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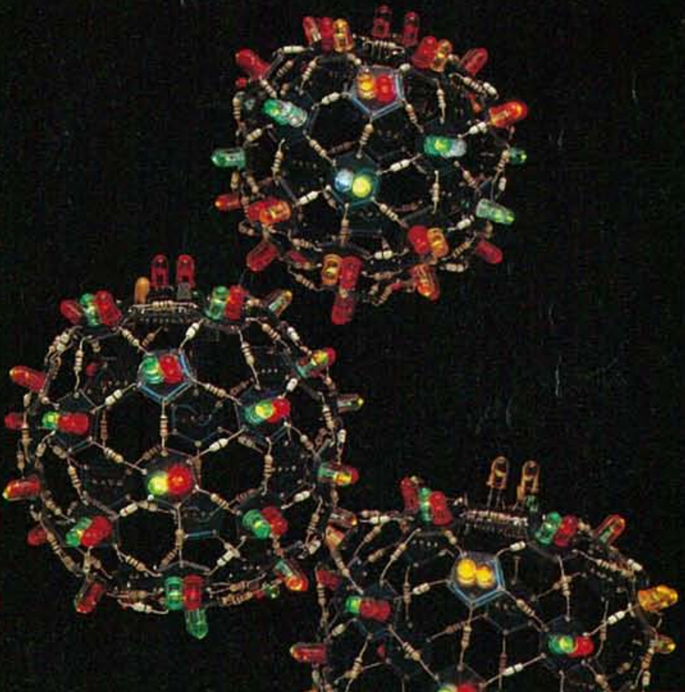

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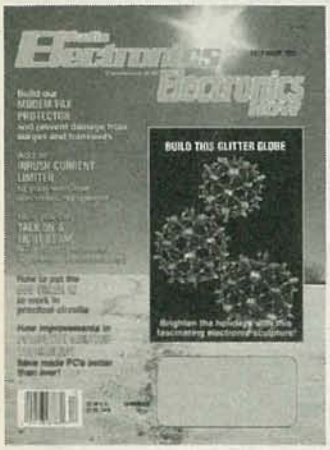

Once again, the holidays are just around the corner, and it's time to start thinking about gift giving and tree trimming. If you agree with us that hand-made items make the nicest gifts and add special sparkle to the holiday decor, be sure to check out the Glitter Globe. Not an ordinary ornament, this sophisticated piece of "electronic sculpture" is made entirely of electronic components and small circuit boards. The two LED's on each PC board "chase" each other, creating the illusion that the Glitter Globe is spinning. Hanging on the tree, or in a window, it's a sure attention-grabber! Turn to page 35 for all the details.

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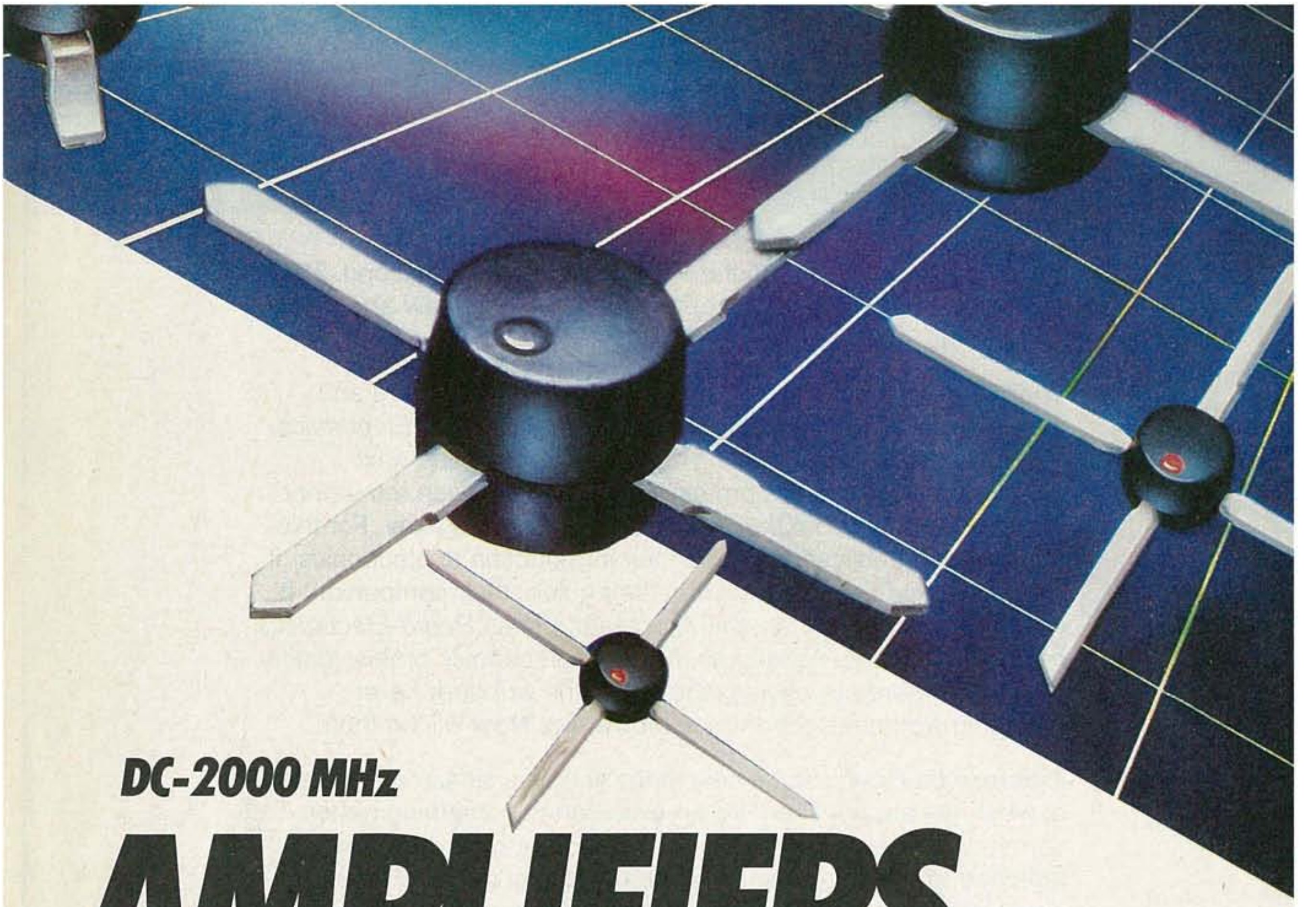

DC-2000 MHz

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	MAR-1 1.04	MAR-2 1.40	MAR-3 1.50	MAR-4 1.60	MAR-6 1.34	MAR-7 1.80	MAR-8 1.75	
	MAV-1 1.15	+MAV-2 1.45	+MAV-3 1.55	MAV-4 1.65				MA\ 2.15
CERAMIC SURFACE-MOUNT	RAM-1 4.95	RAM-2 4.95	RAM-3 4.95	RAM-4 4.95	RAM-6 4.95	RAM-7 4.95	RAM-8 4.95	
PLASTIC FLAT-PACK	MAV-1 1.10	+MAV-2 1.40	+MAV-3 1.50	MAV-4 1.60				MAV 2.10
	MAR-1 0.99	MAR-2 1.35	MAR-3 1.45	MAR-4 1.55	MAR-6 1.29	MAR-7 1.75	MAR-8 1.70	
Freq.MHz,DC to	1000	2000	2000	1000	2000	2000	1000	1000
Gain, dB at 100MHz	18.5	12.5	12.5	8.3	20	13.5	32.5	12.7
Output Pwr. +dBm	1.5	4.5	10.0	12.5	2.0	5.5	12.5	17.5
NF, dB	5.5	6.5	6.0	6.5	3.0	5.0	3.3	3.6

Notes: + Frequency range DC-1500MHz ++ Gain 1/2 dB less than shown

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EDITORIAL

IT'S NOW OR NEVER

Now. This moment, this instant—it lives but a microsecond. Then it moves on and changes and becomes something new and different and better.

That's exactly what our magazine—our magazine, yours and mine—is doing. I grew up on *Radio-Craft* and *Radio-Electronics*. You've probably grown up on *Radio-Electronics*. The next generation of electronics professionals may not even remember *Radio-Electronics*, but they will know **Electronics Now**. For this new, yet old, publication will be their introduction to electronics. It will be their primer, their teacher, their guide, their companion. It will travel with them through their career just as *Radio-Electronics* has through yours. As long as there are electronics professionals, as long as there are people who follow the wonderful ever-changing world of electronics, **Electronics Now** will be there.

Electronics Now is not a new magazine, it is simply a refinement of what has always been. It's an evolution to something better, something wiser, something stronger. A magazine more closely matched to electronics today. Carefully designed, tailored and directed by selected experts who can point you, our reader, through our pages, toward tomorrow.

Electronics Now is *your* magazine. It is the culmination of almost 100 years of progress from the *Electrical Experimenter* to *Radio-Electronics* and finally **Electronics Now.**

If our founder, Hugo Gernsback, were here today, he'd probably note that we should have acted sooner. Perhaps he would have been right. But no matter what, we know we are correct in taking you and us on this new adventure. Join us as we go. Revel in the excitement of today and the adventure of tomorrow. Tell us what you like, what you hate, what we should do, and what we shouldn't.

Write our editors, contact our bulletin board, send me your ideas, comments, and criticisms. Help us make **Electronics Now** exactly the kind of magazine you know it should be. And never forget we may now bear the name **Electronics Now**, but at heart we are *Radio-Electronics, Radio Craft, Shortwave Craft, Television*, and the *Electrical Experimenter*.

Larry Steckler, EHF/CET
Editor-in-Chief and Publisher

WHAT'S NEWS

A review of the latest happenings in electronics.

Fluke and Philips restructuring

John Fluke Mfg. Co., Inc. (Everett, WA) and Philips Electronics N.V. (Eindhoven, The Netherlands) on August 26 announced their intention to restructure their five-year-old alliance in the test and measurement business. Under the plan, which is expected to take several months to finalize, Fluke would acquire most of Philips' test and measurement operations for cash and stock. Once the contingency factors have been met (approval by Fluke shareholders and the Philips Board of Management, and review by the appropriate social and regulatory organizations), Fluke would acquire essentially all existing Philips' test and measurement businesses, with the exception of professional TV test equipment and power supplies. Fluke would then assume direct responsibility for worldwide marketing, development, manufacturing, sales, and support of most of the combined companies' present product lines. That includes the acquisition of sales and service operations in Europe. About 900 Philips employees would transfer to Fluke.

The management of both companies see the move as a logical progression in their alliance. According to Bill Parzybok, Fluke Chairman and CEO, "All along, we have been evolving the alliance to optimize our performance and improve our position in a changing marketplace. It has become apparent to both companies that a unified management structure, aligned under a single mission, would accelerate our growth and success." That mission, he said, is to position Fluke as the leader in compact, professional electronic test tools. The single focus is expected make the combined company more effective in product definition, design, and marketing, leading to streamlined production and better time-to-market for new products. In addition, Fluke hopes its European presence will allow the company to take advantage of EC'92.

The transaction is expected to add about $125 million to Fluke's revenues, and to favorably impact Fluke's earnings per share beginning in the first year of operations. Fluke expected to issue its proxy statement to shareholders in early November.

See-through magnetic material

Scientists at Xerox Corporation's Webster Research Center (Webster, NY) have produced a transparent magnetic material with potential applications in color imaging, computer information storage, magnetic fluids, and even magnetic refrigeration. (When a magnetic material is moved into a magnetic field it heats up; when moved out, it cools down. That so-called magnetocaloric effect can theoretically be used to build refrigerators. Although magnetic refrigerators have been built, none have worked at anything near room temperature.) The crystalline material is chemically identical to the gamma ferric oxide that has been used for decades to coat audio and video recording tape. But the crystals that make up the physical form of the new material are far smaller than those of conventional magnetic material. The Fe_2O_3 crystals comprising the magnetic material range in size from two to ten nanometers. With such small crystals, the material loses its usual ferromagnetic property and becomes superparamagnetic—a state in which the crystals will stick to a magnet but not to each other.

The transparency is an added bonus that is not generally found in magnetic materials at room temperature. The scientists have not yet determined why the nanocrystals are more transparent than the larger crystals of conventional Fe_2O_3. though some transparent magn materials already exist, their m netic properties are either too w to be useful, or they function onl temperatures near absolute ze

World's most powerful las light beam

A breakthrough in the inter tional race to create the wor most powerful laser-light beam been achieved by scientists at University of Michigan (Ann Ar MI) and the French National Ato Energy Commission. The terawatt beam of laser light— terawatt is equivalent to one tri watts—was produced in April 1 at the Centre d'Etudes de Lin Valenton (Limeil, France). The vious record, set last year in Jap was 30 terawatts. The beam produced by the Center's P- laser with a laser amplification te nique and a second preamplif laser developed by Gerard Mourou, professor of electrical gineering and computer scienc Michigan, and his co-researche

During the brief laser burst, searchers produced the terawatt of power—the equiva of 100 times the total electr power generated in the Un States. According to Mourou, " laser beam can be focused ov spot smaller than the diameter human hair to produce extren high power densities." The searchers say that the most im diate application of the technology will be to detern what happens when extremel tense laser beams interact matter.

Preliminary experiments sho that when high-powered la pulses are shot through plas shock waves are created that capable of accelerating electr close to the speed of light in small distances. That could lea

Continued on page

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VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• **Nintendo goes 32-bit.** Taking its competitors by surprise, Nintendo announced that, unlike other video-game manufacturers, it will skip the current generation of 16-bit games and go directly to a 32-bit processor when it introduces its CD-ROM accessory next year. The company announced that it had developed a proprietary "Super FX" chip that will make possible 16-bit cartridge games with "true 3D effects." Because its next-generation cartridge games will be 16-bit, the company decided that it would need an enhanced CD-ROM to offer customers a "truly superior game experience."

The new CD-ROM drive will function within the CD-ROM/XA environment, Nintendo said, which theoretically would make it compatible with Philips' CD-I.

• **VIS vs. CD-I.** Tandy's Video Interactive System, or VIS, designed to play CD-ROM's through consumer TV sets (**Electronics Now**, November 1992), formally carries a suggested list price of $699, which includes Compton's *Multimedia Encyclopedia*. Philip's incompatible CD-I system also lists at $699, after recent price reductions, and dealers have been selling it at $599. Consumers who bought players at higher prices are being mailed coupons good for $100 worth of free software. In addition, purchasers returning warranty cards are sent coupons that are good for transfer of their photos to a Photo CD. The CD-I format is compatible with Kodak's Photo CD system (but VIS currently isn't).

• **TV's are growing.** Larger picture sizes continue to grow as a share of the television-receiver market. In the first half of 1992, sales of direct-view sets with tubes 30 inches and larger (diagonally) were up 64% from the same period of 1991. Projection TV sales were up 14%, but the larger sized projectors (50 inches and larger) rose by more than 21%.

• **Who's number one?** Number one in TV set sales, that is. That position is still held by RCA as the leading brand in the United States, with just over 16% of the market. Zenith continues as number two, with a little more than 10%, followed by Magnavox with 9%. Sony is fourth with 7%, and Sharp is fifth with 5½%. The rankings are by *Television Digest*, which has been surveying TV market shares for 26 years. In the first brand rankings for projection TV, Mitsubishi was the clear winner with 22.6% of the market, followed by Magnavox with 4% and RCA with 13%.

• **Digital HDTV works.** The first report on digital high-definition TV by the Advanced Television Test Center (ATTC), which is testing proposed systems for the FCC, offered great encouragement for the future of digital TV transmission. Reporting on the first digital system it tested—General Instrument's DigiCipher—the ATTC's results indicated generally good picture quality with low levels of interference. Contrary to doubts expressed in Europe and Japan, where analog systems are espoused, the tests showed that DigiCipher produces less interference with other broadcasts than the analog NTSC system used in the United States. The tests also appeared to show that the DigiCipher system can provide the same coverage distance from the transmitter as the NTSC system, but at 13-dB lower power. However, digital HDTV does appear to be more sensitive to phase noise, which can probably be overcome by the development of improved filters in TV sets.

• **Priming HDTV's pump.** The fact that HDTV is technically possible doesn't necessarily mean th will proceed rapidly once a syst is chosen. As a matter of fact, difficult to determine how the f HDTV pictures will be delivered—terrestrial broadcast stations, dir satellite, cable, or even possibly prerecorded media such as vid tape or laserdisc. Although FCC-sponsored tests are desig to determine the best system terrestrial HDTV broadcasting, entirely possible that broadcast will take a wait-and-see attitude ward HDTV before going to the mendous expense of adding r studio and transmission equ ment—and quite likely new ante towers to disseminate two separ types of broadcasts during the in im period of HDTV's introduct while NTSC signals are still be broadcast.

When color TV was introduc TV station owners were extrem reluctant to add color originat equipment because the lack of dience meant that they coul charge advertisers a premium color broadcasts. And it wasn't u 10 years after the introductio color TV that consumers bough million sets in any year. (The figur now well over 20 million a ye Broadcasters say they can't be tain that there is any market HDTV—but they do see a lucra by-product of the current HD tests. All digital HDTV systems on data compression to sque four times the current informa into a single 6-MHz channel. broadcasters are asking wheth might be more lucrative for them use compression technology cram two or more standard-de tion broadcasts onto a single ch nel, and thus help on-air bro casters attain the multi-chan capacity that will let them comp with cable.

Cable itself is in a better posi than broadcasters to provide e

Continued on page

See page 100A
for envelope.

Q & A

Write to Q & A, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

50-OHM TERMINATION

I recently bought a card for my PC that lets me control things like motors and relays. My problem is that the instructions tell me that each line to the relay or motor must be terminated with at least 50 ohms. I'm not exactly sure what that means, and I was hoping you could explain it to me.—G. Cherben, Nighten, IN

I'm not exactly sure what kind of hardware you bought for your PC, but no matter what it is, yours is the kind of question I like—nice and easy.

All the instructions are telling you is that each of the card's outputs want to see a load of 50 ohms. That kind of termination is standard for computer networks and other things. If you're having a hard time understanding why it's needed, think for a minute of the power-amplifier outputs on a stereo. It's never a good idea to leave them unconnected to anything because an infinite load like that (that's what an open connection is) can put an unnecessary strain on the stereo's output transistors.

The same is evidently true for your controller card. Just as it doesn't want to see a direct short on the control lines, it doesn't want to see too high a resistance either.

I'm a bit surprised that an external termination is required since it would have been easy for the card's designers to include it on the card itself. Most motors and relays have fairly low winding resistances, so the addition of a 50-ohm resistor is pretty silly—kind of like putting a 10-amp fuse on a line that will draw a maximum of only 1 amp. Remember that adding a 50-ohm resistor in parallel to a motor winding with a resistance of 3 ohms or so isn't going to add much to the equivalent total resistance of the pair.

You can buy 50-ohm terminators or just solder a 50-ohm resistor on the line. By the way, for all intents and purposes, a 47-ohm resistor is close enough.

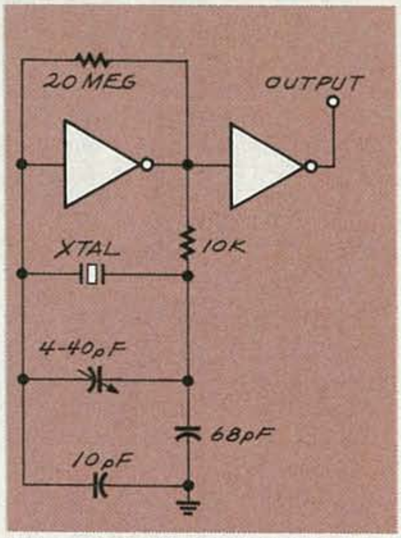


FIG. 1—CRYSTAL OSCILLATOR. If you use an inverting hex buffer like the 4049, powered from a 5-volt supply, the circuit will work with crystals as high as 14 MHz.

CRYSTAL OSCILLATOR

I'm building a circuit that requires a crystal oscillator, but I'm not sure which design to use. I don't have to worry about any extreme temperatures, and I have a bunch of spare gates left over on the board. Most of the crystal oscillator designs I've seen require the addition of special chips, and I don't have a lot of room left on the board. Have you got a simple circuit that will do the job?—J. Gillan, Her NH

If your requirements are as s and straightforward as you sa circuit in Fig. 1 is exactly wha need. It can be made from the gates you have, is self-startin is also extremely reliable.

The circuit will work well w little as a 5-volt supply, and the tal frequency limit really depen the amount of gain there is i gate you use. Something l 4049 will work with crystals a as 14 MHz. If you use more t volts for the supply, you shou able to go even higher.

One interesting variation o circuit is to use a two-legged instead of a simple inverter. Th let you turn the design into a oscillator so you can turn it o off under circuit control. I know if that's important in yo plication, but it's a good thi keep in the back of your mind

SCAN RATES

I know this information probably been printed so where before, but could yo me what the scan rates ar the various kinds of IBM vid have several monitors avail and I'm not sure which ones be used with which grap cards.—S. Heller, New York

The variety of IBM video dards has always caused confu

IBM VIDEO STANDARDS

VIDEO TYPE	ACRONYM	COLOR	SCAN RATE
MONOCHROME DISPLAY ADAPTER	MDA	B&W	18432kHz
HERCULES GRAPHICS ADAPTER	HGA	B&W	18432kHz
COLOR GRAPHICS ADAPTER	CGA	8	15750kHz
ENHANCED GRAPHICS ADAPTER	EGA	16	21800kHz
PROF. GRAPHICS ADAPTER	PGA	256	30480kH
VIDEO GRAPHICS ARRAY	VGA	256	31500kHz

It's usually a problem when people want to upgrade their video. In any event, the IBM standards are listed in Table 1. Notice that it doesn't include any of the super VGA frequencies. The reason for that is simply because super VGA frequencies can be anywhere from the regular VGA standard to as high as 50 kHz with a 70-Hz vertical refresh rate. That usually shows up when you get into super VGA with interlaced or non-interlaced video.

QIC AND EASY

I have a QIC-40 tape backup in my computer, and I have just increased the size of my hard drive to 120 megabytes. I know I can back up the drive on several different tapes, but it's a pain in the neck to tag a bunch of files, back them up, then tag another bunch, back them up, and so on. Is there an easier way or will I have to buy a tape drive with a larger capacity?—D. Tunn, Tenafly, NJ

I can't accept the idea that having to use a couple of tapes to back up your new, larger, drive is such a chore. You've obviously forgotten what it was like to back stuff up on floppies. But there are several alternatives you can try.

The first, and most obvious, is that the software that drives the tape usually gives you a way to build a tag list and, by specifying that you want to back up everything in the listed directories, you should be able to avoid having to tag the files individually.

Most tape software also allows you to compress the files on the tape so you can effectively turn a 40-megabyte tape into a larger one. The number of extra files you can get on the tape depends on what kind of files you have to back up, and how effective the software's compression algorithm is. Text and other data files will squeeze down by at least 70%. That is only an estimate, but you should be able to get a substantial savings by compressing the files as you back them up.

If the software that came with your tape drive doesn't have any of those features, there are other programs that will provide them. QIC-40 is a standard that allows a tape recorded on any QIC-40 drive to be read on any other QIC-40 drive.

Another alternative to shelling out bucks for a new tape drive is to use a DC 2120 cartridge rather than the standard DC 2000 that you're probably using now. Those cartridges are compatible with your drive and, because thinner Mylar is used for the tape itself, you can format it to about 60 megabytes. When you add data compression, you should be able to get over 100 megabytes on the tape.

If you are interested in buying a new tape drive, QIC-80 tape drives double the storage capacity of QIC-40 drives by packing twice as much data on the same tape. A QIC-80 drive formats a DC 2120 tape to 120 megabytes, and roughly doubles that to about 250 megabytes using software compression. A new drive won't even set you back by much—QIC-80 drives, such as the Colorado Memory Systems' Jumbo 250, sell for as little as $250, mail order.

LESS THAN MTS

I have an RCA stereo TV that I'm happy with for the most part. It's just that, on occasion, a stereo broadcast will sound like it's coming out of a seashell. I'd love to blame the cable company—and I usually can—but my VCR doesn't suffer the same problem. Friends have told me that the problem is because my TV isn't a true MTS-compatible set. Is this true?—M. Johnson, Lindenhurst, NY

Many people have complained about problems similar to yours—including the folks over at dbx, whose noise-reduction circuitry *must* be incorporated into any stereo TV circuitry in order for it to be called MTS. Lots of manufacturers insist that they can meet the MTS specifications without using dbx, but that's usually done to avoid paying licensing fees to dbx. I suspect that your RCA TV does not have dbx, while your VCR does. If the noise really bothers you, and you're not ready to buy a new TV—with dbx noise reduction—then just use your VCR as the tuner for as long as you have to. **R-E**

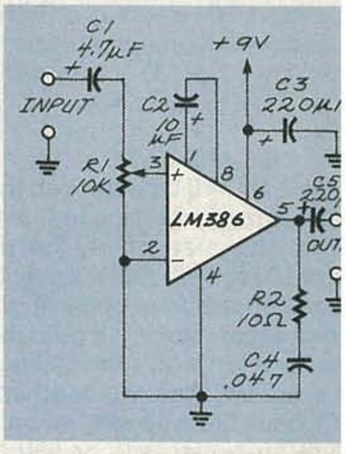
Write to Letters, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

DISTORTIONLESS POCKET STEREO AMP

I have some information regarding the "Pocket Stereo Amp" (*Ask R-E*, **Electronics Now**, August 1992) that might be helpful to the person who was having distortion problems when using an LM386. I've experimented extensively with that IC, and while simplicity has its merits, we must remember that a job worth doing is worth doing well. Because pocket stereos often have excellent sound quality, steps should be taken to maintain that quality when building an add-on amplifier for it.

The bare-bones design shown in Fig. 2 of the article might work, but the inclusion of a few junk-box components will yield better results. I've been using the design shown to the right, which is the one that generally shows up in projects that incorporate an audio section. Though the values sometimes differ slightly, all of these components usually appear in the circuit.

The first time I built this amplifier, I omitted capacitor C3 thinking that it would be unnecessary with a battery supply that contains no ripple. That resulted in severe distortion even at low input signal levels. The amplifier even tended to oscillate at times. After some head scratching, I connected a large-value electrolytic capacitor between pin 6



(supply) and ground, which e
nated the problem completely.

The amplifier can be driven w
line-level signal from an auxiliary
put or from the headphone jack
pocket stereo. In the latter c
with R1 adjusted for maximum
ume level, the pocket stereo's
ume control should be adjuste
the minimum level that will pro
adequate sound. That will pre
the possibility of overdriving
LM386's. Once that is done, R
be used to adjust the volume.

If two such amplifiers are b
used for stereo, C3 can be
nected between the common
ply line and ground. If you u
power supply that contains a
capacitor, C3 might not be ne
sary. C2 is optional as stated i
original article, depending on
need for gain. I recommend us
because even though the amp
in the pocket stereo provides
most of that gain will be lost w
the controls are adjusted to lim
level of the input signal.

Capacitor C1 can be omitt
there is no DC component on
input signal line. There probab
none if the source is an earp
jack or auxiliary output of a CD
er or cassette player. I have c
sionally seen pin 7 (byp
connected to ground through
pacitor, but it doesn't seem to r

any noticeable difference in this application, so I've never used it.

The design shown in Fig. 1 gives a surprisingly good sound considering the low cost of the IC.

As always, I'm grateful for the *Letters* column in **Electronics Now** that allows the exchange of information among readers.

STEVE BABBERT
Worthington, OH

THEFT OF SERVICES

I fail to understand you guys. Is **Electronics Now** a socialist magazine, advocating ripping off cable companies because they are Robber Baron Capitalist Fat Cats, or something? Robert Grossblatt says, "If the cable companies put the signal on your wire, you should have the right to use it." Does he steal from coin newspaper boxes too? After all, his quarter has purchased him access to the box, right? Hasn't he ever heard of "implicit contracts?"

When he took his cable service, he agreed to take the services he paid for. I agree that he should have the right to experiment. But if he steals programming, he isn't just stealing from the Fat Cat Cable Company—he steals from a lot of other people: technicians who work for the cable company, artists who do the programming, electronics manufacturers who supply products to the cable companies, and ultimately from little electronics companies like mine. We design and repair cable, and that work keeps a technician and an engineer employed. That's how *I* see it. And I think that the law agrees with me.

P. MIHOK
Don Mills, Ontario, Canada

TURN-SIGNAL FLASHER UPDATE

The circuit suggested by Timothy Brooks in September's *Letters* column, designed to augment the too-faint click of the automobile turn-signal flashers (a 47-µF capacitor in series with a small speaker connected across the flasher unit) works fine. However, there must be a current-limiting resistor in the circuit. Without it, the speaker's voice coil soon opens up.

F.G. HUTCHINSON
Redwood City, CA

ANOTHER FLASHER UPDATE

The letters in the September issue of **Electronics Now**, suggested different complicated electronic solutions for amplifying an automobile's turn-signal sound. There is a much simpler solution to the weak turn-signal sound problem; I have been using it for a number of years. Many automotive departments of retail stores stock replacement flashers. Look for an Ideal Loud Turn-Signal Flasher No. 577V (Ideal Division, St. Augustine, FL 32084).

It can replace any 12-volt, two-terminal flasher. Only one problem might be encountered: The loud-flasher's case is slightly more than twice as long as a regular flasher's case. That becomes a problem only if there is a lid covering the terminal box containing the flasher. In that case, you can cut a hole in the lid to accommodate the new flasher, or leave the lid off entirely.

VINCENT M. SARITI
Dover, NJ

DISKETTE CONVERSION

In the *Q&A* column in the September issue of **Electronics Now**, there was a discussion of double- and high-density diskettes, and whether or not there really is a difference between them I have converted 3.5-inch "floppy" disks from double-density to high-density by forming a hole in their cases, and I have found that the converted disks work fine without problems. However, *be very careful not to let any small material chips get inside the disk case.*

When a hole is made in the proper place, a small opening into the disk case is created. If a chip from the drilling or punching gets into that hole, it could cause serious damage to the disk—or, even worse, to the disk drive. I consider drilling the hole to be out of the question, and recommend using a very sharp and sturdy punch. Several of these are now on the market.

EMERSON M. HOYT
Beaverton, OR

R-E

Beckman Industrial HD160 Digital Multimeter

Many people who use digital multimeters—even those who use one every day—consider DMM's to be little more than commodity items. Other people, especially those whose livelihoods depends on the DMM, know the importance of a well designed meter. They'll want to know about a new DMM from Beckman Industrial Corporation (Instrumentation Products Division, 3883 Ruffin Road, San Diego, CA 92123-1898): the *HD160* heavy duty digital multimeter.

The *HD160* is the latest entry in Beckman Industrial's "HD" line of heavy-duty DMM's. It is housed in a sleek, bright yellow case that measures about 6.8 × 2.8 × 1.3 inches. A black rubber holster is supplied with the DMM to provide extra protection. Although the holster adds significant bulk to the meter, it can actually make handheld operation easier, thanks to two probe holders on the holster. The user can hold the meter with one attached probe in one hand, and the remaining probe in the other. The probe holders also provide a secure, safe place to store the probes when the meter is not in use.

The holster also provides a tilt stand that is particularly convenient for bench-top use; a tilt bale provides fixed tilt angles of 20 or 60 degrees from perpendicular. We would expect the *HD160* to be used away from the benchtop as often as not. If you've ever used a DMM while at the top of a ladder or while perched on the service platform of a large industrial machine, you've undoubtedly found that three hands could come in very handy. The *HD160* offers what might be the next best thing: a "Flex-Strap." The Flex-Strap is a Velcro-covered fabric strap that lets you hang the meter vertically from a wide variety of pipes, beams, and the like. Pipes up to about three inches in diameter will serve just fine.

A meter for heavy-duty professionals

The face of the meter is agreeably uncluttered. A large, 7-position rotary control sets the main function selections: AC volts, DC volts, resistance, diode test/continuity, DC current, and AC current. Below the rotary control are four input jacks: a common, one for voltage and resistance measurements one for current measurements of 40 milliamps or less, and one for current measurements up to 20 amps.

At the top of the meter's face, below the 4-digit (10,000-count) LCD readout, are three round pushbuttons: MENU, SELECT, and CLEAR. The sensible menu system is what helps keep the meter face so uncluttered. When the meter is first powered up, it is in its autoranging mode. To change the range, you would press the menu key; a four-item menu (RANGE, HOLD, REL, and MIN MAX) flashes above the digits. With the first press, the menu cursor is on the range selection. Successive pushes of the SELECT but changes the range. Success pushes of the MENU button chan the cursor position. The CL button can clear a given entry, can clear the entire menu, reset the meter. We found the menu s tem to be intuitive.

The meter's hold mode, wh Beckman Industrial calls "Pr Hold," automatically freezes meter's display when a stable re ing is reached. That means meter user can keep his hands the probes, not on the meter- important feature if you work aro dangerous voltages.

The relative mode lets the m measure values with respect reference other than zero. The ture works in the voltage, re tance, current, and diode- modes.

The max min mode lets the m measure and record the minin and maximum values of input nals. The feature works with all fu tions except diode test. The m is not useful for capturing t sients, but it can be used to m sure the operating parameters circuit. The automatic power-d feature does not, fortunately, c ate in max min mode.

An analog bar graph, made u forty LCD segments, is usefu peaking circuits; they respond er than the digital display (20 dates a second as opposed updates a second), and—as wit analog moving-coil meter—s changes are more obvious.

The *HD160* offers true-rms r surement capability depending the input signal's crest factor. crest factor is the ratio of a sig peak voltage to its rms value. A wave has a crest factor of 1.41 full-wave rectified sine wave h crest factor of 3.247. Signals crest factors up to 5.0 can be r sured when the display is at or low 2500 counts. At half s

Continued on page

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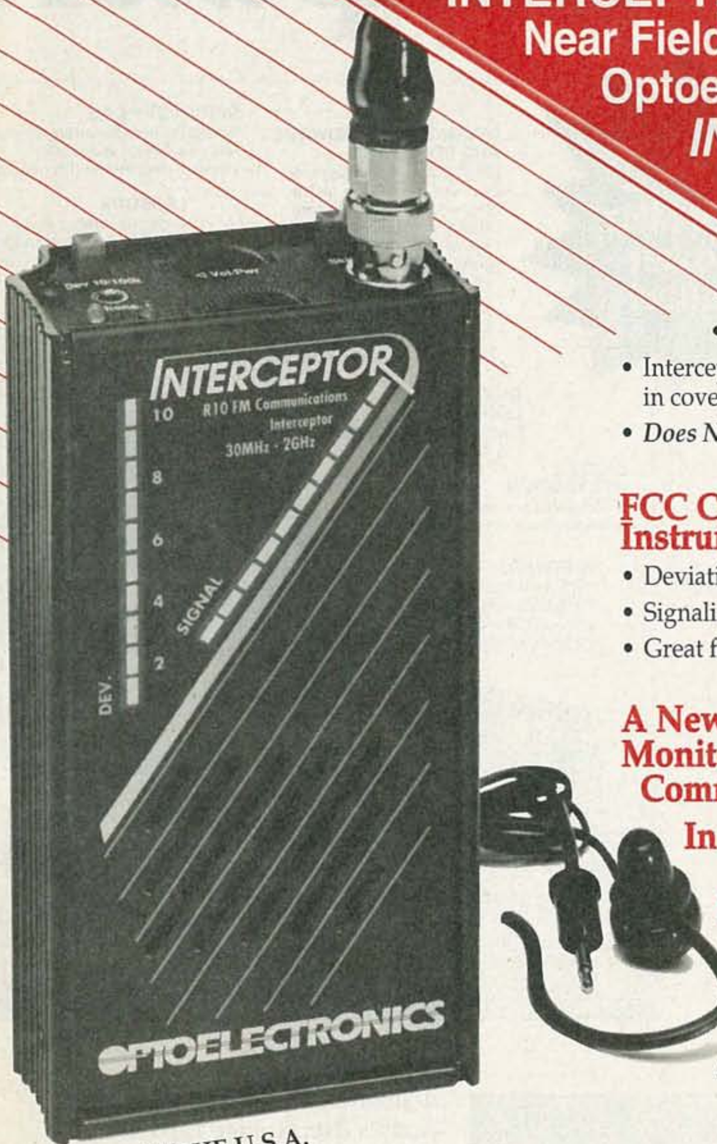

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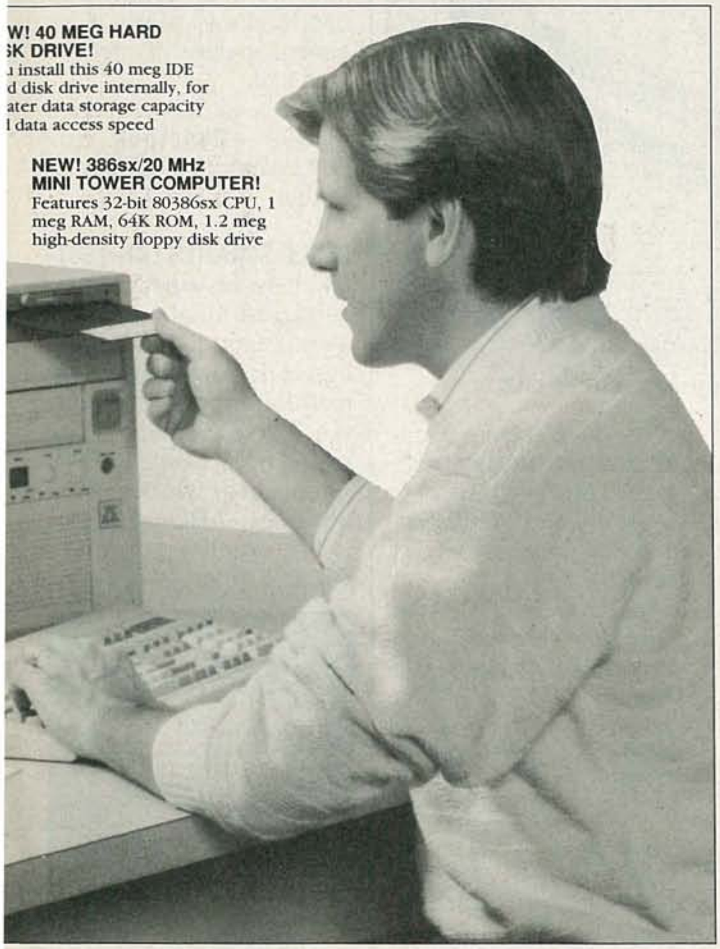

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NEW PRODUCTS

Use the Free Information Card for more details on these products.

