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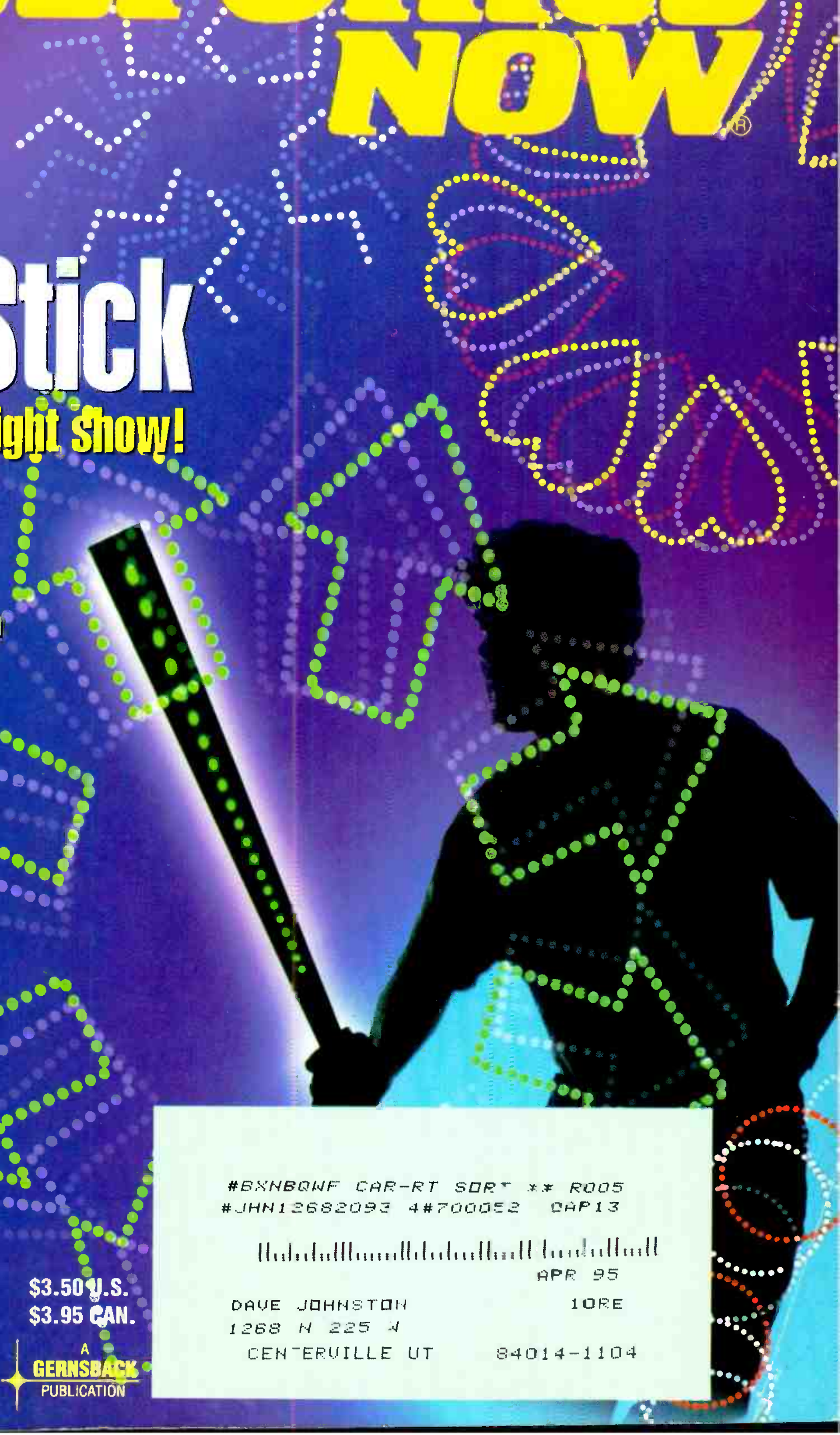

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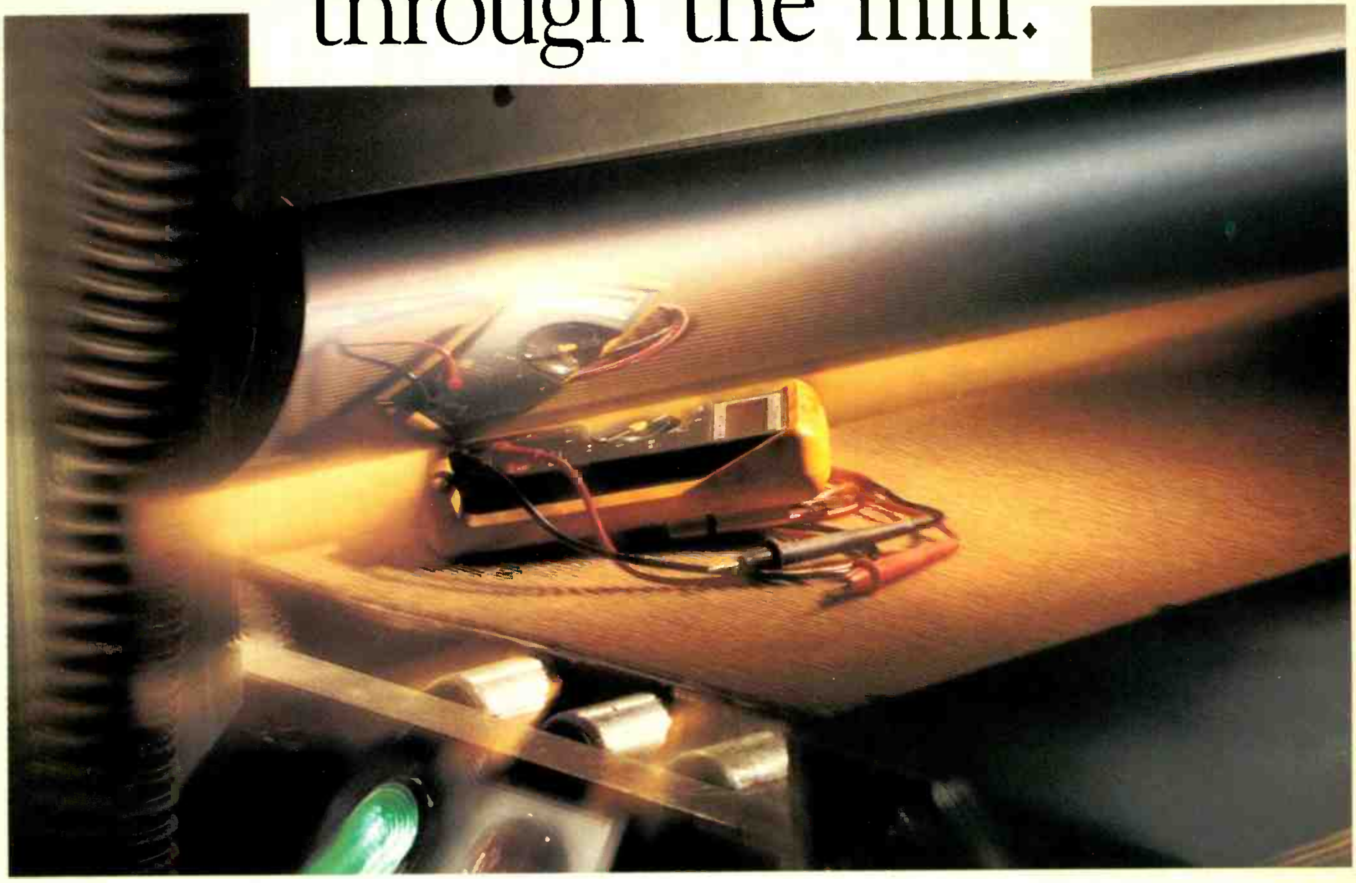

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Vol. 65 No. 10

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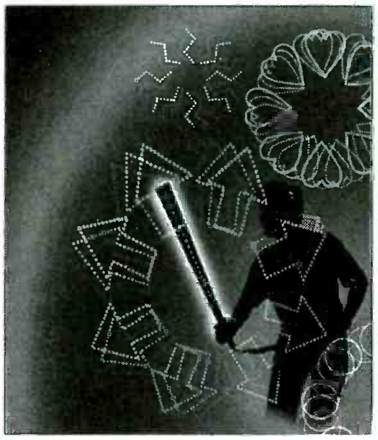
Do you think that only magicians can use magic wands? Think again! The Picture Stick is an electronic "magic wand," an inexpensive, easy-to-build device that can light up the night with computer-generated graphics. It looks like a garden-variety yardstick connected to a small PC board. But add a couple of batteries and the Picture Stick begins to glow. Wave it around over your head, and the flickering green light changes into recognizable images of stars, circles, and diamonds. It might not conjure a rabbit out of a hat, but the Picture Stick will amaze your friends and family and leave them wondering if you have something up your sleeve! — Scott Edwards



BUILD THIS

51 TELEPHONE CALL RESTRICTOR

Block access to those costly "900" and "976" numbers — *or any others — with this telephone device. — Terry Weeder*

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Put military surplus gear to work in this pair — *one passive, one active infrared — of affordable, see-in-the dark,* night-vision scopes.— *Bruno Justic and Peter Phillips*

85 AUTOMATIC RECHARGEABLE FLASHLIGHT

You might want to build two of these handy combination emergency light/flashlights: one for the car, and another to keep at home. — *Marc Spiwak*

ELECTRONICS NOW, (ISSN 1067-9294) October 1994. Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735. Second-Class Postage paid at Farmingdale, NY and additional mailing offices. Canada Post IPM Agreement No. 334103, authorized at Mississauga, Canada. One-year subscription rate U.S.A. and possessions $19.97, Canada $27.79 (includes G.S.T. Canadian Goods and Services Tax, Registration No. R125166280), all other countries $28.97. All subscription orders payable in U.S.A. funds only, via international postal money order or check drawn on a U.S.A. bank. Single copies $3.50. Printed in U.S.A.

POSTMASTER: Please send address changes to ELECTRONICS NOW, Subscription Dept., Box 55115, Boulder, CO 80321-5115.

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Electronics Now is indexed in *Applied Science & Technology Index*, and *Readers Guide to Periodical Literature*, *Academic Abstracts*, and *Magazine Article Summaries*.
Microfilm & Microfiche editions are available. Contact circulation department for details.

Advertising Sales Offices listed on page 94.
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WHAT'S NEWS

A review of the latest happenings in electronics.

High-density disk-drive recording head

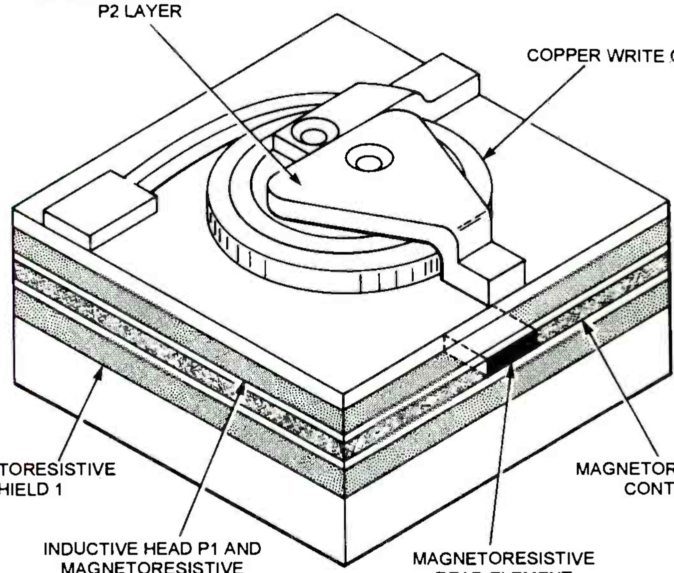
IBM has developed a new, very sensitive sensor for detecting data on computer magnetic hard disks. The company plans to put the new sensor in read/write heads that will be installed in IBM disk drives by 2000. The drives at that time are expected to be able to store information at about 20 times the density possible today—10 billion bits of data per square inch of disk surface.

The new sensor, called a *spin-valve* head, is said to be five times more sensitive than today's best commercially available disk-drive sensors. This is due to their ability to harness the "giant magnetoresistive" (GMR) effect, which was discovered about six years ago.

The new sensor was developed at IBM's San Jose, California, research center. It can read data bits written onto a magnetic hard disk at a density of 1 billion bits (gigabit) per square inch. That density was selected so that the results could be compared with a landmark 1989 demonstration of reading a gigabit per square inch with an earlier magnetostrictive (MR) head.

The spin valve's electrical signal—one thousandth of a volt per micron of track width—is five times greater than that of the best IBM MR sensor installed in drives today. The spin valve's stronger signal offers disk-drive designers the option of packing more bits into a given area of disk surface or relaxing other design restraints to increase overall performance.

For example, a faster data rate can be achieved by spinning the disk faster, and reliability can be enhanced by "flying" the head higher above the disk, making accidental collisions less likely. Most of the data-density increase is expected to come from a six-fold decrease in the disk track width—from 3 to 0.5 micrometers.



IBM's SPIN VALVE MAGNETORESISTIVE HEAD should permit disk drives with storage densities nearly 20 times what is possible today.

A recording head writes data onto a disk and reads that data back. Until recently, all recording heads were based on electrical induction. To write data, electric current sent through a coil induces a magnetic field within the head that is projected through a small gap onto a spinning platter. That leaves a tiny magnetized region on the disk's surface.

To read data, the process is reversed. Magnetic fields on the disk surface, which are picked up by the gap, induce a current in the head's coil. As the size of magnetized regions representing a bit shrank because of increasing storage density, it became more difficult to sense a current strong enough to be read.

IBM introduced the first hard-disk drive equipped with a magnetoresistive (MR) reading sensor in 1991. It was made from several thin layers of an MR material whose electrical resistance changes in a magnetic field. The 300-angstrom thick MR sensor is placed within or near the gap of the write element, and it gives a much stronger signal than an induction sensor when reading data at comparable densities and data rates.

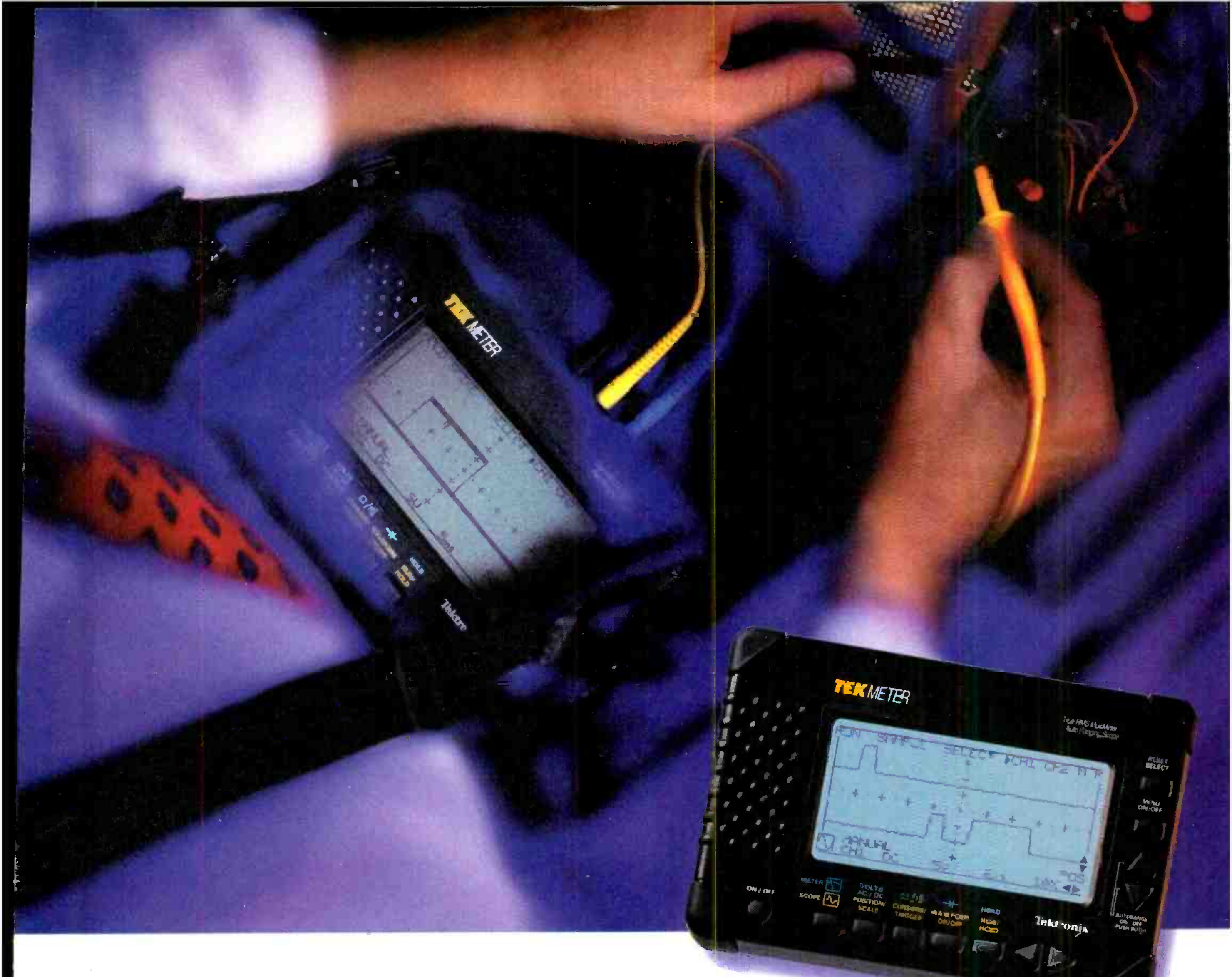
The added feature permitted the inductive coil and gap to be optimized for writing. IBM is reportedly the only company now shipping disk drives in volume with recording heads that include MR sensors.

