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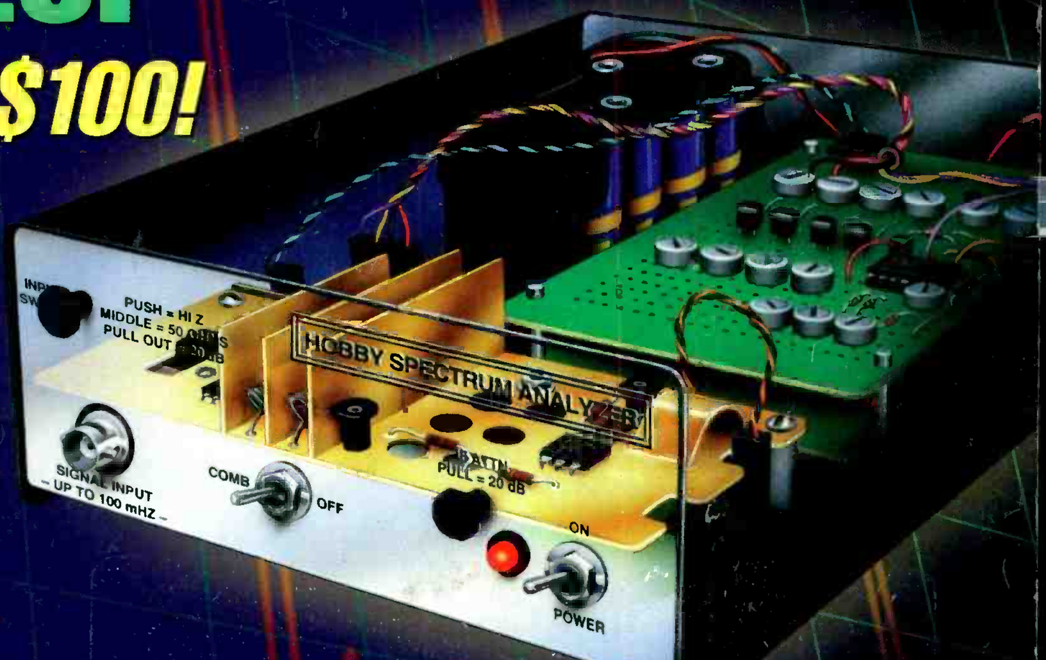

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Electronics NOW

Vol. 67 No. 9

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A spectrum analyzer is among the most useful pieces of test gear a radio hobbyist could own. For one thing, it allows the user to actually see the signals on a large portion of the spectrum at a glance. Unfortunately, its cost often puts it out of reach for many. That is, until now. This month, we show you a spectrum analyzer that can be built for less than $100! While not a lab-grade instrument, when mated with virtually any oscilloscope it will provide performance that will be more than adequate for most applications. — *Bob Kopski*

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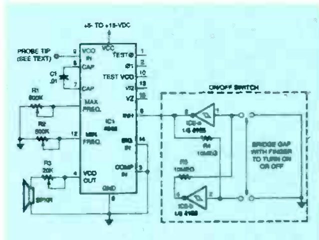

Put your ears to work for quick relative voltage checks. — *Mark O. Bender*

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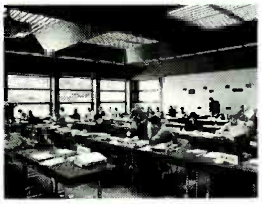

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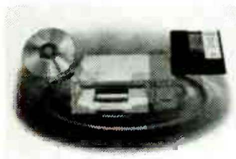

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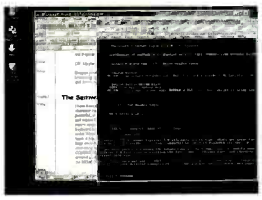

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EDITORIAL

HELLO, AGAIN

Eagle-eyed readers might have noticed a few changes in the masthead for this month. First and foremost, Brian Fenton, the long-time editor of this magazine has left to pursue other interests. I have had the privilege of knowing Brian for many years, and his contributions to **Electronics Now**, and all of Gernsback Publications will be sorely missed. It is truly an honor to succeed him here.

For those not familiar with me, I have been Managing Editor and Editor for our sister publication, **Popular Electronics** since 1988. But prior to that (from 1980 to 1988) I had been Assistant Editor and Associate Editor for this magazine's predecessor, **Radio-Electronics**. While I really enjoyed my stint at **Popular Electronics**, it is great to be re-united with an old friend—and the magazine where I got my start.

Now that the introductions are out of the way, I am sure that there is one question that has occurred to most of you: How will this change affect me and **Electronics Now**? The answer is: That's up to you.

Electronics Now is at a bit of a crossroads, and there are some important decisions we need to make to keep serving you, our readers, in the best possible way. First of all, we have always been, and always will be, a technical magazine, but have we gotten too technical? Or, are we not technical enough? Would you prefer to see simpler projects? Or, would you prefer to see ones that are more complex?

What about computers? Do we spend enough space on computer-related articles and projects? Or should we spend less? And what do you think we should cover?

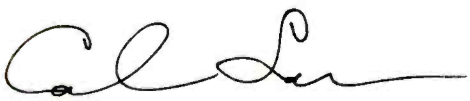
How about consumer electronics? Would you like to see expanded coverage—including, for instance, buyer's guides of consumer video and audio gear?

Or, would you prefer to see things stay pretty much as they are?

Drop us a note and tell us what you think. While we won't be able to respond to each of you individually, your thoughts are important to us, and we promise that each and every letter will be read and considered.

And while we are on the topic of change, there are a couple of things you should be made aware of. First, you may notice that some of the articles in this issue have a slightly different look to them. We are phasing in changes in type and style so that we can squeeze a little extra information into each article. The changes will be gradual and should be complete within a few months.

And last, but not least, I am pleased to announce the introduction of the Gernsback Web page. Readers have long asked when we will have a site on the World Wide Web. Well, the wait is over. Why the delay? We wanted to make sure that when we committed to the Internet, we did things right. The site will include things like current issue information, subscription information, an FTP site for recent story-related files, and more. The URL is http:\\www.gernsback.com\. It should be operational by the time you read this, so why not check it out today!



Carl Laron
Editor

WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

A PC in every class

Declaring, "We must make sure all of our children—every single one of them—has access to the education opportunities of the present and the future," President Clinton launched America's Technological Literacy Challenge, a national campaign to equip the country's children with the communication, math, science, and critical thinking skills required for success in the Information Age. He challenged federal, state, and local governments, along with the private sector to meet four specific goals: To provide teachers with the training they'll need to teach students to effectively use computers and the Internet; to develop software and online learning resources as part of the school curriculum; to provide teachers and students access to modern computers; and to connect every school and classroom in the country to the information superhighway.

The President proposed the creation of a \$2-billion fund to catalyze government and private-sector participation over the next five years. To receive funds, a state must develop a strategy to ensure that *every* school meets those four goals. State strategies should include significant private-sector participation, at least matching the amount of federal support. Public progress reports are also required of each state.

Even if a state does not come up with a comprehensive strategy, communities can present local plans. And whether or not a state-wide plan exists, private companies and local communities can cooperate in a competition to receive part of the \$50-million annual Innovation Challenge Fund.

The amount of funding per state will be based on the number of students in each state, with the money to come from slashing other, lower priority programs. The Telecommunications Act, passed in February 1996, is expected to lower the costs of getting schools and classrooms online by billions of dollars, through requiring carriers to provide telecommunications services to schools and libraries at discounted rates.

MAXELL'S DIRECT OVERWRITE DISKS double the rewrite speed of conventional magneto-optical disks.

Direct OverWrite magneto-optical disks

Using Light Intensity Modulated Direct OverWrite (LIM-DOW) technology, Maxell Corporation of America (Fair Lawn, NJ) has introduced the 3.5-inch magneto-optical (M-O) disks with rewrite speeds that are twice those of conventional M-O media.

Current technology requires an erase cycle before new data is written to the disk. The disk must rotate twice, once to erase and once more for writing. Direct OverWrite eliminates the erase cycle. New data is written directly over existing data, doubling the transfer rate. The disks also feature Mark-edge recording technology, which reduces the laser wavelength to form much smaller recording marks and provide much higher recording density.

Three models of Direct OverWrite disks are available. The RO-M640 (638 megabytes, 2048 bytes per sector) and the RO-M540 (534 megabytes, 512 bytes per sector) are compatible with ISO/IEC standard drives that have LIM-DOW function. The RO-M230 (320 megabytes, 512 bytes per sector) was created specially for the Fujitsu 17mm-height drive designed for notebook PCs.

Interactive application notes

Hewlett-Packard's Test and Measurement Organization (TMO) is now providing animation and interactive features to the application notes

continued on page 27

VIDEO NEWS

WHATS NEW IN THE FAST-CHANGING VIDEO INDUSTRY

BY DAVID LACHENBRUCH

Video game price war

The war between the three major video-game systems now includes prices as well as format and performance. The second annual Electronic Entertainment Expo, or E3, was supposed to serve as the launching pad for Nintendo's widely promoted (and oft-postponed) 64-bit N64 format. But Sony, whose PlayStation has been clobbering the competition, decided to take no chances and to rain on Nintendo's parade. Despite its best-selling status, Sony sent a thunderbolt into the game scene by reducing the price of its console by $100—to $199.

That put Sega into a strange position. Just six weeks after cutting the price of its Saturn game to $249 from $299, it was forced to chop off another $50 to equal the Sony tag. Nintendo, whose 64-bit game is priced at $249, cried foul and said that Sony's move was a sign of desperation and confirmation that N64 would "eat their lunch." Sony, of course, scoffed at that and claimed it has sold 5,000,000 PlayStation platforms worldwide, including 1,200,000 in the U.S. alone. Obviously, the money is in the software, and both Sony and Sega can afford to lose money on their consoles if they can sell large quantities of games. Sony says it will have 170 titles by year end, as opposed to N64's twelve.

Get ready for a big war of words (and TV commercials) among the video-game proponents. Sony and Nintendo each plan to spend more than $50 million to promote their platforms by year-end. Sega says that once consumers are in the stores and try out all three games, they will be convinced of Saturn's superiority, and that Saturn's lower software prices will give it an edge.

SEGA'S SATURN VIDEO-GAME CONSOLE is enmeshed in a three-way price war with Sony's PlayStation and Nintendo's N64.

Satellite prices plunge

Here's a tip if you're contemplating buying a Digital Satellite System (DSS) receiver: Shop around. You can spend as much as $800 on a receiver to get the multi-channel broadcasts, but if you're a good shopper, you might not have to put up more than $499—or even $399.

That is because the two main satellite programmers—DirecTV and United States Satellite Broadcasting (USSB)—are subsidizing retailers to sell their services. Some retailers are applying the subsidies to the price of the hardware. If you go DSS, you're going to have to subscribe to the program services anyway, so it might be a good idea to take advantage of the cuts in the price of the hardware. AT&T is direct-marketing its DSS hardware at $499.

Another way to save money on DSS gear is to install it yourself. Thomson Consumer Electronics, RCA's parent, says that more than half of DSS buyers do their own installations—not very difficult in view of the small dish and complete instructions package with every reciever. Meanwhile, EchoStar, a DSS competitor, is offering its Digital Sky Highway (DISH) receiver for just $199 in selected markets, with a one-year subscription to its program service priced at $300.

RCA teams with Compaq

As computer makers rush to add TV tuning, and TV makers pull out all the stops to add PC features, it's interesting to find two top manufacturers in both fields joining hands for the future. RCA, one of the top brands of TV, has joined with Compaq, which is a leader in PCs, to develop combination products that will be sold under both brand names. At our deadline,

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Q & A

READERS QUESTIONS, EDITORS ANSWERS

Wanted: 700 Volts

Q *I would like to build a regulated 700-volt, 0.25-mA power supply for a Geiger counter, powered by batteries.—A. H., Petaluma, CA.*

A Figure 1 shows a circuit you can use as a starting point for experimentation. Powered by a 9-volt battery, it delivers 700 volts at 0 to 0.3 mA. Although not regulated, it's stable enough for a Geiger counter and has less than 1% ripple. To add regulation, modify the circuit as shown in Figure 2.

The basic circuit consists of an oscillator to chop the DC into AC, a step-up transformer, a voltage doubler, and a load resistance to keep the voltage from going too high. The step-up transformer is actually a split-primary power transformer used backward. It has two 8-volt windings, which we connect in parallel, and two 120-volt windings, which we connect in series. The transformer (note its unusual pinout, as indicated in the diagram.) is available from Signal Transformer Company, 500 Bayview Avenue, Inwood, NY 11096, as part number LP-16-700 for $14.30 plus shipping. The smaller and lighter LP-16-150, priced at $10.50, will probably work just as well, as will similar transformers from other manufacturers. Signal Transformer is a good company to know about; they make rugged, reliable power transformers and sell them in single quantities. You can phone them at 516-239-5777.

The diodes and capacitors in the voltage doubler are not critical as long as all of them are rated for at least 1 kilovolt (1000 volts). Radio Shack's 276-1114 diodes are ideal.

The regulated version of the circuit (see Fig. 2) uses a tripler instead of a doubler in order to ensure that the voltage is well above 700 volts. The actual regulation is done by a string of neon lamps. We used fourteen NE-2s, but each batch of bulbs is different and you may need a different number of them.

You may also want to look at the Geiger counter parts available from Electronic Goldmine, PO Box 5408, Scottsdale, AZ 85261, including special transformers, high-voltage capacitors, and kits.

Hard Disk Vs. CD-ROM

Q *The designers of the IBM PC seem to have made a bad mistake when the CD-ROM came around. Why is it necessary to load the contents of the CD-ROM onto the hard disk in order to run the software? On a Commodore computer, every program can be loaded from its own disk without taking up room on the hard drive.—C. E. S., Anacortes, WA.*

A The same is true of PCs; the CD-ROM has a file system just like that of any other disk, and you can run programs from the CD-ROM without copying them elsewhere. In fact, the contents of the CD-ROM are usually too large to copy onto the hard disk even if you wanted to.

So why does CD-ROM software have to be "installed"? For several reasons. First, even if running it from the CD-ROM, the user generally wants to have a Windows icon to launch the program. That requires a small amount of information to be recorded on the hard disk, but it certainly doesn't require copying the entire contents of the CD-ROM.

Second, it's impossible to write on a conventional CD-ROM, so if the program or its installation are customized in any way, that information has to go on the hard disk. That's why, even when running software from the CD-ROM, you'll often need to install some configuration files.

Third, CD-ROMs are considerably slower than hard disks; large programs load slowly when you try to run them from the CD-ROM. With many large software packages, the speed when executing from the CD-ROM is not acceptable. Accordingly, it's common for software to be delivered on CD-ROM but run from the hard disk. The CD-ROM takes the place of the box of diskettes on which the software would otherwise be delivered. In that situation, there is often a "runimage" directory on the CD that contains a ready-to-run copy of the software, so

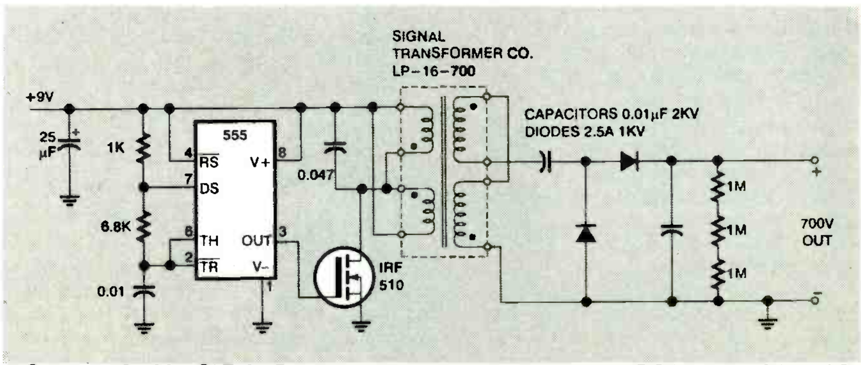

FIG. 1—THIS 700-VOLT, 0.25-mA power supply converts a +9-volt DC input to 10-kHz AC, then uses the step-up transformer and the voltage doubler circuit to produce the required output.

Two ways to fit a 100 MHz benchtop scope in your hand.

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that you can run it from the CD if you don't have the disk space to do a full installation.

Mystery Diode

Q *I'm repairing a Sanyo Plus 55 AM-FM stereo receiver and am having trouble locating a replacement for a Zener diode #W-I35. I wrote to Sanyo and have not received a reply. Can you help?— G. O., Monte Lake, B.C., Canada.*

A We didn't find "W-I35" or "W-135" in the ECG replacement directory. But Sanyo parts are distributed by Diversified Parts, 2114 SE 9th Avenue, Portland, OR 97214; Tel: 800-338-6342; they can probably help you. You can get a service manual for your receiver from Howard W. Sams and Company at 800-528-7267. Both companies will probably need an exact chassis number or model number from the back of the unit (more than just "Plus 55," which might cover several variations of the design).

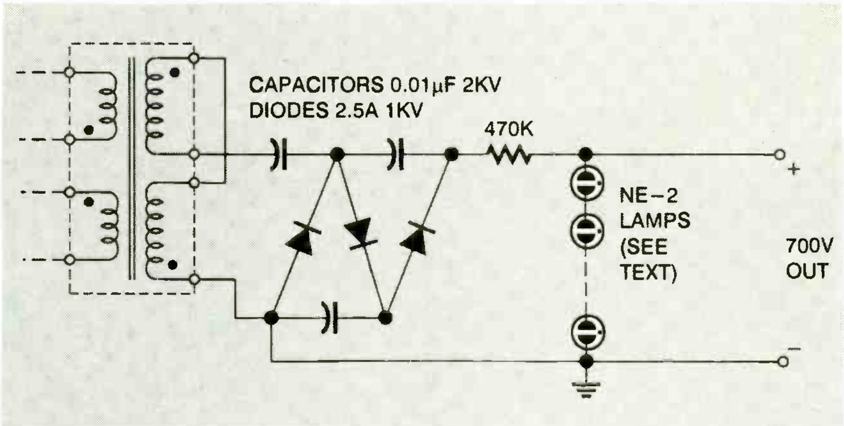


FIG. 2—IF YOU NEED A REGULATED OUTPUT, change the voltage doubler to a tripler, and use neon lamps as a regulator. The number of lamps you will need will depend on the characteristics of the lamps used, and will have to be found by experimentation.

Scoreboard Puzzle

Q *I'm trying to find out how a computerized scoreboard works. I don't want to buy one and take it apart. I know that it contains some counters and clocks, but how does the controller turn the message that is going to the scoreboard into a one-wire data stream and then decode it to drive the numbers on the scoreboard? Could you give me a schematic of a small version of one?—S. W. R., Verona, VA.*

A It's done with microprocessors, and a schematic wouldn't tell you much. The control unit and the scoreboard each contain at least one CPU with memory and input-output circuitry. The control unit scans its keyboard and responds to the switches that are closed; the scoreboard unit scans the screen and turns each light on or off as required. They are connected by a serial data stream whose format might be anything the manufacturer dreamed up. Several microcontroller families, such as the 8051, have built-in UARTs (universal asynchronous receiver-transmitters) built right into the CPU; that device enables CPUs to transmit or receive data over a single wire.

We know of no books specifically dealing with scoreboards, but the chapter on microprocessors in Horowitz and Hill's *The Art of Electronics* (published by Cambridge University Press) should help you understand how they work.

DC Converter Needed

Q *I need a DC-DC converter. The input will be 11.5 to 12.5 volts DC and the output will be 14.5 volts at up to 10 amps.—W. S., Jacksonville, FL.*

A That's a lot of amps, certainly well beyond the capacity of standard DC converter modules. The most economical solution is probably to convert the incoming DC to 120-volt AC with an inverter such as Radio Shack's 22-138, and then convert the AC back to DC with a conventional power supply. Ham and CB radio dealers have 13.8-volt, 10-amp power supplies that will probably do the job; for information on building your own, see RadioShack's book, *Building Power Supplies*, and the ARRL's *Handbook for Radio Amateurs*. If 13.8 volts at 2.5 amps will do, you can use Radio Shack's 22-120 ($39.99); you may be able to convert it to 14.5 volts by changing one Zener diode.

Four Heads Better Than Two?

Q *What is the advantage of a four-head rather than two-head video cassette recorder?*

Also, how is 1/1000-second exposure accomplished in a camcorder, since it takes 1/30 second to scan a full frame?—F. J. B., Fallbrook, CA.

A A four-head VCR has a separate pair of heads for standard play and for extended play tapes. Thus, each pair of heads can be optimized for best performance at one speed rather than being a compromise between two different speeds. Camcorders that record at both speeds can equally well benefit from four heads.

As for the 1/1000 second, it's possible because the CCD sensor in a modern video camera does not do the exposure and the scanning at the same time. Instead, it exposes a frame all at once, then reads it out in a sequential scan. The exposure could be as long as 1/30 second (the duration of a whole scan), but it also could be shorter.

Measuring Loudness

Q *Please tell me if there is any way I can make a sound detector with a meter. Can I buy one?—J. M., Terre Haute, IN.*

A If all you need to do is compare two sounds, connect a microphone to a suitable amplifier, and then put an AC voltmeter across the output. Louder sounds produce higher voltages. An analog meter is best because the sound level is likely to be fluctuating.

To measure loudness in decibels is trickier because the meter must respond logarithmically, the frequency response must be flat over the relevant part of the audio range, and the instrument must be calibrated against a sound of known loudness. Fortunately, RadioShack sells two inexpensive decibel meters, the 33-2050 ($31.99) and the 33-2055 ($59.99).

Projection CRT

Q *Where can I buy used or rebuilt blue and green CRTs for an NEC projection TV?—N. M., Gloucester, Ont., Canada.*

A Start by contacting NEC's parts department at 1255 Michael Drive, Wood Dale, IL 60191; Tel: 708-860-0335. Also, replacement CRTs of all types are available from Video Display Corporation, 1868 Tucker Industrial Drive, Tucker, GA 30084; Tel: 770-938-2080. EN

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

AXIS GENERATOR SOURCES

I really appreciated the June 1996 installment of "Experiments with Laser Light." I read the article when I was on vacation at the beach, and it made the trip all the better. The article got me interested in controlling the X-Y modulators/axis generators. I was wondering if you would be so kind as to give me a few good places to look for axis generators, so that I might try to control them with a computer.

Thanks a lot, and, again, it was a very nice article!
ADAM RIXEY

Happy to hear that you liked the article, Adam. Hope you continue to enjoy the rest of the series.

I don't have the answer to your question. However, I will send it on to the author, who may be able to help.—Editor

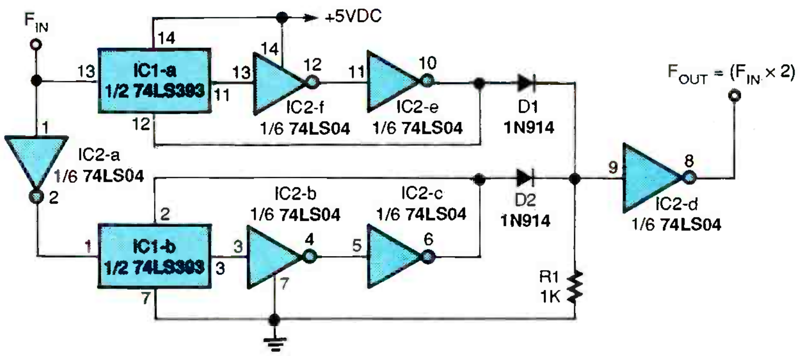


FIG. 1—A SIMPLE FREQUENCY DOUBLER. IC1 is a 74LS393 dual counter; IC2 is a 74LS04 hex inverter.

SIMPLE FREQUENCY DOUBLER

I recently got involved in a project that required a frequency doubler without a lower frequency limit and was unable to locate one in any reference books or magazine articles. Left to my own ingenuity, Fig. 1 is a design that I came up with. It works quite well, and I thought that it might be of some use to your readers.

The circuit is really quite simple. The 74LS393 (dual counter) is used to keep down the parts count, but any counter with a reset input should work equally well. The 74LS393 is designed to advance one count on the positive to negative transition of the pulse at the clock input (pins 1 and 13). An inverter in front of the B section of the counter causes the B section to advance one count on the negative to positive transition of the input pulse.

Each section of the counter is cleared with a positive-going pulse on the master reset input (pins 2 and 12). By connecting the Q0 output of each counter (pins 3 and 11) to its respective master clear pin, through two inverter sections, we end up with positive-going output pulses from pins 6 and 10 of IC2, which resets the respective counters.

The duration of the pulses depends upon the propagation delay of the inverters. With the 74LS04 hex inverter, that delay will probably be in the vicinity of 20 to 25 nanoseconds. The output pulses are also connected to the remaining inverter gate through switching diodes and a pull-down resistor, which configures the remaining inverter as a NOR gate. The output at pin 8 of IC2 represents the input frequency multiplied by two.

Because the output pulse lengths are about 25 nanoseconds, they are difficult to see on the typical hobby oscilloscope. But if you have a logic probe with a pulse mode, you can put in an input frequency of just a few hertz and see it quite well. If you would like to experiment, you can connect the output of the doubler to a divide-by-two circuit. That will allow you to confirm that the circuit is working because the frequency at the output of the divide-by-two circuit will be the same as the input frequency to the frequency doubler. If you have a dual-trace scope to connect to those two points, you will notice that the waveforms are identical. Keep in mind that the only way to get evenly spaced output pulses from the doubler is to feed it with a 50% duty-cycle squarewave.

There you have it. I hope others can find a good use for this circuit. Keep up the good work. I always look forward to the next issue of **Electronics Now.**
BOBBY SMITH
Eddy, TX

EN

Write To:
Letters
Electronics Now
500 Bi-County Blvd.
Farmingdale, NY 11735

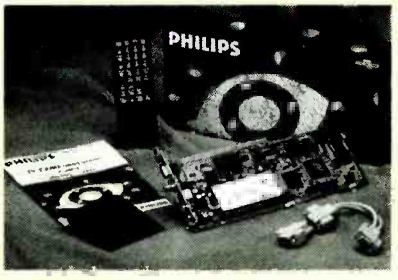
Due to the volume of mail we receive, not all letters can be answered personally. All letters are subject to editing for clarity and length.

EQUIPMENT REPORTS

A TV-TUNER CARD FOR YOUR PC FROM PHILIPS PROFESSIONAL SOLUTIONS

Keep track of important news while you work, easily store video images on your hard disk, and more, when you turn your PC into a cable-ready TV set.

CIRCLE 15 ON FREE INFORMATION CARD



At first glance, you might wonder why anyone would go to the trouble of adding a TV function to a PC. After all, the "TV" that results is more expensive than a standard TV and doesn't perform quite as well. However, there are many situations that are ideal for just such a PC/TV combo. For instance, if your job entails keeping tabs on news or financial data, a small TV window can help you do just that without cluttering up your work area with another large device (a TV receiver). Also, if you need to move video images from tape, or to capture them off the air, and store them on disk, such a setup might be the easiest way to go about it.

So how do you go about adding a TV function to your PC? Easy! You purchase and install the new *PCA 20 TV* television-tuner card from *Philips Professional Solutions* (2099 Gateway Place, Suite 100, San Jose, CA 95110; Tel: 800-235-7373).

The PCA 20 TV is a $329 cable-ready television tuner with stereo sound on an ISA expansion card. The card installs in an empty ISA slot in a 386 or better PC, comes complete with an infrared remote control, and is available in NTSC and PAL versions.

Hardware hurdles

Installing the PCA 20 TV card is quite simple, although there was one obstacle along the way—one that was more of a problem with the PC being used rather than with the TV card. The ¾-length card (10½ inches) would only fit in one expansion slot in the computer. The CPU heat sink and a voltage-regulator heat sink blocked long cards from most of the slots in the system. We had to juggle the positions of all the ISA cards that were already installed to fit the TV card.

Another inconvenience is that you need two slots to install the TV card. The card really needs just one slot, but an accessory bracket must be installed in another slot. The slot itself is actually not used, just the bracket space. The extra bracket is necessary for the IR sensor jack, because the bracket on the TV card is all filled up with a D connector, an F-type cable-TV input jack, an S-video input, a composite-video input, and an audio-output jack. The wired IR sensor plugs into the extra bracket and sticks onto your monitor bezel (or wherever you like). The sensor then receives IR commands from the remote control.

You don't have to use the sensor or install its jack in an extra slot, but since they are included with the package, it's a shame not to use them—and less convenient as well. One alternative is to drill out one of the vent holes on the back of your computer, large enough to fit the sensor jack when it's removed from the bracket. And that's only if there isn't a large enough hole to begin with. Then the TV card needs only one slot with the sensor installed. The only requirements for making this modification is that you must have the nerve to put a drill to your PC, and the common sense to keep metal shavings from falling into the system or from putting a drill bit through one of your expansion cards.

An included "Y" adapter cable connects the TV card to your graphics card and monitor. The TV card does not affect your graphics card in any way, and the adapter cable eliminates the need for a feature connector on your graphics card—something found on most, but not all, graphics cards. This is also much easier than having to deal with internal connectors. A line-level audio output on the TV card connects to amplified speakers or to an external input on your sound card. Alternatively, you can make an internal connection between the TV card and your sound card.

TV on PC

The software for the TV card, contained on a single diskette, couldn't be easier to install. The installation configures the card to work in DOS and Windows 3.1x and higher. We tested the card under Windows 95 with no problems at all. The TV card defaults to seldom-used settings (IRQ10 and I/O port address 510h) so that there's less of a chance of encountering hardware conflicts. If necessary, the default settings can be changed, although they worked fine for us. We had the card working in minutes. We then set it to scan for all received channels and store them in memory.

The TV card's picture quality is nearly as good as a standard, good-quality TV receiver; however there are some artifacts due to the conversion from NTSC to VGA video. To minimize those, settings within the TV software let you adjust various parameters for the best picture. For example, you can set the X and Y position relative to the TV window, and set the VGA clock delay for the best picture within a particular system. In our setup, we got the best picture with an inverted delay for the VGA clock. You will have to experiment with the VGA clock settings to see what works best for you. After selecting the best type of delay, you can set the rising and falling portions of it for an even better picture.

You can control the TV card with the IR remote if you've installed the sensor, or with an on-screen set of controls. Either way, you'll see TV-like on-screen displays for channel, volume, color, brightness, and so on.

As we alluded to earlier, perhaps the most valuable feature of the TV card is its ability to freeze and capture video, and then store it on your hard disk. The video can be from any standard source—over-the air TV, videotape, laserdisc, or camcorder.

The remote control lets you change video sources (RF, S-video, composite video), switch between full-screen and window modes, adjust sound and picture quality, change channels and volume, and do everything else you would expect from a TV remote. Pressing a picture-in-picture (PIP) button first decreases the size of the TV window, and subsequent presses move the downsized TV window to different corners of the screen. This way you can see different parts of the screen depending on what's there. We tested the TV while working in Microsoft Word, and found no compatibility or operational problems—both worked flawlessly at the same time.

If you need (or like) to watch TV while you work on your computer, the Philips PCA 20 TV television-tuner card can't be beat! It doesn't take up any extra space in your office or work area, and if you need to capture and store video images of almost any type, it is hard to find anything that can do the job better. EN

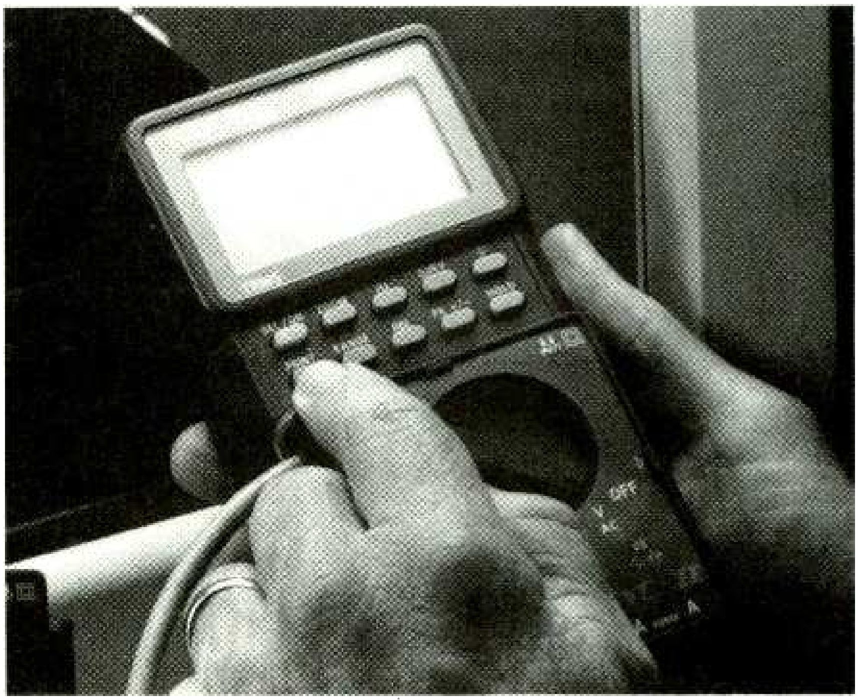
NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

High-Resolution Digital Multimeters

THE FOUR MODELS IN Metrix's ASYC IIB Series are among the first handheld digital multimeters to offer backlit displays and the ability to print hard copy of either test results or calibration results. All models have a 50,000-count digital-display resolution and offer true-rms (AC, and DC plus AC) measurements for accuracy in handling non-sinusoidal, or irregular, waveforms. The digital multimeters feature basic DC accuracy to 0.025%; bandwidths to 100 kHz; provide facilities for automatic storage of the last reading; and hold, fast, peak-capture, and relative-reading modes. The DMMs also perform comprehensive autoranging voltage, current, capacitance, and frequency (to 500 kHz) measurements. Duty-cycle percentage, positive or negative pulse width, and pulse-counting functions are provided as well. The top-of-the-line model adds a resistive power function that offers a choice of reference resistances.

An optional calibration kit allows you to recalibrate the ASYC IIB meters without opening them. Calibration results are printed on a personal computer; an optional adapter is provided for a serial printer connection. LabWindows drivers and calibration software are provided with the calibration kit. Recalibrating the ASYC IIB meters is done by removing the fuse/battery-compartment cover, temporarily replacing it with a face-plate, and then following software prompts to recalibrate and print the results. The meter need not be opened during the procedure.



CIRCLE 20 ON FREE INFORMATION CARD

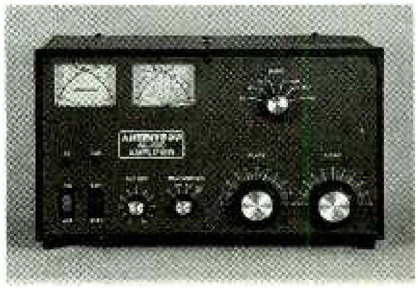
The ASYC (Advanced Safety Concept) meters offer a host of safety features including full water and dust sealing to IP677 standards. A separate compartment allows the battery or fuses to be replaced without using metal tools and without breaking the calibration label. Test lead retainers keep leads from being accidentally disconnected.

Prices for the four models in the ASYC IIB Series of digital multimeters range from $259 to $399. The SX-ASYC IIC calibration kit costs $199.

METRIX
P. O. Box 332
Brea, CA 92622-0332
Tel: 714-992-1239

TRIPLE-OUTPUT POWER SUPPLY

THE MODEL 1670 TRIPLE-output power supply from B+K Precision is designed for applications in the servicing, educational, and hobbyist markets where a low-cost solution to multiple outputs is desired. The power supply features a variable DC supply—0 to 30 volts at 0 to 2.5 amps—with variable current limiting, constant current or constant voltage operation, tight regulation, low ripple, and separate digital LCD current and voltage meters. Another fixed 5-volt, half-amp supply is provided for TTL projects, and a fixed 12-volt, half-amp supply is included for mobile electron-



CIRCLE 21 0 ON FREE INFORMATION CARD

ics and digital CMOS projects.

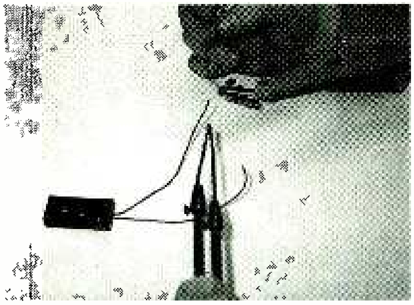
The Model 1670 costs $199.

B+K PRECISION
6740 West Cortland Street
Chicago, IL 60635
Tel: 1-800-462-9832
Fax: 312-794-9740

Helping Hand For Soldering

WHEN YOU'RE TRYING TO hold the soldering iron, solder, wire, and connectors, sometimes you could use an extra hand. Ironwood Pacific's Free Hand provides just that.

The Free Hand cuff fits around your wrist. Attached to the cuff is an arm with a holding clip mounted at its end. The clip can be opened to hold a wire or electrical component, freeing both of your hands to hold the soldering iron (or gun), wire, or solder.



CIRCLE 22 ON FREE INFORMATION CARD

The Free Hand is equipped with a built-in cutter and six-inch ruler for cutting fine wire and measuring distances. Its two-piece design allows it to be easily stored or to be adapted for mounting directly to the table or work surface. Molded from high-impact plastic, the cuff is adjustable to fit most wrist sizes.

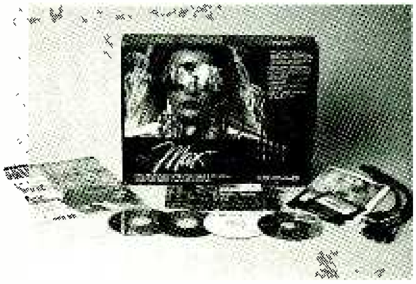
The Free Hand costs $8.95 plus $3 shipping and handling.

IRONWOOD PACIFIC INC.
P. O. Box 1568
Lake Oswego, OR 79035
Tel: 800-261-1330

Desktop Personal Theater

ONE CONSUMER-ELECTRONics buzzword that you'll be hearing a lot in coming months is "PC/TV," which refers to any single unit that combines computer and television functions. Core Dynamics presents an inexpensive add-on solution with its DynaMax Hi-Rez Plus interactive video/television card. Compatible with all VGA cards without the need for internal cables, the 8-inch ISA bus card supports up to 1280×1024 resolution and displays 16.7 million colors at full frame and full motion.

The interactive video and television card allows you to use your PC to watch broadcast, cable, or direct-access TV, as well as videotapes from your VCR or camcorder. A built-in video snapshot captures images that you can use for personal home pages,



CIRCLE 23 ON FREE INFORMATION CARD

add to school projects or business presentations, or store in video albums. You can also use the Hi-Rez Plus as the basis for a video-conferencing or security system. On board spatial stereo sound enhances the video.

Three CD-ROM titles—A Guided Tour of Multimedia, Second Edition; ESPN's Baseball Tonight; and CNN's Time Capsule—are included, as is Corel's PhotoPaint 5 Special Edition. The video/TV card also comes with a VCR input cable, loopback cable, software drivers for Windows 3.1x and Windows 95, an installation manual, and a trial subscription to Multimedia World magazine.

The Dynamax Hi-Rez Plus card costs $299.

CORE DYNAMICS
8 Thomas Street
Suite 100
Irvine, CA 92718
Tel: 800-611-CORE
Web site: http://www.core-dynamics.com

Fixed-Output Power Supplies

TWO FIXED-OUTPUT POWER supplies from B+K Precision are aimed at the mobile-electronics and hobbyist markets. The Model 1680 is well-suited for use when bench testing autosound equipment, two-way radios, cellular phones, and amateur-radio gear. Its standard binding posts are augmented with a convenient cigarette-lighter jack.

CIRCLE 24 ON FREE INFORMATION CARD

The Model 1680 features a 13.8-volt output with an intermittent-current capability of up to 6 amps. Ripple voltage is a low 5mV rms. Overload protection is provided via current foldback with air-convection cooling.

Designed for higher current applications, the Model 1682 features up to 15 amps intermittent duty at 13.8 volts. Ripple voltage is 6 mV rms. The Model 1682 offers convection cooling and foldback overload protection with a built-in overload indicator.

The Models 1680 and 1682 fixed-output power supplies cost $50 and $90, respectively.

B+K PRECISION
6470 West Cortland Street
Chicago, IL 60635
Tel: 1-800-462-9832
Fax: 312-794-9740

Clamp-On Digital Multimeters

THREE ADDITIONS TO Wavetek's line of clamp-on digital multimeters are designed for the installation, testing, verification, servicing, and troubleshooting of modern electrical systems. The clamp-on method is non-invasive, allowing for quicker and safer current measuring without disrupting the circuitry.