PROGRAMMABLE PC-BOARD TESTER. You can test more than 600 TTL and CMOS digital IC's with as many as 28 pins with a new *Model 560A B+K-Precision* tester. Said to be able to perform in- and out-of-circuit tests, it was designed for both speed and accuracy.

The tester's vacuum fluorescent display and front-panel LED's prompt the user through the test procedures for a device, and clearly indicate test results and the IC pins where failure has occurred. The "loop test" continuously checks the device under test until a failure is encountered. This technique detects intermittent failures before the components are assembled in a product.

A memory stores responses from a known to be good PC-board for in-circuit testing.

Responses are permanently stored in one of two internal EEPROM's or any of the four EEPROM's located behind the instrument's front-panel access door. In out-of circuit testing, the device to be tested is inserted into the zero-insertion-force socket on the instrument, and a button is pressed so a display shows either a "pass" or "fail" and the pin numbers that have been identified as faulty.

CIRCLE 16 ON FREE INFORMATION CARD

The *Model 560A* includes a device data library that contains data on more than 90% of existing 14- to 28-pin IC's. That library will be updated free of charge as new IC's are introduced. Optional *AK-560A* custom programming software, which does require a processing by a personal computer, allows users to organize tests for non-standard and custom TTL and CMOS IC's.

The *Model 560A* is sold complete with an instruction manual, condensed instructions, IC library list, power cord, in-circuit IC test clips and cables, EEPROM for board-test routines, ground cable, and a spare fuse. It has a price of $3500.—**B+K-Precision**, 6470 est Cortland Street, Chicago, IL 60635; Phone: 312-889-1448.

RADAR-DETECTOR TESTER. When you are out driving, do you worry that your radar detector might not be working correctly—and you could get caught in a speed trap?

Dynaspek eases your worries with its *Leash*, just what you need to be sure that your radar detector (and those of your friends and neighbors) are up to snuff. A handheld radar transmitter, it simulates the feared signal of an X-band police radar gun. Used to test detectors, the unit activates when a button is pressed. A single red LED indicates that it's transmitting. A full signal intensity reading will appear on your police radar detector if it is functioning properly. The "Leash" has an effective range for test purposes of up to a mile.

CIRCLE 17 ON FREE INFORMATION CARD

The size of an audio cassette tape, (4.5 × 2.75 × 1 inch), *The Leash* transmits at least 12 milliwatts of power at 10.525 GHz. The manufacturer specifies an 8 dB antenna gain and a 36 × 72 antenna beamwi A 9-volt alkaline battery keep it on the air for ab six hours of continu use, and will power it several months of inter tent use.

The Leash has a list p of $99.—**Dynaspek**, 564, Westmont, IL 605 Phone: 708-325-7450.

CABLE SCANNER LAN TI ER. It is now possible eliminate local-area n work faults and decre network downtime wl malfunctions occur v the *Cable Scanner* L tester from *Contact E* The tester works v Ethernet, ARCnet, S LAN, Token Ring, Twis Pair and other network

CIRCLE 18 ON FREE INFORMATION CARD

A stand-alone tes *Cable Scanner* pern system analysis to de mine if the fault is within cabling. It then assist pinpointing the locatio the faults or breaks. scanner provides meas ments of cable resista and noise level, and gi audible continuity chec It can accommodate a printer to log activity.

After the fault has b located with CE's *Ca Scanner*, an inter "Tracer" circuit indica exactly where the cable is located in the wall or above the ceiling. It picks up signals introduced into the the cable by the scanner. The *Cable Scanner* can also be coupled to a personal computer or oscilloscope for system analysis while the LAN is operating. The complete *Cable Scanner* system includes the Tracer, three adapters (Ethernet, ARCnet, and twisted-pair), printer cable, a PC program disk, printer test connector, six AA nickel-cadmium rechargeable batteries, and an operator's manual. The tester is in a case measuring 1 × 4 × 7.5 inches and weighs 2 pounds.

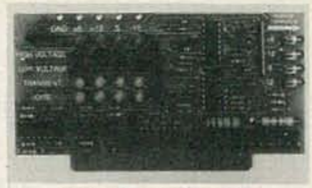
The LAN *Cable Scanner* is priced at $1495.—**Contact East**, 335 Willow Street South, North Andover, MA 01845; Phone: 508-682-9844.

SOLDER PASTE EVALUATION KIT. Solder cream, powdered solder mixed with flux, has many advantages over conventional flux-core wire solder or preforms in electronics manufacturing. The cream can be applied more precisely to the parts to be soldered, less solder is needed, there is better control of metal deposition, and the wetting of metals to be bonded is more uniform.

CIRCLE 19 ON FREE INFORMATION CARD

ESP is offering its *Kit-5*, containing five prepackaged containers of ESP solder cream, molded dispensing tips, and a reusable hand dispenser for precise solder application to help you evaluate its product. The kit includes two tubes each of 60% tin, 40% lead solder paste alloy and lead-free 96% tin and 4% silver solder. Each 35-gram tube is supplied with both an activated rosin flux and a water-washable flux. Also included in the kit is a prepackaged tube of ESP's activated rosin paste flux for evaluating its desoldering effectiveness.

The *Kit-5* evaluation kit is priced at $89.—**ESP Solder Plus**, 14 Blackstone Valley Place, Lincoln, RI 02865-1145; Phone: 1-800-338-4353; Fax: 401-333-4954.



CIRCLE 20 ON FREE INFORMATION CARD

DIAGNOSTIC CARD. A faulty power supply can introduce errors into a computer. The *Power Good* from *Sibex* is said to be the first diagnostic card dedicated to the test of PC power supplies. It is intended to assure the user that quality power at the specified voltage is being drawn by the computer.

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into an expansion slot on his PC and observes the included LED lamps. Green LED's indicate a good power supply. Red or yellow LED's indicate problems. The unit tests each of the four voltages for high- or low-voltage conditions and the presence of ripple or noise. A built-in latch detects spikes and transients. A connector on the card allows the user to test power supplies before they are installed in the user's computer.

The *Power Good* card is priced at $139.95.—**Sibex Inc.**, 1040 Harbor Lake Drive, Safety Harbor, FL 34695; Phone: 813-726-4343; Fax: 813-726-4434.

FM COMMUNICATIONS RECEIVER. A small handheld FM radio receiver is now available for security, communications, and recreational monitoring. The Model R10 FM Communications Interceptor from *Optoelectronics* is classified by the FCC as a communications test instrument. It can measure deviation (wide and narrow band), relative signal strength, signaling tones (CTCSS), and other demodulated FM. The receiver can also test VHF, UHF, and cellular radio transmitters.

According to its manufacturer, Model R10, unlike conventional radio receivers or scanners, receives any strong signal present, and is actually stabilized by the received signal. The company says the Model R10 does not have to be tuned to a specific frequency to receive a signal. Any FM signal from 30 MHz to 2 GHz can be intercepted without any gaps in coverage.

The *Interceptor* works best in the near-field, the

CIRCLE 21 ON FREE INFORMATION CARD

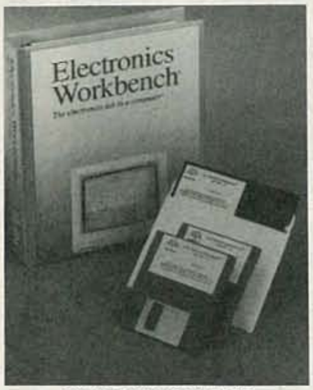
region surrounding a tra mitter where sig strength is high but falls rapidly with increasing tance. The receiving ra varies, depending on presence of strong sig in adjacent bands. But tances of 200 to 400 from a 5-watt UHF or V transmitter are typical Model R10.

The unit is comple automatic for hands-f operation, and is sm enough to be carried shirt pocket. For test plications, demodula audio output is availa from a stereo phone ja The *R10* also has a bui speaker.

A lock-release pushb ton frees the unit to l onto a different signal. feature is handy when eral relatively large sig are present. Dual ten-s ment bargraphs indic deviation and relative si level. A pushbutton sw selects wide- or narr band bargraph calibrat An internal rechargea battery pack provides u six hours of operation.

The *Model R10 Communications Interc tor* is priced at $359.—**toelectronics Inc.**, 5821 14th Avenue, Fort Lau dale, FL 33334; Pho 800-327-5912 305-771-2050; F 305-771-2052.

ELECTRONICS WORKBENCH SOFTWARE. *Interactive Image Technologies Ltd.* calls its *Electronics Workbench* software "the electronics lab in a computer." The program in a computer is said to allow users to design, assemble, and test analog and digital circuits by simulation. The company recommends its software for teaching electronics, electronics experimenting, and the prototyping of circuits. The patterns on the computer screen are identical to those that would be displayed on an oscilloscope in an actual test procedure.



CIRCLE 22 ON FREE INFORMATION CARD

The program consists of two modules: the analog module permits the simulation of electronics components and transistors as they would be done with hardware in a real lab. The digital module provides simulated ideal digital components and instruments needed to build and test logic circuits. The analog module includes SPICE simulation. This permits both transient and steady-state analysis.

Among the components that can be simulated with the software are resistors, capacitors, inductors, transformers, diodes, LED's, bulbs, fuses, Zener diodes, and transistors. Both AC and DC voltage and current sources can be simulated. A function generator provides square, triangular, and sinusoidal waves for test purposes, and a multimeter, dual-trace oscilloscope, and a bode plotter can be called up for making simulated on-screen measurements.

The digital module permits the simulation of ideal logic: and, OR, XOR, NOT, NAND, and NOR gates. Also available in the program are RS, JK, and D-flip-flop functions, a half adder, and a seven-segment LED display. The user can call up a voltmeter and an eight-channel logic analyzer to check out his work. Both logic conversion and simplification can be performed with the software.

Three versions of *Electronics Workbench* are available:

- IBM-compatible Professional—a color version that supports a math coprocessor.
- Personal Plus—for IBM PC's and compatibles, a monochrome alternative.
- Macintosh Program—available in monochrome only.

The Professional Version of *Electronics Workbench* is priced at $299.—**Interactive Image Technologies Ltd**, 908 Niagara Falls Boulevard, North Tonawanda, NY 14120-2060; Phone: 416-361-0333; Fax: 416-368-5799.

DC-TO-AC POWER INVERTER. Progress is still being made in the development of DC-to-AC power inverters, according to*Statpower Technologies*. The company says its new *PROwatt 800* 12- volt DC to 115-volt AC power inverter is designed for industrial applications and has a power output of 1000 watts for 10 minutes, 900 watts for 30 minutes and 800 watts continuous.

CIRCLE 23 ON FREE INFORMATION CARD

The *PROwatt* inverter is packaged in a small case measuring 3 × 9 × 10 inches and weighs five pounds. It can produce very high temporary power levels to run loads with high starting surge requirements (such as compressor motors). An LED bar-graph display provides continuous information on battery voltage and power draw. The unit can be easily connected to any deep-cycle storage battery.

PROwatt's low no-load current draw easily permits the conversion of most of a vehicle's battery power to usable AC power. Solid-state circuits regulate the output voltage and frequency. *Prowatt's* modified sinewave output is suitable for most electric motors and inductive loads. The output waveform does not change as the input voltage rises or falls. This permits it to power computers, test equipment, TV's, VCR's, and CCTV equipment from an automotive supply.

PROwatt 800 shuts down if the battery voltage exceeds its high and low limits. Audible alarms and LED indicators warn of faults so that corrective action can be taken. Once a fault is corrected, the unit will automatically restart.

The *PROwatt 800* is priced at $499.—**Statpower Technologies Corporation**, 7725 Lougheed Highway, Burnaby, BC, Canada, V5A 4V8; Phone: 604-420-1585; Fax: 604-420-1591.

RGB VIDEO GENERAT[...] This programmable R[...] video generator is intend[...] for use in the design, p[...]duction, service, and qu[...]ty control of the m[...] advanced computer-driv[...] CRT and LCD monitor d[...]plays. The *Leader mo[...] 1605* handles pixel rates [...] 300 MHz. Its graphic u[...] interface uses on-scre[...] menus and graphic d[...]plays with mouse contro[...] provide visual guidance [...] raster assembly, patt[...] selection and design, s[...]nal drive options, stora[...] and retrieval. Wavefor[...] are displayed to help [...] organizing rasters, and p[...]terns are assembled on [...] screen with a palette [...] 256 colors from a range [...] 16.7 million colors.

CIRCLE 24 ON FREE INFORMATION CARD

many as 100 address[...] can be stored in both R[...] and ROM and storage [...]pability can be expande[...] 1800 addresses on [...] built-in floppy dis[...] EPROM's can be p[...]grammed by the this vid[...] generator without ad[...]tional equipment, and it [...] accept data from all ear[...] Leader RGB video gen[...]ators. High-speed d[...] transfer can be carried [...] with analog, TTL, and E[...] outputs. Those outpu[...] have a wide range of s[...] options including tri-le[...] sync, half-line equalize[...] and serrations.

The *Model 1605* R[...] video generator is [...] priced at $18,500.—**Le[...]er Instruments Corporati[...]** 380 Oser Avenue, Ha[...]pauge, NY 11788; Pho[...] 800-645-5104 (in N[...] 516-231-6900).

NEW LIT

Use The Free Information Card for fast response.

1993 CATALOG; from Radio Shack, 700 One Tandy Center, Fort Worth, TX 76102; free at local Radio Shack Stores.

Radio Shack's 1993 catalog has a redesigned layout and organization as well as a lot of new products. The 172-page, full-color, magazine-sized catalog now has a "Quick Index" up front, and a complete index at the end. New products highlighted in this edition include the Duofone ET-499 voice-scrambling cordless telephone. It scrambles the transmission between the handset and the base so

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people with nearby scanners can't eavesdrop on your conversations.

Others are the Memorex Model 800 8mm home VCR with stereo sound and the portable Model 17 8mm VCR/TV combination, both with 179-channel TV tuners. Tandy is offering a 25-MHz, 486-based multimedia PC that includes a wide selection of software for voice mail, communications, travel planning, and more.

Also included in the 1993 catalog are telephones and accessories, pagers, scanners, world-band transceivers, VHS VCR's, remote controls, and automotive sound systems. There are also entries on home-control products, batteries, flashlights, multi-use testers, remote-controlled toys, computer based language and information sources, calculators, personal organizers, and notebook PC's.

21ST-CENTURY ELECTRONIC PROJECTS FOR A NEW AGE; by Delton T. Horn. TAB Books, Division of McGraw-Hill Inc., Blue Ridge Summit, PA 17294-0850; Phone: 1-800-822-8138; $16.95.

The term "New Age," usually associated with mysticism, music, and cultural fads, has now been applied to electronics projects by Mr. Horn in his new book. This volume—from a well known and prolific writer—presents an array of unusual electronic projects intended to test and demonstrate theories underlying New Age beliefs.

Included among the projects in the book are a dual-LED visual hypnotic aid, an alpha-wave biofeedback monitor, a two-choice ESP tester, a negative-ion generator, a biorhythm clock, a Kirlian photography experimental circuit, and a magnetic-field tester. Mr. Horn does not take a stand ei-

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ther for or against the th ries that are the subject his experiments. Howe the underlying conce are fully explained.

1992/1993 DISCOUNT T EQUIPMENT CATALOG. P Products International, 8 Brookville Road, Sil Spring, MD 20910; Pho 1-800-638-2020 1-301-587-7824; F 1-800-545-0058 1-301-585-5402; free.

Here is another disco equipment catalog. T one has 68 pages fil

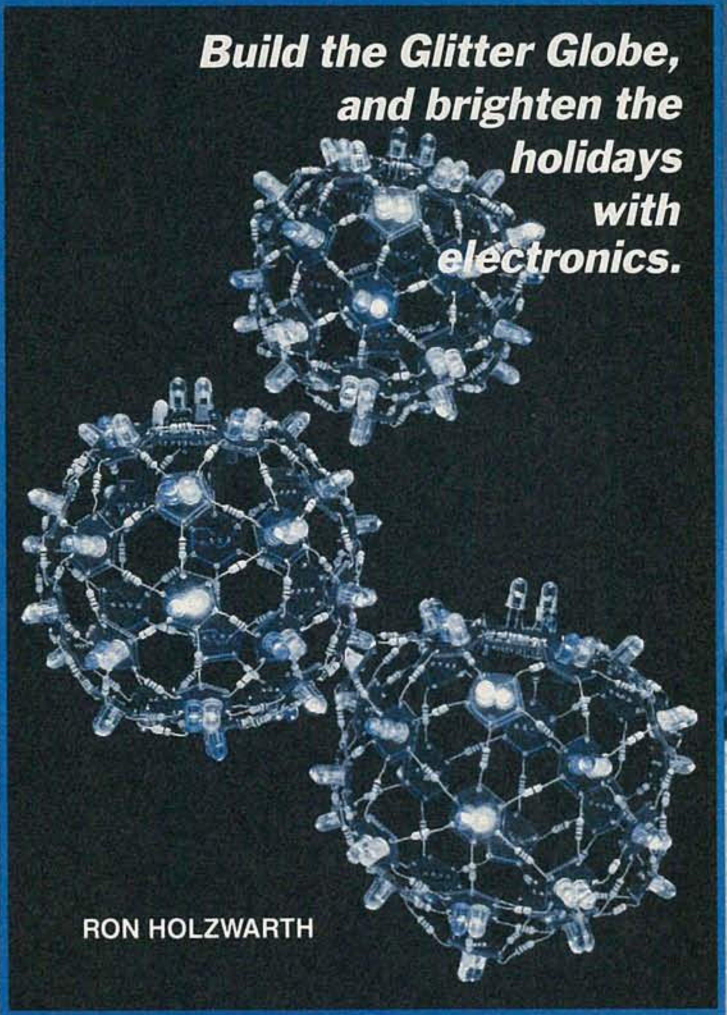
CIRCLE 38 ON FREE INFORMATION CARD

with entries on barga priced test and measu ment equipment from su well-known manufactur as Kenwood, B+K, com, Pace, Philips, Hita and Leader. Included in catalog's coverage are cilloscopes, power su plies, meters, and sp trum analyzers. In additi the catalog describes n lines of closed-circuit systems for security a monitoring.

GLITTER GLOBE

Build the Glitter Globe, and brighten the holidays with electronics.

RON HOLZWARTH



WE'D LIKE TO PRESENT ONE OF THE most unusual construction projects you're likely to build. Calling the Glitter Globe simply a construction project does not do it justice—calling it an *electronic sculpture* is more accurate. This is a challenging project, and not for the inexperienced builder. Building the Glitter Globe is a lot like building a model airplane or car, because the quality of your workmanship will be very evident in the finished appearance of the circuit. You can't hide sloppy construction inside a case!

The Glitter Globe is perhaps the world's most sophisticated Christmas ornament: it's constructed entirely of electronic components and very small circuit boards. Each circuit board holds a pair of LED's that chase each other around the globe, creating the illusion that the globe is spinning. The LED's can be the same or different colors, and at least 12 LED's light up at each step. One diagonal line of LED's is always one step ahead of another, creating the illusion that the Glitter Globe is spinning.

Two different animations are possible depending on the value of a resistor (R2): the globe can appear to accelerate and decelerate smoothly over a time period of about 20 seconds, or it can slow gently until almost stopping, and then accelerate quickly. The cycle then repeats. The globe can hang from its power cord in a Christmas tree or lie on any flat surface.

The small PC boards used to make the Glitter Globe can also be hidden in various places (other than as part of the Glitter Globe), such as in clothing or behind photographs, to add lights at strategic places. Art forms of this kind are rather popular.

The Glitter Globe is a geodesic sphere; the particular shape is a star-dodecahedron with twenty vertices, which is one of two star-dodecahedra known as the star polyhedra of Kepler. The other star polyhedra has twelve vertices, and could also be constructed from the Glitter Globe's board set.

Circuit description

Figure 1 is the schematic for the Glitter Globe, which is powered from a 12-volt DC supply. (It can therefore be powered from a car's cigarette lighter.) The first stage of the circuit is a triangle/sawtooth waveform generator made from IC1-a and -b, which are part of an LM3900 quad-amplifier chip. This stage varies the acceleration of the globe's apparent rotation by integrating a DC voltage to the trip point of a Schmitt trigger (IC1-b). After IC1-b trips, IC1-a integrates in the opposite direction until the other trigger point is reached. Increasing the value of C1 will lengthen the time period between accelerations. Resistor R2 is set at 2 megohms for a triangle wave output and 200 kilohms for a negative-ramp sawtooth output.

The output of the waveform generator goes to the input of IC1-c, a voltage-controlled os-

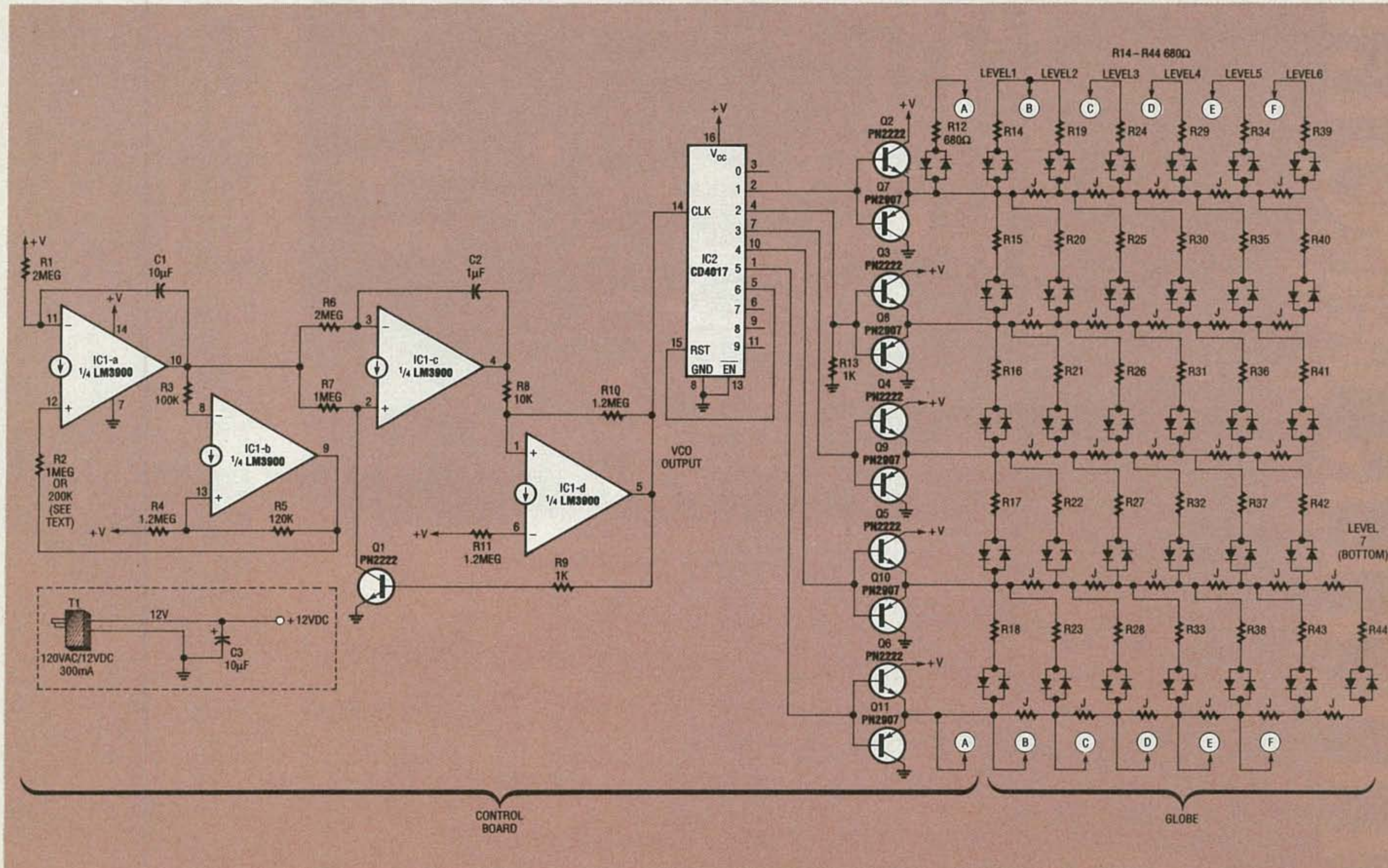


FIG. 1—GLITTER GLOBE SCHEMATIC. The first stage of the circuit, a triangle/

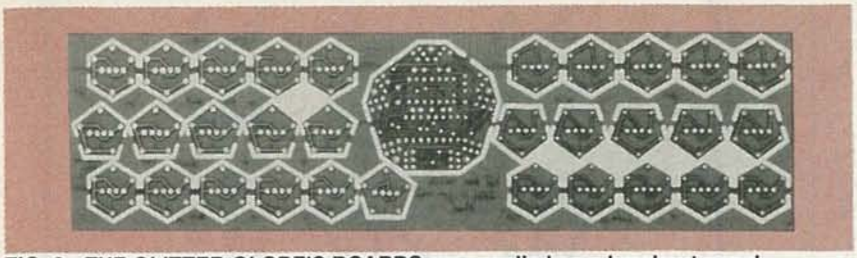


FIG. 2—THE GLITTER GLOBE'S BOARDS are supplied on a breakout panel.

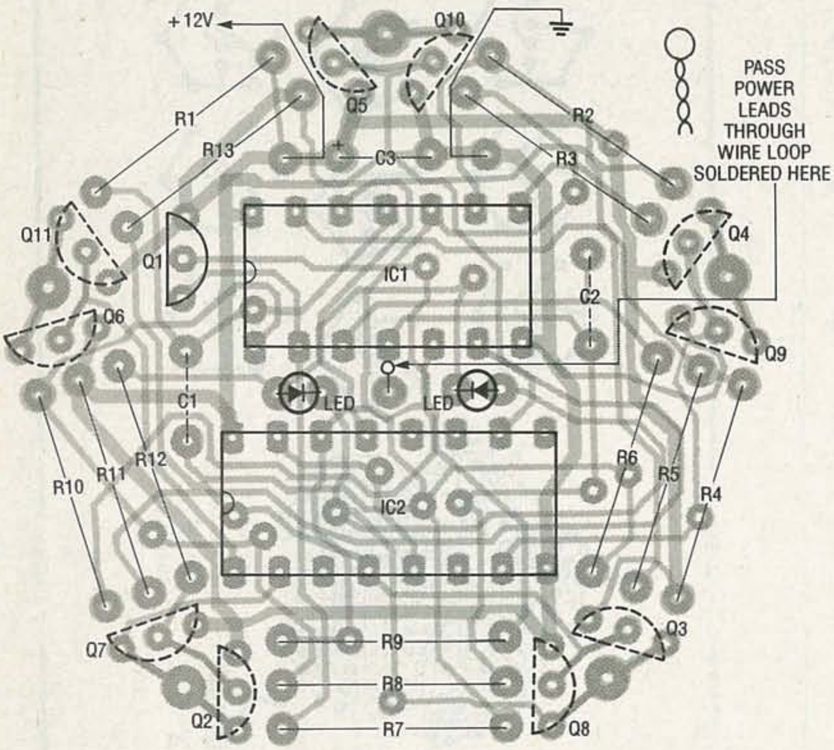


FIG. 3—CONTROL BOARD PARTS PLACEMENT. Capacitors C1 and C2, and all of the transistors, except Q1, are installed on the solder side of the board. The "c" silkscreened on the board indicates the collector lead of each transistor.

FIG. 4—YOU CAN MAKE a softball-sized star dodechehedra by forming all the structural resistors and jumpers approximately ¾-inch long. The pentagon boards stick out a little more than the hexagon boards.

cillator (VCO). The VCO operates very much like the waveform generator except that its voltage reference is the output of the waveform generator instead of the power supply. When transistor Q1 conducts, it grounds pin 2 of IC1-c and the output voltage of the integrator decreases. When the trip point is reached, Q1 ceases conduction, and the output then rises again. The value of C2 (as well as the voltage from the function generator) determines the speed of rotation. To decrease the speed of the spin action, simply increase the value of C2.

The output of Schmitt trigger IC1-d is the input for IC2, a CD4017 decade counter. Only five outputs of the counter are used; after a count of five, the counter resets, resulting in continuous "motion" around the globe.

Since the outputs of IC2 cannot provide enough current to drive a dozen or more LED's, transistor pairs (a PN2222 and a PN2907) are used to drive them. A high output from IC2 turns on the NPN transistors (the PN2222's) and a low output turns on the PNP transistors (the PN2907's). The output of IC2 that is high will turn on the PN2222 transistor connected to it, which sources the LED current. The current is then drained through the two PN2907 transistors on the adjacent outputs.

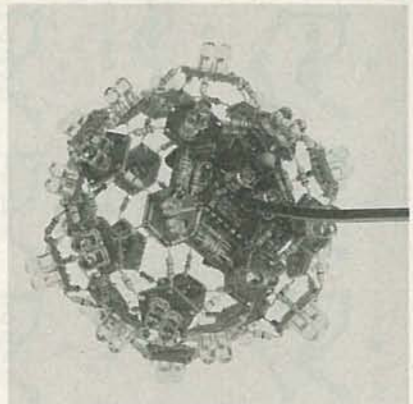


FIG. 5—YOU CAN MAKE a hardball-size star dodechehedra by keeping all the structural resistors and jumpers approximately ½-inch long.

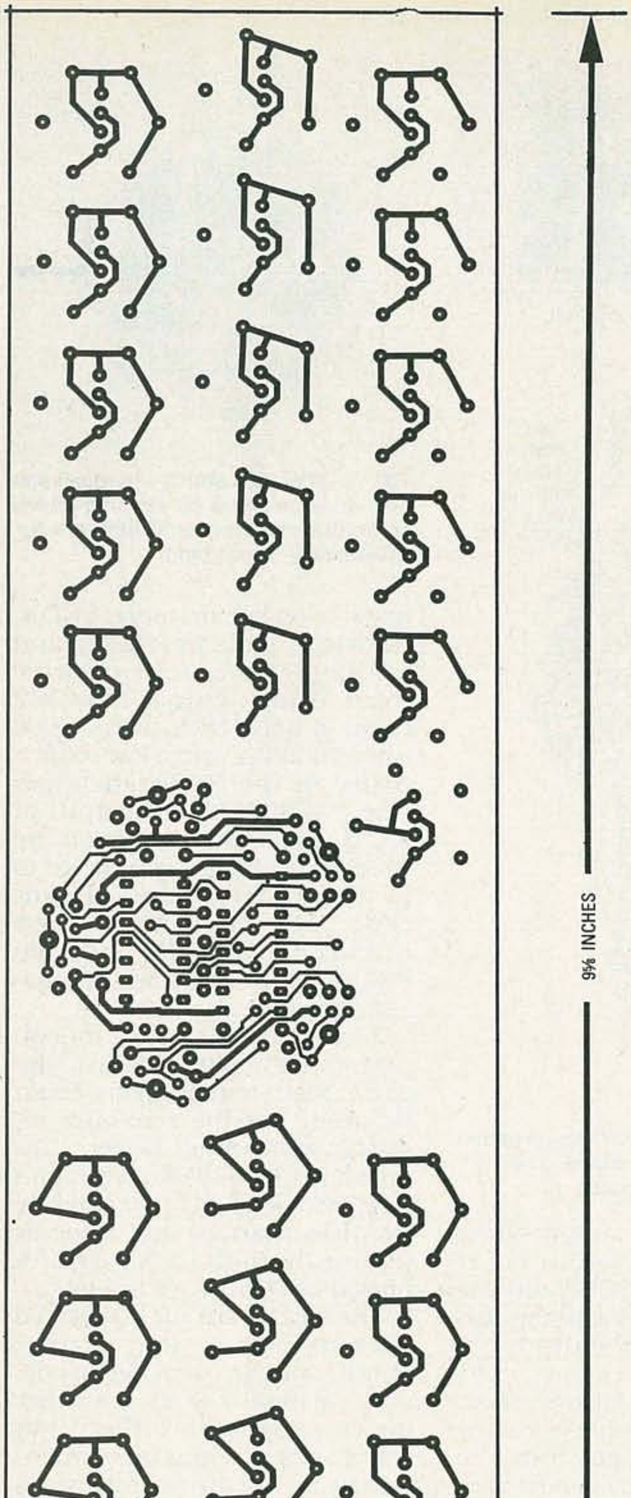
Zero-ohm resistors (jumpers) distribute power around the globe. Plain wire jumpers could be used, but the zero-ohm resistors look much better. Current-limiting 680-ohm resistors (one for each LED pair) ensure that less than 20 milliamperes passes through each forward-biased LED during conduction.

The LED's are all connected back to back so that current flow in one direction lights one, and current flow in the other direction lights the other. That way a color orientation is maintained as the Glitter Globe steps around its five outputs.

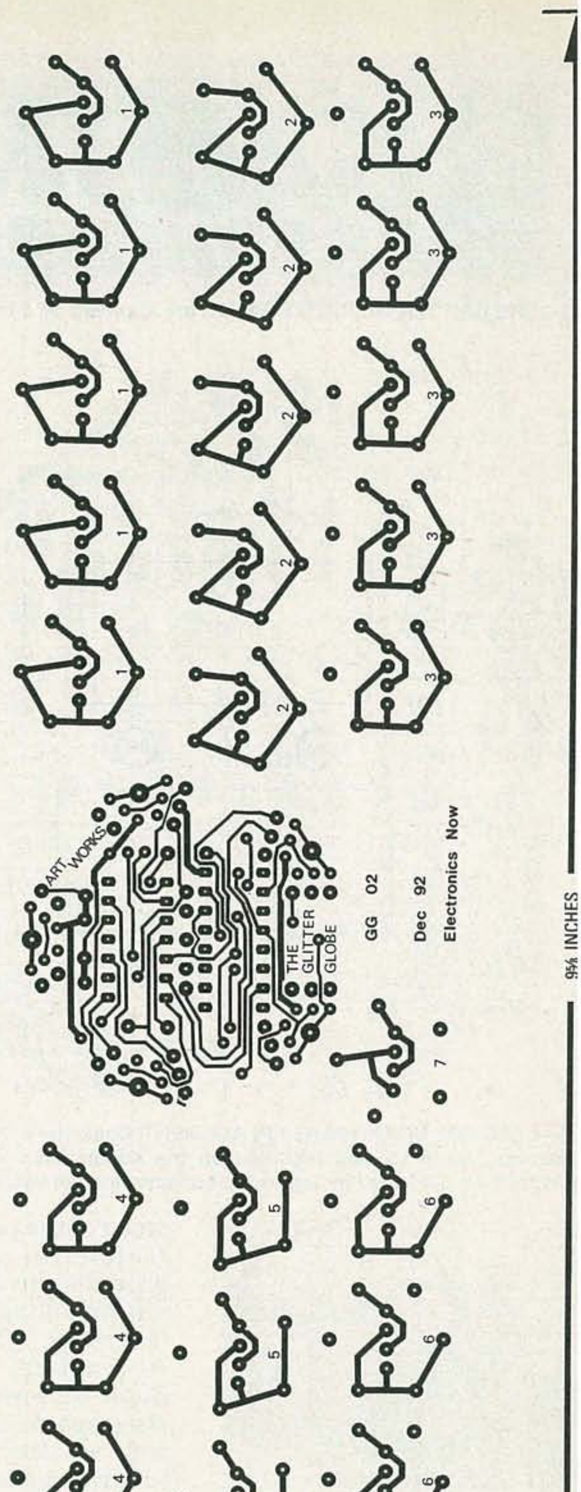
Conduction through one LED limits the reverse voltage across the opposite LED. That's not a concern, except with blue LED's which have a reverse-voltage limit of only 5 volts.

Assembly

Before beginning assembly, have the following tools on hand: a small vise or clamp to hold the globe steady as you work, a pair of needle-nose



COMPONENT SIDE of the Glitter Globe's breakout panel.



SOLDER SIDE of the Glitter Globe's breakout panel.

PARTS LIST

All resistors are ¼-watt, 5%.
R1, R6—2 megohms
R2—1 megohm for triangle wave, 200,000 ohms for sawtooth wave
R3—100,000 ohms
R4, R10, R11—1.2 megohms
R5—120,000 ohms
R7—1 megohm
R8—10,000 ohms
R9, R13—1000 ohms
R12, R14–R44—680 ohms

Capacitors
C1—10 µF, 16 volts, nonpolarized electrolytic
C2—1 µF, 16 volts, nonpolarized electrolytic
C3—10 µF, 25 volts, tantalum electrolytic

Semiconductors
IC1—LM3900 quad amplifier
IC2—CD4017 decade counter
Q1–Q6—PN2222 NPN transistor
Q7–Q11—PN2907 PNP transistor

Miscellaneous: 64 LED's (any color), 28 structural resistors (680-ohm units will match the rest of the resistors), 25 zero-ohm jumpers, 12-volt DC 300-mA wall transformer, PC board set, solder, etc.

Note: The following items are available from Art Works, 415 E. Emerson Street, Saint Francis, Kansas 67756:
- **Set of 32 PC boards, supplied on a breakout panel—$30.00 each, three or more are $25.00 each**
- **Complete Glitter Globe kit (includes PC board, 300-mA wall transformer, 64 LED's, and all components)—$65.00 each, three or more are $55.00 each**

All prices include taxes, shipping, and handling. Please state LED color preference (red, green, or yellow); colors can be mixed. Visa/Mastercard orders (800) 486-6862. For technical assistance call (913) 332-2726. Blue LED's are not available with the kit.

pliers, a small file, a pair of clippers, and a desoldering tool or desoldering braid.