The giant magnetoresistive (GMR) effect was discovered in France in 1988 in perfect multilayer crystal samples exposed to very high magnetic fields. IBM researchers then demonstrated that the effect could be found in structures of sputtered polycrystalline whose layers are thinner than the MR films (5 to 100 vs. 300 angstroms).

That discovery led to a search for a structure that would exhibit the GMR effect in the weak external magnetic fields of magnetic disks and be useful in a disk-drive recording head.

A multilayer structure was fab-

Continued on page 13



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VIDEO NEWS

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

DAVID LACHENBRUCH

• **Widescreen TV.** Widescreen TV sets with 16:9 aspect ratios (more like movie screens than the conventional 4:3 sets) are available in the United States under a variety of brand names in several direct-view and projection sets, But they haven't been selling too well—probably because of the lack of available programs in 16:9, or letterbox, aspect ratios. In Japan, however, 16:9 has become an immediate success, and it has been forecast that next year more than half of all TV sales there will the widescreen models. That might be because there is greater availability of recorded movies in the wide format or because the Japanese are more accustomed to seeing widescreen TV. Widescreen sets exhibited in public places are designed to display the satellite-delivered Hi-Vision HDTV signal, which has widescreen proportions. Or, possibly, it's just because the Japanese are "early adopters." At any rate, the Japanese trend is being viewed as an encouraging sign for the prospects of widescreen TV here. Another encouraging sign is the increase in letterboxed movies available on both videotape and laser disc.

Widescreen TV sets have some drawbacks. Standard 4:3-dimensioned pictures can't be properly displayed on them without eliminating part of the picture, displaying black spaces on both sides, or showing a distorted picture. However, JVC has developed an interesting way to display standard pictures on widescreen sets with none of those disadvantages. Basing its development on psychological factors—including the finding that the viewer's attention is drawn to the center of the screen—the JVC system leaves the center 70% of the standard picture undistorted on the widescreen. Both sides of the picture are stretched according to a formula that expands the extreme sides more than the area closer to the center of the picture. Amazingly, when viewing the "stretched" 4:3 picture full-width on a 16:9 screen, it's very difficult for the human eye to perceive any distortion.

WIDE-SCREEN TVs with aspect ratios of 16 × 9 will likely become popular in the U.S. Pioneer's PRO-107 is shown here.

Most widescreen pictures available are of the letterboxed variety. When displayed on a standard 4:3 screen, they don't fill the entire picture area—there are black spaces above and below. When shown on a widescreen set, these pictures are stretched vertically to fill the screen. Because they don't really fill the entire height of the transmitted TV frame, their vertical resolution leaves something to be desired. Some TV sets being sold in the U.S. use various line-doubling or "IDTV" (improved definition) circuits to minimize that problem, but those are compromise solutions at best.

In Europe, however, transmissions have begun using a system called "PALPlus," which restores full vertical resolution to letterboxed pictures displayed on a wide screen. When a PALPlus picture is being transmitted, the blank spaces above and below the picture area contain information needed to restore the missing definition to the letterboxed picture. A viewer watching a PALPlus picture on a standard TV will see the usual low-definition letterbox picture. However, a viewer watching on a widescreen PALPlus set sees a full-definition picture. The information transmitted in the "blank" spaces is used to fill in the lines missing from the coarse letterbox picture—increasing the resolution to the full PAL quota of 576 active lines from the 432 normally occupied by a letterbox image.

Although there have been no moves to institute a similar system here, there's no reason why it wouldn't work. Of course, "NTSCPlus" doesn't sound quite as catchy as "PALPlus."

• **Five-minute movie.** The dream of "electronic video rental" is drawing closer, as a company called EMC[3] plans demonstrations of a system to download a two-hour movie in five minutes to home recording equipment. A pioneer in "time compression," EMC[3] says that it will demonstrate its system in January and has agreements with Japanese and Korean VCR manufacturers to work toward a common standard. The company aims to download movies to homes at about a 20:1 compression ratio, so that a full two-hour movie could be sent in a five-minute burst.

The reception device could be a recording optical disc or other system of the future, but EMC[3] is betting that the first applications will be with modified VCRs. To send to home VCRs, the system would transmit, from a satellite or other origination point, a time-compressed movie in digital form. This could be recorded by standard analog VCRs at regular speed in "ones and zeros" form. For playback, the modified recorder plays at 1/20 the normal recording speed to reproduce the movie. EMC[3] says that this can be done with servo-controlled playback modifications and unchanged VHS head-to-tape speed. The transmission would include "substantial error correc-

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Q & A

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

WHAT'S A NULL MODEM?

I need a null modem cable to connect two computers together but I'm not sure how to make one. Can you give me a list of the connections that have to be made?—R. Fenbis, Washington DC.

Probably the oldest joke in the computer business is told simply by using the terms "RS-232" and "standard" in the same sentence. Thanks to the IBM PC, the RS-232 (now EIA-232) standard truly is standard.

Most computers can be connected together via their serial ports with just three wires, as shown in Fig. 1-*a*. That setup will connect the signal and ground lines, but won't take care of any of the timing and flow-control signals. You didn't go into much detail about what you want to do, but that most serial communication is asynchronous so the timing and control signals are not necessary.

If you use a simple three-wire null modem, the software you're using will have to take care of controlling the flow of data and ensuring correct transmission. If that isn't possible, you'll need more than a basic three-wire connection. There are several common null-modem configurations that connect all the active pins, but the one that will work best for you depends on what you plan on to do. The safest and must useful configuration is shown in Fig. 1-*b*. This scheme is only for PC-to-PC connections. To connect a computer to a serial printer or other device, you might have to contact the manufacturer instructions.

Trying to set up a serial link between two devices can turn into a real can of worms. I would strongly suggest that you read a book on RS-232 connections. There are several books available that will give you a description of the signals and pin configurations for connecting specific of equipment.

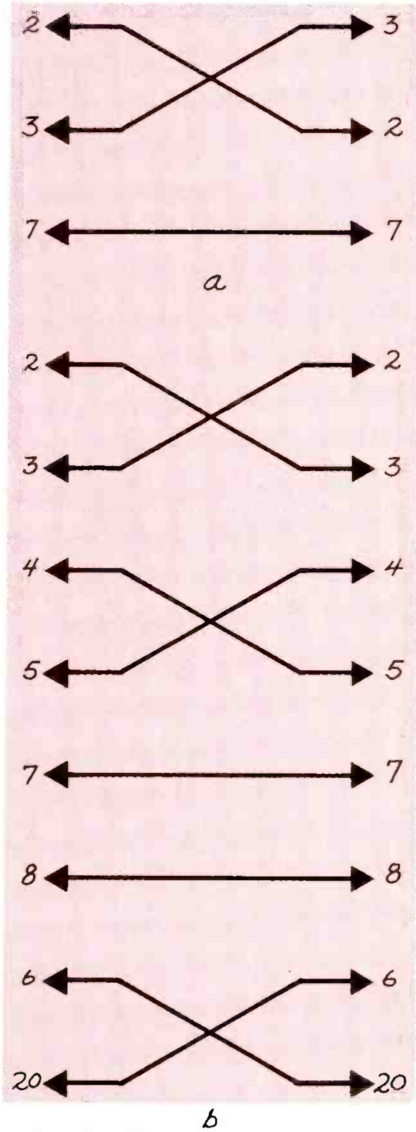


FIG. 1—MOST COMPUTERS can be connected together via the serial ports with just three wires, or a simple null modem (*a*). If the software you're using can't control the flow of data between the two computers, you'll need more than a basic three-wire connection, or a complete null modem (*b*).

SOUND DISTORTION

I'm using a commercial phone-dialing device that connects between the speaker jack of my computer and the phone line through a transformer. The device also has a small built-in speaker built-in because the computer's speaker is disabled when anything is plugged into the jack. I replaced the device's built-in speaker with a larger one because the output wasn't loud enough.

I recently got a new computer and its line output isn't powerful enough to drive both the dialer and the dialer's internal speaker, so I added a minimum-configuration amplifier for the speaker based on an LM386 op-amp. Everything works fine but when the amplifier is first turned on, I get distorted sound for the first quarter second or so and everything works fine after that. Do you have any idea what's causing this distortion and how I can eliminate it?—N. Duncan, Washington, DC

This is one of those problems whose symptoms can be due to many causes. When you're faced with a problem like this, the best approach to solving it is the Sherlock Holmes method—the process of elimination. But before you suspect any circuit design flaws, test the amplifier with a different input devise (a cassette player) and see if the same problem occurs. If the problem is caused by the input signal, then you'll have to figure out what to do about it yourself. Otherwise, if the problem is definitely with the amplifier itself, I have some suggestions.

Because the distortion shows up only for the first quarter second, and it happens only the first time audio is presented to the amplifier, my first response would be to suspect a capacitor. The distortion could also be caused by insufficient supply current, too low a signal level to the amplifier input, or too much DC in the input signal. You haven't mentioned how you're powering the amplifier, but your first test shoul be to power it separately and see how that affects the output audio. The easiest way to do this is with a fresh nine-volt battery. If that solves the problem, add a separate 12-volt supply to the device to power the amplifier.

You might have an adequate signal level at the input of the amplifier, but a DC levelthat is too high. This can be tested by putting a pair of 1-microfarad capacitors on both sides of the amplifier inputs (signal and ground). This capacitively isolates the computer from the amplifier. If this solves the problem you can locate the capacitors in the amplifier housing.

The last thing I would do is try to reduce the size of the capacitor at the amplifier output. You can put in one as low as 100 microfarads and still get significant gain from the amplifier. If the gain is too low, you can raise it by putting a 10-microfarad capacitor and 5-kilohm potentiometer in series between pins 1 and 8 and removing of your input volume control.

ANY DIFFERENCE BETWEEN EMI AND RFI?

Can the terms EMI and RFI be used interchangeably? What is the difference between them?—G. Lyons, Brooklyn, NY

Electromagnetic interference (EMI) is unwanted electrical interference caused by a stray electromagnetic fields radiated from lightning, motors, power lines, and other electrical equipment. Enclosing the circuitry in metallic shielding is one way to prevent circuit problems due to EMI.

Radio-frequency interference (RFI) is EMI in the radio-frequency region of VLF (10–30 kHz) to SHF (3–30 GHz) that interferes with the output of amplifiers, detectors and other sensitive circuits. Its principal causes are radio and TV stations, emergency vehicles, trucks, and aircraft flying overhead. It can also be generated by computers, light-dimmers, and other equipment not designed to be radiators.

High-frequency circuits are most susceptible to RFI because long printed-circuit board traces and leads act like antennas for RFI, so these should be kept as short as possible when building the circuit.

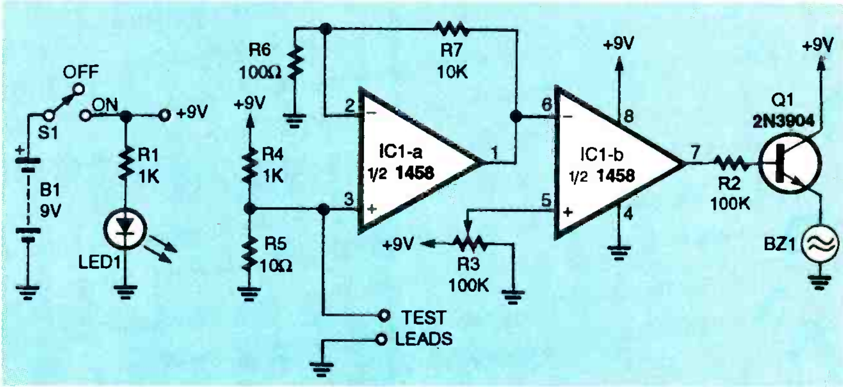
Shielding equipment that generates RFI can be an effective technique to eliminate the interference. Ω

LETTERS

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

MISSING RESISTOR

Any reader who tried to build our adjustable continuity tester (August 1994) should have noticed that R2 shown in the Parts List did not make it into the schematic—unfortunately, we should have noticed it first! The 100K resistor should be inserted between the pin 7 output of IC1-b and the base of Q1, as seen in the corrected schematic shown to the right. Sorry for the inconvenience.—*Editor.*



RELAY POINTERS

I am writing about the very informative article, *All About Relays*, in the June 1994 issue of *Electronics Now*.

A diode across a relay coil will, of course, damp out the large transient when the coil is de-energized. However, a diode can dramatically increase the relays drop-out or release time. In some applications this might not be acceptable. In those instances, a resistor and capacitor in series across the coil can avoid the use of a diode. The resistance and capacitance values depend on the coil characteristics and the coil voltage, and those values can be found in the relay manufacturer's data books.

The article said a lot about the CD4016B CMOS quad bilateral switch. It is a fine device, but there are at least three other CMOS bilateral switch ICs that offer additional functions and lower *on* resistance. My favorites are the CD4051B, CD4052B, and CD4053B, prime sourced by Harris Semiconductor.

Each of these inexpensive analog multiplexers/demultiplexers offers a single-pole, eight-position switch; two four-pole, two-position switches; and three single-pole, double-throw switches in 16-pin plastic DIP packages.

There are some subtle differences between these ICs and the CD4016B, but they are generally insignificant. I have used these ICs for complicated audio-switching systems and for logic-controlled computer I/O switching (parallel and serial ports), with no attendant problems.

EMERSON M. HOYT
Beaverton, OR

DISK-DOUBLING DOUBTS

In "Q&A" (*Electronics Now*, July 1994), P. Murphy asked for advice about the use of "disk-doubling" software. There are a couple of points that should have been made in Q&A's reply.

The disadvantage mentioned, "... that you never know for sure exactly how much room is left on the drive," is very real. An even greater concern might be the prospect of reaching a point where it is impossible to decompress your files because you have no room for them in their original state.

Nevertheless, readers should be cautioned about the greatest hazard attendant to the use of the disk-compression routines: untimely power interruptions that occur while files are open and the "real" directory is in use. Those interruptions can be caused by factors such as power outages, a nearby lightning strike, or turning off the computer while software is still working.

If the power goes off while the disk-compression software is working on files or on the "real" directory, you are at risk of losing access to all compressed files on the drive!

My advice is to follow two rules: First, if you don't have an uninterruptable power supply that provides enough battery backup to allow you to exit your programs and close all the files in the event of a power failure, *don't* use a disk-compression program.

Second, *never* turn off the power to your computer unless a prompt is displayed and the disk activity light is out on the compressed disk. Windows users will be safe if they exit Windows to the DOS prompt and verify that the disk activity light is out.

Quite frankly, with disk space as inexpensive as it is now, I recommend that users spend their money on more disk space and avoid the disk-compression routines.

GEORGE BICKMORE
Ormond Beach, FL

DIGGING INTO DOWSING

In "Hardware Hacker" (*Electronics Now*, August 1994), Don Lancaster asked if "dowsing" is for real. I'd like to address that.

In 1953 I was fresh out of college with a master's degree in electrical engineering. I was assigned by my company, IT&T, to assist in the installation of a line-of-sight microwave system for the Michigan Wisconsin (gas) Pipeline Company.

At station C-10 in Sandwich, Illinois, I ran into a problem. The cable between the microwave shack and

READERS: TELL US WHAT YOU THINK ABOUT THIS ISSUE

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

If you would like to be considered for this special *Electronics Now* project, take a few minutes to answer the questions on this page and return it to us.

While we cannot accept everyone, we will randomly select our participants, giving each one of you an equal chance of being selected.

Please mail the completed questionnaire no later than November 30, 1994, to:

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

Larry Steckler,
Editor-in-Chief

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3. **How old are you:**
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4a. **Highest education achieved?**
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Graduated College ☐
Earned PhD ☐

4b. **Do you**
Hold FCC license ☐
Hold other license, Certif. ☐

5. **What is your total household income?**
Total household income, before taxes is $ ____________

6. **Name the article in this issue that you liked the best.**
____

7. **Name the article in this issue that you liked the least.**
____

8. **Name the department or regular column in this issue that you liked the best.**
____

8a. **Name the department or regular column in this issue that you liked the least.**
____

9. **Do you earn your living working in the electronics industry?**
Yes ☐ No ☐

10. **If you were the editor, would you make the articles:**
More complex ☐
Simpler ☐

Longer ☐
Shorter ☐

More build it ☐
Less build it ☐
More how to ☐
Less how to ☐

11. **What articles would you publish?**
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12. **What new columns would you add?**
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13. **What else would you change?**
Use a separate sheet for your comments. Please give as much detail as possible.

Name ____________
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State, Zip ____________

the compressor station building had a short circuit. I contacted the company electrician, a fellow named Greg Fallenstine, and told him that we would have to dig up the cable and replace it. I then asked him if he had any equipment to locate the cable, and he told me that he just uses "witchin' sticks."

Now, as a city kid from Brooklyn, I was sure that he was pulling my leg. Well, he did use "witchin' sticks"—two welding rods bent at 90° ("L"-shaped). He located the cable, then followed the path of the cable with the sticks. When the cable was dug there were no misses in the trench digging.

I still thought he was pulling my leg, so I asked him if he could teach me to dowse. He said he could. Still doubtful, I bet him a steak dinner at the best place in town that he couldn't teach me. Without hesitation, he said, "You're on!" He *did* teach me, and he taught me well. I lost the bet! I even taught others, including my boss at that time, another skeptical big city guy.

Here are some of the facts, however puzzling they are: First, the sticks will only locate a long conductor, not buried metal.

Second, the rods we used were ferrous (iron content) welding rods with magnetic properties. I have tried copper and aluminum rods and they also work.

I mentioned earlier that the electrician used the sticks to follow the cable. He held the sticks parallel, facing forward. If he crossed the conductor perpendicular to his travel, the sticks spread out to form a 180° angle. In following the conductor, if he was to the left, the right stick would face away; if he was to the right, the left stick would face away.

