should it become necessary.

The battery pack needed for test purposes can also be the permanent power source, if desired. It consists of eight AA alkaline cells. If you intend to connect the system to a vehicle’s electrical system, do it with approved automotive-style sol-
the reference point on your ruler with the reference point on your chart.

Test the circuit by turning op-
Build this EPROM-based video pattern generator and put it to work testing TV sets and experiment with the generation of video patterns.

THE MULTIFUNCTION VIDEO SIGNAL generator project described in this article produces three independent video test patterns: a black and white checker pattern, a color-bar pattern, and a programmable custom picture. When any one of those patterns is combined with a sync signal and sent to a television signal modulator IC, a video signal is formed.

How does it work?

Figure 1 is a block diagram for the video pattern generator. A clock pulse generator initiates the base time clock pulses. Those clock pulses drive a counter, which sends the address signals to an erasable programmable read-only memory (EPROM). The EPROM contains all of the previously stored sync and pattern signals. The outputs of the EPROM, as selected by a pattern-selection switch, are synchronized by a latch, and sent to the NTSC (television) modulator. The modulator combines the sync and pattern signals to form a video output signal.

Figure 2 is the schematic for the video signal generator. The main clock pulse signal for the generator is based on XTAL1, which has a frequency of 3.579545 MHz or a period of 0.279 microseconds. (Color television sets contain a 3.58 MHz color-burst oscillator.) A horizontal sweep period based on 227 clock pulses was selected. The period is calculated as $227 \times 0.279$ microseconds, which equals 63.33 microseconds, the length of time for a horizontal line scan in a receiver conforming to the NTSC (National Television System Committee) standard. The vertical deflection contains 262 horizontal sweep lines, so that one field consists of $227 \times 262$, or 59,474 clock pulses.

Four 74HC161 binary programmable counters (IC1 to IC4) form a 59,474 clock pulse counter. The two modes of the counter are controlled by its LOAD signal. If LOAD pin 9 has a logic 1 (high) state, the 74HC161 is in its normal counting mode. However, if LOAD pin has a logic 0 (low) state, the 74HC161 enters its load mode. The clock pulses will load the program data at input pins A through D (pins 3 to 6) of the four 74HC161 binary counters.

When all four binary counters
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| 0303932   | $17.95  | Designing, Building and Testing Your Own Speaker System |
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count to logic 1 (FFFFH). IC4's ripple-carry output (RCO) pin 15 becomes a logic 1. This signal is sent to the four counters' load input pins after inversion by 74HC00 IC6-a. Then the counters load the data at their a to d inputs when the next clock pulse occurs. In this case, 0001 0111 1010 1110 equals 17AEH will be loaded into the counters. The binary counter, which counts from 17AEH to FFFFH, requires E851H or 59.473 clock pulses. This is the required counter sum after adding one more clock pulse for loading data.

The counters' outputs are sent to a 27C512-15 64K X 8 CMOS EPROM (IC5) as address signals. For each address, IC5 provides an 8-bit output. These outputs are listed in Table 1.

Pins D0 to D2 of IC5 send the custom pattern signals red (R2), green (G2) and blue (B2). Pin D3 provides the black and white checker pattern. Pins D4 to D6 send the color bar red (R1), green (G1), blue (B1) signals. The sync signal that combines both the horizontal and vertical sync signals is obtained at pin D7.

The EPROM's outputs are latched by the 74HC273 (IC6) octal D flip-flops for synchronizing purposes. Three-pole, three-terminal switch S1 selects each of the three video patterns. As shown in Fig. 2 the S1 top position (1) selects the 14 x 18 B/W checker pattern. When this pattern is selected, the B/W signal is sent to the MC1377 television RGB-to-NTSC encoder (IC7) with equal red, green and blue values. As a result, the picture will be black if B/W is logic 0 and it will be white if B/W is logic 1.

The second pattern selected by the mid-position (2) of switch S1 is the color bar pattern. The order of the colors in the color bar pattern is white, yellow, cyan, green, magenta, red, blue and black, from left to right. The third video pattern selected by bottom position (3) of S1 is a custom picture which is composed of 237 lines and each line contains 287 pixels. Thus, the total number of pixels in the custom pattern is 43,605. Each of those pixels can be programmed as one of the eight different colors in the color bar pattern.

The RGB to NTSC encoder MC1377 (IC7) performs all of the functions of a color TV encoder. These functions are: color subcarrier oscillator; RGB to R-Y and B-Y converters; voltage-controlled 90° phase shifters; and chroma modulators. The inputs required for the proper operation of the MC1377 are 1-volt peak-to-peak red, green and blue (R, G and B) signals, and a TTL-level sync signal. The MC1377 provides a 2.5-volt, peak-to-peak, composite-video output to jack J1.

Because IC6 is a high-speed CMOS device, its output signal level will be very stable. This means that if the output is logic 0, the level will be close to zero volts. If output is logic 1, the voltage should be +5 volts. The selected pattern signals are divided by resistors R1 to R6 to meet the MC1377's input level requirements. Those resistors are specified as 1% to eliminate any error caused by different R G B levels that would cause color distortion. You can hand-select these from a group of 5% resistors by measuring and sorting them with a DMM.

Because pin 17 of the MC1377 can provide only 0.1 volts peak-to-peak subcarrier output, the signal is amplified.

The output of IC7 (the MC1377) is buffered by Q1, a 2N3904 NPN transistor, to improve its drive capability. To keep the circuit simple, the main clock pulses are generated by the MC1377. Because pin 17 of the MC1377 can provide only 0.1 volts peak-to-peak subcarrier output, the signal is amplified.

### TABLE 1—EPROM Outputs

<table>
<thead>
<tr>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
<th>Sync</th>
<th>R1</th>
<th>G1</th>
<th>B1</th>
<th>B/W</th>
<th>R2</th>
<th>G2</th>
<th>B2</th>
</tr>
</thead>
</table>

**FIG. 1—FUNCTIONAL BLOCK DIAGRAM for the Video Pattern Generator.**
Obtain outstanding performance from a home-brew radiator built from readily-available parts and materials.

WILLIAM SHEETS, K2MQJ, AND RUDOLF F GRAF, KA2CWL

SCANNER ENTHUSIASTS. AMATEUR radio operators, and UHF experimenters are interested in simple antennas that are more effective than ground-planes and whips. You can build a high-performance UHF corner-reflector antenna that is compact and easy to tune using readily available materials.

A corner-reflector antenna provides good performance radiation for directional UHF work since it has 8 to 10 dB gain, is fairly easy to build, and has reasonable bandwidth of 5% to 20%. Also, the corner-reflector antenna exhibits a good radiation pattern and front-to-back signal ratio.

The corner-reflector antenna consists of a balanced half-wave dipole placed in front of a conducting surface that is folded with an angle of 90 degrees or less. As the angle gets smaller, the gain tends to increase but the antenna structure tends to get larger and the dipole feed impedance becomes lower. The dipole may be constructed with thick dipole elements to increase bandwidth. The spacing of the dipole from the reflector can be adjusted to optimize the feed impedance.

The gain of a corner-reflector antenna with a reflector surface of one to two wavelengths is typically 8 to 10 dB over an isotropic radiator. Antenna gain can be made 14 to 15 dB or more with a large reflector (greater than 5 wavelengths) and a narrow (45 degree or less) angle.
However this is mechanically impractical at frequencies below 1000 MHz.

Dipole operation
A dipole is a balanced antenna and should not be fed directly with coaxial cable. Doing so would cause the outer conductor of the coaxial line to act as part of the antenna, and a large amount of signal would be radiated or received by the outer conductor. For casual reception this may not matter much, but the directional radiation pattern of the antenna is destroyed and reception/transmission results are no longer predictable.

In order to derive a balanced feed for the dipole some sort of a transformer is necessary. For the corner reflector described here a slot-fed balun is used (see Fig. 1). This is accomplished by splitting the outer conductor (made from a brass tube) lengthwise for a quarter wavelength and connecting the inner conductor (a much smaller diameter tube or rod) to the end of one segment, and to one dipole element. The other segment is connected to the opposite half of the dipole. This type of balun gives a 4:1 impedance transformation and can feed a simple dipole. A satisfactory impedance match was achieved (1.5:1 or better VSWR) by adjusting slot length and trimming dipole length, and adjusting dipole-to-reflector spacing. Dipole-to-reflector spacing affects the dipole's impedance (see Fig. 2).

Construction
Fig. 3 shows some details of a corner-reflector antenna that you can build. Virtually all materials for the antenna are available at hobby shops and building supply centers. Total cost should be $20 or less. The corner-reflector antenna described here was designed for operation at 900-MHz. For other frequencies, the dimensions can be scaled from the information given in Table 1 and inserted into Fig. 4. However, at lower frequencies, the antenna is larger so some compromises have to be made to keep within practical mechanical size, weight and structural stability. A good idea from a performance standpoint is to keep the reflector as large as you can, up to a few wavelengths. This becomes impractical at 400 MHz, more so than at 1300 MHz, because of the antenna's overall size. As antenna size increases the extra gain may not be worth the mechanical difficulties and cost. Also, wind loading must be taken into account as this corner-reflector antenna presents a large wind surface area from all compass directions.

The antenna shown in Fig. 3 is fairly easy to construct with hand tools. Before you begin construction, review all the illustrations from Fig. 1 to Fig. 8, including Tables 1 and 2 to obtain a visual mechanical understanding of what is to follow.

Begin by cutting a 6.5-inch piece of %4-inch O.D. (outside diameter) brass tubing with a 0.015-inch wall thickness (available at well-stocked hobby shops). See Fig. 5. This length is the sum of half of a wavelength at the desired operating frequency, plus another 1 to 2 inches to allow for the connector and mounting flange as shown. Make sure the ends are squarely cut. A tubing or pipe cutter will provide a better cut than a hack saw. Cut a piece of %4-inch tubing to a length about % inch shorter than the length of the %4-inch tubing. These tubes will form the dipoles feed assembly and balun.

Continued on page 75
Disk-space management

Judging by my e-mail, disk partition management is a very popular—but much misunderstood—topic. To help dissipate the mist, I'll discuss how partitioning affects overall system resource availability. Then I'll talk about some products that help manage those resources in a more efficient manner than operating-system-only tools: Partition Magic, System Commander, Remove-It, and the OS/2 Boot Manager.

Should you care about disk partitioning? Not if you have a high-capacity hard disk with no danger of running out of space, and you run a single operating system. But if you want to run more than one operating system on a single machine, maximize space-utilization efficiency, provide better organization of data, or add additional hard drives, then you'll want to understand this discussion.

How partitioning works

Any given physical drive can be divided into several sections called partitions. A given drive may have as many as four partitions. There are two types of partitions: primary and extended. In general, you can think of primary partitions as bootable, and extended partitions as for data. You can subdivide the extended partition into logical drives, but you cannot subdivide a primary partition. Both types of partitions can be either hidden or visible. Hidden means that the partition will be ignored by the operating system when booting, and inaccessible thereafter. The main differences between primary and extended partitions are summarized in Table.

All partition information (where it starts, where it ends, whether it's visible, its type, and so on) is stored in a data structure near the physical beginning of the disk. That data structure is called the Partition Table. You can view it using various utilities, including DOS's FDISK, the Disk Editor in the Norton Utilities, and several of the utilities discussed below.

In the past, only one primary partition could be marked visible. But recent versions of DOS (and Windows 95) can have multiple visible primaries (MVP's). However, some operating systems (such as OS/2) are confused by MVP's; consequently, data corruption can occur.

All versions of DOS, Windows, and OS/2 come with a utility called FDISK, which allows you to create, destroy, and (in a very limited way) modify partitions. Using only utilities supplied with the operating system when repartitioning a disk usually means backing everything up, repartitioning, possibly installing an operating system and restoration software, and restoring data to the new partitions.

A company called PowerQuest recognized that limitation and has developed an extremely useful partition-manipulation utility called Partition Magic, which allows you to create, destroy, move, resize, hide/unhide, and set active partitions. (Setting a partition active means designating it as the boot drive.)

Partitioning issues

When deciding how to divide up a hard disk, there are three primary issues: 1) Cluster size and disk efficiency; 2) The number of operating systems and their boot requirements; and 3) Drive letter sequences.
Cluster size. I discussed this issue in some detail in the January 96 issue, so I won't repeat it here. The bottom line is that when it comes to cluster size, big is bad. You can easily waste 150 megabytes or more on today's common 1-gigabyte drives. It is to your advantage to partition large drives in as small chunks as possible.

OS requirements. The questions to ask here are: How many operating systems do you want to run? How much space does each need? How much isolation do you want between them? Do they need to have access to each other's data? The cleanest, safest approach to running multiple operating systems on a single hard disk is to create four primary partitions, and mark only one visible at any given time. But then you can't share data among them. In addition, some operating systems "predatory:" On installation, a predatory operating system alters the partition table and the boot-strap loader on all drives so that only that operating system will be visible. Windows 95 is notorious in this respect. However, that's easy to fix using FDISK or Partition Magic.