CIRCLE 25 ON FREE INFORMATION CARD

Models AC60 and AC65 feature AC transformers, while the Hall-Effect transducer of the Model AD105 allows both AC and DC measuring. All three meters include a 4000-count LCD readout, autoranging, true-rms measuring, wide measuring ranges, and a data-hold button. The compact meters' "hand-guard" design meets new international standards, and their rugged construction allows them to withstand drops of up to four feet without damage.

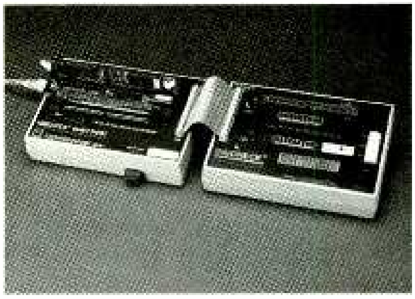
The AC60 and AC65 DMMs measure AC current to 600 amps, AC voltage to 600 volts, resistance to 40K ohms, and they offer a quick continuity-check function. The AD105 is a high-range ammeter that measures both AC and DC to 1000 amps and frequency to 10 kHz. A peak-hold button captures and holds peak measurements, which comes in handy in many real-world situations.

The AC60, AC65, and AC105 clamp-on DMMs have list prices of $109.95, $149.95, and $249.95, respectively.

WAVETEK CORPORATION
9045 Balboa Avenue
San Diego, CA 92123
Tel: 619-279-2200
Fax: 619-565-9558

DIMM Module Tester

THE DIMMCHECK 168P IS AN add-on option for Aristo Computers' SIMCHECK PLUS SIMM/SIP memory module and DRAM tester. With the addition of the DIMMCHECK 168P, you can test the popular 168-pin Dual In-Line Memory Modules, or DIMMs. The unit tests the DIMMs with 64, 72, and 80 bits, as required by Pentium and other RISC processors. The adapter supports ECC and Parity types, as well as some non-standard wiring.



CIRCLE 26 ON FREE INFORMATION CARD

The adapter connects to the SIMCHECK PLUS base unit. The test identifies the size, speed, type, and structure of the DIMM and provides a reading of the DIMMs presence detect (PRD) code. When a fault is encountered, explicit error information is provided.

The DIMMCHECK 168P has a retail price of $295. The SIMCHECK PLUS base unit costs $1490.

ARISTO COMPUTERS INC.
6700 SW 105th Avenue
Beaverton, OR 97008
Tel: 800-3ARISTO or
503-626-6333
Fax: 503-626-6492

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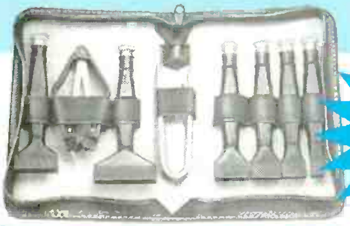

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Eight piece kit contains specific insertion tools for 8 pin DIP, 14/16 pin DIP, 18/20 pin DIP, 22 pin DIP, 24/28 pin DIP, and 36/40 pin DIP packages. ALso includes IC extractor tweezer and square IC extractor. Housed in vinyl zipper case.

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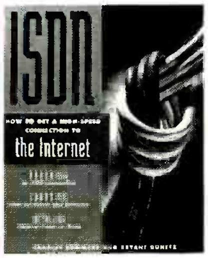
NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

ISDN: How to Get a High-Speed Connection to the Internet

by Charles Summers and Bryant Dunetz
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 800-CALL-WILEY
Web site: http://www.wiley.com/compbooks
$22.95



CIRCLE 337 ON FREE INFORMATION CARD

Downloading graphics and sound from the Internet and World Wide Web can be excruciatingly slow. Although today's 28.8-baud modems work fairly well over traditional phone lines, the bandwidth of those lines can hardly manage the massive amounts of data moving onto and off the Internet.

ISDN, or Integrated Services Digital Network, is a technology that allows people to use existing phone lines to access data at much higher speeds. Although it has existed in conceptual form since 1988, its actual availability has been very limited until recently. Internet access is the "killer application" that could put ISDN on the map. ISDN telephone service is becoming available throughout the country, and Internet service providers have begun offering ISDN connections.

This book is a complete guide to getting and using an ISDN connection to the Internet. It shows individual dial-up and small-business users how to analyze their needs and select the best type of ISDN connection, obtain the necessary telephone service, secure an ISDN connection from an Internet service provider, and install ISDN hardware and modify Internet software to work with ISDN. The book helps readers get the most out of their ISDN connection to the Internet and World Wide Web, and provides extensive lists of ISDN resources, including ISDN carriers, service providers, and capability requirements.

Electronic Components and Computer Products Catalog

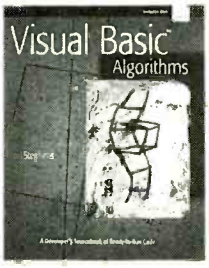
Jameco
1355 Shoreway Road
Belmont, CA 94002-4100
Tel: 800-831-4242
Fax: 800-237-6948
Web site: http://www.jameco.com
Free

CIRCLE 338 ON FREE INFORMATION CARD

Jameco's complete product line includes more than 5000 electronic and computer products, such as ICs, discrete components, power components, prototyping equipment, tools and test equipment, sockets and connectors, books, consumer electronic products, and cellular phones. This catalog features more than 250 new products, including Gentron relays, cellular-phone accessories, networking products, ADAM remote data-acquisition and control modules, and high-capacity Seagate hard drives. It also offers hundreds of sale items and closeouts. A free gift is shipped with each order; the gifts range from a mousepad to a 16-bit IDE disk-drive adapter, depending on the amount of your order.

Visual Basic Algorithms: A Developer's Sourcebook ofReady-to-Run Code

by Rod Stephens
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 800-CALL-WILEY
Web site: http://www.wiley.com/compbooks/
$39.95, with companion diskette



CIRCLE 339 ON FREE INFORMATION CARD

Visual Basic's popularity stems from its point-and-click programming interface—but that falls short of the task when a programmer needs to implement more sophisticated code into a Windows program. This book give Visual Basic programmers everything they need to create complex applications and put more muscle into their everyday programs.

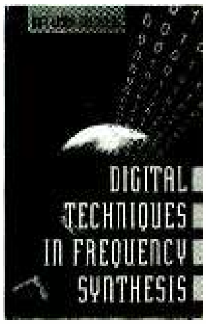
The book provides a solid working introduction to the world of algorithms, and serves as a sourcebook packed with valuable, ready-to-run code. Readers learn the basics of how algorithms work, how to analyze the usefulness of any algorithm, and how to incorporate algorithms into Visual Basic programs. Dozens useful algorithms are presented, implemented in Visual Basic and clearly explained in plain English. Those algorithms can be used for a wide variety of common programming tasks, including memory allocation, sorting, searching, hashing, trees, networking, assignment, shortest path, and queue simulation.

The book also provides an array of implemented algorithms for user-interface design and graphics programs.

The companion disk includes a wealth of Visual Basic source code, including practical algorithms that can be modified to fit each programmer's specific needs. The disk also contains working examples of applications that demonstrate the uses of every algorithm covered.

Digital Techniques in Frequency Synthesis

by Bar-Giora Goldberg
McGraw-Hill, Inc.
11 West 19th Street
New York, NY 10011
Tel: 800-2-MCGRAW
$60



CIRCLE 340 ON FREE INFORMATION CARD

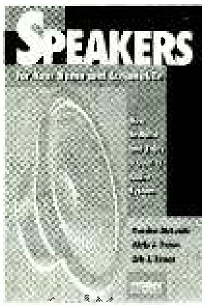
Technological progress and the ability to integrate complex circuitry in a single chip makes possible low-power, low-cost frequency synthesis. As a consequence, digital and analog technologies are now used synergistically in the implementation of complex signal generation and modulation.

This comprehensive guide to frequency synthesis technology focuses specifically on the modernization and digitization of signal generation. Digital frequency synthesis is used in a wide variety of modern electronics and communications technologies ranging from radar, satellite communications, medical imaging, and spectroscopy to cellular, wireless, and PCS/PCN systems.

The book is filled with design examples and hands-on approaches, helping readers analyze and manipulate the methods described in the text. It provides detailed coverage of direct digital synthesizers (DDSs), phase-locked loops (PLLs), and fractional-N PLLs used to generate and modulate signals accurately and effectively.

Speakers for Your Home and Automobile: How to Build and Enjoy a Quality Audio System

by Gordon McComb, Alvis J. Evans, and Eric J. Evans
Prompt Publications
2647 Waterfront Parkway East Drive
Indianapolis, IN 46214-2041
Tel: 800-428-7267
$14.95



CIRCLE 341 ON FREE INFORMATION CARD

High-quality speakers are an integral part of any fine audio system. This book shows you how to build quality speakers for use in your home and car. Directions for four home speaker systems and automotive installations are presented with easy-to-follow instructions and clear illustrations. The book also covers enclosures and finishing touches, construction techniques, and wiring speakers.

Soldering Irons Catalog

M.M. Newman Corporation
24 Tioga Way
P. O. Box 615
Marblehead, MA 01945
Tel: 617-631-7100
Fax: 617-631-8887
Free

CIRCLE 342 ON FREE INFORMATION CARD

This eight-page catalog features the full line of Antex precision miniature and standard-size soldering irons, iron stands, temperature control stations, and a wide variety of slide-on tips.

Photo-graphs and specifications for each product, and a fully illustrated chart of available tips in different shapes and sizes, are included. Highlights include the new 600 Series of static-dissipative, temperature-controlled soldering stations; a 60-watt electric hot knife; and a portable soldering iron that operates from any automotive-type 12-volt battery.

1996 Equipment, Tools & Supplies Catalog

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Silver Spring, MD 20910
Tel: 1-800-638-2020 (in Maryland, 301-587-7824)
Fax: 1-800-545-0058 (in Maryland, 301-585-5402
E-mail: smprodintl@aol.com
Free


CIRCLE 343 ON FREE INFORMATION CARD

The 84 pages of this catalog are packed with electronic test gear for anyone who builds, maintains, services, or purchases today's advanced electronics. Products range from simple scopes, power supplies, and soldering stations to the most advanced spectrum analyzers, digital storage oscilloscopes, surface mount rework and repair equipment, arbitrary waveform generators, and analog/digital cellular test sets.

Law on the Net: Easy Access to Online Legal Resources

by James Evans
Nolo Press
950 Parker Street
Berkeley, CA 94710-9867
Tel: 510-549-1976
$39.95

Lawyers might compare self-help law to do-it-yourself brain surgery. You might not want to defend yourself in a court of law, but it is possible to find the answers to some of your legal questions without consulting an attorney. The resources are right at your fingertips if you are connected to the Internet—and if you

CIRCLE 344 ON FREE INFORMATION CARD

know where to look.

This book points you directly to the locations of hundreds of online legal resources. It tells you all you need to know about what sites are available, what information they offer, and exactly how to get to them. The book's comprehensive index—which includes such topics as biotechnology, divorce and custody, immigration, tax law, privacy, intellectual property, environmental law, computer regulation and crime, health care, and bankruptcy—takes you straight to the information you need.

The book shows you how to tap into federal and state statutes and regulations, White House and executive offices, the U.S. Congress, federal and state courts, law firms, law schools, bar associations, and even international treaties and constitutions. More than 150 law-related "listservers"—automated mailing lists that will keep you informed on issues in your field are listed. You'll also find more than 100 law-related newsgroups, where you can exchange information and discuss legal issues with experts.

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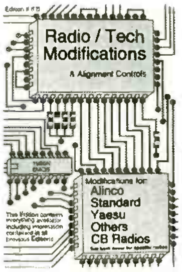
Web site: http://www.earthlink.net/~artsci

$19.95 each, plus $4 shipping

This two-volume set is aimed at radio repair technicians and amateur-radio hobbyists who are serious about enhancing their radio transceivers and scanners. The typical modifications presented in the books increase the radios' transmit and reception frequency coverage. Many of the modifications will allow a radio or scanner to monitor "illegal" frequencies.



CIRCLE 345 ON FREE INFORMATION CARD

The new editions (8A and 8B) cover radios that were introduced in 1995, as well as all the radios presented in previous editions. A new page format simplifies the modifications. Illustrations are detailed and easy to follow.

The "A" edition contains modification information for Kenwood and Icom amateur radios and Uniden, Regency, and RadioShack scanners. The "B" edition (pictured here), completes the set with all the modifications for Alinco, Yaesu, Standard, Azden, RCI, and other amateur radios, as well as modifications for citizen band (CB) radios. EN

WHAT'S NEWS

continued from page 6

available on its Web site (http://www.hp.com/go/tmdir), giving a cutting-edge means of viewing highly technical information.

"We are continuing to evolve the [Web] site from a place that is simply a passive repository for information to one that will ultimately allow interactive, two-way communication on many levels with customers," said Jeff Gruszynski, TMO's web master.

Customers can download the full text of many popular application notes. The animations that have been added to the downloadable notes illustrate technical product information such as wave frequency and amplitude. Viewers can stop the animations at any point and zoom in to see intricate details in even the most complex graphs. Key portions of the notes can be viewed online along with interactive mathematical models whose parameters can be adjusted in real time.

To access the interactive notes, users must be working in the Windows 95, Windows NT, Power Macintosh, or UNIX operating environment and must be running a JAVA-enabled Web browser such as Netscape. Adobe Acrobat Reader 2.0 and Quicktime, both of which can be downloaded free from the Internet, are also required to download the full electronic text of the notes and to view the animated graphics.

The TMO Web site also provides a complete list and descriptions of service and support programs, descriptions of course offerings covering a wide range of instrument and computer solutions, and online product selection.

HDTV host station announced

The Model HDTV Station Project, jointly sponsored by U.S. broadcast television stations and the professional- and consumer-electronics industries, has selected WRC-TV as the host station for the HDTV Project. WRC-TV is located in Washington, D.C., and is owned and operated by NBC. The Model HDTV Station Project also contracted with the David Sarnoff Research Center (Princeton, NJ) to implement the construction of the HDTV station. Funds for the three year project are being collected and provided by the Association for Maximum Service Television (MSTV) and the Consumer Electronics Manufacturers Association (CEMA). MSTV invites all U.S. television stations to contribute to the funding.

"With Sarnoff, NBC, and WRC-TV, we have a team in place that will turn the dream of the Grand Alliance into a reality for broadcasters and consumers," enthused Gary Shapiro, president of CEMA.

For the duration of the project, WRC-TV will serve as a source of encoded digital television signals to aid equipment manufacturers in the development of professional- and consumer-electronic equipment. It will also provide public demonstrations of HDTV, as well as HDTV training for broadcast-station technical personnel. EN

VIDEO NEWS

continued from page 8

details hadn't been announced, but it's understood that the products of the collaboration are likely to use RCA's 36-inch fine-pitch picture tube and incorporate Web browsing and perhaps a wireless keyboard. According to Compaq, the requirements for the first products will include Internet access and compatibility with direct satellite broadcasting systems. The two companies have discussed software requirements with Microsoft and Intel. The resulting product will be sold by both companies under a joint trade name.

70 firms back net computer

Oracle announced a "reference profile" for its own idea for a network computer—a low-cost net browser, using the TV screen for display—for people who don't want to buy computers. Although the "profile" was a bit short of actual specifications, Oracle was able to give the names of 70 companies that it said endorse the system. In addition to the usual computer suspects, the list includes such consumer-electronic heavyweights as LG (Goldstar), Matsushita (Panasonic), Mitsubishi, Nokia, and Toshiba. Oracle chairman Larry Ellison had touted the $500 netcruiser as an inexpensive, simpler successor to the computer for home use. However, there were some estimates that the cost would escalate from the proposed $500 to $1000, bringing it into the same price category as low-end PCs.

A major defector from Oracle is Farzad Dibachi, formerly senior vice president, who complained that Oracle's price was escalating. He and his brother Farid formed a company called Diba, which developed a platform called "IDEAS" (for "interactive digital electronic appliances") to push a system of single-function, low-priced "information appliances," such as a telephone with a small screen and keypad for fax and e-mail, priced at less than $300. That caught the fancy of Zenith, which introduced 27- and 35-inch "NetVision" TVs using Diba technology at $1099 and $3499, designed for net browsing and telephony as well as ordinary TV viewing.

Cable modems hot

Virtually all major cable-TV operators are now experimenting with high-speed cable modems. CableLabs, the industry-supported testing organization, says that "thousands" of cable systems are currently using them, and that trials have been successful. Modems being testing vary from 4 to 40 Mbps and will provide the latest service that cable systems can charge their viewers for. The cable modems are hooked not to the customer's TV, but to his or her PC. Telephone companies are responding by testing different methods to develop higher speed modems to work with their existing or planned lines. The result: Much faster modems are in the works, one way or the other—or both. EN

BUILD THIS Hobby Spectrum Analyzer

At less than $100 to build, this spectrum analyzer is a must for every hobbyist!

BOB KOPSKI

The project described in this article was inspired by a need to analyze the radio-frequency spectrum for hobby applications related to radio-controlled (R/C) model planes. The author suspected that some microprocessor-controlled R/C accessories were causing interference with the onboard guidance radio. Those problems were tracked down by using a borrowed Smith Design "Spectrum Probe" and very expensive HP spectrum analyzer. (Smith Design is located in North Wales, PA.) That experienced prompted the author to design and build this inexpensive, yet effective, Hobby Spectrum Analyzer (HSA).

What is it? A spectrum analyzer might be perceived as an automatically-tuned visual radio. To envision this, connect the audio output from a radio to an oscilloscope's vertical input. Spin the tuning dial slowly; every time you tune through a station the output will show up as a random vertical blip on the oscilloscope. Now imagine you are able to tune the radio and synchronize the oscilloscope's horizontal sweep in step with it. The horizontal axis on the oscilloscope would simulate a radio tuning dial. Radio signals would show up on the display at their frequency locations. In addition, the size of the blip could be an indication of the radio signal's relative strength.

The HSA can do all of the above and be built for less than $100 using commonly available parts. The HSA tunes from low MHz frequencies to 100 MHz. With a few inches of antenna wire connected to the input terminal, the HSA routinely displays RF signals within its operating range on an inexpensive oscilloscope. Those detected signals include CB and amateur-radio activity, wireless phone, RC signals, local TV stations, and a significant portion of the FM band; plus any local EMI, all *at the same time and on one display*!

The HSA is actually a double-conversion superhetrodyne radio. The tuning sweep is electronically and repeatedly generated by an internal sweep circuit that linearly tunes the frequency range in a 10-mS time period. If the oscilloscope time base is set to 1 mS per-major-division, then each division represents a 10-MHz segment of the tuning range. This is the "frequency dial" analogy and the blips on it are received radio-frequency signals. The HSA outputs a trigger pulse to initiate the internal sweep of the oscilloscope coincident with the beginning of the frequency sweep. This assures solid synchronization between the HSA's frequency tuning and the oscilloscope display.

The HSA is an excellent relative RF voltmeter or power meter. It has a sensitivity of better than −80 dBm which is about 22 microvolts rms on a 50-ohm line. It has an amplitude dynamic range exceeding 50 dB, which can be further increased with built-in RF and IF attenuators. A built-in comb generator allows accurate calibration of both frequency and amplitude performance. When the HSA is aligned, it has a frequency accuracy within ±1 MHz, and the prototype has an amplitude flatness/accuracy better than ±2 dB across the entire range. The HSA is battery powered with eight alkaline AA cells in an internal battery pack.

Almost any inexpensive, one-channel oscilloscope with a triggered-sweep feature can serve as the HSA's companion unit. A two-channel oscilloscope, or one with a time-base magnifier adds versatility, but is not necessary. The HSA is easy to align and use. What is needed to align the HSA is the companion oscilloscope, plus a DVM, an adjustable DC power supply, an audio or function generator producing a 10-kHz (or so) sine-wave signal, and a source of 145 MHz for IF alignment.

While the HSA will be more than adequate for hobbyist or other "less demanding" applications, remember that it is not intended to be a "lab-grade" instrument. For example, the HSA has no input filter, so signals beyond 100 MHz may sneak in as im-

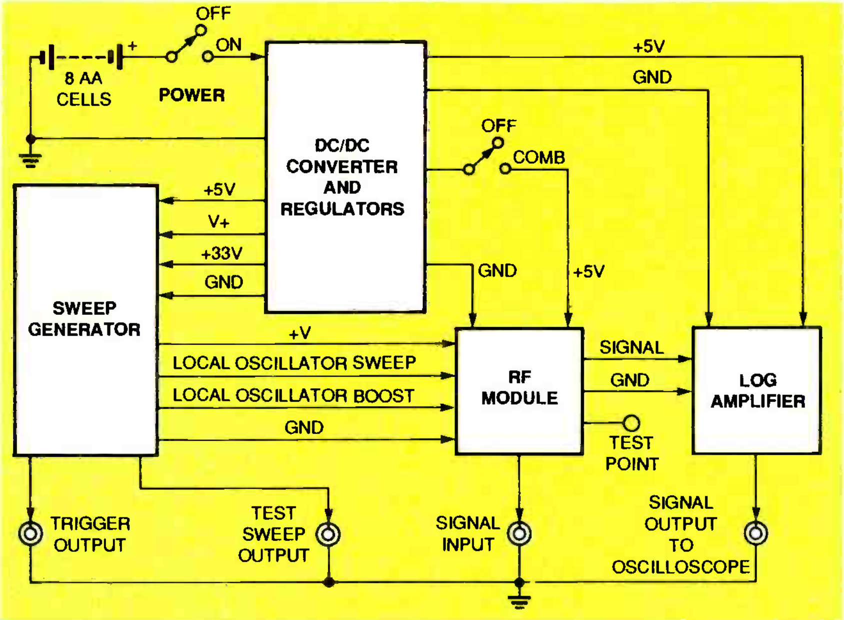


FIG. 1—SIMPLIFIED BLOCK DIAGRAM for the Hobby Spectrum Analyzer. Functional blocks are actual circuit boards which make circuit understanding and construction easier for the hobbyist.

ages and appear on the display. Also, the HSA uses a simple heterodyne detector technique and the resulting spectral lines are actually swept-through zero beats. This results in some amplitude display jitter. You just have to look a bit more carefully at the oscilloscope display for more accurate readings.

How it works. The Hobby Spectrum Analyzer's four main functional blocks (see Fig. 1) are the sweep generator, RF module, log amplifier, and DC/DC converter and regulators. All four blocks are constructed as individual assemblies. They are tested individually for basic operation, then interconnected with short cables, and housed in a metal case.

RF circuit module. The RF circuit module schematic diagram is shown in Fig. 2. The RF input signal first reaches the INPUT SWITCH S1, which is a three-pole, three-throw slide switch. It selects either a HIGH Z input, a 50 OHM input, or a -20-DB input for the first mixer/converter. The HI Z input is very useful with a short-wire antenna connected to the SIGNAL INPUT jack while the latter two options are useful for more accurate amplitude measurements in 50-ohm cable systems. (The same basic idea can be extended to 75-ohm systems if that is your preference.) The comb generator block is the built-in calibrator function mentioned earlier and will be discussed in detail in the alignment section.

The signal from S1 flows to the first converter IC1, a Signetics NE602 oscillator-mixer. The local oscillator is a varactor-tuned Colpitts configuration. A sweep voltage of about 4 to 30 volts is applied to varactor D1 and that causes the local oscillator to vary from about 145 MHz to about 245 MHz. Thus, the first converter is an "up converter". For example, when an incoming signal is at 50 MHz, it is mixed with the swept local oscillator signal. At some point in the timed local-oscillator sweep signal, the 195-MHz point of the sweep mixes with the 50-MHz signal to produce the mixer output signal at 145 MHz, which is the first IF frequency. This spot frequency signal is then processed by the remainder of the HSA functions. The LO (local oscillator) boost input shown in Fig. 2 is a finer detail and will be discussed later.

The first converter is followed by a simple double-tuned, 145-MHz bandpass filter and then the IF ATTN switch. The latter uses a double-pole, double-throw slide switch and permits the filtered 145-MHz signal to flow either directly into the second converter or to first experience 20 dB of attenuation. Since the second converter is the first circuit to overload with high input levels, the IF attenuator is aptly located.

PARTS LIST FOR THE RF CIRCUIT MODULE (Fig. 2)

SEMICONDUCTORS
D1—MV209 varactor diode
IC1, IC2—NE602A oscillator-mixer, integrated circuit (Signetics)

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1, R3—60.4-ohm, 1%, metal film
R2—249-ohm, 1%, metal film
R4—49.9-ohm, 1%, metal film
R5—100-ohm
R6—22,000-ohm
R7—10,000-ohm
R8—1300-ohm
R9—150-ohm

CAPACITORS
(All capacitors are ceramic discs unless otherwise noted.)
C1, C2, C4, C5, C8–C11, C20, C21, C25, C28—0.001-µF
C3, C22—0.1-µF
C6, C13, C17, C18, C27—2.5–7.5-pF trimmer, 6 millimeter
C7—4-pF
C12—15-pF
C14, C16—7-pF
C15—1-pF
C19—100-pF
C23—5-pF
C24—2-pF
C26—12-pF

ADDITIONAL PARTS AND MATERIALS
L1, L5—Ferrite bead (Panasonic EXC-L351390)
L2, L6—5 turns of #30, solid, enameled wire, 3/32-in. i.d., air-core, spread turns as required (see text)
L3, L4—5 turns of #20, solid, tinned wire, ¼-in. i.d., air-core, spread turns as required (see text); L4 is tapped (tack soldered) at 1 turn above ground to lead from C15
S1—Three-pole, three-throw, slide switch (Digi-Key SW336, or equiv.)
S2—Two pole, two-throw slide switch (Digi-Key SW335, or equiv.)
Double-sided PC board material (unetched) plus scrap pieces from PC universal prototyping board (RadioShack 276-168); BNC male connector, flange mount; 6-pin, straight, male plug with 0.1-in. centers; metal and plastic spacers; screws; nuts; washers; copper foil; etc.

The second converter has a fixed local oscillator frequency of 145 MHz. Thus, its input signal from the at-

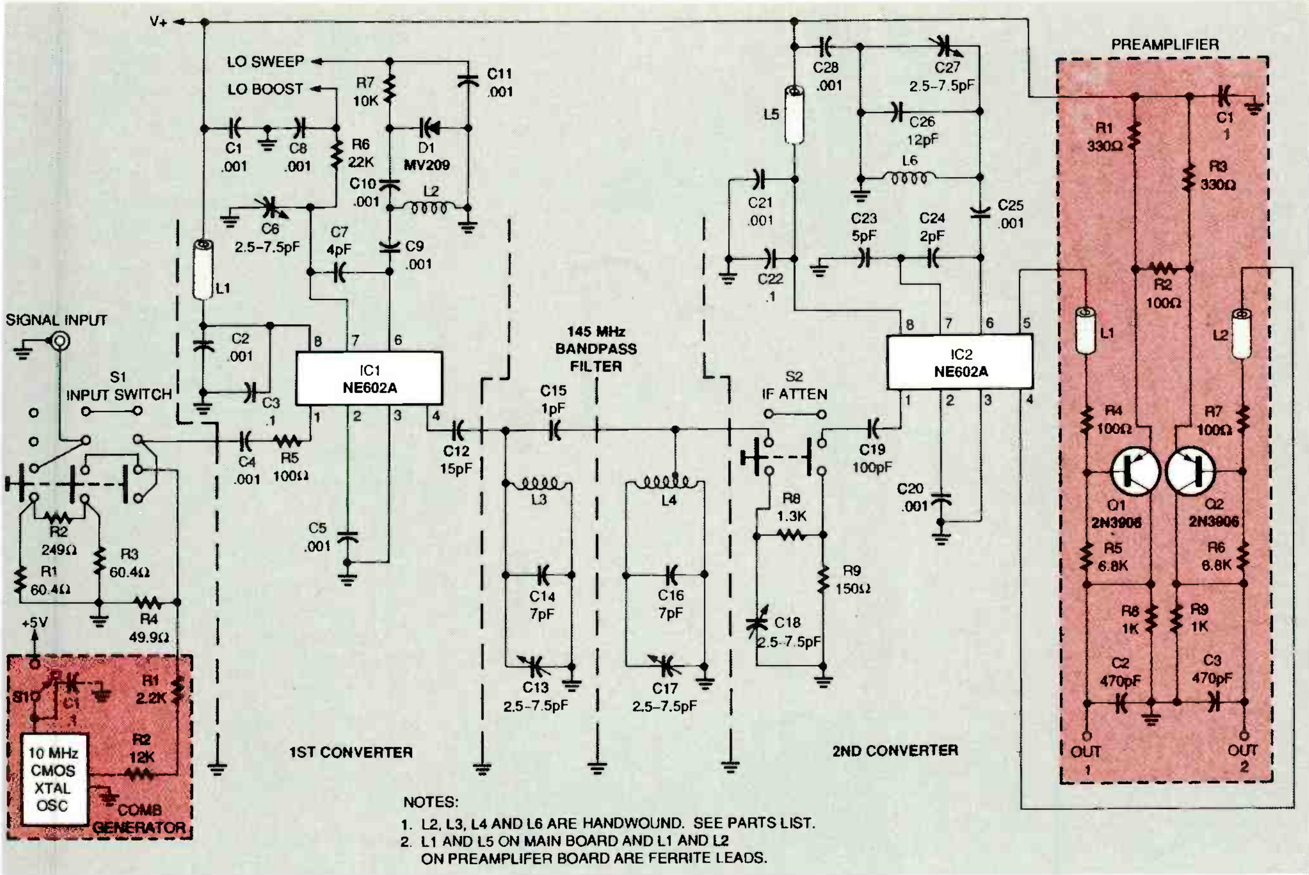


FIG. 2—SCHEMATIC DIAGRAM for the RF circuit module. Note that the circuit includes two subassemblies—comb generator and preamplifier—each of which is assembled on its own board. Since the parts symbol for each assembly section begins with "1," there are three R1s, etc., in the diagram. The text clearly separates discussion on each section so there is no confusion.

tenuator and its own oscillator signal heterodyne (mix) to produce swept zero-beat signals with incoming signals.

The second converter also uses a Signetics NE602, and its balanced output drives a preamplifier. The heterodyne output signals are low frequencies that range from zero at "beat" upwards to low 100s of kHz during the heterodyne sweep. The preamplifier and the log amplifier need only be low-frequency circuits. A bandwidth of 100 kHz for the second IF is adequate.

DC/DC converter and regulators module. The DC/DC converter and regulators module (See Fig. 3) receives 12-volt DC from the eight AA dry-cell pack and provides three regulated output voltages to operate the HSA. What are those outputs and why are they needed? A separate +5 volt regulated supply powers the sweep generator, log amplifier, and comb generator boards. There is also a V+ output which only powers the RF and preamplifier circuits. The V+ output is adjusted during alignment to between 5 and 7 volts to optimize HSA performance. Finally, there is a +33-volt DC output. This high voltage powers the sweep generator output system for varactor tuning. The voltage is obtained from a simple, regulated voltage multiplier powered directly from the 12-volt battery. While the +5 volts and the V+ voltages are obtained from common-type 78L05 three-terminal regulators, the +33-volt generator deserves some expanded explanation.

The DC/DC converter and regulators module uses a classic diode

PARTS LIST FOR THE COMB GENERATOR SUBASSEMBLY (Fig. 2)

C1—0.1-µF, disc, ceramic capacitor
R1—2200-ohm, ¼-watt, 5% resistor
R2—12,000-ohm, ¼-watt, 5% resistor
S1—Single-pole, single-throw, toggle switch
10.0-MHz crystal-controlled, CMOS oscillator integrated circuit (Digi-Key CTX114); piece of PC universal prototyping board (Radio Shack 276-168); wire, etc.

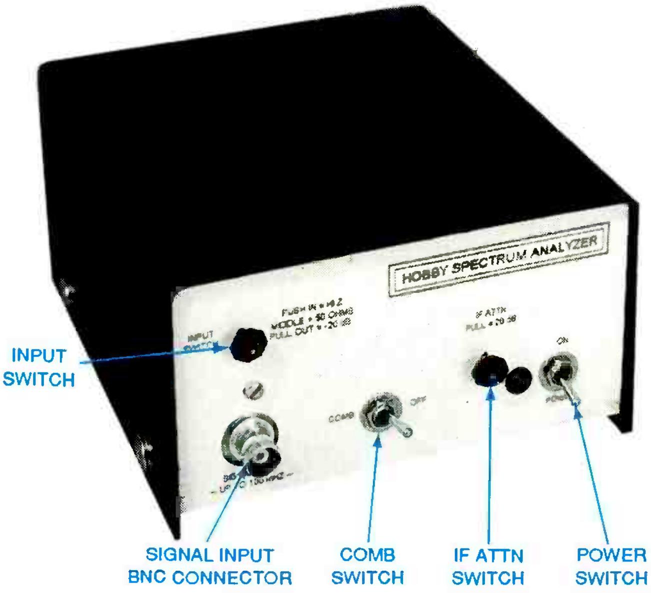
PARTS LIST FOR THE PREAMPLIFIER SUBASSEMBLY (Fig. 2)

SEMICONDUCTORS
Q1, Q2—2N3906, PNP, RF amplifier transistor

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1, R3—330-ohm
R2, R4, R7—100-ohm
R5, R6—6800-ohm
R8, R9—1000-ohm

CAPACITORS
C1—1.0-µF, 16-WVDC, tantalum
C2, C3—470-pF, ceramic disc

ADDITIONAL PARTS AND MATERIALS
L1, L2— Ferrite bead (Panasonic EXC-L351390)
PC universal prototyping board (RadioShack 276-168), wire, hardware, etc.



FRONT PANEL OF THE HSA mounts four switches and a BNC connector for the input signal. The rear panel (not shown) has four RCA phono jacks that provide three output signals and a battery test point.

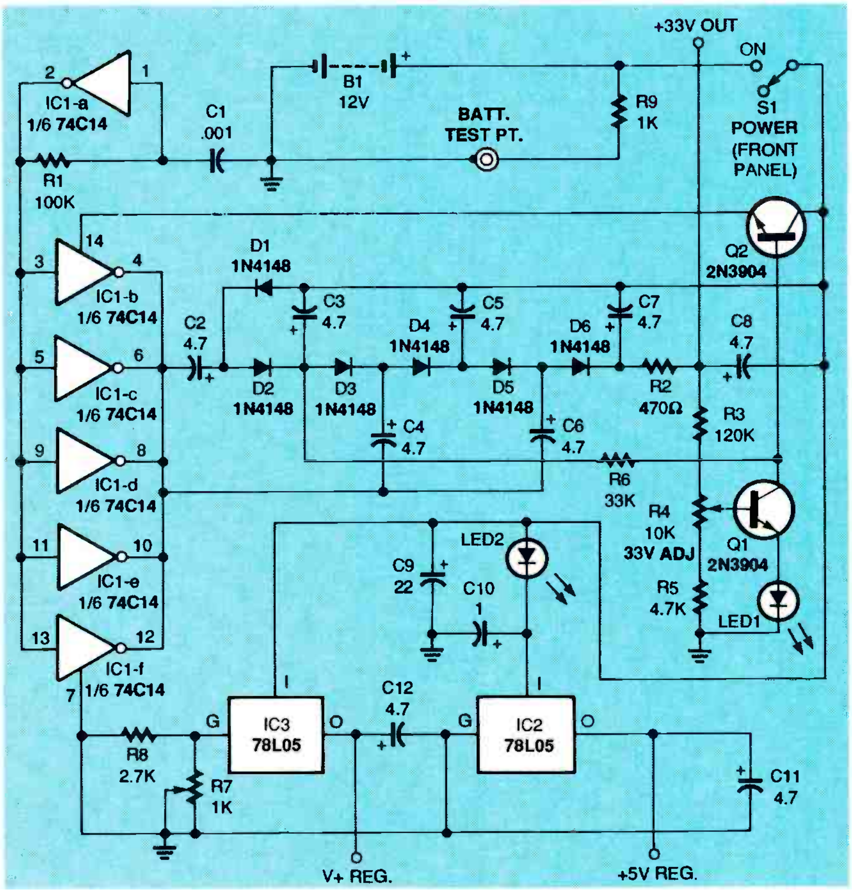


FIG. 3—SCHEMATIC DIAGRAM for the DC/DC converter and regulators module. The V+-volt DC supply is used in the RF module where the final voltage setting of R7 is made for optimum performance. The +33-volt DC output is used in the sweep circuit module to generate the output log sweep.

and capacitor voltage multiplier chain with some *tricks* added in. Integrated circuit IC1 contains six CMOS Schmitt inverters with IC1-a wired as an astable squarewave oscillator. The oscillation frequency is set by R1 and C1 to about 65 kHz. The remaining five Schmitt inverter sections are wired in parallel to form a power amplifier. This combination of Schmitt triggers delivers squarewave current to the diode-capacitor multiplier string (D1-D6 and C2-C7).

The DC/DC voltage-multiplier converter would output about 45 volts were it not for transistors Q1 and Q2. Those semiconductors and their associated circuitry form an adjustable DC-voltage regulator wherein Q1 serves as an error amplifier. Transistor Q1 compares the voltage at wiper of

PARTS LIST FOR THE DC/DC CONVERTER AND REGULATORS MODULE (Fig. 3)

SEMICONDUCTORS

D1–D6—1N4148 diode, or equiv.
LED1, LED2—Light-emitting diode, red
Q1, Q2—2N3904, NPN, RF amplifier transistor
IC1—74C14 CMOS hex Schmitt inverter, integrated circuit
IC2, IC3—78L05 +5-volt regulator, integrated circuit

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—100,000-ohm
R2—470-ohm
R3—120,000-ohm
R4—10,000-ohm, PC-mount, potentiometer
R5—4700-ohm
R6—33,000-ohm
R7–1000-ohm, PC-mount, potentiometer
R8—2700-ohm
R9—1000-ohm

CAPACITORS

C1—0.001-µF, Mylar
C2–C8—4.7-µF, 35-WVDC, aluminum electrolytic
C9—22-µF, 16-WVDC, tantalum
C10—1.0-µF, 16-WVDC, tantalum
C11, C12—4.7-µF, 10-WVDC, tantalum

ADDITIONAL PARTS AND MATERIALS

B1—+12-volt battery (see text)
S1—Single-pole, single-throw, toggle switch
PC universal prototyping board (RadioShack 276-168), 8 AA-cell holder (RadioShack 270-387, or equiv.), battery snap (RadioShack 270-324, or equiv.) phono jack, copper foil, etc.

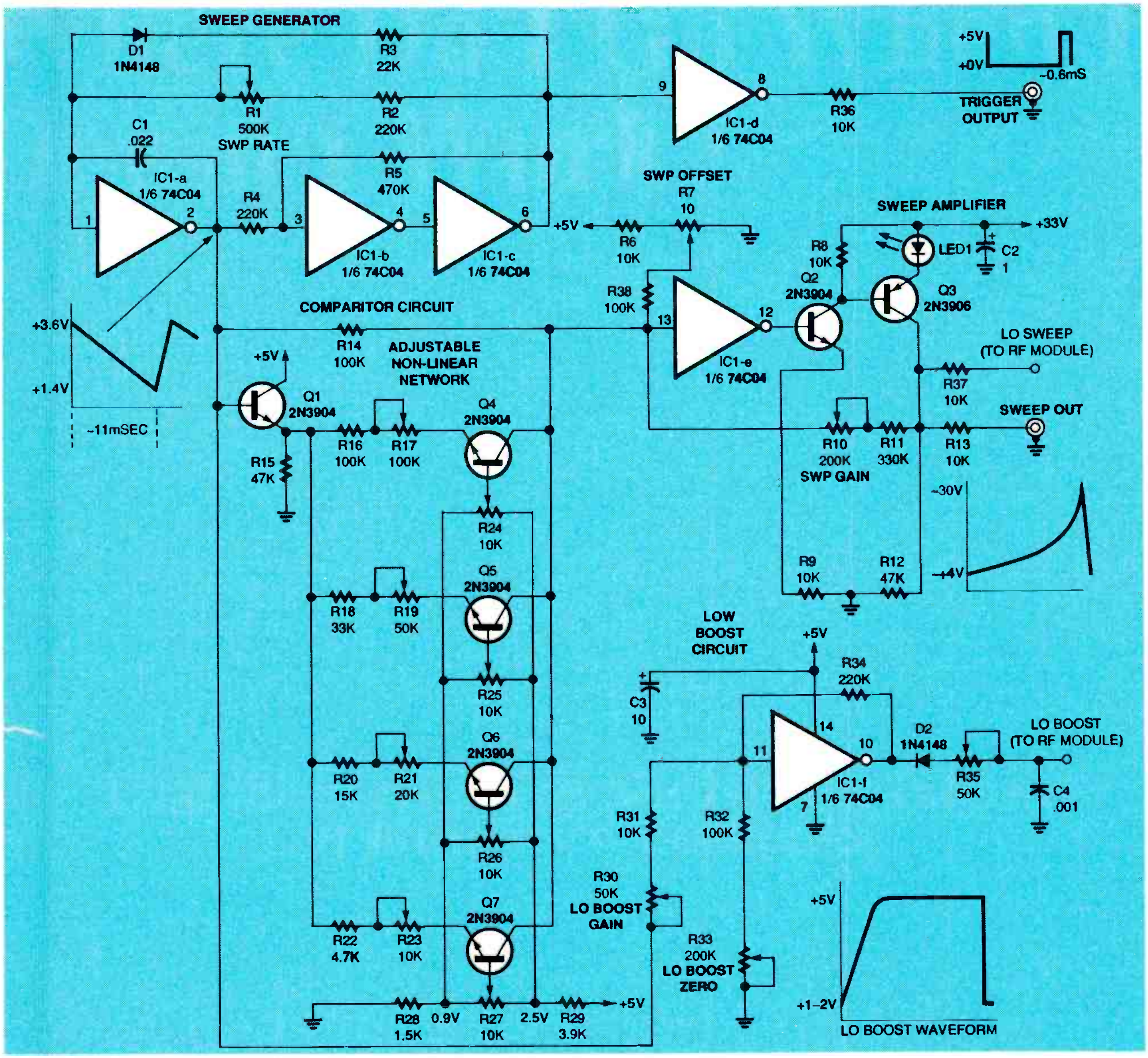


FIG. 4—SCHEMATIC DIAGRAM for the sweep-circuit module. This module provides the "curvy" sweep voltage for the first-converter local oscillator to make the frequency sweep (radio dial) linear, and also provides the oscilloscope's trigger signal.