All of the Glitter Globe's boards are supplied on a breakout panel (see Fig. 2). The control board should be assembled first; its parts-placement diagram is shown in Fig. 3. Remove the control board from the breakout panel and file off the excess material.

Insert the components into the control board, making sure that the IC's are inserted correctly and that the tantalum capacitor (C3) is inserted with the proper polarity. Capacitors C1 and C2, and all of the transistors, except Q1, are installed on the solder side of the board. The "c" silkscreened on the board indicates the collector lead of each transistor. Looking at the flat side of the transistors with the leads pointed down, the leads are, from left to right, emitter, base, and collector.

In the center of the control board there is a hole for soldering a loop of wire that acts as a strain relief for the power leads. Strip and tin the ground and power wires from the transformer, and then insert them through the center support loop before soldering them into the PC board. The transformer included with the kit (see the Parts List) has the positive lead marked with a white stripe—other transformers can be marked with the opposite convention, so be sure to check the polarity before soldering!

Test the control board to make sure that it works correctly before building the rest of the globe. When powered up, the two LED's on the control board should light sequentially, and then stay off for a brief time. The flash rate change will be

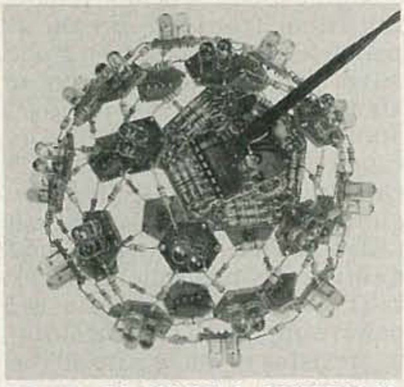


FIG. 6—TO MAKE A SPHERICAL GLOBE, all of the resistors and jumpers that connect to any five-point board (levels 2, 5, and 7) must be preformed to ⅝-inch, with the rest remaining ¾-inch.

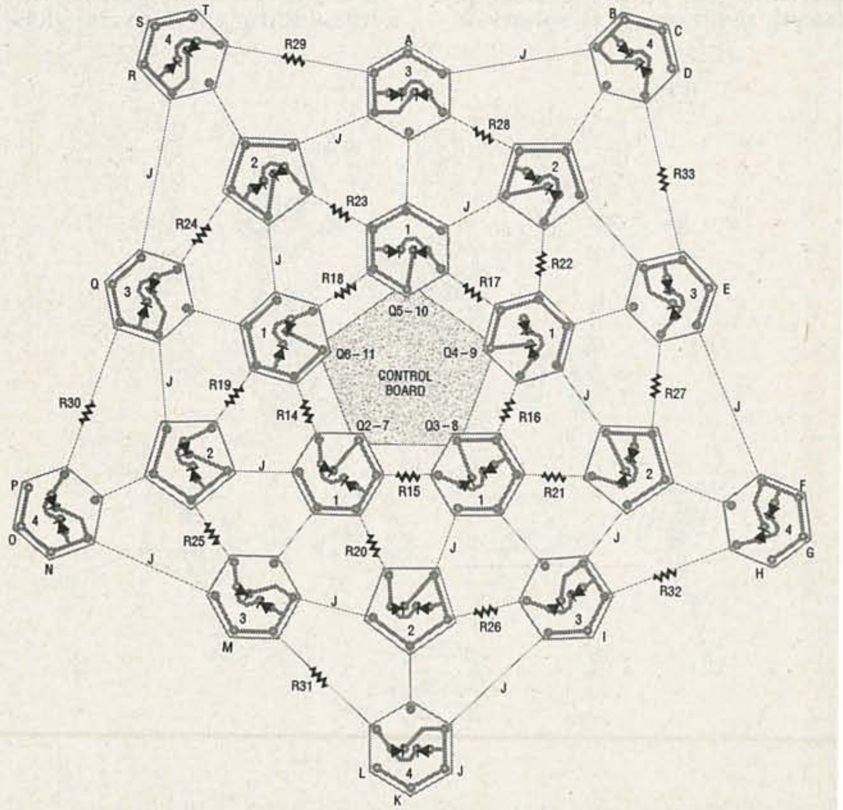


FIG. 7—THIS "COMPONENT MAP" shows how the level 1–4 pieces connect togethe All connections marked "J" are zero-ohm jumpers, all connections showing a resisto symbol must be 680 ohms, and all unmarked connections can be made using an material you like.

very obvious. Unplug the transformer before continuing.

The LED boards are numbered on one side in groups from 1 to 7. Groups 1–6 contain five boards each; group 7 is just a single board. The numbers represent the levels away from the controller board in which the LED boards are installed. For example, level-1 boards are installed immediately around the controller board, level 2 surrounds level 1, 3 surrounds 2, and so on. All boards in each level are identical. Locate the numbered side of each board on the inside of the globe, with the LED's on the outside. Putting the numbers on the outside of

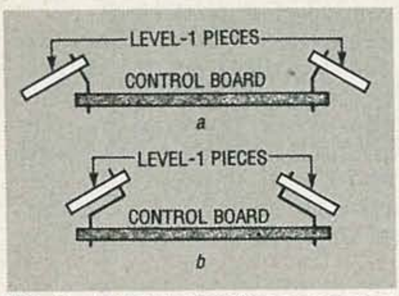


FIG. 8—IF YOU USE ¾-inch spacing, level 1 mounts as shown in *a*; for ½-inch spacing, level 1 mounts as shown in *b*.

the globe will result in the diagonal power busses (and thus the lighting pattern) running the other way, although the spin direction will remain unchanged. Also, always position the LED boards so that the numbers on their inside surfaces are pointing away from the control board.

Solder the LED's into the small PC boards before removing them from the breakout panel. If you are making a globe with two colors, one color should always be on the left, and the other on the right. Because changing a defective LED can be very difficult after the globe is assembled, test all LED's before soldering. Some multimeters can quickly check LED's; otherwise set up a DC power supply and current-limiting resistor to make sure all the LED's work. The LED's are installed in the boards with their cathodes facing each other (with the flat sides toward each other). Clip excess leads after soldering.

It's much easier to keep the small boards oriented correctly while adding them to the globe if you remove them from t panel only as needed. When y remove the boards from t breakout panel, use a small to remove any excess materi

Shapes

The least difficult shape complete is the st dodechehedra. That's the sha that results if all the structu resistors and jumpers are p formed to the same length—a proximately ¾-inch. Their act al lengths are not critical, long as they are all equal. Th results in the pentagon (fi point) boards sticking out a l tle more than the hexagon (s point) boards (see Fig. 4). Wi ¾-inch spacing, the globe w be about the size of a softball

It is possible to construct globe with a uniform resist spacing of ½-inch, but th should be attempted by only t most skilled assemblers. Th results in globe the size of baseball (see Fig. 5). Once y decide on the proper lead spa ing for the globe you wish build, use a bending jig to ma all components the san length. If you don't have a re bending jig, cut a piece of wo to the proper width (½-inch, ¾ inch, etc.), and make a depre sion in it for the body of t component. You can do that pressing an unneeded resist into the wood to leave an i pression. (Try to center the i pression within the width of t wood.)

Although it might seem to l easier to loop the resistors a jumpers through the boards, is not recommended becau they are difficult to remove lat in case of an error. It's best put the lead straight throug the PC board, and then snip off after soldering. If a repair necessary, the lead can then l lifted straight out after reme ing the solder.

To make the globe into spherical shape about the si of a softball, all of the resisto and jumpers that connect any five-point board (levels 2, and 7) must be preformed to ⁵ inch, with the rest remaining -inch (see Fig. 6).

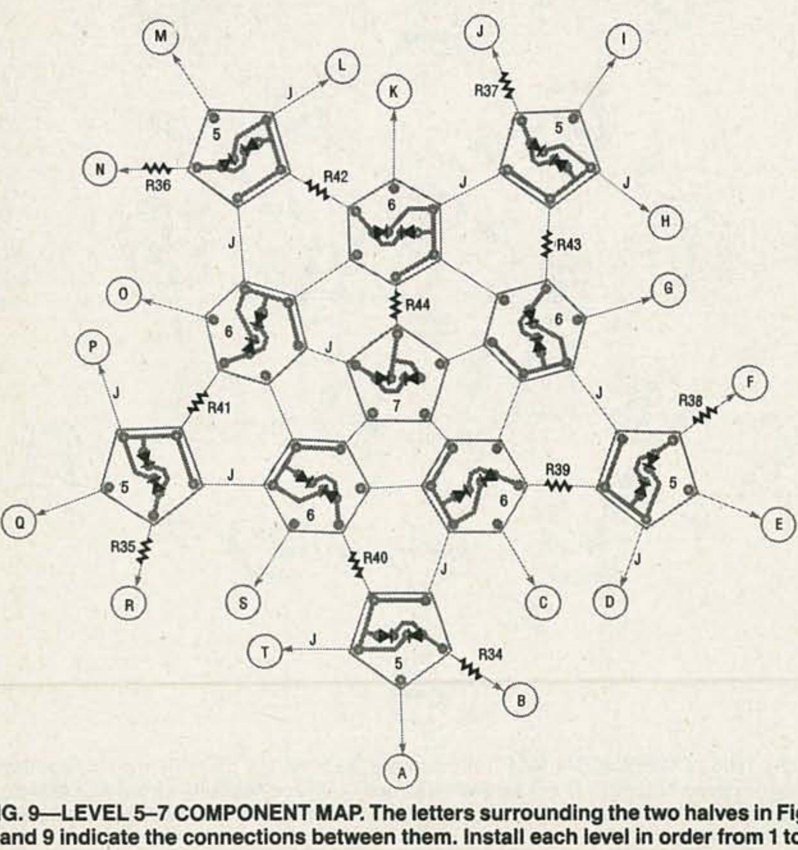
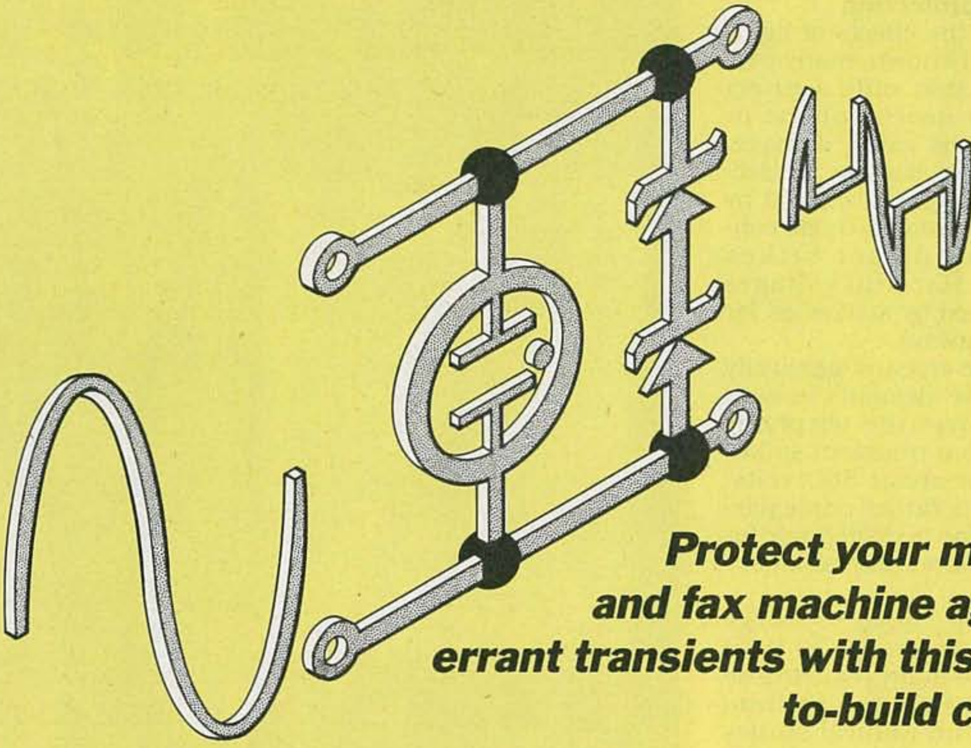


FIG. 9—LEVEL 5–7 COMPONENT MAP. The letters surrounding the two halves in Figs. 7 and 9 indicate the connections between them. Install each level in order from 1 to 7.

Continued on page 8



Protect your modem and fax machine against errant transients with this easy-to-build circuit.

FAX/MODEM PROTECTOR

TOM PETRUZZELLIS

SHIELD YOUR MODEM, FAX, OR ANswering machine against harmful transients arriving over the phone line by building this fast-acting Modem/Fax Protector. Then you'll be able to relax when electric storms bear down on your home or office. It's an easy, inexpensive project, and low-cost insurance for your expensive telephone-dependent equipment.

Even people who plug their computers and entertainment electronics into power-line surge protectors (and wouldn't dream of leaving them unprotected) are likely to forget about protecting modems, faxes and answering machines from transients arriving over the phone line. Then comes the first thunder storm of the season. Before they remember to do anything about it, the innards of that equipment could disappear in a puff of smoke.

You could, of course, disconnect your telephone gadgets with a switch when they're not in use. But will you remember to do it in time? Needless to say, the switch won't help much if the devices are running when the lightning starts to flash.

Telephone electrical values

When a telephone handset is "on the hook"there is 48 volts DC is across the two wires designated "tip" and "ring." The green tip wire is at ground potential, or zero volts, and the red ring wire is at negative 48 volts. Approximately 21 to 35 milliamperes of current flows in this condition.

When the handset is picked up, phone-line voltage drops to 6 volts DC. The 20- or 30- Hz telephone-ringing signal can be from about 100 volts to about 120 volts AC. It is superimposed across the normal 48-volt DC signal. That "ringing" voltage determines the voltage ratings of the protective devices.

Telephone protection

Although the effects of lightning are well known, many people believe that only a direct strike on a nearby phone or power line will cause damage. However, most damage to electronic equipment is caused by voltages *induced* in those conductors by direct stikes elsewhere. Harmful voltages can be caused by strikes as far as 15 miles away!

Telephone circuits generally have resistive elements in each wire to protect the telephone handsets from transient spikes in excess of about 500 volts. However, this rather crude passive protection is inadequate for protecting more vulnerable electronics.

Spark-gap tubes or surge voltage protectors (SVP) have been used for many years to protect electronic circuits from manmade and natural surges arriving over either power or phone lines. They provide low-resistance paths for excessive voltage transients but appear open to normal voltages. The devices are hermetically sealed gas-discharge tubes. Typically made of ceramic with properly spaced electrodes, they are filled with a rare gas.

The main purpose of the SVP is to provide a conductive path for unwanted and excessive transients, thereby preventing the transient energy and associated voltages from damaging equipment and components—and harming people. They are designed to switch current at a pre-established breakdown voltage.

The breakdown voltage causes the internal gas to ionize and change from a non-conducting to a conducting state, thus permitting an arc to form and short the connected wires to ground. During conduction, the SVP can monmentarily carry high currents. After the voltage transient has been discharged, the gas deionizes and the SVP is ready for another voltage transient.

The SVP is bipolar and has a symmetrical characteristic. In the restored or extinguished condition, it causes very little loss because of its high impedance. This characteristic contrasts with those of transient absorbtion Zener diodes and metal-oxide varistors that exhibit leakage. However, both of those devices have faster response times than SVP's.

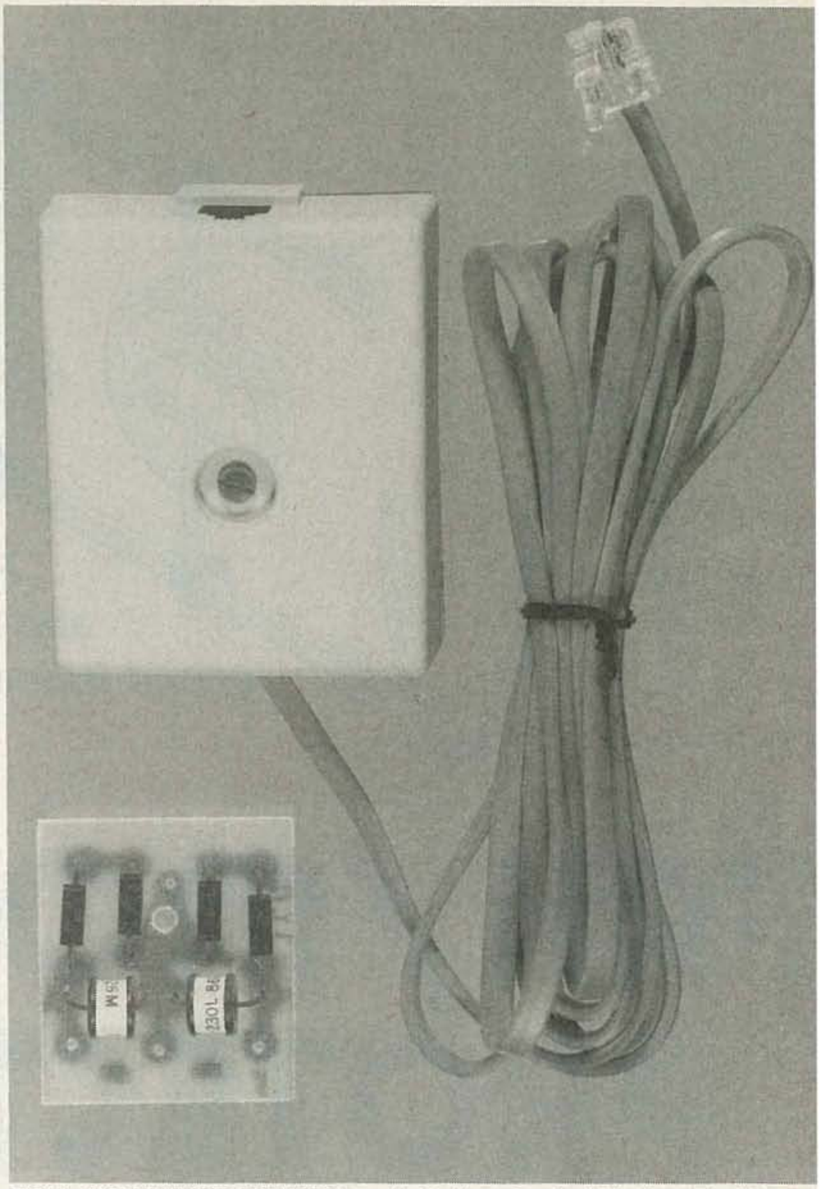


FIG. 1—MODEM/FAX PROTECTOR packaged in a standard telephone jack box.

The metal-oxide varistor (MOV or SIOV) has also been used to protect electronics connected to telephone lines. It is made from finely powdered zinc oxide mixed with binders and pressed into a disk. After firing, the disk becomes a matrix of conductive zinc-oxide grains separated by highly resistive boundaries. This property gives them a symmetrical electrical characteristic similar to the SVP (or two back-to-back Zen diodes).

However, the MOV's brea down time is too slow to prot connected electronics agair the fastest voltage spik caused by lightning. As a resu faster Zener diodes and SV have been combined in c Modem/Fax Protector.

How the protector works

The Modem/Fax Protec (Fig. 1) is shown schematica in Fig. 2. It has a typical sponse time of about 10 nanc conds—fast enough to prot your equipment against speediest voltage spikes. Ze diodes D1 and D2 are connec back-to-back in parallel w surge-voltage protector SVP1 between the ring and the PC board earth ground connection. Similarly, Zener diodes D3 and D4 are connected in parallel with SVP2 between the tip wire and the PC board earth ground. The SVP's are rated for a nominal DC voltage of 230 volts with breakdown voltage from 195 to 265 volts DC.

The Zener diodes break down at 180 volts DC within about 10 nanoseconds to protect the telephone circuits from the fastest initial voltage spikes, and then the SVP's ionize to ground the overcurrent. Note that the circuit has no batteries; all it really needs to protect your equipment is an effective ground.

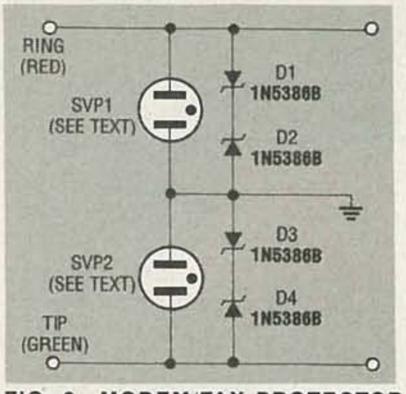


FIG. 2—MODEM/FAX PROTECTOR schematic showing Zener diodes in parallel with surge voltage protectors.

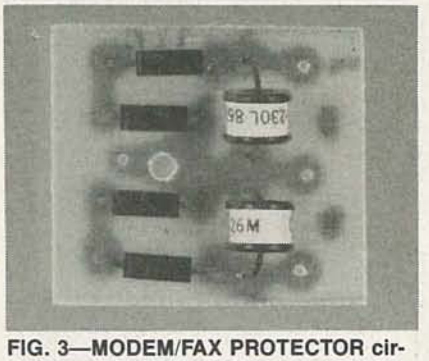


FIG. 3—MODEM/FAX PROTECTOR circuit board assembly shown actual size.

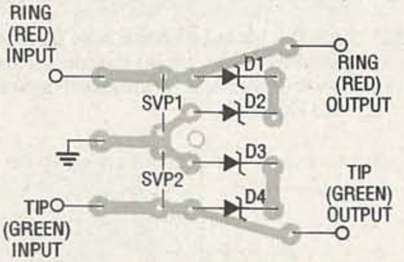
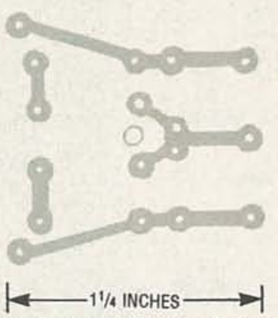


FIG. 4—PARTS-ASSEMBLY DIAGRAM for the the Modem/Fax Protector circuit board.



FOIL PATTERN for the modem/fax protector.

Construction

The prototype Modem/Fax Protector was built on a small square PC board measuring 1½ inches on a side (see Fig. 3). However, point-to-point wiring techniques can also be used. Note that the board has a hole drilled through it for the screw that clamps the enclosure together and provides the ground connection.

Refer to parts-placement diagram, Fig. 4. Install all of the components as shown, observing the polarities of the Zener diodes. Solder all components in position and trim excess leads.

Obtain a small modular plastic phone jack cover with an included jack. The jack should have a short section of 4-wire telephone cable attached. Cut off the black and yellow wires and connect the red ring and green tip wire pigtails within the box as shown in Fig. 5. Cut a bottom plate from sheet micarta, phenolic or other suitable thin but rigid insulating material slightly larger (about 1/16-inch) than the outer dimensions of the jack box. Carefully mark the location on the cover plate for a hole to accommodate the central screw so that it is opposite the hole in the jack box, and drill a hole of the same diameter through the cover.

Determine a suitable length for the four-wire telephone cable between your telephone outlet or junction box and the Modem/Fax Protector, and attach a plug to one end of that cable. Carefully form a hole in the side wall of the jack box, as shown in Fig. 5, large enough to permit the bare end of the telephone cable to be pulled through a distance of 3 to 4 inches. Clamp the cable with a plastic cable tie.

Strip the cable jacket back to about ⅛ inch from the cable tie, select out the red ring wire and green tip wire and strip their ends, and cut off the yellow and black wires close to the cable tie. Then strip the ends of the red and green wires from the jack. Solder both red and green wires to the circuit board, as shown in Fig. 4. Cut a short length of insulated 14 or 16 AWG wire, strip both ends, and solder one end to the ground pad on the PC board.

Apply four drops of silicone RTV adhesive to the inside of the jack box as shown, align the hole in the circuit board over the hole in the jack box, and bed the board down in the adhesive. Allow sufficient time for the adhesive to set up before proceeding. Determine a suitable length for a 14 to 16 AWG solid-copper ground wire based on the proximity of your telephone apparatus to a suitable location for a ground rod (to be discussed later).

Form a loop in one end of the heavy ground wire to accommodate the central screw in the Modem/Fax Protector. Then insert the screw through the loop in the ground wire, jack box, and circuit board. Tightly wrap the bare copper end of the ground wire on the circuit board several times around the screw to complete the ground connection. Then apply solder to the outside of the turns.

Plug your modem or fax into the jack, and plug the length of cable into your telephone wall outlet. The ring and tip wires of the telephone line must remain consistant throughout. The tip lead must be positive with respect to the ring lead.

After making sure that all connections have been made correctly, apply a thin layer of RTV adhesive to the rim of the jack box, assemble the cover over the screw, and clamp it in position with a washer and two nuts, as shown in Fig. 5.

Good grounding

The necessity for a good

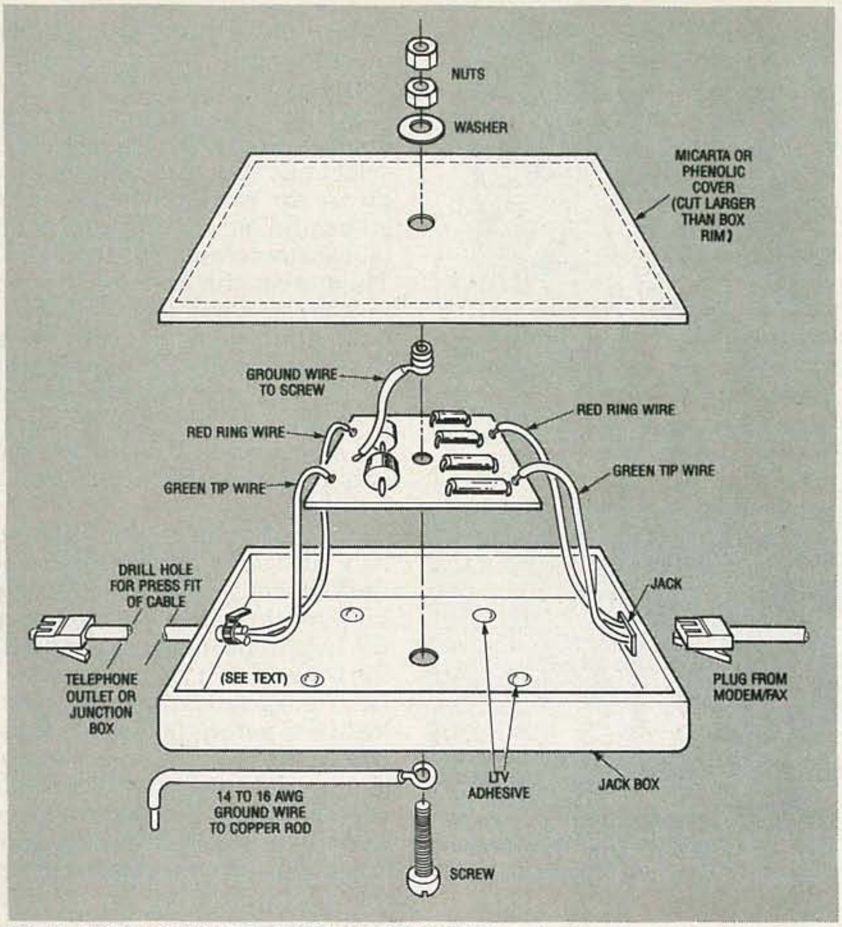


FIG. 5—MODEM/FAX PROTECTOR ASSEMBLY. Note the location of the hole formed for the 4-wire telephone cable. Only the red and green wires are used; the others are cut off near the cable clamp. The assembly is set on four spots of RTV adhesive, and the cover is held on with the central screw, nuts and washer.

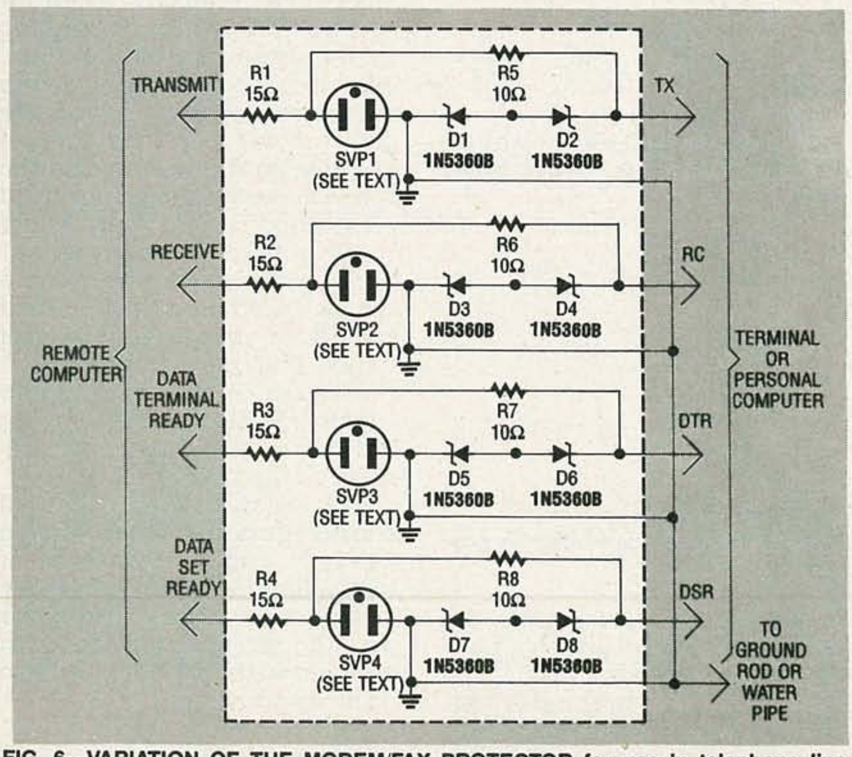


FIG. 6—VARIATION OF THE MODEM/FAX PROTECTOR for use in telephone line connections between PC or terminal and larger distant computer.

ground in protective circu cannot be overstated; a ground is no ground at all! most effective ground achieved with a metal rod, p erably copper, at least four long, driven into moist s Connect the ground rod to Modem/Fax Protector with other end of the insulated s copper ground wire. It car led to the ground strap thro a window opening or a h drilled through the wall. S able grounding rods with w connecting clamps are availa from electronics supply sto

The next best ground

PARTS LIST

Surge voltage protector

SVP1, SVP2—gas surge arrestor, 25 volt, CG-230L (C.P. Claire) or equ alent

Semiconductors

D1–D4—1N5386B Zener diode, 18 volt, 5-watt.

Miscellaneous: PC board, modu plastic phone jack box with jack, ph nolic or micarta cover, length of 4-w telephone cable, modular phone ja length of insulated 14 to 16 AWG so copper wire, copper ground rod least 4 feet long), nuts, bolt, wash silicone RTV adhesive, solder.

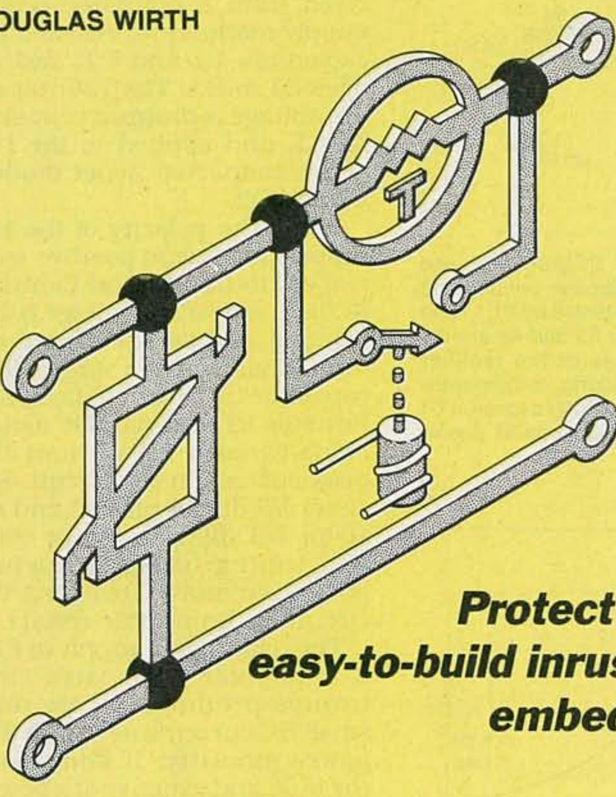
method is to connect the 14 16 AWG wire to a cold-wa pipe. The third, and least sa factory method (not reco mended), is to connect ground wire to the ground of 120-volt AC outlet. (This grou can actually be at a higher tential than true earth grou by many millivolts!)

Variations on a theme

Figure 6 shows the Mode Fax Protector concept applied the protection of remote co puter terminals or perso computers connected to a lar computer over long-distan phone lines. The schema shows a typical four-chan protective circuit.

The SVP's and transient sorbtion Zener diodes in Fig differ from those in the Mode Fax Protector. The SVP's are C Clare C675L's or equivale and the Zener diodes a 1N5360B units. Resistors through R4 are 2-watt wi wound units, and resistors through R8 are 1/2-watt.

DOUGLAS WIRTH



INRUSH CURRENT LIMITER

Protect sensitive electronics with an easy-to-build inrush-current limiter that can be embedded in host equipment or be a stand-alone unit.

THE INRUSH-CURRENT LIMITER DEscribed here can protect sensitive line-powered electronics against normal current surges that occur when that circuitry is powered up. The limiter gives a "soft start," to any product or system it protects, and it can be expected to lengthen the operating life and improve the reliability of the host. A thermistor and relay protect against normal "turn-on" overcurrent, and a metal-oxide varistor protects against unwanted overvoltages and overcurrents occuring after startup.

Our inrush-current limiter, shown packaged in an enclosure in Fig. 1, can protect any equipment operated from 120-volt, 60-Hz AC. It can also protect non-electronic circuits such as lighting networks and appliances, provided that they do not include motors. (Many appliance motors depend on surge current for starting.) The circuit can be modified for protection at higher or lower AC voltages or DC voltages.

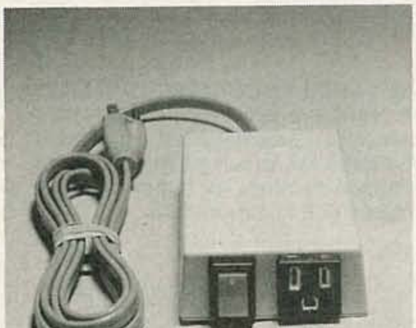


FIG. 1—INRUSH-CURRENT LIMITER circuit as a stand-alone component.

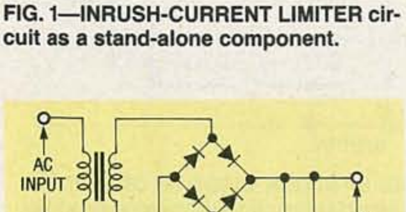


FIG. 2—SIMPLIFIED SCHEMATIC for a linear power supply with a full-wave rectifier and capacitor filter.

Current limiting

Most power supplies for electronic equipment that are embedded within the enclosure (typically sharing a PC board with other circuitry) are conventional linear circuits. As shown in Fig. 2, they consist of a transformer, bridge rectifier circuit, and one or more filter capacitors. When AC power is applied to such equipment, there is no charge on its capacitors, and the circuit components present an extremely low impedance to the line voltage.

As a result, a large inrush current surge with a fast rise time occurs, and it decays exponentially only as the filter capacitors charge. The peak inrush current is orders of magnitude greater than the circuit's steady state current. It is limited primarily by the short circuit characteristics of the power transformer and rectifier, which are determined by their internal resistance and inductance values and the wiring, as shown in Fig. 3.

An inrush-current limiter, as its name implies, limits inrush current and allows the voltage to rise gradually across the protected circuit. The limiter was designed for high-power stereo amplifiers to avoid the excessive current surges that occur at turn-on. The current drain of large stereo amplifiers is high enough to dim the lights in an average home when it is turned on.

Electronic-equipment and power-supply manufacturers typically limit inrush current by placing a momentary switching device with a fixed resistance at the power input terminal of the circuitry to be protected. After a predetermined time interval, relay contacts close, shorting out the input resistor so that full voltage is applied to the load.

Our inrush-current limiter circuit takes that conventional approach one step further. The fixed-value protective resistor is replaced by a temperature-variable resistor whose resistance value declines with increasing inrush current. A negative temperature-coefficient (NTC) thermistor optimized for inrush-current protection, its manufacturer refers to it as an *inrush-current limiter.*

A typical temperature vs. resistance curve for an inrush current limiter device is shown in Fig. 4. These devices are widely used in AC/DC switching power supplies. The unit specified for this project has a resistance of 120 ohms ± 25 % at 25°.C, a maximum steady state current of 2 amperes, and an approximate resistance of 1.18 ohms at maximum current.

Inrush-current limiting

Refer to the simplified block diagram, Fig. 5. The hot side of the AC line is fed through the inrush-current limiter (shown as a resistor with the letter "T.") Actual resistance change depends on the magnitude and duration of the current drawn. With a nominal resistance of 120 ohms, the maximum instantaneous current through any connected circuit will be limited to 120 volts/120 ohms = 1.0 ampere. (The current drawn will be less than the theoretical value because of the impedance of other components.)

At the end of a preset elapsed time after power is applied, a relay is actuated and it shorts out thermistor R9; that applies full power to the protected circuitry. The time delay is adjustable and determined by the value of a single resistor or po-

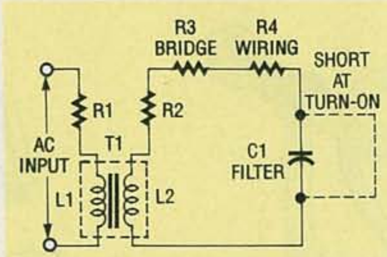


FIG. 3—EFFECTIVE RESISTANCE and inductance of transformer primary and secondary are represented by R1, L1 and R2, L2, respectively; R3 and R4 are the effective resistances of the rectifier bridge and circuit wiring, respectively. The dotted line across filter capacitor C1 represents zero resistance at power turn-on.