Drive letters. When experimenting with different partitioning schemes, you quickly learn that partitions have a tendency to appear at different drive letters. That can be merely inconvenient or a major pain, depending on the types of applications you run. You can minimize this effect by understanding how drive letters are allocated. There are also utilities to help migrate applications from one drive to another, in the process updating all relevant system files.

The drive-letter assignment process works like this. Scan through all physical drives; for each that has a visible primary partition, assign a drive letter. Scan through all physical drives again; for each that has an extended partition, assign drive letters for all visible logical drives in that extended partition. Scan the physical drives again; for all unassigned visible primary partitions, assign drive letters. The process is represented in pseudocode in Listing 1.

In sum, think of the ordering process as active primaries, extendeds, and inactive primaries.

Examples

To understand how that works, let's try a few examples. Assume that our system has two hard disks with the layouts shown in Fig. 1-a. Each drive has a primary active partition and an extended partition containing a single logical drive, neither of which is hidden. In this case, drive lettering is straightforward.

Figure 1-b adds an additional primary partition to both drives; both partitions are visible. Note the new primaries are added to the end of the letter sequence.

Now suppose we hide Drive 1, Partition 1, and make Drive 1 Partition 2 active; Fig. 1-c shows the results.

Under DOS, we could leave D1P1 visible, and simply make D1P2 active; Fig. 1-d shows how that would work. Note that our former C drive (D1P1) has now become the G drive.

Suppose now that instead of one logical drive in the extended partition, we have several. Figure 1-e shows how that might work. Figure 1-f shows one way of creating a clean multi-operating system scenario using two hard drives. Drive one might be a relatively small (500-megabyte) drive divided into several primary partitions. Each partition holds a different operating system, only one of which is visible at any given time. The second drive, perhaps a 2-gigabyte monster, might contain a single extended partition subdivided into eight 256 K logical drives.

A single-drive variant of that theme appears in Fig. 1-h, which consists of a single physical drive with three prima-
ry, bootable partitions (which would share the "C" designation), and a group of extended partitions that would remain at the same drive letters.

Disk management tactics

If you can accurately forecast your partitioning needs, great. But if you find this a slippery territory requiring occasional updates, you'll appreciate several tools for handling boot, partition, and application-configuration management.

Boot management

A boot manager helps you switch among several operating systems at boot time. If you need only a few operating systems, and don't mind some inconvenience, you can always use FDISK to set a partition active (bootable).

A step up in convenience is the Boot Manager that comes with OS/2. It allows menu-based selection, at boot, of several operating systems.

A product called System Commander, by V Communications, is probably the most versatile utility in this category. It allows you to select among more than 100 operating systems, broken down as follows: 56 in primary partitions on fourteen drives, 16 in logical (extended) partitions, and 32 in the primary DOS partition.

System Commander manages the latter by storing copies of crucial boot files (e.g., AUTOEXEC.BAT, CONFIG.SYS, and COMMAND.COM) in separate subdirectories, and then copying them to the root when you select the corresponding operating system at boot time.

One key point not noted in System Commander's advertising is that you cannot arbitrarily boot any operating system from any of those 104 slots. Flexibility may be limited by the operating system itself. For example, DOS and Windows 95 must be booted from a primary partition on the first physical drive. Other operating systems, such as Windows NT and OS/2 are more flexible, and may be booted from extended partitions and other drives. System Command also supports non-DOS operating systems including NetWare, Linux, SCO UNIX, Solaris, and many more.

I found that System Commander worked fairly well. At one point it got confused and mangled a copy of MSDOS.SYS, a text file that supplies boot parameters to Windows 95. Windows 95 would not boot, and gave a spurious error message about not being able to locate HIMEM.SYS. It took only a few minutes to figure out what was going on, but that type of thing could drive a novice bonkers.

Partition management

Partition Magic is a fantastic program. It's powerful, easy to use, and the price is right. The program gives you fine-tooth control over disk partitioning. You can easily add, delete, move, and modify primary and extended disk partitions on one or several drives from a nicely done OS/2-like interface. You can also convert partitions from DOS/FAT to OS/2's HPFS format. As long as you maintain a pool of free space, it's easy to move and resize partitions at will. You should absolutely back up before performing any operations with Partition Magic. Operating your computer from a UPS is also highly advisable. If something happened while Partition Magic was doing its thing, you could end up with garbage. My only criticism of the program is that if you have several partitions packed tightly together, and want to insert one between them, you have to move those to the right of the insertion point manually. An insert function would be welcome. Also, conversions among other formats (particularly NTFS) could be useful.

Application configuration management

If you repartition a large drive into smaller drives to increase cluster efficiency, applications may end up on different drive letters. For small command-line utilities and DOS (character-mode) applications, that's not usually much of a problem. But moving Windows applications can be tricky. The best way I've found of doing so is using the Move Application function in a program called Remove-It. The primary purpose of that program is to help you safely delete DLLs, INI files, Registry settings, and other system components that are no longer necessary. The program is slow, and its user interface is frustrating. But it can help you save both time and disk space.

RESOURCES

Partition Magic 2.0 ($49.95)
PowerQuest Corporation
1093 North State Street
Orem, UT 84057
(800) 379-2566
(801) 226-8977

System Commander 2.26 ($99.95)
V Communications Inc.
4320 Stevens Creek Blvd., Suite 120
San Jose, CA 95129
(408) 296-4224

Remove-It 3.0
Vertisoft Systems, Inc.
Four Embarcadero Center, #3410
San Francisco, CA 94111
(800) 295-5875

OS/2 Warp 3.0
IBM Corp.
(800) 426-3333

The documentation for each of these programs is confusingly written, but loaded with useful tidbits, so if you're interested in this topic, well worth reading. Chapter 18 of the User's Guide to OS/2 Warp has the clearest discussion of booting and partitions. The System Commander manual does not give a good overview, but does provide detailed scenarios for installing various operating systems. Partition Magic's manual has a pretty good overview, but falls short on operation and particularly the error messages it presents. The Remove-It manual is a joke.
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You can build a laser-based seismometer that is simple, yet remarkably sensitive and accurate.

Seismometers are best known for their use in measuring the intensity of earthquakes. However, they can also detect other vibrations, such as heart of the seismometer device is the sensor unit. It incorporates a variation of the speaker modulator described in the last column (Electronics Now, June 1996, page 51).

Figure 1 shows all three parts of the sensor unit. It is simply a 1 1/2-inch square of rigid, aluminized mylar attached to one end of a 2-inch length of medium tension spring. Epoxy, silicon, or hot-melt glue will do the job. Fasten the other end of the spring to a 2-inch square block of 1 x 2 pine. This assembly, when mounted to a very stable foundation, will vibrate in response to any shock waves traveling through the earth.

For an indoor location, use an upright stud or pillar that is sunk into your home’s foundation. Such a spot in your garage or basement will work well. Outdoors, a 6- to 8-foot fence post, or an antenna ground rod that has been driven 4 to 6 feet into the earth, will provide the needed stability and coupling to the earth.

Once you have determined the location, mount the sensor assembly firmly. If you select an outdoor spot, place a small box around the sensor to protect it from air currents and wind. Leave a 1- or 2-inch opening in the box for the laser beam. With the sensor in place, aim the laser at the mylar square. Adjust the laser beam angle so the reflected beam shines into the detector described in the previous column. Adjust the volume and gain of the receiver until you are able to obtain a uniform sound signal.

Your unit is now in its monitor mode, and the signal will remain unchanged until it detects vibrations. Strike the foundation gently and notice the change in the audio output. Drop a heavy object near your detector and again note the change in the audio output. Experiment with a variety of different objects and actions that causes the sensor to react. You will soon see a pattern develop that will let you estimate shock intensity by hearing the change in the sound.

If you have a frequency meter, you’ll be able to draw some interesting graphs based on a plot of the

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actual frequency readings. If you connect a peak meter, an LED bargraph, an analog meter, or even a lamp and relay, you will be able to obtain all kinds of different data. If you want an alarm, use a relay to trigger a lamp or some other alarm device based on the sensor's output frequency.

**Building a seismograph**

While all of these demonstrations are interesting and informative they do not produce any record of the result. So for a more ambitious effort, you can build the simple seismograph based on the photographic recorder shown in Fig. 2. This device will receive the modulated laser beam, collimate it to a pinpoint of light, and record it on ordinary photographic print paper (the kind used to make black and white copy prints or enlargements).

In the prototype a threaded rod is coupled to a clock motor, which rotates the rod. Nuts that match the thread of the rod are cemented to a plate that holds a strip of photographic paper. This plate assembly is then threaded onto the rod, through the nuts. As the motor rotates, the plate moves from right to left. A metal guide is positioned at the bottom to keep the plate from spinning around the rod; a Teflon strip attached to the metal guide reduces friction. As the plate moves, it passes through the laser beam. This exposes the paper to whatever pattern is present.

With normal activity, the beam will create a rather straight line with a little background noise. But when the sensor detects significant movement, the line will break, and peaks will be displayed on both sides of the center line. This movement will be in direct proportion to the intensity of the vibration.

The project is not as simple as it sounds. Your detector will have to housed in a light-tight box as shown. Note the baffle that runs the length of the box, to further reduce stray light. The way it is set up, only laser light enters the lens and is sharply focused on the photo paper. The window in the light baffle must be kept as small as possible—mine measures only 3 inches by \( \frac{1}{2} \) inch. Notice the medium-red filter on the inside end of the collimator (lens tube). It helps keep ambient white light out of the box.

The rate at which the plate carrying the photographic paper moves is determined by the number of threads per inch that the rod has. The greater the number of threads per inch the slower the plate will move. If you use a rod with 20 threads per inch, the plate will move about 1-1/4 inches in a 24-hour period.

The unit is shown set up to record vertical (up-down) movements. To detect horizontal (side-to-side) movements, simply set the recorder on its end. Either way you will have an accurate and permanent copy of the movements you monitor.

When your unit is complete, load it with a piece of photographic paper (in total darkness or under a red photographic safe light). Then seal the box and you are almost ready to go. Line up the laser and the recorder and turn on the motor. Come back the following day and retrieve and develop your photographic paper. It's simpler than it sounds and you should have a lot of fun with this simple device.

---

**FIG. 2—FOLLOW THIS PLAN TO BUILD YOUR OWN photographic recorder.** It makes a permanent record of vibrations and other earth movements over a 24-hour period.

**FIG. 3—PHOTOTRANSISTOR SENSING STRIP is easy to make and can be coupled to an LED display panel. Complete details are in the text.**
Detecting small or slow movements

You can also put lasers to work to detect an object’s small or slow movements that might otherwise escape the naked eye—the growth of a plant, for example, or the settling of a new building's foundation. This kind of study requires long-term monitoring. One method to try is to attach a small piece of reflective mylar to the object being observed, and to reflect a laser beam off the mylar at a slight angle. The position of the return beam can be marked on a scale. As the object moves, the angle of the reflected beam will change and the spot will appear at a new location on the scale. Note these changes at regular intervals and you can chart the movement.

Let's use a clock's hour hand as a specific example—it will provide results quickly. As the hand moves around the dial, mark the reflections on a piece of graph paper. Then draw a curve using the points you have plotted. Remember, this is only an example to let you see results quickly. If you come up with an interesting test procedure, let us know.

To perform this kind of measurement you will need a collimator, a convex lens, to concentrate the laser beam into a small spot to make the markings more accurate. If an electronic display is needed, take a look at Fig. 3. On a strip of plastic or some other mounting material, set up a row of phototransistors edge to edge, keeping them as close together as possible. The miniature plastic types will let you squeeze in about 10 to the inch. Connect a 220-ohm resistor to each phototransistor's collector. Then tie the anode of a standard LED to each phototransistor's emitter. Make sure that the LED cathodes are all connected to the negative side of a 6-volt DC power source. The free end of each resistor connects to the positive side of the supply. Whenever the laser beam hits one of the phototransistors, the corresponding LED lights.

Reflected sound modulation

The last experiment in this section uses the high-gain amplifier described in the laser column in the June 1996 issue of Electronics Now, as a receiver. It demonstrates how sounds can create vibrations in solid materials. The degree of movement depends upon the volume of the sound present and is usually unnoticeable to the human eye. Yet it is there, and the receiver is sensitive enough to detect it. To illustrate this principle, aim your laser at a surface on a nearby building and align your receiver so it can pick up the reflected beam as shown in the diagram of Fig. 4.

Glass or metal surfaces are best, as both tend to vibrate better than more solid materials. When you bounce the beam of a pane of glass, only part of the light comes back, while the rest passes on through to strike whatever surface it finds. For more detailed information about the process see the article Laser Listener by Richard Pearson, in the October 1987 issue of Radio-Electronics magazine.

Adjust the receiver's gain and volume and you should be able to hear sounds within or around the building. Scan the beam around the structure to find the points of best reception. This type of system has been employed for clandestine eavesdropping, and such use is illegal.

It is interesting to note the sensitivity of the equipment and the variety of sounds received. For the best possible reception, try using a metallic parabolic dish to increase the concentration the incoming light and maximize the strength of the incoming audio signal (see Fig. 5) at the dish's focal point.
In addition to circuit simulation, EE Works comes with a healthy helping of circuit-design routines, like the filter design in Fig. 1, that calculates the value of the various components after you enter the desired response. There's a schematic-capture routine, of sorts, that lets you build your own design and submit it to the rigors of this cruel simulator.