R4 to the reference pedestal of its own base-emitter junction and LED1 in the emitter circuit (which is about 2.4-volts DC equivalent).

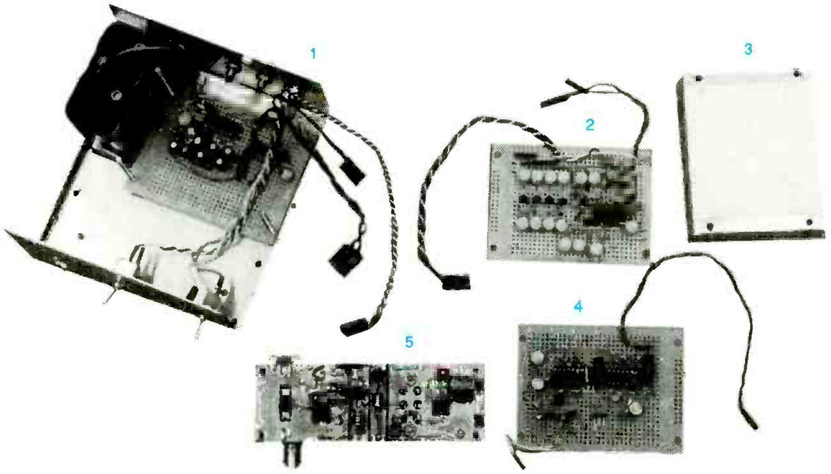
In operation, an error signal is amplified by Q1 which controls series-pass transistor Q2 (Fig. 3). Thus, a variable voltage is supplied to power IC1 as needed to control the squarewave amplitude that drives the voltage multiplier in the first place! For example, if for some reason the +33-volt level would tend to drop, Q1 would conduct less and its collector voltage would rise. This would increase the voltage powering IC1, which in turn would make the squarewave drive to the multiplier chain increase, pre-empting the precipitating voltage drop! Should the +33-volt level increase, the opposite occurs.

The nominal value of +33-volts DC is adjusted by trimmer R4 and that value holds over the useful range of the battery voltage (+13 when *fresh* to +10 volts when *dead*). Light-emitting diode LED1 will glow rather dimly, but light-emitting diode LED2, which is in the supply path to regulator IC2, glows brightly and serves as the HSA's POWER indicator.

The sweep circuit. The schematic diagram for the sweep circuit is shown in Fig. 4. A CMOS hex inverter, IC1, has four sections wired as operational amplifiers. Section IC1-a is configured as an integrator circuit. With capacitor C1 connecting from the inverter's output to input, a linear voltage ramp will appear at the output, pin 2, for a step change in the DC voltage (astable squarewave) applied to a resistor on input pin 1.

Inverters IC1-b and IC2-c are wired as a comparator circuit, which is not a linear system. The inverters here have outputs that are either high or low and *nothing* in-between. This is assured by the positive feedback connection via R4 and R5. Thus, a switched waveform at pin 6 of IC1-c will either be +5 volts or 0 volts.

To visualize operation of the com-



THE FOUR MAJOR ASSEMBLIES of the HSA are: 1–DC/DC converter and regulators, which is mounted in the case, 2–sweep circuit, 4–log amplifier, and 5–RF circuit. The aluminum shield (3) is positioned between the DC/DC converter and regulators and log amplifier assemblies when the unit is assembled.

parator circuit, assume that pin 6 of IC1-c is high (+5 volts) and assume that resistor R4 in the comparator circuit is not present (open circuit). That means that the input at pin 3 is high, and thus pins 4 and 5 are low (0 volts), thus assuring the high condition at pin 6, which is where we started. The comparator made up of sections IC1-b and IC1-c is *latched* high.

Had we started with pin 6, IC1-c low, all voltage levels described above would be reversed and the circuit would be latched low. The changeover from one latched state to the other can be forced by driving pin 3 to approach mid-voltage range, or about 2.5 volts. With R4 back in the circuit and ramp voltages from IC1-a pin 2 driving it, the 2.5-volt condition at pin 3 occurs at ramp waveform levels of about 1.3 and 3.7 volts, depending on the state of pin 8 and the associated ramp direction.

PARTS LIST FOR THE SWEEP CIRCUIT MODULE (Fig. 4)

SEMICONDUCTORS

IC1—74C04 or CD4069, CMOS hex inverter
Q1, Q2, Q4–Q7—2N3904, NPN, RF amplifier transistor
Q3—2N3906, PNP transistor
D1, D2—1N4148, fast-switching, silicon diode (or equiv.)
LED1—Light-emitting diode, red

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—500,000-ohm PC-mount trimmer potentiometer
R2, R4, R34—220,000-ohm
R3—22,000-ohm
R5—470,000-ohm
R6, R8, R9, R13, R31, R36, R37—10,000-ohm
R7, R23–R27—10,000-ohm PC-mount trimmer potentiometer
R10, R33—200,000-ohm PC-mount trimmer potentiometer
R11—330,000-ohm
R12, R15—47,000-ohm
R14, R16, R32, R38—100,000-ohm
R17-100,000-ohm PC-mount trimmer potentiometer
R18—33,000-ohm
R19, R30, R35—50,000-ohm PC-mount trimmer potentiometer
R20—15,000-ohm
R21—20,000-ohm PC-mount trimmer potentiometer
R22—4700-ohm
R28—1500-ohm
R29—3900-ohm

CAPACITORS

C1—0.022-µF, Mylar
C2—1.0-µF, 35-WVDC, tantalum
C3—10-µF, 10-WVDC, tantalum
C4—0.001-µF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

PC universal prototyping board (RadioShack 276-168); phono jacks (2 required); 5-pin 0.1-in. centers, right-angle male connector; 6-pin 0.1-in. centers, female connector; wire, solder, etc.

PARTS LIST FOR THE LOG AMPLIFIER MODULE (Fig. 5)

SEMICONDUCTORS

IC1, IC2—74C04 or CD4069, CMOS hex inverter, integrated circuit
Q1, Q2—2N3904, NPN, RF amplifier transistor

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—10,000-ohm
R2—20,000-ohm, PC-mount, potentiometer
R3—27,000-ohm
R4—68,000-ohm
R5, R8, R11, R14, R17, R20—39,000-ohm
R6, R9, R12, R15, R18, R22—150,000-ohm
R7, R10, R13, R16, R19, R23—100,000-ohm
R21, R25—5100-ohm
R24, R31—2200-ohm
R26—10,000-ohm, PC-mount, potentiometer
R27—3900-ohm
R28—5000-ohm, PC-mount, potentiometer
R29—2700-ohm
R30—1000-ohm

CAPACITORS

C1—4.7-µF, 10-WVDC, non-polarized, aluminum, electrolytic
C2—18-pF, ceramic disc
C3—2.2-µF, 10-WVDC, non-polarized, aluminum, electrolytic
C4—100-pF, ceramic disc
C5—0.01-µF, Mylar
C6—10-µF, 10-WVDC, tantalum

ADDITIONAL PARTS AND MATERIALS

PC universal prototyping board (Radio Shack 276-168), Connector, 3-pin, male, 0.1-in. centers, right angle, phono jack, wire, solder, etc.

The ramp motion is caused by pin 6 of IC1-c driving integrator inputs via R1 and R2 or D1 and R3. The ramp voltages corresponding to crossover are determined by the ratio of R5/R4. Thus, for the pin 6 high condition we began with, the integrator's pin 2 voltage is decreasing, and when it hits about 1.3 volts, the comparator pair of IC1-b and IC1-c changes state. This drives pin 6 low, and the integrator output ramps upwards. When it hits approximately 3.7 volts, the comparator pair again changes state, and the process begins over. The repetitive waveform

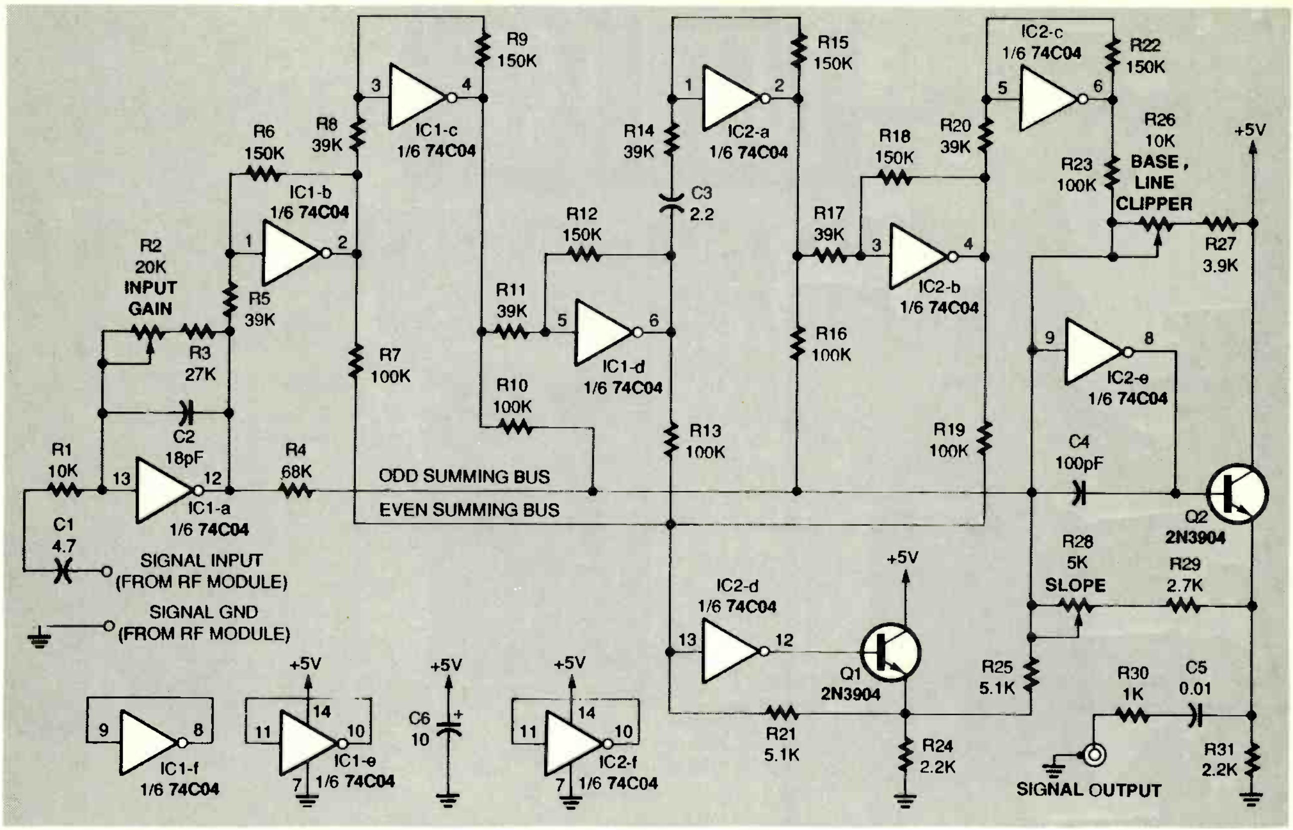


FIG. 5—SCHEMATIC DIAGRAM for the log amplifier module. The log amplifier provides the accurate non-linear transfer function needed to make the oscilloscope's graticule read out in dB instead of linear voltage.

MATERIALS LIST FOR THE HSA CASE ASSEMBLY

1—3 × 5 × 5⅞ metal cabinet (RadioShack 270-253)
4—6-32 × 2-in. machine screws
23—6-32 × ¼-in. hex nuts
4—Plastic or metal spacers (see text)
4—#6 outside star washers
4—¼-in. × 1¾-in. plastic or metal standoffs, 4-40 thread
12—4-40 × ¼-in. cap head screws
1—Sheet of 0.010 to 0.020-in. aluminum for formed shield cover (see text)
1—Sheet of copper tooling foil, 36 gauge (craft store)
1—5-in. brass (or comparable) 1/16-in dia. rod stock (hobby shop)
4—1/16-in. metal wheel collars w/set screws (hobby shop)
2—Decorative beads, 1/16-in. bore for pull knobs (craft store)
2—6-32 × ¼-in. machine screws (to mount slide switch)
2—6-32 × ⅝-in. machine screws (to mount slide switch)
2—4-40 × ⅜-in. threaded spacers
1—¼-in. × ¾ × 2¼-in. wood or foam spacer block
1—¾-in. × 2½-in. double-stick Velcro (to mount battery holder)

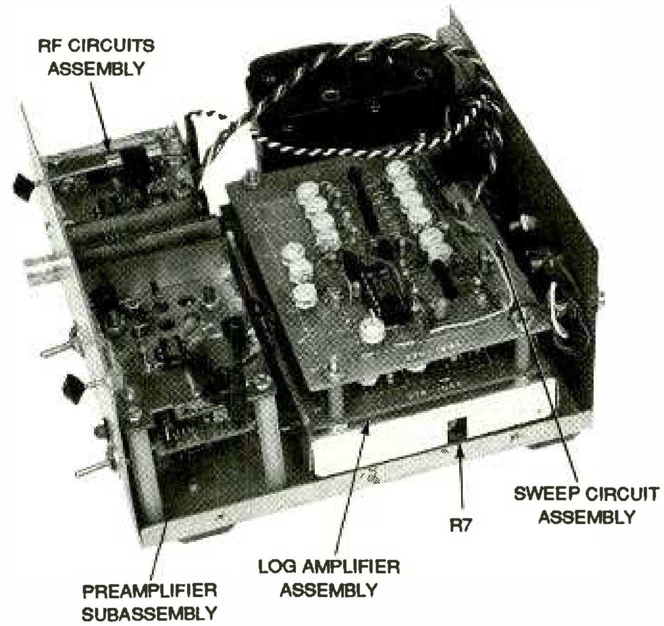
at pin 2 is depicted in Fig. 4 as an asymetrical triangular wave. It's a fast positive ramp followed by a slower negative going ramp. The latter is what's ultimately used to sweep the local oscillator's first converter.

In all the above, the waveform at pin 8 is a rectangular waveform which is buffered by inverter IC1-d. This waveform is the trigger output used to initiate oscilloscope sweep on the negative going slope of the pulse. This sweep is time coincident with the beginning of the slow negative ramp at pin 2 of IC1-a.

The triangle waveform voltage at IC1-a, pin 2 is about 2.4 volts peak-to-peak. Varactor D1 in the first converter local oscillator (Fig. 2) requires about a 28-volt swing to effect a local oscillator frequency change of about 100 MHz. Thus, the limited ramp levels at pin 2 of IC1-a (Fig. 4) must be amplified to much higher levels. Not only that, but the change in frequency of the first converter is non-linear with respect to varactor D1's bias drive, so the drive shape must be "bent" into shape. Those dual requirements are met with the sweep amplifier and adjustable nonlinear network in Fig. 4.

The sweep amplifier assembly consists of IC1-e, Q2, and Q3, which are configured as an operational inverter whose basic gain is established by the ratio of three resistors: (R10 + R11) ÷ R14. Gain is adjustable by adjusting trimmer R10. The output transistor, Q3, is powered from the +33-volt line, so it is capable of swinging the high voltage needed by varactor D1 (Fig. 2). The sweep voltage at Q3's collector and SWEEP OUT jack is shown in Fig. 4. Remember, the first converter local oscillator needs a "curvy" sweep voltage to make the frequency sweep ("radio dial") linear.

Sweep voltage shaping is obtained by "piecewise linear waveform shaping" as brought about by the circuitry of Q1, Q4 through Q7, and their related components. Given that the ultimate output voltage at Q3 collector is governed by the sweep drive to IC1-e's input, all that's needed is to vary the sweep drive dynamically in a nonlinear manner. In effect, what's needed is to equivalently "lower" the value of R14 during the driving ramp time. However, there is no resistive val-



RIGHT-SIDE VIEW OF THE HSA shows part of the preamplifier subassembly under the RF circuits assembly. The small slot cut in the shield that covers the DC/DC converter and regulators permits adjustment of potentiometer R7, which sets the V+ voltage.

ue change. Rather, transistors Q4 through Q7 sink more and more current from the IC1-e input node as a sweep progresses, simulating what appears to be lowered resistance in R14.

Transistor Q1 buffers the ramp waveform at IC1-a, pin 2, and drives the four resistive networks shown in Fig. 4. Transistors Q4 through Q7 have base biases adjusted by their individual base-voltage-divider potentiometers, R24 through R27. Emitter currents (and collector currents) in those transistors can only flow for Q1 emitter voltage levels falling lower than the emitter voltages of Q4 through Q7. The magnitude of those currents is then controlled by resistors R16 through R23. As Q1's emitter ramp voltage sweep moves in a negative going direction, and with the transistor base biases properly adjusted, transistors Q4 through Q7 sequentially come into conduction and progressively sink more current from the IC1-e input node. As that sequence takes place the sweep output voltage at Q3's emitter increases nonlinearly. The exact shape of the resulting waveform is easily adjusted (tuned) during the HSA alignment.

LO boost. Now for that elusive LO-boost function mentioned earlier. During the development of the HSA, several RF modules were built and tested. In each, the amplitude response rolled off about 5 dB from about 30 MHz to zero. The output display suffered response flatness at the lower third of the frequency sweep. This problem was fixed by time-varying the local oscillator power level in the first converter. Thus, from sweep initiation to about one-third the frequency range, the local oscillator power of the first converter is adjusted "on the fly" to yield an overall flat frequency response. The circuitry of IC1-f and associated adjustment trimmers perform that mission, and those tuneup details are discussed later.

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Electronix Express
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Avenel, NJ 07001
Tel: 800-972-2225

Hosfelt Electronics Inc.
2700 Sunset Blvd.
Steubenville, OH 43952-1158
Tel: 800-524-6464

Ocean State Electronics
PO Box 1458
6 Industrial Drive
Westerly, RI 02891
Tel: 401-596-3080

The log amplifier module. A log amplifier module output is the mathematical logarithm of the input signal. The log amplifier displays a diminishing gain as its input signal increases. A good log amplifier has an accurate "log transfer characteristic". The log amplifier function in the HSA is accomplished with 74C04 CMOS hex inverter logic circuits operating in linear/limiting fashion (See Fig. 5).

The HSA transfer function will be set to 100 mV per 10 dB during alignment. Then a 10 dB increase in input signal will cause a 100 mV output increase. So does the next 10 dB. And the next. And so on. The HSA has a nominal 60 dB log amplifier. This means that the output changes only about 0.6 volt for an input signal range of 1000:1 (60 dB).

The log amplifier module schematic diagram shown in Fig. 5 is a configuration known as a "piecewise linear synthesized log amplifier". This means that the overall 60-dB transfer is "constructed" of individual short quasi-linear transfer segments strung end to end to look like a smooth log function. While that may sound like a "bumpy-curve" technique, the resulting circuit behavior is actually very smooth. In fact, the log linearity of the HSA circuit is better than ±1 dB over the entire range.

Seven sections from two hex inverter ICs are connected as amplifiers in series. Except for the first stage (IC1-a), all stages have a fixed voltage gain of about 10 dB. This is primarily established by the 150,000-ohm and 39,000-ohm resistors around each stage. The 7-stage amplifier has over 70 dB of gain. A very small input signal causes a large output signal at the last stage (IC2-c). This last stage quickly saturates with increasing input. More input causes the next-to-the-last stage to similarly saturate. Eventually all the preceding stages saturate.

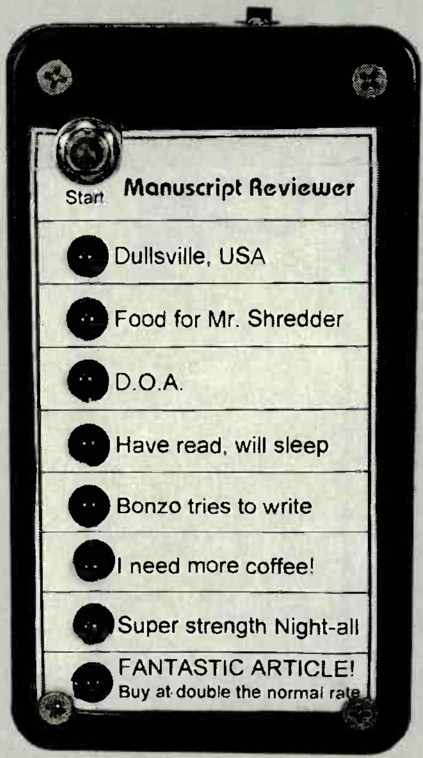
Each interim amplifier stage drives two loads. One load is the next amplifier stage. The other load is a 100,000-ohm resistor connected to a summing

(Continued on page 80)

Executive Decision Support System

Here's a great gift for anyone who makes major decisions.

JAMES EDWARDS



Let's face it—the world is getting more and more complicated every day. At the grocery store, it's aisles of breakfast cereals. For investors, there are more mutual funds than stocks to choose from. And don't even think about trying to select a computer without considering a mind-numbing range of configurations!

If you feel that this is all too much to deal with, we agree. And we want to help. *Ergo*, the Executive Decision Support System (or EDSS). Based on little known but indisputable scientific principles, the device can quickly and easily help you resolve all the troubling issues of your life. Can't decide what to eat for lunch? EDSS can help. Can't decide where to go to college? No sweat for EDSS. Can't decide whether to pop the question to your significant other? Easy. Just ask EDSS beforehand what the answer will be.

As useful as such a device can be in your own life, it also makes a great gift—one that's both inexpensive and easy to build. Not only that, but the device can be easily configured to cover a wide range of different types of decisions. So you might want to build several to have on hand, and customize them as the need arises.

For example, suppose your company is opening a branch office and your buddy John is being promoted to a management position in the new office. As you bid John farewell, you explain that in his new position he'll need to make a lot of important decisions. And, because you want the new office to do well, you certainly don't want to leave those decisions entirely in his hands! Therefore you give him an EDSS labeled as shown in Fig. 1. Now whenever John needs to make an important decision, he'll have all the help he needs.

The technology behind this wizardry is Motorola's popular 68HC705K1 microcontroller, a favorite of **Electronics Now** readers. We've purposely kept the cost low, used easy-to-find parts, and have made arrangements to supply circuit boards and preprogrammed microcontrollers. So you've got no excuse! (By the way—the scientific principle we referred to above is known as *random-number generation*.)

The project centers around a small microcontroller (a 68HC705K1), eight LEDs, a power switch, and a start switch. On the front panel of the unit, beside each LED, is a word or phrase describing a potential decision outcome. When you apply power to the circuit, the microcontroller initializes. That process involves reading the states of two jumpers, which determine operating mode. After determining mode, the microcontroller blinks out a test sequence on the eight LEDs, and sounds the buzzer to let you know the unit is operating properly. All lights are extinguished after the test sequence completes.

To begin the decision-making process, quickly press the start button. The lights then blink in a random pattern. Eventually the display settles down so that a single LED is lit; that LED represents the outcome of the decision-making process. Repeat the process as often as you like by pressing start.

To increase flexibility, EDSS has three modes of operation that are set using a pair of jumpers; those jumpers are implemented using a pair of 0.1-inch header blocks. Mode 0 provides truly random output; any of the eight LEDs may light up. Mode 1 *always* ends on LED8. Mode 2 *never* lights LED8.

The mode is determined on power-

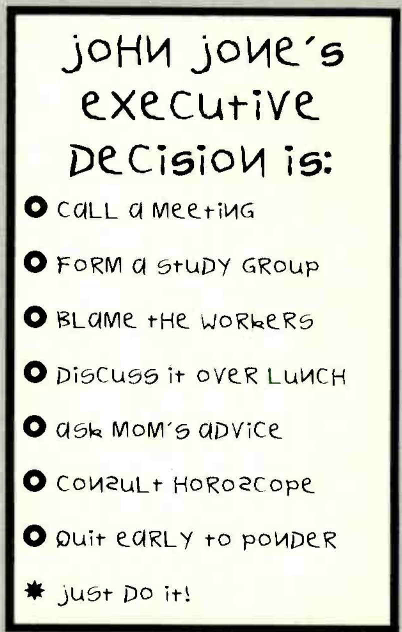


Fig. 1. The Executive Decision Support System can be easily customized by changing the front-panel label. One possible example is shown here; others can be found as part of the EDSS.ZIP file on the Gernsback BBS.

up. If you set jumpers for Mode 1, but hold the start button when turning on the power, it actually comes up in Mode 0. Now give the EDSS to someone. That person quickly figures out that the answer is always the same. Of course, you insist that it's not, cycle the power with your finger on the Start button, and prove that it's not. Then you power down, return the unit to the "victim," and let him or her try again. It's positively devious!

Note that the trick only works when you start in Mode 1. If you start in Mode 2, the LED is physically disconnected from the circuit, so the EDSS cannot revert to either of the other modes.

The circuit. As shown in Fig. 2, the EDSS consists of a single microcontroller, a Motorola 68HC705K1. The microcontroller contains 32 bytes of RAM (for variable storage), 504 bytes of ROM (for code storage), and ten digital I/O ports, all in a 16-pin package. Although compact in size, it has plenty of resources for this application.

The 68HC705K1 drives nine outputs and reads three inputs. The outputs are the eight LEDs and a low-current buzzer, which emits a short beep whenever a new LED turns on. The three inputs are start switch S1 and two mode-select jumpers.

Careful readers may note that the circuit contains two more I/O devices (12) than the microcontroller has I/O lines (10). Close examination of the circuit yields the cause of the apparent discrepancy.

Pin 4 of the microcontroller is the interrupt request (IRQ) line. IRQ is a dedicated input line that, when temporarily shorted to ground via S1, tells the microcontroller to execute a special section of code known as an *interrupt service routine*, or ISR. In our application, the ISR starts the LED blinking sequence. By using that pin, one of the "regular" I/O lines is spared for other uses.

Microcontroller port PA3 (pin 8) does double duty. In Mode 2, LED8 never lights. We set Mode 2 by connecting JU2 to ground (position B). That in turn grounds PA3, which would otherwise be high. During power-up initialization, one of the first things the firmware in the microcontroller does is examine the state of PA3. It can only be high if the LED is connected via the

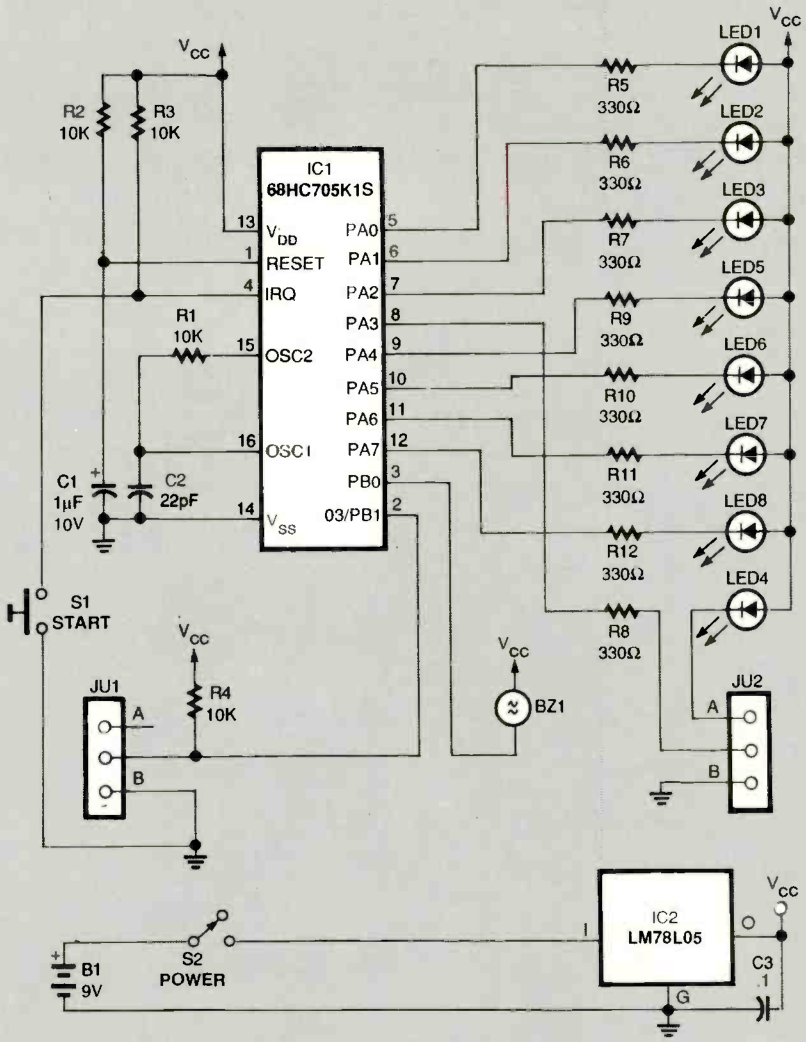


Fig. 2. The circuit centers around Motorola's popular 68HC705K1 microcontroller. Although fairly simple, it has power to spare for our application.

appropriate pins of JU2 (position A). If it is high, the EDSS enters Mode 0 or Mode 1, depending on the state of JU1 and S1, as described above. On the other hand, if the microcontroller sees a low, it puts the unit in Mode 2, and that's that. The appropriate jumper settings for each mode are summarized in Table 1.

The microcontroller has five other pins used for "housekeeping." Pins 13 and 14 supply the device with power and ground, respectively, and pin 1 is the reset line. Whenever reset goes low, the microcontroller restarts itself in

TABLE 1—JUMPER SETTINGS

Mode	JU1	JU2
Mode 0: Random Output	B	A
Mode 1: Always the last LED	A	A
Mode 2: Never the last LED	A or B	B

an organized manner. For our purposes, the only reset required is on power-up.

The lines labeled OSC1 and OSC2, in conjunction with resistor R1 and capacitor C2, generate a clock signal that sequences events inside the microcontroller. The RC clock is not as accurate as a crystal clock, but it is significantly cheaper and more than accurate enough for our application.

Circuit power is supplied by a 9-volt battery. The battery drives a standard LM78L05 voltage regulator, which provides 5-volt circuit power. Capacitor C3 filters the regulator's output.

Software. The software that controls the EDSS must be "burned" into the microcontroller. If you have the appropriate hardware, you can burn the IC yourself. The object code is stored in a file called EDSS.ZIP, which is available on the Gernsback BBS (516-293-2283). The Zip file contains an S-record file, a readme, and some sample labels and templates you can use (with Word for Windows 2 or later versions) to dress up the front panel. You can also simply purchase a pre-programmed IC, as explained in the Parts List. Even if you don't want to burn your own microcontroller, you might want to download the Zip file for the label templates.

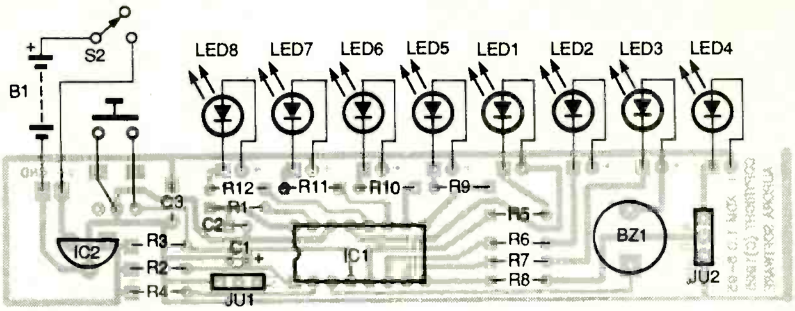
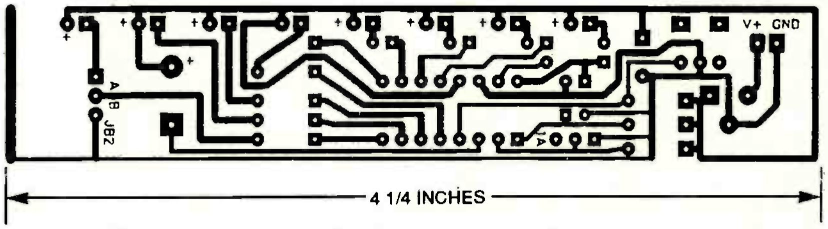


Fig. 3. Here's the component placement diagram. The LED lead length is critical, so test one LED before soldering the rest to the board.



Here's the PC board for the Executive Decision Support System. It is shown full sized.

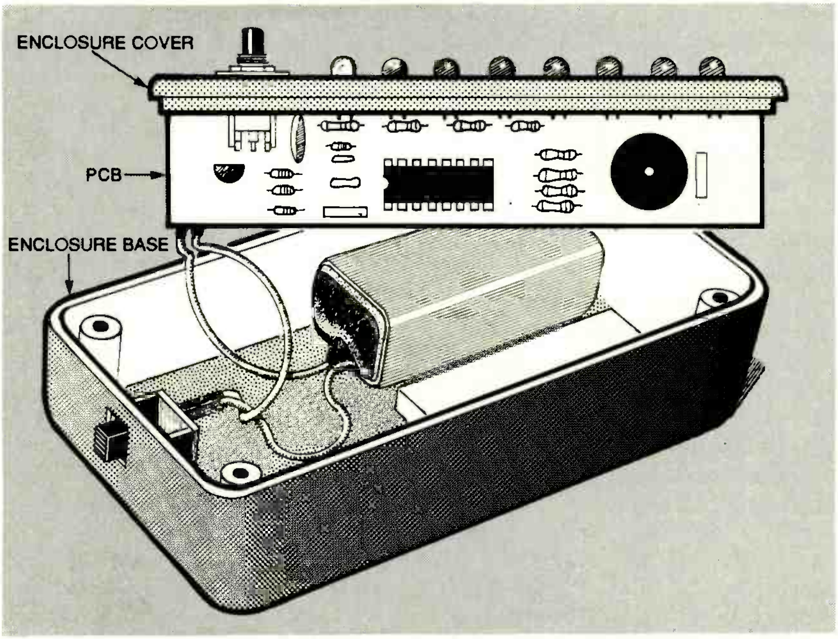


Fig. 4. The recommended case for the project has molded rails that allow the PC board to slide in to its permanent mounting spot. Use the left-most set of moldings to allow room for the 9V battery.

Construction. The main design goals of this project were that it be inexpensive as well as quick and easy to build. Thus we used very common components, most of which are available at RadioShack.

Most components mount on a single PC board, as shown in Fig. 3 (the parts-placement diagram) and Fig. 4 (the assembly diagram). The PC board is designed to slide into containment rails molded into the sides of the recommended project enclosure. This slide-in design greatly reduces assembly time because no additional mounting hardware is required.

With that mounting scheme, the board stands perpendicular to the enclosure's display face. Consequently, the LEDs must be bent at a right angle relative to the surface of the PC board. Lead length both before and after the bend is critical; if the leads are too long the enclosure cover will not fit, but if they're too short the board will not mount securely. You'll want approximately ⅛-inch be-

(Continued on page 80)

PARTS LIST FOR THE EXECUTIVE DECISION SUPPORT SYSTEM

R1–R4—10,000-ohm, ¼-watt, 5% resistor
R5–R12—330-ohm, ¼-watt, 5% resistor
C1—1.0-µF, 10-volt, tantalum capacitor
C2—22-pF, polyester capacitor
C3—0.1-µF, ceramic-disc capacitor
IC1—68HC705K1S microcontroller, integrated circuit
IC2—LM78L05, +5-volt, 100-mA regulator, integrated circuit
LED1–LED8—Light-emitting diodes, red
BZ1—9-volt piezoelectric buzzer (Radio Shack 273-074 or equivalent)
B1—9-volt transistor battery
S1—Normally-open, momentary, pushbutton switch
S2—SPST toggle or slide switch, panel mount
JU1, JU2—0.1-inch male PCB mount 3-pin connectors
Enclosure (RadioShack 270-221 or equivalent), PC board, 0.1-inch female header blocks, 16-pin DIP socket, wire, solder, etc.

Note: The following are available for purchase from: Aurora Software, PO Box 080133, Rochester, MI 48309-0133: pre-programmed 68HC05K1CP microcontroller ($12.78); 360k (5.25-inch) or 1.44M (3.5-inch) PC disk containing S-record file of the software for IC1 ($6). Please add $2 shipping and handling for all orders and (sorry) no Michigan orders can be accepted. An etched, drilled, and tinned PC board for the project is available for $4.50 from Chelco Electronics, 61 Water Street, Mayville, NY 14757. NY residents must add 7% sales tax.

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Boise, ID 83714

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Mt. Prospect, IL 60056

Maryland

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Amateur Radio Center
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Massachusetts

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The Elec. Connection
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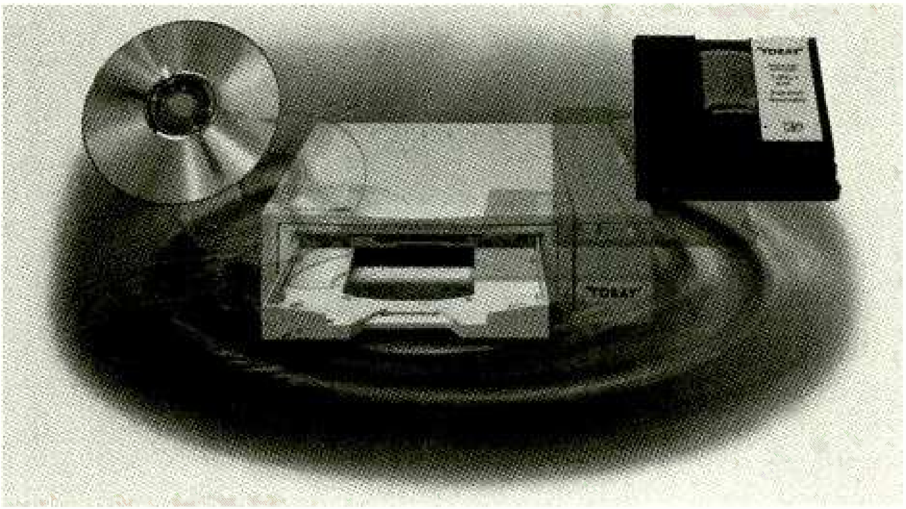
ALL ABOUT
Removable Media Drives



Whether for data backup or exchange, removable-media-drive technology is evolving to meet the needs of today's—and tomorrow's—user.

TJ BYERS

Like a good entree, each ingredient of a computer has to blend with the others if it's to work properly. If even one component is out of balance, the flavor will be off.

Now consider the following recipe: Stir together an Intel Zappa Tritron motherboard with a Pentium 133-MHz CPU, 256K cache, and 16MB EDO RAM; Matrox 1.6GB EIDE hard-disk drive; Teac 1.44MB floppy drive; Diamond Stealth 64 with 2MB RAM; 17-inch ViewSonic monitor with 0.26mm dot pitch; Sound Blaster 16 sound card; Toshiba 6X CD-ROM; Zoltrix 28.8 kbps fax/modem; Logitech Mouseman; Microsoft Windows 95 keyboard; Labtec 100W amplified speakers; and an Epson ink-jet color printer.

From all appearances, this is a gourmet system made with only the finest ingredients. That is, except for one: Check out the 1.44MB floppy drive. Is that supposed to be your backup device? If so, it's going to leave a bad taste in your mouth.