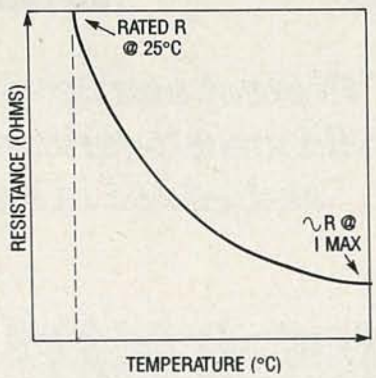


FIG. 4—INRUSH-CURRENT LIMITER device shows negative-temperature coefficient (NTC) characteristics. A thermistor optimized for circuit protection, its resistance declines as temperature increases due to current flow.

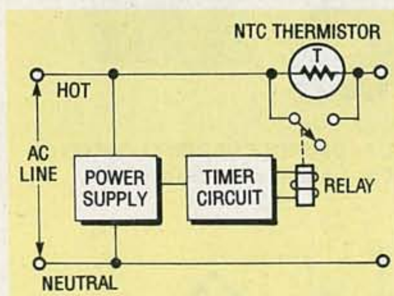


FIG. 5—BLOCK DIAGRAM OF INRUSH-current limiter circuit shows relay power supply and an inrush-current limiter component to protect against current surges at turn-on.

tentiometer; it can range from less that a second to more than a minute.

How the limiter works

The schematic of the inrush-current limiter circuit is given in Fig. 6. The 24-volt DC for the timer circuitry and relay are derived from a regulated pow supply made up of resistor F capacitors C1 and C2, and odes D1 to D3. The 120-volt put voltage is dropped primar by C1, and applied to the t series-connected Zener diod D1 and D2.

When the polarity of the h (upper) AC line is positive wi respect to the neutral (botto AC line, a positive voltage is veloped across the Zener odes. That voltage charges fil capacitor C2 through diode D Resistor R1 and parallel met oxide varistor MOV1 limit t peak current in the circuit. F sistor R2 discharges C1 and sistor R3 discharges the fil and timing capacitors wh power is removed, readying t circuit for immediate restart.

The relay power supply in F 6 is popular in isolated ele tronics products where or small DC currents are needed power circuitry. It eliminat the bulk and expense of a pow transformer. However, appr priate safeguards must taken because the supply is n isolated from the AC line. T timing circuit consists of sistors R4 to R7, capacitors C diode D4, transistors Q1 a Q2, and relay RY1. Timing pacitor C3 charges throu timing resistor R4. (With a v ue of 150 K, the time delay w be 11 seconds.)

The PC board provides thr holes for 1 megohm boar mounted potentiometer R9. adjustment will give a contin ous range of time delays fro about 1 second to 60 second As an alternative, Table 1 lis the values of resistor R4 need to obtain time delays from 1.5 180 seconds in discrete inc ments. The time delays given the table can vary because of t wide tolerances of electroly capacitors.

When the voltage on reaches the 12-volt breakdov threshold of Zener diode D4, conducts and applies base dri to turn on NPN Darlington tra sistor Q1. When Q1 conduc its collector voltage decrease turning on PNP Darlingt transistor Q2, whose collect current actuates relay RY1. T

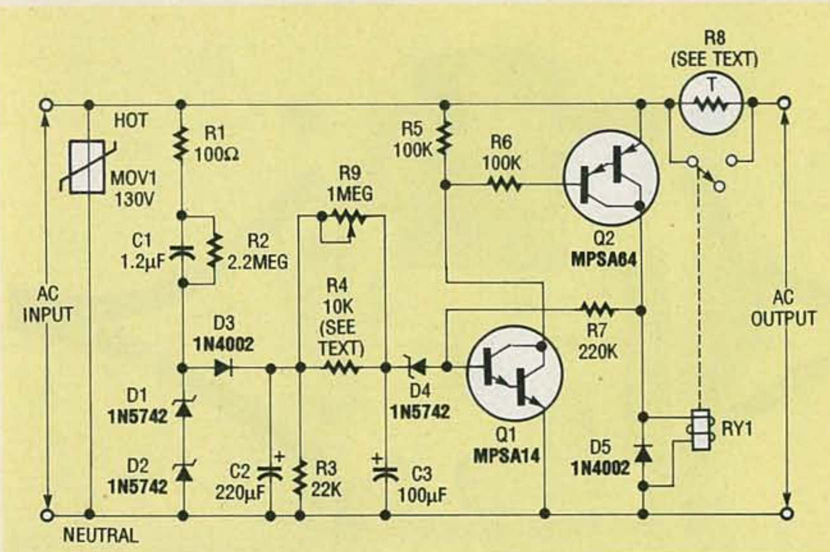


FIG. 6—SCHEMATIC OF INRUSH CURRENT LIMITER. Note that Q1 is a an NPN Darlington and Q2 is a PNP Darlington. MOV1 is a metal-oxide varistor and R8 is an NTC thermistor for limiting inrush current.

relay's normally open contacts are connected across the inrush current limiting device. When closed, the contacts apply full power to any connected load. Resistor R7 provides positive feedback to Q1's base, ensuring positive turn-on of the relay.

Diode D5 protects the circuit from the inductive "kickback" of the relay coil when it is de-energized. The resistance of the relay's coil must be at least 1.3 K for effective relay operation. The metal-oxide varistor MOV1 will protect the load against voltage spikes and transients, but it is not a requirement for the operation of this circuit. It has symmetrical bidirectional "breakdown" characteristics similar to those of back-to-back-connected Zener diodes.

Construction

All of the circuitry fits on a PC board measuring 2.5 x 2.5 inches. However, you might want to make the PC board's outer dimensions larger or smaller. If you plan to mount the circuit in a case, the board size and the hold-down screw spacing will depend on the case selected. The complete circuit assembly can also be mounted within the enclosure of its host equipment with mounting holes and insulating standoffs, if desired.

The PC board for this project

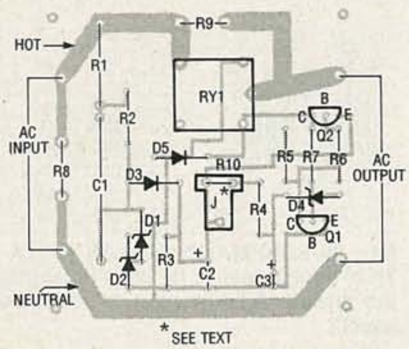
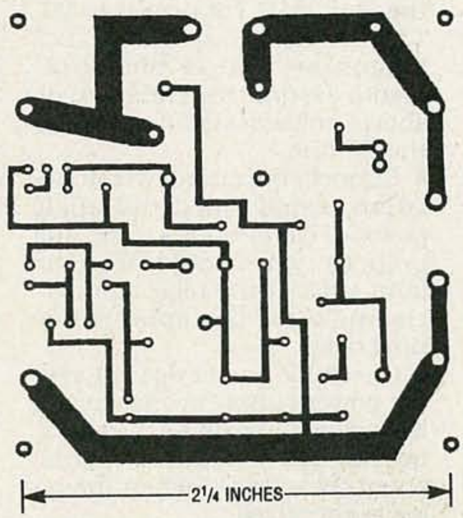


FIG. 7—PARTS-PLACEMENT DIAGRAM for the inrush-current limiter circuit.



FOIL FOR INRUSH-CURRENT LIMITER PC board.

is simple enough for an amateur to make, so its foil pattern is included here. However, because there are no critical components on the board, the components can be assembled on prepunched insulating board and connected by point-to-point wiring. Before doing any assembly work, drill the four corner holes in the board for the screws to mount the board to the case or inside the host's enclosure with standoffs.

Figure 7 is the parts-placement diagram. Install the resistors, capacitors and diodes first, observing the proper polarities for the capacitors and diodes. If you elect not to use the 1 megohm potentiometer R9, the value of R4 should be 150 K ohms rather than the 10 K shown on Fig. 6, and a jumper should be installed across two of the holes as shown. (Table 1 gives values of R4 for specific time delays.) After all the components are assembled on the board (see Fig. 8), solder them, and trim all excess leads. Recheck your work, carefully examining the circuit for shorts before continuing with the checkout.

Checkout procedure

Warning: This is a line-operated device, so perform all testing and troubleshooting with a line-isolation transformer. *Never* operate the circuit outside of an insulating housing and *never* make adjustments or any kind of modifications to it when it is directly connected to the AC line.

An isolation transformer is recommended for testing this circuit. If you cannot obtain a commercial unit, you can build one by connecting the secondaries of two identical transformers back-to-back as shown in

TABLE 1
TIME DELAY VS. RESISTANCE

Resistance (R4) (ohms)	Time delay (seconds)
22 K	1.5
47 K	3.0
68 K	5.0
100 K	7.0
150 K	11.0
220 K	17.0
470 K	40.0
1.0 MEG	80.0
2.2 MEG	180.0

Fig. 9. (It can also be used to test other transformerless electronic circuits.) The 120-volt line is stepped down, and then stepped back up to 120 volts. Use only transformers with the same secondary voltages, and do not exceed the current or power ratings of each of the transformers.

With no power applied to the circuit, perform the following resistance checks:

• Measure the resistance between the AC inputs, the hot AC line connected to R1, and the neutral AC line connected to the anode of D2. The readings should be greater than 10 megohms—anything less could indicate a problem.

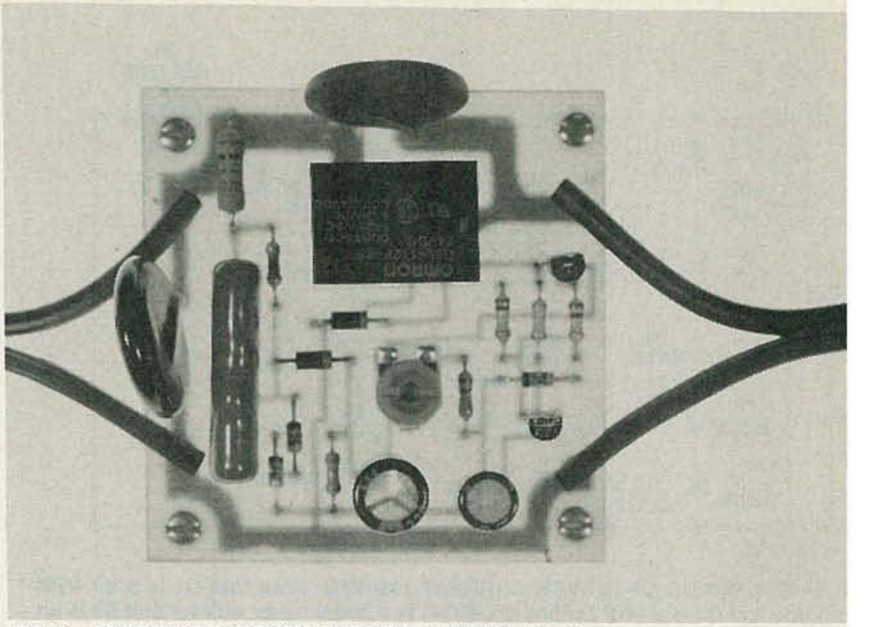


FIG. 8—ASSEMBLED INRUSH-CURRENT LIMITER circuit.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise stated

R1—100 ohms, 2 watt, 5%, metal-oxide
R2—2,200,000 ohms
R3—22,000 ohms
R4—10,000 ohms (see text)
R5, R6—100,000 ohms
R7—220,000 ohms
R8—120 ohms inrush-current limiter (NTC thermistor) 2-ampere (Keystone) CL-90 or equivalent
R9—1,000,000 ohms potentiometer, 3-pin, PC board-mount, insulated knob.

Capacitors

C1—1.2 µF, 250-volt, polyester-film
C2—220 µF, 35-volt, aluminum electrolytic
C3—100 µF, 16-volt, aluminum electrolytic

Semiconductors

D1, D2, D4—1N5742, Zener diode, 12-volt, 1-watt
D3, D5—1N4002, 1 ampere, 100 peak volts
Q1—MPSA14, NPN Darlington transistor, (National Semiconductor) or equivalent
Q2—MPSA64 PNP Darlington transistor, (National Semiconductor) or equivalent

Other components

MOV1—metal-oxide varistor, 130-volt AC, (Panasonic) 20K201U, or equivalent
RY1—SPST relay, coil: 24-V, contact: 5 A, 250-V AC, 30-V DC, coil resistance 1300 ohms, PC-mount, (Omron) G5L-112P-Ps or equivalent
S1—toggle or rocker switch, panel-mounted, 350-volt, 3 amp

Miscellaneous: circuit board, panel-mounted receptacle (three-prong), length of 3-conductor power cord 18 AWG with 3-prong plug, four 1/4-inch insulated standoffs (see text), insulated case with cover, cable grommet, screws as needed, and solder.

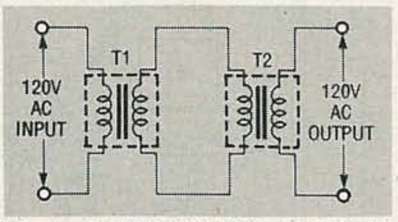


FIG. 9—SCHEMATIC FOR AN ISOLATION transformer to be used in testing the circuit. All turns ratios must be equal.

• Measure the resistance between the same end of R1 and the end of R2 connected to D1. The readings should be 2.2 megohms. Those measurements assure that there are no shorts or low resistances across the AC line.

• Connect the circuit to the isolation transformer and apply power. If the circuit is operating properly, you should hear the faint click of the relay contacts closing after the appropriate time delay.

• Check for proper operation of the power supply by measuring the voltage across filter capacitor C2. The reading should be about 22 volts DC when the relay is energized.

When testing and experimenting with loads connected to the inrush-current limiter, allow several minutes for the circuit to cool down to room temperatures and the nominal resistance values to be restored. The allowed time should depend on the magnitude and d ration of the current draw through the device. In norm operation, allow about a minu after power is removed for tir ing capacitor C3 to dischar before initiating a new time d lay sequence.

Installation

The inrush current limit can be installed within the e closure of the host equipmer Connect the circuit to the A line after the host equipme power switch and preferab after the line fuse or circu breaker. Install the circuit that the hot leg of the AC line connected to the surge limit as shown in Fig. 6. Cut the A line to the host and install t circuit in series, as shown Fig. 8. Be sure the circuit boa for the inrush-current limit and all components are ins lated from the equipmen chassis and all other comp nents with insulated standof

As an alternative, install t inrush-current limiter in a su able insulated case with a li cord, power receptacle, and c OFF power switch as shown Fig. 9. The prototype case me sured 4⅜ × 3¼ × 1½ inch deep.

It might be necessary to c down the four standoff pos within the case to accommoda

continued on page 7

LIGHT BEAM COMMUNICATOR

Build the Air Hop, an inexpensive system that communicates with light.

RODNEY A. KREUTER

IMAGINE YOU WERE CHALLENGED TO build a device that could send an optical audio signal—with a bandwidth of 300 to 3000 Hertz—as far as possible. To make the contest as fair as possible, the rules would require that only commonly available parts could be used. Also, because optics would play a large role in determining the range of such a device, no optics with a collection area greater than seven square inches could be used.

A dozen years ago, the author lost just such a contest by achieving a communications distance of a little over two and a half miles. The winning entry achieved a distance of 6 miles!

The optical communications system presented here is a somewhat modified version of the author's original Air Hop. The circuits have been redesigned in order to use common parts and provide a decent link at a reasonable cost. The unit has an output power of about 10 milliwatts peak and 5 milliwatts average. It uses frequency modulation on a 50-kilohertz carrier and has a bandwidth of 300–3000 Hertz. Without optics, the Air Hop can communicate about 40 feet—with 3-inch diameter optics (a magnifying glass), the range is increased to over a mile.

Air Hop can be used as a simple point-to-point audio communications system or to transmit digital data. Since its bandwidth is the same as a phone line, modems can be used to send and receive digital data. It can also be used as a link for a remote control such as that used in a TV receiver, perhaps with a tone encoder/decoder combination. A remote link to a repeater or a long-distance "broken beam" security system can also be made. Whether you need a link from a house to a barn or a short jump across the commotion of Wall Street, Air Hop can do it.

Electro optics

Before we get into the design and construction of the Air Hop, let's explain some optical terms.

PIN Diode. A photosensitive diode with a response time of a few nanoseconds. It can be used in a photoconductive mode where the current through it is a function of light, or in a photovoltaic mode where the voltage across it is a function of light (see Fig. 1).

Phototransistor. A transistor whose base current is a function of light. The collector current is the base current times the gain of the device. Response time is a few microseconds.

Photodarlington. Two transistors in the same package connected in a Darlington configuration. The first transistor is a phototransistor and the second is an ordinary transistor. Response time is tens to hundreds of microseconds.

Detector area. The area (in square inches or millimeters) of the light-gathering detector. Most PIN diodes have a plastic case that acts as a simple lens and provides a collection area of 0.01 to 0.025 square inches. This area is important when you're calculating lens gain.

Inverse square law. This is the "killer" in nearly all communications systems. Very simply stated, it means that if you increase the distance between the transmitter and the receiver, the signal strength will drop in proportion to the square of the distance. For example, if you receive 9 microwatts of power when the distance between the transmitter and receiver is ten feet, you will receive only 1 microwatt of power if you increase the distance to thirty feet.

Transimpedance amplifier. An amplifier with a very low input impedance. Sometimes called current-to-voltage converters, these special amplifiers are often used in optical systems because their low impedance load will ensure maximum current from a photodiode. They can provide a bandwidth up to a few hundred megahertz.

Lens gain. The ratio of the lens area to the detector area. Since the area of a lens is larger than the area of the detector, more light is gathered by the lens. Lens losses and focusing errors (which together should be about 15%) must be included in

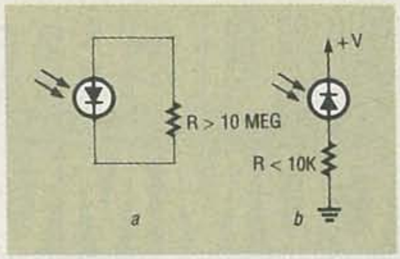


FIG. 1—A PHOTOSENSITIVE PIN diode has a response time of just a few nanoseconds.

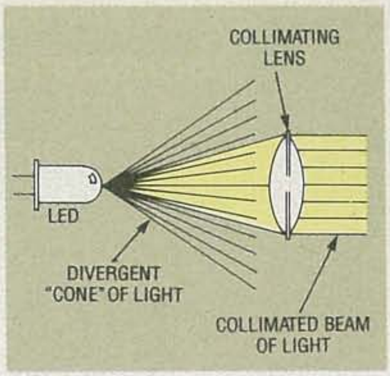


FIG. 2—THE LIGHT FROM AN LED diverges or spreads out as it leaves the LED. A lens will then collimate the light so that it travels in parallel beams.

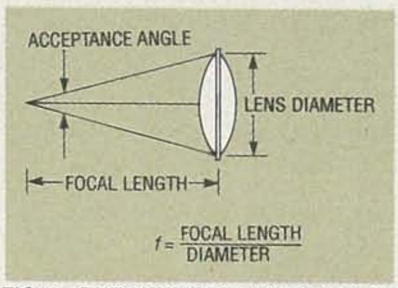


FIG. 3—THE f NUMBER or lens speed is the ratio of the focal length to the diameter. You can think of this as an optical acceptance angle.

a rigorous calculation of lens gain.

Infrared. The region of the light spectrum next to the color red (about 800 nanometers). Most infrared LED's emit at either 880 nanometers or 940 nanometers. Most silicon detectors have their maximum response at about 900 nanometers. Infrared is used because most red (visible light) LED's have trouble producing a half a milliwatt of power, while many IR LED's have an output of 10 milliwatts or more.

Collimate. To direct in a straight line. When light from a source travels in parallel beams instead of a divergent cone, i said to be collimated. Althou you can't form a truly collima beam, the lens on the transr ter attempts to do that (see I 2).

Divergence. The "spread out" of an optical beam. In ot words, a divergent beam is opposite of a collimated be All optical beams diverge, so more than others. If you co form a beam with zero di gence (you can't), it would obey the inverse square law. other words, you could se your beam an infinite dista because the energy would spread out. Laser beams h small divergence compa with other light sources. S lights are built to have a sn amount of divergence, wher flood lights are built to hav great deal of divergence (see F 2).

Responsivity. A measure of relationship between the tical and the electrical signa a detector. A rule of thumb PIN diodes is 0.4 to 0.6 an per watt. This means that milliwatt of light strikes a diode, a current of 0.4 to milliamps will flow through diode. To put that in persp tive, Air Hop will work at le of about 100 picoamps of c rent or about 200 picowatts optical power.

AC and DC light. If you pulse LED on and off it becomes AC-light source. If you sim apply DC though it, it becon a DC-light source. This conc is important because most li sources contain some AC a some DC light. Normal tu sten-filament light bulbs c tain a lot of DC and some light (because of the therr time constant of a hot filame The sun contains a lot of *and* a lot of AC. Fluoresc lights contain some DC an lot of AC. The only reason t this is important is that if build a DC-coupled optical ceiver and operate it outdo where there is a lot of sunlig the receiver can easily "sa rate" and your AC signal will be amplified correctly. So kind of "light shield," such those that are used on so camera lenses, will help. That's why the Air Hop uses an AC-coupled detector.

f number or lens speed. In lenses, the ratio of the focal length to the diameter is called the "f" number (f = fl/d). The smaller the number, the "faster" and more expensive the lens. It is convenient to think of this as an optical "acceptance" angle (see Fig. 3). This will be important in choosing the transmitter's collimating lens. In cameras, where the focal length is fixed, a lens with a larger diameter than another lens has a smaller "f" number, and is said to be faster. That's because the larger lens gathers more light and the shutter can be set to a faster speed than the smaller lens. Table 1 shows f numbers vs. acceptance angles.

Thermal noise. Although thermal noise is not applicable to optical devices such as lenses, the electronic performance of your optical system will be limited by thermal noise. Thermal noise is caused in an electrical device by the random movement of molecules. The thermal current noise (i_N) of a resistor is given by:

$(i_N)^2 = 4KTB/R$

where

K = Boltzmann's constant (1.38×10^{-23})

T = temperature in Kelvin (300)

B = bandwidth in Hertz

R = resistance in ohms

A 300K resistor operated at near room temperature in a receiver with a bandwidth of 20 kilohertz will have a thermal noise current of 33 picoamps

Although 33 picoamps might not sound like a lot of current, the noise it will cause at the output of the transimpedance amplifier will be about 10 microvolts (RMS). Converting to peak-to-peak noise gives about 60 microvolts peak-to-peak.

In the Air Hop, the only amplifier between the transimpedance amplifier and the comparator is a differential amplifier with a gain of about 50. That amplifies the 60 microvolts of noise and produces about 3 millivolts of noise at the output of the optical amplifier. Actual measurements showed 5 millivolts of noise. That is reasonable because there are other noise-producing devices in the system such as the current noise of the first transistor. Although every transistor produces some noise, the first one produces more because of its higher signal amplification.

One reason it's important to present equations like this is that they give us insight into system improvement. If there were no noise, virtually unlimited distances could be achieved. However, when the strength of the signal is less than the noise, we're out of luck. We can control temperature to some extent, and the equation shows that at a lower temperature, the noise is lower. But lowering the temperature of the transimpedance resistor even by 100 degrees Kelvin will decrease the noise power only by a factor of about 1.2.

If a system requires only a small amount of bandwidth, say a few hertz, as in a television remote control, we could decrease the bandwidth from 20 kilohertz to 20 Hertz and decrease the noise by a factor of about 30. Even with the inverse square law working against us, that would improve the range by a factor of about 5. Such a bandwidth reduction would require a good tunable filter, but it certainly can be done. Of course, audio signals sent over a link with a 20-Hertz bandwidth wouldn't be recognizable as audio. It would, however, permit Morse-code communication.

Photodetector. Any device that can convert light into an electrical signal. Phototransistors, photo SCR's, phototriacs photocells, solar cells, and photodiodes are all examples. Even photoresistors and thermocouples can be loosely considered as forms of photodetectors.

Phototransistors and photodarlington detectors are often used to detect light. Both work well if you don't require high speed. Typical phototransistor rise and falls times are 1 to 5 microseconds; for Darlingtons they are hundreds of microseconds. In electronics that is equivalent to measuring bandwidth with a stop watch and a calendar, respectively.

The author prefers to use PIN diodes in the photoconductive mode as detectors. Rather than being limited by the gain and bandwidth of a phototransistor, PIN's give us the choice of both by allowing us to design our own amplifiers. PIN diodes are also very "quiet." Their noise is almost unmeasureable.

LED's. A light-emitting diode is a semiconductor device that emits light when forward biased. You would think that choosing an LED for a system such as this would be a simple matter, but it's not. Characteristics such as power output,

TABLE 1
f NUMBER VERSUS ACCEPTANCE ANGLE

f	Angle (in degrees)
0.5	90
0.75	67.4
1.0	53.2
1.5	36.8
2.0	28
2.5	22.6
3.0	19
3.5	16.2
4.0	14.2

FM TRANSMITTER PARTS LIST

All resistors are ¼-watt, 5%.
R1, R5, R9, R15, R16—1000 ohms
R2—22,000 ohms
R3—10,000 ohms
R4—1000 ohms, potentiometer
R6—100 ohms
R7—5600 ohms
R8, R13—2200 ohms
R10—470 ohms
R11—50,000 ohms, potentiometer
R12—33,000 ohms
R14—15,000 ohms
R17, R18—22 ohms (see text)

Capacitors
C1–C3, C6—1 µF, 16 volts, electrolytic
C4—100 µF, 16 volts, electrolytic
C5, C9—10 µF, 16 volts, electrolytic
C7—0.001 µF, ceramic
C8, C10, C11—0.01 µF, ceramic

Semiconductors
IC1—NE555 timer
Q1–Q4—2N3904 NPN transistor
LED1–LED4—IR LED (Optek OP293A 880nm, Optek OP295A 880nm narrow beam, Lytron 940nm, see text)

Other components
MIC1—electret microphone

Miscellaneous: 4 "AA" batteries and holder, PC board, PVC pipe and plastic disks, hardware, wire, solder, etc.

wavelength, speed, and beam angle all come into play.

The first consideration is usually the power output. However, if you can't get the power into your lens, it's simply wasted, and if it's at the wrong wavelength, your detector won't see it.

Wavelength is important. The most widely used wavelengths for infrared devices are 880 nanometers and 940 nanometers. The first choice is to find a detector and emitter that match. We used 940 nanometers, which is further into the infrared than 880. Many detectors made for 940 nanometers have a built-in visible-light filter. Filters are not often put on the 880-nanometer devices because that wavelength is near the visible spectrum and such a narrow filter would be difficult to produce in large quantities.

If you wish to produce a hundred thousand Air Hop systems with optics, you would want to buy emitters with wide but uniform beams. Then you would have a custom lens designed and produced at a small cost in plastic material. That would produce the most uniform beam and would be reproducible in large quantities. In applications such as remote control, you might want to use an emitter or many emitters to "flood" an area. In that case, you would want an emitter with a wide beam.

If, on the other hand, you're just trying to see how far you can "air hop" a signal, you will want something totally different. Narrow beam angles are necessary for efficient coupling to an off-the-shelf lens. As a matter of fact, choosing the smallest beam angle available will save money when it comes to buying a lens. The smallest easily obtainable beam angle for an LED is about 20 degrees. When a manufacturer specifies that angle, he really means a "half angle" of 20 degrees, or a solid cone of 40 degrees.

The angle also specifies the half-power point. For example, if a manufacturer specifies 5 milliwatts and a beam angle of 20 degrees, that means that if you can capture all of the power contained in a 40-degree cone, you will get 2.5 milliwatts of optical power. In any case, purchase an LED with a small beam angle, as much power as possible, and a reasonable speed.

Lenses. Lenses are to the optical world what antennas are the world of RF. The importance of even simple lenses cannot be over emphasized. If any high-frequency RF engineer could build an antenna with 60 dB of gain for less than ten dollars, we would see a lot of happy RF engineers! Since the optical world deals with very small wavelengths, 60 dB (a gain of 1000) is certainly possible.

Although at first it might be hard to believe, the size of the lens on the receiver is very important, but on the transmitter it isn't. That's because at the receiver you are trying to intercept as much light as possible, so the larger the lens, the better. The purpose of the lens at the tran mitter is to collimate the bear so any lens with the right " number will work.

The "speed" of a lens, als called the "f" number, should l familiar to anyone with ph tography as a hobby. It's a me sure of the angle of acceptan of a lens. On the transmittir end, any light from the LED th

OPTICAL AMPLIFIER PARTS LIST

All resistors are ¼-watt, 5%.
R1—100,000 ohms
R2—10,000 ohms
R3, R9, R10, R16, R23—,5,000 ohm
R4, R5—150,000 ohms
R6, R17, R24—3300 ohms
R7, R12—100 ohms
R8—3900 ohms
R13, R14—5600 ohms
R11, R15, R18, R21—4700 ohms
R19, R22—22 ohms (see text)
R20—360 ohms

Capacitors
C1, C4, C8—10 µF, 16 volts, electrolyti
C2, C5, C9—0.1 µF, ceramic
C3, C12, C14–C16—0.01 µF, ceramic
C6, C7, C11—470 pF, ceramic, 10%
C10—0.001 µF, ceramic, 10%
C13—100 µF, 16 volts, electrolytic

Semiconductors
Q1—MPS918 NPN transistor (Motorola
Q2–Q6—2N3904 NPN transistor (Q and Q6 must be a matched pair, se text)
D1—PIN diode (Siemens SFH20 940nm usable at 880nm, Panasoni PN323BPA 940 nm, Panasoni PN334PA 880 or 940 nm, see text)

Other components
SPKR1—8- to 45-ohm speaker

Miscellaneous: PC board, wire, solde etc.

TABLE 2—LENS GAIN

Lens Diameter/Area (inch/sq. inch)	Power Gain (at 0.01 sq. inch)	Distance Improvement (85% lens efficiency)
2/3.14	314	×16
3/7.07	707	×24
4/12.6	1260	×33
6/28.3	2830	×49

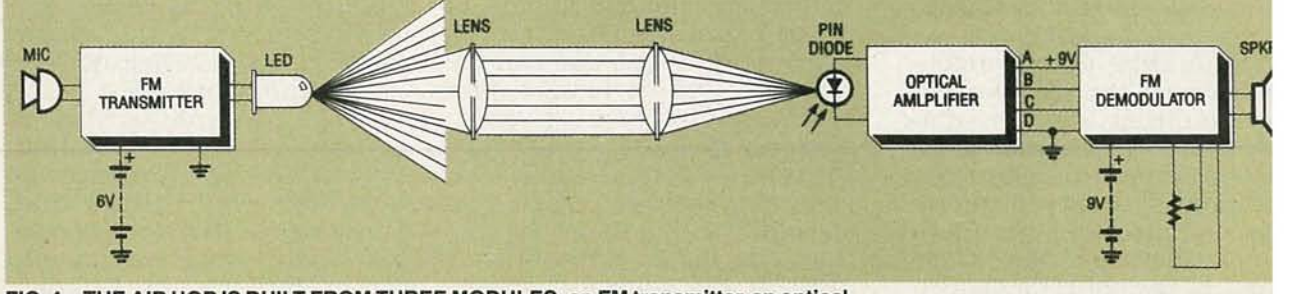


FIG. 4—THE AIR HOP IS BUILT FROM THREE MODULES: an FM transmitter, an optical amplifier, and an FM demodulator.

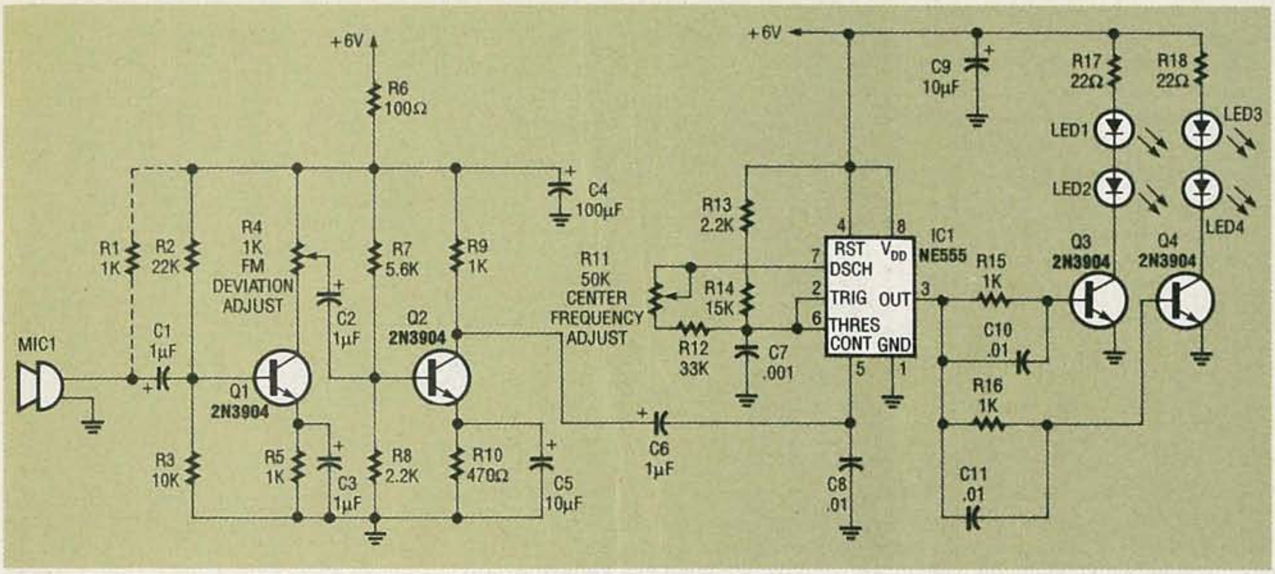


FIG. 5—FM TRANSMITTER MODULE. It provides a microphone amplifier and FM modulator.

FM DEMODULATOR PARTS LIST

All resistors are ¼-watt, 5%.
R1—100 ohms
R2, R3, R6, R11–R13, R16—10,000 ohms
R4, R5—100,000 ohms
R7—33,000 ohms
R8—50,000 ohms, potentiometer
R9, R14, R15—68,000 ohms
R17—4700 ohms
R18—10,000 ohms, potentiometer
R19—22,000 ohms
R20—470,000 ohms
R21—10 ohms

Capacitors
C1, C6, C10, C16—1 µF, 16 volts, electrolytic
C2, C5, C9, C12—0.1 µF, ceramic
C3—100 µF, 16 volts, electrolytic
C4, C7—0.001 µF, ceramic, 10%
C8—470 pF, ceramic, 10%
C11—0.01 µF, ceramic
C13—100 pF, ceramic
C14—4.7 µF, 16 volts, electrolytic
C15—470 µF, 16 volts, electrolytic

Semiconductors
IC1—LM311 or LT1011 comparator
IC2—CD4046 phase locked loop
IC3—MC34119 audio amplifier (Motorola)
Q1—2N3904 NPN transistor

Miscellaneous: 9-volt battery and clip, PC board, blank PC-board material and solder-wick straps for shield (see text), PVC pipe, plastic disks, hardware, wire, solder, etc.

Note: The following items are available from Q-Sat, P.O. Box 110, Boalsburg, PA 16827:
- **Complete Air Hop kit including all three PC boards (does not include speaker, 10K volume control, lenses, PVC pipe and batteries), AIRHOP-KIT—$30.00**
- **Transmitter kit including one IR LED and PC board, AHTX-KIT—$11.00**
- **Transmitter PC board only, AHTX-PCB—$5.00**
- **Optical amplifier kit including PIN diode and PC board, AHOPTAMP-KIT—$12.00**
- **Optical amplifier PC board only, AHOPTAMP-PCB—$6.00**
- **FM demodulator kit including PC board (no speaker or 10K volume control), AHFMDEMOD-KIT—$12.00**
- **FM demodulator PC board only, AHFMDEMOD-PCB—$6.00**

Add $3.00 shipping and handling to all orders. Pennsylvania residents must add 6% sales tax. Please allow 3 to 4 weeks for delivery.

doesn't stay within that cone is lost. A 50-milliwatt LED will be of no value if the light "sprays" out at 90 degrees—any light that can't be coupled into the lens is lost.

The gain of a lens is basically the ratio of the area of the lens to the area of the detector. For example, the area of most PIN diodes is about 0.01 square inch. The area of a 2-inch diameter lens is 3.14 square inches. Therefore, the gain of a 2-inch lens is about 3.14/0.01 or 314. Remember that this amplifier (the lens) consumes no power, has (for our purposes) infinite bandwidth, and adds no noise to the signal. A device of this kind in the electrical world would be nothing short of a miracle.

Table 2 shows the gain for some different size lenses. The calculations assume that no light is absorbed or reflected by the lens, and the detector is at the exact focal point of the lens. Those asumptions are certainly not true. Even fine-quality camera lenses, which are coated with anti-reflective coatings, do not pass 100 percent of the light. There's plenty of room here for experimentation. Some crude experiments showed about 85% of the theoretical gain.

FM transmitter

The Air Hop is built from three modules. The first module is the FM transmitter. Two other modules (the optical amplifier and FM demodulator) comprise the receiver. A block diagram of the system is shown in Fig. 4.

The FM transmitter module, shown in Fig. 5, provides a microphone amplifier (Q1 and Q2) and an FM modulator built from a 555 timer (IC1). There are two adjustments, one for the FM center frequency (R11) and one for the amount of deviation (R4). Resistor R1 is for microphones that require an external power source, such as an electret type. For an external audio source, the input must be limited to a few millivolts.