Because of the modular design, though, EE Works' myopic view of the world results in very fast simulations. It can do in 10 seconds what it takes a Spice-modeled simulator three minutes to do. Moreover, it delivers more information than you can possibly digest in a single session. While the graphics are a bit skimpy, what graphics it does have are dynamite—if you know how to read the results. In addition to an X-Y plot, you're given a table of values that created the plot, plus a list of the DC parameters at each sampling. These can then be used to optimize the circuit.

Fast, accurate, and thorough are the trademarks of EE Works. However, it's a real nut-buster program that requires a lot of preparation to work and an engineering background to use to the fullest.

**Product:** Analyser III  
**Version:** 1044C  
**Price:** $149  
**Platform:** DOS  
**Distributor:** BSOFT Software, Ohio Automation

Analyser III is a DOS-based, non-SPICE analog simulator from Number-One Systems Ltd., the same people who make the Easy-PC line of schematic-capture and PC-board layout software. Analyser III is an AC-only analyzer, specifically measuring magnitude, phase, and delay times. It doesn't do DC analysis or operating-point analysis. However, it can display these values by gain, input impedance, or output impedance of the circuit under test.

At the heart of Analyser III is a sweep generator with a frequency range of 0.001 Hz to 1.000 GHz. To do a simulation, you load the circuit, set the desired frequency sweep, and press the "go" button. Analyser III does everything else for you by automatically setting the input voltage level and adjusting the X-Y scales so that the waveforms fill the display area (Fig. 2).

You can either import the design from a schematic you drew in Easy-PC Professional, or you can create the circuit with Analyser III's assistance. Because Analyser III doesn't have a schematic-capture function, though, you have to "build" the circuit as an ASCII netlist using Analyser III's text editor. You simply list the components, and use node numbers to identify their interconnections. Analyser III then translates the list into the proper netlist format. Unfortunately, the process isn't intuitive; it's not easy to keep track of the many nodes used in a complex circuit. Consequently, you'll find it a lot easier if you sketch a diagram of the design before you begin the netlist building process.

Analyser III comes with a library of 100 components and includes a good mixture of bipolar transistors, field-effect transistors, and operational amplifiers. Additional components can be added to the library using a text editor and information gathered from the device data sheets.

For straightforward gain-versus-frequency analysis, there's nothing faster or easier to use than Analyser III. Moreover, it can do simulations well into the GHz range, making it ideal for evaluating transmission lines, open stub filters, and stripline filters.

**Product:** B²Spice for Windows  
**Version:** 1.1  
**Price:** $149  
**Platform:** Windows  
**Publisher:** Beige Bag Software

By the time you read this, the B² Spice for Windows program reviewed here will be replaced with a newer version. Unfortunately, we couldn't get the beta version of the new simulator (version 2.0) to work without it crashing our system. So rather than rate it over the coals, we went with what works—Version 1.1. We are told the look and feel is about the same in V2.0, but more about that later.

Unlike most SPICE simulators, which easily run from an ASCII netlist, B²Spice for Windows has to run from a schematic-capture program. It cannot import SPICE decks. Fortunately, the schematic-capture function is included in the $149 price. Unfortunately, it's not the best-looking drawing program, and the nomenclature is always expressed in scientific notation (Fig. 3).
<table>
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1) Separate program
2) Version 2.0 only
3) Separate instruments
4) Advanced version only
SuperSPICE is a demanding simulation program that barely makes it under our S350 cap. No, the program itself is not pricey—SuperSPICE costs only $149. But it has to be linked with SuperCAD for Windows. Mental Automation's S149 schematic capture program, before it'll work. It also requires a math coprocessor, which means you'll probably have to be running at least a 486DX2 processor on your PC.

When you install SuperSPICE into your system, it upgrades your existing SuperCAD models to include SPICE parameters. Also loaded into the SuperCAD libraries by SuperSPICE is an amazing assortment of test instruments. The signal sources includes a sinewave, pulse, FM modulated, and AC sweep generator. The list of sources also includes a piece-wise generator that lets you create your own customized waveforms—an instrument that's found in only one other simulator, CircuitMaker. The monitoring devices include a multiple-trace oscilloscope, Bode frequency analyzer, curve tracer, and an unlimited number of voltage and current meters (Fig. 4).

To start a simulation, you first start SuperCAD for Windows and load the desired schematic design. The netlist is created by SuperCAD when you click on the Simulate option. The current version of SuperCAD only allows one kind of primary analysis at a time. The three analy-
s supported are DC sweep, AC sweep, and transient. You can also select the DC operating point by changing the information in the setup menu and fiddling with the settings of the signal generators. Quitting SuperSPICE returns you to SuperCAD.

While SuperSPICE works best with analog circuits that fit on a single sheet, you can work with multiple sheets—but you'll probably have to switch from one sheet to another to view the simulation results. On the other hand, SuperSPICE, doesn't do mixed mode simulations. So by using different schematic sheets to split up analog and SPICE digital devices, it makes it easier to move information from one function to the other.

SuperSPICE is a venerable circuit design veteran that has been around for a decade. It interfaces flawlessly with its schematic capture program, the test instruments are second to none, and it's easy to use. Demos of both SuperCAD and SuperSPICE can be downloaded from the Electronics Now BBS.

Product: TurboSIM
Version: 1.1
Price: $149
Platform: Windows
Publisher: Island LogiX

TurboSIM is new to the low-cost circuit CAE (computer-assisted engineering) fray. So new, in fact, that it almost escaped our attention. Despite its youth, this is a well-thought-out program that's loaded with a lot of really good features.

TurboSIM can be broken down into three components: a schematic-capture module, a SPICE simulator, and a digital simulator. Both simulators can link to the schematic-capture editor for simulation input, or read directly from a netlist file. However, the simulators are totally separate and independent of each other. Therefore, you can't mix analog and digital devices in the same circuit.

Actually, there are two versions of TurboSIM. There's the standard version which has all three modules. It supports DC operating point, DC sweep, AC sweep, and transient simulations (Fig. 5). For most users, this is all the simulation you'll ever need to find out if your design will fly or not. But heavy-duty designers will probably want the added benefits of noise, distortion, sensitivity, Fourier, and pole zero analysis that the Advanced version (also $149) serves up. Because of programming limitations, though, there isn't enough room for the schematic capture program or digital simulator. All you get is a fully-packed TurboSPICE simulator program with the monitoring instruments.

TurboScope is the oscilloscope display module that comes with all versions of TurboSIM. It works in real time, updating the display as the SPICE simulation progresses. And lets you easily jump from one wire or node to another without interrupting the simulation. Scale adjustment for the best display is automatic. If you really want to roll up your sleeves and get your hands dirty, TurboScope recognizes a long list of math functions that lets you display your waveform in just about any format you can think of—and some that you've probably forgotten.

TurboSIM is easy to use and perfect for electronics students and hobbyists—yet powerful
enough to handle complex simulations demanded by engineers and technicians who handle hierarchal schematics and circuits containing multiple sub-circuits and pages.

**Mixed-mode simulators**

Sometimes it's necessary to mix analog and digital components in a single design. A good example is any circuit that uses an analog-to-digital (ADC) or digital-to-analog (DAC) converter. A short list of typical mixed mode applications include timers, PWM controllers, Class D audio amplifiers, switching power supplies, and ADC and DAC circuits. Until recently, there was no easy way to handle analog and digital simulations simultaneously, and the process was generally broken down into two steps: an analog simulation followed by a digital simulation. Obviously, this makes it hard to get an overall view of circuit operations. Since then, many of the basic digital functions, like NAND and NOR, have been defined in analog terms using SPICE models. This allows you to do limited digital simulation as well as mixed mode simulation.

Although all the following mixed-mode simulation programs are SPICE based with a schematic capture front end, they are quite diverse in the way they work and play their trade. The first, ICAP/4, does what you'd expect from a mixed mode simulation program—which is basically SPICE models put through their paces. This program is for the professional designer or hobbyist who knows what's happening and knows how to interpret the results. The next two programs, CircuitMaker and Electronics Workbench, have added the added in that they teach you about electronics as you proceed through the tutorials. So you don't have to be a rocket scientist to use them.

ICAP/4Lite is an interesting analog-mostly simulator with as many twists as an Agatha Christie novel. To begin with, ICAP/4Lite is a 32-bit program that runs wonderfully well under Windows 95 and Windows NT. Unfortunately, it has some problems coping with Windows 3.1. Specifically, the included Windows 32S driver, which converts Windows 3.1 into a 32-bit operating environment, has a penchant to lock out the keyboard at the slightest whim.

The most interesting aspect, though, is its price—which is $899. Before you blast past this program as too expensive, you should know that you can buy a student version for a very low $40. Sure, the student version has limitations. For example,

WHERE TO BUY

**Analysys III**

BSOFT Software, Inc.
444 Coltran Rd.
Columbus, OH 43207
(614) 491-0832

Ohio Automation
7840 Angel Ridge Rd.
Athens, OH 45701
(614) 592-1810

**BSpice**

Beige Bag Software
2000 Hoggback Rd., Ste. 2
Ann Arbor, MI 48105
(313) 971-4227

**CircuitMaker**

MicroCode Engineering
1943 North 205 West
Orem, UT 84057
(801) 226-4470

**EE Works**

Geoban Engineering
418 N Inyo St.
Ridgecrest, CA 93555
(800) 645-6806

**Electronics Workbench**

Interactive Image Technologies Ltd.
111 Peter St., Ste. 801
Toronto, Ontario, Canada
M5V 2H1
(800) 263-5552
E-mail: bieglesley@interactiv.com
http://www.interactiv.com

ICAP/4Lite

intusoft
P.O. Box 710
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(310) 633-0710

**SuperSPICE**

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(206) 641-2141

**TurboSIM**

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Waukegan, IL 60079
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**FIG. 5—TURBOSIM IS A POWERFUL WINDOWS SIMULATOR** that comes in two versions. For most of your designs, the basic package will fill all your analog and digital simulation needs — plus it includes a schematic capture front end. If you need to do noise, distortion, or zero pole analysis, then you'll prefer the Advanced version, which costs the same but doesn't include schematic capture.
the component library is smaller, and you're limited to designs of 15 parts or less. But in this day of highly integrated circuits, 15 parts can go a long way.

ICAP/4LITE is actually a medley of four interactive programs. The first is a text editor that you use to compose SPICE netlists. IsSpice is the next program, and the SPICE engine that runs the simulation. The IntuScope program is the waveform analyzer and main display (Fig. 6). Finally, there's the schematic capture function.

There are three types of analysis performed by ICAP/4LITE: DC sweep and operating point, AC Bode plots, and transient analysis. ICAP/4LITE can also do temperature analysis and simulation breakpoints. Breakpoints are IsSpice4 commands that can be used to stop a simulation when certain conditions are met. For example, you could have the simulation stop when the voltage on pin 7 of IC3 exceeds 4.5 volts. ICAP/4LITE can pull this off because IsSpice4, intusoft's proprietary SPICE programming language, is a superset of Berkeley SPICE 3F.2.

While ICAP/4LITE isn't the easiest analog simulator to use, it certainly has more power than most. Best of all, though, it's the least expensive at just $40, if you can live with the limited parts count of the student version. A fully-functional ICAP/4LITE demo can be downloaded from the Electronics Now BBS or from intusoft's WEB site (http://www.intusoft.com).

CircuitMaker is a powerful yet easy-to-use schematic capture program and circuit simulation program. However, while CircuitMaker claims to be a mixed mode simulator, it's sharply divided between the analog and digital world. A single icon makes all the difference. Click on the AND gate and you're in the digital simulation mode. Click on the transistor and... well you get the message. Fortunately, CircuitMaker is SPICE based, so you can mix simulations if a SPICE model exists for the digital device you are considering inserting into your analog design.

All simulations begin with a schematic. However, the schematic-capture program has changed considerably since the last time we looked at it. It used to be that there were ten or so columns of parts, L1 through L10, each holding 24 devices. Now there are only two columns, with Browse at the beginning of the first column. Clicking on Browse opens up a whole new world of device options (Fig. 7) that weren't available in the CircuitMaker we looked at a year ago. The remaining forty listings let you bypass the browse menu and quickly place commonly-used components, like capacitors and resistors.

What makes CircuitMaker so powerful as a simulator is its Probe and Trace tools. As its name suggests, the Probe is a touching tool that taps into the inner workings of a circuit. In the digital mode, the Probe acts like a logic probe, indicating whether your test point is logic high or low. In the analog mode, it becomes a voltmeter (Fig. 8). The Trace button is a digital-only tool that indicates the current state of the simulation by changing the colors of the wires. A wire at logic high is red, zero logic is blue, and three-stated (high-impedance) is green. While it's really cool to see these wires change colors, it's fairly slow — but that's for a good reason. Imagine trying to follow the changing colors at a rapid pace!