Well, you might ask, what's the alternative? The answer is that there are plenty of them. In fact, presently there are four technologies vying for the title of *de facto* removable-media standard: floppy disk, hard (rigid) disk, streaming tape, and optical storage. This article looks at the most popular removable-media products on the market today, and how they might fit your needs and your lifestyle.

Back it up! The main use for removable storage is backup. For that application it probably won't matter whether or not the particular format you choose is common in other computers. As long as you can store lots of data and reliably retrieve it, you should be happy.

The ideal candidate for this job should be reliable, inexpensive, and durable. While speedy access to the data is desirable, it's not a high priority. Above all, though, the storage system must be easy to use. No matter what else the backup system has going for it, if you have to do more than insert a blank cartridge and click an icon, chances are you won't back up as often as you should. The two competing media for the "ease-of-use championship" are recordable CD-ROMs and streaming tape.

On the road again. Another use for removable storage is data exchange. While the use of local- and wide-area networks (specifically the Internet) has largely reduced the need to exchange data using a portable media, there's still a place for it. That is particularly true of large files, generally those in excess of 5MB, that would tie up network resources for long periods of time (typically an hour or more).

The solution is to use the tried and proven "sneakernet" method of exchanging files. That method requires a transportable media, like a 1.44MB floppy, that you can easily slip in your pocket or a diskette mailer. It also requires the same hardware and software standards at both ends. Physical size, durability, and speedy data access are the desired traits here. Competing in this arena are flexible disk, hard disk, and optical disk.

Although it's not stated anywhere in the job description, the removable media should be rewritable. That is, you should be able to write over or erase the old data. Some devices, like the recordable CD-ROM, can't be erased or recycled.

Magnetic drives. Storage devices

based on magnetic-recording technology are the least expensive. With a track record that spans more than three decades, magnetic recordings have proven to be cost effective for all types of data storage, including long-term archival. Basically, you have three choices in this area: floppy media, like the 3.5-inch, 1.44MB floppy; the removable hard disk, which is popularly called the Winchester drive; and streaming tape, most notably the QIC-80 cartridge variety.

Flexible flyer. The market leader, by a good margin, of new floppy technologies is Iomega's Zip drive (see Fig. 1). Each Zip diskette holds 100MB of data (200MB if you use compression software). Taking a cue from the successful 1.44MB floppy, Iomega designed the Zip diskette to be a rugged, small cartridge that easily slips into your shirt pocket or a diskette mailer. In fact, the Zip cartridge is exactly the same size as a 1.44M floppy, but a little bit fatter, and slides in and out of the Zip drive exactly like a 1.44M diskette. And there's a combo Zip with a built-in 1.44MB drive that fits into a standard 5.25-inch bay.

Zip is a hybrid between the 1.44MB floppy and the hard disk. Like the 1.44MB diskette, the rotating media is flexible, not solid. To condition the platter to the properties needed for hard-disk recording, the drive spins the disk at a dizzying 2945 rpm. (That is slightly slower than the 3600 rpm of a real hard disk, and eight times faster than the floppy.) At that speed, centrifugal force stretches the flexible plastic as tight as a drum skin, making it rigid and dimensionally stable.

Now that we have a solid platform to work on, all we have to do is lay down the tracks (see Fig. 2). Because the Zip disk has to hold 70 times more data than its floppy counterpart, the tracks are narrower and closer together. Consequently, the low-level formatting is done at the factory using a precision servo positioner.

The no-frills construction of Zip should allow for drastic price cuts as the production lines crank up to full speed, perhaps leveling off at $100 from its present street price of $200. That, plus the fact that the drive and cartridge are so similar to existing 1.44MB technology, makes Zip a logical replacement for the floppy.

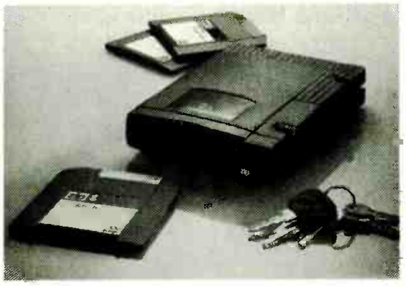


Fig. 1. Iomega's Zip floppy-based drive is today's market leader. This 1.44MB look-alike provides 100MB at low cost, and is the most likely replacement for the venerable floppy.

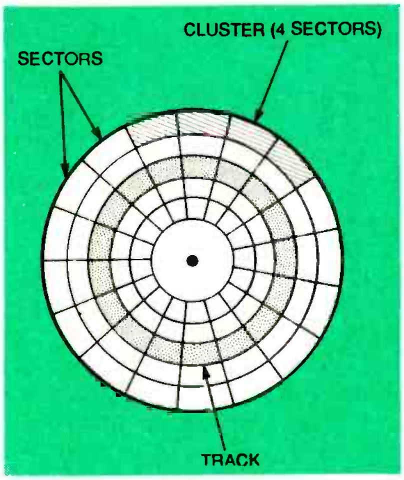


Fig. 2. Zip can hold 70 times more data than its floppy counterpart, which makes the tracks narrower and closer together. As a result, you can't do low-level formatting; that's done at the factory using a precision servo positioner.

Although 100MB isn't big enough to back up your gigabyte hard disk, it's just the right size for many projects. In fact, 100MB is large enough to hold both the application software and data files in many cases, which lets you quickly switch from one project to another by simply swapping diskettes.

The hard choices. Hot on the heels of Zip is SyQuest's EZ135 removable hard-disk drive (see Fig. 3). It, too, is built along the lines of the 1.44MB-floppy form factor and sells for $200. Unlike Zip, though, EZ135 is a true Winchester-drive design. As such, it offers hard-disk-like performance. For example, the EZ135's average access time is 13.5 ms, compared to 29 ms for Zip and 10 msec for an Enhanced IDE (EIDE) hard disk.

In fact, the only difference between your internal hard disk and the EZ135 is that the platters in your hard disk are permanently sealed inside the drive's case, whereas the EZ135's platters are contained in a removable cartridge. Access to the platters are through a trap door that works in much the same way as the protective cover of a VHS videotape cartridge works. When you insert the EZ135 cartridge into the drive, the door flips open and the read/write heads slide through the opening and into place, ready for work. Altogether there are eleven platters stacked inside the cartridge

TABLE 1—TECHNOLOGIES AT A GLANCE

Technology	Capacity	Initial Investment	Drive Cost ($ per megabyte)	Media Cost ($ per megabyte)
Flexible				
3.5" floppy	1.44 MB	$40	27.78	0.34
Zip	100 MB	$200	2.00	0.20
Hard disk				
EIDE	1,000 MB	$250	0.25	0.25
SQ327	270 MB	$400	1.48	0.22
EZ135	135 MB	$200	1.48	0.15
Jaz	1,000 MB	$600	0.60	0.10
Tape				
QIC-80	250 MB	$150	0.60	0.07
Travan TR-1	800 MB	$200	0.25	0.03
Travan TR-2	1,600 MB	$400	0.25	0.03
Travan TR-3	3,200 MB	$450	0.14	0.01
Optical disk				
Magneto-optical	230 MB	$600	2.60	0.17
MiniDisk DATA	140 MB	$400	2.86	0.21
HyperStorage	650 MB	tba	tba	tba
Phase Change Dual	2,300 MB	$599	0.26	0.07

TABLE 2—TRAVAN MINICARTRIDGE SPECIFICATIONS

	TR-1 Minicartridge	TR-2 Minicartridge	TR-3 Minicartridge	TR-4 Minicartridge
Capacity				
Uncompressed	400MB	800MB	1.6G	4G
Compressed	800MB	1.6G	3.2G	8G
Data Transfer Rate				
Minimum	62.5K/s	62.5K/s	125K/s	567K/s
Maximum	62.5K/s	125K/s	250K/s	567K/s
Tape				
Length	750 ft.	750 ft.	750 ft.	750 ft.
Width	.315 in.	.315 in.	.315 in.	.315 in.
Coercivity	550 Oe	900 Oe	900 Oe	900 Oe
Recording				
Number of tracks	36	50	50	72
Data density	14,700 ftpi	22,125 ftpi	44,250 ftpi	50,800 ftpi
Drive Interface	floppy	floppy	floppy	SCSI/EIDE
Backward compatibility	QIC-80 (read/write) QIC-40 (read only)	QIC-3010 (read/write) QIC-80 (read only)	QIC-3020 (read/write) QIC-3010 (read only)	QIC-3080/3095 (read/write) QIC-3020 (read only)

Fig. 3. With an average access time of just 13.5 seconds, Syquest's EZ135 demonstrates the very fast speeds typical of removable hard disk media.

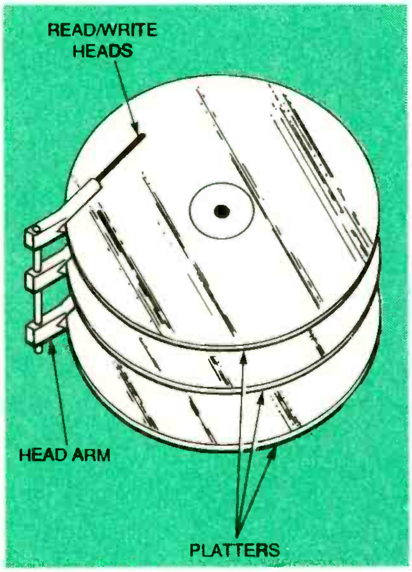


Fig. 4. Most removable hard-disk cartridges have several platters attached to a common spindle. The read/write heads often read only one side of the platter, instead of both top and bottom as is done in sealed hard disks.

(see Fig. 4), compared to the single platter of the Zip, which explains why the EZ135 cartridge is thicker than the Zip cartridge. A motor spins the disks at a whirling 3600 rpm, which is fast enough to generate a positive air pressure inside the cartridge that prevents smoke and dust particles from entering through the open door. Removing the cartridge disengages the motor, retracts the heads, then closes and seals the door to protect the disks from contamination.

Unfortunately, the EZ135 cartridge suffers from the same affliction as the Zip cartridge: Its 135MB capacity is too small for serious backup. It takes way too many cartridges to backup a 1.6GB drive. The cartridge is also bigger and more expensive to manufacturer than the Zip diskette.

Another choice in this area is Jaz from Iomega. Like the EZ135, Jaz is based on removable hard-disk technology, and the two drives have a lot in common. For example, both have multiple platters and the typical sliding dust-cover door.

But there are important differences, too. For one, the Jaz cartridge has a 1GB capacity, which is much better suited to backing up today's larger drives. Also, the cartridge is physically larger than the EZ135's, but that's to be expected given the bigger capacity. Jaz also has a unique disk-capture system that secures the disk platters when not installed in the drive; that system reduces the possibility of losing valuable data during transportation and storage. It has a motorized, cartridge-ejection mechanism, and a data-transfer rate of 10MB/sec in the burst mode.

While Jaz will cost you the most bucks up front, its per-byte cost is among the cheapest. Jaz comes in two configurations: an internal drive that fits in a 3.5-inch bay ($499), and an external parallel-port version ($629). A 1GB cartridge is included; extra cartridges come in 540MB and 1GB capacities, and sell for $69 and $99, respectively. Both drives need a SCSI interface, but there's talk of an EIDE version which should bring the price down below $400.

Streaming along. One of the major drawbacks of the systems we've discussed so far is that none is capable of backing up your new 1.6G hard disk in one pass. In every case you need a bevy of cartridges—and deep pockets—to even come close. For example, it takes 16 Zip cartridges ($320), a dozen EZ135 cartridges ($240), or two Jaz cartridges ($198). And you don't even want to know how many floppy diskettes it'll take or how much they cost. (Hint: 1111 disks at $0.50 each = $555).

Instead, for one-pass backups, the reel-to-reel minicartridge reigns supreme. Data minicartridges come in a wide variety of capacities, ranging in size from 80MB to 4GB. For years, savvy users turned to QIC-80 tape drives, which have a capacity of 250MB, as the affordable answer to

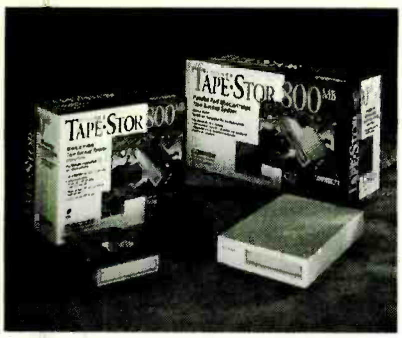


Fig. 5. Using Travan technology, Segate's (formerly Conner) Tape-Stor 800 tape drive can boost the compressed capacity from the 250MB level of the QIC-80 minicartridge to 800MB.

How To Shop For A Removable Media Drive

There are several factors to consider when buying a removable media drive, not the least of which is speed. Even if you only use the drive for archival backup, you don't want to be kept waiting while the drive endlessly grinds away. If it takes too long to backup your work, you're less likely to do it. Here are the parameters you should consider when comparing the speed of one drive to another.

Average Access Time is the most commonly-used measure of a drive's speed. That is the average time it takes to find and read the selected data on the media. Generally, the smaller the number, the faster the drive.

Data Transfer Rate is another popular measure of drive speed that tells you how fast data moves from the drive to your PC's memory. Those numbers typically range from 500KB/sec to 5MB/sec. A related measurement, the **Burst Transfer Rate**, measures the transfer rate for a small block of data in a single burst. Those figures typically range from 4MB to 10MB per second. In theory, larger numbers should mean faster throughput. However, that isn't always the case, especially when comparing rotating-drive media.

Rotational Speed is a better measure of data throughput when considering a rotating disk drive, like Zip, EZ135, and MO drives. That measurement is important because part of the data-transfer latency is caused by the head-positioning mechanism that locates the head over the track containing the requested data. Just placing the read/write head on the right track doesn't guarantee instant data access. It still has to wait for the sector that contains the data to pass under the head. The faster the platter rotates, the more often that sector passes under the head, thus reducing wait time.

Cache Size often plays a large role in determining how fast data can be retrieved from a drive. In many cases, the requested data has already been asked for one or more times. So it's really a waste of time and effort to locate the data and read it again when the data can be stored in a cache for quicker access. In fact, that is generally the case with disk drives. The on-board cache usually ranges in size from 64KB to 256KB. Generally, the larger the cache, the more likely the data you're looking for is in the cache, and the faster it can be retrieved. Ω

archival data storage. Over the years, the QIC-80 standard expanded to its present day format—the Travan drive. Developed in the laboratories of 3M (the inventors of data-cartridge technology), the Travan platform allows minicartridge technology to keep pace with rapidly increasing hard-disk capacities, while providing backward compatibility with previous QIC formats.

The amount of data storage available depends on the length and width of the tape. For example, the DC2120 QIC-80 minicartridge contains 307 feet of quarter-inch tape for 250MB of storage space, while the QIC-3010 minicartridge has 400 feet of quarter-inch tape with a 750MB capacity. The larger TR-1 Travan cartridge holds 750 feet of ⅜-inch tape, which can store up to 800MB.

The compressed capacity of the Travan minicartridge is really an estimate rather than a specification that's based on a 2:1 compression ratio. The actual compressed capacity depends on the type of the data file. Files that compress a lot will yield a greater capacity, while those that compress little or not at all result in storage capacities that are closer to the native (uncompressed) capacity of the tape. For example, a TR-1 Travan minicartridge filled with GIF graphics images can hold only 400MB worth of data because the GIF files are already in compressed format. By comparison, the same TR-1 minicartridge can hold 950MB of ASCII text files, which are highly compressible.

To make the Travan drive compati-

TABLE 3—ROTATING MEDIA BACKUP DRIVES

	APS 230 MO	Fujitsu M2512A	Iomega Jaz	Iomega Zip	Olympus MOS 320E	Panasonic PO/CO-ROM
Capacity (MB)	128MB/230MB	128MB/230MB	540MB/1GB	100MB	230MB	650MB
Technology	Optical Disk	Optical Disk	Hard Disk	Floppy Disk	Optical Disk	Optical Disk
Recording method	MO	MO	DOS	DOS	MO	PD
Price	$449	$599	$599	$199	$699	$599
Cartridge						
Disk size	3.5"	3.5"	5.25"	3.5"	3.5"	5.25"
Price	$40	$40	$69/$99	$20	$40	$50
Interface	SCSI	SCSI	SCSI	EPP/SCSI	SCSI	SCSI
Average access time	27 msec	35 msec	12 msec	29 msec	35 msec	180 msec
Sustained transfer rate						
Maximum	1.3M/s	5M/s	5M/s	1.4M/s	5M/s	1M/s
Minimum	500K/s	3.3M/s	3.3M/s	800K/s	3.3M/s	500K/s
Burst transfer rate	4M/s	10M/s	10M/s	5M/s	10M/s	n/a
Rotational speed	4500	3600	5400	2945	4200	2026
Buffer size	256K	237K	256K	32K	1MB	256K
Start time	n/a	n/a	10 sec	3 sec	n/a	6 sec
Stop time	n/a	n/a	5 sec	3 sec	n/a	3 sec

TABLE 3 (cont)

	Pinnacle Apex 4.6GB	Pinnacle Tahoe 230	Sharp MD	Sony MDH-10	Syquest EZ135	Toray Phasewriter
Capacity (MB)	4.6GB	128MB/230MB	140MB	140MB	135MB	650MB
Technology	Optical Disk	Optical Disk	Optical Disk	Optical Disk	Hard Disk	Optical Disk
Recording method	LIMM	MO	MiniDisk	MiniDisk	DOS	PD
Price	$1695	$699	$200	$470	$199	$599
Cartridge						
Disk size	5.25"	3.5"	2.5"	2.5"	3.5"	5.25"
Price	$199	$25/$35	$6.50	$29	$20	$50
Interface	SCSI	EPP/SCSI	AT floppy	SCSI	IDE/SCSI	SCSI
Average access time	17 msec	28 msec	500 msec	300 msec	13.5 msec	165 msec
Sustained transfer rate						
Maximum	6M/s	1.47M/s	n/a	150K/s	2.4M/s / 5M/s	512K/s
Minimum	2.5M/s	490K/s	n/a	150K/s	1.4M/s / 2M/s	1.14M/s
Burst transfer rate	10M/s	5M/s	n/a	2.5M/s	4M/s / 10M/s	n/a
Rotational speed	3755	3600	n/a	990	3600	n/a
Buffer size	1M	256K	n/a	320K	64K	256K
Start time	n/a	5 sec	n/a	n/a	8 sec	n/a
Stop time	n/a	3.5 sec	n/a	n/a	10 sec	n/a

ble with quarter-inch data cartridges, the drive has a notch at the top two corners that allows it to distinguish between the smaller QIC-80 minicartridge and the larger Travan cartridge. To date, only the TR-1 minicartridge has been widely used, but greater capacities are evolving even as we speak. 3M expects the Travan minicartridge to have capacities that exceed 15GB by 1997.

Among the vendors participating in the Travan program are 3M, Aiwa, Colorado Memory Systems, Seagate (formerly Conner Peripherals), and Iomega (see Fig. 5). In addition, Rexon, Sony, and Pertec Memories have announced plans to develop products incorporating Travan technology.

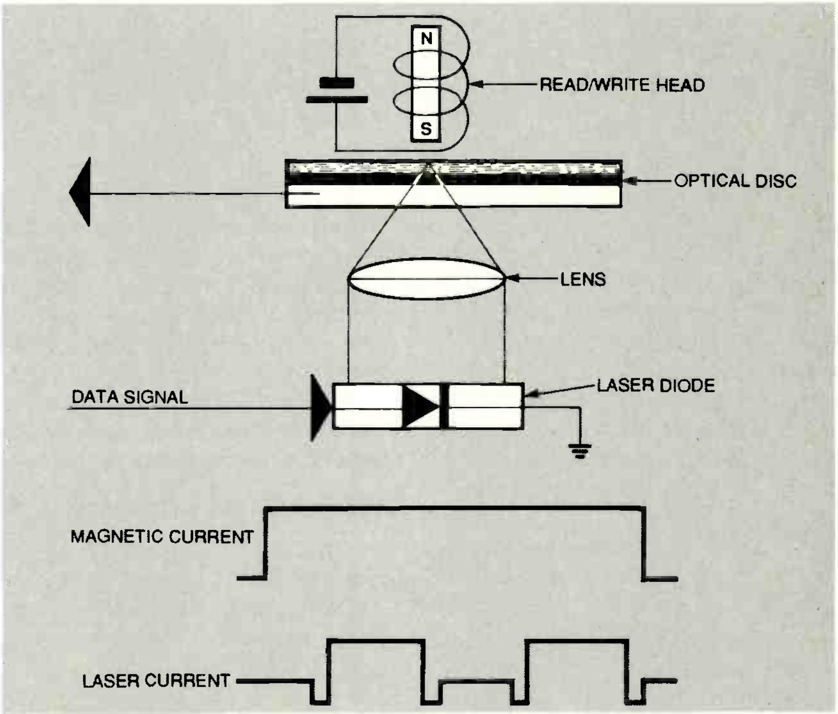


Fig. 6. The standard recording format for 640MB magneto-optical disks is optical modulation, where data is stored on the disk by applying a constant external magnetic field while using a pulsed laser to write the bits.

Optical storage. While floppy-disk, hard-disk, and tape-stream technologies are all widely used and well established, a fourth technology—optical—holds the greatest long-term solution for low-cost, high-capacity, removable-media data storage. An optical recording is small, lightweight, robust, and durable. Because it's a non-contact medium, the disk isn't susceptible to wear or head crashes, as is common with floppy- and hard-disk drives. Moreover, optical disks are immune to erasure from stray magnetic fields.

Magneto-optical drives. Magneto-optical technology, abbreviated MO, combines the ease of use and transportability of a floppy disk with the capacity and speed of a hard disk. Magneto-optical disks come in two sizes, 3.5 inches and 5.25 inches, and four capacities: 128MB and 230MB for the 3.5-inch format, and 650MB and 1.3GB for the 5.25-inch format.

As the name implies, magneto-optical drives perform their magic using both magnetic and optical technology. An MO drive writes to the disk using a read/write head assisted by a laser. The laser heats up the disk surface to its Curie point—the temperature at which the magnetic alignment of the recording media is unfrozen. You can now realign the magnetic particles on the disk surface using the magnetic field of the read/write head. Presently, there are three different methods used to record data on the magneto-optical disk: optical

TABLE 4—TRAVAN TAPE DRIVE BACKUP

	Segate Tape-Stor 800	Segate Tape-Stor 3200	Exabyte Eagle TR-3	Iomega Ditto Easy 800	Iomega Ditto 3200	HP Colorado T-1000
Price						
Internal	$170	n/a	$279	$150	$325	n/a
External	n/a	n/a	n/a	$300	$425	$224
Media type	TR-1	TR-3	TR-3	TR-1	TR-3	TR-1
Capacity						
Native	400MB	1.6G	2.2G	400MB	1.6G	400MB
Compressed	800MB	3.2G	4.4G	800MB	3.2G	800MB
Interface	floppy/EPP	floppy/EPP	floppy	floppy/EPP	floppy/EPP	EPP
Data transfer rate	500K/s / 1M/s	1M/s / 2M/s	5M/s	500k/s / 1M/s	1M/s / 2M/s	500K/s / 1M/s
Effective backup rate	9.5M/min.	19M/min.	20M/min.	9.5M/min.	19M/min.	9.5M/min.
Recording tracks	36	50	50	36	50	36
Recording density	14,7000 bpi	44,250 bpi	44,250 bpi	14,700 bpi	44,250 bpi	14,700 bpi
Recording method	MFM	MFM	MFM	MFM	MFM	MFM
Read/write tape speed	34 ips/68 ips	45.3 ips	45.3 ips	34 ips/68 ips	45.3 ips	34 ips/68 ips

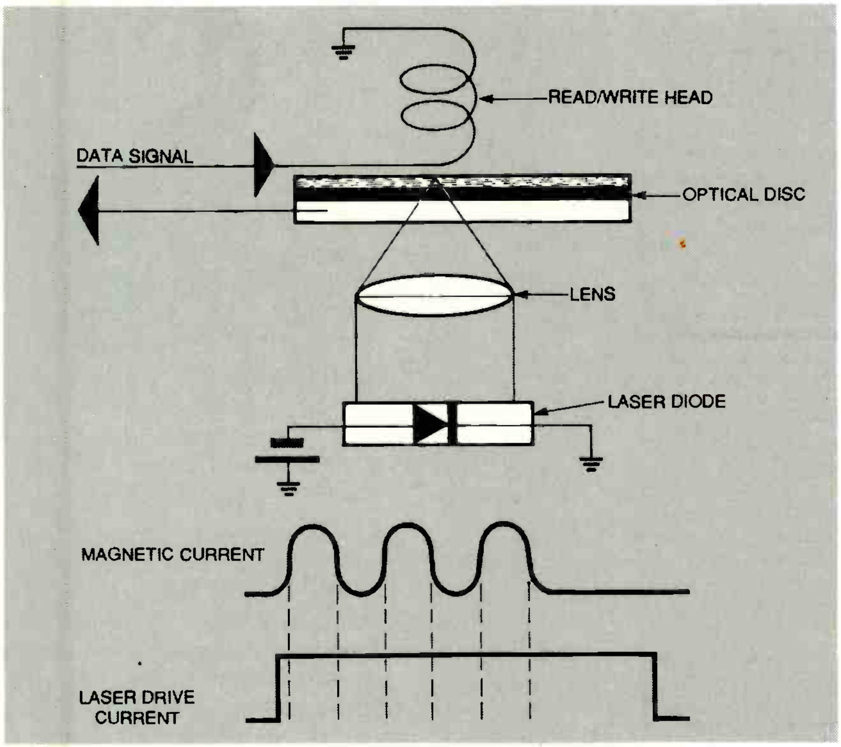


Fig. 7. Magnetically-modulated optical drives, like Sony's MiniDisk Data, store data by shining a DC-powered laser on the disk and modulating the magnetic field.

modulation, magnetic-field modulation, and laser-strobed magnetic-field modulation.

The standard for the 230MB and 650MB MO disks is optical modulation, where an external magnetic field is held constant while a pulse-modulated laser beam writes the data on the disk (see Fig. 6). It takes two rotations of the disk to write a bit. In the first rotation, all the bits are set to the same orientation, effectively erasing the data; in the second pass, select bits are reoriented to the opposite pole to establish the 0 and 1 data-bit pattern.

MiniDisk format. In the magnetic-field modulation method, the laser current is held constant and the magnetic field is modulated (see Fig. 7) using the read/write head. That is the method used by Sony for its MiniDisk (MD) Data format. Sony has sold more than a million audio players using that 2.5-inch technology, and plans to extend the technology to other consumer products, like cameras.

While the technology is well suited for PC data storage, especially in notebook and palmtop computers where its small size and low power requirements are a real plus, Sony hasn't aggressively pursued that market. As a result, production volumes of Sony's MD optical drive are quite low and the cost is a hefty $470—way too expensive for a drive of just 140MB with a very slow 500-ms average access time.

Sharp and National Semiconductor have jointly taken a different tack on the MD technology. Using an interface chip created by National Semiconductor, Sharp links its MD DATA drive to the PC through the floppy-drive port built into all PCs. That approach saves money on two fronts. First, it makes use

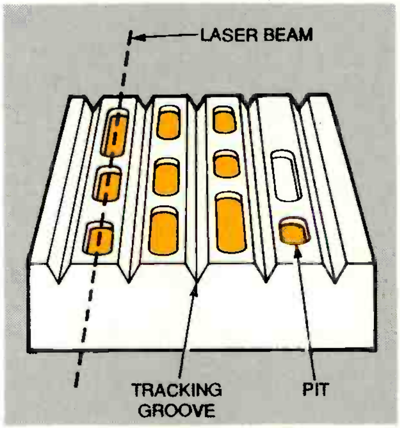


Fig. 8. When writing to an optical disk, pits are etched into the surface to represent data. The areas surrounding the pits are called lands. The closer together the pits are, the more data the disk can store.

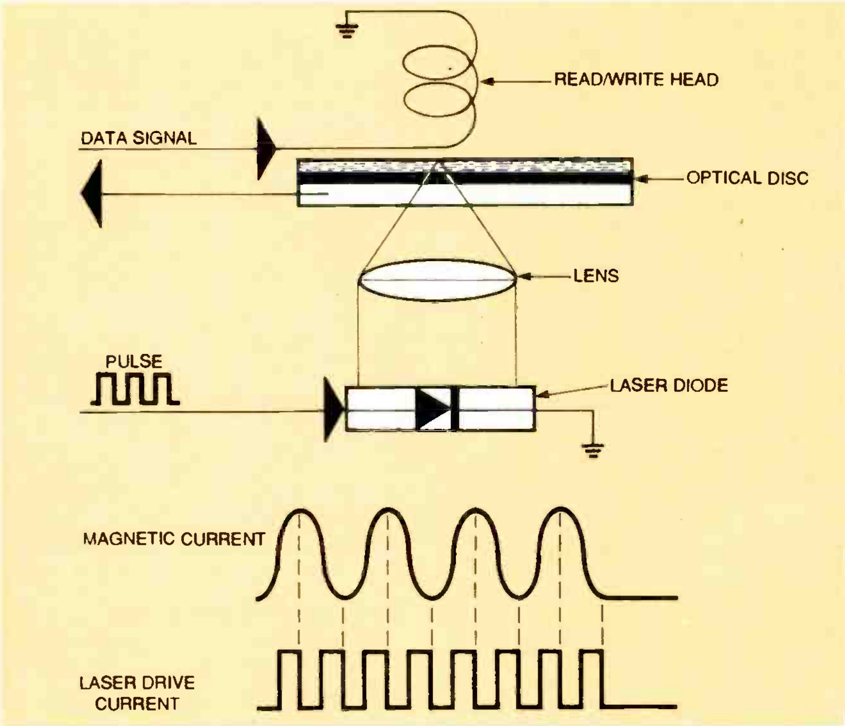


Fig. 9. Laser-strobe magnetic field modulation, like that used in HyperStorage drives, provides increased storage capacity by synchronizing the magnetic field's modulation with the laser pulse. That produces a sharper pit edge that doesn't depend on the magnetic field's reversal speed, a problem that limits the capacity of magnetically-modulated drives.

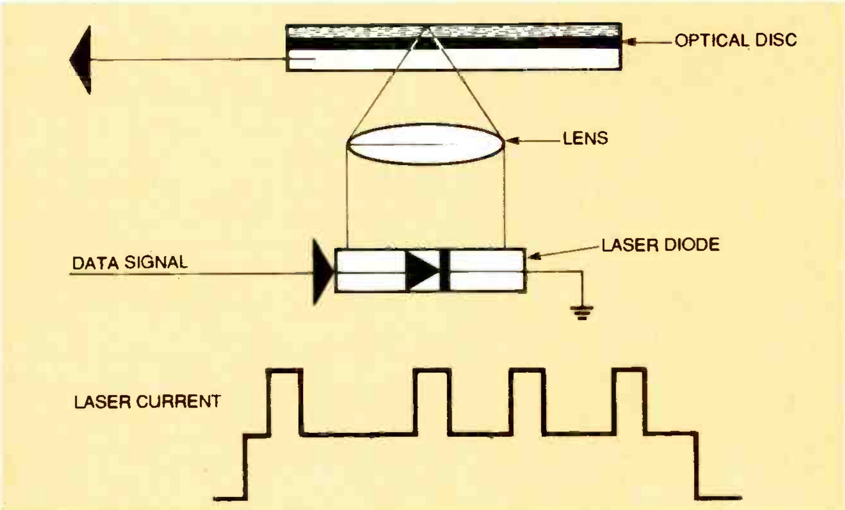


Fig. 10. Phase Change Dual (PD) drives use the Light Intensity Modulation Method (LIMM), which eliminates the need for a magnetic field. Instead, a laser beam changes the active recording layer back and forth between a crystalline and amorphous state.

Ditto Easy 800 Has 1-Step Backup

While everyone knows how important it is to back up your hard drive, it's easy to put it off when it takes more than a few seconds to set the gears in motion. Iomega's Ditto Easy 800 drive takes a lot of the pain out of doing backups with its "1-Step" software. Simply click on the Ditto Easy's icon and that's it. You can also have Ditto Easy do the backup for you using its "no-brainer" day and time scheduler.

The Ditto Easy 800 is but one in a family of Travan drives from Iomega. It has a street price of $150, and uses the TR-1 minicartridge. Other Ditto products include the Easy 450 ($99) and the Easy 3.2GB ($300). Ω

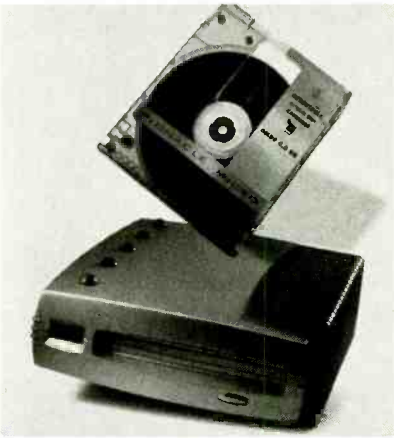


Fig. 11. Pinnacle's Apex 4.6GB Optical Hard Drive uses enhanced PD technology to boost the storage capacity to 4.6GB per disk. The drive is backward compatible with 2.3GB MO disks.

of the floppy-drive-interface electronics already in place. Second, the use of National's interface chip renders what few drive electronics are left into a single package, which results in lower production costs. The result is an MD drive that sells for $200 in OEM quantities. To further reduce the cost, rather than create a specialized data cartridge, Sharp uses standard, blank audio MDs for storage. That is a smart move, because a blank MD audio cartridge, which works equally well in data drives, sells for as little as $6.50. By comparison, Sony MD Data cartridges sell for $29.

HyperStorage. In the last couple of years, there's been a growing presence of powerful digital signal-processing (DSP) chips in multimedia computers. That trend has allowed multimedia programmers to create bigger and better multimedia applications—applications that bring together the elements of visual, textual, and audio data. As multimedia applications grew in size, so did the need for a new type of storage medium that's inexpensive, compact, fast, and has enough capacity to handle this new breed of software. In August 1994, Sony, Hitachi and 3M announced the release of the HyperStorage (HS) optical drive, a new 3.5-inch magneto-optical drive that intends to fill the needs of that new discipline.

HyperStorage is based on the principle of laser-strobe magnetic-field modulation, where both the magnetic field and laser beam are modulated. In conventional magnetic-field modulation, the formation of edges between pits depends upon the speed with which the field can change polarity (see Fig. 8). Because the field is fairly intense, switching times are relatively slow, which leads to jitters that limit the density of the data on the disk. Laser-strobe magnetic field modulation (see Fig. 9) eliminates that problem by synchronizing the magnetic field's modulation with the laser pulse. The pit edge no longer depends on the magnetic field's reversal speed, but rather on the laser beam's timing, which reduces the likelihood of jitters and, in turn, opens up more area for data.

In current MO-disk technology, a sector must be erased before data can be written to it. That normally takes two spins of the platter, which takes extra time and limits the disk's usefulness as a back-up or file-transfer medium. Laser-strobed magnetic-field modulation, on the other hand, doesn't have that limitation. It can directly overwrite old data, resulting in faster write operations—about the same speed as read operations. In tests done by Sony where MPEG2 moving-picture data was written to a HS drive over a SCSI-2 interface, the HS drive was able to maintain a sustained data rate of better than 4 MB/sec—good enough for real-time recording.

In addition, the HS disk can be partitioned into two areas: a read-only boot sector, and a read/write data sector. That makes it possible for a HS drive to serve as the primary storage medium for a personal computer. Booting up the system or launching an application from the HS drive feels no different than it would from a hard drive.

Although HyperStorage technology has been around for a while, it's taken a long time to reach the market. The wait might soon be over, however; as of this writing, Sony is predicting delivery sometime this fall. The first drives will be targeted at high-end multimedia applications where complex graphics must run in real time, like fast-action games and virtual-reality applications. As the technology matures, look for prices to drop to the level where they will be affordable in the more traditional desktop setting.

NAMES AND ADRESSES

Exabyte Corporation
Eagle Division
4665 Nautilus Court South
Boulder, CO 80301

Fujitsu Computer Products of America Inc.
3055 Orchard Dr.
San Jose, CA 95134-2022
http://www.fujitsu.com/FCPA/

Iomega Corp.
1821 W. Iomega Way
Roy, UT 84067
http://www.iomega.com/

Olympus Image Systems Inc.
2 Corporate Drive
Melville, NY 11747

Panasonic Communications & Systems Co.
One Panasonic Way
Secaucus, NJ 97094
http://www.panasonic.com/

Pinnacle Micro Inc.
19 Technology
Irvine, CA 92718
http://www.pinnaclemicro.com/

Quantum
500 McCarthy Blvd.
Milpitas, CA 95035
http://www.quantum.com/welcome.html

Segate
1650 Sunflower Ave.
Costa Mesa, CA 92626

Sharp Electronics Corporation
Sharp Plaza
Mahwah, NJ 07430
http://www.sharp-usa.com/

Sony Electronics Inc.
3300 Zanker Rd.
San Jose, CA 95134-1901
http://www.sel.sony.com/

SyQuest Technology, Inc.
47071 Bayside Pkwy.
Fremont, CA 94538-6517
http://www.SyQuest.com/default.htm

Toray Optical Storage Solutions
1875 S. Grant St. #720
San Mateo, CA 94402

Toshiba America, Inc.
9740 Irvine Blvd.
Irvine, CA 92718
http://www.toshiba.com/text/

Phase Change Dual. Another way to achieve one-pass writing is via Phase-Change Dual (PD) technology. Unlike MO-disk technology, Phase-Change technology doesn't need a magnetic field. Both the reading and the writing operations are done using laser light alone.

Also called the Light Intensity Modulated method (LIMM), PD uses the intensity of a laser beam to change the active layer (a thin coating of wavelength-sensitive resins) of an optical disk back and forth between a crystalline and amorphous state (see Fig. 10). Because the method relies on light intensity, not heat, there is no heat build up like there is with the magneto-optical methods. A cooler laser reduces heat leakage on the disk surface, which means the laser can pack the data tracks much closer together yielding higher storage capacities.

Sometimes the PD drive is combined with a CD-ROM, as is the case with Panasonic's PD/CD-ROM and Toray's Phasewriter Dual. Both drives have the ability to read and write 650MB optical cartridges and to play CD-ROMs at 4× speed. That is a marriage of convenience, not of necessity. Because LIMM technology is relatively expensive, combining the two often justifies a sale that might otherwise be lost. However, the combination results in some tradeoffs. PDs typically have an average seek time of around 45 msec and a data transfer rate of 1.5MB per second, whereas a 4X CD-ROM has a 180-msec access time and a 870K data-transfer rate. When the two technologies share the same mechanics and electronics, the PD is doomed to run at the slower speeds of the CD-ROM.

When LIMM technology is freed from its CD-ROM constraints, it can do amazing things. Take Pinnacle's Apex 4.6GB Optical Hard Drive, for example (see Fig. 11). By fine tuning the LIMM technology, Apex is able to cram 4.6GB of data on a single 5.25-inch disk (2.3GB per side), and move that data back and forth (read and write) between the drive and the PC at speeds up to 6MB per second while keeping it compatible with the emerging 2.3GB standard still in committee. At the time of this writing, no less than four other vendors are poised and waiting to announce their versions of a LIMM drive.

Summary. There you have it: four technologies competing for your back-up buck. All of the technologies have their strengths and weaknesses. Which, if any, will eventually become a *de facto* standard will be determined by the marketplace—a marketplace that, of course, includes users like you! Ω

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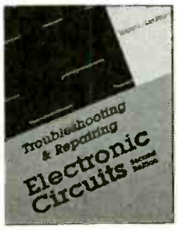

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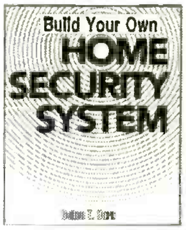

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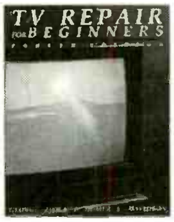

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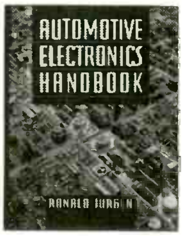

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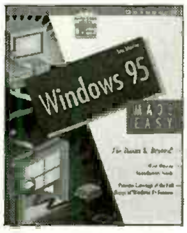

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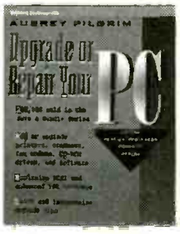

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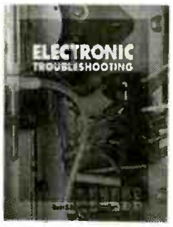

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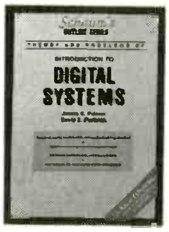

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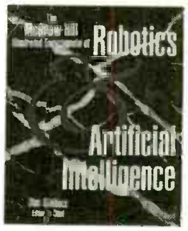

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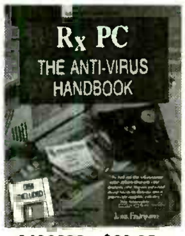

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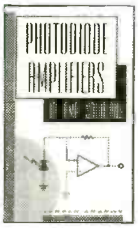

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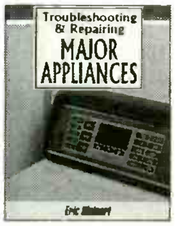

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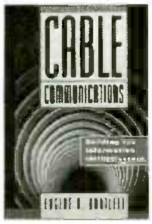

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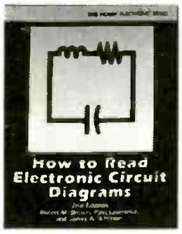

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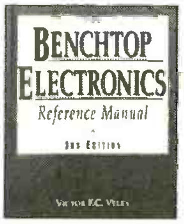

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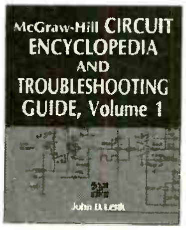

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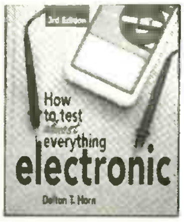

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The Coming Revolution In Shortwave Broadcasting

Planning and common-sense scheduling unchoke the shortwave broadcast bands.