Do divining rods work for water? I don't know; however, I do know that station personnel have located sewer-drain tile with the sticks (I guess with water acting as the conductor). I suppose that divining rods would work with water running in an underground stream, particularly if the water contains minerals.

Is dowsing real? The answer, in my opinion, is a definite *yes*.

HARRY PLACE
Ridgewood, NJ

WHAT'S NEWS

continued from page 4

ricated in which the angles of magnetization within its layers change as a magnetized bit region passes under it. This causes the resistance of the multilayer structure to change, and triggers a strong bit signal. The result was the spin-valve sensor.

EM fields could threaten women's health

Women who work in electrical jobs are 38 % more likely to die of breast cancer than women in other occupations, according to a study conducted at the University of North Carolina. It also found that the death rate from breast cancer in women who work with or around telephone installations is higher than for those working in electrical power generation and distribution.

The study published in the *Journal of the National Cancer Institute* indicated "epidemiological evidence" of a link between breast cancer and electromagnetic fields, but was unable to trace cause and effect relationships.

The authors of the report caution that the evidence is still not very strong because it was drawn entirely from public records relating gender, occupation and cause of death. The death certificates of 138,831 American women, including 27,814 who died of breast cancer, were studied.

The results are consistent with evidence that high lifetime exposure to estrogen is an important cause of breast cancer. Exposure to low-level electromagnetic fields apparently suppresses the brain's production of the hormone melatonin. Studies have shown that when melatonin falls, estrogen levels rise.

The breast cancer death rate was more than twice as high for women who install and repair telephones or work on telephone lines than those who work in occupations that do not involve electricity. The results were adjusted to rule out income, age, race and marital status.

The risk was found to be 75 % higher for female electrical power-line workers and electricians, 70% higher for female electrical engineers, and 28% higher for female electrical technicians.

Many other occupations such as computer programmers, computer equipment operators, data-entry personnel, and telephone operators also involve sustained exposure to electromagnetic fields, but the study found that the female death rate from breast cancer was no higher for those jobs than for the rest of the work force.

David Loomis, chief author of the study, believes that the difference might be explained by the higher levels of exposure to electromagnetic fields in jobs like telephone repair and equipment installation. He said other factors might explain the differing breast cancer rates. One could be exposure to polychlorinated biphenyls (PCBs), cancer-causing chemicals once commonly used in electrical insulation.

QST now on the newsstands

QST magazine is back on the newsstands. For the past 37 years, the monthly magazine, published by the American Radio Relay League (ARRL), has been available only to members and subscribers.

Each issue includes tutorial articles for beginners and reports on the latest technology for the more experienced hams. It also contains new product reviews and an events calendars.

Al Brodgon, managing editor of *QST*, reports that evidence of increasing popularity of amateur radio prompted the magazine to reverse its policy and return it to the newsstand.

IEEE Founders Medal to Sony chairman

Akio Morita, chairman of Sony Corporation, received the Founder's Medal of the Institute of Electrical and Electronics Engineers (IEEE) at its annual Honors Ceremonies, held on June 19 in Denver, Colorado.

The citation accompanying the medal said it was for Mr. Morita's "distinguished corporate leadership and for a lifetime of innovative contributions in bringing advanced technologies to consumer-electronic products."

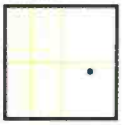
Under his leadership, Sony developed Japan's first magnetic-tape recording system, all-transistor radio, and the world's first all-transistor television receiver. Sony went on to develop two products that were accorded unprecedented commercial success. They were so successful that their names have became part of the language: the Trinitron color television picture tube and the Walkman personal stereo/AM/FM receiver.

Mr. Morita is an honorary member of the IEEE, the world's largest technical professional society, and he holds an honorary doctor's degree in engineering from the University of Illinois. He is a graduate of Osaka Imperial University as a physics major.

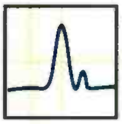
The award was accepted on Mr. Morita's behalf by his wife and one sons because the Sony chairman was recuperating from a stroke that he suffered in November 1993. Ω

Get a sample of reality.

Looking for analog confidence in a digital oscilloscope? Tektronix' TDS 350 sets the standard with Digital Real Time. ■ Its incredible *one gigasample / second sampling* delivers real-life capture like never before — both for single shot or repetitive events. Select peak detect for slow events, or push the scope to its full 200 MHz bandwidth — with no aliasing. ■ And, like the entire TDS 300 family, the TDS 350 sets a new standard in price/performance: under $4,000.



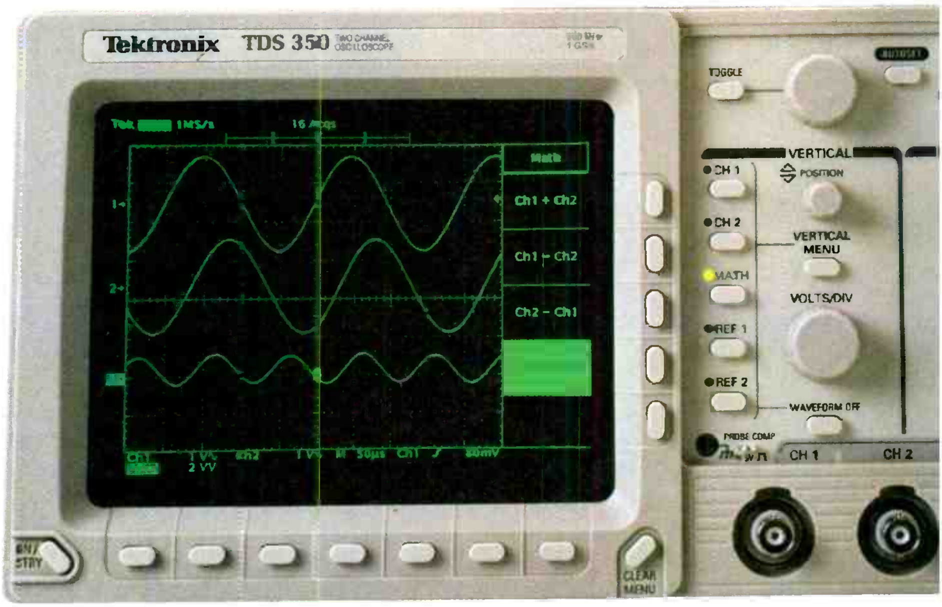
ONE POINT CAPTURED. SINGLE EVENT CAPTURE USING EQUIVALENT TIME SAMPLING. 20 MS/s 100 MHz DSO.



REAL LIFE CAPTURE. SINGLE EVENT CAPTURE USING DIGITAL REAL TIME. 500 MS/s 100 MHz DSO.

Analog look and feel. The TDS 300 family is simple and intuitive; just like your trusty analog scope. Even the digital interface is simplified with on-screen icons. You may never have to crack open the instruction manual!

High-end digital features. Each model features over 20 automatic measurements. Continuous update for hands-free operation. Four acquisition modes and video trigger — perfect for tailoring the display. And a communication option for hardcopy to most printers, or to send/ receive waveforms and setups.



There's a TDS 300 Series scope for every application. And every budget.

FEATURES	TDS 310	TDS 320	TDS 350
Bandwidth	50 MHz	100 MHz	200 MHz
Max Sample Rate	200 MS/s/chan	500 MS/s/chan	1 GS/s/chan
Sweep Speeds	10 ns/div - 5 s/div	5 ns/div - 5 s/div	2.5 ns/div - 5 s/div
Channels	2	2	2
Vertical Sensitivity	2 mV - 10 V	2 mV - 10 V	2 mV - 10 V
Vertical Resolution	8 bits	8 bits	8 bits
Record Length	1K/channel	1K/channel	1K/channel
Standard Advanced Features	TV Line & Field Trigger, Roll Mode, Autoset, 21 Automatic Measurements, Peak Detect		
Comm. I/O (Option 14)	GPIB, RS-232, Centronics and VGA video output		
Price	$2295.	$2995.	$3995.

Get real. For more real-time benefits of the TDS 300 family, call your authorized Tektronix distributor today. Or call Tektronix at (800) 426-2200, ext. 212.

Tektronix

CIRCLE 128 ON FREE INFORMATION CARD

40W-284274

EQUIPMENT REPORTS

Tektronix Tekmeter Portable Oscilloscope

When a DMM isn't enough, and a full-size oscilloscope is too much, you need a combination of both.

CIRCLE 15 ON FREE INFORMATION CARD

The general-purpose digital multimeter is the tool of choice for technicians on the go. It comes in handy for performing almost any troubleshooting task—except when you need to see waveforms. When it's important to see the shape of a waveform, an oscilloscope is required. A technician armed with an oscilloscope can do more than just measure voltages; he can make various timing adjustments, analyze the shape and timing of a waveform to determine the sorce of a problem, and he can often diagnose the problem simply by observing the characteristics of the waveform.

DMMs are popular because of their portability and versatility. By contrast, most oscilloscopes are large, heavy, and they require an AC outlet for power. But when a waveform must be seen, is there any other choice but an oscilloscope?

A new choice when you need to examine waveforms in the field is the *TekMeter* from Tektronix, Inc. (P.O. Box 500, Beaverton, OR 97077, 503-627-7111). The TekMeter combines an autoranging 5-megahertz oscilloscope and an autoranging DMM in one battery-powered package with an LCD screen.

The DMM function built into all TekMeter models is fully autoranging, and it has DC and true RMS ranges from 400 millivolts to 600 volts AC and 850 volts DC. The meter can also measure resistance from 400 ohms to 40 megohms and includes a diode and audible continuity test. The autoranging oscilloscope function automatically finds, scales, and displays signals for hands-free operation. Autoranging can be turned off, if necessary.

The TekMeter measures about 4½ × 6 × 1½-inches, weighs about two pounds, and has a "user feel" that's a lot more like a DMM than an oscilloscope. The unit has a rubber "bumper" on each corner to protect it if it falls. The bumpers also serve as anti-skid feet no matter what position it's in.

Six AA power cells fit in a compartment in the back of the unit. Two screws hold the compartment shut, so there's no danger of the cells accidently spilling out. The Tekmeter will operate for up to four hours on six AA alkaline cells. The rugged plastic case has projections molded on the back and front to provide a comfortable grip when holding the meter in the left hand. The 2½- × 5-inch LCD screen is big enough to display a wide variety of information.

Three TekMeter models are available: the single-channel *THM 550* for $859, the dual-channel *THM 560* for $999, and the backlit dual-channel *THM 565* for $1,259. A set of four probes is supplied with each model.

All TekMeters can also test motors, measure transformer harmonic derating factor (THDF), and monitor power lines. Models THM 560 and THM 565 can also measure power and three-phase voltage. Model THM 565, in addition to its backlight feature, has the ability to store up to eight reference waveforms and setup configurations in memory, twice as many as the other two TekMeter models.

TekMeter operation

Each TekMeter has a row of pushbuttons along its bottom edge. The round button at the far left turns power on and off. The next five rectangular buttons to the right initiate both DMM and oscilloscope functions. DMM functions are labelled in blue, and oscilloscope functions are labelled in yellow. Some of the buttons can toggle between two functions in either mode.

The first dual-function pushbutton toggles the unit between the METER and SCOPE modes. The second pushbutton toggles the meter between VOLTS AC/DC in the DMM mode, and between POSITION and SCALE functions in the Scope mode. Two sets of triangle-shaped cursor-control buttons, one horizontal and one vertical, let you position or scale the waveform, depending on the mode that you have selected.

The third dual-function pushbutton toggles the meter between resistance and continuity test in the DMM mode. In the Scope mode, it acts as a CURSOR/TRIGGER toggle, which lets you either position voltage and timing cursors on the display or set the scope to trigger.

The fourth pushbutton selects the diode test in the DMM mode and acts as a WAVEFORM ON/OFF toggle in the Scope mode. The fifth dual-function pushbutton (HOLD) holds the data on the display in the DMM mode and acts as a RUN/HOLD toggle in the Scope mode to stops and restart the waveform display.

In addition to the digital display in the DMM mode, a bargraph gives

gives an analog indication of a measured value. Because the display is so large, certain data can be displayed at all times in the DMM mode. These include MAX, MIN, and MAX–MIN values; the most recent DATA HOLD value; and the instantaneous variation between the last held value (ΔHOLD). A RESET SELECT button on the right side of the unit resets the displayed data.

A MENU ON/OFF button on the right side of the meter switches the display to a function menu specific to either the DMM or Scope mode. Functions such as turning on the LCD backlight (model THM-565 only), setting a trigger mode, and retreiving a stored waveform can then be scrolled and selected.

A versatile instrument

A full line of accessories is available for the TekMeter, including an inductive current probe, hard and soft carrying cases, and a rechargeable nickel-cadmium battery pack and charger. Both an optional RS-232 adapter that lets the TekMeter send data to a printer or computer, and an AC adapter are included.

The TekMeters are small, rugged and convenient to use. For a technician on the go, or one working in a cramped location, a TekMeter is an ideal test instrument. If it weren't for the TekMeters' steep prices, we're sure that everyone would own one. If you think you could use a TekMeter, contact Tektronix today. Ω

VIDEO NEWS

continued from page 50

tion," almost doubling the quantity of information sent. Transmitted movies could be encoded to permit playing only once.

• **Who makes our TVs?** I'll bet you think the Japanese. Actually, because of the high value of the yen against the dollar, it's no longer practical for the Japanese to sell TVs here that are made in Japan. With the signing of the NAFTA treaty, an increasing number of TVs sold here are made in Mexico. In the first four months of this year, more

SHARP IS RESPONSIBLE for the recent consumer interest in camcorders with buit-in monitors. After the success of its first ViewCam, Sharp now has a full line of camcorders with built-in monitors.

than 70% of TVs imported into the U.S. came from Mexico. For the first time in recent memory, more TVs are being imported than assembled in the U.S.

As sources for color TV, after Mexico—actually, a long way after—comes Malaysia, Thailand, and China, followed by Japan. Although many TVs are made by Japanese companies, they are now being made in countries other than Japan, where labor is cheaper. Even the sets that are sold in Japan by Japanese companies are, by and large, now being built in Japanese-owned plants in other Pacific Rim countries.

• **Monitor camcorders.** The latest fad in camcorders is their combination with video monitors for quick viewing of "rushes," prerecorded cassettes, or even TV (with an optional tuner). It was all started by Sharp, whose ViewCam, incorporating a four-inch LCD monitor, was so successful that the company came out with a whole line of camcorders with three- and four-inch monitors built in. Sharp's success inspired somewhat similar models by Sony, Fuji Photo, JVC, and RCA, and there are now forecasts that as many as half of all camcorders will include the monitor feature in the future. The industry says that it's just the feature needed to push camcorder sales off dead center—and that could be true because the market came out of the doldrums and camcorders set a new record for sales in the first half of 1994. Ω

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

PROGRAMMABLE POWER SUPPLIES. Four new programmable power supplies have been introduced by Tektronix. The PS2510 and PS2511 have a broad range of adjustable power output options with keypad programming for 100 different combinations of voltage, current, and timing for the automation of repetitive tests. The PS2510G and PS2511G have GPIB-based interfaces that support the SCPI format (industry-standard commands for programmable instruments).

CIRCLE 20 ON FREE INFORMATION CARD

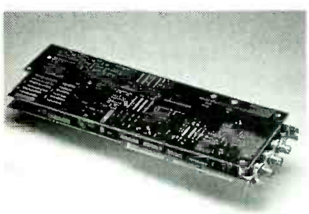
The PS2510 and PS2510G provide adjustable power of 0 to 36 volts DC at up to 3.5 amperes, and the PS2511 and PS2511G provide 0 to 20 volts DC with current to 7 amperes.

The PS2510 (pictured) and PS2511 power supplies are priced at $895. The PS2510G and PS2511G power supplies are priced at $1095.

Tektronix, Inc.
Test and Measurement Group
P. O. Box 1520
Pittsfield, MA 01202
Phone: 1-800-426-2200

COMPUTER-BASED PLUG-IN OSCILLOSCOPES. PC Instrument's PCI-425 and PCI-435 plug-in cards for personal computers are said to offer the features of a 300-MHz oscilloscope. The PCI-425 has a single-channel and the PCI-435 has a dual-channel. Each plug-in card occupies one slot in the case of an IBM PC/AT or compatible personal computer.

The common specifications for both cards are 300-MHz bandwidth, 50-ohm input, 500-picosecond per division minimum timebase setting, and 200-gigasample per second equivalent sampling rate.



CIRCLE 21 ON FREE INFORMATION CARD

Each board also provides seven voltage ranges, AC/DC coupling, and a probe-compensation signal. They also offer 27 timebase settings from 500 picoseconds per division to 200 milliseconds per division, and an automatic trigger algorithm to establish a valid trigger level.

PCI reports that the characteristics of the plug-in cards make them suitable for use in ATE systems for testing communications signals, component pulse responses, and high-speed digital signals.

BenchCom software is included with each oscilloscope card. Optional BenchTop software provides a "point-and-click" graphics user interface (GUI) for storing and recalling waveforms, test setups, and the automation of test routines.

The PCI-425 sells for $1695 and the PCI-435 sells for $2695. BenchTop software is priced at $495.

PC Instruments Inc.
9261 Ravenna Road,
Building B11
Twinsburg, OH 44087
Phone: 216-963-0800

DIGITAL VOLTMETER. The Intelligent DVM from DeltaQuest is a peripheral for use with an IBM PC/AT or compatible computer that permits data acquisition. It is equipped with a Windows-based software program.

The system, which connects to the computer's parallel port, has a stated resolution of 5½ digits. It can be interfaced to low-level signal sources such as thermocouples and pressure and strain gauges. Voltage measurements range from ± 0.1 µvolt to ±200 volts with autoranging on the higher ranges.

An optional eight-input differential multiplexer simplifies the measurement of multiple sources, and each channel can have its own unique rescaling format. Thermocopuple measurement compensation is provided by software look-up tables.