We were totally impressed with the signal generator. Not only does it do the necessary sine, pulse, and sawtooth functions of a mixed mode simulator, you'll also find an exponential generator, piece-wise generator, and an FM generator for spectrum analysis. Of all the circuit simulators, CircuitMaker has the most robust signal source.

We like the fact that CircuitMaker is a tutor as well as a schematic capture program and simulator, and that the test instruments are super. However, I'd certainly check out Electronics Workbench, which fol-
FIG. 7—CIRCUITMAKER IS A POWERFUL, yet easy to use, schematic capture and simulation program. It has a long list of test instruments, and the best looking display of any of the simulators.

When it comes to mixed mode simulation, Electronic Workbench takes top honors. You're allowed to field both types of instruments, analog and digital, including a logic converter (Fig. 9). You can even change instrument settings as the simulation progresses. For example, if the oscilloscope's time base isn't showing what you want to see, simply click on the time base button and watch your display expand or collapse—as you simulate. Unfortunately, Electronics Workbench is not a fast simulator. Version 4.1, a 32-bit program, promises to speed along at about five times the speed of the sample we tested.

Like CircuitMaker, Electronics Workbench is a teaching tool as well a circuit simulator. The Help library goes into immaculate detail about the small-

Whether you're using Electronics Workbench to draw schematics or simulate your newest brainstorm, you'll find it extremely easy to use and a welcome design partner. The reason why Electronics Workbench is so easy to use is because it has the look and feel of a real test bench, like the kind you'd expect to find in a professional R&D laboratory environment.

Even the test instruments have the look and texture of the real thing. For example, to set up the oscilloscope you simply click on buttons to incrementally change the voltage and time base settings like you would on a real oscilloscope. This is in contrast to the imaginary instruments used by many simulators where you have to fill in a table of settings from the keyboard, and hope they are within the range of the instrument. The equipment inventory includes an oscilloscope, function generator, Bode plotter, multimeter, word generator, logic analyzer, and logic converter. In addition, there's an unlimited number of DVM current and voltage meters that can be inserted into the circuit at any point.

est components, like the battery. It is a great supplement for someone starting out in electronics career.

Whether you're a novice or a nerd, you'll find Electronics Workbench a gem of a program and a great teacher. It's well worth the $299 asking price.

Next month, we'll look at the wide world of logic simulators.
VIDEO PATTERN GENERATOR

continued from page 56

fied by gate IC6-b of IC6, a quad 2-input NAND IC and shaped by gates IC6-c and IC6-d to drive the counter consisting of the four 74HC161 synchronous binary counters.

Figure 3 is a schematic for a dual +12-volt and +5-volt power supply that can be built on a separate perforated board or be integrated with the rest of the circuit on the main circuit board. It contains two integrated circuit voltage regulators, IC9, an MC7805 positive 5-volt regulator and an MC7812, a positive 12-volt regulator.

EPROM code listing

The EPROM codes can be conveniently generated by a personal computer. The program in Listing 1 is the C program for forming the sync, B/W checker and color bar codes. However, the listing does not include the code for the custom pattern. This program will generate a VIDEO.DAT file with 59,474 pixels. Any EPROM programmer can be used to program the 64 K × 8 74HC512 EPROM, IC5.

Building the generator

Refer to the video pattern generator schematic, Fig. 2, the dual power supply schematic, Fig. 3, and the parts placement diagram, Fig. 4. The author built the video pattern generator and the dual power supply on a rectangle of perforated board that measures 3¾ × 4½ inches. The perforations are 0.10-inch apart on centers, and the board has foil pads and power buses.

Before beginning any assembly work, drill the four mounting holes in the four corners of the circuit board, and drill a hole large enough to admit the bushing of panel-mounted switch S1. Make a paper template of the circuit board hole spacing and bushing hole location for later transfer to the base of the plastic project case as a hole-drilling pattern.

Begin circuit construction by
inserting and soldering the eight DIP sockets approximately in the positions shown on Fig. 4. Insert and solder the axial-leaded 470 µF aluminum electrolytic capacitors C16 and C18 so they lie horizontally on the circuit board. Insert and solder the TO-220-packaged 7805 and 7812 voltage regulators at approximately the locations shown. Insert panel-mounted, rotary switch S1 on the circuit board in the pre-drilled hole, and fasten it with the ring nut and washer provided.

Insert and solder all resistors, radial-leaded ceramic disc and aluminum electrolytic capacitors, silicon diodes, and crystal case at the locations approximately as shown on Fig. 4.

**Mechanical work**

A standard commercial two-piece plastic project case was selected for this project. It measures 7½ × 4¾ × 2¼ inches. This case is large and tall enough to accommodate the AC-line to 15-volt AC transformer T1. Locate transformer T1 at one end of the case as shown in the assembly drawing Fig. 5, and use the holes in its mounting bracket as a template for drilling the two mounting holes. Then drill those holes.

Position the paper template at the bottom of the case and tape it in position. Drill the four mounting holes and the hole for the switch shaft and bushing. Then drill a hole in the end wall of the case nearest the transformer location for the line cord, and drill another hole at the opposite end of the case for mounting the coaxial jack J1.

**Final assembly**

Refer to assembly diagram Fig. 5. Fasten ¼-inch standoffs to the underside of the circuit board at all four corners with screws or nuts. (The author selected standoffs with internal and external threads.) Solder a short length (approximately 6 inches) of RG174 or RG58 coaxial cable from capacitor C16 to the coaxial jack J1. Solder one end of the braided shield to the ground terminal of J1 and the other end to pin 3 of IC1.
LISTING 1—C PROGRAM TO FORM VIDEO.DAT

#include <stdio.h>
int main()
{
    int line, pixel, x, y, buffer;
    int cross = 0x08;
    long data;
    FILE *stream;
    /* open EPROM code file "VIDEO.DAT" */
    if ((stream = fopen("VIDEO.DAT", "wb+")) == NULL)
    {
        fprintf(stderr, "Cannot open output file.\n");
        return 1;
    }
    /* generate first four line codes */
    for (line=1; line<4; line++)
    {
        for (pixel=0; pixel<227; pixel++)
        {
            if (pixel<210)
                data = 0;
            else data = 0x80;
            fwrite(&data, 1, 1, stream);
        }
    }
    /* generate 4-25th line codes */
    for (line=4; line<25; line++)
    {
        for (pixel=0; pixel<227; pixel++)
        {
            if (pixel<17)
                data = 0;
            else data = 0x80;
            fwrite(&data, 1, 1, stream);
        }
    }
    /* generate 25-262th line codes */
    for (line=25; line<263; line++)
    {
        if (line-7==((line-7)/21*21))
            cross = cross & 0x08;
        for (pixel=0; pixel<227; pixel++)
        {
            if (pixel < 17)
                data = 0;
            else if (17<=pixel && pixel<38)
                data = 0x80;
            else if (38<=pixel && pixel<61)
                data = 0xf0;
            else if (61<=pixel && pixel<84)
                data = 0xe0;
            else if (84<=pixel && pixel<107)
                data = 0xb0;
            else if (107<=pixel && pixel<130)
                data = 0xa0;
            else if (130<=pixel && pixel<153)
                data = 0xd0;
            else if (153<=pixel && pixel<176)
                data = 0xc0;
            else if (176<=pixel && pixel<199)
                data = 0x90;
            else
                data = 0x80;
            if (pixel==pixel/13*13)
                cross = cross & 0x08;
            if (pixel==37 && pixel < 223)
                data = data & cross;
            fwrite(&data, 1, 1, stream);
        }
    }
    fclose(stream);
    return 0;
}
Cut two slots lengthwise along one end of the \( \frac{5}{8} \) tubing, on opposite sides of tubing. Use a hacksaw or small saw and cut both slots at the same time with the saw passing through the center axis of the tube. The slot lengths should be \( \frac{1}{4} \) wavelength at the operating frequency. For 923 MHz operation this cut should be approximately 3.2 inches. The slot width is not very critical.

Next, drill holes for the dipole elements as shown in Fig. 5. Leave about \( \frac{1}{16} \)-inch space between the edge of the hole and the end of the tube. The dipole elements can be either \( \frac{1}{16} \) or \( \frac{1}{8} \)-inch diameter brass rods or \( \frac{1}{32} \)-inch diameter brass welding rod. Use a drill that is the same diameter as the dipole elements for a snug fit. Cut a length of brass rod that is to be used for the dipole elements to 1.05 wavelengths long at the desired center frequency. See Table 2 for data on the dipole length.

Carefully clean up and deburr the cut edges on the \( \frac{5}{8} \)-inch and \( \frac{1}{4} \)-inch tubes. File the ends of the dipole element rods to remove burrs and sharp projections. Solder one end of the \( \frac{1}{4} \)-inch tubing to the center pin of a type N connector so that the center line of the tube is aligned with the centerline of the center pin on the type N connector. Allow \( \frac{1}{8} \)-inch of space between the tube and the type N connectors flange as shown in Fig. 5. If necessary, build up the diameter of the center pin with some bare copper wire for a snug fit to ensure concentricity. Place the \( \frac{5}{8} \)-inch tube over the \( \frac{1}{4} \)-inch tube, and check to see that the end of the center tube is flush with or is slightly shorter than the outer tube by approximately \( \frac{1}{16} \) inch, or less. Trim the center tube as needed. Clean the square flange on the connector with fine steel wool for soldering later.

Slip a \( \frac{1}{2} \)-inch copper pipe coupling (use the kind that has no internal pipe stop) over the outer \( \frac{5}{8} \)-inch tube. The commonly used \( \frac{1}{2} \)-inch copper pipe has a \( \frac{3}{8} \)-inch outside diameter so a smooth slip fit should result. If OK, remove and drill a hole at one end to pass a \#4 machine screw. See Figs. 6 and 7. A \#33 drill is large enough, but a \#28 drill was used to allow extra clearance. Polish the copper pipe coupling with fine steel wool to a bright finish. Using rosin core solder, solder a \#4 brass nut to the coupling centered over the hole. Use a stainless steel \#4 screw about 1-inch long to hold the brass nut in place while soldering. Solder will not stick to stainless steel.

Remove the screw after the solder joint cools.
LIST OF MATERIALS
Parts specified for 800-1300-Mhz range. Lengths given in brackets are for 400-470-Mhz range.

1—$$\frac{3}{4}$$-in. O.D. x $$\frac{3}{8}$$-in. I.D. brass tubing, 0.015 nominal wall thickness, 6.5-in. long (14-in. long)
1—$$\frac{1}{4}$$-in. O.D. brass tubing or rod, I.D. not critical, 6- $$\frac{3}{4}$$-in. long (13$$\frac{3}{4}$$-in. long)
1—$$\frac{1}{4}$$-in. to $$\frac{3}{8}$$-in. O.D. brass rod, or $$\frac{3}{8}$$-in. brass welding rod, 15-in. long
1—Type N UG58A/U UHF connector, flange mount, or BNC UG290A/U RF connector, flange mount (either item preferably silver plated)
1—3-in. sq. ft material for reflector, 0.019-inch thick, perforated or grille aluminum recommended (see text)
1—4-40 brass hex nut
1—4-40 x $$\frac{1}{2}$$-in. brass screw
1—4-40 x 1-in. stainless-steel screw
1—0.032 brass or copper plate, 2 x 2-in. square, or double sided G-10 material, 2 x 2-in. x 0.062-in. thick
1—$$\frac{1}{2}$$-in. stop-less copper pipe coupling, sweat type
1—Wood, 1- x 2- x 12-in.
8—#6 x $$\frac{1}{2}$$-in. sheet metal or wood screws

Also: Solder (both resin core and solid), fine steel wool, hardware as needed, miscellaneous wood blocks, $$\frac{1}{2}$$ x $$\frac{1}{2}$$-in. wood lengths for bracing as required, suitable plastic container for optional cover.

A catalog describing kits for ATV transmitters, ATV receiving converters and other projects useable with the antennas described in this article is available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804. Please include a #10 SASE and $1.00 to cover handling and postage.

E-mail: Ncradio200@aol.com
Compuserve 102033,1572

Note: Materials illustrated and listed are for a corner-reflector antenna operating at about 900 MHz. Antennas for lower frequencies are larger and will require correspondingly larger or more materials. Brass tubing for inner and outer conductors can also be any other reasonable dimensions as long as they have approximately a 2.3 to 1 ratio of ID (outer) to OD (center). See Table 2 for other suitable sizes and corresponding impedances.

Prepare a mounting flange from a 2 x 2-inch square plate made of copper, brass, or surplus PC board G-10 material. See Fig. 7. At its center, punch a hole in the flange to the outside diameter of the pipe coupling.

Solder the coupling in place about the entire circumference. Make sure coupling is perpendicular to the plate. Slip the flange assembly over the $$\frac{3}{8}$$-inch tube, the slit end opposite the nut as shown. Clean both ends

FIG. 5—PRE-ASSEMBLY DETAILS of the feedline/balun tubes. For 400 to 470-MHz operation of the corner-reflector antenna the outer tube length should be increased to 14 inches; the inner tube, 13.785 inches.