The output of IC1 (pin 3) is adjusted via R11 so that the frequency is 50 kHz (20 microseconds). The output of the 555 can be frequency modulated by applying the upper trip-point

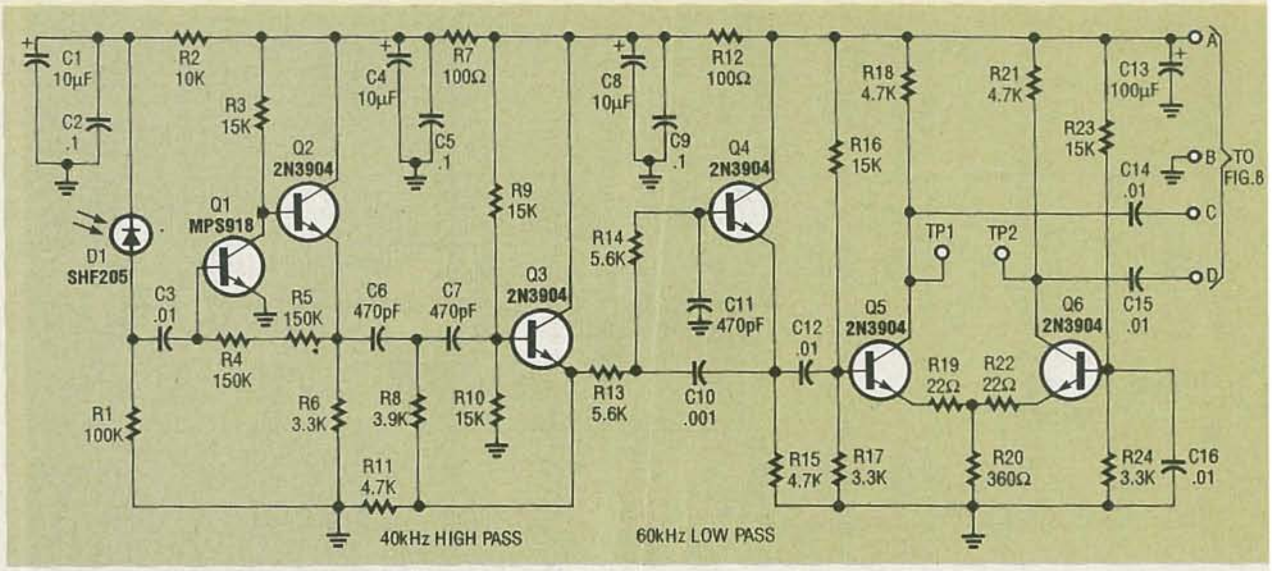


FIG. 6—THE OPTICAL AMPLIFIER MODULE converts the optical signal into an electrical signal, limits its bandwidth, and provides a differential drive to the comparator.

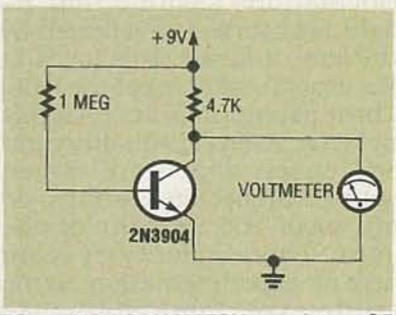


FIG. 7—YOU CAN MATCH transistors Q5 and Q6 using this circuit. Any transistor having less than about a volt between the collector and emitter has too much gain. Choose two transistors that have the closest match between collector-to-emitter voltages.

voltage reference to pin 5. Although you cannot sweep the frequency very far, deviations of 10 percent or so can be obtained easily. The FM deviation is a function of the amplitude of the signal applied to pin 5. If a DC voltage is applied to pin 5 and switched on and off, FSK (digital) data will result. Although the output of the 555 could drive a modest LED, transistor drivers are provided to drive multiple LED's.

Current-limiting resistors R17 and R18 are adjusted to limit the current for your particular LED. Currents of up to 200 milliamps pose no problem for the LED's, but they will drain your batteries quickly. If you're using one LED, values of about 47 ohms will yield about 45 milliamps, average. Systems using two LED's in series will require about 22 ohms for the same current.

The prototype system uses four AA alkaline type batteries for the transmitter power supply. Although they give reasonable life, you may want to use something a little larger, perhaps four D cells.

Optical amplifier

The purpose of the optical amplifier module, shown in Fig. 6, is to convert the optical signal into an electrical signal, limit its bandwidth (to reduce noise), and to provide a differential drive to the comparator.

The PIN diode detector (D1) is AC coupled to a simple transimpedance amplifier consisting of Q1 and Q2. Even though the signal is AC coupled, the bias for the PIN diode must be DC coupled. That is done through resistors R1 and R2. If Air Hop is used in a high ambient light situation, resistor R1 might have to be reduced in value to prevent DC saturation of the PIN diode. If the DC voltage across R1 is greater than about 3 volts in operation, you should lower the value of R1.

The transimpedance resistors (R4 and R5) set the overall gain of the amplifier. Two resistors in series were used instead of just one because every resistor has some capacitance across it. Using two re-sistors decreases the capa-tance by a factor of two. All y have to do is join the two re-sistors above the PC board.

The output of t transimpedance amplifier simply its input current tin the transimpedance resistan That's why it's sometimes cal a current-to-voltage conver As you increase the resistan the signal increases, but bandwidth decreases. Since signal increases directly w the value of the resistance a the noise increases with t square root of the resistance makes sense to have the res tance as large as possible- would, if you still had enou bandwidth. That's why Q1 i VHF transistor.

Since the center frequency the signal is at 50 kilohertz, desirable to limit the ban width of the optical amplifier reduce the total noise. Tra sistor Q3 and the surround components form a two-p high-pass filter at about 40 k hertz. That eliminates such l frequency noise as the 60-he optical noise given off by ro lights.

Transistor Q4 and its asso ated circuitry form a 60-k hertz low-pass filter. That eli nates high-frequency electri noise such as that from AM dio stations.

When the low-pass and hi pass filters are cascaded, t form a bandpass filter cente

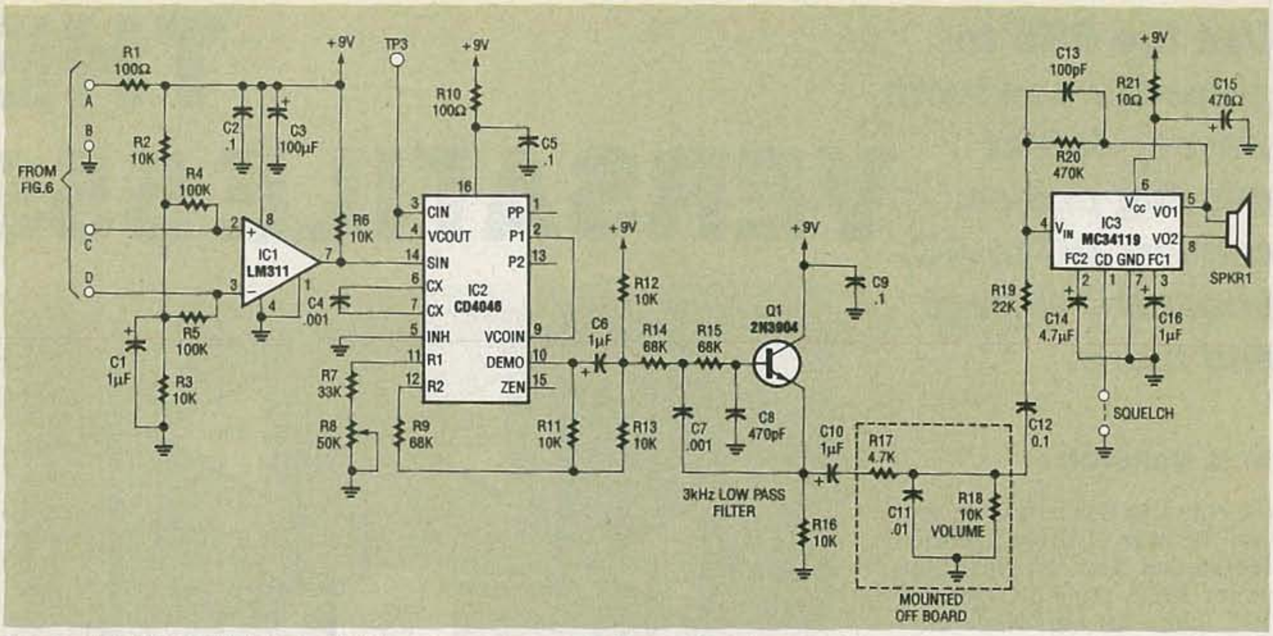


FIG. 8—FM DEMODULATOR. An LM311 comparator converts the small analog signal to a digital level for the CD4046 phase-locked loop, which is configured as a first-order FM demodulator.

on 50 kilohertz, with a pass band of about 20 kilohertz. You could reduce the noise by making the filter narrower, or by putting a narrower filter between the output of the optical amplifier and the input of the demodulation board. The disadvantage of doing that is that you would have to make the narrow filter tunable, and use a scope to adjust it.

Transistors Q5 and Q6 form a differential amplifier that is the only real gain stage in the optical amplifier besides Q1. The purpose of using a differential amplifier is so that a differential signal will be available to drive the voltage comparator. It's nice to drive a comparator differentially because you get twice the signal but not twice the noise. There is one problem with a differential amplifier: if you want a reasonable amount of gain, the transistors must be well matched. That prevents one transistor from "current hogging" and saturating.

The matching of transistors can be done a number of different ways—a curve tracer is best but most people don't have access to one. Next best is a meter that actually measures gain at a given base or collector current. As a last resort, the circuit in Fig. 7 can be used. Some kind of socket, such as an IC socket with only three pins can be used to hold the transistor. Simply measure the voltage from the collector to emitter, and choose two transistors that have the closest match between the collector-to-emitter voltage. Any transistor having less than about a volt has too much gain.

It's also a good idea to use bias resistors that have nearly the same values. Try to match the values of R16 and R23 and R17 and R24 as close as possible. If the final amplifier isn't matched within a volt, you might want to adjust the values of R19 and R22. Those resistors were purposely put there to allow some "balancing" of the differential amplifier. Values from 10 to 33 ohms should be fine. (Potentiometers were not used because they are expensive.)

FM demodulator

The schematic for the FM demodulator is shown in Fig. 8. An LM311 comparator (IC1) converts the rather small analog signal to a digital level for the CD4046 phase-locked loop (IC2). Remember that the amplitude of the recovered audio has nothing to do with the amplitude of the received signal. The amplitude of the recovered audio depends only on the amount of frequency deviation set by the transmitter and the amplitude of your voice.

The phase-locked loop (IC2) is configured as a first-order FM demodulator. With no input signal, the center frequency of the loop (pin 3 of IC2, which is also TP3) is adjusted by R8 for a frequency of 50 kilohertz. Because the variation from one CD4046 to another can be quite large, you might have to adjust R7 and, perhaps, R9 as well.

The demodulated output from IC2 is low-pass filtered at 3 kilohertz by Q1 and its associated circuitry, and then sent to audio power amplifier IC3, a Motorola MC34119. A wider bandwidth can be obtained by making the filter higher in frequency. Since the "carrier" frequency is only 50 kilohertz, don't try extending the audio bandwidth to more than 6 or 7 kilohertz. Pin 1 of the MC34119 can be used for squelch or in conjunction with a push-to-talk switch to silence the receiver while transmitting. If you don't need the squelch, simply jumper pin 1 of IC3 to ground.

Although you can use a standard alkaline 9-volt battery to power the receiver, the current draw can be quite high on voice peaks. Six AA cells would be a much better choice.

We'll finish up the project next month with complete construction details. **R-E**

Use the 555 to generate sawtooth waves, detect missing pulses, convert DC to AC, boost DC voltage and more.

TH VERSATILE 55

RAY M. MARSTON

THE POPULAR 555 TIMER IC HAS been the star of three previous **Electronics Now** articles (September 1992, page 58, October 1992, page 69 and November 1992, page 61.) Just when you thought that all possible applications for that versatile 555 had been exhausted—surprise! This article takes the 555 into new territory—a sawtooth generator, a "ramp" generator, a time-base generator, a frequency meter, and even a tachometer for your car.

But that's not all—there is a missing-pulse detector, and DC voltage doubler, tripler and quadrupler. There are also negative and high-voltage generators and a DC to AC inverter!

If you've been following the previous articles and (we hope) building some or all of the circuits presented in them, you'll be all set for the circuits presented here. Who said the microprocessor was the most versatile IC, anyway?

The last three articles on the 555 explained its basic operating principles. You would have learned (or refreshed your memory) about how to place external components so the timer functions either as a monostable or astable multivibrator. You might want to reread the introductory sections of those articles to brush up on the unusual features of the 555. A complete schematic of the circuitry contained in the 555 is given as Fig. 2 on page 64 of the September 1992 issue.

Figure 1 is another functional block diagram and pinout of the bipolar 555 with a different arrangement of functional blocks than the others given earlier, illustrating yet another manufacturer's preferred data book presentation. Neither diagrams nor data sheets on the 555 have been standardized.

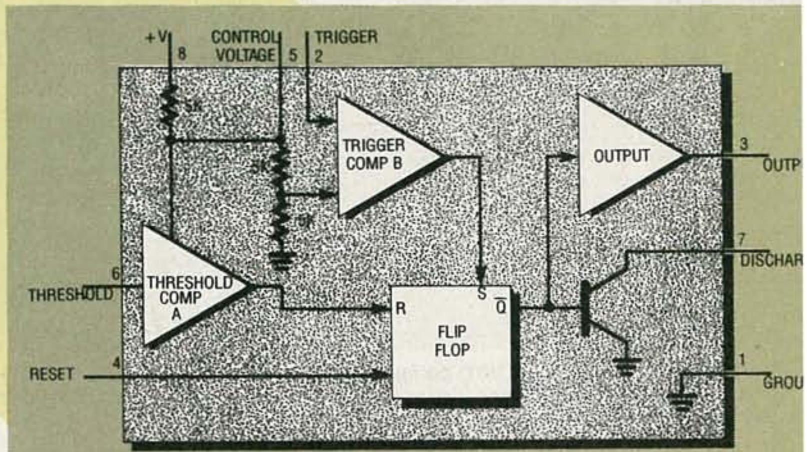


FIG. 1—FUNCTIONAL BLOCK DIAGRAM and pinout for the bipolar 555 timer IC.

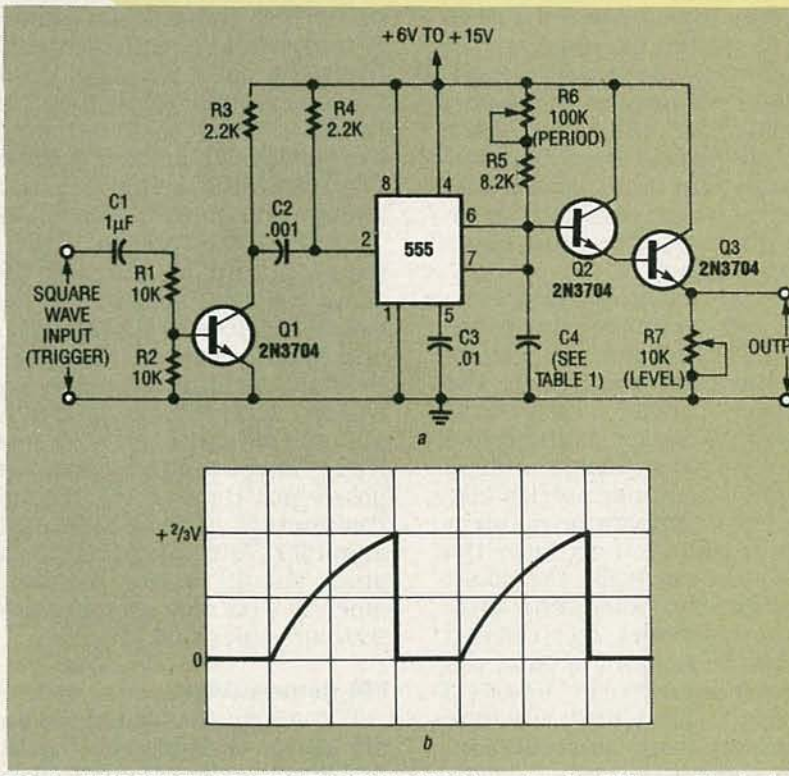


FIG. 2—TRIGGERED SAWTOOTH GENERATOR based on the 555, a, and typical ou waveform, b.

Sawtooth-wave generators

The 555 with external com nents can become a trigge nonlinear (exponenti sawtooth waveform genera as shown in the schematic 2-a. The circuit is a modi

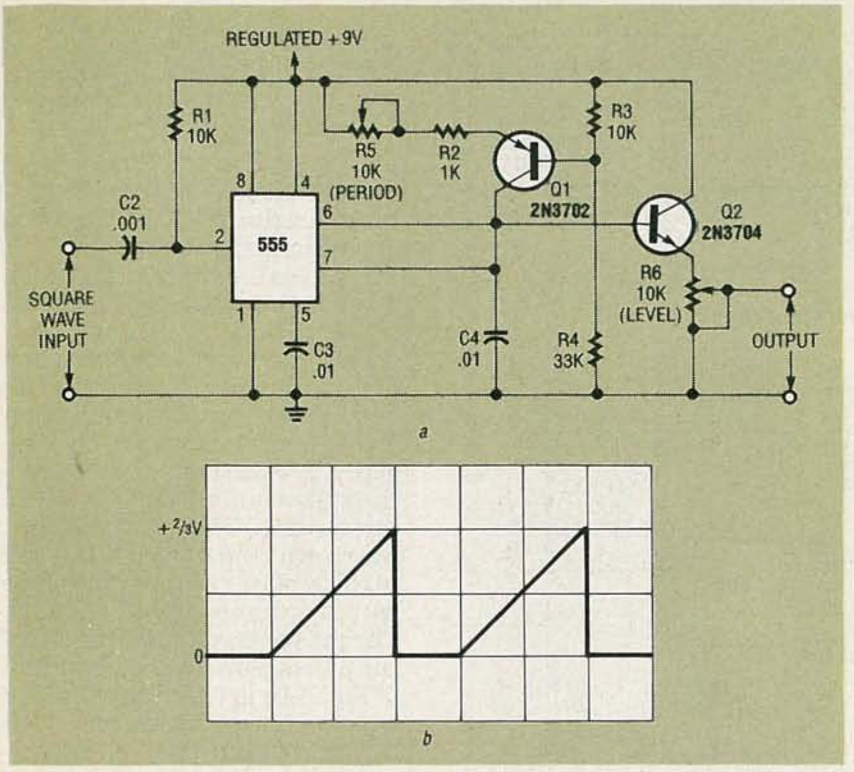


FIG. 3—LINEAR SAWTOOTH OR RAMP waveform generator based on the 555, a, and "ramp" waveform, b.

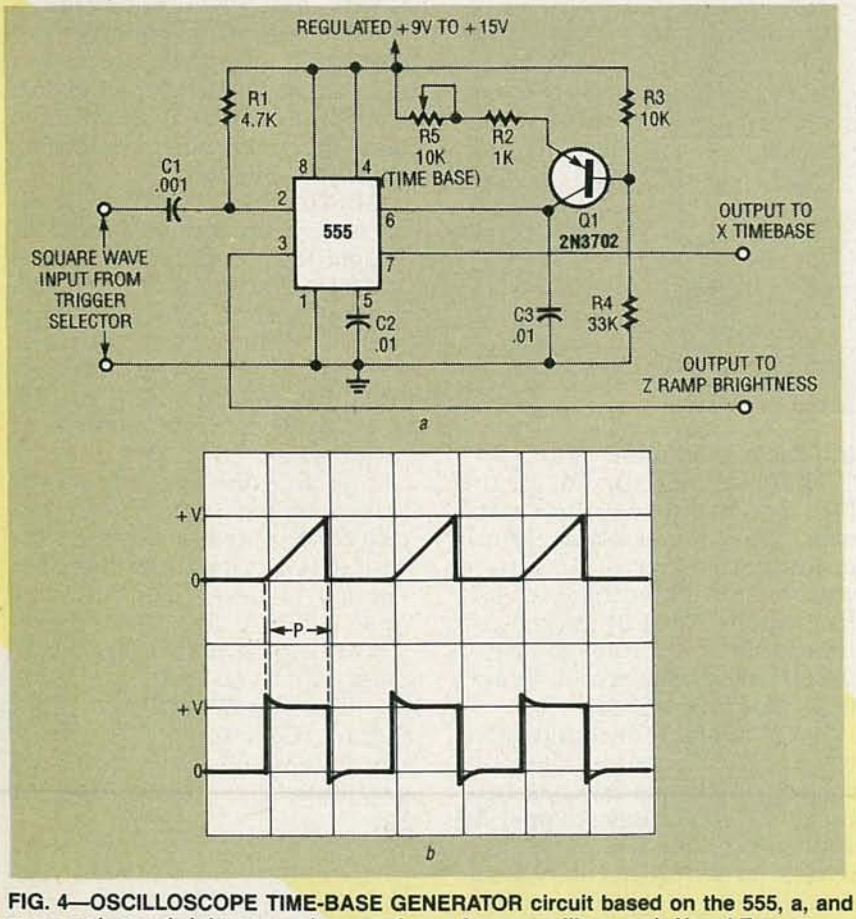


FIG. 4—OSCILLOSCOPE TIME-BASE GENERATOR circuit based on the 555, a, and ramp and ramp brightness pulse waveforms for an oscilloscope's X and Z axes.

monostable multivibrator that is triggered by an external square wave TRIGGER pin 2 obtained through capacitor C2 from the collector of transistor Q1. Note that OUTPUT pin 3 of the 555, used in most of the 555-based circuits presented earlier is unused here.

The voltage across C4 (the timing component) is normally zero, but whenever the circuit is triggered, C4 charges exponentially through resistor R5 and PERIOD potentiometer R6 to two-thirds of the supply voltage. At that time, the monostable period ends and the voltage across C4 drops abruptly to zero. The output sawtooth waveform (Fig. 2-b) is taken across capacitor C4 through buffer transistors Q2 and Q3 and LEVEL potentiometer R7.

The period of the sawtooth or width can be varied from 9 microseconds to 1.2 seconds with the capacitance values for C4 listed in Table 1. The circuit's maximum usable repetition frequency is approximately 100 kHz.

The generator must be triggered by rectangular input waveforms with short rise and fall times. Potentiometer R6 controls the sawtooth period over a decade, and potentiometer R7 controls the amplitude of the output waveform.

Figure 3-a shows a triggered linear sawtooth or *ramp* waveform generator. Capacitor C4 is charged by a constant-current generator that includes Q1. The output waveform (Fig. 3-b) is taken at the wiper of LEVEL potentiometer R6, which is coupled to the voltage across C4 through Q2. Note that the curved ramps of Fig. 2-b have been flattened.

When a capacitor is charged from a constant current source, its voltage rises at a predictable linear rate that can be expressed as:

Volts/second = amperes/farad

By introducing more practical values, alternative expressions for the rate of voltage rise are:

V/μs = A/μF, or

V/ms = mA/μF

Those formulas state that voltage rate-of-rise can be in-

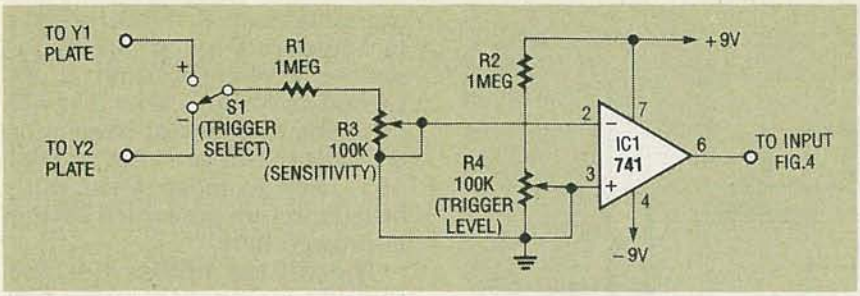


FIG. 5—TRIGGER SELECTION CIRCUIT for the Fig. 4 circuit

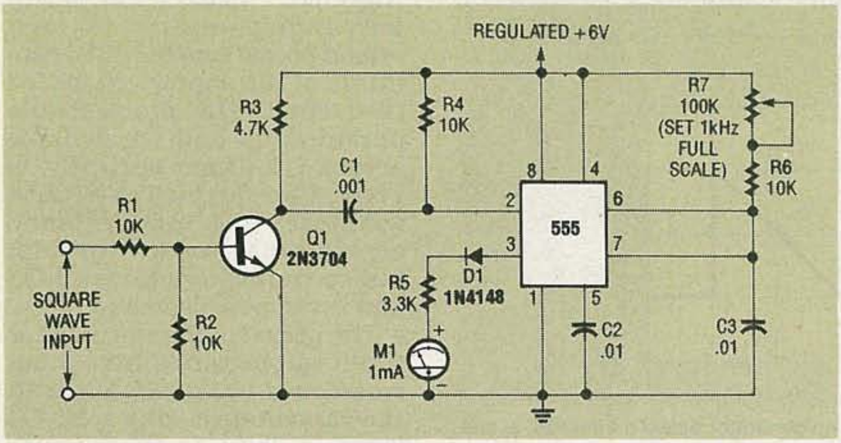


FIG. 6—A 1-kHz LINEAR-SCALE ANALOG FREQUENCY meter circuit based on the 555.

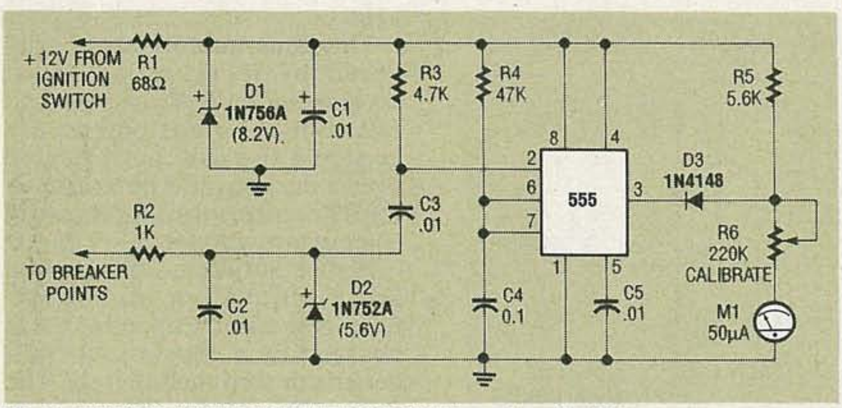


FIG. 7—VEHICULAR TACHOMETER CIRCUIT based on the 555.

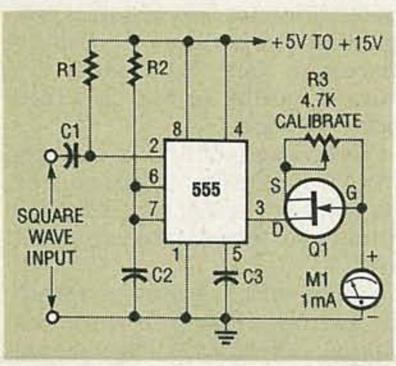


FIG. 8—ALTERNATIVE ANALOG TACHOMETER CIRCUIT to Fig. 6.

creased either by increasing the charging current or by decreasing the capacitance value.

The charging current in the Fig. 3-a circuit can be varied over the range of about 90 microamperes to 1 milliampere with PERIOD potentiometer R5, thus giving the 0.01 microfarad timing capacitor rates-of-rise of 9 volts per millisecond to 100 volts per millisecond.

Each one-shot or monostable cycle of the 555 ends when the voltage across C4 reaches two-thirds of the supply voltage. As shown in Fig. 3-a, the supply is 9 volts, so two-thirds of 9 volts is 6 volts, the amplitude of the ramp waveforms in Fig. 3-b. The sawtooth cycles of the cir- cuit have periods variable fr 666 microseconds (2/3 mill cond) to 60 microsecon (6/100 millisecond).

Periods can be increa beyond those values by incre ing the value of C4, or redu by reducing the value of C4 this circuit, stable timing p ods depend on a stable volt source.

Fig. 4-a shows how the circ in Fig. 3-a can be modified become an oscilloscope ti base generator. It can be t gered by external square wa through a suitable trigger se tor circuit. The *ramp* out waveform (top of Fig. 4-b is to the X plates of an oscillosc with a suitable amplifier sta The pulsed OUTPUT from pin the 555 (shown in the lower of Fig. 4-b) is fed to the CRT axis to trace the ramps w higher brightness.

The shortest useful ra period that can be obtai from the circuit in Fig. 4-a (v a 0.001 microfarad capac C3) is about 5 microsecon That value, when expanded give full deflection on an cilloscope with a ten-divis graticule, yields a maxim timebase rate of 0.5 micro cond per division.

The timebase circuit of Fig a can synchronize signals trigger frequencies up to ab 150 KHz. At higher frequenc the input signals must be di ed by a single- or multi-dec frequency divider. With that proach, the timebase can used to view input signal megahertz frequencies.

Figure 5 illustrates a sim but versatile trigger selector cuit for the timebase gener in Fig. 4-a. Operational am fier IC1 (a µA741) has a re ence voltage fed to its n inverting input pin 3 TRIGGER LEVEL potentiom R4. The signal voltage is t fed to IC1's inverting pi through switch S1, resistor and SENSITIVY potentiom R3.

Switch S1 selects either phase or out-of-phase input nals from the Y-driving am fier of the oscilloscope, per ting the selection of either the plus or minus trigger modes. The output of the circuit in Fig. 5 is coupled directly to the C1 input of Fig. 4.

Analog frequency meters

Figure 6 shows the 555 IC organized as a linear-scale analog frequency meter with a full-scale sensitivity of 1 kHz. The circuit's power is obtained from a regulated 6-volt supply, and its input signals can be pulses or square-wave signals with peak-to-peak amplitudes of 2 volts or greater. Transistor Q1 amplifies this input signal enough to trigger the 555. The output from pin 3 is fed to the 1-milliampere full-scale deflection moving-coil meter M1 through offset-canceling diode D1 and multiplier resistor R5.

Each time the monostable multivibrator is triggered, it generates a pulse with a fixed duration and amplitude. If each generated pulse has a peak amplitude of 6 volts and a period of 1 millisecond, and the multivibrator is triggered at an input frequency of 500 Hz, the pulse will be high (at 6 volts) for 500 milliseconds in each 1000 milliseconds. Moreover, the *mean* value of output voltage measured over this period is 500 milliseconds/1000 milliseconds × 6 volts = 3 volts or half of 6 volts.

Similarly, if the input frequency is 250 Hz, the pulse is high for 250 milliseconds in each 1000-millisecond period. Therefore, the mean output voltage equals 250 milliseconds/ 1000 milliseconds × 6 volts = 1.5 volts or one quarter of 6 volts. Thus, the circuit's mean value of output voltage, measured over a reasonable total number of pulses, is directly proportional to the repetition frequency of the monostable multivibrator.

Moving-coil meters give *mean* readings. In the circuit of Fig. 6 a 1-milliampere meter is connected in series with multiplier resistor R5, which sets meter's sensitivity at about 3.4 volts full-scale deflection. The meter is connected to give the mean output value of the multi-

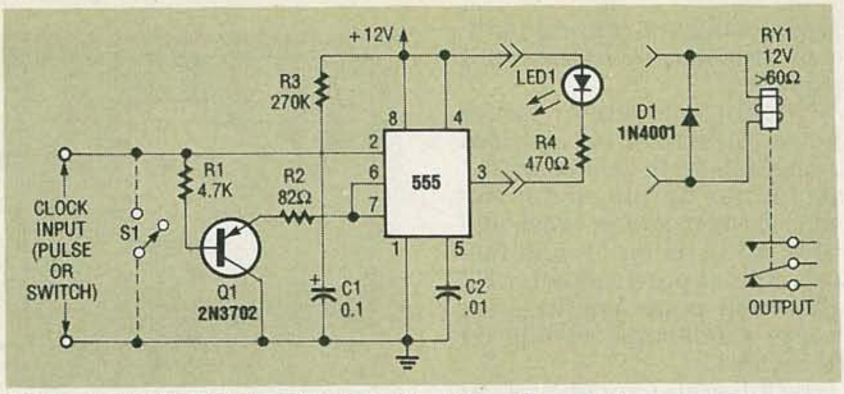


FIG. 9—MISSING-PULSE DETECTOR with LED or relay output.

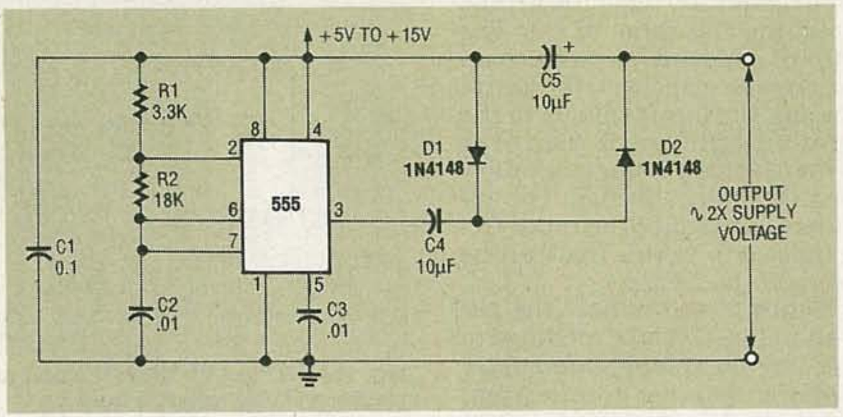


FIG. 10—DC VOLTAGE-DOUBLER based on the 555.

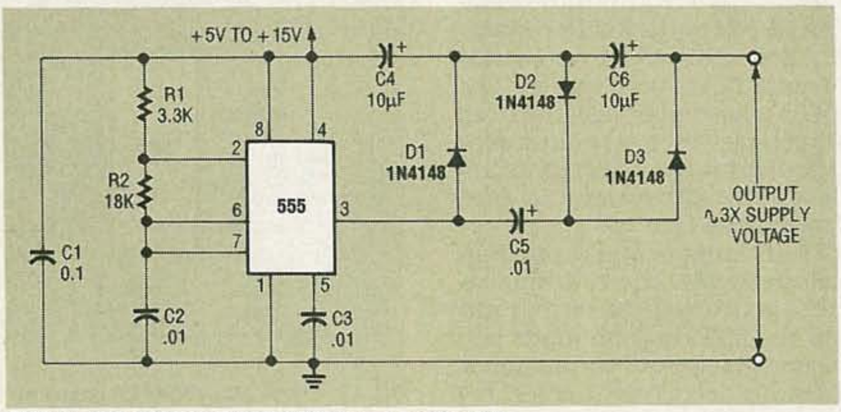


FIG. 11—DC VOLTAGE-TRIPLER based on the 555.

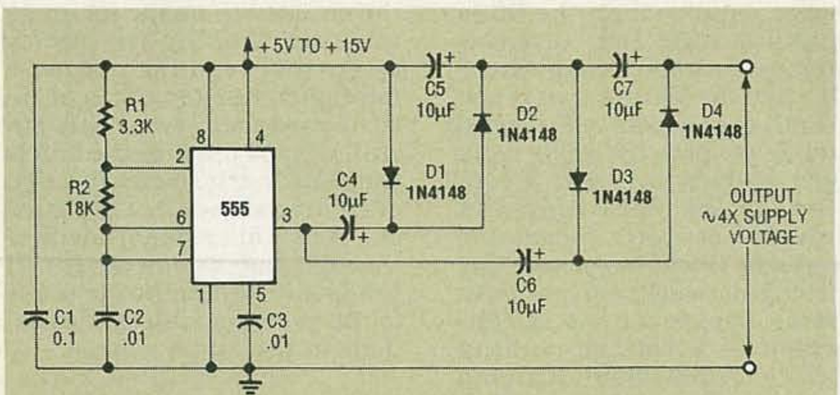


FIG. 12—DC VOLTAGE-QUADRUPLER based on the 555.

vibrator, and its reading is directly proportional to the input frequency.

With the component values shown, the circuit is organized to read full-scale deflection at 1 kHz. To set up the circuit initially, a 1-kHz square-wave signal is fed to its input, and full-scale-adjust potentiometer R7 (it controls pulse length) is set to give a full-scale reading on the meter.

The full-scale frequency of the circuit in Fig. 6 can be varied from about 100 Hz to 100 kHz by selecting the value of C3. The circuit can read frequencies up to tens of megahertz by introducing the input signals to the monostable multivibrator through either a single or multi-decade digital divider. The dividers can reduce the input frequencies to values that can be read on the meter.

Figure 7 shows how the circuit in Fig. 6 can be modified to become an analog tachometer or revolutions per minute (rpm) meter for motor vehicles. The circuit is powered by a regulated 8.2 volts derived from the vehicle's 12-volt battery with resistor R1, Zener diode D1, capacitor C1, and the ignition switch. The 555 is triggered by a signal from the vehicle's breaker points conditioned by the network of resistor R2, capacitor C2, and Zener diode D2.

The 50-microampere moving-coil meter M1, the rpm indicator, is activated from OUTPUT pin 3 of the 555 through diode D3. Current is applied to the meter through series-connected resistor R5 and CALIBRATE potentiometer R6 from the power supply when the 555's output is high. But current is dropped nearly to zero by diode D1 when the 555's output is low.

Both the circuits of Figures 6 and 7 are powered from regulated sources to ensure a constant pulse amplitude and provide accurate, repeatable readings from the meter. The meter is actually a current-indicating device, but it is connected as a voltage-reading meter with suitable *multiplying* resistors. They are R6 and R7 in Fig. 6 and R5 and R6 in Fig. 7.

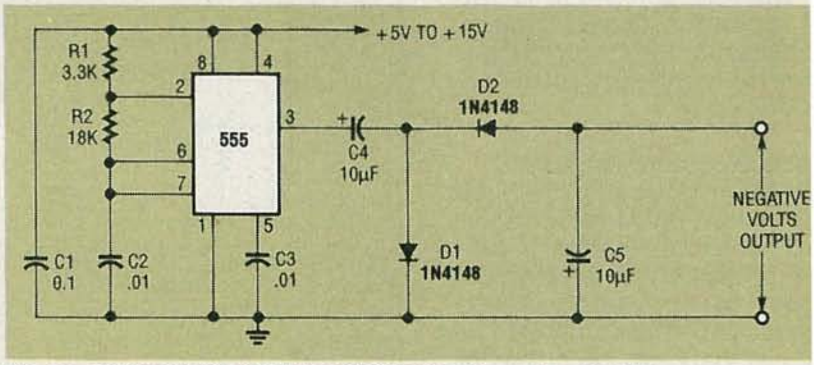


FIG. 13—DC NEGATIVE-VOLTAGE GENERATOR based on the 555.