STANLEY LEINWOLL

IF YOU'VE NOTICED THAT SHORTwave radio reception is better than it has been for recent years, it is probably due to the work of a group of broadcasting experts who meet semi-annually to reduce interference by coordinating their shortwave broadcasting schedules. This work is all the more noteworthy because it comes at a time of minimum sunspot activity, when reception conditions are ordinarily at their worst.

Known as the High Frequency Coordinating Committee (HFCC), the group consists of some 70 delegates from 27 countries, representing approximately 50 shortwave broadcasting organizations. The HFCC coordinates more than 17,000 frequency hours, which amounts to more than 70 percent of the world's total shortwave broadcasting effort. Table I lists the countries attending the HFCC Conference held in Bern, Switzerland, from February 5th through the 9th, 1996.

The HFCC first met in April, 1991. There were 14 countries in attendance. The cold war had ended, radio jamming had ended, and telecommunication authorities from East and West were discussing methods of eliminating, or at least alleviating, unintentional harmful interference which permeated the shortwave bands.

Committee membership has grown with time. Admission to the HFCC is open to all broadcasters; any administration wishing to attend is first invited to attend a semiannual conference as an observer. Membership is extended to them at the conclusion of that meeting.

HFCC meetings last a full week, and they have been increasingly successful in their efforts to resolve co-channel and adjacent-channel frequency conflicts, termed "collisions."

The HFCC coordinates a winter schedule [W], and a summer schedule [Z], the periods of each are now determined by European clock time-shifts. For example, the current Z schedule commenced March 31, 1996, when European Daylight Time started, and will end on October 27, 1996, when European Standard Time is resumed. Most broadcasters now conform to these two-per-year schedule formats. Meetings are convened about six weeks before the commencement of a new schedule, and the participants have been taking turns hosting conferences.

TABLE 1—COUNTRIES ATTENDING FIRST 1996 HFCC CONFERENCE

Austria	Monaco
Belgium	Netherlands
Bulgaria	Norway
Canada	Poland
Czech Republic	Romania
Denmark	Russia
Finland	Slovakia
France	Sweden
Germany	Switzerland
Greece	Turkey
Hungary	Ukraine
Iran	United Kingdom
Israel	USA
Italy	Vatican City

Note: The United States was represented by delegates from the International Bureau of Broadcasting (IBB) on behalf of Radio Free Europe, Radio Liberty and The Voice of America. The Federal Communications Commission (FCC) was present on behalf of 23 privately owned shortwave broadcast stations licensed by the FCC. Monaco was represented by TransWorld Radio.

Participating broadcasters submitted their requirements on diskette, and the data is inserted into a data bank; a computer compiles it in useful form and a book is published by a host country. A typical schedule is more than 200 pages long. At the beginning of a conference, schedules are distributed to each participant. A representative Z-96 (Summer, 1996) schedule page at the begining of the conference is shown at the top of Fig. 1. The technical characteristics of each requirement include the frequency, hours of operation, transmitter power, type of antenna being used, beam heading of the antenna, location of the transmitter site, and the target area. Target areas are depicted and described in Fig. 2.

The software, which has been developed by J.W. Drexhage of Radio Nederland, and H. Scholz and T. Feustel of Deutsche Welle [Radio Germany] is being constantly refined to handle data inputs and readable outputs. The software can now analyze conflicts among two or more entries, defining these as co-channel (two stations beamed to the same target areas on the same frequency), or adjacent channel (± 5 kHz conflicts beamed to the same target area). In Fig. 1, a co-channel collision between Ukraine (RRT) and Israel (ISL) on 11,590 kHz is indicated by the dark shading. Adjacent-channel collisions are shown by light shading.

Resolving conflicts

The software is now at the stage where each organization participating in an HFCC conference receives a list of collisions between their requirements and those of other broadcasters, and a list of all the requirements as they appear in the HFCC book on the first day of the conference. Each broadcaster can then check to be certain that requirements have been correctly posted; incompatibilities with other broadcasters are then examined and possible solutions can be suggested. At that point, the informal coordination process of the HFCC begins.

Collisions are dealt with during bilateral consultations; these are conducted in English, with Russian to English, and English to Russian translation, where appropriate. The languages used are only limited by the number of participants. The discussions are generally amicable, because those taking part in the HFCC meeting are interested in resolving as many problems as possible. The bottom of Fig. 1 is a page from the most recent version of the Z-96 schedule; it shows that the collision at the top of Fig. 1 was solved by Israel, which moved its requirement from 11,590 kHz to another frequency.

There are several unwritten rules which guide the conference members in their efforts to resolve collisions. Among these are:

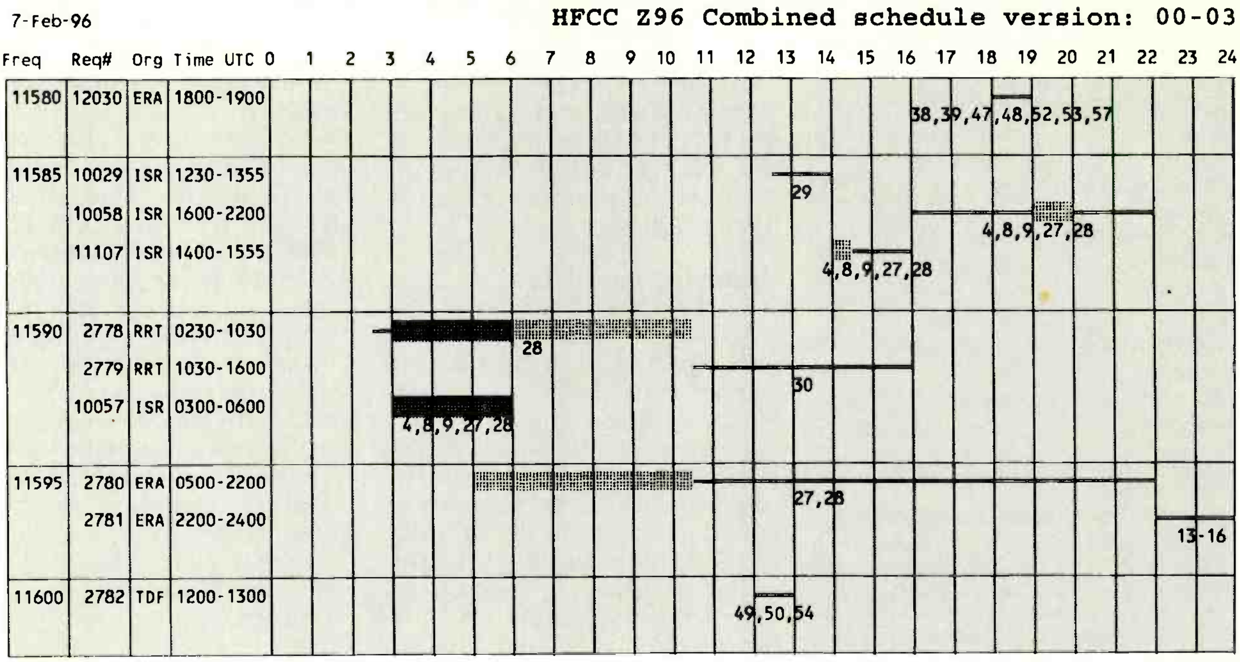
- If a broadcaster has been operating on a frequency-time slot in previous schedules, and a conflict is created by another broadcaster who is new on the same frequency, the newcomer is generally expected to move to another frequency, or delete the requirement.
- If a broadcaster has a transmission on a frequency for a long period, and another broadcaster is on the same frequency for a shorter period and they have a collision, it is generally easier for the shorter transmission period to find another frequency. Usually the broadcaster with the shorter collision period vacates the frequency.
- A problem can sometimes be resolved if one of the broadcasters in conflict can move its transmission to another useful band where the propagation features are not compromised.

About the Author

Stanley Leinwoll has worked as a hands-on shortwave broadcaster for almost half a century. He started working for the Voice of America as a Propagation Specialist in 1950. In 1957 he joined Radio Free Europe as its Radio Frequency and Propagation Manager. He was the Director of Engineering for Radio Free Europe/Radio Liberty from 1975 until his retirement in 1994. He is currently working as a Technical Consultant to three private sector US shortwave broadcasters, WYFR, WEWN, and WVHA, and he attended the February 1996 HFCC in Bern on behalf of his clients.

Mr. Leinwoll has served on five United States Delegations to International World Administrative Radio Conferences, and has also written extensively; of his ten books, titles include, *From Spark to Satellite, A History of Wireless Communication*, *Shortwave Propagation*, and *Space Communications*.

STANLEY LEINWOLL at work at the HFCC in Bern.



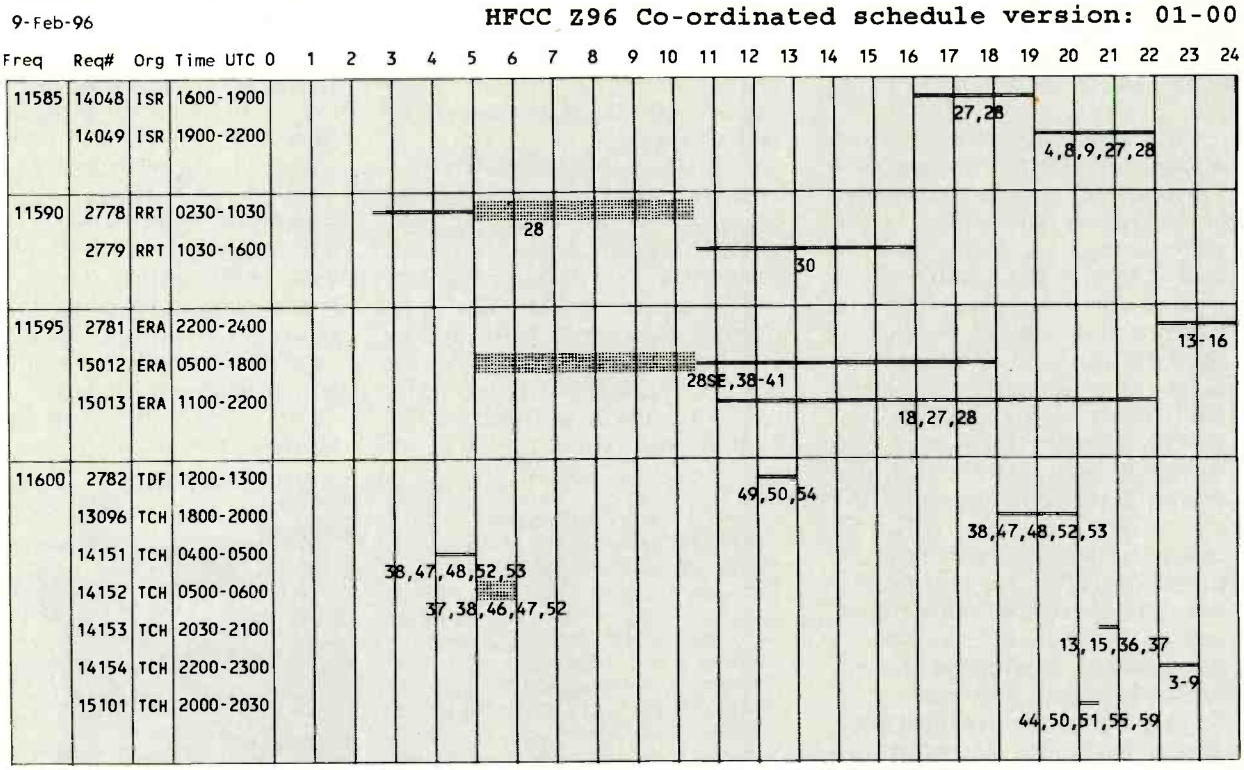


FIG. 1—TWO VIEWS OF A PAGE from the Summer 1996 HFCC working schedule. The top view printed at the beginning of the conference shows a co-channel collision (darkly shaded area) on 15,590 kHz between Ukraine (RRT) and Israel (ISL). Adjacent channel collisions (± 5 kHz) are shown lightly shaded. The bottom view is the result of the conference's final version, indicating that the colision between Ukraine and Israel was solved by Israel vacating the frequency. An adjacent channel problem betwen Ukraine on 15,590 kHz and Greece (ERA), on 11,595 kHz, could not be resolved. Note the the 11,600 kHz frequency has many new schedules added, obviously taken from many other frequencies to avoid collisions.

It is common to switch from the 9-MHz band to either 7-MHz or 11-Mhz band.

The general practice has been that the larger broadcasters have been helpful in trying to assist the smaller ones. Some of the smaller participating broadcasters have as few as one or two transmitters, while some of the larger ones may have more than 100 transmitters at many sites hundreds of miles apart. It is a typical result for a broadcasting giant to switch from his original requirement to another on a different frequency, at another transmitting site and still enjoy favorable propagation results for his transmission. Small broadcasters with one or two

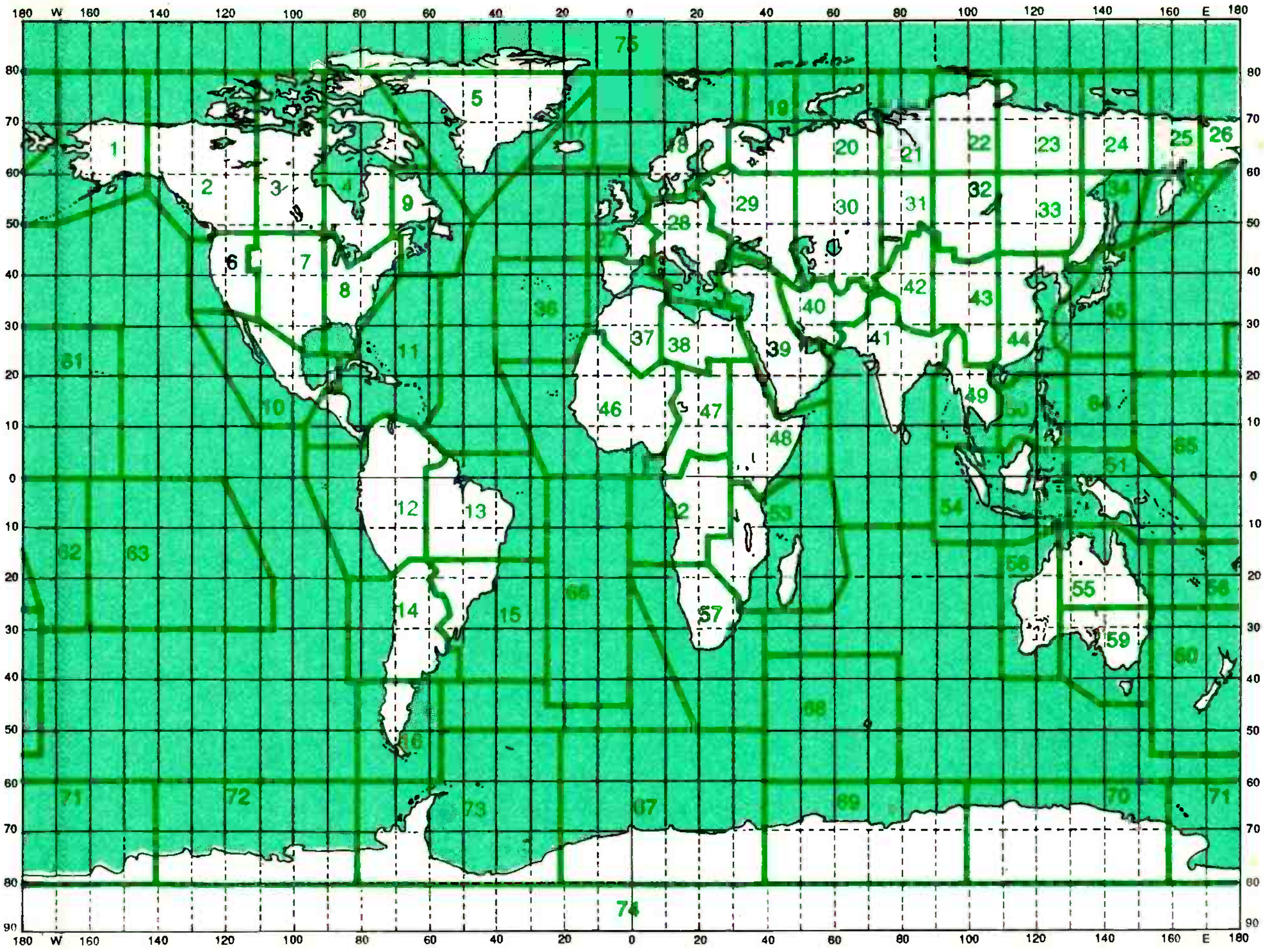


FIG. 2—THE TARGET AREA MAP of the world used to define collisions. The numbered areas are target areas often referred to as "CIRAF" zones, a Spanish acronym referring to the International High Frequency Radio Conference held in Mexico City in 1947 where they were first defined. Collisions are said to occur when two or more broadcasters target the same CIRAF zone on the same frequency, or on adjacent frequencies.

sites usually do not enjoy this flexibility of choice.

Russian conflicts

The Russians are the world's largest shortwave broadcaster, and their broadcasting requirements are generally about five thousand frequency hours per schedule, or about 30 percent of all submitted requirements. Consequently, the Russians have the greatest number of collisions with other participants. The HFCC has found the most efficient way of dealing with collisions involving the Russians has been to divide the collisions and to set them up at two separate tables at the conference. The six member Russian delegation generally divides into two groups, one of which handles the lower frequencies (6-11 MHz), and a second group with handles collisions involving 13 MHz and higher.

Broadcasters who have problems involving the Russians make an appointment to speak to them. The Russian delegates have been extremely cooperative in the HFCC, and have contributed toward the solution of numerous conflicts.

The evolution of HFCC

Since the formation of the HFCC its membership has doubled; as a natural consequence of this growth the number of collisions and the number of solutions has increased significantly. At a recent conference, there were 507 co-channel collisions at the start of the conference. By noon of the fifth and final day the number had been reduced to 299, an impressive 41 percent reduction in the most serious conflicts. This may not sound like much improvement; however, consider this: Each collision involves at least two broadcasters. When 208 collisions are rectified, that means at least 416 additional uninterfered daily and weekly broadcasts are transmitted for the world to hear.

Rapid resolution of conflicts has been brought about, in part, by the application of dedicated software, which has enabled the HFCC to provide the conferees with daily, completely up-to-date, usage books, requirements lists, and lists of collisions. In order to produce timely lists, changes made on a given day are collected at 4 P.M. and inserted into the data base. The computer processes the requirement changes and prints new lists that are available at the start of the next day's proceedings.

Figure 3 indicates the shortwave bands that have been generally available to the participants. Since 1979 the bands allocated to high-frequency broadcasting have been expanded twice. The latest expansion occurred in 1992, but the new frequencies allocated at that time have not become universally available.

Unresolved problems

Like all human endeavors, there are problems within the HFCC which currently limit its effectiveness. Several of these are worthy of mention.

The frequency managers participating in HFCC activities have differing levels of technical sophistication, and different levels of experience. Nevertheless, the members treat each other as co-equals. Those who are more experienced have been working with their counterparts in other organizations to assist with the dissemination of shortwave radio propagation data, and with information dealing with actual occupancy of the shortwave bands.

The handling of in-season changes has not yet been fully mastered. The distribution of information involving some 50 broadcast organizations is sometimes cumbersome. Methods of distributing schedule changes are constantly improving. They are not yet perfect.

The HFCC has evolved into a highly productive group dedicated to the solutions of problems in the high-frequency bands being used for broadcasting. Progress in the last five years has been significant and should continue as the software continues to be improved, and as participating broadcasters become more aware of the realities in specifying their requirements and the responsibilities of coordination.

The future—more planning

Over the past fifty years there have been numerous unsuccessful attempts to plan the bands used for shortwave broadcasting. Such planning attempts have failed because the number of requirements submitted by the broadcasters has always far exceeded the amount of available radio spectrum. To fit all the requirements into a master plan would necessitate either mandatory reduction of some of these requirements, or the massive expansion of the bands allocated to high-frequency broadcasting.

The most recent efforts to plan the high-frequency bands at high-frequency broadcasting planning conferences in 1984 and 1987 left much to be desired. The HFCC conferences, which are, in essence, short-term planning exercises, have provided the most viable means of establishing a world-wide planning model. The informal approach taken by the HFCC participants has provided a relaxed forum for solving many problems, and suggests a world-wide planning procedure.

By establishing regional committees like the HFCC for Asia and the Far East, Africa and the Middle East, Europe and the Americas, a procedure exists for coordinating up to 100 percent of the world's shortwave broadcasting allocations. Such informal regional conferences could provide the world with the framework for a revolutionary planning procedure, offering a degree of success never before achieved in the arena of world high-frequency broadcast planning. Such a revolution appears to be a distinct possibility for the future. Ω

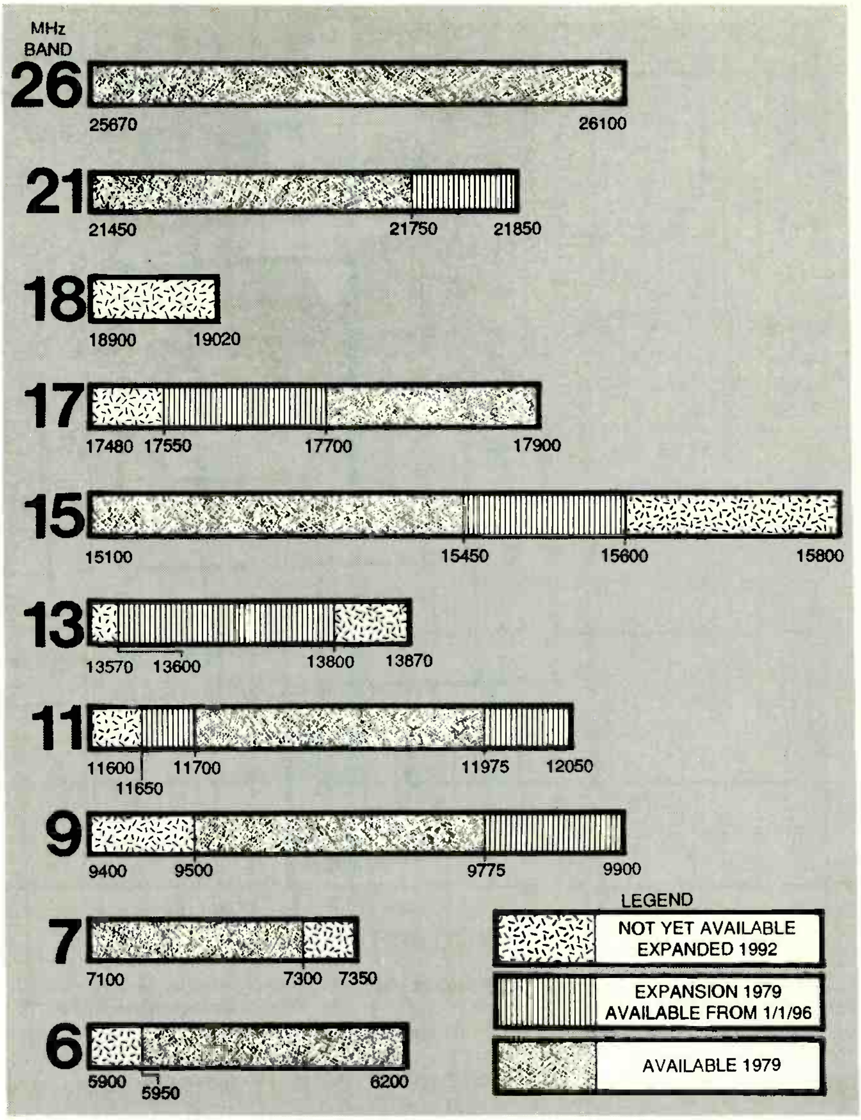


FIG. 3—THESE ARE THE SHORTWAVE bands that are available to participants. They have been expanded twice since 1979.

MARK O. BENDER

TONAL VOLTMETER

This circuit gives an audible indication of voltage levels.

MOST VOLTMETERS HAVE A DIGITAL or analog moving-needle display to indicate the voltage being measured. However, the tonal voltmeter, or TVM presented here emits a tone that changes in pitch according to changes in the voltage being measured. While this is no substitute for the accuracy of a digital display, it can give a quick, relative indication of a voltage value without the user having to stop and look at a display.

The TVM is a great time-saver when performing quick voltage-level checks as normally done with a logic probe. If one regularly repairs or tests many of the same circuits, a tonal pattern of the various test points will soon be recognized. Then, any voltage reading that generates an unfamiliar tone will immediately be suspected as an indication of a possible problem that can then be investigated in greater detail with more sophisticated test equipment. The TVM is also a great way to find voltage peaks or nulls when making circuit adjustments. The simple circuit's main limitation is that the input voltage to be measured cannot be greater than the TVM circuit's supply voltage.

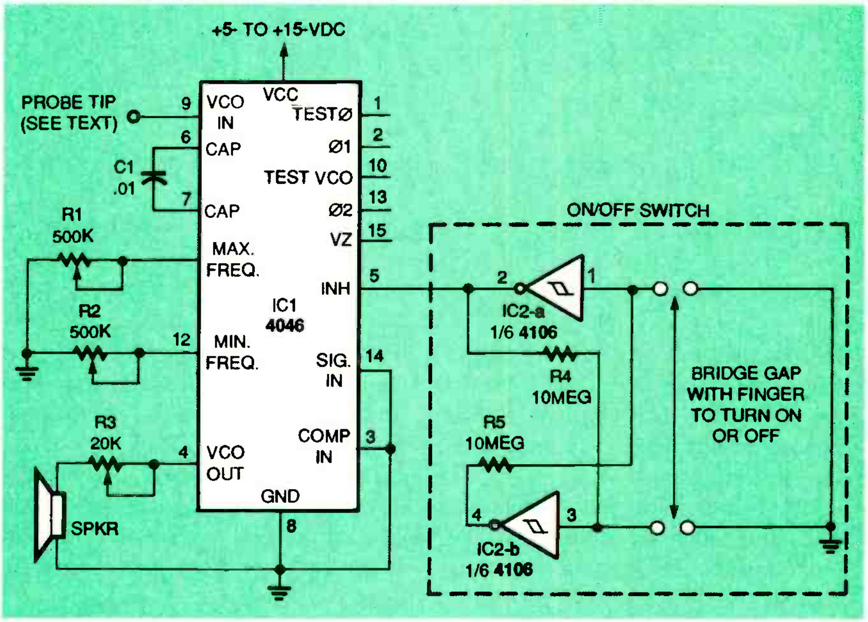


FIG. 1—TVM SCHEMATIC. The frequency of the VCO contained within IC1 is determined by the voltage at pin 9, C1, R1, and R2.

Circuitry

A schematic of the TVM circuit is shown in Fig. 1. The circuit is based on a CD4046B phase-locked loop (PLL) IC with a built-in voltage-controlled oscillator (VCO). The frequency of the VCO is determined by the voltage at pin 9, capacitor C1 between pins 6 and 7, potentiometer R1 at pin 11, which sets the maximum frequency, and potentiometer R2 at pin 12, which sets the TVM's minimum frequency.

The VCO output, which appears at pin 4, is normally fed back into the comparator input at pin 3. However, in this circuit, the VCO output drives a speaker directly. The VCO operates while the inhibit line (INH) at pin 5 is held logic low, and it turns off when INH is logic high.

A touch switch consisting of two Schmitt-trigger inverters (IC2-a and -b) turns the circuit on and off to conserve power when the TVM is not being used. The touch switch can be replaced with a standard SPST switch, if so desired. This is recommended if you don't have a Schmitt-trigger inverter and don't want to purchase one.

The TVM emits a low tone when reading a logic low. As voltage input increases, the tone pitch increases until the input voltage reaches a logic high. As the voltage input decreases, the pitch decreases.

Construction

The circuit is simple enough for point-to-point wiring on perforated construction board; no foil pattern is available. As mentioned before, a standard switch can replace the touch switch. If you use the touch switch, bring the two touch points shown in Fig. 1 (IC2 pins 1 and 6) to the outside of the enclosure you use and connect them to any pair of conductive pads. Leave a gap between the pads that you can bridge with your finger.

A probe for the VCO input can be made from a ball-point pen

Continued on page 79

PARTS LIST

- R1, R2—500,000 ohms, potentiometer
- R3—20,000 ohms, potentiometer
- R4, R5—10 megohms
- C1—0.01 µF, ceramic disc
- IC1—CD4046B CMOS phase-locked loop, Harris or equiv.
- IC2—CD4106B CMOS hex Schmitt trigger, Harris or equiv.
- 8-ohm speaker, probe body and tip (see text), shielded cable, 5-volt power supply, enclosure, solder

A Glossary of DSO test terms

FINDING YOUR WAY THROUGH THE MAZE OF TERMINOLOGY IN TODAY'S TEST ENVIRONMENTS CAN BE A CONFUSING EXPERIENCE FOR EVEN THE MORE EXPERIENCED USERS—PITY THE NEWCOMER. IF YOU ARE A FORMER ANALOG oscilloscope user or a new digital storage oscilloscope (DSO) user, you may sometimes feel as if you have a whole new set of terminology to understand. And in fact, you do.

But help is on the way. We've compiled the following glossary of DSO and other test and measurement terms to help acquaint you with the exciting new world of digital test equipment, and to ease the transition from an analog world to the digital storage realm. Keep in mind, however, that there will always be some overlap between the two environments, and thus between their respective terminologies.

To facilitate understanding all of the terms, we've organized the glossary around four general categories. Each one describes a specific class of activities that you will be performing with your DSO. They are:

- acquisition
- viewing the signal
- interpreting the waveform
- storage

We hope you will find this a helpful guide to understanding DSO terminology and some of the new capabilities of your digital storage oscilloscope.

ACQUISITION

Acquisition — The process of sampling signals from input channels, digitizing the samples, processing the results into data points, and assembling the data points into a waveform record to be stored in memory.

ADC, analog to digital converter — A circuit module that converts a voltage or current (analog) into discrete binary values (digital) that can be displayed or further analyzed.

Auto trigger mode — A trigger mode that causes the oscilloscope to automatically acquire a signal if it doesn't detect a triggerable event.

Average acquisition mode — A mode in which the oscilloscope acquires and displays a waveform that is the averaged result of several acquisitions. This reduces the apparent noise.

Digital-to-analog converter — A device that converts an input binary code (digital) into a continuous variable voltage (analog).

Digital Real-Time (DRT) digitizing — A digitizing technique that samples the input signal with a sample frequency of four to five times the oscilloscope bandwidth. This technique is ideal for capturing transient or single-shot events.

Digitize — The process of converting a continuous analog signal, such as a waveform, to a set of discrete numbers representing amplitude of the signal at specific points in time.

ET, equivalent-time sampling — A sampling mode in which the oscilloscope constructs a picture of a repetitive signal by capturing some information from each repetition.

GS/s, gigasamples per second — One billion samples per second.

Normal trigger mode — A mode where the oscilloscope only acquires a waveform if a valid trigger event occurs.

Peak detect — An acquisition mode for digital oscilloscopes that captures and displays the extreme peaks of a signal.

Real-time — The actual time during which a physical event takes place.

Real-time sampling — A sampling mode in which the oscilloscope collects as many samples as it can as the signal occurs.

Sample acquisition mode — A mode in which the oscilloscope creates a record point by saving the first sample during each acquisition interval. This is the default mode of the acquisition system.

Sweep — One horizontal pass of an oscilloscope's electron beam, from left to right across the CRT. In digitizing scopes, this spec has evolved into time/division range.

Transient or single-shot event — An oscilloscope-measured signal that only occurs once. DSOs, especially, digitizing real-time DSOs, excel at capturing these kinds of elusive events.

Trigger — The circuit that initiates a horizontal sweep on an oscilloscope and determines the beginning point of the waveform.

Trigger level — The voltage level that a trigger source signal must reach

Tektronix, Inc.

before the trigger circuit initiates a sweep.

VIEWING THE SIGNAL

Active cursor — The cursor that moves when you adjust the +/− rocker. The @ readout on the display shows the position of the active cursor.
Cursors — Reference lines or markers on an oscilloscope display that can be aligned with a waveform to make accurate measurements, expressed in voltage or time values.
Delayed sweep — An oscilloscope function that permits delaying the start of waveform display for a specified time after a trigger event.
Envelope — The outline of a signal's highest and lowest values acquired over many repetitions.
Horizontal bar cursors — The two horizontal bars that you position to measure the voltage parameters of a waveform. The oscilloscope displays the active cursor value with respect to ground and the voltage value between the bars.
LCD, liquid crystal display — A type of display used on many handheld oscilloscopes because of its easy readability and low power use.
LED, light emitting diode — The bright digital display used on many bench test oscilloscopes.
Paired cursors — Two cross-shaped cursors that automatically track the vertical values of a waveform when you adjust its horizontal position. The oscilloscope displays the voltage and time values between the paired cursors.
Pixel — The smallest image-forming unit on a video display. The TekScope display is 320 pixels wide by 240 pixels high.
Pop-up menu — A submenu that temporarily occupies part of the waveform display and presents you with choices associated with the main menu item selected.
Pulse — A common waveform shape that has a fast-rising edge, a width and a fast-falling edge.
Record length — The number of waveform points used to create a record of a signal.
Resolution — The smallest unit that can be detected and displayed by an oscilloscope or other measurement device.
Roll mode — The ability of a DSO to continuously update its display memory as new data points are captured, permitting continuous observation of signal changes. Used with very slow time base speeds.
Sawtooth wave — A waveform containing a ramp and an abrupt return to its initial value; its graphic plot has the shape of sawteeth.
Selected waveform — The waveform on which all measurements are performed and which is affected by vertical position and scale adjustments of the oscilloscope.
Sinewave — The most common waveform (and normal AC waveform) whose graphic plot of voltage against time has the shape of a sine curve.
Spike — A short duration pulse superimposed on an otherwise regular or desired waveform.
Symmetry — A way of changing the shape of the output signal waveform without changing the signal frequency, so the waveforms are not symmetrical with respect to their longitudinal axis.
Vertical bar cursors — The two vertical bars positioned to measure the time parameter of a waveform record. The oscilloscope displays the value of the active cursor with respect to trigger and the time value between the bars.
Vertical resolution — In a DSO, this value indicates how precisely the ADC can turn input voltages into digital values.
Waveform — A graphic representation of a voltage varying over time.
Waveform point — A digital value representing the voltage of a signal at a specific point in time. Waveform points are calculated from sample points and stored in memory.
XY format — A display format that compares the voltage level of two waveform records point for point, useful for studying phase relationships between two waveforms.
YT format — The conventional oscilloscope display format showing the waveform voltage (on the vertical axis) as it varies over time (horizontal axis).
Zoom — The ability to expand a particular segment of a waveform to see details more clearly and to limit measurements within a given region of data. This capability is found only in DSOs.

INTERPRETING WAVEFORMS

Analog — Data in the form of continuously variable physical qualities such as voltage.
Automatic measurements — The broad range of measurements performed by the digital signal processors in DSOs, including such measurements as add, subtract, divide, multiply, as well as more complex measurements including averaging, FFT functions, histograms and pass/fail testing.
Autoranging — Automatically selects the appropriate range for making a measurement.
Continuity — A test to verify electrical conductivity from one point to another.
Delay time — The time by which a signal is retarded.
Diode test — A test to verify polarity and to measure the forward voltage drop of a semiconductor junction.
Distortion — An undesirable change in the waveform of a signal.
Floating measurements — Voltage measurements where the reference voltage is not earth ground.
Frequency — The number of events per unit of time for a periodic function. Measured in hertz (Hz).
Gain — The increase in signal amplitude as it passes through an amplifier or other circuit, expressed as a ratio.
Glitch — An intermittent error in a circuit.
Ground loop — Current flow between two or more ground connections, where each connection is at a slightly different potential due to the resistance of the common connection.
Harmonic — A sinusoidal component of a periodic wave with a frequency that is an integral multiple of the fundamental frequency.
Impedance — The total opposition to current in a circuit, composed of resistance and reactance (inductive or capacitive).
Linearity — The closeness with which a quantity represents a straight line when plotted against a variable.
Lissajous figure — A special case of x-y plot in which the signals applied to both axes are sinusoidal functions. Useful for determining phase and harmonic relationships. For a stable display, the signals must be harmonics.
Load — The impedance that a circuit

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presents to the output of the reference instrument.

Loss — Power expended without accomplishing useful work, typically expressed in watts.

Modulation — A process by which the amplitude, phase or frequency of a sine wave is altered in accordance with information to be transmitted.

Noise — Unwanted disturbances superimposed on a useful signal that tend to obscure its information content.

Output frequency — The frequency of the signal produced by an instrument.

Overrange — Signal amplitudes or frequencies above the specified limits of the instrument.

Peak-to-peak voltage (Vp-p) — The voltage between the positive and negative peaks of a sine wave.

Phase — A relative quantity — expressed in degrees of phase — that describes the time relationship between or among waves of identical frequency; the frequency of the signal determines the length of time corresponding to one degree of phase.

Peak — The highest or lowest point of a signal wave, referred to as the maximum voltage level measured for a zero reference point.

Polarity — The positive or negative direction of voltage or current.

Pulse amplitude — The difference between the two states in a pulse, usually measured in volts.

Pulse fall time — The time interval for the falling edge of a pulse to go from 90% to 10% of the amplitude.

Pulse rise time — The time it takes for the rising edge of a pulse to go from 10% to 90% of pulse amplitude.

Pulse width — The time interval between the 50% amplitude points of the rising and falling edges of a pulse.

Ramp — The transition between voltage levels of a waveform where that transition occurs at a constant rate of change.

Response time — The time required for a resulting condition to reach steady state after variation of an input quantity.

Ringing — A distortion, in the form of circulating currents in the inductance and capacitance, which usually follows a major transition.

RMS — Root Mean Square—an expression of the effective value of an AC waveform.

Sensitivity — The smallest input signal to which an instrument can respond.

Shunt — A conductor of known resistance used to measure current flow between two points in a circuit.

Signal path compensation (SPC) — The ability of the oscilloscope to minimize the electrical offsets in the vertical, horizontal and trigger amplifiers caused by ambient temperature changes and component aging.

Slew rate — The maximum limit, under linear operating conditions, that the speed of output voltage can change with respect to change in input voltage. Measured in volts per second.

Totalize — A measurement mode that counts signal events at one-count-per-event increments.

Vertical resolution — In a DSO, this value indicates how precisely the ADC can turn input voltages into digital values.

Vertical sensitivity — A value indicating how much an oscilloscope's vertical amplifier can increase a weak signal voltage.

Wavelength — The distance between two points of corresponding phase in consecutive cycles of a periodic wave.

STORAGE

Memory store/recall — Stores a setup, waveform or series of waveforms in memory that can be recalled at a later time.

Min/max store — The min/max function captures and stores minimum and maximum readings in memory and can be used to monitor a signal for seconds or days.

Reference waveform — A saved waveform selected for display. Some DSOs can display two reference waveforms simultaneously.