FIG. 6—TWO VIEWS OF THE DIPOLE AND FEEDLINE construction details. In the end view drawing note that the right dipole element connects to the inner and outer tubes and shorts them together. The left dipole element connects just to the outside tube. The ends of both dipole elements are equi-distant from the center of the inner tube.

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of the outer tube with fine steel wool to facilitate soldering in the following steps.

Insert the ¼-inch tube and type N connector assembly into the outer ½-inch tube placing type N connectors flange flush against outer tube (see Fig. 6). Check to see that pre-drilled holes for dipoles are aligned. You can insert the dipole elements and fasten them in place with tape to check for correct alignment. When the tubes are concentric, solder connector flange to ½-inch tube all around the edge. Use as little solder as you can for a neat job, and if possible use a hot 100-watt iron with a ¼-inch tip. A few wooden blocks drilled with ½-inch diameter holes will be useful for holding parts during assembly and soldering operations.

Clean all solder residues deposited in the previous step with isopropyl alcohol, flush with water and blow dry. Do this outdoors away from flame or sparks. Remove the dipole elements and make sure no electrical contact (short) between the outer and inner tubes exist.

Solder the dipole elements in place. The outer and inner conductor are shorted together by one dipole element. This is normal. Make sure they are aligned as shown in Fig. 6. Measuring from center of center tube, the dimensions of each side of the dipole should be equal in length and symmetrical.

You now have a half-wave, slot-fed dipole. Connect it to a receiver and check to see if it works as a receiving antenna. It should work as well as your whip antenna or better. Try orienting vertically and horizontally for best signal reception.

If you have the test equipment, use an RF source and a SWR or power meter to check the VSWR. It should be 2.0 or better. The dipole elements can be trimmed for lowest VSWR later. This will be affected by reflector spacing, slot length, and also presence of nearby reflecting objects. If the antenna pulls in no signals, check for shorts from burrs, solder drops, steel wool fragments, or other foreign material.

**The reflector**

Almost any perforated, stiff aluminum material can be used to make the reflector. A 0.019-inch thick perforated aluminum sheet was used. It is available in hardware stores for making grilles and covers for radiators, etc. The holes reduce the overall weight and wind resistance. Solid sheet aluminum, copper, wire mesh, or screening can be used since all you need is a conducting surface. Plywood or heavy cardboard covered with aluminum foil can also be used. If weatherproofing is not needed, for experimental or temporary use. Hardware cloth (aluminum or copper screening material) is also useful but hard to handle.

Referring to Fig. 3, you see that the reflector is made by bending a 1 x 2-foot sheet of perforated aluminum sheet. The exact reflector dimensions are not critical, larger being better. Instead of one 90-degree bend, two 45-degree bends were used leaving a 1½-inch valley that provides a surface for a good mechanical support. A piece of 1½ x ¾ x 12-inch wood is used to support the reflector and to mount the dipole in the center of the reflector. This piece of wood can also be used for mounting a bracket to hold the completed antenna to a mast or other support.

Bracing can be added to the reflector if desired as shown in the photo. Use wood, plastic, fiberglass, or other non-conducting material. Conductive materials in front of dipole will cause detuning and pattern distortion. If thin sheet metal is used alone for the reflector it is wise to cut the metal 1-inch larger in width and length and use this extra material to form a folded edge around the perimeter to stiffen the reflector surface. A block of wood can be used to form the bends, as the material is easily worked by hand. Make bends along perforated lines in the aluminum for sharp and true bends.

After the reflector is formed, cut a hole in the center of the valley fold as shown in Fig. 3 and fasten the flange on the dipole assembly to the reflector. The dipole should be parallel to the bend in the reflector. Initially set the dipole about 0.3 wavelengths from the reflector. Install a 4-40 screw in the nut previously soldered to the flange assembly to lock the dipole in place. Final adjustment can be made later by setting the dipole position for lowest VSWR, with an RF source and reflected power meter or SWR bridge. For receive only applications, no further adjustments are needed. You could try peaking...
the adjustments on a weak signal if you are fussy, but you will find that they are very broad and have little noticeable effect.

Next, mount the antenna in its final location. Make sure to mount the antenna for correct polarization. Polarization is same as dipole (e.g. vertical for vertical polarization). Vertical polarization is generally used for amateur and commercial two way FM, but horizontal is used for SSB amateur work and some amateur TV. UHF TV is generally horizontal or circular. As a compromise, the antenna could be mounted at 45 degrees to vertical.

You will find that the antenna has pronounced directivity, maximum pickup occurring along a line bisecting the reflector angle, in the direction the dipole faces. The pattern is clean and well defined. Pickup towards the sides or rear is much less. Therefore, face the antenna in the direction of desired reception. Two or more of these antennas can be used if multi-directional reception is desired, or a rotator can be used. Bandwidth depends on the VSWR desired, but this antenna should work well over a range of 10 percent or so. An antenna made for 900 MHz will easily work well from 800 to 1000 MHz, and reception at 450 MHz and 1280 MHz will be adequate, but not optimum. You should find this antenna easy to make and quite effective and may even wish to build several for different frequency ranges. Simply scale the dipole element length and reflector size as needed.

For outdoor use, it would be a good idea to cover the dipole and slotted feedline assembly with a plastic cover to keep out water and insects. Use a clear, plastic-food container that is microwave safe. If it does not heat up in a microwave oven, it probably has low RF losses and will not affect the antenna. The container can be slit and placed over the dipole with the slit facing down. The lid can be used to cover the open end of the tubing. Clear silicone seal can be used to seal edges and joints against leakage. Clear materials are preferred since pigments such as metal dust or carbon can be lossy for RF. Make sure to leave a small hole in the bottom of the container to allow escape of condensation.

**How it performs**

The corner-reflector antenna provides noticeable improvement over an omni-directional or ground-plane antenna. It can be used indoors as well. Fig. 8 shows the antenna mounted on a photographer’s tripod for initial testing. The transmitter (or antenna) is mounted on the rear surface of the aluminum grille. This corner-reflector antenna is not intended for moon-bounce, weak-signal SSB, DX contests or other such exotic amateur radio uses but it will be a darn good antenna for much scanner listening and routine ham use, or as a temporary, cheap antenna to use before investing in a larger Yagi or other expensive setup. With a low-loss feedline, an 8 to 10 dB antenna will give very good results both in transmission and reception.

The author has used two of these antennas for amateur TV transmission at 923 MHz, one antenna at the home station about 30 feet above ground, the other in a vehicle with a portable TV set and a receiving downconverter to allow reception of the 923 MHz amateur TV signals on VHF channel 3. A 1-watt transmitter was used at the house. Excellent pictures were received 8 miles away and, although snowy, a picture was seen at 17 miles. The tests were repeated at 1289 MHz with a pair of corner-reflectors designed for this frequency and similar results were obtained. The transmitters and receiving downconverters were described in articles published in the April and May 1996.
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- TEK 492/D1/D2 Spectrum Analyzer 50KHz to 21GHz: $6,995
- Option D1: Adds Internal Preselection and D2: Adds Digital Storage: +$1,775
- Option 51: 150KHz to 500MHz Waveguide: +$750
- TEK 496 1KHz 18GHz Spectrum Analyzer: +$4,750
- TEK 7112 100KHz to 1800MHz Spectrum Analyzer Plug-in: +$1,950
- TEK 7113 1KHz to 18GHz Spectrum Analyzer Plug-in: +$2,695
- TEK 185300 Tracking Generator w/ TM500 Power Supply: +$1,450
- HP 1411/8552/8555A 10 MHz to 18GHz Spectrum Analyzer: +$2,195
- HP 1411 Variable Persistence/Storage Display: +$550
- HP 1431 Non-Storage Display: +$425
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- TEK 2485 300MHz Foxable Scope: +$2,195
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- HP 54202B 50MHz/200M/sx DigiScoping: +$2,690
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- BOONTON 2500A Power Meter Calibrator: +$450
- HP 747A Power Meter Calibrator: +$495
- HP 11683A Range Calibrator: +$775
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- TEK 7050A Time Mark Generator: +$1,350
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- HP 8660A/001 160MHz Universal Counter: +$3,995
- HP 8690A 2 to 18GHz Universal Counter: +$1,750
- HP 8690A 2 to 18GHz Universal Counter: +$2,395
- HP 8690A 2 to 18GHz Universal Counter: +$2,995
- HP 8699A 2.1 to 18GHz Universal Counter: +$2,395
- HP 8699A 2.1 to 18GHz Universal Counter: +$2,995
- HP 8699A 2.1 to 18GHz Universal Counter: +$3,995
- HP 8699A 2.1 to 18GHz Universal Counter: +$4,995
- HP 8699A 2.1 to 18GHz Universal Counter: +$7,995
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Fluke 77 II $155
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Fluke 29 I $175
Fluke 76 $175
Fluke 867 $1199
Fluke 97 $1199
Scope Meter $1785
Fluke 105 $1599

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Dual Trace, Component test, 6" CRT, X-Y Operation, TV
Sync, Z, Modulation, CH2 Output, Graticule Illum, 2 probes each has x1,x10 switch. Best price with delay sweep:

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- PS-400: 40 MHz DUAL TRACE $494.95
- PS-405: 40 MHz DELAY SWEEP $589.95
- PS-805: 60 MHz DELAY SWEEP $789.95
- PS-1000: 100 MHz DUAL TRACE $999.95

Scope Probe: 50mHz x1, x10 $15, 100MHz x1, x10 $22
250MHz x1, x10, 500MHz x10 $39

**DC Power Supply PS-303 $159.90**

- 0-30 VDC, 0-3A output
- Constant voltage & constant current mode: 0.02%+2mV line regulation
- 0.2%+3mV load regulation: 1mVrms noise and ripple
- Short circuit and overload protected
- Dual output with digital voltmeter $179.90
- Also available: 30V/3A, 60V/3A, 60V/5A

**RF SIGNAL GENERATOR SG-4160 $124.95**

- 100 kHz-150 MHz sine wave in 8 ranges
- RF Output 100mVrms to 35 MHz
- Internal 1kHz, External 50kHz-200kHz
- AM modulation
- Audio output 1 kHz, 1 Vrms

**AUDI0 GENERATOR AG-2601A $124.95**

- 10kHz-1MHz in 5 ranges
- Output, 0-10Vms sine wave
- 0-10Vp-p squarewave
- Synchronization: ±3% of oscillation frequency per Vrms
- Output distortion: 0.5% 50Hz - 50kHz
- 0.5% 50kHz - 500kHz
- Output impedance: 600 ohm

**FUNCTION GENERATOR FG-2100A $169.95**

- 0.2 Hz-2 MHz in 7 ranges
- Sine, square, triangle, pulse and ramp
- Output: 5mV to 10V
- 1% distortion, DC offset ±10V
- VCF, 0-10V control frequency to 1000:1

**FUNCTION GEN/COUNTER FG-2102AD $229.95**

- Generates signal same as FG-2100A
- Frequency counter 4 digits
- Feature TTL and CMOS output

**SWEEP GENERATOR GEN./COUNTER $329.95**

- 0.5Hz to 5MHz in 7 ranges
- Source: Linear 10:1,Log 1:10 to 2ms to 2s
- AM Modulation
- Gated Burst, Voltage Control Generator
- Control Voltage & 8 digit counter 1Hz-10MHz for internal & external sources

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<th><strong>Test &amp; Measuring Instruments</strong></th>
<th>ISO 9002 CERT. #934163</th>
</tr>
</thead>
</table>

**100 MHz Cursor Readout Scope**

- 4 channels, 8 traces
- Time/ Voltage cursor measurement
- ALT triggering function for 4 ch
- Sweeps to 200ns/div, Delayed Sweep
- TV Sync, CH 1 output, Z-axis input
- 2 probes (x1, x10)

- **OS-6101**
  - **Price**: $1,499.95

**DC Linear Power Supplies Single Output**

- Constant voltage and constant current mode
- Voltage regulation ±0.01%
- Current regulation ±0.2%
- Low ripple and noise
- Overload and reverse polarity protection
- Features 2 analog or 1 digital meter (PS series)
- Features 4 analog or 2 digital displays (PC series)

<table>
<thead>
<tr>
<th>Model</th>
<th>Output Voltage</th>
<th>Output Current</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-1830</td>
<td>(0-18V, 0-3A)</td>
<td>$209.95</td>
<td></td>
</tr>
<tr>
<td>PS-1850</td>
<td>(0-18V, 0-5A)</td>
<td>$219.95</td>
<td></td>
</tr>
<tr>
<td>PS-1850D</td>
<td>Digital Display</td>
<td>$219.95</td>
<td></td>
</tr>
<tr>
<td>PS-3000</td>
<td>(0-30V, 0-5A)</td>
<td>$234.95</td>
<td></td>
</tr>
<tr>
<td>PS-3000D</td>
<td>Digital display</td>
<td>$234.95</td>
<td></td>
</tr>
<tr>
<td>PR-6100</td>
<td>(0-18V, 0-10A)</td>
<td>$349.95</td>
<td></td>
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<tr>
<td>PR-6060</td>
<td>(0-30V, 0-6A)</td>
<td>$314.95</td>
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<tr>
<td>PR-6030</td>
<td>(0-60V, 0-6A)</td>
<td>$314.95</td>
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<tr>
<td>PR-6003D</td>
<td>Digital display</td>
<td>$399.95</td>
<td></td>
</tr>
</tbody>
</table>