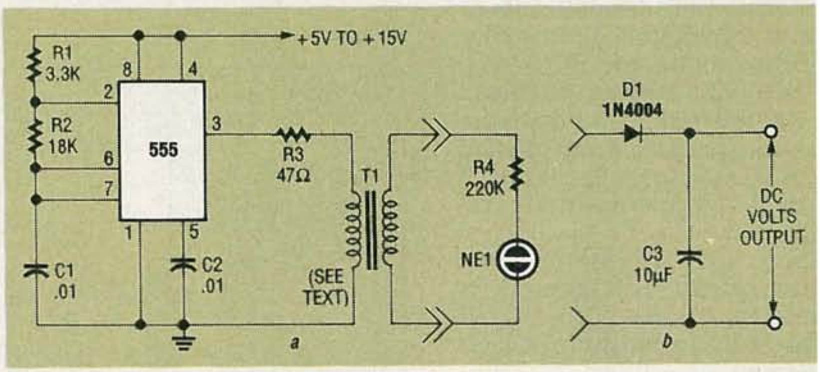


FIG. 14—NEON-LAMP DRIVER based on the 555, a, and DC-to-DC converter w rectifier and filter replacing lamp, b.

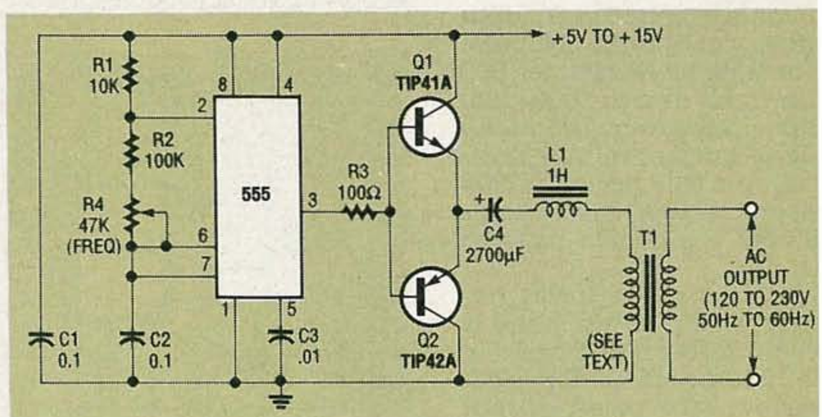


FIG. 15—DC-to-AC INVERTER based on the 555.

The diagram of Fig. 8 shows the outline schematic for an alternative analog frequency meter that requires neither a multiplier resistor nor a regulated power supply. In this circuit, OUTPUT pin 3 of the 555 is connected to the meter through JFET transistor Q1. Configued as a constant-current generator through potentiometer R3, it sends a fixed-amplitude pulse to the meter regardless of variations in the supply voltage.

Missing-pulse detector

Figure 9 illustrates how the 555 can become the key comp nent in a *missing-pulse dete tor* that closes a relay illuminates a LED if a norma expected event fails to occu The 555 is connected as monostable multivibrator e cept that Q1 is placed acro timing capacitor C1, and i base is connected to TRIGG pin 2 of the IC through R1.

A series of short pulse-switch-derived clock input si nals from the monitored eve is sent to pin 2. The values of I and C1 were selected so that t natural monostable period

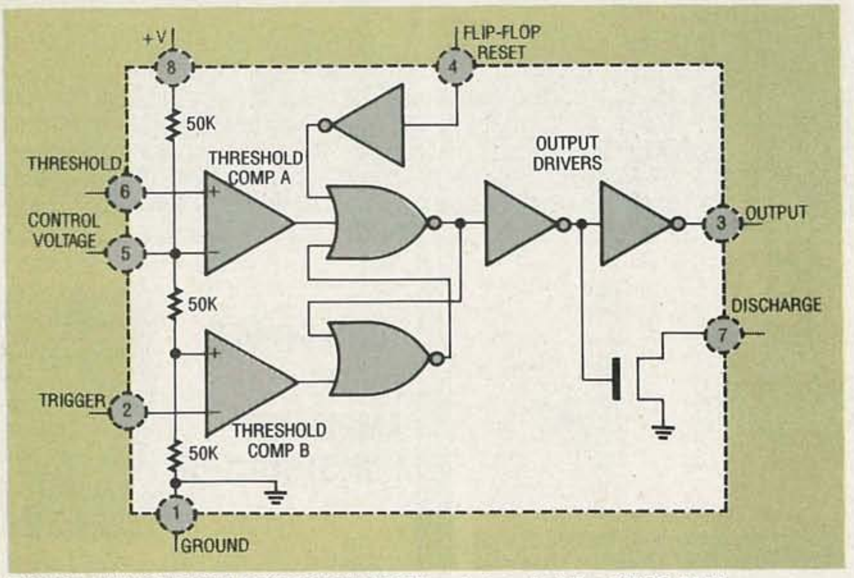


FIG. 16—FUNCTIONAL BLOCK DIAGRAM and pinout of the CMOS 7555.

the IC is slightly longer than the repetition period of the clock input signals.

Thus, each time a short clock pulse arrives, C1 is rapidly discharged through Q1, and simultaneously a one-shot timing period is initiated through TRIGGER pin 2 of the IC, forcing OUTPUT pin 3 high. Before each monostable period can terminate naturally, however, a new clock pulse arrives and starts a new timing period. Therefore OUTPUT pin 3 remains high as long as clock-input pulses continue to arrive within the preset time limits.

If a clock pulse is missing or its period exceeds the pre-set limits, the monostable period will end on its own. If that happens, pin 3 of the IC will go low and drive either the relay or LED "on." As a result, the circuit becomes a missing-pulse detector. It will produce a pulse output when an input pulse fails to occur within the timer delay.

Missing-pulse detectors like this can automatically warn of gaps or one or more missing pulses in a stream of pulses at the input. They are used in communications systems, continuity testers, and security systems. With the component values shown, the timer has a natural period of about 30 seconds. This period can be changed by changing R3 or C1 to satisfy specific needs.

Voltage converters.

The 555 IC can be instrumental in converting a DC voltage to a higher DC voltage, reversing the polarity of a DC voltage or converting it to an AC voltage. Figures 10 to 15 show variations of those circuits.

Figure 10, for example, shows how the 555 functions in a DC voltage doubler. The 555 is organized as a free-running astable multivibrator or square-wave generator that oscillates at about 3 kHz. (The oscillation frequency is set by the values of R1, R2 and C2.) The circuit's output is sent to the capacitor/diode voltage-doubler network made up of C4, D1, C5, and D2. That network produces a voltage that is about twice the supply voltage. Capacitor C1, across the supply, prevents the 3-kHz output of the 555 from being fed back to the IC, and C3 stabilizes the circuit.

The voltage-doubler circuit of Fig. 10 will operate from any DC supply offering from 5 to 15 volts. As a voltage doubler it can provide outputs from about 10 to 30 volts. Higher output voltages can be obtained by adding more multiplier stages to the circuit circuit. Figure 11 is the schematic for a DC-voltage tripler that can supply from 15 to 45 volts, and Fig. 12 is the schematic for a DC voltage quadrupler that supplies from 20 to 60 volts.

The DC negative-voltage generator is a particularly useful 555-based converter circuit. It supplies an output voltage that is almost equal in amplitude but opposite in polarity to that of the IC supply. This circuit can provide both positive and negative voltages for powering op-amps and other IC's with dual power requirements from a positive supply. The DC negative-voltage generator in Fig. 13, like that shown in Fig. 10, is a 3-kHz oscillator that drives a voltage-doubler output stage made up of C4, C5, D1, and D2.

Figures 14-a and 15 show DC to AC inverters that change input DC voltage to output AC voltage by means of transformer coupling. The AC voltage from these inverters needs no further conditioning, and it can be converted back into higher DC voltages with the addition of only a half-wave rectifier and a capacitor filter.

The inverter shown in Fig. 14-a can drive a neon lamp with its AC output. If the lamp and resistor R4 are replaced by the diode and capacitor filter as shown in Fig. 14-b, the AC output can be converted back to a low-current, high-voltage DC output. For example, with a 5- to 15-volt DC input, the inverter can produce an output of several hundred volts DC.

The 555 in Fig. 14-a is configured as a 4-kHz oscillator and its square-wave output from pin 3 is fed back to the input of audio transformer T1 through resistor R3. Transformer T1 has the necessary ratio of primary to secondary turns to produce the desired output voltage. For example, with a 10-volt supply and a 1:20 turns ratio on T1, the unloaded output of T1 will be 200 volts, peak.

The DC-to-AC inverter schematic of Fig. 15 produces an AC output at line frequency and voltage. The 555 is configured as a low-frequency oscillator, tunable over the frequency range of 50 to 60 Hz by FREQUENCY potentiometer R4. The 555 feeds its output (amplified by Q1 and Q2) to the input turns of transformer T1, a reverse-connected filament transformer with the necessary step-up turns ratio. Capacitor C4 and coil L1 filter the input to T1, assuring that it is effectively a sinewave.

A CMOS version of the 555

The standard bipolar 555 timer IC is still one of the most popular and versatile IC's today, but it has some drawbacks that were overcome by a CMOS version. For example, the 555 will not operate from voltages less than about 5 volts. Moreover, it typically draws 10 milliamperes of quiescent current when run from a 15-volt supply. This rather large current drain makes it unsatisfactory for most battery-powered circuits.

In addition to those shortcomings, the 555 produces a massive 400-milliampere current spike from the supply as its output is switched from one state to the other. A spike, lasting only a fraction of a microsecond, can cause lost bits in digital circuits near the 555 or powered from the same supply.

The CMOS version of the 555 timer, also able to operate in both monostable and astable modes, is known generically as the 7555. Figure 16 shows the functional block diagram and pinout of the 7555. This can be compared with the functional block diagram of Fig 1. Note that the pinout is identical.

Harris Semiconductor's version of the 7555, for example, is designated the ICM7555. In common with all other 7555's, it will run from a +2- to +18-volt DC supply. Notice that the resistors in its internal voltage divider are 50 K rather than the 5K of the 555. Other sources of the 7555 are Maxim (ICM7555) and Sanyo (LC7555).

Supply current to the 7555 is typically only 60 microamperes when run from an 18-volt supply. In addition, typical TRIGGER, THRESHOLD, and RESET currents are 20 picoamps, orders of magnitude lower than those of the bipolar 555. Those low currents permit the use of higher impedance timing elements for longer RC time constants. The 75 can be organized to time ou periods from microseconds hours.

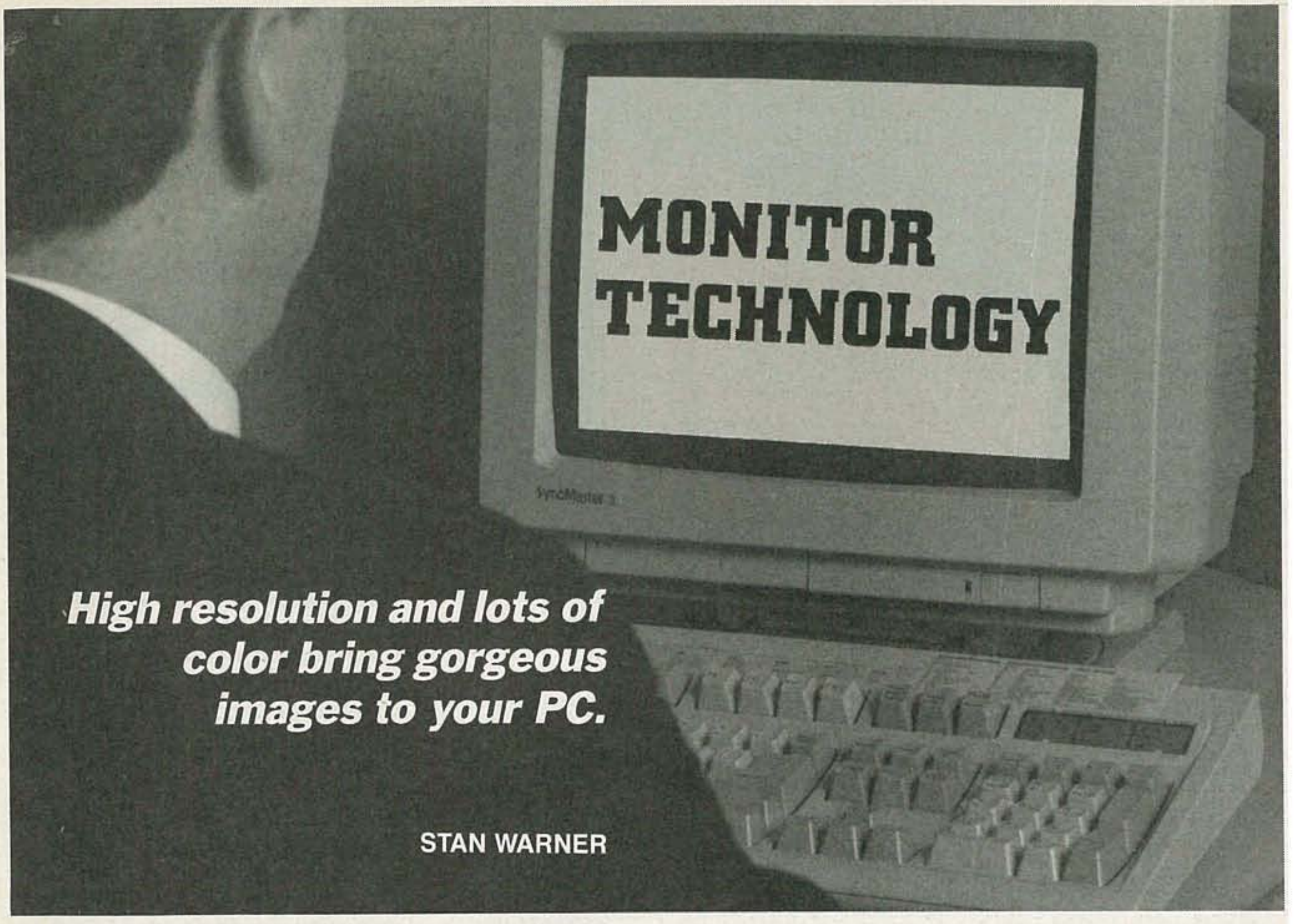
Table 2 compares the cha teristics of the 7555 to thos the 555. The 7555 permits:

- Lower supply current
- Wider supply voltage rang
- Lower power dissipation
- Lower current spikes in put transitions
- Higher switching freque performance

These improvements mus balanced against the hig cost of the 7555. The 75 should be specified only if:

- It is to be used in a batt powered circuit where po economy is critical
- Available power is 5 volts less (too low for the 555)
- It is to be in digital circu whose signal output could degraded by noise.

The 7556 is the dual CM counterpart of the bipolar 5 The 7555 can directly repl any 555 in all the circuits sented in this series.



MONITOR TECHNOLOGY

High resolution and lots of color bring gorgeous images to your PC.

STAN WARNER

TUMBLING PRICES AND SURGING power have brought computers into nearly every facet of our lives. Gone forever are the days when only large companies could afford computers. No longer does it take a mainframe that nearly fills an entire room to sort business records or do mind-bending arithmetic. Today's powerful yet affordable desktop machines are taking on exciting new chores in every phase of business—and the home.

According to the Electronic Industries Association (EIA), the computer and peripheral market more than doubled during the 1980's, from $24.3 billion in 1980 to $56.1 billion in 1990, as shown in Fig. 1. According to the EIA, the home computer market grew 50% in one three-year period, from $4.5 billion in 1988 to $6.4 billion in 1991. In addition, personal computers can be found in 33% of the homes in the United States.

Today's computers can crunch reams of data at blinding speeds, but improvements in monitor technology have also increased the number of computer applications. Desktop publishing systems that combine text and graphics are bringing print-shop quality to financial reports, company newsletters, and sales presentations. Surgeons create computer-generated, 3-D images of their patients' insides long before they pick up a scalpel. Landscape artists design lifelike layouts with trees, shrubs, and flowers before turning a single spade of dirt.

Monitor manufacturers are continually working to improve graphics clarity and resolution, and large strides have occurred during the past decade. The monitors of the early eighties had poor resolution and fuzzy graphics compared to those on the market today. Today's mainstream monitors are capable of displaying crisp graphics and text. High-end monitors produce fabulous pictures with crystal-clear resolution.

Monitor improvements

These improvements have come about as a result of enhancing four primary performance-defining characteristics: horizontal frequency, horizontal resolution, vertical frequency, and vertical resolution, as shown in Fig. 2. Each is defined below:

Horizontal Frequency The number of times per second the electronic beam travels horizontally across the CRT and back. Horizontal scan time is the inverse of horizontal frequency ($1/f_h$).

Horizontal Resolution The number of dots or picture elements ("pixels") that can be displayed horizontally. A pixel is the smallest dot the monitor can display.

Vertical Frequency The number of times per second the electron beam travels from the

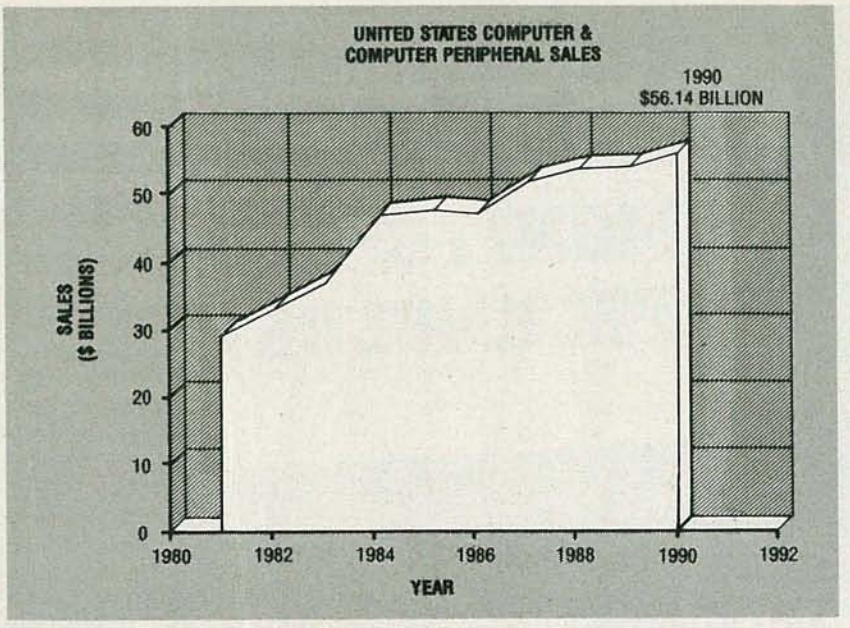


FIG. 1—**SALES OF COMPUTERS AND PERIPHERALS** surged in the 1980's, and continue to grow in the 1990's.

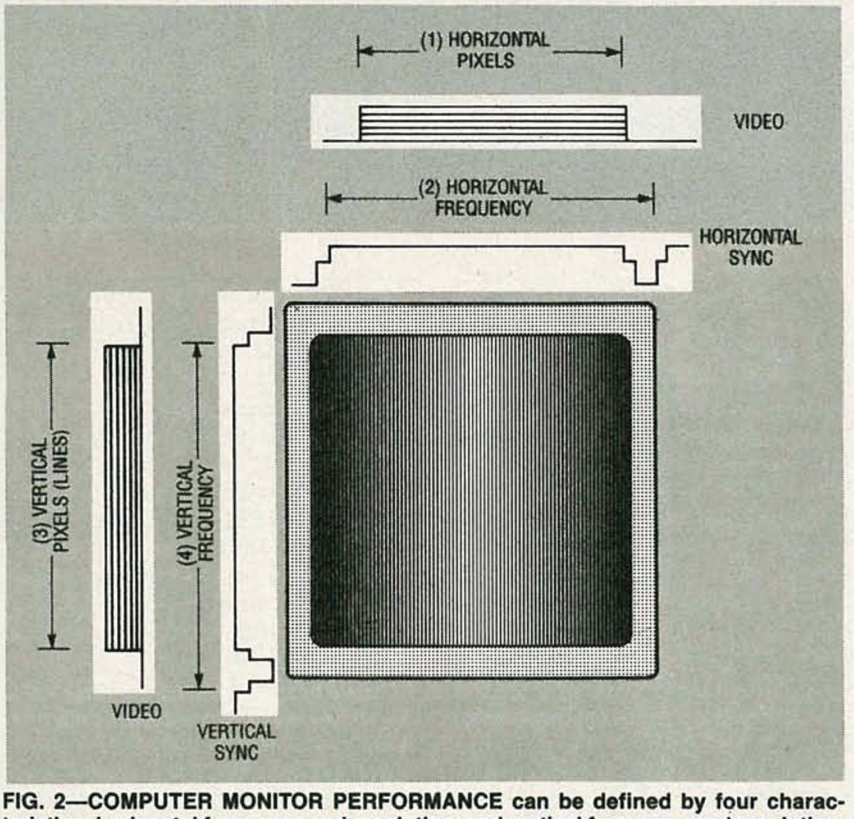


FIG. 2—**COMPUTER MONITOR PERFORMANCE** can be defined by four characteristics: horizontal frequency and resolution, and vertical frequency and resolution.

top of the CRT to the bottom and back. Vertical scan time is the inverse of vertical frequency ($1/f_v$).

Vertical Resolution The number of picture elements displayed vertically on the CRT. Vertical resolution is comparable to the number of "lines" in television terminology.

A fifth characteristic, dot pitch, also plays a role in determining the resolution of a monitor. Dot pitch is the distance between like colors in the shadow mask. Dot pitch determines the size of the smallest pixel a color CRT can display. The smaller the dot pitch, t sharper the image. Typical v ues of dot pitch are betwe 0.26 and 0.50 mm. Figure shows the distance between t centers of two red dots.

Today's high-resoluti

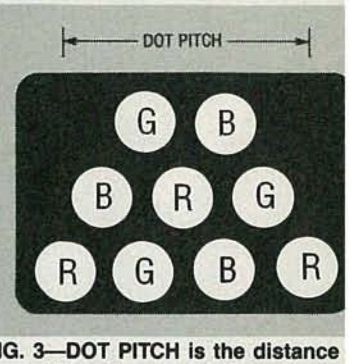


FIG. 3—**DOT PITCH** is the distance tween like colors in a CRT shadow ma

monitors represent improv ments over their predecesso in several ways, including i creased horizontal and verti frequency and resolution, a decreased dot pitch. On ea monitors, the electron bea typically took 63.7 µs(corres onding to a frequency of 15 kHz) to scan one line. Today it not uncommon for the beam complete its trip in 13.0 µs(76 kHz) or even less, as shown Fig. 4.

In addition, more pixels a being displayed per horizon line, and more lines are d played per frame. Whereas ea computer monitors had 6 horizontal pixels and 200 lin common monitors today ha 1,024 horizontal pixels and 7 lines—or more. A faster sc rate gives the monitor ext time to display additional lir and pixels.

Video bandwidth

Video bandwidth is the hig est frequency the monitor's vi eo circuits can pass. In gener higher resolution requir higher bandwidth. A visual dication of sufficient ban width comes from displaying pattern that produces a sing pixel line, as shown in Fig. 5

To get a basic understandi of the bandwidths required high- and low-resoluti monitors, let's calculate t bandwidth required by eac

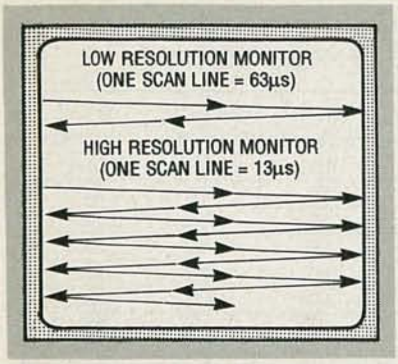


FIG. 4—A HIGH-RESOLUTION MONITOR scans across the screen more than four times, while a low-resolution monitor does so once.

We'll analyze a high-resolution monitor that scans at 64 kHz and displays 1024 pixels per line, and a low-resolution monitor that scans at 15.7 kHz and displays 640 pixels per line.

High-Resolution Bandwidth Inverting the horizontal scanning frequency (64 kHz) gives a total horizontal scan time of 15.6 µs. As shown in Fig. 6, about 80% of that time is for active video (what's seen on the monitor) and about 20% is for blanking. Using the 80/20 ratio in the example translates into 12.5/3.1 µs active/blanking. If it takes 12.5 µs to display 1024 pixels, it therefore takes 12.5/1024 = 12.2 ns to display a single pixel. Inverting that figure gives a bandwidth of 81.9 MHz. So, to see a crisp, distinct line, one pixel wide, the bandwidth of the video amplifiers in a high-resolution monitor must be 81.9 MHz or greater.

Low-Resolution Bandwidth A horizontal scan rate of 15.7 kHz gives a horizontal scan time of 63.7 µs. Eighty percent of that is 51.0 µs, during which 640 pixels will be displayed. Thus the time per pixel = 51/640 = 79.6 ns. Inverting that figure gives a low-resolution bandwidth of 12.6 MHz.

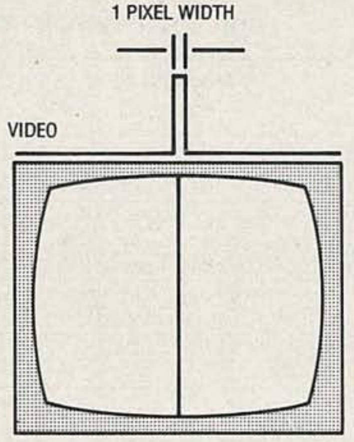


FIG. 5—A ONE-PIXEL VERTICAL LINE is a good indicator of a monitor's maximum bandwidth. A crisp, distinct line shows that the monitor has sufficient bandwidth.

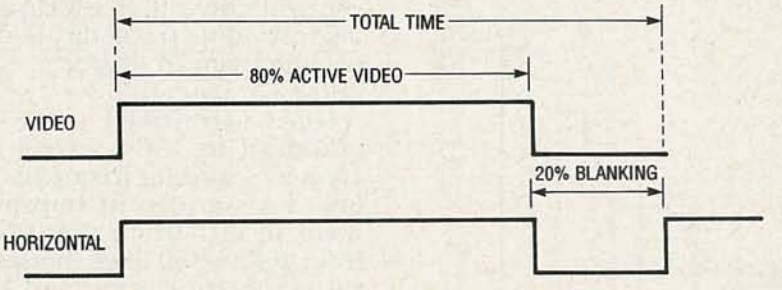


FIG. 6—A TYPICAL VIDEO SCAN LINE consists of 80% active video and 20% blanking.

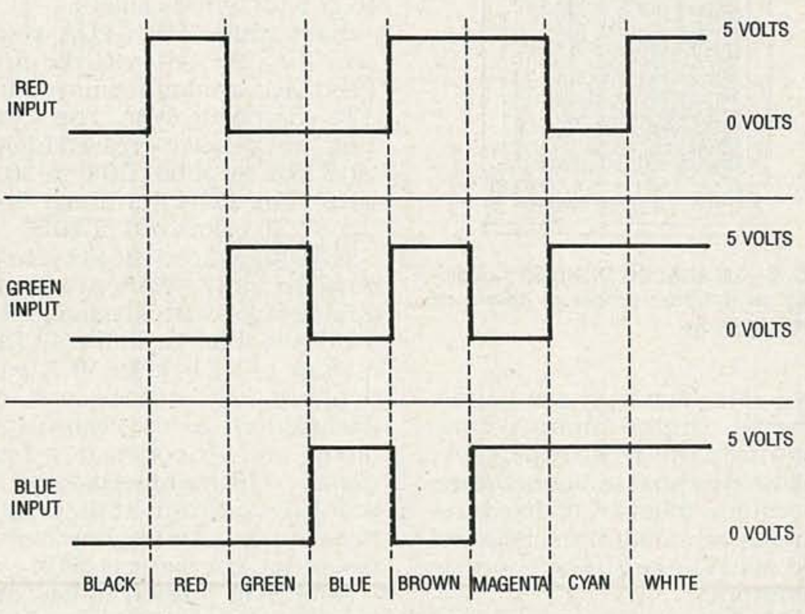


FIG. 7—A DIGITAL-INPUT MONITOR PRODUCES COLORS based on various combinations of signals. For example, the monitor displays magenta when red and blue are high and green is low.

Computer monitors

Monitors can be divided into three basic categories: digital, analog, and ECL (emitter-coupled logic). Digital and analog monitors can be either monochrome or color. ECL monitors are always monochrome.

The video input signals to a digital monitor are TTL logic levels that are either high (greater than 2 volts) or low (less than 0.8 volts). A color digital monitor has red, green, blue and (usually) intensity inputs, and it can display as many as 64 colors, depending on the binary code on the RGBI inputs. Figure 7 shows how different combinations of 1's and 0's translate into different colors on a digital color monitor. A digital monochrome monitor can display as many as 64 shades of gray (or green or amber, depending on the phosphor), also by using combinations of logic levels.

An analog monitor can display an infinite number of colors (or shades of gray). The video signal fed to an analog monitor is usually 0.7 volts peak-to-peak (black to white). Figure 8 illustrates the correspondence between analog input voltage and gray level.

To achieve fast switching time and higher resolution, some high-end monitors use ECL IC's. ECL monitors are monochrome, can display only a limited number of shades of gray, typically have a 19-inch or larger screen, and horizontal resolutions greater than 1024 pixels.

Video adapters

Most IBM-compatible personal computers have a video adapter card that is responsible for generating the video and sync signals used by the monitor. There are many standards for the different video formats, as shown in Table 1. Each format has a different resolution and scan rate. Fixed-frequency monitors are built to handle just one format; multi-frequency monitors can handle several. Digital monochrome monitors are least expensive, followed by analog monochrome monitors, followed by fixed-frequency color monitors, followed by multi-frequency color monitors.

TABLE 1—COMMON COMPUTER MONITOR FORMATS

System/Mode	Horizontal Frequency (kHz)	Vertical Frequency (Hz)	Horizontal Resolution (Pixels)	Vertical Resolutic (Lines)
Color/Graphics Array (CGA)	15.7	60	640	200
Monochrome Display Adapter (MDA)	18.4	50	720	350
Hercules Graphics Adapter (HGC)	18.4	50	720	350
Enhanced Graphics Adapter (EGA)	21.8	60	640	350
Professional Graphics Adapter (PGA)	30.5	60	640	480
Video Graphics Array (VGA) Mode 1	31.5	70	640	350
Video Graphics (VGA) Mode 2	31.5	60	640	480
Video Graphics (VGA (Mode 3)	31.5	70	720	400
Super VGA	35.2	56	800	600
8514A	35.2	87	1024	768
Extended Graphics Adapter (XGA)	35.2	87	1024	768
Apple Macintosh II	35.5	67	640	480

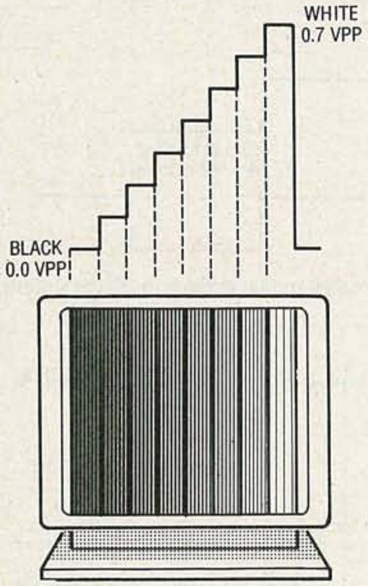


FIG. 8—AN ANALOG MONITOR can display an infinite number of colors or shades of gray.

IBM introduced the CGA and MDA formats in the early 1980's. Both are digital formats. CGA provides 16 colors and can display bit-mapped graphics at a resolution of 640 × 200. MDA provides only two shades of a single color and cannot display graphics. The Hercules card met a need by providing total compatibility with the MDA and also providing the ability to display bit-mapped graphics, e.g., graphs in Lotus 1-2-3.

IBM introduced the EGA standard in 1984. EGA's increased scanning frequency allowed a significant improvement in resolution over CGA, from 200 to 350 lines (horizontal resolution remained the same). EGA is a digital standard that can simultaneously display 16 of a total of 64 colors.

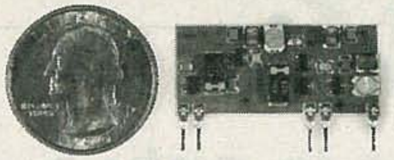
Next came IBM's PGA standard, in 1985. It was the first PC-based analog format, with TTL composite sync. The scanning frequency increased EGA's 21.8 kHz by about 50% to 30.5 kHz. The PGA standard displays 256 colors out of 4096.

IBM introduced the VGA standard in 1987. VGA produces analog video with separate TTL sync, and a horizontal scan frequency of 31.5 kHz. VGA can display 256 colors out of 256,000 in a low-resolution mode, and 16 colors in a text mode. VGA increased vertical resolution from 350 to 480 lines, again keeping horizontal resolution the same at 640.

After VGA started to become popular, the market demanded even more resolution and color. IBM introduced the 8514, but prices were high, and at first only a model for the PS/2 was available. So video-card vendors introduced a variety of Sup
VGA formats that typically-ma
out at 1024 × 768, with 2
colors. IBM later introduc
XGA, the current version
which supports 1024 × 768
256. There are rumors that
upcoming 80x86 micr
processor from Intel will hav
built-in XGA video processor.

The Macintosh II standa
produces an analog video sign
with separate composite T
sync. Other MAC standar
place the composite sync on t
green video line. Some Mac
tosh video cards are capable
producing 256 colors from mo
than 16 million. These cards a
also available for PC's.

The video formats shown
Table 1 illustrate the va
changes that have occurred
the PC side of the compu
market during the past t
years. But the chart doesn't
the entire story; these are o
the monitors sold for ma
stream applications (e.g. wo
processing, spreadsheets, a
home finance). In other are
(e.g., engineering works
tions, medical imaging devic
high-end publishing equ
ment), it is not uncommon
monitors to have resolutions
2,048 pixels or more, and ho
zontal scan frequencies three
four times greater than that
VGA. Wouldn't it be great
have one of those monitors s
ting on your desk? If curre
market trends continue, the
a good chance that you wil
and soon.



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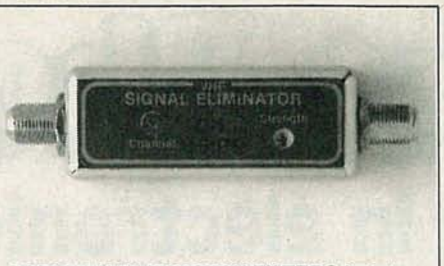

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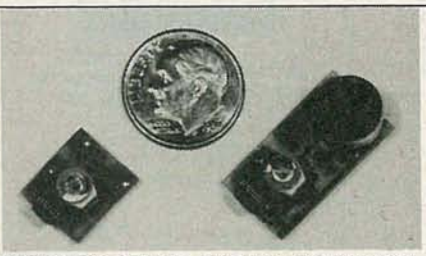

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WHAT'S NEWS

continued from page 6

the development of table-top, las
powered particle accelerators,
opposed to today's massive, exp
sive accelerators. Another poter
use for supercharged laser bea
is the development of an X-ray la
capable of observing the molecu
and atomic action of living cells

The secret to the record-break
power levels is a technique cal
chirped-pulse amplification,
which laser pulses are first p
duced in short bursts of a fractio
a picosecond (about one trillionth
a second). The duration of
pulses is then stretched out abou
thousand times before the puls
enter the laser's amplifier. After a
plification, the pulse is compress
back to the original fraction c
picosecond burst.

The research teams' "ultim
goal," according to Jacques C
tant, department head at the C
tre, "is to push the power of
beam to 1000 terawatts."

VIDEO NEWS

continued from page 8

HDTV service, since most majo
ble systems have channel
spare. It's easy to see the possi
of a pay channel carrying movi
widescreen near-theater defini
the way they were intended t
seen. In fact, HBO and other
cable operators are excited ove
prospect. The same is true o
proposed multi-channel direct s
lite-to-home systems, suc
Hughes Aircraft's DirecTV, w
seem certain to earmark s
channels for HDTV.

The real key to the equatio
with consumers. Will they be w
to pay $2000 and up—perhaps
up—for the first HDTV sets w
there is little or no programm
Test after test shows average
ers regard program content as
important than picture quali
massive education job and s
significant program pump-pri
seem indicated if HDTV is to c
on in a faster time frame than
TV's 10 years.