CIRCLE 22 ON FREE INFORMATION CARD

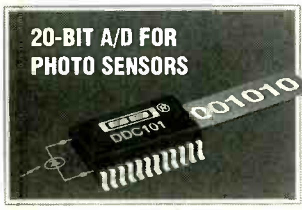
Two digital outputs allow The Intelligent DVM to control peripheral equipment and their measurement processes. Digital voltmeter functions are controlled externally by two digital inputs, an on-screen pushbutton, and the DVM displayed value. Initiation, sampling, and termination are controlled by combinations of time, trigger, count, and displayed value.

All significant parameters can be recorded. The software provided permits the automatic rescaling or conversion of measurements. It can convert volts to decibels, degrees C, PSI or other scale. Graphics can be "cut and pasted" into other Windows programs, or printed.

The Intelligent DVM is available in three models: The Professional Model is priced at $339.95, the Basic Model is priced at $299.95, and the Single-Range Model is priced at $239.95.

DeltaQuest
4960 Almaden Expressway, Suite 238
San Jose, CA 95118
Phone: 408-997-8644
Fax: 408-997-6730

PHOTOSENSOR ANALOG-TO-DIGITAL CONVERTER. Burr-Brown's DDC101 20-bit, current-input analog-to-digital converter offers digital filter noise reduction, (1.6 ppm, RMS), digital error correction (correlated double sampling (CDS) and a conversion rate up to 15 kHz. The monolithic IC contains a digital-to-analog converter, comparator, digital integration tracking and control logic, a digital filter and error correction, and a serial I/O register.



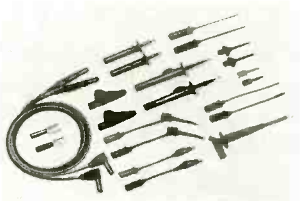
CIRCLE 23 ON FREE INFORMATION CARD

The DDC101 is intended for direct connection to low output sensors such as photosensors, precision instrumentation, infrared pyrometry, precision process control and chemical analysis.

DDC101 A/D converters, packaged in plastic 24-pin SOIC and 28-pin dual in-line (DIP) cases, are priced from $22.95 in thousands quantities.

Burr-Brown Corporation
P. O. Box 11400
Tucson, AZ 85734
Phone: 800-548-6132

MODULAR TEST LEAD KITS. Probe Master is offering its 9100 Series modular test lead kits. Each is available with up to 25 different plug-in accessories. These include sprung, pincer, and wire-piercing hooks, extender probes, alligator clips, and five-way telephone clips.



CIRCLE 24 ON FREE INFORMATION CARD

The leads have flexible strain relief, 440-strand wire, and silicone insulation that is flexible but impervious to burning from soldering tools. Kits are offered with straight, retractable, shrouded banana plugs or right angle , fixed shrouded banana plugs.

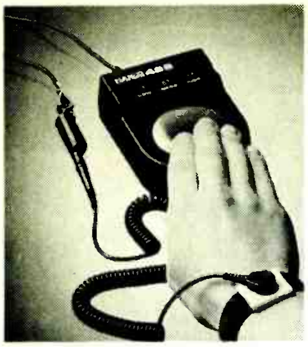
Prices of 9100 Series test lead kits start at $24.90. The Electronic Deluxe Kit(pictured) has a price of $64.90.

Probe Master Inc.
215 Denny Way
El Cajon, CA 92020
Phone: 800-772-1519
Fax: 619-258-7413

ESD GROUNDING SYSTEM TESTER. HMC's Model 489 electrostatc discharge (ESD) tester is intended for checking the integrity of the grounding in ESD-pro-

CIRCLE 191 ON FREE INFORMATION CARD

CIRCLE 122 ON FREE INFORMATION CARD



CIRCLE 25 ON FREE INFORMATION CARD

tective systems. It will check wrist straps and grounding wires, measure the contact resistance between wrist straps and the skin of operators in ESD protected workstations, and the contact resistance between ESD-protective mats and grounding wires.

By verifying the specified resistance between system elements, the Model 489 can prevent both employee exposure to electric shock and the destruction or damage of ESD-sensitive devices or circuits. After connecting the Model 498's grounding wire, the test is performed by pressing a large pad on the instrument.

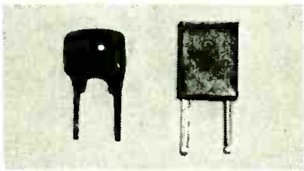
A green *good* lamp lights and an audible signal sounds if the grounding system is safe (resistance between 500 kilohms and 10 megohms). The red *high* lamp lights to indicate a loose electrical contact between the operator's wrist band and skin (resistance greater than 10 megohms). A red *low* lamp lights to indicate a faulty ground cord resistor (resistance less than 500 kilohms).

The Model 489 ESD grounding system tester with an eight-foot grounding wire and a 9-volt battery is priced at $95.

Hub Material Company
33 Springfield Avenue
Canton, MA 02021
Phone: 617-821-1870
Fax: 617-821-4133

CERAMIC RESONATORS WITH CAPACITORS. Integrity Technology's ZTS high-frequency piezoceramic resonators in the frequency range of 2.0 to 12 MHz have built-in capacitors. The capacitors have typical values of 30 picofarads, and they are connected at the center pin for standard TTL circuits. Optional 100-pF capacitors for CMOS circuits are available.

Frequency tolerance is ± 0.3 % at ambient temperature. Operating temperature range is from −20°C to +80°C. Frequency tolerance from



CIRCLE 26 ON FREE INFORMATION CARD

aging is given as ±0.3% per year for 10 years.

The combined components are intended to save PC board space and save the cost of two additional load capacitors to ground. The resonators are made with capacitors at the insulating pads connecting to the three output leads.

Resonator/capacitors are intended for phone tone dial DTMF circuits for telephones, answering machines, fax machines, and modems. The are also intrended for infrared remote controls and battery-powered microcontrollers in pocket transmitters.

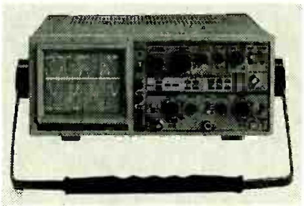
The ceramic resonator/capacitors are priced at $0.17 each in quantities of 10,000.

Integrity Technology Corporation
1400 Coleman Avenue, Suite E15
Santa Clara, CA 95050-4358
Phone: 408-262-8640
Fax: 408-262-1680

60-MHz DIGITAL STORAGE SCOPE. B + K Precision has introduced its Model 2560, a portable, dual-channel digital storage oscilloscope with a 60-MHz bandwidth and 20-megasample per second sampling. It offers cursors, readouts, and an RS-232C port for sending data to a computer.

Cursor measurements include voltage, time interval, frequency, and pre-trigger. Readouts include volts per division, seconds per division, data-acquisition method, and the instrument's display function.

The bandwidth of the Model 2560 covers DC to 60 MHz (−3 dB). Its main timebase is equipped with variable hold off. Sweep speed can be varied from 0.1 microsecond per division to 0.2 seconds per division in 20 steps The delayed timebase is adjustable from 0.1 microsecond per division to 10 microseconds per division in seven steps.



CIRCLE 27 ON FREE INFORMATION CARD

Sweep delay is adjustable from 1 to 10 divisions or more. Up to 10 times sweep magnification is available. Eight trigger modes and X-Y operation is provided. The Model 2560 has a 6-inch CRT with 10 kilovolts accelerating potential.

The Model 2560 digital storage oscilloscope is priced at $2395.

B + K Precision
6470 West Cortland Street
Chicago, IL 60635
Phone: 312-889-1448
Fax: 312-794-9740

30-MHZ DUAL-CHANNEL OSCILLOSCOPE. Hameg Instruments' HM303 30-MHz, dual-channel oscilloscope has vertical amplifiers with sensitivity down to 2 millivolts per division. Overshoot is limited to 1%.

CIRCLE 28 ON FREE INFORMATION CARD

Probe compensation adjustment is achieved with a built-in, dual-frequency, 1-kHz per 1-MHz calibrator which can optimize probe-tip display fidelity. Maximum sweep rate is 10 nanoseconds per division with the ×10 magnifier. The HM303 can trigger on signals greater than 100 MHz and on inputs less than one-half a graticule division on the screen. An active sync-separator allows detailed examination of complex TV signals.

The HM303 includes a built-in component tester, which operates from a stabilized measurement voltage for rapid pushbutton test of active and passive circuit components. A built-in, low-noise switching power supply provides 90 to 260 volt AC.

The HM303 oscilloscope sells for $548.

Hameg Instruments
1939 Plaza Real
Oceanside, CA 92056
Phone: 800-247-1241
Fax: 619-630-6507

RF COUNTER. Hewlett-Packard's single-channel HP 53181A radio frequency counter has a bandwidth of 225 MHz.

An automatic limit-testing feature permits upper and lower boundaries to be set on any measurement. An analog display provides a graphic indication if a measurement is within pre-assigned pass/fail limits. The counter logs and flags out-of-limit conditions and can generate an output signal to trigger external devices when a limit is exceeded.

Built-in statistics and math functions permit the analysis and display of measurement data without the need for transferring the data to a computer. A standard HP-IB port provides full SCPI-compatible programmability.

A data transfer rate of more than 200 fully formatted measurements per second is suitble for computer-controlled systems. A standard RS-232C (talk only) interface supports a printer or data transfer to a computer through a terminal emulation program.

CIRCLE 29 ON FREE INFORMATION CARD

The RF counter provides 10 digits of resolution per second. For applications that demand frequency resolution, a digit-blanking function eliminates unnecessary digits for rapid reading.

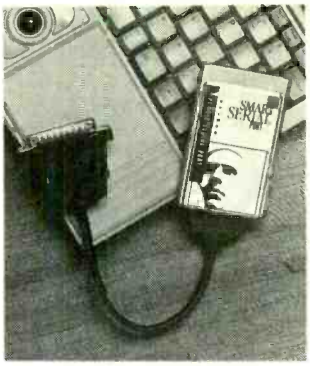
Optional second channels provide high-frequency measurements up to 1.5 GHz and 3 GHz.

The HP 53181A RF counter has a price of $1500. The optional 1.5-GHz two-input channel has a price of $500 and the 3-GHz two-input channel has a price of $800.

Hewlett-Packard Company
Direct Marketing
P. O. Box 58059,
MS51 L SJ
Santa Clara, CA 95051-8059
Phone: 1-800-452-4844, ext. 8327

PCMCIA SERIAL I/O CARD. A serial I/O Card in PCMCIA format from Smart Modular Technologies provides high-speed serial ports for battery-powered notebook computers and personal digital assistants (PDA) and many other systems equipped with Type II slots. It is compatible with all DOS- and Windows-based software.

The card includes a 16550 UART and an 8530 USART permitting either asynchronous or synchronous communication. The asynchronous port can be configured as COM 1, 2, 3, or 4; the synchronous port is fully programmable. The included software eliminates jumpers. A power-down mode extends battery life when the card is not in use.



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The PCMCIA Serial I/O Card sells for $145 when purchased in hundreds.

Smart Modular Technologies
45531 Northport Loop W
Fremont, CA 94538
Phone: 510-623-1231

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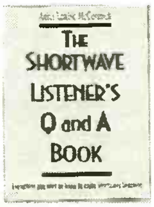
NEW LITERATURE

Use The Free Information Card for fast response.

The Shortwave Listener's Q and A Book: Everything You Need to know to Enjoy Shortwave Listening; by Anita Louise McCormick. Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; $12.95.

Shortwave radio allows listeners to "travel" to different places around the world and listen to foreign languages, music, and news from different perspectives. This book is intended to encourage and help people get started in shortwave listening, now easier and less expensive to do, thanks to the new generations of solid-state, synthesized receivers.



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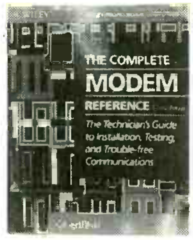
Arranged in a question and answer format, the book answers most of the commonly asked questions about shortwave radio. It provides guidance on the selection of receivers matched to the listener's budget and listening habits. It also lists vendors of those receivers and their locations. Other topics include concepts of international time zones, how and when to receive international broadcasts, amateur signals and special purpose stations of interest.

In Q and A format, the book also explains where to learn about changes in transmission frequencies and broadcast times, how to write reception reports, and how to receive shortwave stations. A discussion of the fundamentals of radio transmission includes the basics of amplitude and frequency modulation and single-sideband transmission. Also discussed are such subjects as antennas and environmental factors that affect signal reception. Appendixes include a directory of shortwave stations and radio listening clubs, and a bibliography of author-selected books on radio.

The Complete Modem Reference: The Technician's Guide to Installation, Testing, and Trouble-free Communications; Second Edition; by Gilbert Held. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012; Phone: 1-800-CALL-WILEY; $34.95.

This second edition to the modem reference book is a practical guide to the purchase, test, installation and troubleshooting of modems. It contains useful tables, checklists, and summaries that reflect technical advancements since the publication of the first edition.

New material includes a discussion of the V.32bis standard and V.FAST modulation and modem settings. Other new topics include fax-modem standards and their relation to computer software, pocket modems, PCMCIA inter-



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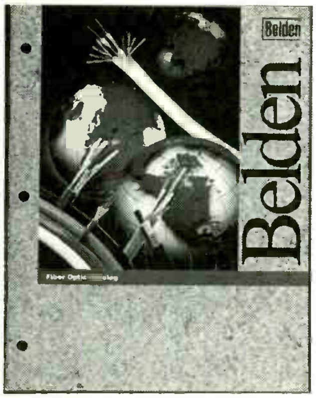
faces, and modems suitable for networks.

The book discusses all popular modulation standards and the factors that govern modem compatibility. It presents methods for communicating with information utilities, and covers E-mail, bulletin boards, mainframe computers, and other information sources. A checklist of 25 statements will remind readers of the most important considerations when shopping for a modem.

Fiber Optic Catalog. Belden Wire & Cable Company, P. O. Box 1980, Richmond, IN 47375; Phone: 1-800-BELDEN-4; free.

This 60-page, illustrated catalog describes Belden's extensive line of fiber-optic



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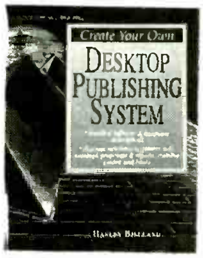
cables, and includes comprehensive application and technical information. A fold-out, color-coded selection guide identifies the different applications for Belden fiber-optic cable.

The product section contains detailed information and drawings of the company's line of fiber-optic cables. A 30-page technical information section contains color code, metric conversion, and buffer tube configuration charts. A basic guide gives information on fiber optics, fiber-optic system design, installation, connectors, and a glossary. A cable-substitution chart and a standards reference guide are also included.

Create Your Own Desktop Publishing System; by Harley Bjelland. Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; Fax: 717-794-2103; $24.95.

This book on desktop publishing is intended to help readers find the right components needed to assemble cost-effective, custom desktop-publishing systems. It is written at a level that is suitable for everyone from entry-level amateur publishers to professional publication designersand producers.

Bjelland's book includes step-by-step instructions for integrating three levels of desktop publishing performance. All are based on high-level word processing programs, entry-level desktop publishing software, and such application programs as Pagemaker and



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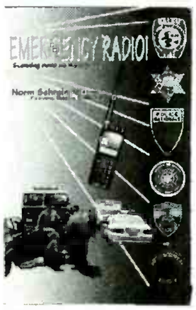
QuarkXPress, and Ventura Publisher.

Chapters discuss how to buy and install equipment such as additional random-access memory, graphics cards, printers, monitors, scanners, CD-ROM drives, disk drives, modems, and fax machines. A lists of mail-order hardware and software vendors is included, and checklists offer guidance in evaluating specific equipment needs.

Emergency Radio! Scanning News as it Happens; by Norm Schrein. Index Publishing Group, 3368 Governor Drive, Suite 273F, San Diego, CA 92122; Phone: 800-546-6707; $14.95 plus $3 shipping and handling.

This book is filled with practical information on how to monitor the transmissions from emergency



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services: police, fire departments, emergency medical services, and the Coast Guard, to mention but a few. It explains how the amateur radio operator and ordinary citizens can listen to emergency transmissions to stay informed on events as they happen.

The author's background gives him a unique perspective on the events behind emergency radio transmissions. He has been a police officer, a fireman, and an emergency medical services technician. Known as "Mr. Scanner," he is the president of the Bearcat Radio Club. He is able to give the reader important insights into the meanings of codes and terse messages that are heard during natural and manmade disasters.

Pressure Sensor Device Data Book. Motorola Inc., Literature Distribution Center, P. O. Box 20924; Phoenix, AZ 85063; Phone: 800-441-2447; Fax: 602-994-6430; free.

This first revision of a pressure sensor data book from Motorola includes new product information and extensive background

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technical information on the company's latest IC sensors that are microprocessor compatible.

Data sheets give the specifications of individual sensors, and application notes describe compatible interface circuitry. Other sections give reliability data, package outline drawings, information on sensor evaluation boards, and guidance on handling and mounting the devices.

Illustrated UNIX System V: Complete Command Reference with Tutorial; by Robert Felps. Wordware Publishing, Inc., 1506 Capital Avenue, Plano, TX 75074; Phone: 214-423-0090; $24.95.

This reference book is a complete guide to the Unix system V operating system based on the AT&T Unix System V, Release 4 and Berkeley Software Distribution (BSD) 4.3. It is intended as a tutorial for those at all levels of experience in computing. One objective is to take the mystery out of the cryptic Unix command set.

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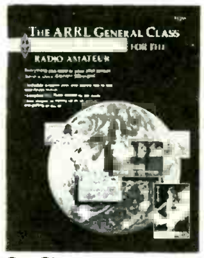
Felp's book discusses over 160 of the more popular Unix user commands. It also provides an overview of the Unix system and DOS-to-Unix and VMS-to-Unix command cross references. It is organized into sections which describes the command and its applications and explain typical usage.