**100 MHz Scope, 4 ch. 8 traces Best value all purpose scope**

- **OS-6100B**
  - **Price**: $1,329.95

**50 MHz Triggering Oscilloscope**

- Dual Channel
- Hold Off Function
- Delayed Sweep
- Built-in Delay Line
- TV Sync

- **OS-653**
  - **Price**: $699.95

**20 MHz Oscilloscope**

- Dual trace, X-Y operation
- TV Sync, Z-axis input, CH 1 output
- High sensitivity 1 mV/div
- Trigger level knob
- 2 probes (x1, x10)

- **OS-622B**
  - **Price**: $344.95

**Digital Display Function Generator**

- Frequency Range: 0.02Hz to 2MHz
- Three instruments in one: Function generator, Pulse generator & Frequency counter
- Sin. Triangle, Square, TTL Pulse and CMOS output
- Built-in 6 digit counter with INT/EXT function
- 1000:1 tuning range
- Variable DC offset control

- **FG-8016G**
  - **Price**: $239.95

**Digital Multimeter & C Meter**

- **DM-8034(3½ digits)**
  - **Price**: $179.95

**Programmable DC Power Supplies**

- Two variable 0-30VDC, 0-3A outputs
- One fixed 100V/60A output
- Auto tracking
- Auto serial and parallel operation
- Constant voltage and constant current mode
- Variable DC offset control
- Continuous/current load can be selected
- Auto power off
- Overload protection
- Audible continuity check
- Digital display
- Auto range, relative mode, Max/Min

<table>
<thead>
<tr>
<th>Model</th>
<th>Output Voltage</th>
<th>Output Current</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC-3030</td>
<td>(0-30V, 0-3A)</td>
<td>$499.95</td>
<td></td>
</tr>
<tr>
<td>PC-3030D</td>
<td>Digital display</td>
<td>$549.95</td>
<td></td>
</tr>
</tbody>
</table>

**Model DM-392 (3½ digits)**

- Auto/manual ranging (38 ranges)
- 42 Segment analog bar graph
- Data Hold/Max/Min memory
- Relative mode
- Auto power off
- Overload protection
- Audible continuity check
- Digital display
- 20 Amp range
- Double high energy fused (1A, 20A)
- 0.3% DCV accuracy

<table>
<thead>
<tr>
<th>Model</th>
<th>Output Voltage</th>
<th>Output Current</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM-392</td>
<td>(0-20V, 0-2A)</td>
<td>$549.95</td>
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<tr>
<td>DM-393</td>
<td>(0-30V, 0-5A)</td>
<td>$549.95</td>
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<tr>
<td>DM-395</td>
<td>(0-400V, 0-5A)</td>
<td>$549.95</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Instrument</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT-100 (Reg. $599)</td>
<td>$419.00</td>
</tr>
<tr>
<td>FG-140 (Reg. $249)</td>
<td>$149.00</td>
</tr>
<tr>
<td>FG-150 (Reg. $399)</td>
<td>$229.00</td>
</tr>
<tr>
<td>FC-200 (Reg. $399)</td>
<td>$219.00</td>
</tr>
</tbody>
</table>

### 2MHz Function Generator

- **FG-140** (Reg. $249)
  - 2MHz Function Generator
  - Frequency Range: 0.2 Hz - 2.0 MHz
  - Modes: Sine, Square, Triangle, Pulse, Skewed Sine, Ramp, Skewed Sine
  - Features: 4 Digital LCD Display, VCF, Symmetry, Variable DC Offset Control

### 2MHz Sweep Function Gen. w/Freq. Counter

- **FG-150** (Reg. $399)
  - 2MHz Sweep Function Generator
  - Frequency Range: 0.2 Hz - 2.0 MHz
  - Features: 4 Digital LED Display, VCF, Symmetry, Variable DC Offset Control

### 1.05GHz Frequency Counter, High Resolution

- **FC-200** (Reg. $399)
  - 1.05GHz Frequency Counter
  - Features: 3-1/2 Digit LCD, Triple output: 1.0 Hz, 100MHz

### DC Power Supply

- **PS-500** (Reg. $249)
  - DC Power Supply
  - Frequency Range: 0-1500 VDC

- **PS-540** (Reg. $399)
  - DC Power Supply
  - Frequency Range: 0-160 VDC

### Deluxe Oscopes w/Phillips CRT

- **OS-3304** (Reg. $399)
  - 25MHz, Dual Trace
  - Features: Digital CRT, 240x240 pixels, 500:1, 100V/div, 2000ns/div

- **OS-3324** (Reg. $599)
  - 25MHz, Triplet DC Power Supply
  - Features: DC Power Supply, 5VDC, ±12VDC, Variable Hold Off

- **OS-3344** (Reg. $899)
  - Frequency Counter
  - Features: Frequency Counter, 100MHz, 7 Digit LED Display

### BEST BUY!

- **OS-3315** (Reg. $599)
  - 40MHz, Dual Trace Sweep Delayed
  - Features: DC to 40 MHz, Delayed Sweep, 100ns to 1.0s

### Digital Engine Analyzer

- **DM230** (Reg. $119)
  - 3.5 Digit LCD
  - Features: Heavy Duty, 20A AC/DC, 0.1% Accuracy, Overload Protection

### Capacitance Meter

- **CM210** (Reg. $499)
  - 3.5 Digit LCD
  - Features: Diode, Continuity, Zero Adjust Knob, Test Leads & Built-in Socket

### Pen-Type DMM w/Logic

- **CM150** (Reg. $599)
  - 3.5 Digit
  - Features: Auto & Manual, AC/DC, Overload Protection

### Multifunction DMM

- **CM4050** (Reg. $64.00)
  - 3.5 Digit
  - Features: Auto Power Off, Data Hold & Peak Hold, Frequency, Amp, Ohm, Continuity, Auto Power Off

### Features (DM5050C/DM5100)

- **DM5050C** (Reg. $199)
  - Features: Basic DCC Accuracy: ±0.25%
  - **DM5100** (Reg. $89.00)
  - Features: AC/DC Volt, Amp, Ohm, Diode, Continuity Beepers, Alligator Clip Test-Leads, Lead Holders/Velcro Strap Holster

### Capacitance (DM5050C, DM5100)

- **DM5050C**
  - Features: 9 Function / 42 Range
- **DM5100**
  - Features: 11 Function / 45 Range

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  - P.O. Box 744, Lake Forest, CA 92630-0744
  - (714) 586-2310 Fax (714) 586-3399
  - www.americanradiohistory.com
301 Standard PanaVise
Designed for the professional and hobbyist, the model 301 turns, tills and rotates to achieve the desired position. Durable nylon jaws open 2-1/4". Net weight: 3 lbs.

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#EN-305-305

Headband Magnifier
Features double lens for choice of 2.3x or 3.3x magnification and Velcro type headband. Net weight: 1/2 lb.

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#EN-360-672

150 MHz Oscilloscope Probe Kit
Deluxe probe kit features a modular design for longer life, switchable 10:1 probe with 150 MHz bandwidth, 2.8 ns rise time, and adjustable capacitance from 10-35 pF. 60" in length. Kit includes 6" detachable ground lead, sprung hook, trimming tool, 2 channel identifier clips, and replacement tip. Includes plastic case.

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Sure Shot 18" Dish for DSS
Built heavier and stronger than OEM models, able to withstand both sides of a gust! "Perfect Curve" manufacturing process allows for maximum signal reflectivity. Ideal for replacement of damaged OEM dishes or for additional viewing locations. Sure Shot comes complete with mounting hardware and instructions. Limited lifetime warranty. LNBF not included. Net weight: 13 lbs.

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#EN-210-405

Grundig LNBFs
Made in England quality! Designed to work in extreme real world conditions. Features "true circular polarization." For use with the Sure Shot and Hot Shot dishes or as a replacement for lightning damaged RCA DSS LNBFs. Available in single or dual feed. 18 month warranty. Net weight: 1 lb.

$99.95 EACH

#EN-210-420

Phone FM Transmitter Kit
Easy to build and tune in the upper part of the FM band. Reaches over 1/2 mile (depending on conditions). Uses RF translator for its final stage. Requires a 9V battery (not included). High quality PCB and components. Circuit schematic provided.

$9.95 EACH

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DeoxIT is a fast-acting deoxidizing solution that cleans, lubricates, and improves conductivity on all metal connectors and contacts. Seals and protects all electrical connections. Reduces intermittent failures, arcing, wear, and abrasion. Temperature range: -34 degrees F to 200 degrees C. Use as a general treatment for connectors, contacts, and other metal surfaces.

$14.95 EACH

#EN-335-525 (Standard lens)

$19.95 EACH

#EN-335-530 (Pin hole lens)

$17.95 EACH

#EN-120-1100 (12VDC power supply)

$17.15 EACH

B & W CCD Board Cameras
Ultra miniature, high performance 1/3" CCD single board cameras feature a built-in 3.6mm wide angle lens and 400 lines of resolution. Requires a 12 VDC power supply (our #120-1100). Dimensions: 1-1/2" W x 1-3/4" H x 1" D.

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#EN-335-530

$7.15 EACH

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GoldStar Oscilloscopes

GoldStar

Weller WLC100 Soldering Station
The Weller WLC100 solder station is adjustable from 5 to 40 watts. Includes 40 watt pencil iron. UL approved. Net weight: 1-3/4 lbs. One year manufacturer warranty.

$39.95 EACH

#EN-372-120

Part # GoldStar # Description Price
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EN-394-115 OS900D 65MHz 699.95
EN-394-110 OS4000 40MHz 599.95
EN-394-105 OS8025 20MHz w/generator 448.95
EN-394-100 OS0020A 20MHz 349.95

Part # Description Solution Price
EN-341-200 DeoxIT DS, 5 oz. Spray 5% $7.95 $7.15 $6.45
EN-341-202 DeoxIT Mini Spray, 15 g. 4.95 4.50 3.95
EN-341-205 DeoxIT D100, 2 oz. Spray 100% 10.95 9.85 8.85
EN-341-210 DeoxIT Pen Applicator 100% 9.95 8.95 8.05
EN-341-215 DeoxIT Vial w/brush, 7/4 ml. 6.95 6.25 5.65
EN-341-220 DeoxIT Precision Dispenser 100% 14.95 13.45 11.10

Phone FM Transmitter Kit
This small circuit, when connected to a phone line, transmits both sides of a telephone conversation into the FM radiation in the 90-95MHz area. The phone line itself is used as an antenna. Includes all components and instructions.

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2 Stage FM Transmitter Kit

$10.95 EACH

#EN-320-066

CAIG LABORATORIES, INC.
**Liquid Crystal Displays**

160 x 128 dot LCD with built-in controller (T6963C)
20 character x 16 line $79.00 or 2 for $149.00
Mfr: Toshiba TLX-1013-EO.
Unit is EL back-lit. Dim: 3.5” L x 4.5” H.
The built-in controller allows you to test text and graphics.

240x64 dot LCD with built-in controller. $79.00
Mfr: AND 4021ST-EO. Unit is EL back-lit. or 2 for $149.00.

**Alphanumeric—parallel interface**

<table>
<thead>
<tr>
<th>Size</th>
<th>Price</th>
<th>Size</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>16x1</td>
<td>$25.00</td>
<td>20x2</td>
<td>$12.00</td>
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<tr>
<td>16x1 (g char.)</td>
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<tr>
<td>16x2</td>
<td>$8.00</td>
<td>20x4 (g char.)</td>
<td>$25.00</td>
</tr>
<tr>
<td>16x2 (g char.)</td>
<td>$12.00</td>
<td>24x4</td>
<td>$25.00</td>
</tr>
<tr>
<td>16x4</td>
<td>$15.00</td>
<td>32x4</td>
<td>$10.00</td>
</tr>
</tbody>
</table>

5V power required. Built-in CMOS LCD driver & controller. Easy "microprocessor" interface. 98 ASCII character generator. Certain models are backlit, call for more info.

**Graphics and alphanumeric—serial interface**

<table>
<thead>
<tr>
<th>Size</th>
<th>Price</th>
<th>Size</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>64x480 (backlit)</td>
<td>$25.00</td>
<td>400x128</td>
<td>$15.00</td>
</tr>
<tr>
<td>640x400 (backlit)</td>
<td>$25.00</td>
<td>256x128</td>
<td>$15.00</td>
</tr>
<tr>
<td>640x200</td>
<td>$15.00</td>
<td>240x128</td>
<td>$20.00</td>
</tr>
<tr>
<td>480x128 (backlit)</td>
<td>$15.00</td>
<td>240x128</td>
<td>$20.00</td>
</tr>
</tbody>
</table>

Assembly required for laser printer. Includes laser diode, polygon motor (6 sided) and mic. optics and lenses.