Relative reference — Stores a reading in memory and shows the difference between it and any future readings. EN

Readers can contact Tektronix by calling 800-479-4490, Action Code 300. Additionally, Tektronix maintains a home page at:

http://www.tek.com/Measurement

BY DON LANCASTER

An introduction to vectors, Earth-field magnetometry, new flux-gate sensors and ICs, and more

WE HAVE A NEW MAGNETIC SENSOR THIS MONTH THAT SURE APPEARS REASONABLY PRICED AND EXTREMELY EASY TO USE, ESPECIALLY FOR COMPASS AND NAVIGATION APPLICATIONS. BUT FIRST, I THOUGHT WE MIGHT GO over a fundamental or two, so let's get right to it.

Vectors

A *scalar* quantity has *one* simple value, such as three quarts of milk. A *vector*, on the other hand, quantity relates *two or more* values. A car may travel at a scalar *speed* of 35 miles per hour, or travel at a vector *velocity* of 35 miles per hour to the northwest.

As Fig. 1 shows, any two dimensional vector can be drawn as an arrow. The *length* of the arrow tells us how strong the vector is and the *direction* of the arrow can tell us exactly where it is heading.

If you plot any vector graphically, you have a choice of many different *coordinate systems*. The *rectangular* coordinate system will go "so many steps over" and "so many steps up" to define a vector.

For instance, in electronics you often will plot real power left to right and the reactive power up and down. Real power is power that is actually generated or consumed in resistors or generators. Reactive power is power that gets swapped back and forth as energy storage between inductors and capacitors in your circuit.

The convention is to put resistors to the right, inductors up, generators (or "negative resistors") left, and the capacitors down. "East" is defined as the zero axis, such as you'd get when routing current into a resistor.

A *phase angle* is usually defined *counterclockwise* from 0 on up to 360 degrees, with zero degrees heading east. Some phase angles can also be separately defined as 0 to 90 degrees *lagging* as you go more inductive. Or as 0 to 90 degrees *leading* as you go more capacitive.

In other times and places, you pick other schemes for your rectangular coordinates. Most geographic maps place north as "up" or to your "top", and then express the *bearing* as so many degrees *clockwise*. Southwest is a bearing of 225 degrees. Needless to say, it is important to use the same origin, notation, and angle direction conventions as everyone else.

Sometimes it is best to use a vector as an arrow pointing in a direction. For example, an impedance of 5 ohms at a phase angle of 53.13 degrees lagging. When you do this, you are said to be in *polar coordinates*. Other times, it is better to *resolve* a vector into its rectangular *component parts*; 4 ohms resistive and 3 ohms inductive, for example.

Simple high school trigonometry can get you between rectangular and polar coordinates. Say you have an electronic vector in polar coordinates that has a strength r and a direction of q degrees. The resolved x and y rectangular components will be

$$x = r \cos\Theta$$
$$y = r \sin\Theta$$

To get to polar from rectangular coordinates, just remember the Indian chief who was running those fertility experiments: *The sum of the squaw on the hippopotamus hide equals the sum of the squaws on the other two hides.* Or, more conventionally:

$$r = \sqrt{x^2 + y^2}$$

And the phase angle

$$\Theta = \tan^{-1}(y/x)$$

tan^{-1} is math shorthand for *arctan* or "*the tangent whose angle is*".

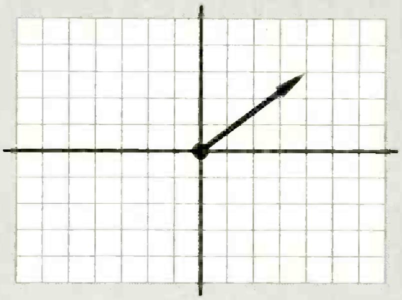
Details end up somewhat different with geographic maps. You substitute *north* for your x component and *east* for the y component to get the correct bearing using the above equations.

Earth field magnetometry

Bunches of helpline calls lately on measuring the Earth's magnetic field: for the solid state compasses used in orienteering, surveying, or caving; for vehicle and robotics navigation; for old archaeological mapping; for virtual reality headgear; or for research into earthquake detection.

The earth is a giant magnet most likely created by its spinning liquid nickel iron core. At any point on the earth surface, you'll find a *three* dimensional magnetic vector having x, y, and z components. The up and down part is known as *magnetic inclination* and can be measured with a *dipping needle*. The inclination varies with latitude; it ends up as horizontal near the equator and as vertical near the

A vector can be shown in its **polar coordinate** form as an arrow. The length of the arrow *r* conveys the vector's **magnitude** and the positioning θ of the arrow will convey the vector's **direction**...



In this example, we have a vector that is five units long. Made up of whatever four blocks stand for on the horizontal *x* axis and whatever three blocks stand for on the vertical *y* axis. These blocks are in **rectangular coordinate** form.

If you are using "math" or "electronic" coordinates, real power relates along the *x* axis and reactive power along the *y* axis. Phase angles are measured **counterclockwise** from due **east**. In this case, we might be showing a 5 Ohm impedance with a 4 Ohm real component and a 3 Ohm reactive component. The phase angle of our vector is easily found to be 36.9 degrees.

On the other hand, if you are using "map" or "geographic" coordinates, north is to the top and east is to the right. Bearings are measured **clockwise** from **north**. The bearing of the very same vector is now 53.1 degrees!

Thus, when in Rome... It is extremely important to use both the axis and the angle direction conventions that are consistent with the intended use.

If you are using electronic coordinates, these trig relationships get you from polar to rectangular coordinates and back again...

$$x = r\cos\theta$$
$$y = r\sin\theta$$
$$r = \sqrt{x^2 + y^2}$$
$$\theta = \tan^{-1}(y/x)$$

FIG. 1—A VECTOR GETS USED to represent a relationship between two or more independent quantities. Here's some of the fundamentals.

poles. The back and forth part is known as a *magnetic declination* and is what gets measured with a *compass*. The difference between where a compass points and where you are heading is called a *bearing*.

For accuracy, the declination and inclination *must* be kept separate. For reliable readings *a compass must be held absolutely level!* Some precision boat compass mountings are known as *binnacles*. They are either floated on some liquid or are gravity-gimbal mounted to keep them level.

Note that a compass does *not* point true north. It points somewhere near true north to an eternally wandering *magnetic pole*. Thus, it is *very* important for you to distinguish between *true north* and a *magnetic north*. Here in Arizona, the declination is some 13 degrees easterly. Which says that a compass points badly to the east of where it is supposed to. Premium compasses and survey gear will have a provision that lets you automatically subtract out this error. If you use this feature, be sure it is correct for where you are.

In Kansas, there is very little error between true north and magnetic north. This is along *the line of zero declination*. But, when you are not in Kansas anymore, the rule is *the error*

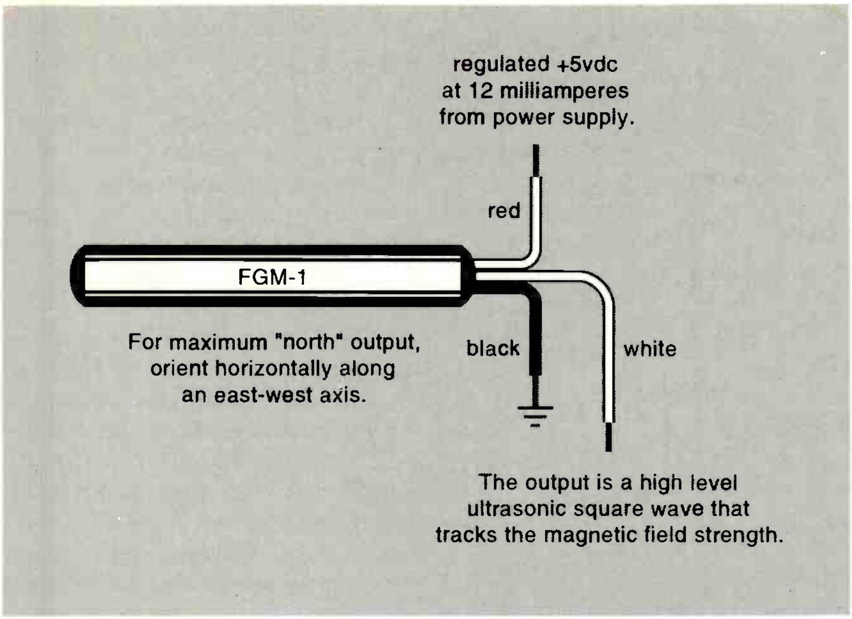


FIG. 2—THE FGM-1 MAGNETIC FIELD SENSOR is extremely easy to interface to microcontrollers. Obvious uses include vehicle detectors, solid state compasses, navigation aides, and virtual reality apps.

points to Kansas. In California, the compass points to the *right* of where you'd expect it to. In Vermont, it will point to the *left*.

Despite its humongous size, the earth's field at any locale is rather weak. One gauss is the nominal field strength. At mid-latitudes, 0.6 gauss is much more typical. An older field measure is the *gamma*. You will find 100,000 gammas in a gauss.

It is extremely difficult to build an electronic solid-state compass having an accuracy that is better than a few degrees. A minimum of twelve bits of resolution is an absolute must, but fourteen to sixteen bits are preferred. Temperature and calibration effects cut into this margin. A level scheme of one sort or another is mandatory.

Also required is some method to compensate for nearby metal. Parts of an automobile exude *ten times* or higher fields than the one you want to measure. A well designed digital car compass offers some calibration procedure you have to go through, such as driving around the block exactly one time. One classic paper on all this is called *Earth's Field Magnetometry* by W. F. Stuart, in the *Reports on Progress in Physics*, 1972, vol 35, on pages 803-881.

Some approaches

The classic approach to a compass is to magnetize something and float it. Another is to mount it on leveled low friction bearings. It will continuously try to point to the north. Obvious problems here include damping, "stiction," and vibration. It is also real tricky to get a digital data conversion.

There are quite a few *Hall Effect* devices cheaply available. These are usually transistor sized devices that produce a digital or analog output when any magnet gets placed nearby. *Allegro* and *MicroSwitch* are typical sources for these. Unfortunately, today's Hall Effect devices aren't nearly sensitive enough for earth magnetometry uses. They will usually miss by a factor of *one hundred* or more. You'll also find *magnetoresistor* components: resistors whose value changes with magnetic field strength. Unfortunately, every magnetoresistor I have seen has such incredibly bad habits as to make it *totally useless* for earth field magnetometry. Today's magnetoresistors aren't all that accurate or linear, have a strong temperature dependence, need bias magnets, and offer poor cross-axis sensitivity. They also have the nasty habit of suddenly turning themselves inside out without warning—literally flipping out!

A *proton precession magnetometer* is a bottle of pure water that has a coil around it. The heavy current through the coil can suddenly cease, causing wobbling of certain spinning water molecules. This precession in turn can induce a noisy and sub-microvolt audio signal around 1500 hertz back into the coil for a tiny fraction of a second. Accurately measuring that frequency indicates the strength of the magnetic field. Sensitivity can be exceptionally high.

The proton precession devices are

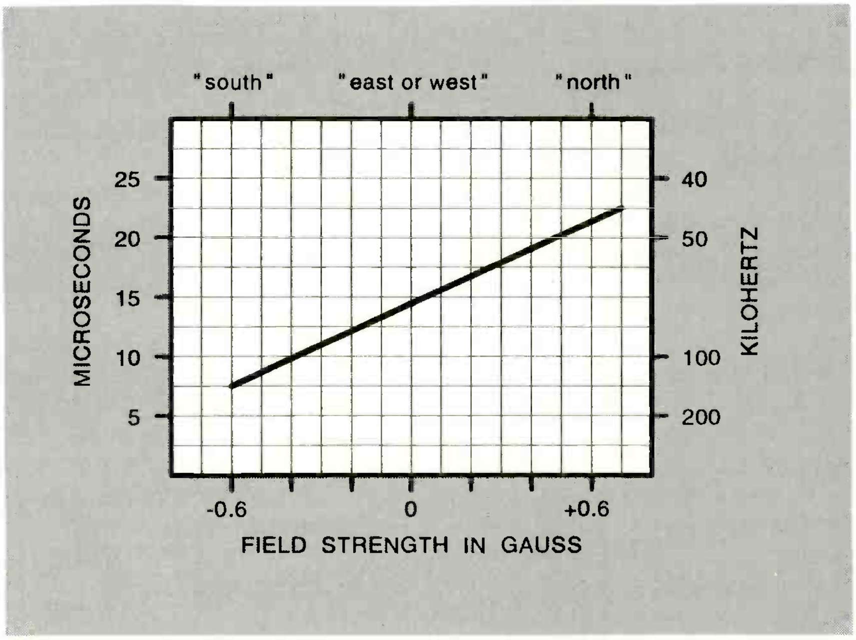


FIG. 3—THE TIME PERIOD OF THE FGM-1 increases or decreases with changing magnetic field strength and polarity. The initial 6% linearity can be significantly improved by table lookup or by using field nulling techniques.

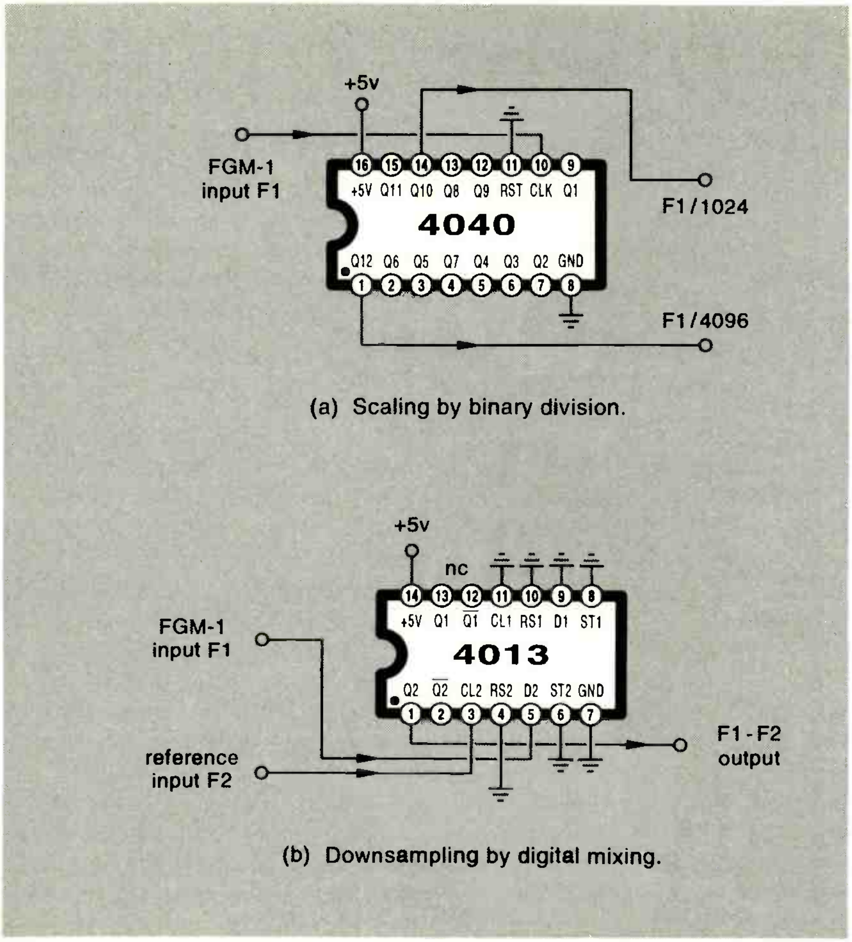


FIG. 4—THE FGM-1's OUTPUT SIGNAL can be reduced in frequency for accurate conversions in certain low end microcomputers.

scalar sensors that measure *only* a total field and *not* its direction. While powerful for archaeological mapping and oil exploration, there is no way to make a compass out of one.

Instead, the mainstream solid state compass sensor for years has been the *fluxgate*. A fluxgate is simply a lower cost *hard saturating* magnetic core with a drive winding and a pair of sense windings on it. Typically, a toroid will be used. A drive winding goes round and round the core as a normal toroid winding. These sense windings are often wound flat on the *outside* of the core, and are arranged precisely at 90 degrees to each other.

When *not* energized, a fluxgate's permeability "draws in" the earth's magnetic field. When energized, the core saturates and then ceases to be magnetic. As a switching occurs, the earth's field is drawn into or released from the core, resulting in a small induced voltage that is proportional to the strength and direction of the external field. This voltage pulse is often at the *second harmonic* of the drive waveform, allowing for fairly simple signal extraction. For more background on fluxgates, see *hack12.pdf* and *hack70.pdf* on *www.tinaja.com*. A rather expensive ready-to-go source for these fluxgate compasses is *KVH Industries*.

A well done *Review of Fluxgate Sensors* did appear in *Sensors and Actuators A*, volume 33 for 1992 on pages 129-141, but your best starting point on all this is the *Magnetic Mesurements Handbook* by J. M. Janicke, newly available from *Magnetic Research*. Included are full construction details on how to build up your own fluxgate magnetometer compass.

A new fluxgate sensor

Several new fluxgate variations have recently emerged. They still are driven and cored small coils, but are potentially a lot cheaper and allow lower operating currents. The highest profile source for these new products has been *Precision Navigation*.

There is an exciting new British magnetometer development from *SCL* called the *self-oscillating fluxgate*. It is offered in the US by Erich Kern at *Fat Quarters Software*. The prices start at around $35. Figure 2 shows details on their FGM-3 sensor. You basically have a small cylinder into which you send 12 mA of regulated +5 volts of DC and ground, and out of which you *directly* will get a high-level and microcontroller-friendly squarewave. There's no low level analog circuitry and no signal conditioning involved! The temperature variation and the cross-axis sensitivities are also low.

The squarewave's *time period* is pretty much proportional to the field strength. As Fig. 3 shows us, the time period ranges from around 7 microseconds at −0.6 gauss (south), to 14 microseconds at 0.0 gauss (east or west), and up to 25 microseconds at +0.6 gauss (north). The initial linearity is around 5 percent or so, but it can be corrected down into the 0.3-percent range for fractional degree accuracy.

These time periods are a tad fast for certain older microprocessors to accurately resolve. Figure 4 shows us two methods of making the outputs more micro friendly. A simple CMOS 4040 binary divider can be used to directly lower the output frequencies and thus lengthen the measurement period. Or half of a CMOS 4013 D-flop can be used to serve as a digital mixer or downconverter. Downconverting can give you a greater difference between minimum and maximum values. Note that creative PIC machine-language programming can eliminate the need for either of these circuits by doing the same job in high-speed internal firmware.

To build a compass, you can place one FGM-3 on some spinnable level surface. Or you might use a pair of these at right angles to each other. There is also a new dual unit called the FGM-2. This one is disk shaped, being a tad over an inch in diameter and a quarter inch thick. The free *SCL* ap notes show you simple *octant* algorithms that get rid of any fancy math.

NAMES AND NUMBERS

Andrews Decal
6559 N. Avondale Avenue
Chicago, IL 60631
Tel: 312-775-1000

Bertonee
184 High Street
7th Fl.
Boston, MA 02110
Tel: 800-510-5400

Clegg
19220 S. Normandie Avenue
Torrance, CA 90502
Tel: 310-542-1600

Instant & SC Printer
425 Huehl Rd., Bldg. 11
Northbrook, IL 60065
Tel: 708-564-5940

National Semiconductor
2900 Semiconductor Rd.
Santa Clara, CA 95052
Tel: 800-272-9959

Paper Plus
300 Oceangate #800
Long Beach, CA 90802
Tel: 213-436-8291

Pericom
2380 Bering Drive
San Jose, CA 95131
Tel: 408-435-0800

Philips Semiconductor
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Sunnyvale, CA 94088
Tel: 800-234-7381

Power Integrations
477 N. Mathilda Avenue
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Tel: 408-523-9265

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Port St. Lucie, FL 34984
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Raychem
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Synergetics
Box 809
Thatcher, AZ 85552
Tel: 520-428-4073

3M
3M Center Bldg.
St. Paul, MN 55144
Tel: 800-826-4886

Velcro Systems
406 Brown Avenue
Manchester, NH 03108
Tel: 603-669-4892

Web Master
492 Old Connecticut Path
Framingham, MA 01701
Tel: 508-872-0080

WEB Trac/LDS
571 Central Avenue
Murray Hill, NJ 07974
Tel: 800-ASK-LDSI

Specialized support chips are also available. For example, their SCL001 is for field nulling gauss meters, the SCL002 is for vehicle detectors, and the SCL006A for single-axis earth magnetometry. The *Basic Stamp* or another PIC is your obvious choice for interface and display. Stay tuned for more.

Magnetometry resources

For this month's resource sidebar, I've gathered together a few places to go for more compass info. *Dinsmore* is big on low-cost and low-resolution devices based on moving magnets and Hall sensors. *Honeywell* is into overpriced magnetoresistors. Your useful tech journals include *Sensors*, *Measurement & Control*, the *ITS World* (*Integrated Transportion Systems*), or GPS World. Books on all this are available from the *Navtech Bookstore*. I have also got some key navigation and GPS web site links up for you on my Web site, *www.tinaja.com*.

Web hits and misses

You don't have to be on the web all that long to discover that *www* means *world wide wait* and *url* stands for *utterly rancid location*. You will also see lots of people ranting and raving over the number of *hits* their site gets. Just what is a hit? Well, a *hit* is an obscenely bloated and utterly misleading measure of the supposed popularity of a web site. So much so that *hits are a totally useless index of your site's popularity!*

Unlike any book reader or a store customer, web site access gets done in bits and pieces. One web page or one file at a time. As these bits and pieces are sent, they get recorded in a pair of very important files, called the *log* file and the *error* file. Your access provider should tell you how to get at these crucial files. They are ordinary text files that can easily be copied to host. Each access is noted as a one line record of characters in the log file.

So is an access a hit? Uh, not so fast. Typical access to your home page probably also grabs some wallpaper, some buttons, and some fancy rules. Which *also* will go into your log file. Is this one hit or four? If the same visitor comes back in a few minutes, is this the same hit or a new one? Or a few hours? Or a few days?

What if the visitor is really some *spider* from a search service? Is this a hit? How many? What if you have no foreign sales or support. Do foreign hits count? What if someone takes one look at your home page and then quickly leaves?

These log files tell you about each visitor. Which pages he requested in what order. Plus how he left and any site bugs they discovered along the way. These mistakes are summarized in the separate error file.

Your simplest and cheapest way to measure site "hits" is to note the *change of size* of your log file each day. Divide by 75 to get your total number of hits. The 75 comes about because there are around seventy-five characters in an average log line. What if you want to know exactly how many left-handed Brazilian cat fanciers visit your site at 2 a.m. on Tuesdays? You can snoop around inside your log file to extract all this info. This is especially easy to hack using the general purpose PostScript computing language. Just write the file to your printer's hard disk. But any old data word processor or database tool will work.

There are quite a few sources for *hit analysis* software. One shareware location is *www.lds.com* with their *Webtrac* product. This one generates all sorts of fancy printed reports and colorful graphs and charts. Your best overall measure of the performance of your web site is how many people actually get far enough to fully download a lengthy file that you really want them to, such as a catalog or some hot new content.

All of which leads to an "exchange rate" between hits and useful visitors. For one month, a while back, when it was just starting, my new *www. tinaja.com* received some 18,000 "any page" US hits, while actually sending out 285 catalogs. My web exchange

EARTH'S FIELD MAGNETOMETRY RESOURCES

Allegro Micro Systems Box 15036 Worcester, MA 01605 Tel: 508-853-5000	**GPS World** 859 Willamette St. Eugene, OR 97440 Tel: 503-343-1200	**Magnetics Inc** Box 391 Butler, PA 16003 Tel: 412-282-8282	**Phillips Magnetics** 1033 Kings Highway Saugerties, NY 12477 Tel: 914-246-2811
F. W. Bell 6120 Hanging Moss Road Orlando, FL 32807 Tel: 407-678-6900	**Honeywell** 12001 State Hwy. 55 Plymouth, MN 55441 Tel: 800-323-8295	**Measurement & Control** 2994 W. Liberty Ave. Pittsburgh, PA 15216 Tel: 412-343-9666	**Precision Navigation** 1235 Pear Ave, Suite 111 Mountain View, CA 94043 Tel: 415-962-8777
Dinsmore Instrument 1814 Remell St. Flint, MI 48503 Tel: 313-744-1330	**ITS World** 859 Willamete St. Eugene, OR 97401 Tel: 503-343-1200	**Micro Switch** 11 W. Spring St . Freeport, IL 61032 Tel: 815-235-6600	**Sensors** 174 Concord St. Peterborough, NH 03458 Tel: 603-924-9631
Fat Quarters Software 24774 Shoshonee Drive Murrieta, CA 92562 Tel: 909-698-7950	**KVH Instruments** 110 Enterprise Center Middletown, RI 02840 Tel: 401-847-3327	**Natl. Speleological Society** Cave Ave. Huntsville, AL 35810 Tel: 205-852-1300	**TDK** 1600 Feehanville Dr. Mount Prospect, IL 60056 Tel: 708-803-6100
Ferroxcube 2001 W. Blue Heron Blvd. Riviera Beach, FL 33404 Tel: 407-881-3200	**Magnetic Research** 122 Bellevue Ave. Butler, NJ 07405 Tel: 201-838-6348	**Navtech Books & Software** 2775 S. Quincy St., #610 Arlington, VA 22206 Tel: 800-NAV-0885	**Walker Scientific** Rockdale St. Worcester, MA 01606 Tel: 800-962-4638

rate here would appear to be around 63:1.

Which leads to this rule: To find your *useful* web site visitors, divide your total hits by *sixty* or your log file characters by *4500*.

Post-it note opportunities

Making up custom ink jet or laser printed Post-it notes is an obvious local service opportunity. For higher quantities, several sources advertise in *Quick Printing* and *Instant Printer* magazines. Doing your own notes has certainly been possible, but this has been rather labor intensive.

The usual do-it-yourself ploy is to make up a carrier sheet with marked rectangles on it, stick a blank note on each one, print your sheet, and then manually stack the results into pads. Another technique is post-applying a gentle spray-on adhesive.

3M has come up with an interesting alternative that greatly reduces your custom post-it note labor and hassle, but at higher materials cost. What they have done is taken *two* sheets of paper and applied magic glue in exactly the right places. They then stuck these two sheets together with *the glue on the inside.*

You'll then print *both* sides of the sheet in some eight-up note pattern. Next, you peel each sheet pair apart, flip the bottom sheet and restick them together, which gives you a pad of 8-up note stock. Finally, you cut up the individual notepads using a paper cutter or shear. Since it is much easier to fuss with one big sheet than eight little ones, the hassles are greatly reduced.

The 3M product is called *Post-it On-Demand Notepaper*. These should be available at *Paper Plus* and other retail or direct-mail chains. Bunches of additional tech venture opportunities appear in my *Incredible Secret Money Machine II*.

New tech lit

From *National Semiconductor* comes a whole slew of fat resources. Included are databooks on *Power ICs*, *Data Acquisition*, *Operational Amplifiers*, *Analog Products*, and on *Application Specific Analog*. From *Philips Semiconductors*, a freebie—*Car Radio Designer's Guide*. From *Raychem* comes a *Circuit Protection Databook*. From *Pericom*, a new data book on high performance CMOS and BiCMOS integrated circuits is now available. Some free samples of line operated switch-mode *TOPSwitch* circuits are obtainable from *Power Integrations*, along with ap notes.

Decal papers for your own custom decals are offered by *Andrews Decal*. Free samples of *One-Wrap Straps* are available from *Velcro Systems*.

An extensive line of very low cost sound systems for greeting cards and ad specialty items are made by *Clegg Industries*. Smaller replacements for neon animation transformers are now offered by *Bertonee*. *Webmaster* is yet another of those brand new internet magazines.

For most individuals and smaller scale startups, most of the time, involvement with patents is virtually certain to end up as a *totally useless* waste of time, energy, money, and sanity. Find out why in my *Case Against Patents* package, along with tested and proven alternatives that work in the real world. It is available per my nearby *Synergetics* ad.

And don't forget that I've got a hot new Web site up at *www.tinaja.com* Your quickest way to pick up my catalogs is as *syncat01.pdf* and *surpcat01.pdf* at this location.

Finally, contacts for most of the mentioned items appear in our *Names and Numbers* or *Earth's Field Magnetometry Resources* sidebars located elsewhere in this article. Be sure to check these first. As usual, a no-charge US technical helpline is available per the *Need Help* box. Let's hear from you! EN

NEED HELP?

Phone or write all your US Tech Musings questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher AZ, 85552
Tel: 520-428-4073

US email: don@tinaja.com
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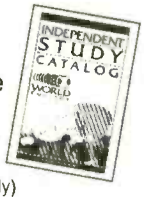

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BY JEFF HOLTZMAN

Java and the DLB

A FRIEND AND I WERE TALKING THE OTHER DAY ABOUT HOW JAVA, THE INTERNET, AND INTERNET TERMINALS ARE CHANGING THE WORLD. YOU MAY FIND PORTIONS OF OUR DISCUSSION INTERESTING. BUT I'M NOT GOING TO tell you which of us played the straight man, and which the wisecracker.

Java is a programming language. *(Another programming language!)* Java is derived from today's most popular programming language, C++. *(Big deal.)* Java is simpler than C++ because, like Basic, it has no pointers, and it does automatic memory management. *(Wow. A better Basic than Basic.)* It's also like Basic in that it is not compiled to machine language, but to an intermediate "p-code" that is subsequently executed on the run-time platform by a Java interpreter. *(Now there's a potential speed demon.)* It was created at Sun Microsystems—not Microsoft. *(Actually, that is interesting.)* As with Web-browsing technology, Java runs equally well on disparate platforms. *(Equally poorly, you mean.)*

Sun and other companies are designing Java CPU's that can execute Java p-code directly. *(Will it run on a 6502? Will there be an Amiga port?)* All the major software-tool vendors, including Microsoft, Borland, Symantec, and others, are rushing Java-development tools to market. *(So will it download nudie GIFs any faster?)*

Java was originally developed as a language to control programmable TV-set top boxes—like today's cable converters on steroids. *(50,000 channels and nothing's on.)* Even Microsoft is endorsing it—sort of. *(Deja vu all over again, Yogi?)* People are fed up with huge monolithic everything-including-the-kitchen-sink applications that gobble disk space, take forever to load, and 90% of which never gets used by 90% of the population. *(Hear, hear!)* Small Java-based programs (*"applets"*) will allow us to recover disk space, eliminate wait, and provide simplified centralized management and control over the apps. *(Who will police the Java police?)*

Then our conversation shifted to hardware, to the so-called internet terminal, *a.k.a.* network computer, *a.k.a.* simply interactive PC. The main idea is a $500 box with no disk drive and no monitor, but with built-in Internet connectivity.

Everybody knows that setting up, maintaining, and upgrading the average computer system is difficult, time-consuming, and expensive. *(Like walking and chewing gum, right?)* Corporations have difficulty showing how computers improve productivity at all, but their negative cost impact is

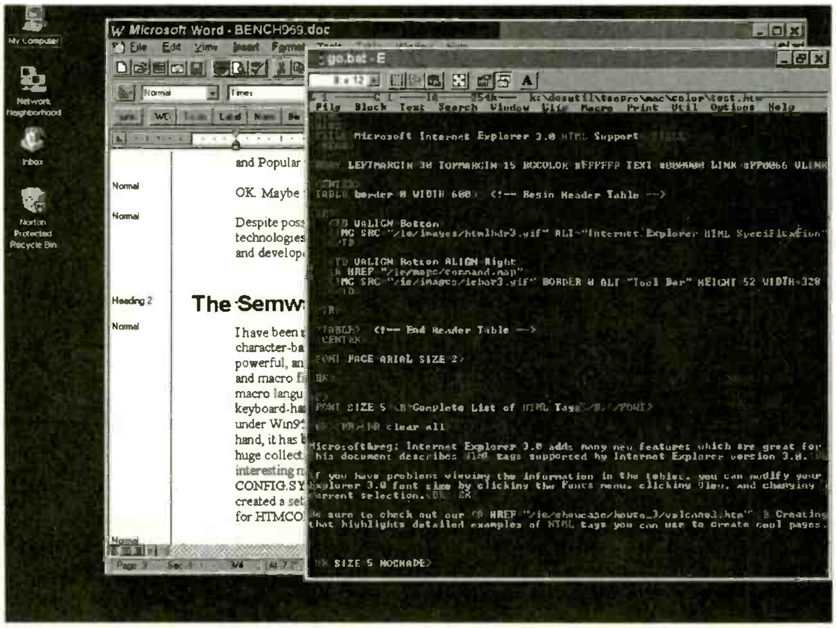

FIG.1—THE SEMWARE EDITOR (TSE) is a powerful character-mode text editor that works great for editing everything from system configuration files to HTML code to programs in C and Basic.

visible for all. *(I'm not going back to a typewriter.)*

Suppose that computers could be made truly appliance-like, even simpler than the Mac. *(And suppose we all decide to limit ourselves to whatever we managed to learn by third grade.)* Suppose they were truly plug-and-run, like toasters. No hardware upgrades or maintenance, and software that is self-healing, self-upgrading, self-maintaining. *(Because it doesn't do anything.)*

Suppose the paradigm represented by web browsers becomes the user interface—for everything. *(Suppose we stop eating protein.)* Telephones, TVs, microwaves, stereos—and computers. All have a simple point-and-click interface. People select things from lists. People accomplish tasks rather than getting mired down in how to do them. *(Gee, it's dumb and dumber.)* The focus shifts to tasks, not tools.

Anyway, that's enough dialog for now.

If Java wins

Seriously: Imagine a world with a different kind of computer infrastructure. Forget about terms like CPU, megabyte, megahertz, video adapter, serial port, network interface card, etc., etc., etc., *ad nauseam.* Think about things like screwdrivers, hammers, pliers. Dedicated tools for dedicated tasks.

By contrast, today's PC, and most of the software that runs on it, was designed from the ground up with the "Swiss Army Knife" philosophy. Everything was made as general-purpose as possible. And that was good. That's what fueled early growth of the PC industry. In fact, every attempt to decrease the general-purposeness of any part of the system was universally rejected. Early versions of OS/2 and IBM's MicroChannel-bus architecture are prime examples.

The PC also represented a sociological response to the then-centralized planning and control of computer resources. The early user said, "I don't need to wait for The Committee. I can do it myself." Now corporations are saying, "Yes, maybe you can do it yourself, but most can't, and for the sake of efficiency (read: better competitiveness in the global market—you'd rather have less control over your computer at work than no job because we're going out of business)—for the sake of efficiency, we're rescinding some of the computer freedoms you've enjoyed till now."

But now think about a Dumb Little Box (DLB), that is easily configured, maintained, and upgraded—all via remote control, *i.e.*, the network. If a box needs a new OS upgrade, it'll get it itself next the next time it logs on. Need an application upgrade? Likewise.

Some in the PC industry are threatened by the DLB. If universally adopted, it could put a lot of computer professionals out of work. It could also wreak havoc with both hardware vendors and software developers.

But let's be realistic. The DLB won't be universally adopted; it can't be. People who create—writers, engineers, analysts designers—will need general-purpose machines that can adapt to various tasks.

On the other hand, low-skill repetitive work situations would be prime targets for DLBs. For example, the DLB could displace dedicated hardware such as smart cash registers, credit-card validation systems, point-of-sale terminals, warehousing and inventory tracking, lookup devices in music and book stores, telemarketing systems, pay phones, vending-machine controls, keyless entry systems, stereo systems, TV sets, smart-home control systems, fax machines, automotive control systems, factory data-collection and monitoring systems, and on and on and on, to the point where anything that has a button or a wire becomes a target for a DLB running Java.

In this scenario, the DLB becomes truly ubiquitous, and costs plummet, unlike anything even we in the PC industry have seen so far. Gone will be all technically interesting but proprietary controllers, microcontrollers, and embedded languages like Basic, C, and Forth. Computer Science departments will stop teaching languages other than Java. Electrical Engineering departments will devise Ph.D. programs around DLB architectures.

All the major computer companies will die, as will Intel. The Far Eastern manufacturing giants (Matsushita, Hyundai, et al) will quickly settle on a few basic designs, and then shave profit margins down to nothing, in the process driving all other competition out of business.

The boxes themselves will be sealed throw-aways. They will be serviceable, but labor for doing so will be expensive, so the direction (as in all other consumer electronics the past thirty years) will be toward low-priced disposable units. Basic functionality will hardly evolve at all, but there will be thousands of packaging variations geared toward different market segments. Upgrades will be available, but ultimately more expensive than replacement systems.

The nature of all support industries will change radically. For example, all those magazines that begin with "PC" will either go out of business or imperceptibly morph into "DLB" mags.

Despite possible abuses, there is potential for evolving lots of overlapping, redundant technologies toward a single architecture with cost savings for all—consumers, manufacturers, and developers. This may be interesting. Or it may fizzle. Time will tell.

Product watch

I have been meaning for months to work in a mention of this little gem. The SemWare Editor is a character-based text editor that traces its heritage to the shareware product Qedit. It's small, fast, powerful, and configurable. The program consists of a run-time engine plus user-interface, help, and macro files, all of which can be combined and "burned in" to a single executable file. The macro language is like a forgiving version of Pascal, with lots of built-in screen-handling, keyboard-handling, and text-manipulation functions.

The program runs fine in a DOS session under Win95 and NT, except that the current version cannot handle long filenames. On the other hand, it has built-in support for cutting to and from the Windows clipboard. And on a 1024 × 768 monitor, running it in a 50-line DOS box is nice, nicer in fact as a window than in full-screen DOS 50-line mode (better fonts).

TSE comes with a huge collection of macros, and more are available through various on-line sources. One interesting macro does color-coded syntax highlighting, with setup files for batch file commands, CONFIG.SYS commands, Basic, dBase, FORTRAN, Modula, Ada, Pascal, and other languages. I created a setup file for HTML commands, valid up through but not including HTML 3.2. Look for HTMCOLOR. TSE on the Gernsback BBS (516-293-2283), and elsewhere. In this color scheme, tags appear in magenta, attributes in gray, entities in green, and other text in cyan. I also implemented a news net browser that allows me to quickly scan news files, delete items I'm not interested in, and save the remainder. TSE comes with extensive documentation on the macro language, and has a well-done hypertext help system.

Another must-have shareware-derived gem is Paint Shop Pro. For capturing screens, converting among bitmap file formats, and general bitmap manipulation, it's extremely powerful, easy to use, and bargain priced. The latest version (3.12) is fully 32-bit. It includes an extensive collection of filters for creating special effects, and is also compatible with an even wilder set of special effects filters, Kai's Power Tools. (In fact, JASC provides a bundle of PSP and KPT for under $100.)

Kai's Power Tools takes advantage of the "plug-in" architecture devised by Adobe; this system allows tools to integrate seamlessly with bitmap editors to provide special effects. KPT is the leading special-effects generator, and Version 3 of the package will knock you out with some of the things it can do. It also has a very interesting and original user interface.

JASC also sells a multimedia cataloging utility called Media Center, and another program for creating stand-alone multimedia presentations called Illuminatus. All are low-priced, well-done utilities, and they're available in various bundles. Trial versions are also available on CompuServe and other on-line services.

PowerDesk is the name of a Win95 shell utility. It actually consists of two components: a pop-up toolbar, and an enhanced version of the Windows Explorer.

The toolbar component allows you to add your own icons for single-click launching of your favorite apps. It also includes a clock and various system-resource monitors. The whole thing is extremely configurable so you can run just the components you need.

The enhanced explorer provides built-in file viewing and ZIP file handling. In fact, it displays ZIP files just like ordinary directories, allowing you to drag and drop files in and out of ZIPs. It's slower than dedicated ZIP utilities like WinZip, but, for most uses, it's good enough. The viewer technology allows you to view most common file formats intact, and an enhanced version is available from a third-party organization. A 30-day trial version is available on CompuServe. EN

RESOURCES

PaintShop Pro ($69 or $99 with KPT), Media Center ($39), Illuminatus ($149)
JASC, Inc.
P.O. Box 44997
Eden Prairie, MN 55344
Tel: 612-930-9171
CIS: Go JASC

Kai's Power Tools 3 ($199)
MetaTools, Inc.
6303 Carpinteria Ave.
Carpinteria, CA 93113
Tel: 805-566-6200.

The SemWare Editor Professional v2.5 ($109)
SemWare Corporation
4343 Shallowford Road
Suite C3A,
Marietta, GA 30062-5022
Tel: 800-467-3692 or 770-641-9002
CIS: Go SEMWARE

PowerDesk ($49.95)
MicroHelp, Inc.
4211 J.V.L. Industrial Park Dr., NE
Marietta, GA 30066-2789.
Tel: 800-922-3383 or 770-516-0899
CIS: Go MICROHELP.

BY CARL J. BERGQUIST

Lasers in security systems

ONE AREA WHERE LASERS CAN BE EXTREMELY VALUABLE IS IN SECURITY. THERE ARE A VARIETY OF WAYS TO USE THEM TO MONITOR PROPERTY AND DELIVER SOME PEACE OF MIND TO THE PROPERTY OWNER.