The ARRL General Class License Manual for the Radio Amateur; edited by Larry D. Wolfgang, WR1B. The American Radio Relay League, 225 Main Street, Newington, CT 06111; Phone: 203-666-1541; Fax: 203-665-7531; $12.

This manual offers clear explanations of the theory that is needed to pass the examination for the General Class License for the radio amateur. This latest



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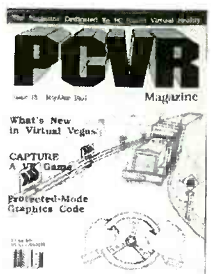
edition has been improved and expanded to make exam preparation easier and more enjoyable.

This edition contains the revised question pool, which was released by the Question Pool Committee for use beginning July 1, 1994. The answer key is printed next to the questions for easy reference. All the FCC rules needed with clear explanations of them are included. A new chapter, entitled "Setting Up Your HF Station," will help the reader get on the air once he or she has obtained the license.

PCVR Magazine. P. O. Box 475, Stoughton, WI 53589; Phone/Fax: 608-877-0909; $4.50/issue, or $26 for 1-year (6-issue) subscription.

The niche taken by PCVR (for personal computer-based, virtual reality) Magazine is showing nonprofessional computer enthusiasts how to experience virtual reality—at realistic prices—on their home computers. Each issue covers one theme, and provides beginner, intermediate, and expert articles on



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that subject. Columns and tutorials give background information for understanding virtual reality concepts.

The May/June 1994 issue covers virtual reality in amusement centers. It includes an overview article, a list of manufacturers of the equipment, and a construction article explaining how to build a virtual reality arcade system. Technical details of a system in a large casino/hotel are included.

Black Box Catalog: The Source for Connectivity. Black Box Corporation, P. O. Box 12800, Pittsburgh, PA 15241; Phone: 412-746-4400; Fax: 800-321-0746; $5.

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This is 200+-page, full-color catalog of the product line offered by Black Box Corp. The line includes connectors for networking and data communications as well as video/multimedia and CD-ROM systems. The company offers products for remote and local data transmission, LAN/WAN, Macintosh, and mobile/wireless.

The catalog includes references to test equipment, power-protection devices, switches, and printer devices. New products introduced include multiplexers, terminal servers, image and data scanners, and short-haul modems. Black Box says it is the only mail-order supplier of LAN, WAN, and data-communications equipment to earn ISO-9001 certification.

Operational Amplifier User's Handbook (order number BP335); by R. A. Penfold. Electronics Technology Today Inc., P.O. Box 240, Massapequa Park, NY 11762-0240; $5.50 plus $2.50 shipping and handling.

This book examines operational amplifiers and circuits based on them including integrators, precision rectifiers, function generators, and amplifiers. It discusses techniques for optimizing the performance of the latest integrated-circuit versions of these circuits.

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Penfold describes many practical circuits that are based on operational amplifier ICs. He has included schematics for build-it yourself projects including a low-noise tape preamplifier, a low-noise RIAA preamplifier, and an audio power amplifier. Other projects include a DC power controller, an optoisolator audio link, a temperature monitor, and a low-distortion audio-signal generator.

U.S. Repeater MapBook, 1994–95 Edition; by Bob Martin, N7JXN. Artsci, Inc., P. O. Box 1848, Burbank, CA 91507; Phone: 818-843-4080; Fax: 818-846-2298; $9.95.

This book will be the valued traveling companion for radio amateurs who like to travel with their gear. It will permit them to find friendly responses to their signals wherever they travel in North America (all 50 states and Canada) Mexico, Central America and the Caribbean. The maps will help them find their way.

This fourth edition has been updated and improved as a result of comments received from ama-

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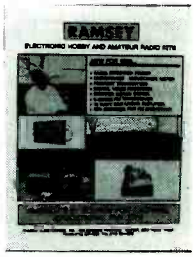
teur operators and frequency coordinators on the earlier editions. It now includes two full page maps for each state, showing repeater locations, offsets, and PL tones. The repeaters listed include 10 meter, 2-meter, 220 MHz, 440 MHz, 900 MHz, and 1.2 GHz. Major roads and cities are shown.

Electronic Hobby and Amateur Radio Kits; from Ramsey Electronics, Inc., 793 Canning Parkway, Victor, NY 14564; Phone: 716-924-4560; Fax: 716-924-4555; free.

This 1993 20-page catalog from Ramsey Electronics lists the company's hobby and amateur radio kits. Among those listed are kits for building a digital voice recorder, a capacitance-inductance meter, an SCA music adapter, a stepper-motor driver,and a fox-hunt transmitter.

Highlighted in the catalog is the DF-1 radio direction finder. Its digital filters and synchronous detection circuitry make it easy to zero in on unknown transmitters. Each kit includes an instruction manual that is both educational and provocative. It is intended to encourage experimentation with the kits after they have been assembled.



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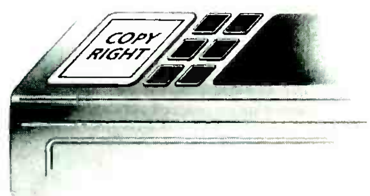
Integrated Circuits Data Books. Burr-Brown Corporation, P. O. Box 11400, Tucson, AZ 85734; Phone: 1-800-548-6132; free.

These two data books on linear and data conversion products from Burr-Brown are worth taking a look at. The books include complete product descriptions, applications notes, performance graphs, specifications, and product ordering information.

The 1100-page linear-products book includes more than 30 new products including operational and instrumentation amplifiers, isolators, reference circuits, voltage regulators, and a product demonstration boards.


CIRCLE 350 ON FREE INFORMATION CARD

The 950-page data-conversion product book includes more than 25 new products including analog-to-digital and digital-to-analog converters, data-acquisition components, sample-and-hold hold amplifiers, voltage-to frequency converters, multiplexers, and demonstration boards for many of these products. ʊ



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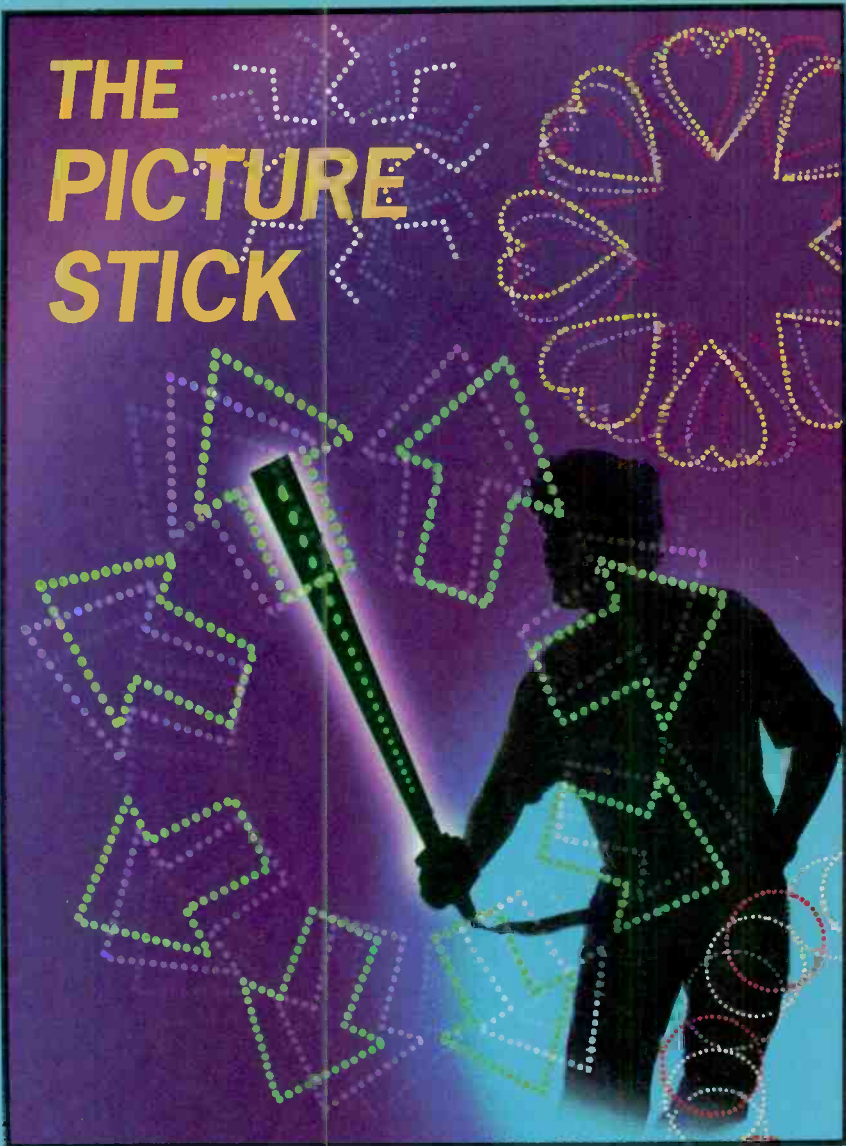
SCOTT EDWARDS



ON A MILD SUMMER EVENING, YOU walk to the top of a small rise overlooking the park. In your left hand you carry a small circuit board and a battery pack and in your right hand you carry a wooden yardstick studded with LEDs. The two parts are connected by a short length of cable.

You connect the batteries to the circuit and the yardstick begins to glow with a flickering green light. People in the park below notice you now, and turn to watch. You wave the stick over your head and the flickering magically changes into images: stars, circles, diamonds. You watch the faces of the people below register amazement, delight, and curiosity. They come closer, smile and ask the question "How did you do that?"

You did it by building the Picture Stick, a project whose parts cost $35. It combines ICs and 16 LEDs, a yardstick, batteries, wire, and duct tape into a unique demonstrator of the visual principles underlying movies, television, and computer displays. Components preprogrammed with 15 images are available, but if you're creative, you can program your own images with a personal computer and free software.

Build the Picture Stick and light up the night with computer-generated graphics.

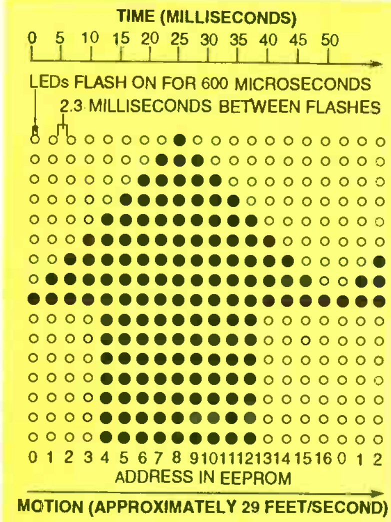
How it works

The Picture Stick consists of two major components: the control electronics and the "wand." The wand is just a wooden yardstick with 16 green LEDs spaced at 1-inch intervals near one end. The LEDs are wired to a ribbon cable that connects them to the controller. The controller turns on the LEDs at 2.3-millisecond intervals, in accordance with one of a series of patterns stored in memory. It leaves the LED pattern on for 600 microseconds, turns the LEDs off, waits another 2.3 milliseconds, loads the next pattern, and repeats the process.

As Fig. 1 shows, the individual LED patterns are pieces of a larger picture. Since the human eye briefly retains the images it sees because of an effect known as persistence of vision, the viewer's eye assembles the sequence of LED patterns into a composite image. Persistence of vision makes it possible for us to see movies and television as seamless, lifelike moving pictures. It also lets electronic circuit designers use fewer components to drive an LED display—only one digit of the display is on at any given instant, but the digits are scanned so rapidly that the eye sees them as a single, stable image. The Picture Stick takes that one step further, eliminating the additional displays in favor of a single moving column of LEDs.

Hardware

The controller, shown schematically in Fig. 2, has two



EEPROM PATTERN MEMORY

ADDRESS	DATA (16-BIT WORDS)
0	0000000010000000
1	0000000110000000
2	0000001110000000
3	0000011110000000
4	0000111111111111
5	0001111111111111
6	0011111111111111
7	0111111111111111
8	1111111111111111
9	0111111111111111
10	0011111111111111
11	0001111111111111
12	0000111111111111
13	0000011110000000
14	0000001110000000
15	0000000110000000
16	0000000010000000

FIG. 1—INDIVIDUAL LED PATTERNS are pieces of a larger picture.

modes: display and download. Assume that there is a series of images stored in IC1 as the display function is described here.

The PIC16C55 microcontroller (IC2) is a self-contained computer with onboard read-only memory (ROM) for permanent program storage and random-access memory (RAM) for storing temporary variables. The chip also includes logic for addition, subtraction, and decision operations. Program control operators allow the programmer to create and call subroutines, or change the order of program execution. The microcontroller in the wand controller has ROM for 512 instruction steps, 24 bytes of general-purpose RAM, and 20 input/output pins.

The wand program is written in assembly language, and is available from the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) as part of the file WAND.ZIP. A programmer for PIC16C5X devices was described in the January 1994 issue of *Electronics Now*. Commercial programmers are also available.

The PIC has three sets of input/output pins: ports RA, RB, and RC. Through RA, the PIC retrieves pattern data from storage in EEPROM IC1 in 16-bit words. The PIC writes these patterns to ports RB and RC. Each of those output ports is connected to a ULN2803 Darlington inverter/driver (IC3 and IC4).

When a pin of port RB or RC outputs a logic 1 (+5 volts) to the connected driver, the driver grounds the cathode (negative end) of the corresponding LED. Since all of the LED anodes are wired to the positive supply, this lights the LED. Resistors R6 through R21 limit the maximum current through the LEDs to about 64 milliamperes. The LED current is calculated by the supply voltage, minus the LED's forward voltage drop, plus the driver's voltage drop, divided by the series resistance calculated as: (6 − (2 + 1))/47 = 63.8 milliamperes.

The PIC lights the LEDs

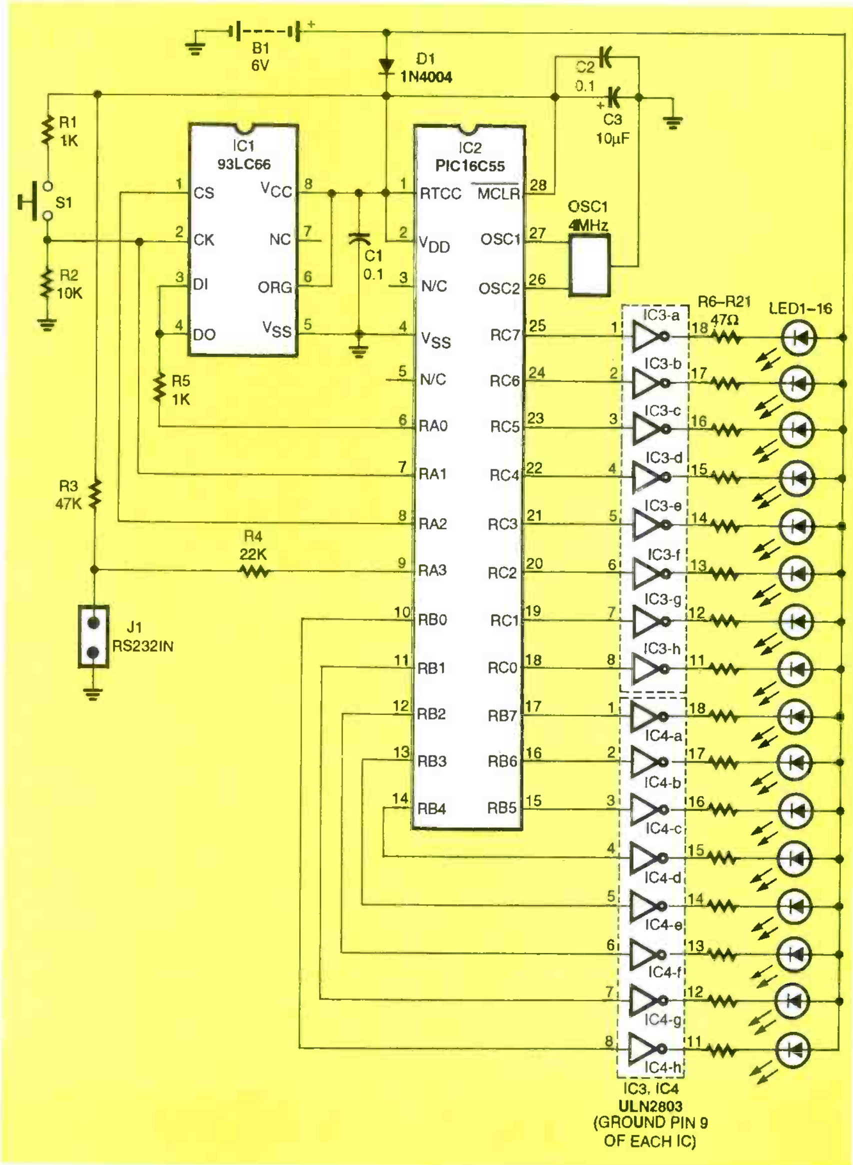


FIG. 2—THE CONTROLLER HAS TWO MODES: display and download.

based on the 16 bits of data it retrieves from IC1, then turns all LEDs off 600 microseconds later. It then waits 2.3 milliseconds, loads another 16 bits, and flashes the LEDs again. It repeats this process—cycling through 17 addresses of 16 bits each—to create the basic 16-row by 17-column image.

Periodically the PIC checks pin RA1, which is connected to pushbutton switch S1. When S1 is open, RA1 sees a logic 0 because resistor R2 pulls it to ground. When S1 is closed, RA1 sees the voltage divider formed by R1 and R2. Assuming that the positive supply is 5 volts, the voltage drop across R1 becomes $5(R1/(R1+R2))$ = $5(1000/11{,}000)$ = 0.45 volts. Therefore, RA1 sees 4.55 volts (5 volts minus 0.45 volts, which is a logic 1).