**Laser Diode**

<table>
<thead>
<tr>
<th>Laser Diode</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HeNe Laser Head</td>
<td>$99.00</td>
</tr>
<tr>
<td>Laser Scanner Assembly</td>
<td>$35.00</td>
</tr>
</tbody>
</table>

**Visible Laser Diode:** 5mw at 670nm $15.00. 10mw at 670nm $35.00. 50mw at 670nm $50.00. Coded index. Threshold current 40 ma typical.

**Polygon Motor Unit & Driver**

Ten-sided first surface mirror mounted on an armature that spins at 125 revolutions per second yielding a beam sweep rate of 125 sweeps per second. The driver for the polygon unit requires 4 volts plus and minus 12 volts to operate. There is also an f-theta lens in front of the polygon scanning mechanism with a three inch diameter. Great for optical experiments, etc. Very high quality units. (MFR: JAPAN ELECTRONICS)

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**Pos & Bar Code**

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HP bar code word (HBCS 2300)...

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quick Connects
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• ST-6 - Screw Driver #1 Phillips
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<thead>
<tr>
<th>Model</th>
<th>Bandwidth</th>
<th>Sensitivity (mV/div)</th>
<th>No. of Channels</th>
<th>Sweep Rate Max (ns/div)</th>
<th>Delayed Sweep</th>
<th>Video</th>
<th>Component Tester</th>
<th>Beam Find</th>
<th>Time Base</th>
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<td>2</td>
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2 Year Warranty

B&K Precision at Discount Prices

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<tr>
<th>Model</th>
<th>40MHz Dual Trace</th>
<th>60MHz Dual Trace</th>
</tr>
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<tbody>
<tr>
<td>Model 1541C</td>
<td>$695</td>
<td>$949</td>
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<td>Model 2160</td>
<td>$1225</td>
<td>$1379</td>
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<td>Model 2190A</td>
<td>$1795</td>
<td>$2945</td>
</tr>
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This attractive small silent alarm in briefcases, medicine cabinets, dressers, drawers, cabinets, etc. and it will silently "stand guard" As soon as someone opens the briefcase drawer, cabinet, etc. It will start sounding a loud shrilling sound. Operates on one 9 volt battery (not included) and uses a light sensitive IC circuit with built-in alarming delay. The alarming delay allows you 5 seconds to put the unit in a safe place. Then, as soon as light strikes it (from someone opening the cabinet door) it will alert sounds and warn you of any ordinary intrusions to areas that children and intruders should stay out of. These have a Versac® peel and stick piece on the back of each unit, that allows you to secretly hold the unit to the back of a cabinet. Although these alarms are new, they were manufactured several years ago and the adhesive on the double side velcro surface has out dried out on the G6948 units which means none on you'll have to use glue on the adhesive sides of the unit if you wish to mount them (mounting is totally optional). The G6949 do not have this problem. Both types are exactly alike but it's only the velcro, adhesive problem. Red plastic clip is approximately 3" x 1 1/2" x 1/8".

G6948 (Bad Adhesive) $2.00
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OPT 003 add $150.00

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Functionally checked. $165.00

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- Save data in ASCII & BMP formats, supports OLE with EXCEL.
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<th>5</th>
<th>10</th>
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<tbody>
<tr>
<td>RF300T</td>
<td>150' Range Transmitter</td>
<td>24.95</td>
<td>19.95</td>
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<tr>
<td>RF300XT</td>
<td>300' Range Transmitter</td>
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Small, High End Quality, 2 Channel Receiver for the RF300 Transmitters 1-1/4” x 3-3/4” x 9/16” PCB w/.1” spaced pads for standard connectors

Input: 8-24 vdc Output: Gated CMOS Momentary and Latching Lines

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<tr>
<td>RF300R</td>
<td>Receiver, Fully Assembled</td>
<td>24.95</td>
<td>20.95</td>
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<tr>
<td>RF300RK</td>
<td>Receiver, Complete Parts Kit</td>
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<td>RF300PA</td>
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Small, Economical, Single Channel Transmitter and Receiver Set
Set Code, 60' Range, 1-7/8”x2-3/8”x7/16” (T), 2”x2-3/4”x9/16” (R)

Receiver Input: 5 vdc Output: Gated TTL Momentary Line

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<th>Qty</th>
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<tr>
<td>RF60</td>
<td>Transmitter and Receiver Set</td>
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The CSD-18 will even allow you to "listen-in" to exactly what the eavesdropper is surreptitiously monitoring. And, without the eavesdropper ever becoming aware that he has been detected! We are unaware of any other detection equipment having this combined capability AT ANY PRICE!

THE ONE "BUG" TO FEAR MOST!

While most individuals are now somewhat guarded in their telephone conversations, they still rather naively feel secure in the "privacy" of their own home or office. However, the most common type of "tap" presently used by eavesdroppers now picks up ALL SOUNDS AND CONVERSATION WITHIN A ROOM ... WITH THE TELEPHONE STILL ON!

Due to this devastating capability, this "infinity" tap (referred to as "Infinity Transmitter", Hookswitch Bypass, 3rd Wire, Harmonica Bug, etc.) has become the "bug of choice".

In flagrant violation of federal law prohibiting their use and sale, these devices in various forms are openly advertised in many technical publications for as little as $30. Literally thousands of these devices are now in the hands of unscrupulous individuals all over the country!

In response to this ever-growing threat, a uniquely engineered feature of the CSD-18 now also detects Infinity type devices anywhere "down the line".

In other words, IF ANYONE...ANYWHERE...is utilizing the telephone tip and/or ring wires to monitor your private room conversations while your telephone is on the hook, you'll immediately be made aware of it via a flashing "LED".

100% POSITIVE INDICATION

The CSD-18 also flawlessly detects "Series" and "Parallel" telephone transmitters and "Telephone Recording Devices". And, a separate feature silently indicates when extension phones are picked up or being used. The CSD-18 completely eliminates all doubt and guesswork!

EXTREME SENSITIVITY!

This is our finest piece of detection equipment! The CSD-18 quickly locates electronic eavesdropping devices in homes, offices, vehicles, boats, or concealed on the body. It will actually pick up many eavesdropping transmitters at ranges up to 25 ft. Extreme sensitivity is obtained by a 2-stage efficient amplification circuitry directly following the RF detection stages. Excellent quality, dynamic headphones exclude outside sounds to further enhance detector output.

Encompassing an extremely wide-band frequency coverage of up to 1.5 to over 3 Gz, the CSD-18 quickly "home-in" on any eavesdropping transmitter and immediately pinpoints its location. The closer you get to the "bug", the further the needle moves to the right. It's as simple as that.

"FLASHING" LED WARNS YOU INSTANTLY!

And, for maximum telephone security, the CSD-18 automatically analyzes a pre-programmed series of electronic measurements along the telephone line and converts the analysis into an easy to follow, step by step, test procedure. No technical knowledge is required or necessary. A visual indication (via a flashing LED) immediately reveals the presence of the various types of telephone "taps" and the flashing sequence identifies the actual type of eavesdropping device.

DETECTS THE LATEST "SUPER-BUGS"

Exclusive GSS proprietry circuitry assures the utmost privacy protection possible today. The CSD-18 detects even the very latest ultra-sophisticated eavesdropping devices specifically designed to defeat detection, including sophisticated Frequency Hoppers and "Burst Bugs". Also includes multi-line option for testing business phones.

MAXIMUM PROTECTION

The CSD-18 detects and locates ALL major categories of surveillance equipment including:

- BUMPER BEEPERS,
- "BODY" TRANSMITTERS,
- TELEPHONE RECORDING DEVICES,
- SERIES & PARALLEL PHONE TRANSMITTERS,
- "INFINITY", MICRO-WAVE AND "LASER" BUGS,
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CSD-18 $495 Complete
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General
Display: 3-1/2 Digit LCD. 21 mm Figure Height with Automatic Polarity
Overrange Indication: 3 Least Significant Digits Blank

Temperature
Temperature Ranges:
Operating: 0°C to 40°C (32°F to 104°F)
Storage: -10°C to 50°C (14°F to 122°F)

Power: 9V Alkaline or Carbon-Zinc Battery (NEDA 18650)
Low Battery Indication: BAT on Left of LCD Display

Dimensions: 188mm long x 87mm wide x 33mm thick
Net Weight: 400g

DC Voltage (DCV):
Range: Resolution: Accuracy:
200mV 100µV 2000mV ±(1%rdg +2dgts)
20V 10mV ±(1%rdg +2dgts)
200V 100mV 1000V 1V ±(1%rdg +2dgts)
Maximum Allowable Input: 1000V DC or Peak AC

DC Current (DCA):
Range: Resolution: Accuracy:
200µA 100µA ±(1%rdg +2dgts)
20mA 10mA ±(1%rdg +2dgts)
200mA 100mA ±(1%rdg +2dgts)
10A 10mA ±(1%rdg +2dgts)
Overload Protection: mA input 2A/250V fuse

AC Voltage (ACV):
Range: Resolution: Accuracy: 750V 1V 45Hz-450Hz
Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
Response: Average Responding. Calibrated in ms of a Sine Wave

Resistance: (Ω)
Range: Resolution: Accuracy:
200Ω 1Ω ±(1%rdg +2dgts)
2kΩ 1Ω ±(1%rdg +2dgts)
20kΩ 1kΩ ±(1%rdg +2dgts)
200kΩ 10kΩ ±(1%rdg +2dgts)
Maximum Open Circuit Voltage: 2.8V

Continuity:
The beeper will sound when the resistance of circuit under measurement is less than 30Ω.

Frequency:
The beeper will sound when the resistance of circuit under measurement is less than 30Ω.

Diode Test:
Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

NHE Test:
Measures transistor NHE.

Switchable Scope Probe Sets
(Selectable X1/Ref/X10) These high quality scope probe sets are for oscilloscopes up to 100MHz (model HP9060) or 150MHz (model HP9150). Each set includes a handy storage pouch and include an IC test-hook adapter for the probe. The BNC connector rotates to avoid cable tangling or kink. Cable length is 1.4 meters.

Positive Photo Resist Pre-Sensitized Printed Circuit Boards
These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP101</td>
<td>100mm x 150mm/3.91&quot; x 5.91&quot;</td>
<td>$2.55</td>
</tr>
<tr>
<td>PP114</td>
<td>114mm x 185mm/4.6&quot; x 6.6&quot;</td>
<td>2.98</td>
</tr>
<tr>
<td>PP152</td>
<td>150mm x 250mm/5.91&quot; x 9.84&quot;</td>
<td>5.40</td>
</tr>
<tr>
<td>PP153</td>
<td>150mm x 300mm/5.91&quot; x 11.81&quot;</td>
<td>6.15</td>
</tr>
</tbody>
</table>

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS101</td>
<td>100mm x 150mm/3.91&quot; x 5.91&quot;</td>
<td>$3.90</td>
</tr>
<tr>
<td>GS114</td>
<td>114mm x 185mm/4.6&quot; x 6.6&quot;</td>
<td>4.80</td>
</tr>
<tr>
<td>GS152</td>
<td>150mm x 250mm/5.91&quot; x 9.84&quot;</td>
<td>8.69</td>
</tr>
<tr>
<td>GS153</td>
<td>150mm x 300mm/5.91&quot; x 11.81&quot;</td>
<td>10.20</td>
</tr>
</tbody>
</table>

Developer
This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions, 50 gram package, mixes with water.

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD101</td>
<td>100mm x 150mm/3.91&quot; x 5.91&quot;</td>
<td>$5.07</td>
</tr>
<tr>
<td>GD114</td>
<td>114mm x 185mm/4.6&quot; x 6.6&quot;</td>
<td>5.95</td>
</tr>
<tr>
<td>GD152</td>
<td>150mm x 250mm/5.91&quot; x 9.84&quot;</td>
<td>10.47</td>
</tr>
<tr>
<td>GD153</td>
<td>150mm x 300mm/5.91&quot; x 11.81&quot;</td>
<td>11.95</td>
</tr>
</tbody>
</table>

Etching Chemicals/Ferric Chloride
A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER-3</td>
<td>Makes 1 pint</td>
<td>$3.50</td>
</tr>
</tbody>
</table>

Etching Tank
This handy etching system will handle PC boards up to 8" x 9", two at a time. Ideal for etching your PCB's! System includes an air pump for etchant agitation, a thermostatically controlled heater for keeping etchant at optimum temperature and a tank that holds 1.35 gallons of etchant. A tight fitting lid is also supplied to prevent evaporation when system is not being used. Typical etching time is reduced to 4 minutes on 1oz. copper board!

Desoldering Pumps
These powerful plastic body desoldering pumps are designed for easy one hand operation for fast, efficient desoldering. Double O-ring piston seals for maximum suction.

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>08-366S</td>
<td>Large Desoldering Pump</td>
<td>$15.89</td>
</tr>
<tr>
<td>08-366E</td>
<td>Regular Desoldering Pump</td>
<td>10.89</td>
</tr>
<tr>
<td>08-366TIP</td>
<td>Replacement Tip</td>
<td>1.95</td>
</tr>
</tbody>
</table>
**Electronic Soldering System**

Here's the ideal solution when Temperature Control is required. Easy to use slide control allows user to set system from 300°F to 840°F. Voltage from iron control unit is 24V Iron heating power is 48W. Replaceable 5.3mm tip is standard. Replacement irons and tips are available.