INRUSH CURRENT LIMITED

continued from page 50

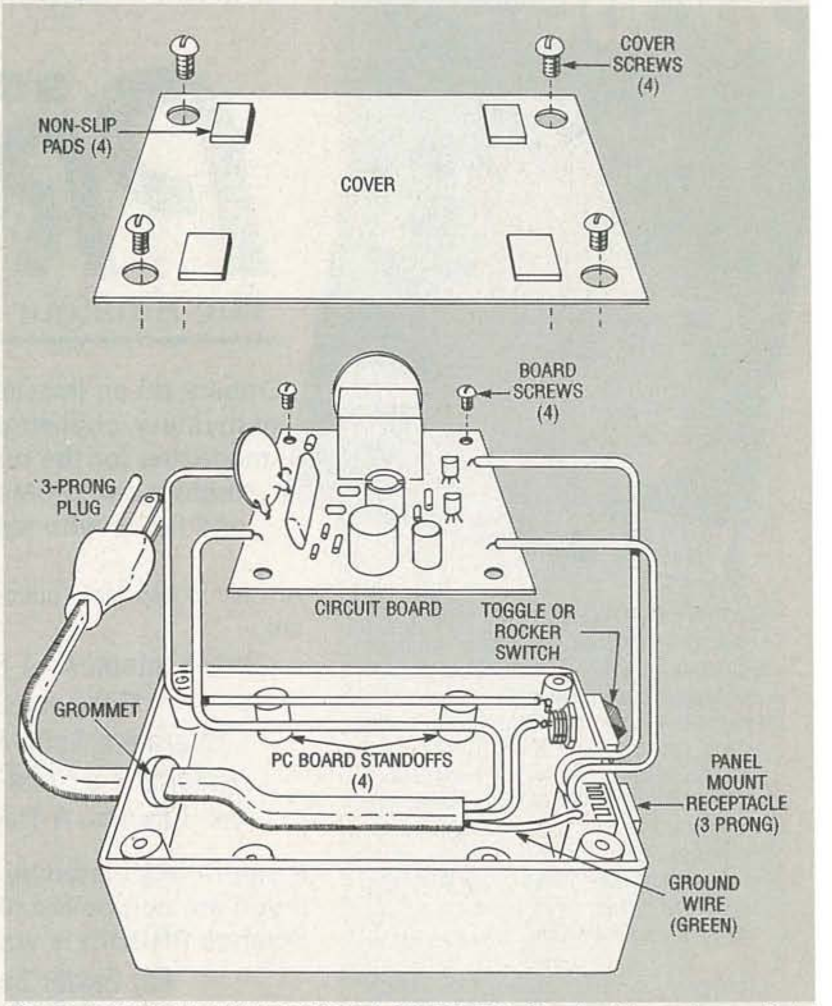


FIG. 10—EXPLODED VIEW OF INRUSH-CURRENT limiter circuit in enclosure. Note t completion of ground within the case with a 3-wire power cord.

the completed circuit. Pull the three-wire cable through a grommet in the case sidewall as shown. Strip the jacket from the cable in the case, strip the end of the green ground wire, and connect it to the ground terminal of the three-prong receptacle. Solder one of the cable's conductors to the PC board, as shown, and solder the other conductor to one terminal of the switch.

Using short insulated lengths of the same cable conductor, solder a connection from the switch to the other side of the PC board, as shown. Solder two more short lengths of conductor to the output pads on the PC board, and connect their other ends to the panel-mount rece tacle.

Fasten the circuit assembly in the case with hold-dov screws and close the cover. Fa ten the cover in position wi the four screws included. T inrush-current limiter then b comes a plug-in accessory a the host equipment need not altered. The equipment's pow switch should be clamped in t "on"position so that power the equipment is then appli with the limiter's ON-OFF tog or rocker switch.

Although the surge protect is in the circuit only for sho time intervals, be sure that a protected equipment does n draw more than 2 amperes. R

HARDWARE HACKER

Conventional currents, assorted wonderments, navigation and navicubes, FM Yagi antenna design, and two new piezo rate gyros.

DON LANCASTER

So many exciting new hacker opportunities have come down this month that I do not even know where to start. We seem to be moving into a boundless new era of hardware hacking.

Before we begin, though, there have been a few recent helpline calls over some really ancient history which we should go over one final time...

Follow that current!

Which way does the current travel in any electrical or electronic circuit? Many years ago, one of the electrical pioneers ventured his wild *guess* that *electrical current always goes from the negative to the positive terminal in an energy source and from positive to negative in an energy sink.*

It took over a century to verify, but the guess turned out to be correct. At least for certain solid-state circuits, at least some of the time.

To this day, this guess is called the *conventional* electrical current, and appears in Fig. 1. Conventional current is the *only* standard taught in *all* university- and *all* graduate-level engineering courses, is used by *all* physicists, and is accepted by *all* large electronic firms worldwide.

Conventional current is shown in the direction of the arrows on *all* the standard electronic symbols. Even the IEEE tie clasp and cuff links strongly restates conventional current. So does the right-hand generator rule and left-hand motor rule.

Yeah, but just which way does the current *really* go? Well, a glib answer for the new age nineties is "any way you want it to."

In semiconductor loads, the current direction is decided by the majority carriers. In any PNP transistor or any P-channel MOSFET, conduction is by hole carriers, and the current does in fact go in exactly the same direction as the conventional current. In N-type devices, the current is the opposite of the conventional current direction.

So what is the problem? And why am I standing here whipping this long-dead horse?

Way back during World War II, PNP vacuum tubes were very few and far between. Come to think of it, they still are. Because of that, the military introduced the concept of the *electron current* to explain how a vacuum tube works. And many trade schools and lower-level textbooks continued the practice into the fifties and sixties.

That led to the absurd result that a few hackers, technicians, and much of the hobby press had their currents heading in one way, while all of the engineers, physicists, and the rest of industry had their currents heading in the exact opposite direction.

The bottom line: If any individual or any textbook still tries to teach you electron current, they are ripping you off. They are also doing you a serious disservice that will lead you to untold confusion and latter day hassles.

Neither electron nor conventional current is correct all of the time. The overwhelming majority of industry and professional-level training *always* goes with the conventional current. Among the other reasons, because there is no compelling reason not to.

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:
Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

Just what would it take to convert industry over to electron current? For openers, extremely frigid conditions in a distinctly unpleasant locale. Or some words to that effect. Even then, I would not expect to see this happen until a few weeks after the Ayatolla's Bar Mitzvah.

Navicube update

Way back in a July 1988 *Hardware Hacker*, we looked at the *Navicube*, a 3-inch, $10 cube that always knew where it was and which way it was pointed. Well, we still don't have $10 Navicubes, although I do expect some Korean toy manufacturer or two kids in an Iowa basement to come up with a really good one shortly.

A lot is happening with Navicubes, both evolutionary and revolutionary. An update summary of Navicube info appears as our resource sidebar.

Today's popular approaches to the Navicubes include the GPS satellite system, fluxgates, real gyros, laser gyros, accelerometers, and a pair of brand new piezo gyros.

The GPS global positioning system is going great guns. Their eighteenth satellite is now in orbit, and Russian and ECC competing systems are now being established. Receiver prices are in free fall, and the $500 barrier has recently been broken.

GPS World is your foremost trade journal. Its publisher also just started up a new *GPS World Showcase* shopper. As before, the *Journal of the Institute of Navigation* is the finest Navicube technical resource.

Although *Rockwell* is still the most obvious source for the GPS chip sets, *Hewlett Packard* has just developed a new single-chip GPS front end. While it's too early for a part number, several details now appear in *Microwaves & RF* for August

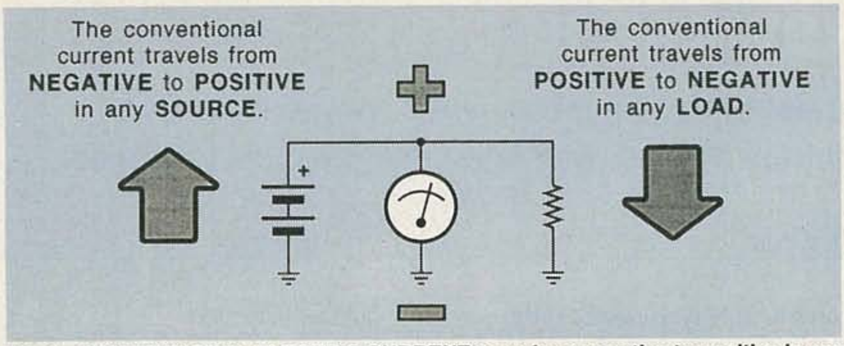


FIG. 1—CONVENTIONAL ELECTRIC CURRENT goes from negative to positive in any energy source and from positive to negative in any energy sink. This is *the* standard used by all graduate engineers and physicists, and in electronic symbols, and the industry worldwide. It even appears on the IEEE cufflinks.

1992. I expect cheap new GPS parts real soon now, from several obvious sources.

North sensing isbest done using fluxgate magnetometers. Radio Shack has a cheap one in its car compass, and *KVH* sells expensive commercial units. We have seen several fluxgate construction projects, and references to them in those *Hardware Hacker II* reprints. Naturally, any magnetic sensor gets confused by nearby iron.

Many hackers still labor under the delusion that Hall-effect devices can be used as compasses. Well, possibly they can, but fluxgates are *thousands* of times more sensitive.

One exception is the very low cost *Dinsmore* magnetic compass sensor. Sadly, its best possible accuracy is a crude 22.5 degrees.

Solid-state accelerometers continue to drop in price, spurred on by newer automotive uses, especially airbags. While *Motorola* and *Micro Switch* are the largest suppliers, the better priced and more innovative sensors are now provided by *Analog Devices*, *SenSym*, *IC Sensors*, and *NovaSensor*.

Your two best accelerometer trade journals are *Measurement & Control* and *Sensors*.

Note that you could integrate (sum through time) any acceleration to get velocity, and then integrate velocity to get the position. There is one huge technical hassle with accelerometers, though—it's called the "t-squared" problem. Any bias or similar error in acceleration ultimately piles up as a position error that is proportional to time *squared*.

That means if you wait around long enough for your position, it is certain to be wrong. Accelerometers work best for short-term uses, when they can be repeatedly recalibrated or reset from some other standard every now and then.

Classic navigation is usually done by using mechanical gyros. They are nothing but rapidly spinning masses, comparable to a toy gyroscope. They can be costly, cumbersome, and often involve precision elements rotating at very high speeds. Gyros are available as surplus from *Fair Radio Sales*, *Radio Resea* *Instruments*, and *AST Servo S* *tems*. One current manufacture *Humphrey Products*.

Yes, there are laser gyroscop A coil of fiber-optic cable has herent laser light beams rou through it in opposite directi which then can be phase compa But not much seems to be happ ing here to drop the costs by 1000:1 needed to make ther practical hacker tool. Good infor tion on laser gyroscopes is availa from the *IEEE Press* and from *S*

But our really big Navicube g news for this month involves a of brand new...

Solid-state rate gyros

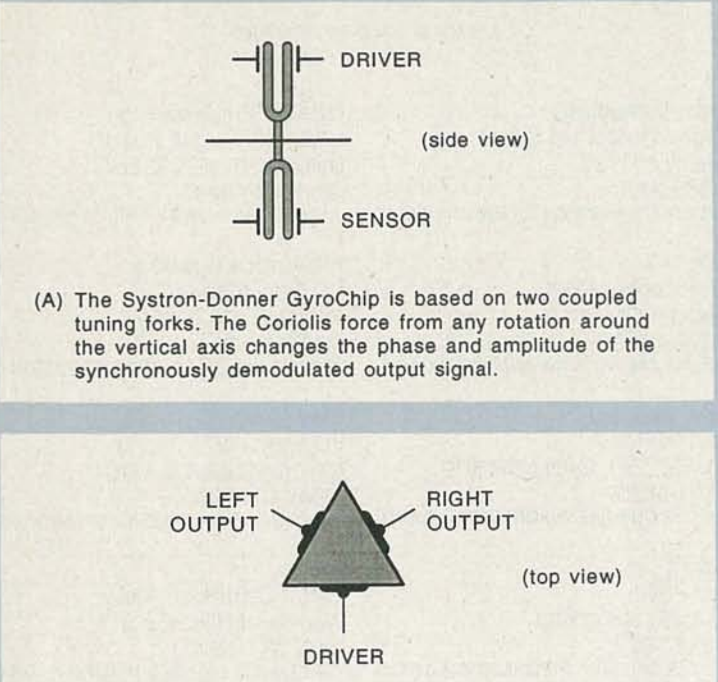
A *rate gyro* is a special gyrosc that can tell you how fast you *turning*. By integrating your rat turn, you can get your direction. combining that with some se rately measured velocity, you find your present position. A there will be no t-squared probl since no double integration is volved.

Traditional rate gyros are availa from the sources of regular gy we just looked at. A hackable ar low-cost fluidic rate gyro was m a few years back by Doug Garne *NASA*. It used an airstream diffe tial cooling a pair of thermistors. not too much seems to have co of that approach either.

A pair of new solid-state r gyros are now available. At least of them promises to end up as a component. Because they both vibrating piezo structures, it is quite correct to say that they h no moving parts. But they certa are simple and rugged single-pi units with no rotating parts or pr sion mechanisms.

The first unit is the *GyroChip* *Systron Donner*, shown in Fig. 2 This is a pair of back-to-back tun forks machined from a single pie of silicon. The phase of the out signal it determined by the *Cori* force caused by turning.

The second piezo gyro is t new *Gyrostar* by *Murata-Er* shown in Fig. 2-*b*. This is just a angular piezo oscillator. The Cori force of rotation again changes phase of the output signal in prop



(A) The Systron-Donner GyroChip is based on two coupled tuning forks. The Coriolis force from any rotation around the vertical axis changes the phase and amplitude of the synchronously demodulated output signal.

(B) The Murata-Erie GyroStar is based on carefully controlled vibration modes in a triangular piezo element. Any relative clockwise or counterclockwise rotation changes the phase and amplitude of the output signals.

FIG. 2—NEW DEVELOPMENTS IN PIEZO RATE GYROS should eventually lead to low cost Navicube solutions. A rate gyro tells you how fast you are now turning. Integrating the turn rate (summing through time) gives the present direction.

tion to the rotation rate. This new scheme looks ridiculously simpler and vastly more elegant than the GyroChip design.

While both of those breakthrough devices have the potential to become low-cost parts, samples today cost $300 for Murata's GyroStar, and a ludicrous $2000 for the GyroChip. Their support literature so far is also utterly dismal. But a new $5 Hong Kong knockoff is just about certain to become quickly available.

Assorted wonderments

Continuing this month's stunning new developments, here is a double handful of great new stuff...

• Image Striking—Be sure to check out *Motion Imaging Processing: Striking Possibilities* in the August 1992 issue of *Advanced Imaging*. What we apparently have here is a unique new concept and toolset for video, movie, and multimedia editing.

Put one frame of a small image in the upper left of your monitor screen. Next, move down one pixel and one pixel to the right, and then repeat the process for the next frame in the sequence. Continue until you have a diagonal smirp on down your screen, ending with a final full small image. While you are at it, show your sound amplitude for each frame along the top diagonal of the smirp.

What do you have? In one place and at one time, a display that lets you view the *temporal content* of a *time sequence* of multimedia or other video. In short, you can instantly look *forward or backward through time*, seeing the relationship between your current frame, its recent history, and its near future!

Looking at this "striking" concept in a slightly different way, say you had a few feet of movie film. Cut the individual images apart so they have no borders. Stack them up and look *sideways* at their top and left edges. Once again, in one place and at one time, you can see what has happened and what is going to happen. An instant and real-time plot of images versus time.

Naturally, the edges will only show you wildly abstract colors or patterns. But, with practice, those patterns can easily be read for the scene, camera angle, panning, duration, sound sync, and much more.

A non-obvious application: Quickly finding a buried sequence in a humongous video data base. It is sort of the video equivalent to that ISAM, or *indexed sequential access method* long used in data bases.

The editing, tweening, scanning, high-speed access, and all the visual flow possibilities of this new scheme seem boundless.

• Wavelets—The onslaught continues. A second book is now available and titled *Ten Lectures on Wavelets* by Ingrid Daubechies and published by *SIAM*, shorthand for the *Society for Industrial and Applied Mathematics*. While it's a first-rate text, this is a very advanced math book that makes for rough reading by mere mortals.

A brief story on optical wavelet uses appears in the August 1992 issue of *Photonics Spectra*. All those optics folks sure do have it easy. They just dump a pile of crockery on the table, squirt some light through it, and they get instant real-time 2-dimensional *Fourier* or wavelet transforms. None of the old point-by-point computation nonsense for them.

An entire issue on optical wavelet transforms appears as the September 1992 issue of *Optical Engineering*. I have added #494 EMERGOP2.PS and #456 WAVELETS.PS to *GEnie* PSRT to go along with all the rest of our wavelet downloads. A complete list appears in Fig. 3.

• Multilayer PC breakthrough—I am still looking for a hacker solution that makes printed-circuit plated-through holes cheaply possible at home. Or some workaround that flat out does away with the need for through holes.

A major step in this direction has been taken by *Sheldahl*, whose new special adhesive lets you build ultra expensive multilayer boards out of the cheaper double-sided ones. Sadly, you still need some plate-throughs.

Their *Zlink 1900* is basically a new adhesive that conducts only in its thickness direction. Just take a pair of double-sided boards and selectively apply the adhesive to one of them. You then add heat and pressure to bond the pair together. You can end up with either a three- or a four-layer board at a tiny fraction of the going price. And, yes, you can do six layers, eight layers, or as many as you want. You can even have buried plated-through holes! Far simpler, cheaper, and with a much lower scrap rate than before.

Carefully isolated solder particles make the adhesive conduct in only one direction with conductivity about the same as real multilayer conductors.

A small free sample is available from Sheldahl on request.

• Buckyballs—The price of Buckyballs continues to drop dramatically, and they are now hacker-affordable. The leading supplier remains *MER Inc.*, and their pricing starts as low as $5.50 a gram raw, and $90 per gram fully refined. Minimum order is $50.

Meanwhile, a *fourth* carbon form has been discovered that is called the *Buckytube*: hollow cylindrical pipes of carbon that have both the hardness of diamond and the surface area of graphite. Possible new uses include their use as lubricants, and unique materials that conduct heavily in only one direction. Check out the August 17 issue of *E.E. Times* for a summary update.

More on FM antennas

Last month, we checked into the fundamentals of distant FM reception. We have had some requests for still more information, so here goes...

The noise situation at 100 MHz is a tad further complicated than I first made out. If you do have any remote rural site, then your first-stage KTB thermal agitation noise does, in fact, dominate. And the best noise figure you can get is super important.

Atmospheric noise is negligible at FM frequencies. Galactic noise runs ten decibels or so above KTB, around 100 MHz. But you do not normally point an FM antenna straight up on a clear day, so this is also no problem. The potential killer is the manmade noise, which can be 25 decibels above KTB in suburban locations, and 40 decibels or more in urban locations. Nearby dimmers or computers could also induce those noise levels.

Most of the manmade nc comes from car ignitions. It s would be interesting to watch FCC try to enforce the same Pa rules and regulations on Detroit that they do on Hardware Hack Talk about potential noise lev The howl over this would prob

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Burlington, IA 52601
(319) 754-0600
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#508 HACK58.TXT & #509 HACKFG58.PS

Reprint of *Hardware Hacker #58* from *Electronics Now*. Wavelets update includes optical applications, and new *Ten Lectures on Wavelets* book.

#494 EMERGOP2.PS

Reprint of *Blatant Opportunist #17* from *Midnight Engineering*. Wavelets are one of the eight hacker-friendly emerging tech opportunities reviewed.

#456 WAVELETS.PS

Reprint of *The Wavelet Onslaught* from the *Midnight Engineering Companion #2*. Brief summary on wavelets and a key resource bibliography.

#403 PAK251.EXE

Utility to unPAK an IBM *.PAK* file, such as #365 WAVELET.PAK

#390 HACK50.TXT & #391 HACKFG50.PS

Reprint of *Hardware Hacker #50* from *Radio-Electronics*. Wavelets update, including new book, IEEE-SP tutorial, Aware application notes.

#373 HACK49.TXT & #374 HACKFG49.PS

Reprint of *Hardware Hacker #49* from *Radio-Electronics*. Mentions *Wavelets and their Applications* book and *Ultrawave Explorer* software from *Aware*.

#365 WAVELET.PAK

Complete and ready-to-run IBM Wavelet Packet Lab shareware. This is a .PAK compressed file that needs file #403 or its equivalent for unpacking.

#313 GURU73.TXT & #314 GURUFG73.GPS

Reprint of *Ask the Guru #73* that discusses three video compression schemes. These include wavelets, DCT/JPEG, and fractal compression methods.

#258 HACK42.TXT & #259 HACKFG42.PS

Reprint of *Hardware Hacker #42* from *Radio-Electronics*. Fundamentals of transforms, along with examples of wavelet video compression.

#195 HACK38.TXT & #197 HACKFG38.GPS

Reprint of *Hardware Hacker #38* from *Radio-Electronics*. A first introduction to wavelets and wavelet theory. Includes 13 entry sampler bibliography that shows the wide extent of wavelet aps.

FIG. 3—WAVELET TUTORIALS AND SHAREWARE available on GEnie PSRT. You can call (800) 638-9636 for your voice-connect info.

be unbearable.

At any rate, you'll still want to get the best first-stage noise figure you can. But it might not help you out too much if your external noise is much stronger than KTB. On the other hand, a slight increase in antenna gain can make a dramatic improvement in your FM reception.

That happens because of a limiter's *capture effect*. For instance, if you've got a noisy FM signal, an increase of only *two* decibels in antenna gain or S/N ratio can make up to a *seven* or *eight* decibel improvement in receiver quieting.

I've found several interesting FM antennas. The Radio Shack 15-1636 is cheap at $17 and easy to find. And it does a good job in near-fringe areas. But it is just plain too small. It measures only four feet by five feet, while a no-compromise Yagi solution will measure five by thirteen.

Radio Shack used the broadband co-linear array, rather than a Yagi design. Then, to save on the materials and size, they apparently designed it up at 120 megahertz or so and hoped there was still some gain down in the FM band. Almost always, a broadband antenna has lower gain than one cut for a single station. From their point of view, this is a useful engineering mix that gives you a small and cheap solution which meets the needs of a majority of their customers. Their gain is 6.4 dB over a dipole.

The most rugged "real" FM DX antenna is the *Cushcraft* Y-FM5. This is available by way of *Anixter*, the leading cable TV distributor chain. The gain is 9.5 decibels over a dipole, and the cost is around $70. Size is 59 by 104 inches.

Another interesting antenna is the *ChannelMaster* 4408 with a 9-decibel gain in a 138-inch boom length. The price seems high at $104.

The highest-gain stock antenna I

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have found is the *Winegard* CA-6065; it has a whopping 10.6 decibels of gain on a 127-inch boom and costs around $78. This appears to be the best choice.

Be sure to remember that raising your antenna height is usually the best way to improve the signal-to-noise ratio in typical locations. The closer to line of sight you can get, the better the results.

But I live in a pecan grove. Nuts. My trees glop over everything, most especially antennas. So some indoor solution seemed better for me.

What about building your own
gle-station FM antenna? In the
you could pick up another decibe
two of S/N and as much as 8–1C
of quieting over full-band comr
cial designs. Especially if you
extra careful in tuning and match
And if you have a high loft in y
living room or a wire- and metal-
attic crawl space, an indoor des
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grommeted screw eyes can be used for support.

First, note that there are two styles of driver elements to a Yagi antenna. As Fig. 4 shows, if you use a half-wavelength *dipole* hairpin loop, the terminal impedance should end up near a balanced 300 ohms.

If you use a pair of straight wires of half-wavelength total spacing, then your terminal impedance should be a balanced 75 ohms. Note that normal 75-ohm coaxial cable is unbalanced; you will need a balin or a 1:1 transformer to go from balanced to unbalanced.

Note that driver impedances inside an antenna array usually end up *lower* than those values. They also must be carefully matched for best results.

The bottom line: use a hairpin loop for 300 ohms balanced or the pair of quarter-wave wires when you want 75 ohms balanced. Either way, a final matching will still be needed.

A six-element narrowband Yagi cut for 100 megahertz is shown in Fig. 5. Use quite *thin* but rigid conductors for the best narrowband gain. Something like *bare* 12 AWG solid copper house wire might be a good choice. To cut the antenna to your desired station, *divide* the frequency in megahertz by 100, and then *divide* all sizes by the resultant number. For instance, to pick up KDKB at 93.3 MHz, all element lengths and all spacings will get divided by 0.933. Note the inverse relationship: stations *under* 100 MHz need slightly *larger* antenna designs.

The directors should point towards your chosen station. Use a map for starters, and then try rotating a tad either way. Your beamwidth should be around thirty degrees, so pointing in just the right direction is super important.

Additional directors can, in theory be added, in a size progression. But all you gain is something like half a decibel per director, and the size does get out of hand real quick. And a careful match, or finding a local hot spot, or a tad extra height can often get you much more signal.

The theory behind a Yagi antenna? The optimum spacing is usually 0.2 wavelengths. The driver should be half a wavelength wide. The reflector should be around five percent longer, while the initial director should be five percent shorter. The rest of the directors should be progressively six, seven and, eight... percent shorter.

More on Yagi antennas appears in two ARRL publications, the *Antenna Handbook* and *Yagi Antenna Design*. Also see NBS technical note No. 688.

Close matching of an antenna to its transmission line is essential for the best gain. The simplest method

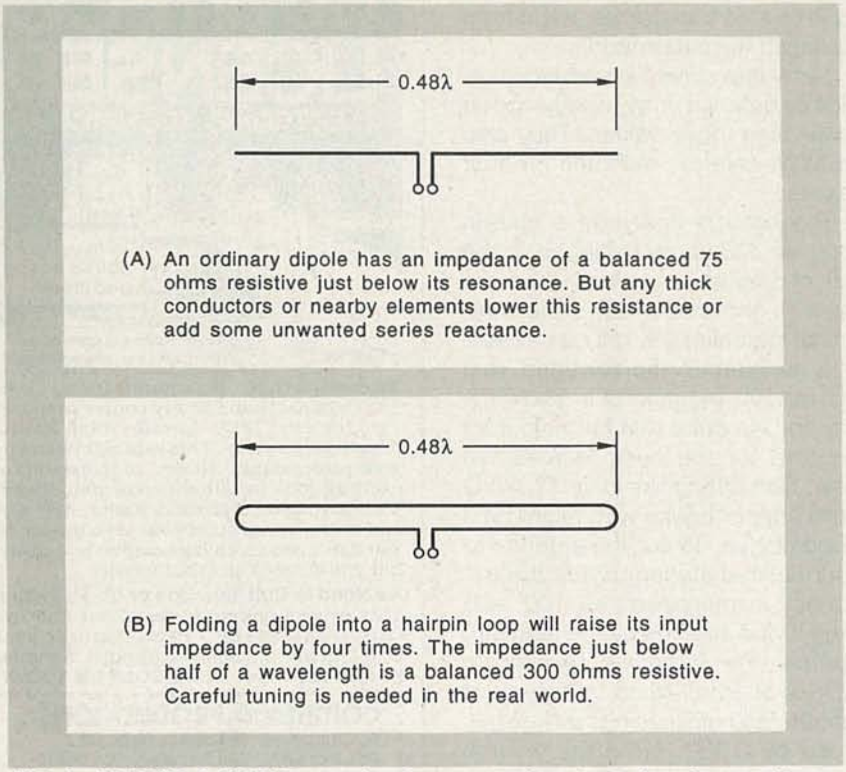

FIG. 4—FOLDING A DIPOLE can raise its resonant impedance by a factor of four.

All dimensions are shown in decimal inches. The antenna is shown top view, and assumes the station is horizontally polarized.

To cut your antenna for a specific station, divide the station frequency by 100 and then divide all sizes shown below by the same value.

For instance, a 93.3 Mhz station needs all the values divided by 0.933. A 104.5 Mhz station needs all of the values divided by 1.045.

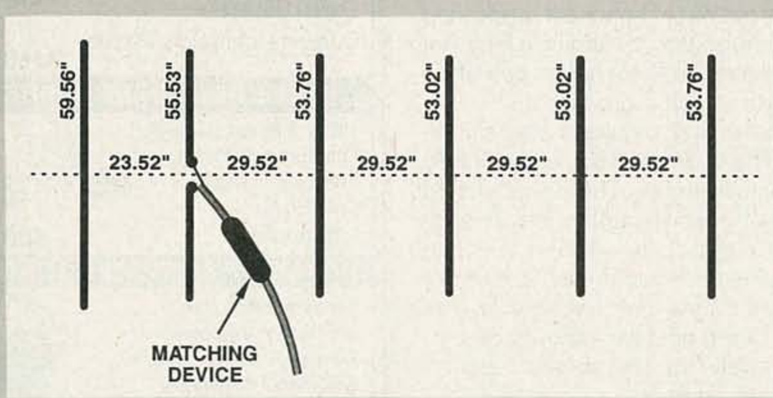

FIG. 5—AN INDOOR SINGLE-STATION long-distance FM antenna can be built using nothing but bare 12 AWG house wire. Here is one possible design. Note that the antenna size should be "cut" for your favorite station. Values shown assume an insulated boom or other supports. All elements must be very straight, rigid, parallel, and precisely centered. Contact a local radio ham for help in matching.

is called a *gamma* match, and it is done by just spreading the ends of a 300-ohm twinlead to tap maximum signal strength. Better methods appear in the books mentioned.

It would be real interesting to route both of your dipole r straight into a VHF differential plifier. Such an *antennafier* greatly simplify tuning and ma ing. But a lot of black magic coulc involved, so be sure to experim

Let me know all your experien with any homemade ultra-range antenna designs. I'll try to pub the best of them.

New tech lit

A green *1991 Product Handb* from *MX-Comm.* This little-kn semiconductor house offers sorts of exciting hacker chips, pecially those involved with t signalling, speech scrambling, lular phones, and pagers. One sleeper: MX-Comm's MX009 o digital gain-controlled amplifier ray. Lots of application-notes also included.

Free engineering samples of new 41VHS-1 humidity sensor h been offered on professional quest from *Victory Engineering.*

Heartland America is yet anot Distressed Yuppy Surplus dire mail outfit. It has all varieties of h tech goodies. Its latest new cata does offer the first laser point that I have seen selling for less t $100.

RePlay and *Play Meter* are two leading trade journals for coin-operated video-game indu While they mostly concentrate the buying and selling of games supply products, there are o sional technical articles plus re books and videos.

If you are interested in startin your own tech venture, be certa check into my at long last avail *Incredible Secret Money Machi* We have also begun shipping latest *Hardware Hacker III* repr with their newest updates. See nearby *Synergetics* ad for more tails.

A reminder here that lots of g technical downloads are avail on *GEnie* PSRT.

As usual, we've gathered mar the resources mentioned toge into either the *Names & Number* the *Navicube Resources* sideb Do be sure to check these *before* you use our no-charge helpline or call for a free hacke crets brochure.

GLITTER GLOBE

continued from page 40

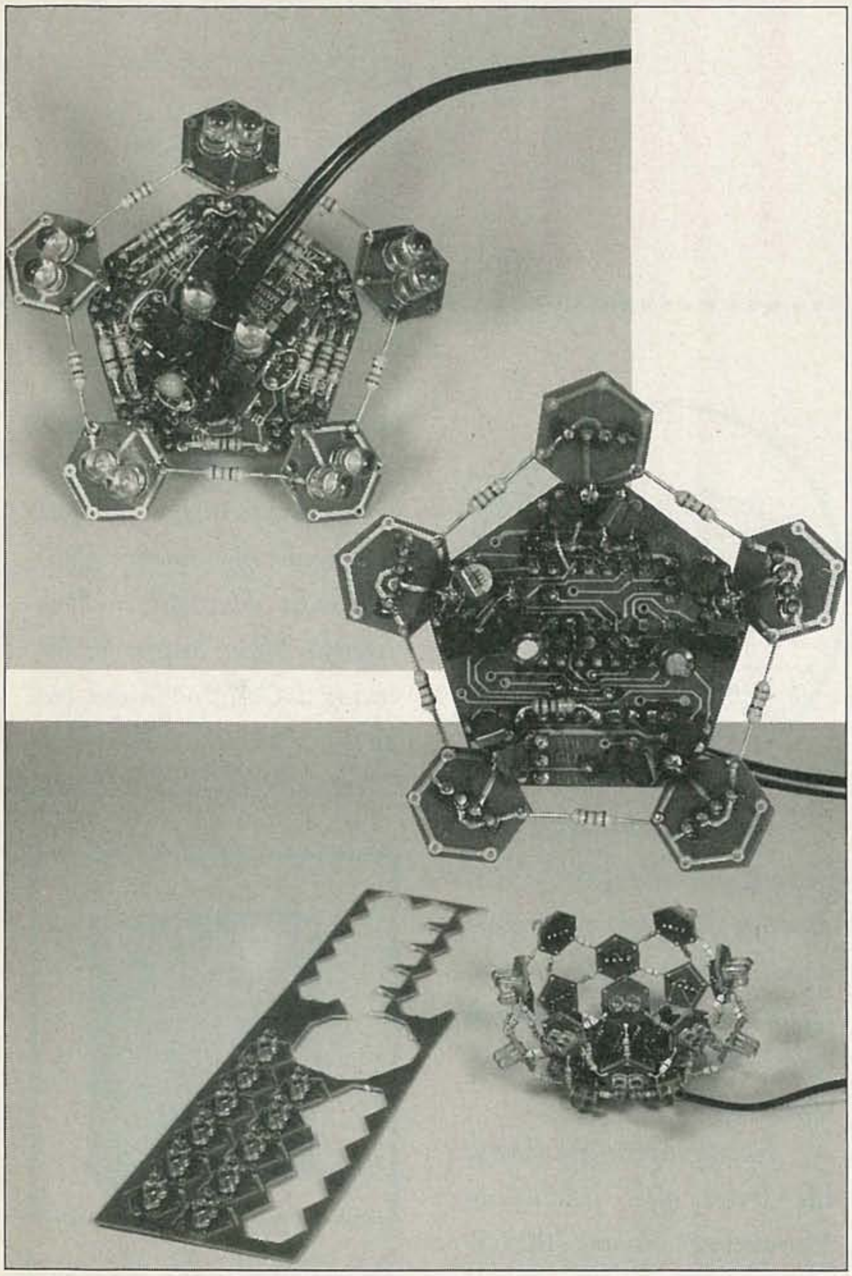

FIG. 10—BOTH SIDES OF THE CONTROL BOARD are shown with only level 1 attached (top and middle), and levels 1–4 have been added in the bottom photo.

After testing the controller board, assemble the five boards of the first level. (A "1" is etched on each of them.) Assemble the level-1 boards into a ring shape using resistors R14–R18, which should already be bent to the proper length—½ or ¾ inches (see Fig. 7). Creating the top ring in that manner will set the proper spacing for the rest of the globe. Leave the top hole on each level-1 board open (the hole farthest from the number etched on the inside surface), for connecting level 1 to the globe's control board.

Figure 7 is a "component map," showing levels 1–4, and how they connect together. All connections marked "J" are zero-ohm jumpers; all connections showing a resistor symbol must be 680 ohms, and all unmarked connections are structural components and can be made from anything you like (the kit includes additional 680-ohm resistors for use in these locations). Connect the level-1 ring to the control board as shown in Fig. 8; if you are using ¾-inch spacing, level 1 mounts as shown in Fig. 8-*a*; for ½-inch spacing, level 1 mounts as shown in Fig. 8-*b*. To connect level 1, install five 1-inch leads rising vertically from the control board. Then bend them to fit the level-1 ring as shown in Fig. 8.

Next add the level-2 boards. Each level-2 board connects to level 1 with one resistor (R19–R23) and one zero-ohm jumper. Solder the resistor and jumper to each level-2 board first, and then attach them to level 1. While building the globe, you'll begin to notice patterns. For example, after level 2 is complete each new board (except for level 7) connects to the previous level with two resistors (one structural only), and one zero-ohm jumper.

Figure 9 shows the rest of the globe (levels 5–7). Note that Figs. 7 and 9 both show the outside surface of the globe. The letters surrounding each half of the globe in Figs. 7 and 9 indicate the connections between the two halves. Install each level in order from 1 to 7 (even though we have shown the globe in two halves).

Layer 2 is composed of five-point boards, so, to make a sphere, keep the lead spacing of the resistors and jumpers attached to all layer-2 boards at ⅝ inch. It's a good idea to plug in the globe after each layer is installed to make sure all LED's are working. It's best to repair errors early before they become difficult to correct. Continue adding each layer and testing the globe until it's finished. Figure 10 shows a globe in different stages of construction.

When complete, the Glitter Globe forms a surprisingly sturdy structure, and you can hold it while it's operating. If the globe is dropped or crushed, it is a simple matter to bend it back into shape. With reasonable care, it will last for decades to come. **R-E**

Your Holiday B

HOLIDAY SPIRIT is your complete headquarters for surviving the holidays! Whether you need tips on the latest technology in sound systems, televisions or video games, Holiday Spirit will provide the latest information on electronic technology that will be just in time for

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Audio Amplifier for your olde teenagers and Royal Appliance Dirt Devil for mom. For thos looking for high fidelity, Hol. day Spirit will profile the Bo. Lifestyle Music System for li. tening to Christmas carols an will showcase Hitachi Ultravision Big Screen Telev.

sion for watching the New Yea bowl games like never before

Holiday Spirit has valua tips and information for eve one. For the youngsters in t family, Sunsoft's Road Runne Death Valley Ralley will be t latest Nintendo game to fill th stockings. For music lovers u

ectronics Center

demand accurate and natural music reproduction, Holiday Spirit will feature Ohm Walsh 5 Loud Speakers for full room stereo sound.

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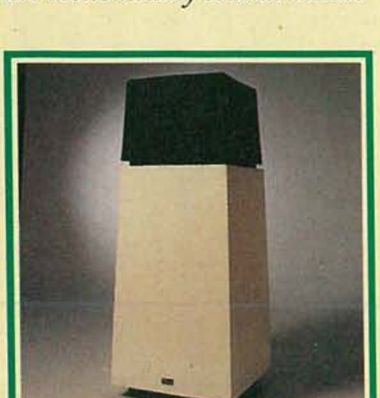

ing? Holiday Inn will give you a comfortable, affordable place to stay with the family.