When the program detects this high (the logic 1), it adds an offset of 17 to the addresses it is cycling through. This causes it to retrieve the next image that is stored in IC1 and display it.

The microcontroller can hold up to 256 16-bit words, but the patterns occupy only 15 pictures × 17 words/picture = 255 words of memory. The leftover memory location isn't wasted; it holds a value that controls the highest frame number to display. Therefore, if you have programmed only 5 of the maximum 15 pictures, you can avoid cycling through the blanks.

In the preceeding description, the role of IC1, the serial electrically erasable/programmable ROM (EEPROM) was neglected. As in normal ROMs and erasable/programmable ROMs (EPROMs), EEPROMs retain their data when unpowered. Unlike ROMs and EPROMs, EEPROMs can be written to or erased while in an operating circuit. Therefore, the PIC can update the data in the EEPROM.

When power is first applied to the wand, the PIC determines whether the wand should switch to its standard operating mode or its download mode. If the serial port is not connected to a PC, the PIC sees a logic 1 on pin RA3, which is connected to the positive power rail through resistors R3 and R4. However, when the serial port is connected, its resting voltage of −10 volts is impressed on the junction of R3 and R4. Pin RA3 sees that voltage as a logic 0. So, upon startup, the PIC executes

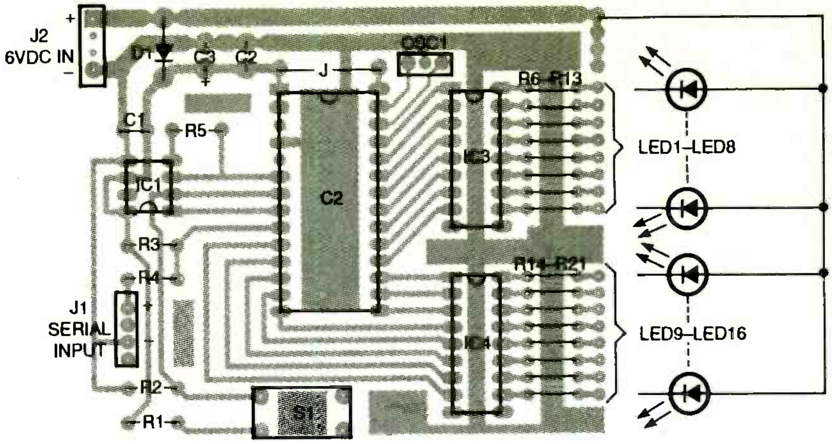
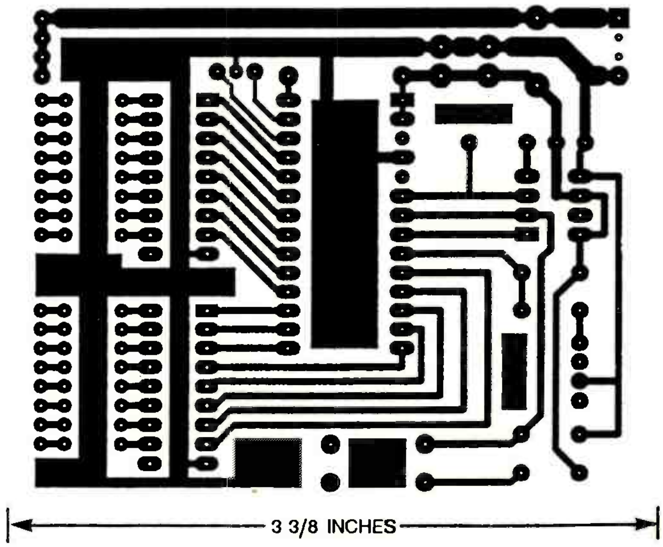


FIG. 3—PARTS-PLACEMENT DIAGRAM. Install sockets for IC1 and IC2, but don't insert the ICs into the sockets until tests are complete.



FOIL PATTERN for the Picture Stick.

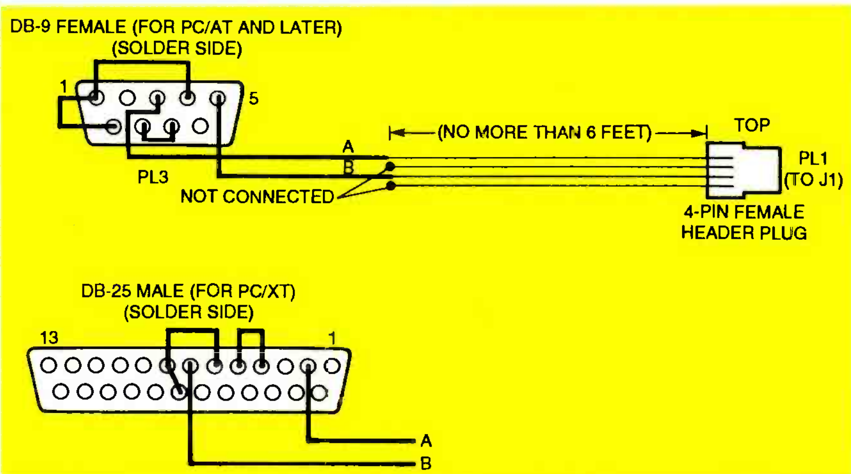


FIG. 4—SERIAL DOWNLOADING CABLE. Install a DB-25 male connector on one end of this assembly and a 4-pin female header plug on the other end.

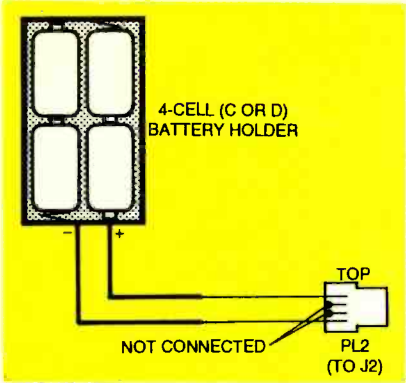


FIG. 5—BATTERY HOLDER WIRING. DC power is connected to the PC board at J2.

the display program if RA3 is 1, and the download program if RA3 is 0.

Once in the download mode, the PIC handles two types of serial communication: synchronous and asynchronous. Communication with the EEPROM takes place over a synchronous or "clocked" serial connection, while the PC serial port is an asynchronous or "unclocked" connection. The basic difference between the two is that synchronous communication requires at least two signals, data and clock, while asynchronous communication requires only a data signal.

Synchronous connections operate on a simple principle: A data bit is valid only at an instant in time defined by some feature of the clock signal. The rest of the time, the receiver can ignore the data signal. In the case of the EEPROM, the data line is valid only on the rising edge of the clock signal; that is, when the clock line is changing from a logic 0 to a 1. (The EEPROM also has a chip select (CS) line. When this line is 0, the EEPROM effectively disconnects itself from the circuit. (This is a standard feature of devices that are intended to share a bus, not a part of synchronous communication.)

Synchronous communication has three virtues: First, it can be implemented with simple edge-triggered flip-flops. Second, it is independent of time. Bits can arrive at intervals of a microsecond or a week; only the state of the clock line determines when a bit is valid. Third,

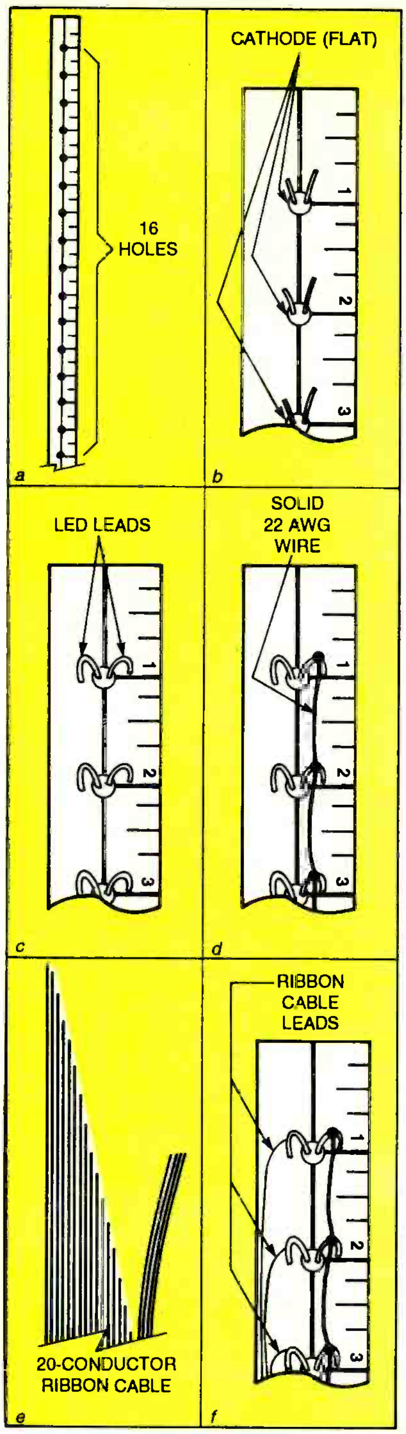


FIG. 6— HOW TO MAKE THE WAND. Drill 16 holes for the LEDs down the center of a wooden yardstick starting at the 1-inch mark (see text).

it does not require the additional start and stop bits associated with asynchronous communication (described below).

The primary disadvantage of synchronous communication is the need for a clock signal. In many cases, such as in this EEPROM, it just means one extra connection on the circuit board. But imagine a synchronous version of the standard telephone modem. It would require two phone lines, one for data and one for the clock signal.

Asynchronous connections work on a more complex principle: After receiving a start bit, the receiver expects a fixed number of data bits at fixed intervals of time, followed by a stop bit that is opposite in polarity to the start bit. The use of start and stop bits makes an asynchronous link less prone to timing errors. Look at it this way: at 1200 bits per second, a bit occupies an 833-microsecond slice of time. With start and stop bits, the sender and receiver can have a combined error of ± 416 microseconds (half a bit) over the time required for 10 bits (8.33 milliseconds). That's a total permissible timing error of 5%; 2.5% for the

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1, R5—1000 ohms
R2—10,000 ohms
R3—47,000 ohms
R4—22,000 ohms
R6–R21—47 ohms (alternately, you can use two 16-pin, 47-ohm DIP resistor networks)

Capacitors

C1, C2—0.1 µF, 50 volts, ceramic disk or monolithic
C3—10 µF, 16 volts, electrolytic

Semiconductors

IC1—93LC66 512-byte serial EEPROM (Microchip—do not use the same part from a different manufacturer)
IC2—PIC16C55 microcontroller, programmed with wand firmware (Microchip)
IC3, IC4—ULN2803A Darlington inverter/driver
OSC1—PX400 4-MHz ceramic resonator with integral capacitors (Panasonic)
D1—1N4004 diode
LED1–LED16—T 1¾ LEDs (the color choice is yours)

Other components

S1—Momentary-contact pushbutton switch (Digi-Key P8034S mounts directly to circuit board)
J1, J2—4-pin single-row male header

sender and 2.5% for the receiver. An alarm clock with that accuracy could be off by almost an hour a day!

Without start and stop bits, timing would become increasingly critical with increases in message length. Ultimately, even the most precise timing devices known would be unable to maintain synchronization.

Now that you know how these two forms of communication work, understanding the download process is easy. The PIC is programmed to receive data at 1200 bits per second (bps). At startup, if the PIC detects a serial port connection, it waits for a start bit. When one arrives, the PIC waits 1½ bit times (1.5(1/1200) = 1.25 milliseconds) to receive the first data bit. By waiting until the middle of the first data bit, it gains a little extra safeguard against timing errors. After the first bit, it receives the remaining seven data bits at 1-bit-time intervals (833 microseconds).

During the stop bit that follows each byte, the PIC stores the received data in its own RAM. Every second byte, it synchronously writes a 16-bit word consisting of the last two received bytes to the EEPROM. Because the synchronous connection with the EEPROM is very fast, the PIC can send all 16 bits (plus 3 bits of instruction code and an 8-bit address) in less than the time required for the stop bit. As a visual check of the progress of a download, the PIC also writes the 16 bits of data to ports RB and RC, causing the LEDs to flash in the patterns of the incoming data.

When the PIC has received 512 bytes of data from the PC and stored them as 256 16-bit words in the EEPROM, it stops "listening" to the serial port and switches to the display mode.

The operation of the major components of the wand have been explained, but what about the "bit players?" Diode D1 has a small but important role: its forward voltage drop of approximately 0.7 volts reduces the 6 volts from the battery pack to around 5.3 volts to supply the PIC and EEPROM. Since these devices will operate from voltages ranging from 4.5 to 5.5 volts, a well-regulated supply isn't required.

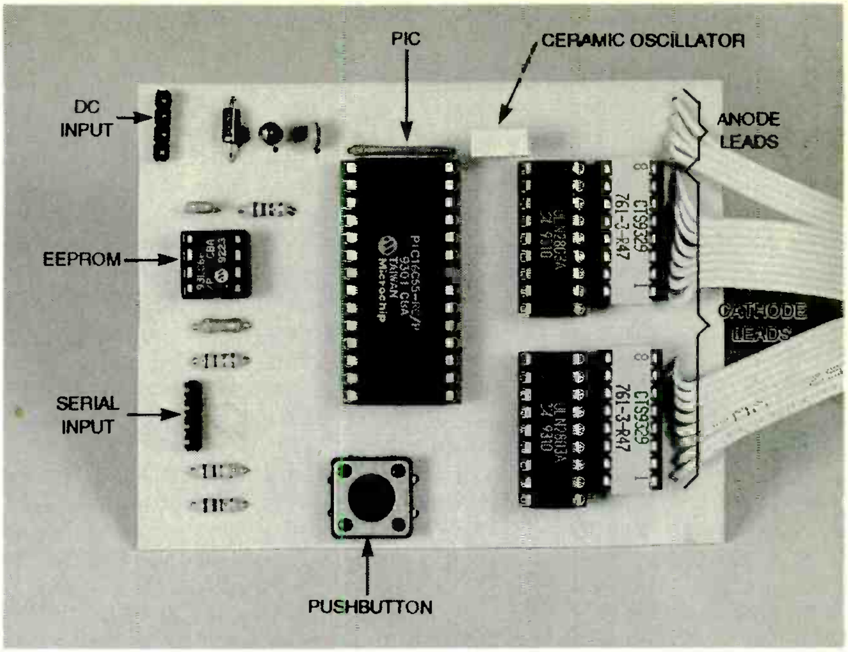


FIG. 7—COMPLETED PC BOARD. The board can be installed in a case of left as-is.

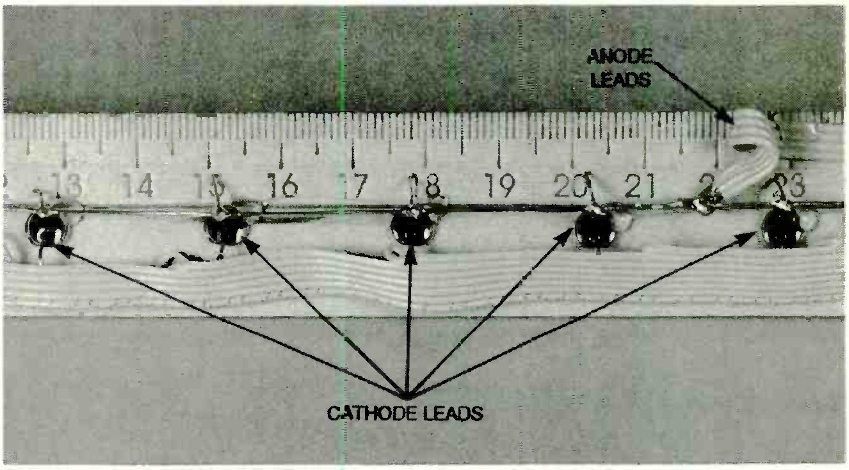


FIG. 8—A WOODEN YARDSTICK forms the body of the wand.

PL1, PL2—4-contact IDC female header plug
PL3—Female DB-9 connector (PC/ATs and later) or male DB-25 (PC-XTs)
Miscellaneous: Battery holder (4 C- or D-cells), PC board, one 8-pin IC socket, one 28-pin IC socket, 9 feet of 20-conductor ribbon cable, solder, hookup wire, inexpensive wooden yardstick, duct tape.
Note: The following items are available from Scott Edwards, 964 Cactus Wren Lane, Sierra Vista, AZ 85635:
- **Pre-programmed PIC16C55 microcontroller (IC2) and ceramic oscillator (OSC1)—$20**
- **93LC66 EEPROM with preloaded images (IC1)—$7**
- **3½-inch PC compatible disk with the downloading software (5¼-inch disks not available)—$7**
- **A kit consisting of IC1–IC4, OSC1, the disk, and a PC board—$42**

All prices are postpaid; check or money order only.
- **Tools for programming PIC microcontrollers are available from Parallax Inc, 3805 Atherton Road, Rocklin, CA, 916-624-8333.**

The rapid switching of the LEDs and the lack of voltage regulation subject the ICs to noise on the power-supply rails. Capacitors C1, C2, and C3 filter this noise.

Finally, OSC1, a ceramic resonator, sets IC2's internal clock to 4 MHz. Since IC2 executes an instruction every fourth clock cycle, in this circuit it executes 1 million instructions per second. Ceramic resonators are similar to crystal resonators, but they are generally cheaper, less fragile, and less accurate. The unit specified here is accurate to better than 1%, which is good enough to receive 1200-bps serial data reliably.

Construction

Begin by obtaining the components in the Parts List. Be sure that IC1 is a 93LC66 manufactured by Microchip Inc. There are subtle differences in other manufacturers' parts with the same part number that make them unusable in this circuit. If you have the necessary programming hardware, you can program the PIC yourself. The program source code (written in Parallax format) is available from the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) as part of the file WAND.ZIP. The downloading programs, as .EXE files and in QBASIC format, are also part of the ZIP file.