But, before we can use lasers in such applications, we need some type of laser "sensor." Figure 1 shows a very simple, two-transistor relay circuit that does that job very well. The relay in that circuit activates whenever phototransistor Q1 is not illuminated; that is, whenever the laser beam projected on the sensor is broken by something moving through its path. Once assembled, the relay circuit could be used to trigger whatever alarm system you require.

What kinds of alarms can be triggered? Well, Fig. 2 presents some possibilities. For example, in addition to a standard audio alarm, the relay circuit can be used to trigger a camcorder or a closed-circuit-television surveillance system. The relay can also be used to turn on lights, activate solenoid-driven door or window locks, and more. The number and variety of possibilities are limited only by the user's needs and imagination. If you can come up with something a little on the unusual side, why not send them to Laser Editor, **Electronics Now,** 500 Bi-County Blvd., Farmingdale, NY 11735, or to the editor's e-mail address: Lartronics @aol.com.

Some security applications

Our first application uses a laser as a room-entry alarm. Arrange the laser so its beam crosses the entrance to the room and shines on the phototransistor. Whenever the beam is broken, either by the door opening or someone coming into the room, the relay closes and activates the attached warning device. Incidentally, that is the way that most of the security systems discussed in this month's installment function.

In the same fashion, the room can be protected by projecting the beam across it. Any movement within the room that breaks the beam sets off the alarm. To fully cover the entire room, add several small front-surface mirrors. Position them to bounce the beam back and forth until the room is filled with beams of laser light that are two to three feet apart. Also, vary the height of the beam. Remember, unless the beam contacts smoke, dust, or something similar, it is virtually invisible except where it reflects.

WARNING! ! !

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The next application is a perimeter alarm. Often used to monitor a fence or wall surrounding a business or house, such a system could also be used to protect an interior room. A typical outdoor application is shown in Fig. 3. As you can see, that example also uses the mirror-reflection technique. The laser and the relay circuit are placed approximately as shown and the beam is aimed at the first mir-

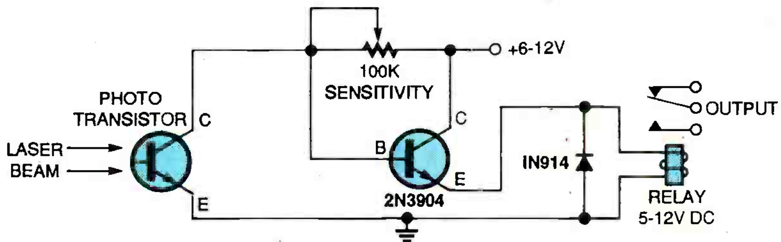

FIG. 1—TWO-TRANSISTOR RELAY CIRCUIT will activate whenever the phototransistor is illuminated by the laser beam.

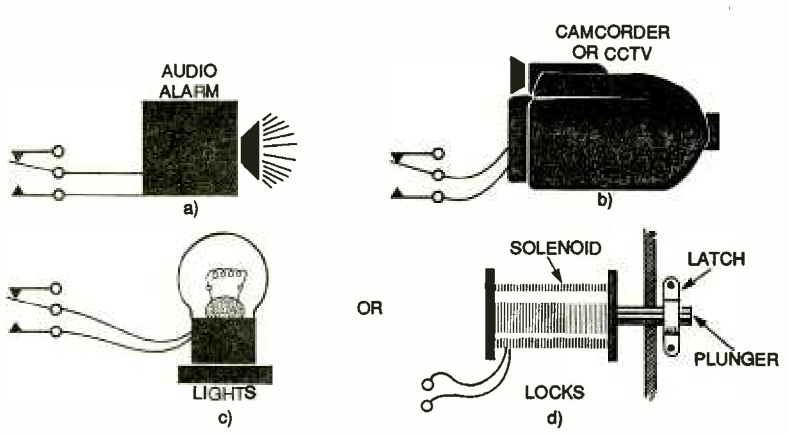

FIG. 2—FOUR DIFFERENT TYPES of alarms or devices: An audio alarm (a), a camcorder or CCTV camera (b), lights (c), and a solenoid operated lock (d).

ror. Additional mirrors are placed at each turn in the fence. The angle of each mirror is adjusted so that the reflected beam from one is aimed at the center of the next. In that way the laser beam travels the entire perimeter of the fence, and finally reflects back into the relay's phototransistor detector.

Since this is an outdoor assembly, the laser, relay circuit, and the mirrors must all be protected from the weather. If possible, locate the laser and the relay circuit inside the protected structure as shown. If that is not possible, keep it under some kind of cover to protect it from the weather. You also need to shelter the mirrors from the elements. Do that by placing them inside small housings that have openings for the beam. A spray coat of clear polyurethane can be applied to each front-surface mirror to provide additional protection.

The mirrors themselves can be either front- or rear-surface types, and should be about one inch square or larger. Mount them securely, but not too close to the protected fence. That will minimize false alarms from fence movement caused by wind or other vibration. Once the alarm system is in place and activated, anything that interrupts the light triggers the relay.

Incidentally, note the gate in the fence. Here the alarm doubles as a gate monitor. Again, the relay circuit can be interfaced to any number of alarms or devices depending upon your needs.

High sensitivity relay circuit

While the relay circuit shown back in Fig. 1 will be more than adequate in most cases, sometimes an application requires a sensor with a higher level of sensitivity. That can be done by adding an operational amplifier in series with the phototransistor detector. In the schematic of Fig. 4, an NE5534 low-noise op-amp is used to boost the gain.

The high-sensitivity relay circuit allows you to use lasers in even more security applications. For example, by reflecting the beam off the bumper of an automobile, then back into the relay, any vibration caused by entering or exiting the vehicle activates the relay. Select a fairly sharp curve on the bumper surface as the laser target; that will exaggerate any movement in the bumper, allowing the alarm to pick up even slight movements.

By using a piece of reflective Mylar mounted on a spring, you can monitor isolated areas for loud or inappropriate noise. Unattended rooms can also be "watched" for telltale smoke that might be a sign of fire. Aim the laser at the high-gain relay, either directly or by reflection, and adjust the sensitivity control, R1, to just activate the contacts. Back the control off just enough to reopen the relay. Now when smoke passes between the beam and the detector, the alarm will energize.

Another possible application is to detect flooding in a room or basement. Fashion a simple float by cementing a small piece of reflective Mylar to an ordinary cork that has a vertical hole drilled through the center. Place the hole in the cork on a spindle (the straight section of a metal coat hanger could serve for that) so it can move freely. Position the assembly in a low-lying area on the floor. Now reflect the laser beam off the Mylar back into the detector of the relay. If water floods the room, the cork will

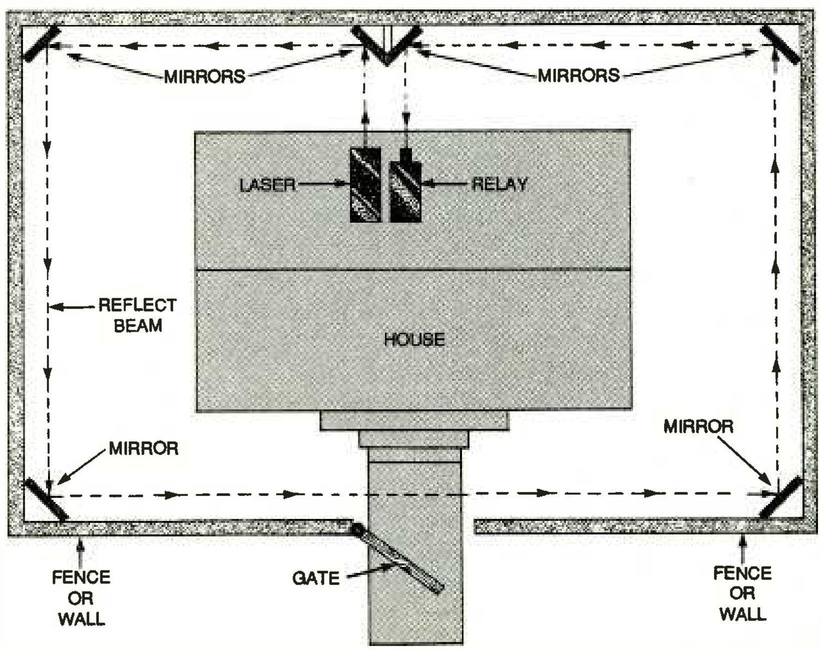

FIG. 3—IF YOU WANT TO USE THE LASER as a part of a perimeter alarm system, this is one way you can do it.

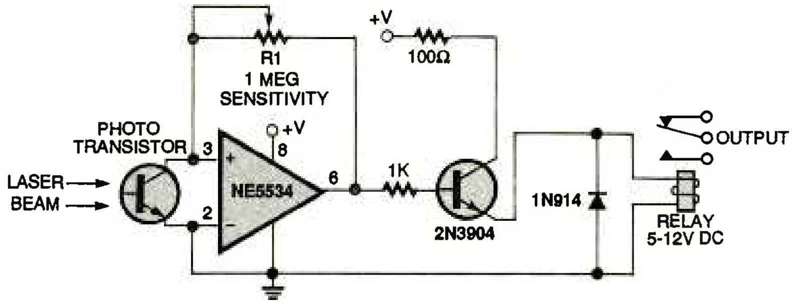

FIG. 4—FOR GREATER SENSITIVITY, add a low-noise op-amp to the relay circuit.

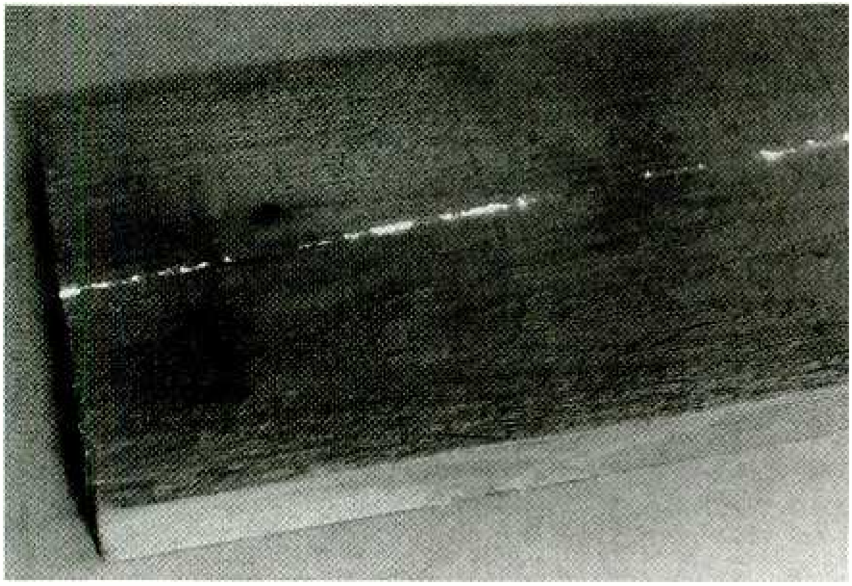

FIG. 5—USE A LASER BEAM TO DETECT high and low spots across a wood plank. The laser beam appears in this photo as a white streak across the board.

float, lifting the Mylar out of the laser beam, and activating the alarm.

These are just a few ideas along the lines of security. I am sure you could come up with even more.

Construction and surveying

One industry where lasers are used frequently is building construction and associated landscaping. The laser is an almost perfect straight edge, as the beam is extremely true even at long distances. Leveling soil beds or foundations, laying straight pipelines, keeping fences and/or walls in line, checking boundaries, and verifying angles on roofs and other structural details are all areas where construction crews use lasers to provide more accurate results. One experiment that illustrates the principle of using the laser in this way is to test the straightness of a piece of wood (see Fig. 5).

Align the wood so the edge of the beam barely illuminates the edge of the plank. A bright red line will appear wherever it encounters the same depth. That will indicate the "high" level of the surface. Now, introduce smoke, fog, or even a mist of fine powder (talc), and the full beam will become visible, pointing out the "low" level of the surface. A quick comparison will disclose how straight that piece of wood really is. Use the same technique to check walls, roofs, foundations, or any other section of a structure.

You can apply the same principle to ensure a correct angle across a wide section of wood that is to be cut. Measure the piece for the leading cut. Start the beam at that point and, with the help of a protractor, align the beam to the correct angle. On the far side, place a piece of cardboard against the edge of the wood and mark where the spot hits. By connecting the two markings, the guideline for the properly angled cut is also marked. EN

TONAL VOLTMETER

continued from page 61

case with the ink cartridge removed. The probe tip can be any sharpened length of metal wire, such as a wire-wrap IC socket pin or small nail. Make the connection between the probe and pin 9 of IC1 with a length of shielded cable.

Any 5-volt DC supply is suitable for this project, either batteries or an AC adapter. Use whatever power supply is most convenient and least expensive for you. Mount the finished circuit in an enclosure that will protect it and you are done.

To adjust the two potentiometers in the circuit, first ground the probe tip and adjust R2 for the lowest tone desired. Then connect the probe tip to +5 volts and adjust R1 for highest tone desired. Adjust R3 to increase or decrease the speaker volume if necessary. Ω

SPECTRUM ANALYZER
(Continued from page 39)

bus with other 100,000-ohm resistors (R7, R10, R13, R16, R19, and R23). Because each stage is an inverter, there are two summing buses; with one for the "evens" and one for the "odds" of the seven stages. Those buses sum signal samples from each of the series-strung stages described above. Once a stage saturates, its output is limited, and it contributes no more to the summation. Thus, as the stages progressively saturate with increasing signal input, the summing buses appear to have less and less gain in front of them.

Each stage within the chain comes into saturation (limiting) very smoothly; there is no sudden "corner" in the individual stage transfer functions. This smoothness is due to the way the CMOS inverters behave. The overall effect is a smooth logarithmic amplifier performance.

Because of the "even-odd" signal collection on the two buses, it is necessary to invert the signal on one so that both are in phase and ready to be totaled. This is done with IC2-d and emitter follower Q1. The signal at the emitter is now in phase with the signal on the other summing bus. The two bus contributions are finally summed in IC2-e and Q2, which form the final output stage of the log amplifier. The transfer function slope (mV/dB) constant is set with resistor R28.

The signal input to the log amplifier is a symmetrical heterodyne "bubble" of sinusoidal signal that consists of positive and negative swings around a baseline. Because spectrum analyzer displays are unipolar (one signal polarity), output stage IC2-e is bias-offset with resistors R26 and R27. This clips the negative going spectral line spikes and so only positive going ones are displayed on the oscilloscope. Finally, input gain trimmer R2 sets the smallest signal at which logging begins, so that logging does not occur on baseline noise but rather just above it.

This completes the theory discussion for the HSA and pretty much all the space we have for this month. Next time, we will get right to work on showing you how you can build your own under-$100 spectrum analyzer. Ω

DECISION MAKER
(Continued from page 42)

neath the LED cap, and about 3/16-inch from the bend to the end of the leads. Don't trim the LED leads until after you have soldered them in place.

First, mount all components except the LEDs. Use a socket for the microcontroller, but don't install that IC yet. Next drill the holes for the LEDs and the start switch in the enclosure's cover, using the template in Fig. 5 as a guide.

Now place the PCB in a pair of slots along the side of the enclosure and bend the leads of a single LED. Insert the LED into the board and tack-solder one lead. Temporarily place the cover on the enclosure to check lead length. If the cover fits properly, finish soldering the LED, then bend the remaining LEDs to fit, and solder them in. Otherwise, adjust the bend in the first LED and try again.

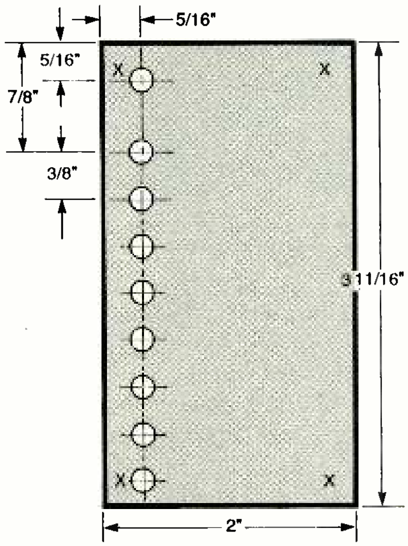

Fig. 5. Here's the hole template for the cover. Nine holes are required, eight for LEDs and one for the start switch. The power switch mounts on the upper end of the case.

To keep the front panel as clear as possible, we mounted power switch S2 in the side wall of the narrow end of the enclosure. We used a low-cost, low-profile slider for S2.

Test and final assembly. After completing construction, but before installing the microcontroller, let's do a few simple tests to ensure that everything is working properly.

Apply power to the circuit by closing S2. The battery voltage should now appear at the input of regulator IC2, and a constant 5-volts should appear at its output. The same voltage should appear at pin 13 of IC1's socket (remember, we have not installed that IC as of yet), at the anode of each LED, and at the buzzer.

Next, with power still applied, use a short jumper wire to short pin 3 of IC1 to ground (pin 14). That should cause the buzzer to sound. Also try grounding pins 5–12 of IC1. Each LED should light in turn. If LED4 does not light, put JU2 in the other position.

The last test verifies operation of S1. Connect your voltmeter between pin of IC1 and ground. When the switch is open, the meter should read +5-volts DC, but when closed it should read zero.

After verifying operation of all components, remove power and install the 68HC705K1 into its socket. Then reapply power. You should see and hear the initialization sequence, after which the unit is ready for use.

The label. The most difficult (and the most fun) part of this project is creating the front panel label. Self-stick labels work well in this application; you can also use heavy stock and rubber cement.

The author created a template file in Word for Windows that allows you to format labels precisely. One is shown in Fig. 1, and another in the lead photo for this article.

Customization is the key to transforming this project from simple blinking lights into a memorable gift. When creating the label, it's best to focus on either the personality quirks of the recipient or on the general humor of the situation. Ask yourself questions like: What things does this person like and dislike? When is he or she the least decisive? Are there any stereotypes concerning the new situation he will soon be in? As soon as you start letting the creative juices flow, you can have a lot of fun. Ω

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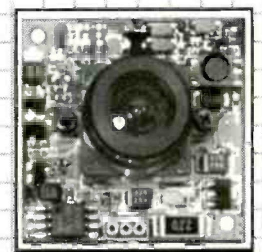

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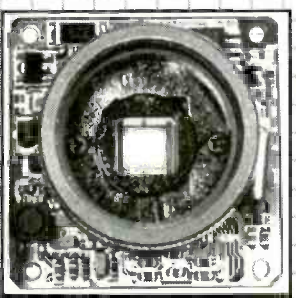

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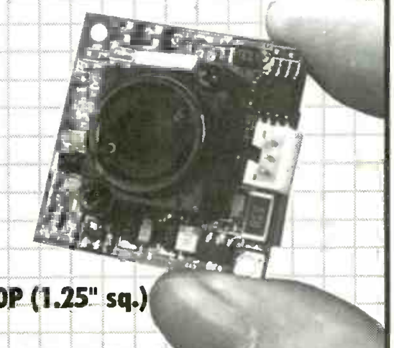

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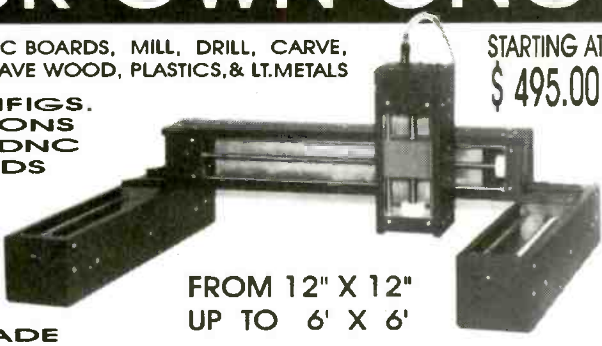

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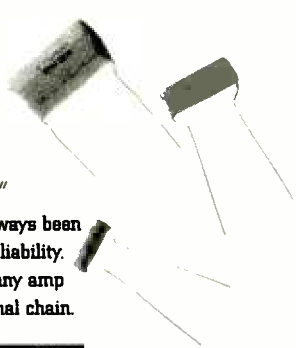

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.0047UF/600V	.49	.38	.34	.31
.01UF/600V	.50	.45	.40	.35
.015UF/600V	.65	.50	.42	.38
.022UF/600V	.68	.55	.46	.39
.047UF/600V	.80	.65	.59	.52
.068UF/600V	.95	.80	.74	.69
.1UF/600V	1.05	.92	.83	.74
.15UF/600V	1.40	1.25	1.05	.95
.22UF/600V	1.90	1.55	1.35	1.24
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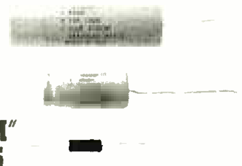

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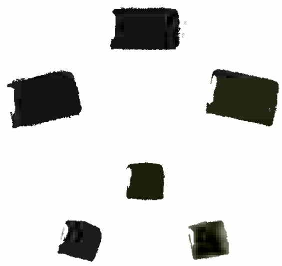
20UF/500V	3.70	3.40	2.80	2.55
20UF/600V	6.70	6.20	5.90	5.65
25UF/25V	.80	.75	.70	.65
25UF/50V	.85	.79	.73	.69
40UF/500V	4.95	4.35	3.80	3.15
50UF/50V	.90	.83	.77	.73
80UF/450V	5.50	4.80	4.20	3.70
100UF/100V	1.75	1.55	1.35	1.30
100UF/350V	4.45	4.05	3.65	3.25
100UF/450V	6.90	6.10	5.50	4.70
250UF/25V	1.25	1.10	.95	.85



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.01UF/630V	.30	.24	.20	.17
.022UF/630V	.35	.26	.22	.19
.047UF/630V	.42	.36	.30	.26
.1UF/630V	.46	.40	.34	.30
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100UF/450V	3.90	3.25	2.95	2.82
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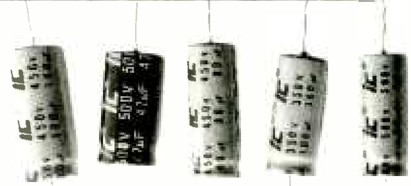

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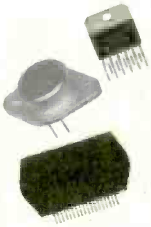

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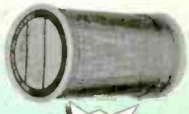

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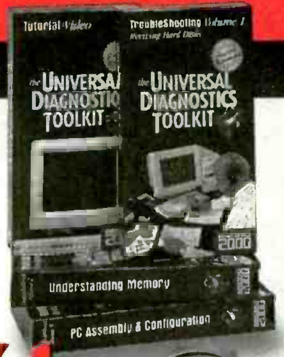

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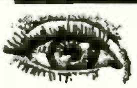
Includes: • 20 character dot matrix display with full alpha-numeric capability • keypanel with full alpha-numeric entry • separate 7.5 VDC/0.5 Amp power supply • standard telephone interface extension cord • lithium battery and flat-cone speaker.
HP bar code wand (HBCS 2300)......................$25.00

POWER SUPPLYS

SWITCHING POWER SUPPLYS $12.00 or 2 for $20.00 115/230 Volts
73 WATT (2) 4 pin power connectors attached • Dim: 8.5" L x 4.5" W x 2" H
Output: +5V @ 2-9.75, A, +12V @ 0-1.5 A, -5V @ 0-0.4 A, -12V @ 0-0.5 A
68 WATT Dim: 5.5" L x 3.2" W x 1.7" H • Output: 5V @ 4 A, 12V @ 4A
60 WATT Dim: 8¾ x 4½ x 3 • Output: 5V @ 6A + 12V @ 1A - 5V @ 1A - 12V @ 1A

CHARGE COUPLED DEVICES



"The Spy In The Sky" $29.^{00} — **MATRIX TYPE**

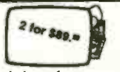
Sony CCD Imager - designed for black and white composite video cameras. Picture elements: 384 (H) x 491 (V)
Chip size 10.7 (H) x 9.3 (V) mm² • Unit cell size 23.0 (H) x 13.4 (V) um². Ceramic 24 pin DIP package • Mfr: Sony, Part# 016AL

LINEAR TYPE
4096 element CCD $19.00
1024 element CCD $15.00
2048 element CCD $15.00 • 1728 element CCD $15.00

MONITORS

Non-Enclosed TTL
Comes with pinout. 12V at 1.4 Amp input • Horizontal frequency 15Khz. • Ability to do 40 and 80 column.
5 inch Amber $29.00 • 7 inch Amber $39.00
9 inch Amber or Green $29.95

5" COLOR MONITOR $49.^{00}



• Flat Faceplate • 320 x 200 Dot Resolution • CGA & Hercules Compatible
• 12 VDC Operation • 15.75 KHz Horiz. Freq. • 60 Hz Vert. Sync. Freq.
• Open Frame Construction • Standard Interface Connector • Degaussing Coil included • Mfr. Samtron

MISCELLANEOUS

ADAPTEC 4070A (RLL) OR 4000A (MFM), SCSI Controller, your choice $25^{00}

IBM 370 option XT and AT emulation boards $35^{00}

HACKER CORNER

POINT OF SALE BANK TERMINAL $69^{00} or 2 for $129^{00}
• LCD Display 20 Char. x 4 Line • Printer 16 Column Dot Matrix - Epson • 24 Key Domed Membrane Keypad • Intel 80C32 Processor • 2 PCMCIA Sockets (ICC Slots) • Dallas DS1287 Realtime Clock • 2 Solid State Buzzers (Piezo Electric) • 4 Crystals • Rockwell Modem Chip • Telephone Line Interface (4 Pin "RJ" Connector) • RS-232 Interface (8 Pin "RJ" Connector) • NI-CAD Battery Pack Inside
Note: We have not been able to bypass an access code in the software. Thus, while time of day and other introductory things are displayed on LCD, the full original capabilities of this unit cannot be guaranteed. Also, we do not have a source for the smart cards that were to go in the PCM CIA sockets. Requires 12 volt adapter for power. (Not included) Dimensions: 9-1/2L x 6-1/4W x 2-1/2 D • Original cost over $450.00

CAMERA BLOCK $149^{00}
FOR ROBOTICS AND EVERYTHING ELSE
Unit is for Hi Band 8mm CamCorders, includes 8X zoom lenses, D/D converters, built-in CCD 2/3 in, 420 thousand picture elements, complementary mosaic filters. Excellent performance. High resolution, high sensitivity, low lag, low smear, good color reproduction, no distortion, 1/60-1/10000sec variable speed digital shutters, TTL auto focus, auto white balance, one-push auto white balance, auto/manual iris and gain up switch. Can be controlled by a 4bit micro computer. Remote controlling is possible for zoom and focusing. **NOTE:** These are PAL (European Standard) Units. **SONY PART #EVI-101 (PAL)**

CELL SITE TRANSCEIVER $79^{00} 2 for $149^{00}
These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030-889.980 MHz with the receive channels 45 HMz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other interface requirements for operation are 26 VDC (unregulated) and on 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receivers, exciter, synthesizer, tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions included.

Encased Black & White Composite CCD Camera with Adapter
IR viewing to 1000 nm 7 ½ L x 2 ¾ W x 1 ¾ H
Comes complete with CCD camera, mounting nut on bottom of casing, 12VDC power supply. Excellent low light capability, standard RCA NTSC video out. **$89.00**
Great for: entryway security/remote monitoring, video conferencing/desktop video conferencing **2 for $159.00**
This miniature camera is perfect for multimedia computer applications as well as security and surveillance. NTSC output allows use with all popular video digitizing boards for Apple Macintosh and Microsoft video for Windows. Connects directly to any composite monitor or VCR with "video" input. Its razor-sharp wide-angle lens focuses from two inches to infinity and its state-of-the-art CCD technology accurately captures 16 level grayscale images for Quick Time movies and still pictures. Records at 30 frames per second and 260 lines resolution with excellent low light capability. Uses 12VDC (adapter supplied) and standard RCA cable.

Portable Micro Terminal $99.^{00} or 2 for $149.^{00} SOLD OUT

Flip up LCD display (9-16 VDC) • Can communicate with any computer having RS 232 port • Can communicate with another Microterminal ... microprocessor, data RAM (32K) and Video RAM (64K) • ... and set up capabilities. • Original intention for POS applications. • display size 40x16 (256 x 128 pixels.) Dimensions: 6.3" W, 11"L, 2"H. (With LCD up height is 7.1")

BAREBONES 286-12 COMPUTER $49.00 (2 FOR $79.00)
Slimline desktop case, 100 watt supply, math co-processor support. On board IDE, & Floppy controllers. 2 COM ports and 1 parallel port with software setup. Supports up to 8 Megs using standard 30 PIN SIMMs. Internal room for (1) 3 1/2 inch IDE hard drive and (2) 3 1/2 inch floppies. Four 16 BIT ISA slots, accepts full length AT size cards. Keyboard can be set to no test at boot. Case size is 15.5'W x 16'D x 4"H.
(Motherboard can be purchased separately: $29.00 or 2 for $49.00)

.6" COMPOSITE MINIATURE COLOR DISPLAY $149.^{00}
Fully encased. Dim: 1.3" x 1.3" x 4". 12 Volts DC power. NTSC signal. 250 H x 300 V resolution. Focus adjustable eyepiece. Applications include camcorder viewfinder, helmet mounted display, etc... Original cost over $600.00

23605 Telo Ave., Torrance, CA 90505
Order desk only: **USA: (800) 872-8878 CA: (800) 223-9977**
L.A. & Technical Info: **(310) 784-5488** Fax: **(310) 784-7590**
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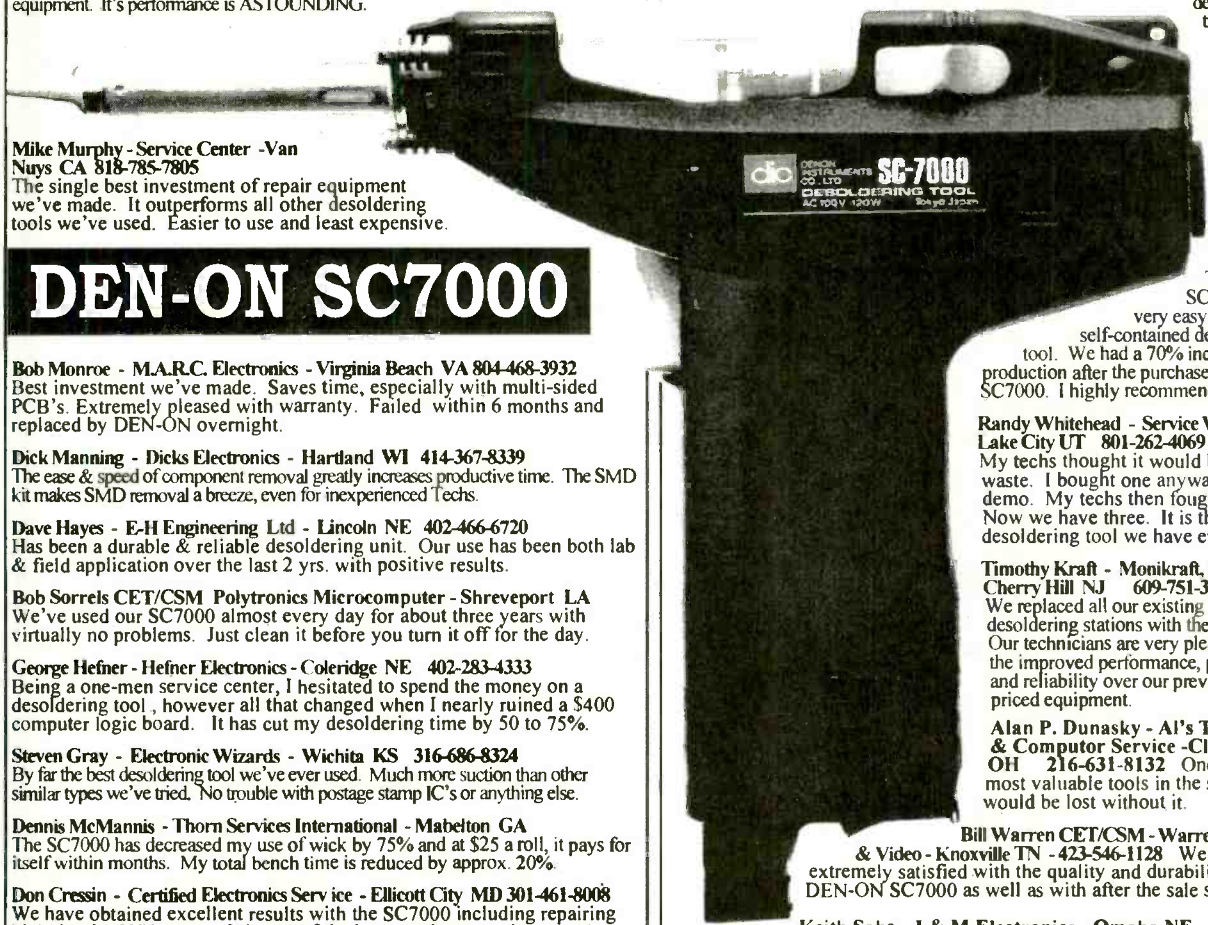
Minimum Order: $20.00. Minimum shipping and handling charge $5.00. We accept cashiers checks, MC or VISA. No personal checks or COD's. CA residents add 8.25% sales tax. We are not responsible for typographical errors. All merchandise subject to prior sale. Phone orders welcome. Foreign orders require special handling. Prices subject to change without notice. 20% restocking fee for returned orders.

CIRCLE 275 ON FREE INFORMATION CARD

PROFESSIONAL DESOLDERING with the

Lane Norman - Normans Electronics Inc. Atlanta GA 404-451-5057
A cost effective solution to desoldering equipment at less than half the price of most equipment. It's performance is ASTOUNDING.

Harold Smedberg - Smedberg Electronics - Custer MI
The SC7000 has reduced my damage to PC boards by 90%. It has also decreased my desoldering time by 50%. The best priced tool on the market.



Mike Murphy - Service Center -Van Nuys CA 818-785-7805
The single best investment of repair equipment we've made. It outperforms all other desoldering tools we've used. Easier to use and least expensive.

Tom Mullett - JC Penny TD&S - Wausatose WI 414-259-2486
The SC7000 is a very easy to use, self-contained desoldering tool. We had a 70% increase in production after the purchase of the SC7000. I highly recommend it.

DEN-ON SC7000

Bob Monroe - M.A.R.C. Electronics - Virginia Beach VA 804-468-3932
Best investment we've made. Saves time, especially with multi-sided PCB's. Extremely pleased with warranty. Failed within 6 months and replaced by DEN-ON overnight.

Dick Manning - Dicks Electronics - Hartland WI 414-367-8339
The ease & speed of component removal greatly increases productive time. The SMD kit makes SMD removal a breeze, even for inexperienced Techs.

Dave Hayes - E-H Engineering Ltd - Lincoln NE 402-466-6720
Has been a durable & reliable desoldering unit. Our use has been both lab & field application over the last 2 yrs. with positive results.

Bob Sorrels CET/CSM Polytronics Microcomputer - Shreveport LA
We've used our SC7000 almost every day for about three years with virtually no problems. Just clean it before you turn it off for the day.

George Hefner - Hefner Electronics - Coleridge NE 402-283-4333
Being a one-men service center, I hesitated to spend the money on a desoldering tool , however all that changed when I nearly ruined a $400 computer logic board. It has cut my desoldering time by 50 to 75%.

Steven Gray - Electronic Wizards - Wichita KS 316-686-8324
By far the best desoldering tool we've ever used. Much more suction than other similar types we've tried. No trouble with postage stamp IC's or anything else.

Dennis McMannis - Thorn Services International - Mabelton GA
The SC7000 has decreased my use of wick by 75% and at $25 a roll, it pays for itself within months. My total bench time is reduced by approx. 20%.

Don Cressin - Certified Electronics Serv ice - Ellicott City MD 301-461-8008
We have obtained excellent results with the SC7000 including repairing high density U/V tuners. It is one of the best purchases we have made.

Doug Pettit - LuRay Electronics - LuRay VA 703-743-5400
We found that the SC7000 not only saves money vs. wick, but saves valuable time in troubleshooting. It allows you to be more accurate in removing SMD's.

Paul Horvat - Service Excellence Inc. - Bergenfield NJ 201-387-7776 It has made a almost impossible job (desoldering a 64 pin CPU) a piece of cake.

Randy Whitehead - Service West - Salt Lake City UT 801-262-4069
My techs thought it would be a waste. I bought one anyway after a demo. My techs then fought over it. Now we have three. It is the Best desoldering tool we have ever used.

Timothy Kraft - Monikraft, Inc. - Cherry Hill NJ 609-751-3252
We replaced all our existing desoldering stations with the SC7000. Our technicians are very pleased with the improved performance, portability, and reliability over our previous higher priced equipment.

Alan P. Dunasky - Al's TV, VCR, & Computor Service -Cleaveland, OH 216-631-8132 One of my most valuable tools in the shop. I would be lost without it.

Bill Warren CET/CSM - Warrens Audio & Video - Knoxville TN - 423-546-1128 We have been extremely satisfied with the quality and durability of the DEN-ON SC7000 as well as with after the sale support.

Keith Sahs - J & M Electronics - Omaha NE 402-291-7100 It's a must tool for my bench. I can desolder multiple pin IC's quickly and clean. It will even take up large solder amounts on tuner and case grounds.

Ray Wurmnest - Ray's Electronics, Inc.-Bloomington IL 309-829-3238
The SC7000 saves time when changing out parts in the home or in the Service Center — Worth every penny we spent.

Specifications

- Totally Self Contained diaphragm vacuum pump and AC motor for high vacuum suction or reversible hot air blow for SMD removal.
- 100Watt Ceramic heater with zero-crossover switching heater control circuit which prevents spikes and leakage currents.
- Unique patented long lasting filter cartridge design. Solder builds up on easily cleaned baffle, while air flows around the outside of baffle.
- Totally ESD Safe. The housing contains carbon and the tip is at ground potential for complete ESD Protection.
- Maximum vacuum of 600mmHg is attained in 0.2 seconds.
- Temperature adjustable from 300°C - 450°C or 572°F - 842°F

FREE TRIAL
Available on Request

Industrial User Price $550.00
Our Regular Price $445.00

Sale Price $395.00

Limited Supply at Sale Price

Price includes Stand, two extra filter cartridges, tip wrench and tip cleaner.

Visa - M/C - Discover - American Express - Terms to Qualifying Companys
30 Day Money Back Total Satisfaction Guarantee - One Year Parts and Labor Warranty

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CIRCUIT SPECIALISTS INC.

Check Out What We Have To Offer:

Fantastic DMM Offer!!!

Don't let the price fool you. This meter is a digital multimeter designed for engineers and hobbyists. Equipped with 5 functions and 19 ranges. Each test position is quickly and easily selected with a simple turn of the FUNCTION/RANGE selector rotary switch. ***Rubber Boot Included***

General

Display: 3-1/2 Digit LCD, 21mm Figure Height with Automatic Polarity

Overrange Indication: 3 Least Significant Digits Blank

Temperature for Guaranteed Accuracy: 23°C±5°C RH<75%

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(NEDA1604)

Low Battery Indication: BAT on Left of LCD Display

Dimensions: 188mm long x 87mm wide x 33mm thick

Net Weight: 400g

Our Best Offer Ever on a High Quality Full Sized DMM

$19.00 any qty

DC Voltage (DCV)

Range:	Resolution:	Accuracy:
200mV	100μV	±(1%rdg+2dgts)
2000mV	1mV	
20V	10mV	
200V	100mV	
1000V	1V	

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

Range:	Resolution:	Accuracy:
200μA	100nA	±(1.2%rdg+2dgts)
2000μA	1μA	
20mA	10μA	
200mA	100μA	
10A	10mA	±(1.2%rdg+2dgts)

Overload Protection: mA Input. 2A/250V fuse.

AC Voltage (ACV)

Range:	Resolution:	Accuracy:
200V	100mV	±(1.2%rdg+10dgts)
750V	1V	

Frequency Range: 45Hz-450Hz

Maximum Allowable Input: 750V rms

Response: Average Responding. Calibrated in rms of a Sine Wave.

Resistance (Ω)

Range:	Resolution:	Accuracy:
200Ω	100mΩ	
2000Ω	1Ω	
20KΩ	10Ω	±(1.2%rdg+2dgts)
200KΩ	100Ω	
2000KΩ	1KΩ	
20MΩ	10KΩ	±(2%rdg+10dgts)

Maximum Open Circuit Voltage: 2.8V

Diode Test

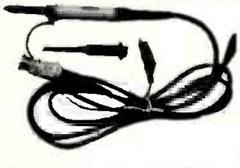
Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

hFE Test

Measures transistor hFE.