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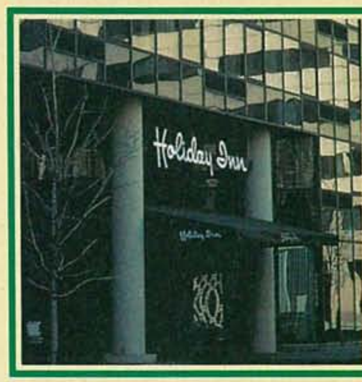
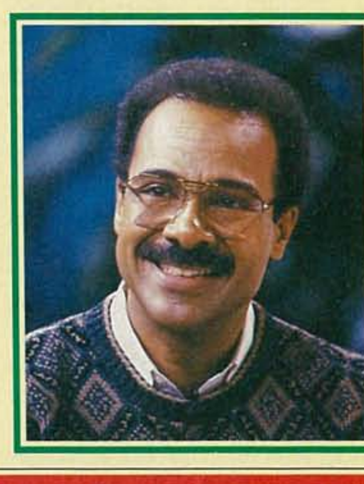
finished in time, Holiday Spirit will show you how to have "Happy Holidays" with time-



saving tips and gift recommendations.

Check your local TV guide for times and dates.



HOLIDAY SPIRIT

A Brookstone Production

DRAWING BOARD

Let's get back to our SSAVI descrambler.

ROBERT GROSSBLATT

Before we get into the nitty gritty of the SSAVI system, I have to take a few lines to make a few things clear. I've touched on them before, but it's important to repeat them. All we've gone into so far is gated sync suppression, which can be considered pretty unsophisticated these days.

The SSAVI system isn't the last word in scrambling but it's reasonably recent and it, or some variation of it, will be the scrambling system of choice for some time to come. That is true even if you consider only the economic side of changing scrambling methods.

I have no doubt that many cable companies use this scrambling technique, or at least something very similar. If that's true in your area, it would be a good idea to do some experimenting with the actual signal—hands-on experience is always the best. What you'll probably find out in the real world is that the system used in your area isn't an exact match for the one we'll be taking apart. The general principles might be the same, but the particular details will undoubtedly vary.

When the SSAVI system first started, there were some constants in the video signal that could be used to descramble it. Remember that the picture can be messed up in any one of three ways (see October's column for the details), and the instructions for the descrambler are transmitted somewhere in the vertical interval. The word "somewhere" is a late addition to the SSAVI system. When it first started, the descrambling information was always on the same line. That's where we'll start.

Once upon a time, the sanctity of the vertical interval was closely guarded by the FCC, but as alternatives to standard broadcast TV became more popular (cable, satellite, etc), more and more junk started to show up there.

When the SSAVI system started, lines 0 to 9 were left alone by a request of the FCC, but lines 10 to 13 were where the cable companies transmitted individual subscriber codes. Don't forget that there are unique ID numbers stored in an EPROM (or some other kind of memory) in the cable box. There's also logic circuits there to count the video lines, read the transmitted code, and match it up against the one stored in the box. This is a big thing for the cable companies because it prevents a New York box from being used in California. The scrambling is the same, but the codes are completely different.

The decoder circuitry is also controlled by this coding process because a match between the transmitted bytes and the c stored in the box will enable o able the decoder. That is tru both the premium cable serv and the pay-per-view events.

That kind of coding might b portant to the cable companies it doesn't mean anything to us can build an experimental scrambler without paying any a tion to them.

Since the video can be trans ted with either normal or inve picture information, one of the t that has to be done by the scrambler is to tell the rest o circuit what has been done to picture. The place to find that i mation was originally in line 20, has been moved around since system became popular. As you see in Fig. 1, the last half of the will tell you whether the pictu normal or inverted. Remember

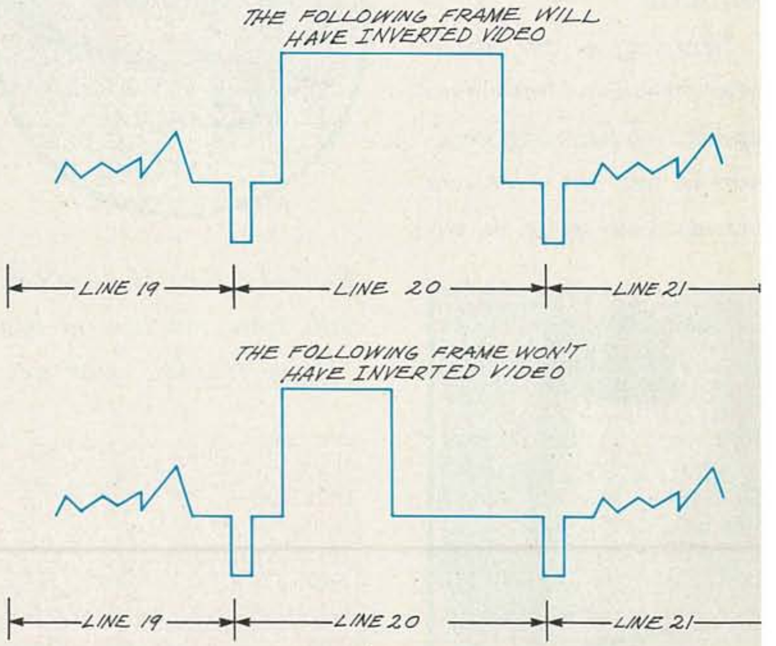


FIG. 1—THE LAST HALF OF THE LINE OF VIDEO will tell you whether the pict normal or inverted. We're talking about the picture part of the line only.

we're talking about the picture part of the line only, and not the control section.

If the following field is normal, the last half of the line will be black, and if the picture is normal, the whole line is white. One of the things a decoder needs, therefore, is some way to detect the line and store the data it contains. The stored data is then used as a switch by the circuit to route the video through an inverter if the picture is being transmitted upside down.

This is pretty straightforward stuff. Since we're looking at only one piece of information, all we need is a place to store one bit of information. Your basic piece of cake. The circuitry needed to detect the data, however, is a bit more complex. We need a reference in the signal. So establish a zero point for a line counter, and some counting circuitry to keep track of which line is being received.

You might be wondering what we can count if the signal is being scrambled. But remember, that in the vertical interval (the first 26 lines of video), the signal is being sent in the clear.

Now that we have an approach to handling the possibility of an inverted picture, the last problem to tackle is the one of varying horizontal sync pulses. Sometimes they're there, sometimes they're absent, and sometimes they're not at the proper level. Anything that unstable is a pretty poor choice for a reference signal. So, to avoid a mammoth circuit design problem, the best way to deal with it is to scrap the transmitted horizontal sync (even when it's there), and come up with a way to generate the signal ourselves.

That can also seem to be an insurmountable problem but, just as in the case of the inverted picture, the answer is going to be found in the vertical interval. Once again, remember that the first 26 lines of video are sent in the clear and, even during the rest of the video frame, (no matter what's going on with the picture), the horizontal sync pulse is never inverted. It might be weak or missing entirely, but it's never upside down. That's important to keep in mind because if we generate our own horizontal sync, we don't want

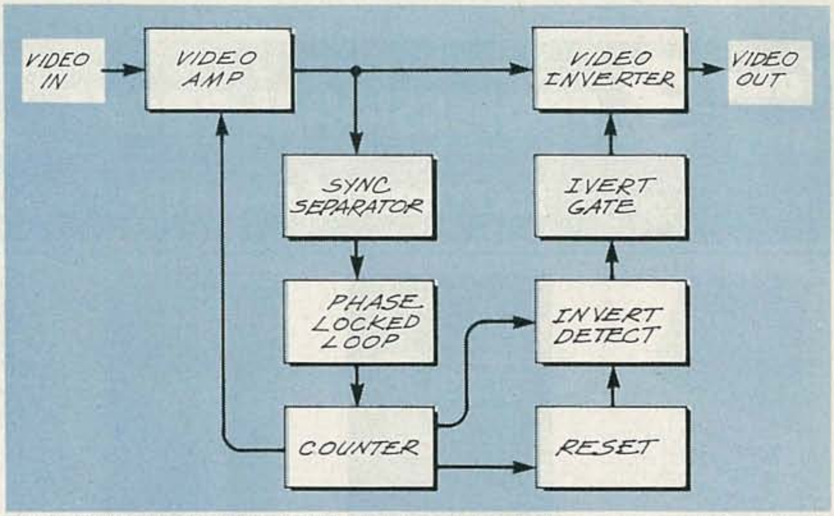


FIG. 2—THIS CIRCUIT WILL MAKE SURE the picture is always present at the output in a non-inverted state, and that it has horizontal sync pulses present at the right level and the right position.

an upside down, positive-going sync signal present. If that was the case, the two sync signals would add together and cancel, which is not a good thing.

We've talked about how to regenerate sync when the signal being received is unreliable. If you don't remember it or haven't read it, go back to October's column and review it. Basically, the approach is to take the horizontal pulses sent in the clear during the vertical interval and use them as the reference for a phase-locked loop that will supply the missing pulses during the rest of the video frame. If you've got twenty or so reliable pulses per frame, you can accurately generate the missing two hundred and forty or so for the rest of the frame.

The block diagram of the circuit we need is shown in Fig. 2. In a nutshell, the job of the circuit is to make sure the picture is always present at the output in a non-inverted state, and that it has horizontal sync pulses present at the right level and the right position.

The scrambled video is fed to an op-amp and the output is sent to a sync separator—the same basic circuit that's found in every TV set in the universe. The sync pulses drive a phase-locked loop whose output is decoded to provide the missing sync pulses for the video lines outside the vertical interval (where most of the interesting stuff is found). These generated sync pulses are mixed with the incoming video and then sent, through a gated inverter, to the back of your TV set.

The gated inverter is controlled by a signal that tells it whether or not the picture portion of the video is upside down. The control signal is derived by watching the state of line 20, as we discussed before.

All this sounds incredibly complicated but, if you look over the block diagram, you'll see that it's just a collection of gates and counters—the same sort of stuff we've been messing around with for years.

The only box in the diagram I haven't explained is the reset circuit for the counter. I'll explain that in the next column but you should be able to figure out for yourself exactly what it is. If you get it right, you've got a good handle on the subject of video in general and scrambling in particular. If you can't figure it out, spend the next month getting ready by boning up on the essentials of basic video theory. **R-E**

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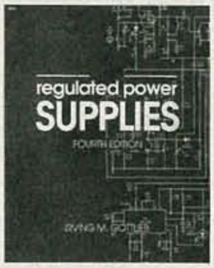

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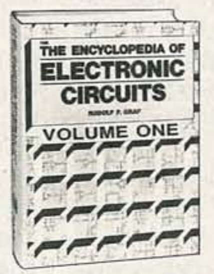

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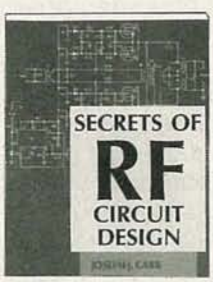

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AUDIO UPDATE

It's a matter of hear today, gone tomorrow

LARRY KLEIN

It's an unhappy paradox that at a time when music reproduction is approaching perfection, there is widespread failure in the music listener's ability to hear it fully. Four years ago I wrote in this column about the audiometric hearing tests given by the Audio Engineering Society at their 1986 Los Angeles convention. The more-than-200 AES members tested showed small but consistent hearing losses that exceeded those expected from the normal aging process. A wide variation of hearing thresholds was measured in the sensitive 3- to 6-kHz range with more than 10% of the respondents showing significant hearing loss at 4 kHz.

It's a sure bet that things have not improved any in the last six or seven years. In fact, from what I hear, the quantity and level of ear-damaging environmental sounds have escalated beyond reason. Under environmental sounds, I include everything from power mowers and blowers to live and reproduced rock music. Can anything be done to tame the wild decibels?

English ears

For some reason, many of the extensive research studies on hearing loss and music listening have been done in the U.K. Several years ago, two researchers at the University of Keele tested two groups of Staffordshire high-school students; one group had frequent exposure to loud music at rock concerts, discos, and through personal stereo headphones. The control group (I wonder where they found them) had little or no such exposure.

Although conventional diagnostic tests revealed no overall hearing loss, two problems did become evident with more precise techniques. There was evidence of the group's diminished sensitivity to a narrow band of mid frequencies and, surprisingly, a reduced ability to distinguish between adjacent musical pitches.

Environmentally engendered hearing loss is not limited to kids addicted to rock concerts, loud headphones, and killer car-stereo systems—all of which have been measured at noise levels over 110 dB. The older, if not wiser, generation is also surrounded by equipment that is not intentionally loud but just happens to be. I'm referring to a variety of home, yard, and recreational equipment. These include power tools (my radial-arm saw cutting through hardwood makes quite a racket!), power mowers, and leaf and snow blowers. Recreational vehicles such as outboard motor boats and snowmobiles, are also potent sources of the kind of
tained sound levels that can be
ticularly damaging.

In general, the rule seems t
that constant sound levels,
ticularly in a narrow band, are
harmful than louder intermi
sounds. In other words, if
sound-pressure level (SPL) n
needle seems stuck at the 9
level, the sound is likely to b
more damaging than if the nee
swinging wildly with occasional
dB peaks.

Since the ear-damaging effe
noise result from cumulativ
posure over time, noise-do
meters have been developed f
dustrial use. They average ou
varying sound-pressure level t
vide an equivalent contin
sound level, or L_{eq}. Such de
are analogous to the radiation
age meters that are suppose
keep workers in the nuclear i
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that some hearing loss will oc
20% to 25% of workers expos
the legally allowed limit of 9
(L_{eq} in dBa) for 8 hours. That i
sound level of heavy street traf
a subway train.

Damage report

Exactly how does hea
damage occur? Aside from ear
rupture caused by a high-pres
pulse from a loud nearby so
rapid pressure changes and
eases of the auditory nerve and
tral nervous pathways, the m
area of damage occurs in the m
scopic hair cells residing in the
ral-shaped cochlea of the inne
Dr. John Rosowski of Harvard M
cal School has been investig
the problem. At relatively low l
of intensity, he says, damag
pears to be proportional to
amount of energy entering th
during a particular period of

MAXIMUM ALLOWABLE OSHA LEVELS

The Occupational Safety and Health Act (OSHA), which became law in late 1970, places limits on the noise conditions to which employers may subject their workers. The maximum allowable sound levels and daily exposure periods are given in the table. For industries that fall under the jurisdiction of the act, those limits have the force of law, and an employer is obliged to take corrective steps if it is found that any employee is being exposed to noise that exceeds the limit.

TABLE 1—MAXIMUM ALLOWABLE OSHA LEVELS

Exposure duration level (hours per day)	Maximum level (L_{eq} in dBA)
8	90
4	95
2	100
1	105
½	110

But beyond some critical level of sound pressure, the hair cells become much more susceptible to trauma. With only a small increase in SPL beyond this critical point, the damage increases significantly and disproportionately.

The microscopic hair cells are the specific transducers that convert the vibrations in the inner ear to the electrical impulses sent to the brain. Each hair cell, which has a diameter about ⅛ that of a hair, is topped off by 20 or so stereocilia that resemble the bristles on a toothbrush. Scanning electron micrographs of sound-damaged microcilia show them bent, fused, and even missing. That results in a medical diagnosis of "nerve deafness," an irreversible condition.

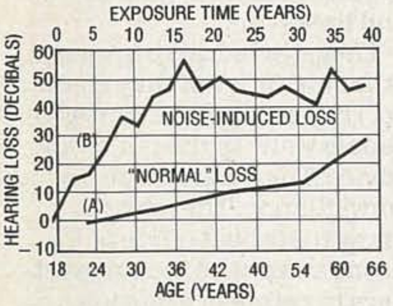

FIG. 1. LOSS OF HEARING is a natural result of aging (a), but a much more severe loss can result from long-term exposure to an excessively noisy environment (b). Both curves are at 4 kHz, but high-frequency hearing goes first.

In general, everyone who lives in a civilized (meaning noisy) environment is subject to some hearing loss over time. [See Fig. 1-a.] At first, the loss appears only in the upper frequencies usually reproduced by tweeters. In time, however, the loss progresses downward to the upper midrange frequencies that differentiate the sounds important to speech comprehension.

Now hear this

There is good evidence that individuals vary in their physical tolerance of loud sounds. Nevertheless, there are some ground rules that those who care about their hearing should follow. Since ear damage is cumulative, resulting in a gradual deterioration, sounds that are instantly heard as too loud—that cause ringing or other inner ear noises—should be avoided or at least diminished by placing damp cotton wads in the ears or by the use of more effective medically-approved ear-protection devices. However, loud, but not obviously excessive, sound sources, musical or otherwise, can also be damaging in the long run.

I have an audiophile friend who wears earplugs in the subway and in other noisy environments. Aside from the noise level in public places, you should consider ear protection when performing such activities as power-tool carpentry and lawn care. Even wads of cotton stuffed tightly in your ear canals will help. It's not just that you are saving yourself an immediate headache, but you might avoid a hearing-aid purchase 30 or 40 years from now. Don't be dumb today—and deaf tomorrow. **R-E**

EQUIPMENT REPORTS

continued from page 16

(5000 counts) signals with crest factors up to 3.0 can be measured. At full scale, a signal must have a crest factor less than 1.5 to be measured accurately.

The *HD160* offers impressive overload and safety protection. The voltage inputs can withstand up to 1000 volts AC or DC. Both current jacks are protected by fuses. An added safety feature protects the meter, user, and the device under test: When a probe is inserted in one of the current jacks and the function switch is set to a non-current mode, the meter's display will show an error message to warn the user.

The *HD160* is priced at $199. The capable, rugged high-quality meter will be appreciated by anyone who needs a DMM for serious professional use. **R-E**

COMING NEXT MONTH

The January 1993 Issue goes on sale December 3, 1992

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Computers and Consumer Electronics

JEFF HOLTZMAN

Computers and consumer electronics are merging. Kodak and Tandy have added fuel to the fire with their recent introductions of Photo-CD and the Visual Information System (VIS), respectively. Photo-CD and VIS join CD-ROM Interactive (CD-I) and Commodore Dynamic Total Vision (CDTV) as the major attempts to put computer-like interactivity on a television screen, thereby capturing the hearts and minds—and pocketbooks—of noncomputerized consumers. VIS, CDTV, and CD-I are direct competitors; although similar in some ways, Photo-CD is really in a category by itself. (You might also want to keep in mind upcoming CD-based systems from Nintendo and Sega.) Photo-CD, CD-I, CDTV, and VIS all share the following in common:

- They are meant to be operated in the family room, not in a home office or corner of the bedroom.
- They use the home entertainment system (TV and stereo) for audio and video output.
- They emphasize early education, games, entertainment, and reference works.
- They use some form of CD-ROM as the primary delivery medium.
- They operate with simple infrared remote-control devices rather than computer keyboards.
- They are meant to appeal to less technically sophisticated consumers than computer users.
- They cost in the $600–1000 range.

To understand what each of these technologies has to offer and which is likely to be successful, let's summarize the key points of each.

CDTV This system descends from a long-time player in the personal-computer market. Starting way back with the Pet (in the late 1970's), and moving on through the C-64, and then to the Amiga, Commodore has always had a presence in personal computing. However, the company has never developed and executed a clear marketing strategy, hence has been a sideline player in most areas. The single exception is video production on the Amiga, where word of mouth and an unbeatable price/performance ratio have brought success. CDTV was introduced in the early summer of 1991, and has yet to achieve major acceptance. CDTV consists of a stripped-down Amiga 500 computer that has been specially modified to respond to commands from an infrared remote. The unit can be expanded to be a functional Amiga 500 by adding keyboard, disk drive, memory, and mouse. CDTV is sold by Commodore dealers.

FIG. 1—KODAK'S PHOTO-CD puts 100 images in five different resolutions on a single CD-ROM disc. The player displays images on your TV screen and plays regular audio CD's through your stereo. A future upgrade will allow you to add audio and text to a Photo-CD disc, thereby allowing annotated, navigable slide shows.

CD-I Philips Consumer Electronics introduced the CD-I system in the fall of 1991 after several delays. It consists of a proprietary 68000-based system running a special version of the OS-9 operating systems. CD-I players are sold by consumer-electronics outlets. Approximately 65 CD-I titles are available, including several "celebrity" titles narrated by Danny Glover, Mia Farrow, Robin Williams, Jack Nicholson, Raul Julia, and Sir John Gielgud. One CD-I disc explores jazz giants such as Charlie Parker, Miles Davis, and Sarah Vaughn. Another disc explores the paintings of Rembrandt, and includes narration in seven languages (Dutch, English, French, German, Italian, Japanese, and Spanish). Titles start at $15; most are priced in the $20 to 40 range.

VIS Like Commodore, Tandy has been involved with personal computers since the earliest days. Its chief products include the TRS-80 series, the Color Computer, the Model 100/200 portables, a line of semicompatible PC's, and a line of fully compatible PC's. While never achieving great success in the business community, the PC compatibles have, nonetheless, held their own in the hobbyist/consumer market. VIS, is in fact, the "Wintendo" device discussed here in the October issue that has fueled the industry rumor mill for months. Unlike the other products discussed here, VIS software architecture is based on MS-DOS and Modular Windows, a ROM version of Microsoft's Windows optimized for use in a consumer (television) environment. Virtually all leading content developers, including Berlitz/Cruise Watch, Broderbund, Compton's New Media, Electronic Arts, Lucas Arts, Sierra, and others, are developing VIS titles; AimTech (IconAuthor) and OWL (Guide) have authoring systems, and Microsoft might have something up its sleeve in that area as well.

The DOS/Windows platform is good for several reasons. Content developers don't have to buy specialized and costly development platforms; standard PC's (with emulation boards) will do the trick. Porting VIS titles to and from other systems (e.g., MPC-compatible PC's) will be simpler than porting to or from a whole new architecture. Tandy's immense retail network ensures broad product availability and servicing. Zenith will also be selling VIS systems under its own brand name.

Photo-CD Kodak's technology is not currently designed to compete in the interactive-TV market, although it does have architectural features that might eventually provide interactivity. Photo-CD is designed to appeal to both professional and broad consumer bases. In the consumer world, Kodak hopes Photo-CD will supplement the family photo album and slide projector. In a professional setting, it will be useful for desktop publishing, corporate image databases, stock photo image bases, medical imaging, image archiving, and probably lots more. Photo-CD works like this: You take or mail a standard roll of print or slide film (up to 4 × 5 inches now, with larger formats coming) to a special Photo-CD processor, which then scans each image at five resolutions ranging from catalog-quality "thumbnails" (128 × 196) to publication-quality scans (6000 × 4000).

Depending on image size and content, it is possible to store about 100 images per disk in the standard consumer Photo-CD format. Other professional formats are available that allow storage of as many as 6000 low-resolution images (e.g., for image catalogs).

For family-room use, Photo-CD's can "play back" on special players (like that shown in Fig. 1) that also handle audio CD's, and on select computer-based CD-ROM drives (in particular, those claiming CD-ROM/XA compatibility). For computer-based use, Kodak has introduced low-cost PC- and Macintosh-based software packages for viewing images and getting them into standard bitmap formats such as PICT, TIFF, and EPS. Some c mercial graphics editors (e.g., lishers Paintbrush) already c built-in Photo-CD support. A has announced that it will sup the Photo-CD format direct System 7 software, and via Q Time (Apple's set of technolo and specifications for time-de dent data, (e.g., audio and vide quences). Kodak has also nounced several advanced im editing packages.

Resources

- **The Visual Display of Quantitative Information ($40), Envisioning Information ($48), Graphics Press, Box 430, Cheshire, CT 06410, (203) 250-7007.**
  CIRCLE 41 ON FREE INFORMATION CARD
- **Photo CD, Eastman Kodak Company, 343 State Street, Rochester, NY, 14650-0519, 800-242-2424.**
  CIRCLE 42 ON FREE INFORMATION CARD
- **Pro 16 Multimedia System, MediaVision, 3185 Laurelview Court, Fremont, CA 94538, 800-348-7116, 510-770-8600.**
  CIRCLE 43 ON FREE INFORMATION CARD
- **Visual Information System, Tandy Corporation, 1800 One Tandy Center, Forth Worth, TX 76102.**
  CIRCLE 44 ON FREE INFORMATION CARD
- **Compact Disc Interactive, Philips Consumer Electronics Company, One Philips Drive, P.O. Box 14810, Knoxville, TN, 615-475-0317.**
  CIRCLE 45 ON FREE INFORMATION CARD
- **Commodore Dynamic Total Vision, Commodore Business Machines, Inc., 1200 Wilson Drive, West Chester, PA 19380, 215-431-9100.**
  CIRCLE 46 ON FREE INFORMATION CARD

Photo-CD uses a multiple-v technology that allows several sions to be placed on a single at several times. If you're intere in using multi-write capabilities computer, make sure your ROM drive can handle it. Cl Kodak's hotline at the num shown in the sidebar for inform on compatible CD-ROM dri processing centers, and soft availability.

You want a revolution?

Will CDTV, CD-I, VIS, or Pl CD bring about some revoluti the computer industry, the con er electronics industry, or both' they destined for the junk h along with the early personal puters and dedicated video ga of the 70's and 80's?

They're probably all heade the junk heap sooner or later VIS and Photo CD have the chance of survival during the few years. Commodore's on-a off-again marketing style ins confidence in neither develo nor consumers. Philips' systen some technical advantages, fo ample hardware-assisted full tion video based on the indu standard Motion Picture Ex Group (MPEG) compressior mat. But even that is an add-o the basic player. Development tems are proprietary, and there lack of broad industry support

Photo-CD, on the other han fers immediate advantages to computing community, espe desktop publishing and profess imaging concerns.

Broad appeal is problema that Photo-CD will be competir consumer dollars against VIS the other systems, all of which more general-purpose functio

FIG.2—TANDY'S VIS or Video Information System runs a Windows-like operating system designed by Microsoft.

It seems unlikely that people would want to buy more than one CD-based digital information appliance to connect to their TV's and stereos. Viewed in that light, Photo-CD might find it difficult to crack the home market. If VIS (or the other systems) could provide Photo-CD compatibility, then Kodak might lose the player battle but win the format/usage war. There is a lot of money to be made in processing Photo-CD's and in selling processing its workstations.

Photo-CD stands a very good chance of survival, simply because the publishing and imaging industries need it. The consumer market might go for it, depending on consumer awareness of the more general-purpose nature of VIS. I think Kodak would be smart to work with Tandy to ensure that VIS can play Photo-CD discs.

On paper, VIS looks like the safest bet among the interactive systems, both for developers and consumers. Like CDTV, VIS is really a general-purpose computer, albeit not in the present incarnation an expandable one. Because VIS is so closely related to the DOS/Windows platform, content developers can create and port titles at low cost and low risk. Assuming Tandy stays with the architecture, upgrading to higher-performance technology (e.g., full-motion video) should be fairly painless. Also, if anywhere near the number of promised titles actually materialize by the time VIS hits the market (presently aimed for Christmas 1992), Tandy will have a huge advantage.

VIS is extremely interesting. If it succeeds, it will mark the first success of a manufacturer in more than a decade in trying to penetrate the consumer market with a general-purpose digital information system. Computerphiles will probably view VIS as under powered. But with the Windows platform underpinning the system, there's lots of potential for growth.

I'm looking forward to hooking a VIS system up to my home-entertainment center. However, I know up-front that it's a throw-away purchase; the computer industry is still evolving so rapidly that VIS will be superseded by something. My hope is that, between now and obsolescence, my kids will get more from it than from a video game.

Product watch

I've looked at several multimedia upgrade kits over the past year, and have reached several conclusions. First, the base MPC specification is pretty low-fi. Nonetheless, results can still be startling. The best MPC upgrade kit I've found is from MediaVision. It includes what is currently one of the best CD-ROM drives on the market, NEC's SCSI-based CDR-83, along with the ProAudio Spectrum 16-bit stereo audio card, which has a built-in SCSI interface. The bundle also includes a slew of software, including Lotus 1-2-3, Compton's Multimedia Encyclopedia, a CD-based version of Sierra's King's Quest V, an authoring tool called Action from Macromind, and numerous DOS and Windows utilities for recording, mixing, and playing back sound and MIDI files. The utility software varies widely in quality, user interface, and usefulness, and it does not include a Windows-based MIDI editor, the major shortcoming of the package. The methods for configuring system interrupts and I/O port use is poorly documented, but once running, the package works like a charm.

Bookshelf

You probably take that voltage-versus-time display on the front of your oscilloscope for granted. What you might not know is that graphical displays of data were not even invented until the latter half of the nineteenth century, long after the invention of calculus. An Englishman, William Playfair, and a Swiss-German, J. H. Lambert, claim the honor of first publishing the many basic techniques of statistical graphics. You might also be unaware of what makes bar charts, time series, and other kinds of graphs really work. Why is that important? Because most technical professionals use spreadsheet, data-analysis, and visualization programs to analyze and display data, be it voltage, current, resistance, impedance, dollars, or other quantities. Computer tools give you lots of options for displaying your data using color, gray scales, hatching, perspective, and more. However, unless you're careful, you can get into trouble, graphically speaking, and thereby obscure your real message.

If you ever produce a chart or graph as part of your job, you absolutely must look at two books by Yale statistics professor Edward R. Tufte: *The Visual Display of Quantitative Information* (originally published in 1983), and *Envisioning Information* (1990). Alternate titles for those two exquisite works could be Volumes I and II of Use and (Especially) Abuse of Statistical Data in Graphical Form. In example after example, Tufte shows and tells why some things work and others don't, along the way exposing numerous misguided attempts at "improving" the presentation of statistical data. Tufte understands that effective communication of information involves carefully meshing form and content. He practices what he preaches. Beg, buy, or borrow copies of these works. You won't be disappointed. **R-E**

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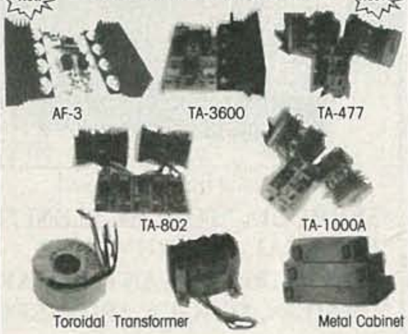

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TY-47	Superior Electronic Roulette ▲▲	21.50	28.50
#016	10,000u/f 80V Capacitor(Suggested for TA-3600,TA-477,TA-1000A&TA-802)		28.00
#017	8,200u/f 50V Capacitor (Suggested for TA-802,TA-120MK2)		14.00
#021	NOBEL (Single) Variable Resistor (Suggested for TA-3600, TA-477, TA-1000A & TA-1200MK2)		12.00
#022	ALPS (Dual) Variable Resistor (Suggested for TA-377A TA-2200 & TA-802)		22.00

MODEL	REGULATORS	KIT	ASSMB.
TR-355A	0-15V Regulated DC Power Supply (case. transformer not included) ▲	16.50	22.76
TR-355B	0-30V 3A Regulated DC Power Supply (case. transformer not included) ▲	16.50	22.76
TR-503	0-50V 3A Regulated DC Power Supply w/Short Circuit & Overload Protection (case. transformer not included)▲▲	17.75	24.65
TR-2025	6.5V to 18V 20A Regulated DC Power Supply (w/4 steps current-limiting & short-circuit protected)▲▲▲	62.75	78.75

MODEL	DIGITAL METERS AND COUNTERS	KIT	ASSMB.
TY-43	3½ Digital Panel Meter ▲	29.00	38.00
SM-43	3½ Multi-Functional Led D.P.M. (w/ABS Plastic Case) ▲▲	34.50	43.00
SM-48	4½ Hi-Precision D.P.M. ▲▲▲	38.00	48.00
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MODEL	H"	W"	D"	MATCHING	PRICE
LG-1273	3"	12"	7"	TA-2800, TA-377A, TA-2200	23.85
LG-1684	4"	16"	8"	TA-323A, TA-377A, TA-2200	28.50
LG-1924	4"	19"	11½"	TA-802, TA-1500, TA-120MK2, TA-800MK2, TA-1000A	34.50
LG-1925	5"	19"	11½"	TA-477, TA-800MK2, TA-1500, TA-1000A, TA-3600 AF-3	38.00
LG-1983	2¼"	19"	8"	TA-377A, TA-2800, TA-2200, TA-120MK2	32.50

POWER TRANSFORMERS

MODEL	DESCRIPTION	MATCHING	PRICE
#001	28V x 2 6A TO 30V x 2 6A	TA-800MK2, TA-802, TA-1000A, TA-1500	28.00
#002	36V x 2 3A	TR-503, TA-323A, TA-400, TA-300,	23.00
#003	40V x 2 6A	TA-477	30.00
#004	24V x 2 6A	TA-120MK2	23.00
#005	26V x 2 3A	TR-355B	17.00
#006	18V x 2 5A	TR-355A	17.00
#007	53V x 2 8A	TA-3600	45.00
#008**	⌀28V x 2, 30V x 2 6A	TA-800 MKZ, TA-802, TA-1000A, TA-1500	38.00
#009**	⌀48V x 2, 53V x 2 8A	TA-3600, AF-3	66.00
#010	30V X 2, 36V X 2 400mA	TA-377A, TA-2200	8.50
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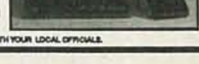

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Modern electronic equipment such as digital TVs or stereos should be repaired by specially trained people.

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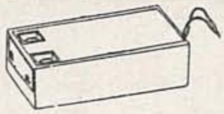

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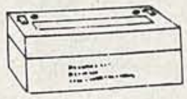

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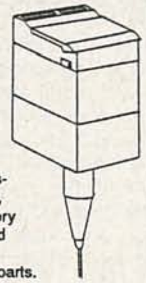

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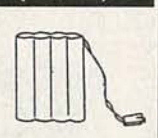

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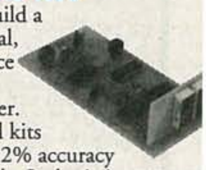

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Countersurveillance

lever before has so much ·rofessional information on the art ·f detecting and eliminating ·lectronic snooping devices—and ·ow to defend against experienced ·nformation thieves—been placed ·n one VHS video. If you are a ·ortune 500 CEO, an executive in ·ny hi-tech industry, or a novice ·eeking entry into an honorable, ·ewarding field of work in ·ountersurveillance, you must ·iew this video presentation again ·nd again.

Wake up! You may be the victim of ·tolen words—precious ideas that would ·ave made you very wealthy! Yes, profes·ionals, even rank amateurs, may be lis·ening to your most private con·ersations.

Wake up! If you are not the victim, ·hen you are surrounded by countless vic·ims who need your help if you know how ·o discover telephone taps, locate bugs, or ·sweep" a room clean.

There is a thriving professional service ·teeped in high-tech techniques that you ·an become a part of! But first, you must ·now and understand Countersurveilance ·echnology. Your very first insight into ·his highly rewarding field is made possi·le by a video VHS presentation that you ·annot view on broadcast television, sat·ellite, or cable. It presents an informative program prepared by professionals in the field who know their industry, its techniques, kinks and loopholes. Men who can tell you more in 45 minutes in a straightforward, exclusive talk than was ever attempted before.

Foiling Information Thieves

Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businnesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted

CALL NOW!

1-516-293-3751

HAVE YOUR VISA or MC CARD AVAILABLE

what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

CLAGGK INC. EN
P.O. Box 4099 • Farmingdale, NY 11735

Please rush my copy of the Countersurveillance Techniques Video VHS Cassette for a total cost of $53.95 each (which includes $4.00 postage and handling).

No. of Cassettes ordered ______
Amount of payment $ ______
Sales tax (N.Y.S. only) ______
Total enclosed ______
Bill my ☐ VISA ☐ MasterCard
Card No. ______
Expire Date ____ / ____
Signature ______
Name ______
Address ______
City ______ State ______ ZIP ______

All payments in U.S.A. funds. Canadians add $4.00 per VHS cassette. No foreign orders.

The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional helf with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

The Dollars You Save

To obtain the information contained ir the video VHS cassette, you would attenc a professional seminar costing $350-75(and possibly pay hundreds of dollars mor if you had to travel to a distant city t attend. Now, for only $49.95 (plu $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and tak refresher views often. To obtain you copy, complete the coupon or call.

Soder-Wick® Facts # 1: The Desoldering System.

Soder-Wick® Fine-Braid is uniquely designed for each desoldering application, from SMT pads to large wire connectors. This ultra-pure, oxygen-free copper is engineered in an open-weave pattern that provides near-perfect capillary action. Solder is wicked cleanly away, without damaging the board or surrounding components.

Choose from nine widths and three flux arrangements, including static dissipative packaging for ESD-sensitive operations. Call us at 1-800-SOS-WICK and get all the facts on the Soder-Wick System.

SW
SODER-WICK® FINE-BRAID
The State of the Art in Desoldering.

Soder-Wick Facts # 22: The SMT Wick.

Soder-Wick® Ultra-Braid is designed for precision cleaning tight-tolerance SMT pads. This ultra-pure, oxygen-free copper wire is engineered for superior thermal conductivity which ensures lower heat transfer and faster wicking action. Solder and contaminants are quickly removed, without affecting surrounding pads or intergrated circuits.

Call us at 1-800-SOS-WICK and get all the facts.

SW
SODER-WICK® FINE-BRAID
The State of the Art in Desoldering.

Soder-Wick® Facts # 12: The Fastest-Acting Wick.

Soder-Wick® Fine-Braid exceeds the desoldering rate specified by Mil Standard 883B, Method 2022. This ultra-pure, oxygen-free copper wire is engineered for superior thermal conductivity, which lowers heat transfer and won't cause damage to the board or surrounding components.

Soder-Wick® Fine-Braid is designed for desoldering operations from SMT pads to large wire connectors. Call us at 1-800-SOS-WICK and get all the facts on the Soder-Wick System.

SW
SODER-WICK® FINE-BRAID
The State of the Art in Desoldering.

Soder-Wick® Facts # 7: The Static Dissipative Syst

Soder-Wick's unique Static Dissipative blue bobbin packaging qualifies under DOD Standard 1686 and DOD Handbook 263, and meets the decay rate provision specified in MIL-B-81705B. Solder-Wick Fine-Braid and Ultra-Braid in the SD blue bobbin provide maximum protection for circuit boards and components during ESD-sensitive operations.

Soder-Wick® is engineered for desoldering applications from SMT pads to large wire connectors. Call 1-800-SOS-WICK for all the facts on the Soder-Wick System.

SW
SODER-WICK® FINE-BRAID
The State of the Art in Desoldering.
CIRCLE 54 ON FREE INFORMATION CARD