You can substitute practically any standard, inexpensive LEDs for the green ones used in the prototype. Since LEDs are commodity items these days, you should briefly connect a sample LED to 6 volts DC through a 47-ohm resistor. If it is initially bright, then seems to fade, it is probably overheating. Disconnect the power immediately, and either substitute a higher value resistor (found by experimentation) or a different LED.

After you have obtained the parts, you can either make a printed circuit board from the foil pattern provided, purchase one from the source given in the Parts List, or point-to-point wire the circuit on perforated construction board. The LEDs on the wand section must be hand-wired, so hand wiring the rest of the circuitry shouldn't be a problem.

If you use a PC board, mount the components as shown in Fig. 3. The order of installation isn't critical. Use sockets for IC1 and IC2. Don't forget to install the single jumper wire near the top end of IC2. Leave IC1 and IC2 out of their sockets on the controller board for the time being. Install them during the checkout and final assembly steps given below.

Figure 4 shows how to assemble the serial downloading cable. This allows you to transfer new light patterns to the Picture Stick from your PC. A DB-25 male connector is attached to one end of this assembly, and a 4-pin female header plug is attached to the other end (two pins of this plug are not used). The plug connects to the 4-pin header (J1) on the circuit board. Instructions for wiring the battery holder are given in Fig. 5.

Figure 6 shows how to make the wand. Start by drilling 16 $^{13}/_{64}$- or $^{1}/_{4}$-inch holes down the center of a wooden yardstick, starting at the 1-inch mark, and ending at the 16-inch mark (Fig. 6-*a*). Push each LED into each hole with its cathode (the flat side of the reflector) facing one side of the stick (*b*). Trim the leads to a length of approximately $^{3}/_{8}$-inch and bend them into a "U" shape, and push the ends into the wood (*c*). Connect all of the anodes together by soldering them to a piece of solid 22 AWG wire (*d*). Next, starting at the colored stripe, separate the first 16 conductors of a piece of 20-conductor ribbon cable to a length of about 2 feet (*e*). (The last four conductors remain attached, and the stripped ends are twisted together at the yardstick end to form one heavier gage wire for the return current.)

Leave the colored wire full-length, and trim each successive lead 1 inch shorter than the previous one. Trim about 8 inches off the four wires that remain connected together. Strip and tin the ends of all 20 wires. Solder the staggered ends of the ribbon cable to the cathodes of each LED. The colored wire goes to the LED at the end of the yardstick (LED16 at the 1-inch mark), and each successively shorter lead goes to the cathode of the next LED. Solder all four of the remaining wires to the middle of the wire that connects the anodes of the LEDs. Secure the ribbon cable to the yardstick with duct tape, nylon wire ties, or other suitable fasteners.

Now solder the stripped wires at the other end of the ribbon cable to the PC board. Start by soldering the colored wire (it goes to LED16) to the pad that connects to R21 (it's the pad on the lower-right side of the board). Solder the remaining wires to the pads in order, working toward the top of the board. Four pads are provided for the four wires that are to be soldered together at the wand end. Figure 7 shows the completed PC board, and Fig. 8 shows a section of the wand.

Checkout

With both IC1 and IC2 out of their sockets, connect the batteries to the power input. Strip both ends of a short length of solid hookup wire, and insert one end into pin 1 of IC2's 28-pin socket. Touch the other end of the wire to pin 10 of the same socket to determine if LED16 (the one at the end of the wand) lights. Move the pin-10 end of the wire to pins 11 through 25. The LEDs should light up in sequence. If any of the LEDs fails to light, recheck your work and correct any errors.

After you have confirmed that all LEDs work, disconnect the power from the circuit and install IC2 (the 28-pin PIC). Leave IC1 out of its socket for now. Reapply power to the circuit. The LEDs should light up. Dim the lights and wave the wand around carefully. The LEDs should appear as a ribbon of dots. If the LEDs don't light, or if there are breaks in the dot pattern, bridge pins 8 and 4 of IC1's socket and try again. If this doesn't correct the problem, remove the power from the circuit and recheck your wiring. Once you have the test pattern working properly, bridge pins 4 and 5 of IC1's socket. Now the LEDs should all be off.

Disconnect power and install IC1 in its socket. If IC1 is purchased pre-programmed (from the source in the Parts List), you can power up the wand and check out the preprogrammed images. If not, you must download some images, as described further on.

To observe the pre-programmed images, take the wand, controller, and batteries to a place you can dim the lights and swing the wand around without danger of damaging property or hurting anyone. Apply power to the controller and swing the wand back-and-forth. If the image appears compressed horizontally, swing the wand a little faster. To change images, press and release S1. To switch rapidly, hold S1 down. If you are demonstrating the wand to someone else, you will find that you can monitor the images from the back of the wand (some light from the LEDs can be seen from the back).

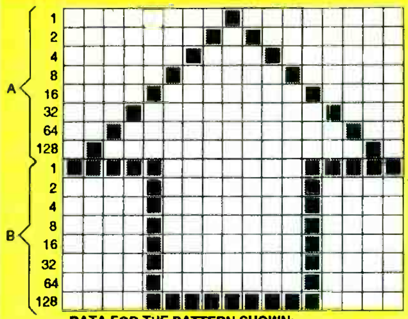
The batteries and controller are kept separate to keep the wand as lightweight as possible for safety reasons. Use common sense; carelessly swinging the wand around in the dark could hurt someone. Supervise children using the wand. (No sword fights! No running!)

Downloading images

To download images to the controller, you'll need the software from the source given in the Parts List or from the *Electronics Now BBS*. The program comes in two flavors: One is graphical and allows you to edit, save, and download pictures simply and easily. The other is a bare-bones downloading program that requires that you calculate the data manually and enter it into a text file. The graphical version requires a VGA monitor; the manual version works in a pure text mode, and it has no special requirements.

Downloading is simple, but it requires a specific sequence. Remove power from the controller. Connect the download cable to the COM1 port on your computer with the computer off. Then turn the computer on. Connect PL1 to the J1 header on the controller board.

Boot the downloading software (WAND for those with VGA monitors; WAND—NO for those without) and load the included image file SAMPLE.WND. Now apply power to the controller. The LEDs should remain dark. Follow the on-screen instructions to perform a download. The LEDs will flash brightly; they are displaying each incoming pair of data bytes. Downloading takes a little more than 4 seconds; after that, the wand will be active in its normal display mode. Remove power from the wand and remove the downloading connector. The images are now programmed into non-volatile EEPROM storage. Whenever you power up the wand from now on, you'll see the downloaded images.



DATA FOR THE PATTERN SHOWN:

0,1,128,1,64,1,32,1,16,255,8,128,4,128,2,128,1,128,2,128,4,128,8,128,16,255,32,1,64,1,128,1,0,1

PROCEDURE:

1. MARK THE SQUARES THAT MAKE UP YOUR PATTERN.
2. FOR THE FIRST COLUMN, ADD UP THE "A" ROW NUMBERS CORRESPONDING TO THE MARKED SQUARES. RECORD THIS NUMBER. DO THE SAME FOR THE "B" ROWS. VALID NUMBERS WILL BE BETWEEN 0 AND 255.
3. REPEAT THIS PROCEDURE FOR EACH OF 17 COLUMNS. WHEN YOU'RE DONE WITH A PATTERN, YOU SHOULD HAVE 34 NUMBERS.
4. REPEAT THIS PROCESS FOR AS MANY PATTERNS AS YOU DESIGN.
5. USING A TEXT EDITOR (LIKE EDIT THAT COMES WITH DOS5 AND LATER) OR WORD PROCESSOR CAPABLE OF SAVING A PLAIN TEXT FILE, TYPE IN THE NUMBERS SEPARATED BY COMMAS. EXAMPLE: 193,255,0,17,111... YOU MAY BREAK THE DATA INTO MULTIPLE LINES, BUT DON'T END A LINE WITH A COMMA.
6. IF YOU HAVE ENTERED FEWER THAN 510 NUMBERS (15 PATTERNS), PAD THE FILE WITH ZEROS (0,0,0,0,0...) UNTIL YOU HAVE 510 NUMBERS OR MORE. (THE DOWNLOADER IGNORES EXTRA ENTRIES.)
7. SAVE THE FILE.
8. RUN THE PROGRAM WAND_NO AND FOLLOW THE PROMPTS TO DOWNLOAD YOUR PATTERNS TO THE WAND. IF YOU HAVE BLANK PATTERNS, BE SURE TO ENTER THE HIGHEST FILLED-IN PATTERN (FRAME) NUMBER WHEN THE PROGRAM PROMPTS YOU TO. FRAMES ARE NUMBERED 0 TO 15.

FIG. 9—TO PREPARE DATA for the manual downloader, work out your patterns on graph paper, calculate the corresponding numeric values, and enter them into a text file.

When the controller is working properly, finish the assembly for a neat appearance. The wand can be encapsulated in clear acrylic plastic or covered with a large-diameter length of clear heat-shrink tubing. You can also leave everything as-is.

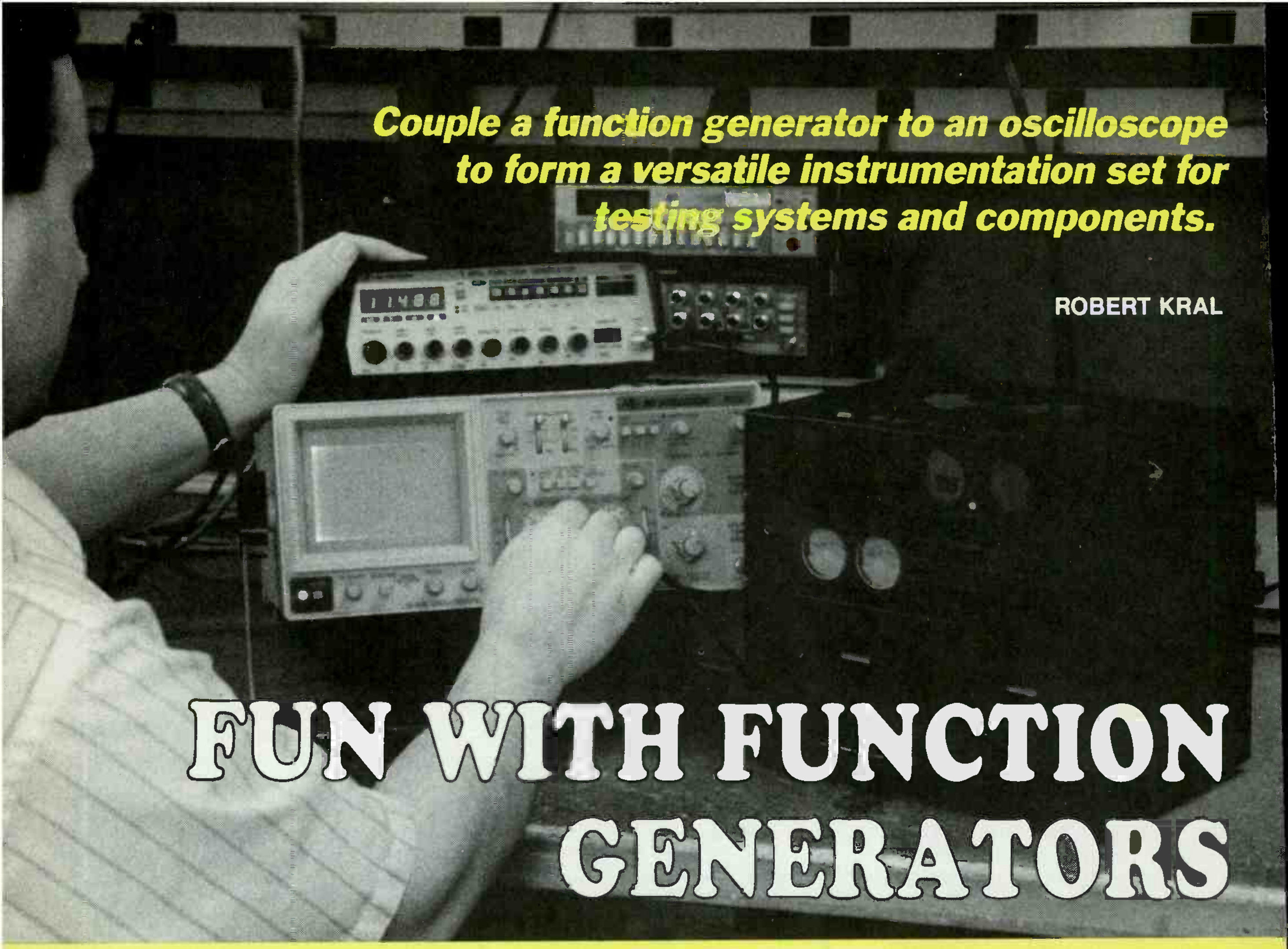
Designing your own images is fun and creatively satisfying. It's a great project for kids. If you have a VGA monitor, make use of the graphical editor (WAND). Move a cursor around a grid of dots with the keypad arrow keys, and toggle individual dots on and off with the spacebar.

Preparing data for the manual downloader (WAND—NO) is more complicated, but educational. Work out your patterns on graph paper, calculate the numeric values, and enter them into a text file. The process is shown in Fig. 9.

You may have noticed that all of the sample images are symmetrical left to right; stars, circles, arrows, etc. That allows you to swing the wand left-to-right and right-to-left and get the same image.

If you choose to create asymmetrical pictures, you must use a different technique to display them. Swing the wand rapidly in one direction, then slowly return it to the starting point. This will prevent viewers from seeing a reversed afterimage of your picture. Remember, you are the mechanical part of the display. If you find this inconvenient, you could modify the wand as follows: Wire a normally closed pushbutton between the controller and the LED anodes. Be sure the switch you select can handle current pulses of nearly 1½ amperes. With this switch in line, you can swing the wand to display your images, and press the button to blank the display while you prepare for another swing.

Another possible modification would be to make a continuous display of the wand's images by mounting the LEDs on a large rotating wheel, or by building a pendulum. Ω



Couple a function generator to an oscilloscope to form a versatile instrumentation set for testing systems and components.

ROBERT KRAL

FUN WITH FUNCTION GENERATORS

THE FUNCTION GENERATOR IS A versatile test instrument that usually functions as a signal substitution source. This article explains how the function generator, when coupled to an oscilloscope, becomes an even more versatile instrumentation set for testing and evaluating systems and components.

The function generator is an instrument that permits the introduction of its signals at specific points in a circuit. This characteristic makes it useful as an audio generator for testing, troubleshooting, and evaluating audio products as well as conventional electronic circuit components.

The oscilloscope paints the "signatures" of electronic components on its screen and a digital multimeter (DMM) makes the routine electrical measurements necessary to perform the tests discussed in this article. In addition to its role in testing, this instrument suit is very effective teaching tool for explaining the behavior of both active and passive components to students.

What do you need?

To perform the tests and demonstrations described in this article, the function generator, oscilloscope and DMM should have the following minimum specifications:

- Function generator—2-MHz internal sweep
- Oscilloscope—two-channel, 20-MHz with X-Y operation
- Digital multimeter—capable of making the basic electrical measurements with a basic DC accuracy of at least 1.0 %

Manufacturers of function generators position the controls and connecting plugs in different ways on the instruments that are designed to fill various market segments. Therefore, there really are no standard signal generators. If your function generator differs from the one shown in Fig. 1, you might want to consult your manual to review the functions of all of its controls.

Fortunately, most signal generators have the same basic controls and input terminals that can be interconnected in the same way. The leading signal generator specifications are: frequency range, sinewave distortion, types of waveforms generated, sweep range, and signal output level.

Selecting a function generator

If you do not own or have access to a signal generator, there are some points to consider when selecting one. Most stock function generators have a frequency bandwidth that extends from a fraction of a hertz to 10 MHz or higher. Most can produce sine, square, and triangle waves. On many instruments, variable symmetry control, also called duty cycle adjustment, allows squarewave pulses to be narrowed to simulate clock pulses.

Amplitude or frequency modulation and internal linear or logarithmic sweep are available on some instruments. Separate TTL or CMOS pulse outputs might be available, providing exact preset voltage levels required for a specific logic family. Some function generators contain a frequency counter that will give a direct readout of output frequency.

The tests described in this article can be performed on a basic economy model function génerator suitable for most electronic hobbyists and most routine electronics maintenance and circuit design. None of the tests described here require a bandwidth in excess of 2 MHz because they are limited to the audio range.

The sinewave distortion specification even for a basic function generator should be less than 1%, and its output should be variable, up to 20 volts peak-to-peak into an open circuit. A built-in counter is desirable feature but is not required for setting the output frequency. An internal linear or log sweep will be needed for making audio measurements. Instruments that meet these requirements typically sell in the $300 to $400 range.

Frequency-response

A function generator is not a constant voltage source. It typically has an output impedance of 50 ohms. Consequently, if you want to test a low-impedance component such as a speaker connected to the generator, the output of the function generator will vary with the impedance of the load.

To correct this condition, either add a series resistor or set up the function generator to drive an audio amplifier which, in turn, will feed the speaker. The low output impedance of the audio amplifier makes the function generator a constant voltage source.

Set up your instruments as shown in Fig 2. Select X-Y operation on your oscilloscope. Temporarily connect the function generator's output directly to the oscilloscope's vertical Y-axis input (typically channel 1). Connect the generator control voltage (GCV) output to the oscilloscope's horizontal X-axis input (typically channel 2).

Select DC coupling on both input channels. Display only Channel 1. While the sweep is disabled, adjust the function generator to the desired maximum (ending) sweep frequency. A vertical line should appear on the screen. Adjust the oscilloscope's channel 1 position and voltage controls so that the line is centered vertically and is positioned to the far right, horizontally.

Adjust the amplitude controls so that the trace nearly fills the screen vertically. Then set the function generator's frequency lower. The vertical line should move to the left. Tape a piece of paper to the CRT screen and mark the position of the vertical trace at the various frequencies that you will use in your tests.