CAT NO	DESCRIPTION	PRICE
9300G	Rugged High Quality DMM with Rubber Boot	$19.00

Switchable Scope Probe Sets



(Selectable X1/Ref/X10) These high quality scope probe sets are for oscilloscopes up to 60MHz (model HP9060) or 150MHz (model HP9150). Both sets include a handy storage pouch and include an IC test-hook adapter for the probe. The BNC connector rotates to avoid cable tangle or kink. Cable length is 1.4 meters.

CAT NO	DESCRIPTION	PRICE EACH 1	10	100
HP-9060	Scope Probe Set DC~60MHz	$16.49	$14.49	$11.58
HP-9150	Scope Probe Set DC~150MHz	24.95	21.95	18.62

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

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114	114mm x 185mm/4.6" x 6.6"	2.98	2.45	1.98
PP152	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10

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

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114	114mm x 185mm/4.6" x 6.6"	4.80	3.49	3.20
GS152	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80

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

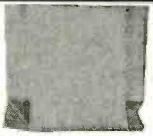
CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114	114mm x 185mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30

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.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3	Makes 1 pint	$3.50	$2.75

Developer



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

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

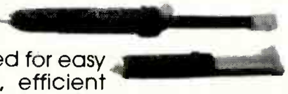
Etching Tank

This handy etching system will handle PC boards up to 8"x9", 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!

REDUCES ETCHING TIME!

CAT NO	DESCRIPTION	PRICE
12-700	Etch Tank System	$37.95

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.

CAT NO	DESCRIPTION	PRICE EACH 1	5	10
08-366S	Large Desoldering Pump	$15.89	$13.49	$11.95
08-366E	Regular Desoldering Pump	10.89	8.59	7.39
08-366TIP	Replacement Tip	1.95	1.95	1.95

SEE OUR ON-LINE CATALOG AT http://www.cir.com

CIRCLE 321 ON FREE INFORMATION CARD

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 to iron from control unit is 24V Iron heating power is 48W. Replaceable 5.3mm tip is standard. Replacement irons and tips are available.

AS LOW AS $50[00]

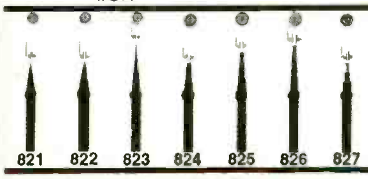
CAT NO	DESCRIPTION	PRICE EACH 1	5
SL10	Temp Controlled Soldering Iron	$56.00	$50.00
SL24V	Spare 24V Soldering Iron	10.50	7.50

Electronic Soldering System with LED Display

Deluxe temperature controlled system with LED display for maximum accuracy. Temperature is adjustable from 160°-480°C (320°-900°F). Iron heating power is 48 Watts. Runs on 24V from controller unit. Replacement irons and tips are available. Tip size is 5.3mm.

CAT NO	DESCRIPTION	PRICE EACH 1	5
SL30	Deluxe Soldering System w/LED	$86.00	$75.00
SL24V	Spare 24V Soldering Iron for SL10 or SL30	10.50	7.50

AS LOW AS $75



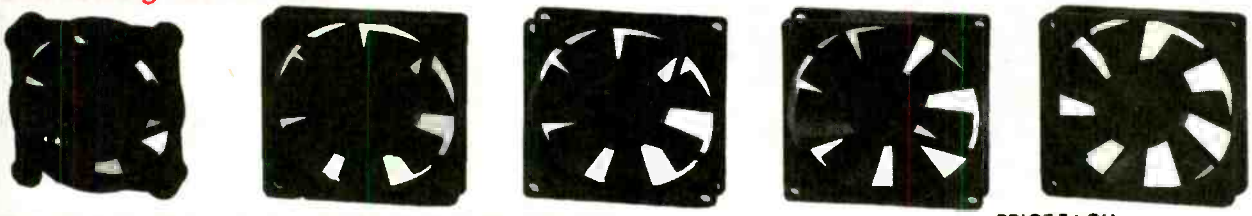
Replacement Tips for SL10/SL30

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

CAT NO	DESCRIPTION	PRICE EACH 1	5
821	1/32" Pencil Tip	$1.39	$1.19
822	1/32" Pencil Tip	1.39	1.19
823	1/64" Pencil Tip	1.39	1.19
824	1/16" Chisel Tip	1.49	1.29

CAT NO	DESCRIPTION	PRICE EACH 1	5
825	1/8" Chisel Tip	$1.49	$1.29
826	3/64" Chisel Tip	1.49	1.29
827	3/64" Pencil Tip	1.59	1.39

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.

INDUSTRY BEST PRICING!

CAT NO	PRICE EACH 1	10	25	100
CSD 4010-12	$ 9.88	$ 6.38	$5.48	$4.87
CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

Specifications

CAT NO	DIMENSIONS (MM)	RATED VOLTAGE (V)	START VOLTAGE (V)	INPUT CURRENT (A)	AIR FLOW (CFM)	STATIC PRESSURE (INCH-H_2O)	SPEED (RPM)	NOISE LEVEL (dB)	WEIGHT (g)
CSD 4010-12	40x40x10mm	12	7	0.06	5.1	0.19	5,500	26	20
CSD 6025-12	60x60x25mm	12	5	0.13	13.7	0.165	4,500	28	65
CSD 8025-12	80x80x25mm	12	5	0.16	37.8	0.177	3,000	31	80
CSD 9225-12	92x92x25mm	12	5	0.32	42	0.18	2,800	37	95
CSD 1225-12	120x120x25mm	12	5	0.35	62	0.180	2,500	42	135

• SOLDER • SOLDER • SOLDER •
• SOLDER • SOLDER • SOLDER •

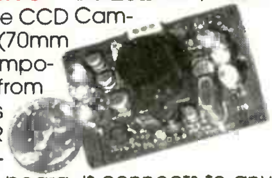
We stock high quality 60/40 (Sn%/Pb%), .031" and 63/37, .031" diameter. This is prime JIS certified solder that we maintain as a regular stock item (It is not "Left-overs, Rejects or Surplus") and you can buy it from us at a fraction of the price that you are used to.

Tired of Paying Inflated Prices for Solder?

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
RH60-1	1-lb. Spool, .031", 60/40	$ 6.90	$ 5.96	$ 5.30
RH63-1	1-lb. Spool, .031", 63/37	6.95	6.10	5.41
RH60-4	4.4-lb. Spool, .031", 60/40	24.00	21.90	17.92
RH60-TUBE	6-oz. Tube, .031", 60/40	.99	.89	.79

CCD Camera - IR Responsive

As Low As $109!!



This black and white monochrome CCD Camera is totally contained on a PCB (70mm x 46mm). 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.

CAT NO	DESCRIPTION	PRICE EACH 1	5
CA-H34A	PCB Mounted IRCCD Camera	$125.00	$109.00

!!!!!!! SEE OUR ON-LINE CATALOG AT http://www.cir.com !!!!!!!

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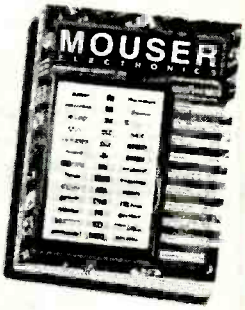

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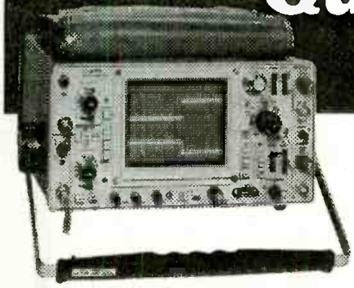

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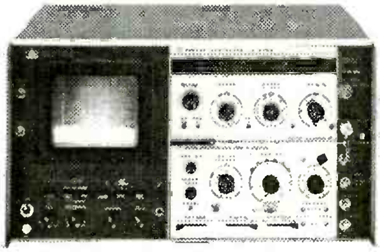

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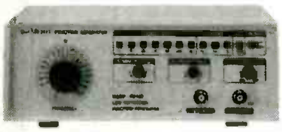

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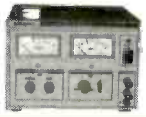

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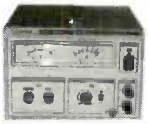

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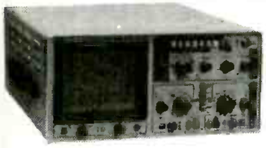

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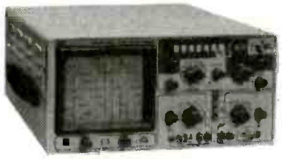

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- Delayed Sweep 100nS to 1.0S 7 decade
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- Uncalibration LED.
- High Sensitivity 1 mV/div to 2mV/div X-Y modes, Z Axis (intensity modulation)
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  Zero Adjust Knob
- Trig Lamp

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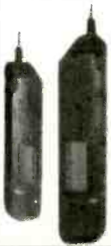

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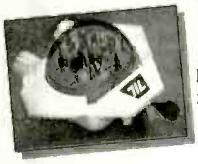
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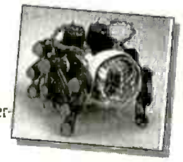
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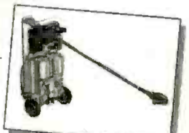
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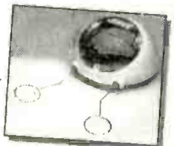
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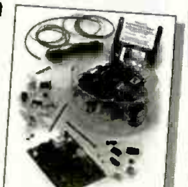
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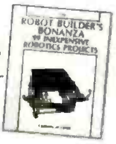
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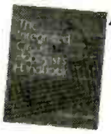
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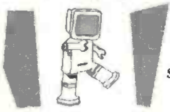
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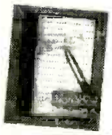
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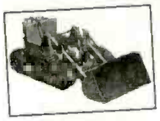
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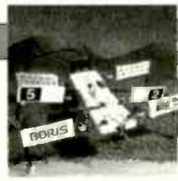
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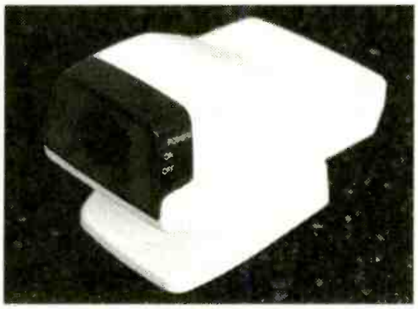

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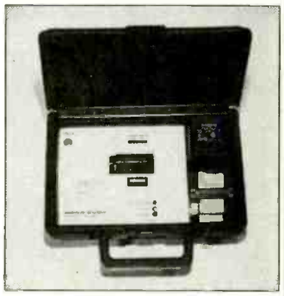

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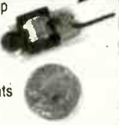

- Sensitive audio amplifier, picks up sounds at the level of a whisper.
- Tunes 88-108 MHz.
- Up to 1/2 mile range.
- Miniature photo battery mounts right on circuit board. (Included)

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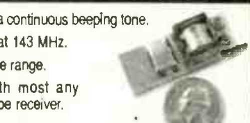

- Transmits a continuous beeping tone.
- Transmits at 143 MHz.
- Up to 1 mile range.
- Works with most any scanner type receiver.

TRACKING TRANSMITTER
Only 0.75 by 1.8 inches including the battery, the XTR300 is ideal for use in locating lost model rockets, bicycles, automobiles, games of hide and seek, and contests.

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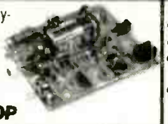

- Dial your phone from anywhere and listen to the sounds inside your home.
- Two digit Touch Tone code for secure operation.

TELEPHONE SNOOP
The latest in home or office security. Call home from anywhere, enter a two digit security code, and hear the sounds in your home. Automatically turns on without ringing the phone, verifies code, then activates for one and a half minutes.

XPS-CASE KIT $13.95
XPS1000 C KIT $55.95

- Smallest Phone transmitter anywhere!
- Tunes 88-108 MHz.
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- Attach to phone line anywhere in house.
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SUPER-MINIATURE PHONE TRANSMITTER
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- Audio jack for privacy ear phone.

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Any intercepted signal causes an audio tone that increases from a low pitched growl to a high pitched squeal as you get closer to the source of the signal.

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The XFM100 has a super sensitive microphone and is capable of picking up sounds at the level of a whisper and transmitting them to any FM broadcast receiver.

XFM100 C Kit .... [illegible]

- Digital voice changing: male to female, female to male, adult to child, child to adult.
- Anonymity on any call.
- Button for normal operation.
- 16 levels of voice masking.

VOICE CHANGING TELEPHONE
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- Use with any modular phone.
- 16 levels of voice masking.
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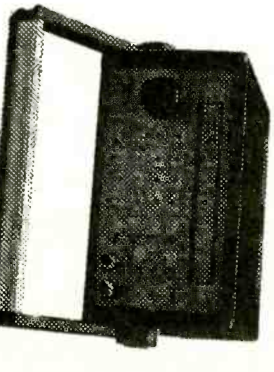

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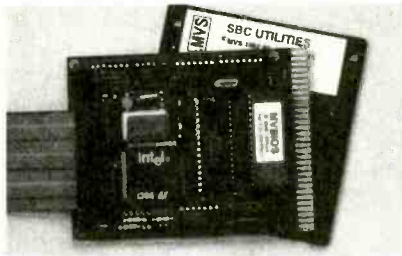

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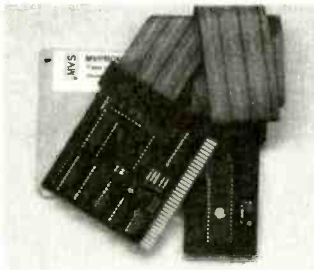

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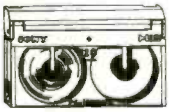

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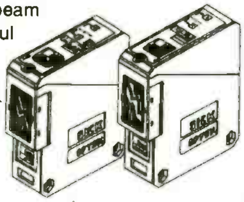

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Invisible infrared beam and switch is useful for a variety of security, safety and sensing applications such as perimeter alarms, electric gate or garage door controls or conveyor line sensing. Modulated beam covers a 20 meter distance even with poor visibility. IP-66 enclosure rating makes it dust proof and splash resistant, suitable for most outdoor conditions. Light/dark switching selector. Sensitivity adjustment control. LED power and sense indicators. Two position cable entry gland (90 deg. apart) accepts 1/2" threaded conduit and a variety of wire sizes. Glass fiber-reinforced plastic housings are 3.05" x 2.5" x 1". Supply voltage: 22-240 Vac. Solid State Output: 0.5 amp (must have load to operate). Includes mounting brackets and hardware. UL and CSA listed.

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3.57" X 0.9" X0.95"

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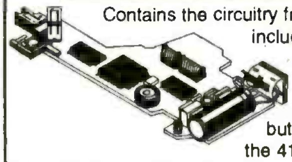

Contains the circuitry from a camera including the flash assembly. We have no hook-up information, but we're sure that the 410 uf, 300 volt photo-flash capacitor, flash tube and trigger transformer are worth the price. 4.5" X 2.7" X 0.8" h.

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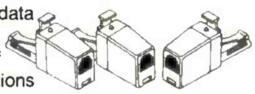

Ora Electronics # MP700
Protects against data interruptions and eavesdropping of private conversations when fax machine, modem or phone shares a line with other similar devices. Easy to install. Plugs inline between wall jack and telephone line. Requires one for each instrument sharing the same line.

$3.00 per package of 3 devices **CAT # MP-700**

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NEW LOWER PRICING

These incredible miniature solid state heat pumps raise or lower temperature in a small area almost instantly. Utilizing the Peltier effect these modules perform the same cooling or heating functions as freon based refrigerators but they do it with no moving parts, and are very reliable. Current applied to the device will produce heat on one side and cold on the other side, up to 68° C difference between the two sides. Modules can be mounted in parallel to increase the heat transfer effect or can be stacked to achieve high differential temperatures. 127 thermocouples per device. Operates on 3-12 Vdc. Requires a heatsink to prevent overheating.

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1.18" (30 mm) square X 0.15" (3.8 mm) thick.

$17.00 each **CAT# PJT-1** 5 for $75.00

1.57" (40 mm) square X 0.15" (3.8 mm) thick.

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Harris / GE # V130LA20B or equivalent
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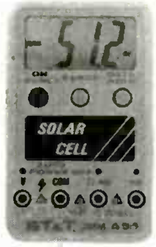
- -80.7 to 81.4 dBm with 4Ω –1200Ω 20 reference impedances
- True RMS
- Frequency counter: 0.01Hz-10MHz
- Capacitance: 1pF-50,000µF
- Measure AC volt to 20kHz
- 5000 counts, 0.1% accuracy
- Auto/manual range, fast bar graph
- Min/Max/Ave/DH/Relative/Zoom
- Auto power off
- Input warning
- Splash proof
- Volt, amp, ohm, logic, diode, continuity
- Ruggerdized case
- Rubber holster included



DMM A91

~~$49.95~~

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Solar Cell Powered
Large Display

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- Volt, Amp, Ohm
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- 7 functions, 19 ranges
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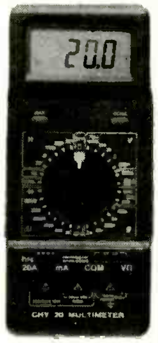

DMM 20 $74.95

- Inductance: 1µH-40H
- Capacitance: 1pF-200µF
- Frequency: 1Hz-20MHz
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Fluke 70 II	$75.95
Fluke 73 II	$97.50
Fluke 75 II	$129
Holster C-70	$16
Fluke 77 II	$155
Fluke 79 II	$175
Fluke 29 II	$175
Fluke 76	$175
Fluke 87	$287
Fluke 867	$1199
Fluke 97 Scope Meter	$1785
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LCR Meter 131D $229.95

Most Advanced LCR

- Dual display:L/Q or C/D
- Inductance: 0.1µH-1000H
- Capacitance:0.1pF-10,000µF
- Impedance:1mΩ-10MΩ
- 0.7% basic accuracy
- Auto/manual range
- Dissipation factor & Q factor
- Serial & parallel mode
- Relative mode for comparison and to remove parasitics
- Statistics, tolerance,
- Best for design, incoming testing & production
- SMD and chip component test probe $25.00

LCR Meter 814 $189.95

Best Resolution LCR

- Inductance: 0.1µH-200H
- Capacitance: 0.1pF-20,000µF
- Resistance: 1mΩ-20MΩ
- 1% basic accuracy
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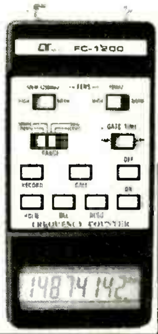
- Zero adjustment to reduce parasitics
- Best for high frequency RF
- SMD and chip component test probe $25.00

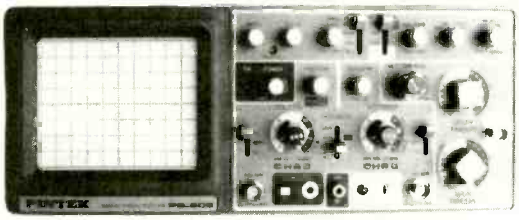
LIMITED QUANTITY SPECIAL
DIGITAL LCR 680 $74.95
0.1pF, 1µH, 10mΩ resolution



Frequency Counter FC-1200 $129.95

- Frequency:0.1Hz-1.25GHz
- Display: 8 digit LCD
- Period: 0.1µs-0.1s
- Records Max/Min/Average
- Data hold, relative mode
- Telescoping antenna $8.00
- Deluxe case $5.00

Also Available:
AC/DC clamp meter,Light meter, Thermometer, pH meter, High voltage probe, Digital caliper, Anemometer, Electronic scale, Force gauge,Tachometer, Stroboscope, Humidity & EMF adapter, Sound level meter, Frequency counter, SWR/field strength/power meter, Dip meter



20 MHz Oscilloscope with Delay Sweep PS-205 $429.95

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.

PS-200	20 MHz DUAL TRACE	$339.95
PS-400	40 MHz DUAL TRACE	$494.95
PS-405	40 MHz DELAY SWEEP	$569.95
PS-605	60 MHz DELAY SWEEP	$769.95
PS-1000	100 MHz DUAL TRACE	$999.95

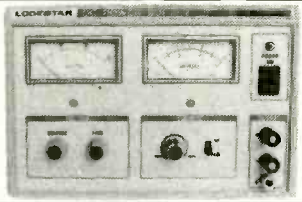
Scope Probe: 60MHz x1, x10 $15, 100MHz x1, x10 $22
250MHz x1, x10 $29, 250MHz x100 $39

Digital Storage Scope

DS-303 30MHz, 20M Sample/sec $849.95

DS-303P with RS-232 interface $1,049.95

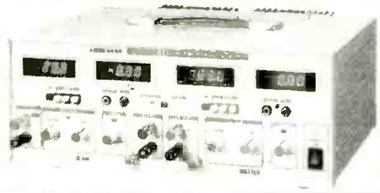
- Switchable between digital and analog modes
- 2 K word per channel storage
- 8 bit vertical resolution (25 Lerel/div)
- Expanded Timebase 10ms/div - 0.5 s/div
- Refresh, Roll, Save all, Save CH2, Pre-Trig
- Plotter control



DC Power Supply PS-303 $159.00

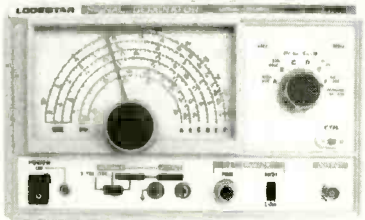
0-30 VDC , 0-3A output

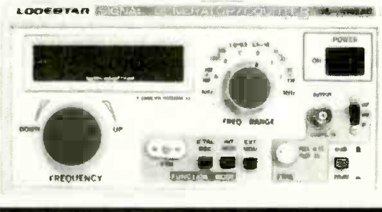
- Constant voltage & constant current mode
- 0.02% + 2mV line regulation
- 0.02% + 3mV load regulation
- 1 mVrms noise and ripple
- Short circuit and overload protected
- PS-8200 with digital voltmeter $179.00
- Also available: 30V/5A, 60V/3A, 60V/5A 16V/10A, 30V/10A



DC Power Supply Triple Output PS-8202 $499.95

- Two 0-30 VDC , 0-3A outputs
- One fixed 5VDC, 3A output
- Capable of independent or tracking operation
- Constant voltage and constant current mode
- Four digital meters for volt and current dispiay
- Excellent regulation and low ripple
- Short circuit and overload protected
- Also available: 30V/5A triple output $549.95
- Dual tracking 30V/3A, 30V/5A, 60V/3A, 60V/5A





RF SIGNAL GENERATOR SG-4160B $124.95

- 100 kHz-150MHz sinewave in 6 ranges
- RF Output 100mVrms to 35 MHz
- Internal 1kHz, External 50Hz-20kHz AM modulation
- Audio output 1 kHz, 1 Vrms

RF SIGNAL GEN./COUNTER SG-4162 AD $229.95

Generates RF signal same as SG-4160B
6 digit frequency counter 1Hz - 150 MHz for internal and external source Sensitivity <50mV

AUDIO GENERATOR AG-2601A $124.95

- 10Hz - 1MHz in 5 ranges
- Output: 0-8Vrms sinewave; 0-10Vp-p squarewave
- Synchronization: ±3% of oscillation frequency per Vrms
- Output distortion: 0.05% 500Hz - 50kHz; 0.5 % 50Hz - 500kHz
- Output impedance: 600 ohm

AUDIO GEN./COUNTER AG-2603AD $229.95

Generates audio signal same as AG-2601A
6 digit frequency counter 1Hz-150MHz for internal and external sources Sensitivity <50mV

FUNCTION GENERATOR FG-2100A $169.95

- 0.2 Hz -2 MHz in 7 ranges
- Sine, square, triangle, pulse and ramp
- Output: 5mV-20Vp-p
- 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 FUNCTION GEN./COUNTER $329.95

- 0.5Hz to 5 MHz in 7 ranges
- Sweep: Linear 10:1/Log 10:1 20ms to 2s
- AM Modulation
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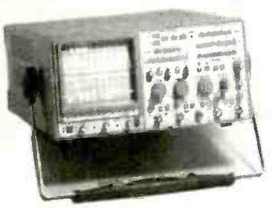
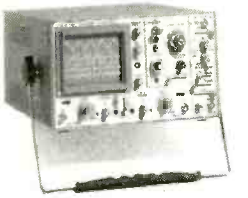
ISO 9002 CERT. #934163

100 MHz Cursor Readout Scope
4 ch, 8 traces OS-6101 $1,499.95



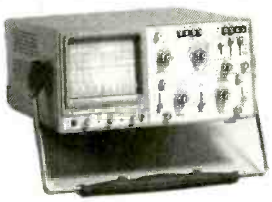
* 4 independent channels, 8 traces
* Time /Voltage cursor measurement
* ALT triggering function for 4 ch.
* Sweeps to 2ns/div, Delayed Sweep
* TV Sync., Ch. 1 output, Z-axis input
* 2 probes(x1, x10)

100 MHz Scope, 4ch. 8 traces
Best value all purpose scope
OS-6100B $1,329.95



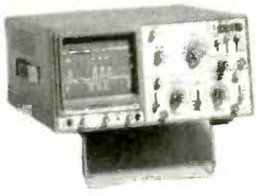
* 4 channels, 8 traces
* High sensitivity 500μV/div
* Sweeps to 2ns/div, Delayed sweep
* 20 kV accelerating voltage
* TV sync., Z-axis input
* A and B gate output
* Best price 100 MHz scope
* 2 probes(x1, x10)

50 MHz Triggering Oscilloscope
OS-653 $699.95



* Dual Channel
* Hold Off Function
* Delayed Sweep
* Built-in Delay Line
* TV Sync
* ALT Triggering
* High sensitivity 1 mV/div
* Trigger level lock function
* Z-axis input, CH1 output
* 2 probes(x1, x10)

20 MHz Oscilloscope
OS-622B $344.95



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

OS-623B - 20 MHz w/Delayed Sweep..................$ 449.95
OS-935 - 5 MHz One channel..............................$ 209.95

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)
  2 analog or 2 digital meters(PR series)

PS-1830	: (0-18V, 0-3A)	$209.95
PS-1830D	: Digital Display	$219.95
PS-1850	: (0-18V, 0-5A)	$219.95
PS-1850D	: Digital Display	$244.95
PS-3030	: (0-30V, 0-3A)	$224.95
PS-3030D	: Digital display	$254.95
PS-6010	: (0-60V, 0-1A)	$209.95
PR-1810H	: (0-18V, 0-10A)	$349.95
PR-3060	: (0-30V, 0-6A)	$314.95
PR-6030	: (0-60V, 0-3A)	$314.95
PR-6030D	: Digital Display	$399.95

Triple Output DC Power Supplies

* Two variable 0-30VDC, 0-3A outputs
* One fixed 5VDC, 3A output
* Auto tracking
* Auto serial and parallel operation
* Constant voltage and constant current mode
* Continuous/dynamic load can be selected
* Features 4 analog or 2 digital displays

PC-3030	: (0-30V, 0-3Ax2)	$499.95
PC-3030D	: Digital display	$549.95

Programmable DC Power Supplies

* High stability , low drift, 4 digit display
* Front/rear output-sense switch selectable
* Auto step running w/timer settings
* 100 point programmability (PPS series)
* 50 point programmability (PPT series)
* Auto serial and parallel operation (PPT series)
* Auto tracking (PPT series), IEEE-488.2 and SCPI compatible command set (optional)

PPS-1860G	: (0-18V, 0-6A)	$1099.95
PPS-3635G	: (0-36V, 0-3.5A)	$1099.95
PPS-6020G	: (0-60V, 0-2A)	$1099.95
PPT-1830G	: (0-18V, 0-3Ax2, 0-6V, 0-5A)	$1399.95
PPT-3615G	: (0-36V, 0-1.5Ax2, 0-6V, 0-3A)	$1399.95

Digital Display Function Generator
FG-8016G $239.95

* Frequency Range: 0.02Hz to 2MHz
* Three Instruments in one: Function generator, Pulse generator & Frequency counter.
* Sine, 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-8015 Function Generator
* 0.02Hz-2MHz (No Counter)..............................$189.95

FC-8131 Intelligent Counter 1.3GHz $469.95
FC-8270 Intelligent Counter 2.7GHz.....................$629.95
UC-2010G Universal Counter...............................$294.95

Digital Multimeter & C Meter
DM-8034(3½ digits) $179.95

* 8 Function, AC/DC voltage, AC/DC current, resistance
* Built-in C meter, diode test and audible continuity check
* High voltage 1000V and 20A range
* 0.5% basic accuracy

DM-8040 (3¾ Digits, True RMS)
* Measures ACV to 50 kHz.....................................$339.95

DM-8055 (5½ Digits)...$649.95
* 0.006% basic accuracy
* 1μV, 1mΩ, 1nA resolution
* dBm measurement
* Auto range, relative mode, Max/Min

DM-8055G(5½ Digits, GPIB)...................................$889.95

Model DM-392
(3¾ digits) $109.95

* Auto/Manual ranging(38 ranges)
* 42 Segment analog bar graph
* Data Hold/Min-Max memory /Relative mode
* Auto power off
* Overload protection
* Audible continuity check /diode test
* Capacitance: 1pF-40μF
* Frequency: 0.1Hz-1MHz
* 20 Amp range
* Double high energy fused (1A, 20A)
* 0.3% DCV accuracy

DM-351	: 3½ Digits w/Continuity, Auto Off	$54.95
DM-352	: 3½ Digits, Cap. Freq. hFE, 20 Amp	$79.95
DM-353	: 3½ Digits, Cap. Freq. Temp. hFE	$84.95
DM-391	: 3¾ Digits, Auto, Cap. Freq. Min/Max	$99.95
DM-392	: 3¾ Digits, Hold, Min/Max 20Amp	$109.95
DM-393	: 3¾ Digits, Peak, Logic, hFE, Freq	$119.95

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$449.95 **Device Programmers** $139.95

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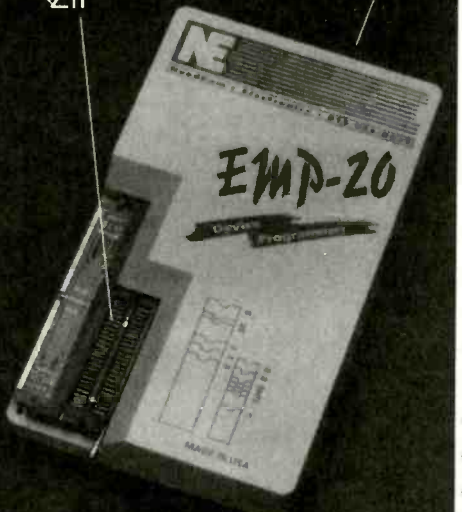
Connects to standard **PC parallel printer port**



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- **Fast Programming** (EMP-20) 27C010A, 23 seconds 28C020, 34 seconds 27C040, 95 seconds
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- 1 Year Warranty
- Technical Support by phone
- 30 day Money Back Guarantee
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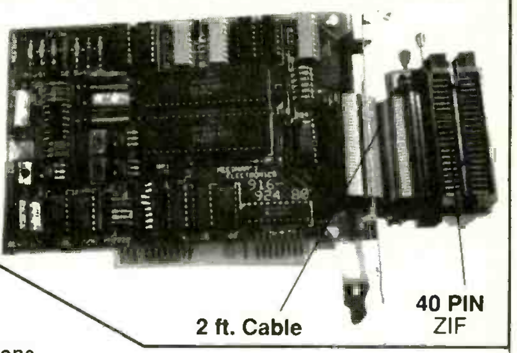
- **Flash** 28F256–28F020, (29C256–29C010 (EMP-20 only))
- **Micros** 8741A, 42A, 42AH, 48, 49, 48H, 49H, 55, 87C51, 87C51FX, 87C751,752
- **GAL, PLD** from NS, Lattice, AMD-**16V8, 20V8, 22V10** (EMP-20 only)

PB-10 Internal Card for PC



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40 PIN ZIF

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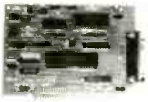
and Control Hardware for PC's

ANA100 Analog I/O .... $ 99



- 8 Channel 8-Bit
- 0 to 5 Volt Input
- 14 TTL I/O lines
- Analog Output
- 400KHz Sampling

DIG100 Digital I/O .... $ 39

- 8255 PPI
- 24 or 48 TTL I/O Lines option
- Selectable Base Address

ANA150 Analog/Counter... $ 89

- 8 Channel 8-Bit 0 to 5 Volt input
- 3 16-Bit Counters
- 400KHz Sampling

DIG200 Counter I/O .... $ 79

- 3 16-Bit Counters
- 8 TTL Input lines
- 8 TTL Output lines
- Selectable Clock Frequency input

ANA200 Analog I/O .... $ 79

- 1 Channel 12-Bit 0 to 5 Volt input optional bi-polar
- 100KHz / 300KHz Sampling rate
- 24 TTL I/O lines

ANA201 Analog .... $ 129

- 8 Channel 12-Bit
- x1, x5, x10, x50 Programmable Channel gain
- 100KHz/300KHz Sampling rate

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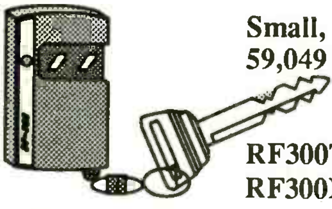
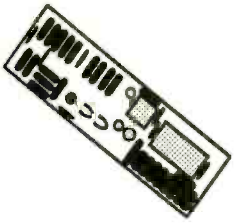
Miniature Transmitters and Receivers



Small, Attractive, High End Quality, 2 Channel 318 MHz Transmitter
59,049 Settable Codes, 120'–300' Range, 1–1/4" x 2" x 9/16", Assembled

	Qty	1	5	10
RF300T	150' Range Transmitter	24.95	19.95	15.95
RF300XT	300' Range Transmitter	29.95	24.95	19.95



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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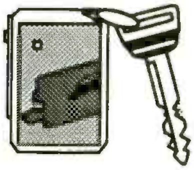

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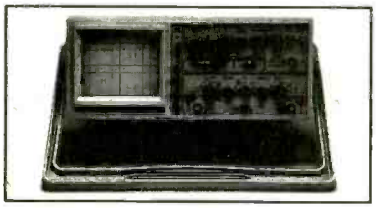

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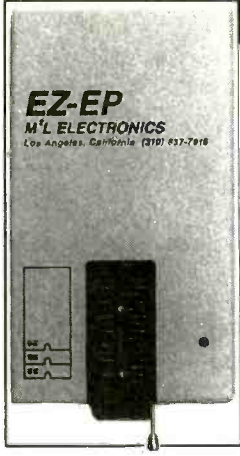

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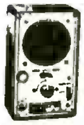

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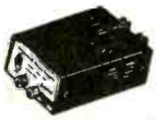

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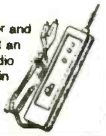

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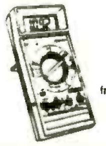

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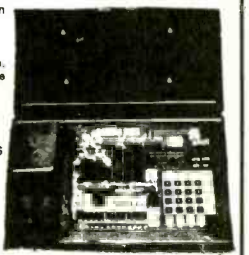

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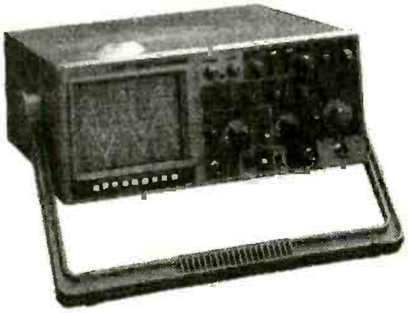

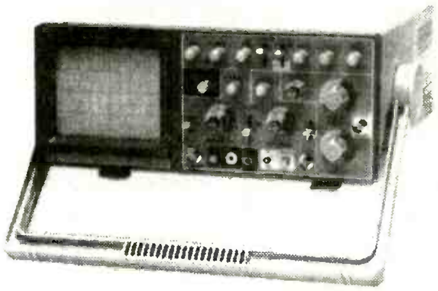

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ANALOG

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S-1365	60	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1360	60	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1345	40	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1340	40	1mV/div	2	10ns/div	No	Yes	No	No	1
S-1330	25	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1325	25	1mV/div	2	10ns/div	No	Yes	No	No	1

DIGITAL STORAGE

Model	Bandwidth MHz	Analog Sen (max)	No. of Channels	Sampling Rate	Memory Channel	Internally Backed Up	Pretrigger %	Output
DS-303	30	1mV/div	2	20MS/S	2K	Yes	0, 25, 50, 75	RS232
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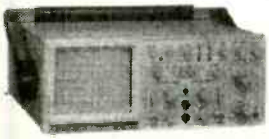

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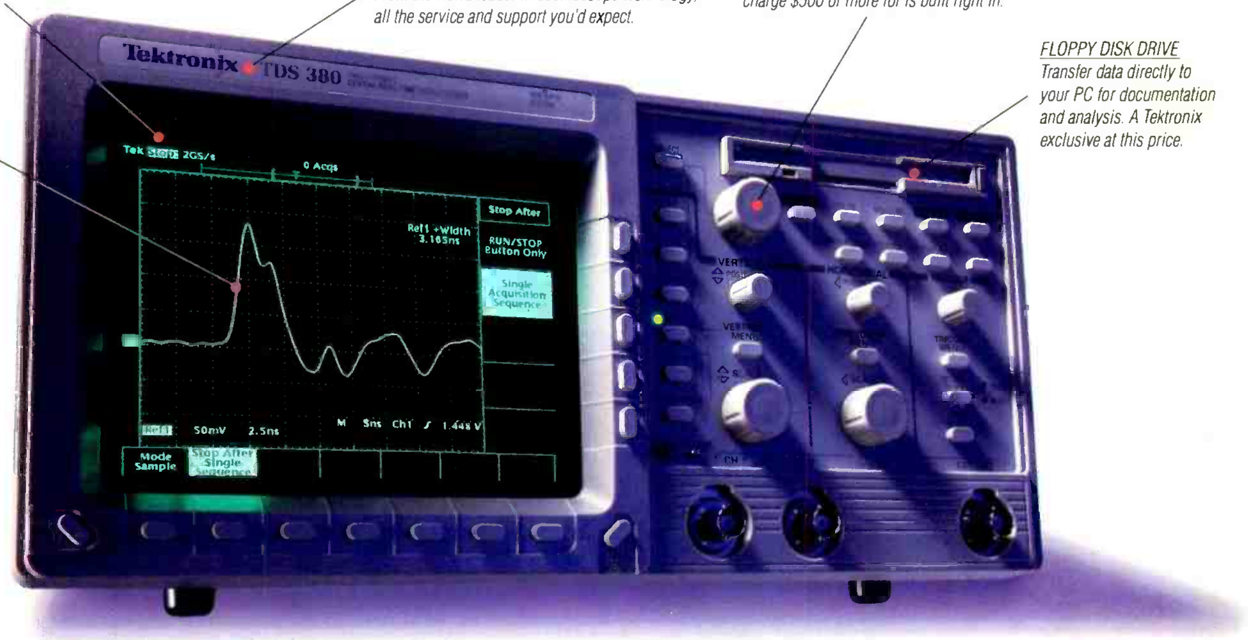

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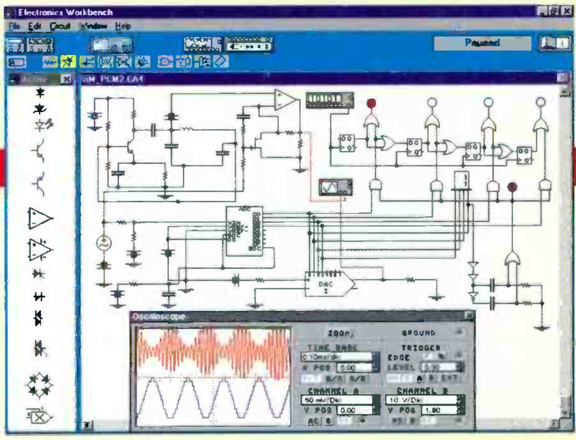

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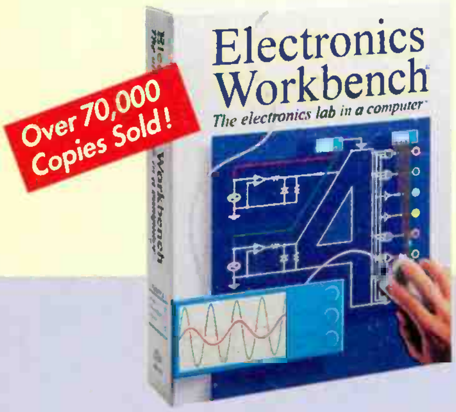

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