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL10</td>
<td>Temp Controlled Soldering Iron</td>
<td>$56.00</td>
</tr>
<tr>
<td>SL24V</td>
<td>Spare 24V Soldering Iron</td>
<td>$10.50</td>
</tr>
</tbody>
</table>

**Electronic Soldering System with LED Display**

Deluxe temperature controlled system with LED display for maximum accuracy. Temperature is adjustable from 160°F-400°C (320°F-900°C). Iron heating power is 48 Watts. Runs on 24V from control unit. Replacement irons and tips are available. Tip size is 5.3mm.

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<tr>
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</thead>
<tbody>
<tr>
<td>SL30</td>
<td>Deluxe Soldering System w/ LED</td>
<td>$85.00</td>
</tr>
<tr>
<td>SL24V</td>
<td>Spare 24V Soldering Iron for SL10 or SL30</td>
<td>$75.00</td>
</tr>
</tbody>
</table>

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**Replacement Tips for SL10/SL30**

We now offer a variety of replacement tips for the SL10/SL30 soldering stations.

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>821</td>
<td>1/32&quot; Pencil Tip</td>
<td>$1.39</td>
</tr>
<tr>
<td>822</td>
<td>1/32&quot; Pencil Tip</td>
<td>$1.19</td>
</tr>
<tr>
<td>823</td>
<td>1/64&quot; Pencil Tip</td>
<td>$1.39</td>
</tr>
<tr>
<td>824</td>
<td>1/64&quot; Chisel Tip</td>
<td>$1.29</td>
</tr>
</tbody>
</table>

**Ball Bearing 12V DC Fans**

These High Quality Fans feature Ball Bearings and Brushless DC Motors. All of them are designed to meet UL, CSA & VDE Standards. Design these fans into power supplies, computers or other equipment requiring additional air flows for heat removal. These fans are regular Circuit Specialists stock items — they are not surplus.

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<table>
<thead>
<tr>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIMENSIONS</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>CAT NO</td>
</tr>
<tr>
<td>CSD 4010-12</td>
</tr>
<tr>
<td>CSD 6025-12</td>
</tr>
<tr>
<td>CSD 8025-12</td>
</tr>
<tr>
<td>CSD 9225-12</td>
</tr>
<tr>
<td>CSD 1225-12</td>
</tr>
</tbody>
</table>

**SOLDER**

We stock high quality 60/40Sn/Pb, .031" and .037/,.031" diameter. This prime JIS certified solder that we maintain as a regular stock item (it is not "Left-overs, Rejects or Surplus") and you can buy it from us at a fraction of the price that you are used to.

**CCD Camera - IR Responsive**

This black and white monochrome CCD Camera is totally contained on a PCB (70mm x 40mm). The lens is the tallest component on the board (27mm high from the back of the PCB) and it works with light as low as 0.1 lux. It is IR Responsive for use in total darkness. It comes with six IR LED's on board. It connects to any standard monitor, AUX or video input on a VCR or through a video modulator to a TV. Works with a REGULATED 12V power supply (11V-13V). Hooks up by connecting three wires: red to 12V, black to ground (power & video) and brown to video signal output.

<table>
<thead>
<tr>
<th>CAT NO</th>
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<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH60-4</td>
<td>IR Camera</td>
<td>$9.99</td>
</tr>
<tr>
<td>RH60-TUBE</td>
<td>IR Camera</td>
<td>$8.99</td>
</tr>
</tbody>
</table>

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3 Mi Telephone Xmitter
- Tune-able 80-130 Mhz. • Undetectable
- Only transmits when phone is used
- WVP77K Kit/Plans $39.50

Extended Play Telephone Taping System
- Taped Phone Conversation • Extends Tape
- TAP70X Ready to Use $88.50

3 Mi Tracker Transmitter
- Tunable Output
- Uses FM Radio
- Excellent Signal Beacon
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- LW2B0 Ready to Use (req'd vid input) $195.50

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- 9 Bit A/D 7 IR
- 1 Bit Counter
- Up to 148 MHz/SEC

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- 8-320 INTERFACE
- Bias 100 KEA/A
- 8 Lines Digital 1/0
- 1 Analog Inputs
- 2 Analog Outputs
- 2 Counters 24 Bit

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- 32 Bit Interface
- 4 Analog Outputs
- 3 Timer Counter
- 24 Digital 1/0

MODEL 60 . . . . . . . S179
- 2 Analog Interface
- 16 Digital 1/0
- 1-8 Bit Analog Interface
- 2 Counters 24 Bit

MODEL 70 . . . . . . . S239
- 8-320 INTERFACE
- 16 Bit A/D
- 2 Analog Inputs
- 1 Analog Output
- Optional 12 Bit A/D

MODEL 40 . . . . . . . $99
- 8-320 INTERFACE
- 8 Lines Digital 1/0
- 2 Analog Inputs
- PWR Output
- Optional 12 Bit A/D

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- 24" dish focuses signals to an ultra-high gain amplifer.
- PM8K Kit/Plans $149.50
- Optional wireless module transmits captured sounds to an FM radio.
- WM8K Kit for Wireless Option $28.50

CYBERNETIC EAR
- Enhances normal hearing 3-4 times!
- Adjustable volume control, fits easily into either ear. Many, many uses.
- CYBERBEAR Ready to Use $19.95

INVISIBLE PAIN FIELD INTRODUCER DETERRENT
- System detects invasions and turns on a sonic field of pain, causing disorientation, acute paranoia, nausea and more.
- The perpetrator • man or animal • soon vacates!
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- PPGY Ready to Use $198.50

CONTROL THEIR MINDS!
- Programmable audible and visual stimus induces hypnocnic trances.
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- HYP2K Book of Hypnosis $14.95

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Selective Level Meter
Makes carrier measurements to 32.5 MHz, voice channel measurements from 50 Hz to 100 kHz, can use the 3336B Level Generator as an automatic tracking generator. Opt 004. Like new condition.
$850.00

Hewlett-Packard 3336B
Synthesizer/ Level Generator covers the frequency range from 10 Hz to 21 MHz, making the 3336B useful for telephone circuit loop testing on most FDM systems. Includes opt 005. Like new.
$850.00

Hewlett-Packard 3325A
Synthesizer/ Function Generator, 1 µHz to 21 MHz, wideband sweeper, programmable, 11 digit resolution.
$2000.00

Hewlett-Packard 3314A
Function Generator, .001 Hz to 19.99 MHz with an amplitude range of .01 mV to 10 V p-p, sine, square and triangle waves, arbitrary signals, AM/ FM/ VCO, gate and counted burst.
$3800.00

Hewlett-Packard 214B
Pulse Generator, high power 100 V, 2 A output into 50 Ω, 10 MHz repetition rate, constant duty cycle.
$1995.00

Hewlett-Packard 8901A
Modulation Analyzer, 150 kHz to 1300 MHz, measures AM and FM to 1% accuracy, measures RF frequency and power, completely automatic, options available.
$5500.00

Hewlett-Packard 8903A
Audio Analyzer, measures distortion, SINAD, signal-noise, frequency (20 Hz to 150 kHz), ac and dc level, options available.
$2750.00

Tektronix 475A DM44
Oscilloscope
250 MHz bw, dual channel, 5 mV/ div sensitivity, 1nS/ div sweep rate. With differential/time/ DMM option. Includes 2 probes.
$975.00

Tektronix 465 Oscilloscope
100 MHz bw, dual trace, 5 mV/ div sensitivity, 5 ns/ div sweep rate, 8 x 10 cm CRT. Includes 2 probes.
$590.00

Tektronix 485 Oscilloscope
350 MHz bw, dual trace, 5 mV/ div sensitivity, 1 ns/ div sweep rate, 3.0 div/ ns writing speed, selectable input impedance.
$1000.00

Tektronix 7834 Package
Dc to 400 MHz Storage Oscilloscope Mainframe with the following plug-ins: (1) 7A19 amplifier, (1) 7A26 dual trace amplifier, (1) 7B65 delaying time base, and (1) 7B80 time base.
$1000.00

Tektronix 7904 Package
Dc to 500 MHz Oscilloscope Mainframe with the following plug-ins: (1) 7A24 dual trace amplifier, (1) 7A26 dual trace amplifier, (1) 7B80 time base, and (1) 7B85 delaying time base.
$1100.00

Fluke 1900A
Multifunction Counter, 5 Hz to 80 MHz, provides frequency, period, period averaging and totalize measurements, 6 digit display, 1 MHz low-pass filter.
$189.00 Special

JFW 75PD-001 Power Divider
2 Way Power Divider, Dc to 1000 frequency range, power division asymmetry (Dc to 500 MHz ± 2 dB, 500 to 1000 MHz ± 4 dB), 75 Ω impedance, input power 1W average @ 25ºC, 1000 W peak (1 microsecond).
$22.00 or 5 for $100.00

Hewlett-Packard 8656B
Synthesized Signal Generator, 100 kHz to 990 MHz, 10 Hz resolution, +1.0 dB absolute level accuracy, 150 ms frequency switching speed, HP-IB.
$5000.00

Hewlett-Packard 8569B
10 MHz to 22 GHz, input preselection, 1.7 to 22 GHz, resolution 100 Hz to 3 MHz.
$9200.00

Tektronix 492 Spectrum Analyzer
50 kHz to 21 GHz, 80 dB dynamic range, amplitude comparison in 0.25 dB steps. Options 01, 02.
$7500.00

Available with Opt 01, 02, 03 $8250.00

Boonton 920A
RF RMS Millivoltmeter, 200 µV to 3V, 1% accuracy, 10 Hz to 2.5 GHz, true rms, display in mV, dBm, dB, dBmV, dBV or dBW.
$325.00

Hewlett-Packard 3311A
Function Generator, 0.1 Hz to 1 MHz, sine, square, triangle and pos. pulse waveforms.
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Telephone Scrambler
Scrambles your voice before sending it over the telephone line. Prevent eavesdropping from an extension or lap. Connects between your telephone and wall jack. No modifications are required to your telephone. Full duplex operation.

Caller ID / RS-232
Connects between a telephone wall jack and an RS-232 serial port. Decodes the caller ID data sent over the phone line and sends it to your PC or Mac in a preformatted ASCII character string. Create your own program to log the name, number, date, and time of all incoming calls.

Telephone Call Restrictor
Connects to telephone wall jack. Disables all phones on the line if attempting to either; dial a number that has been stored in memory "Block" mode or dial a number that has not been stored in memory. "Allow" mode. Use touch-tone phone to enter telephone numbers into memory, and choose mode. Program from any phone on the line using your password.

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  - Fax 1-909-659-2469

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The new Speed Learning Program shows you, step-by-step, how to increase your reading skill and speed, so you understand more, remember more and use more of everything you read. The typical remark from over one million people taking the Speed Learning program is, "Why didn't someone teach me this a long time ago?" They were no longer held back by their lack of skills and poor reading habits. They could read almost as fast as they could think.

What makes Speed Learning so successful?

The new Speed Learning Program does not offer you a rehash of the usual eye-exercises, timing devices, and costly gadgets you've probably heard about in connection with speed reading courses, or even tried and found ineffective.

In just a few spare minutes a day of easy reading and exciting listening, you discover an entirely new way to read and think — a radical departure from anything you have ever seen or heard about. Speed Learning is the largest selling self-study reading program in the world. Successful with Fortune 500 corporations, colleges, government agencies and accredited by 18 professional societies. Research shows that reading is 95% thinking and only 5% eye movement. Yet most of today's speed reading programs spend their time teaching you rapid eye movement (5%) of the problem), and ignore the most important part, (95%) thinking. In brief, Speed Learning gives you what speed reading can't.

Imagine the new freedom you'll have when you learn how to dash through all types of reading material at least twice as fast as you do now, and with greater comprehension. Think of being able to get on top of the avalanche of newspapers, magazines and correspondence you have to read...finishing a stimulating book and retaining facts and details more clearly, and with greater accuracy, than ever before.

Listen — and learn — at your own pace

This is a practical, easy-to-learn program that will work for you — no matter how slow a reader you think you are now. The Speed Learning Program is scientifically planned to get you started quickly...to help you in spare minutes a day. It brings you a "teacher-on-cassettes" who guides you, instructs, and encourages, explaining material as you read. Interesting items taken from Time Magazine, Business Week, Wall Street Journal, Money, Reader's Digest, N.Y. Times and many others, make the program stimulating, easy and fun...and so much more effective.

Executives, students, professional people, men and women in all walks of life from 15 to 70 have benefitted from this program. Speed Learning is a fully accredited course...costing only 1/4 the price of less effective speed reading classroom courses. Now you can examine the same easy, practical and proven methods at home...in your spare time...without risking a penny.

Examine Speed Learning RISK FREE for 15 days

You will be thrilled at how quickly this program will begin to develop new thinking and reading skills. After listening to just one cassette and reading the preface, you will quickly see how you can achieve increases in both the speed at which you read, and in the amount you understand and remember.

You must be delighted with what you see, or you pay nothing. Examine this remark-
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