Tune the function generator back to the end (maximum) sweep frequency. Engage the sweep width adjustment, and set it for the maximum. Adjust the sweep width and frequency controls to obtain the desired start and stop frequencies. The generator will now sweep between these two frequencies.

Now connect the component to be tested. It could be an amplifier, passive or active filter, loudspeaker, or microphone. Adjust the controls as needed so that the oscilloscope display looks like that shown in Fig. 3.

Impedance measurements

Figure 4 shows the setup for making impedance measurements on speakers and passive filters. Connect the GCV output of the function generator to the oscilloscope's X-input. With the oscilloscope in the X-Y mode, the oscilloscope's Y-input is the voltage across the speaker.

With the function generator out of the sweep mode, connect a 2-kilohm resistor in series with the function generator's output. Position the waveform near the center of the oscilloscope screen, and adjust its amplitude.

Adjust the output frequency of the generator until the vertical line reaches its maximum length. This is the speaker's resonant frequency. You can sub-

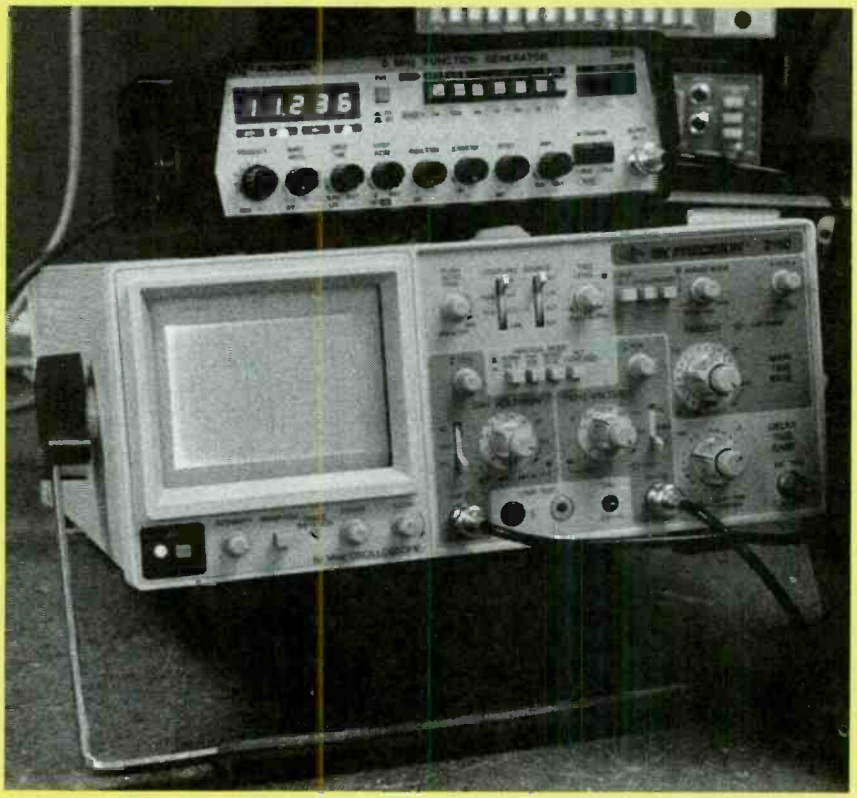


FIG. 1—A FUNCTION GENERATOR/OSCILLOSCOPE SETUP suitable for making the tests described in this article.

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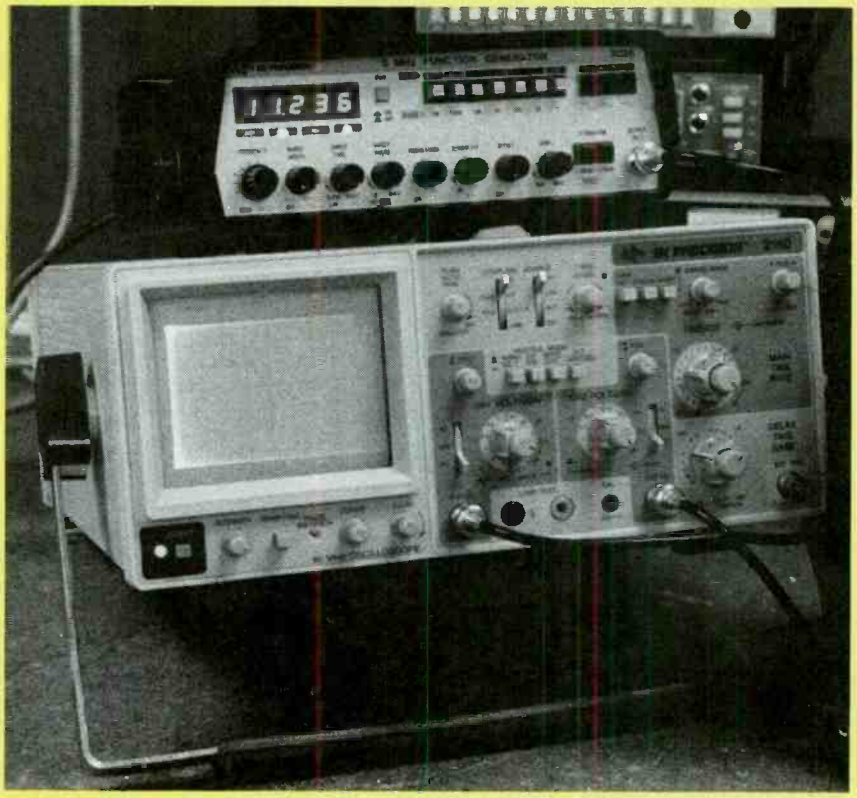


FIG. 1—A FUNCTION GENERATOR/OSCILLOSCOPE SETUP suitable for making the tests described in this article.

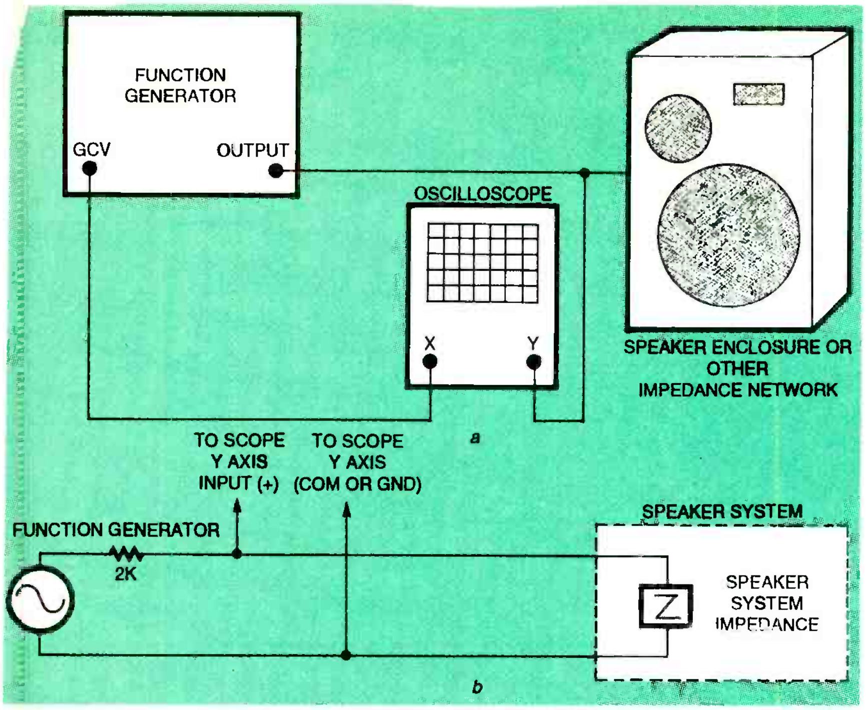


FIG. 4—SETUP FOR TESTING SPEAKER SYSTEMS and impedance networks (a) and eqivalent circuit (b).

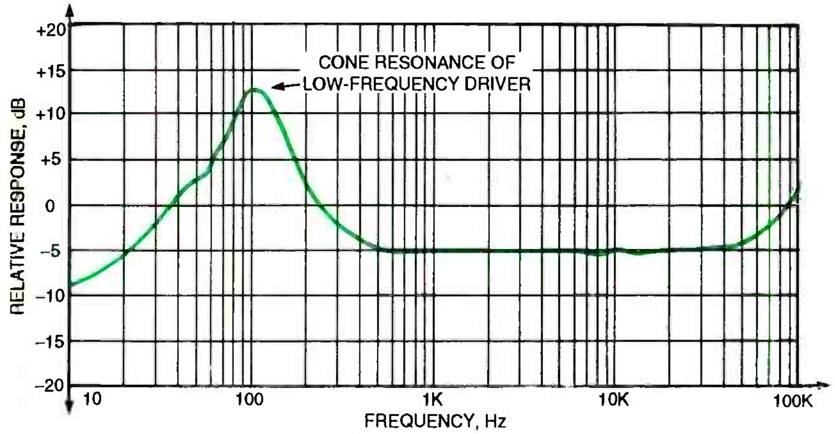


FIG. 5—GRAPH OF RELATIVE RESPONSE vs. frequency for an enclosed, low-frequency speaker showing a single resonance peak.

as horizontal lines. Marginal components can be identified by comparing their waveforms with idealized waveforms of the correct signatures.

Fortunately, you can perform many of the tests best performed on a signature analyzer with a function generator and an oscilloscope and save the $1000 to $3000 you would have to spend to buy an analyzer.

With the instrumentation setup described here, the range of applied test voltage will be somewhat limited. Moreover, repeatability will not be optimum because you must readjust frequency and output voltage each time you perform a test. However, you will become familiar with the E-I test technique without the need to purchase additional instruments.

This setup lacks some of the benefits of the full-fledged signature analyzer such as A-B input switching for rapid good-bad comparisons, multichannel clips for testing the pins of integrated circuits automatically in sequence, and the ability to store component waveforms on a personal computer for comparison purposes. And, of course, without this connection to the PC, you won't be able to generate reports with the data or store test records.

The test setup for the alternative signature analyzer is shown in Fig. 8. Connect the function generator output across both the component under test and a 51-kilohm series resistor. Fix the oscilloscope's Y input across the 51-kilohm resistor in series with a 2-kilohm resistor, and connect its X input across the component under test. Tie the grounds from the two probes to a common point between the resistor and component under test.

Select the sinewave output from the function generator, and set the voltage and frequency controls for a clear display. Again, set the oscilloscope in the X-Y mode.

Familiarity with the waveforms of good components is essential for the most effective troubleshooting. If you are doing routine production testing, have a sample tested and known fault-free board on hand for comparison with any board that contains faulty components. Note, however, that the signature of a component in a circuit will differ from that of the same component out of a circuit.

Select a test voltage and frequency very carefully to produce the optimal signature for the known good component. The signatures expected will, of course, differ with the type of component being tested. Keep a written record of the voltage and frequency settings for the values you test.

Typical signatures

The signature of a resistor is a sloping line as shown in Fig. 9-a. The slope changes with the value of the resistor. Select a voltage so that the slope of the line for a known good resistor is close to 45°.

The signtures of capacitors and inductors are ellipses as shown in Fig. 9-b. They should nearly fill the oscilloscope graticule. High values of each flatten the ellipse along its horizontal (X) axis, and low values flatten it along its vertical (Y) axis.

Here are some points to keep in mind about inductor and capacitor E-I signature testing:

- Inductors with the same value can have different signatures because of differences in their core materials or the position of the core with respect to the winding.
- Capacitor leakage that cannot be found with digital multimeter capacitance measuring circuits can be found with signature analysis.

Semiconductor diodes can also be tested with this method. Diode signature analysis will detect defective diodes that are open or nearly open-circuited, short-circuited, or those with high internal leakage. However, the same information can usually be obtained with the diode test function of the DMM.

- Silicon diodes exhibit the easily identifiable backward "L"-shaped signatures shown in Fig. 9-c. Light-emitting diodes have similar signatures except that they have a greater slope in their vertical portions. This slope varies with the emission color of the LED, as shown in Fig. 9-d.

Zener diodes conduct in both directions as shown in Fig. 9-e. If the diode is good, it will have a sharp, well defined knee, provided the test voltage is set high enough to produce it.

Transistors and ICs

When the signature technique is applied to transistors and integrated circuits (analog or digital), the waveforms have diode-like signatures:

- Bipolar junction transistors must be tested across their base-collector, collector-emitter, and base-emitter junctions. Their signatures are similar to a silicon diode in series with a Zener diode. The separating point between the two waveforms represents the base.
- Field-effect transistor (FET) must be tested across their gate-source, drain-source, and drain-gate junctions.
- Silicon controlled rectifiers (SCR) are connected across the anode and cathode, and pulse generator output is connected to the gate. Increase the pulse generator output until the SCR turns on.

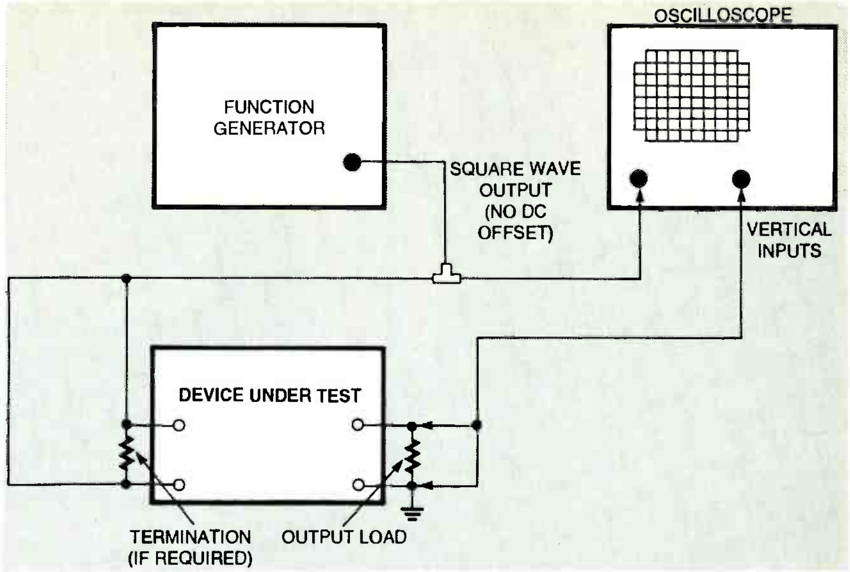


FIG. 6—TEST SETUP FOR AMPLIFIER PERFORMANCE with square waves.

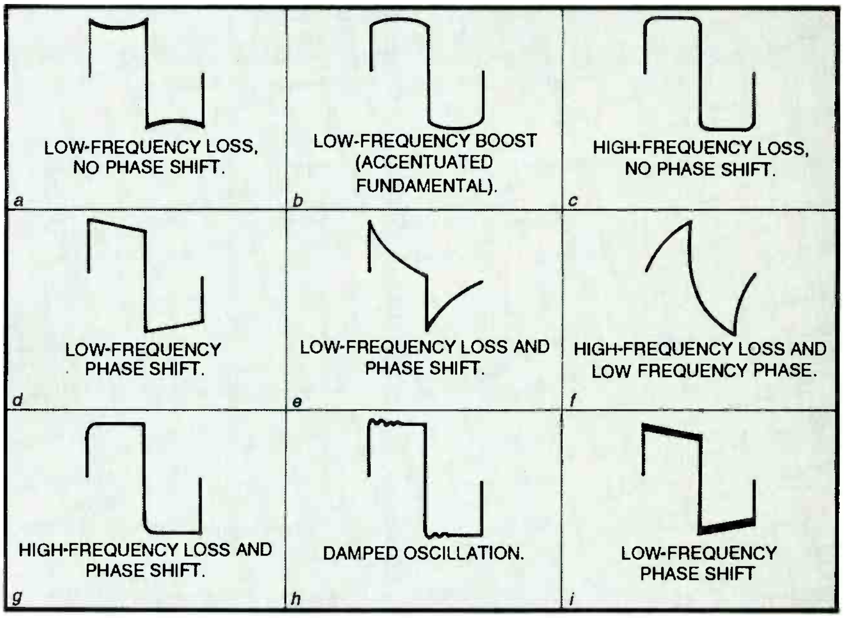


FIG. 7—WAVEFORMS OBTAINED for various test conditions with square waves from the signal generator.

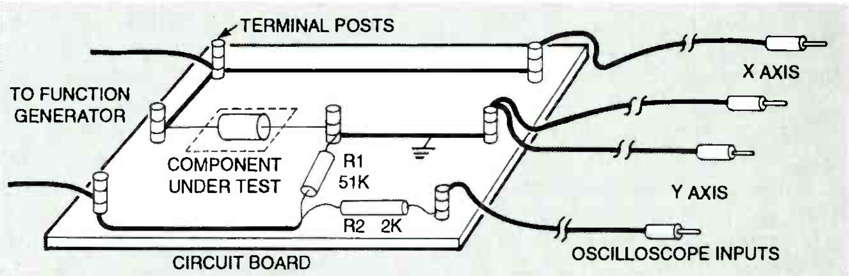


FIG. 8—COMPONENT TEST BOARD that can be hard-wired or put in a project case to simplify the test procedure.

Semiconductor tutorial

Signature analysis is useful in explaining the operating characteristics of semiconductors. For example, in the diode signature shown in Fig. 9-c, the horizontal distance between the vertical axis on the screen and the vertical part of the sig-

Continued on page 73

BUILD THIS TELEPHONE CALL RESTRICTOR

Restrict access to those expensive "900" and "976" numbers with this inexpensive call restrictor.

TERRY WEEDER

OVER THE PAST FEW YEARS, THE "900," "976," and "540" telephone exchanges have become an easy way for people to spend a lot of money—too easy, perhaps. Some of those numbers, which provide access to a wide variety of services from sports scores to sex chat lines, can cost several dollars per minute. You won't even see the damages—a huge phone bill—until the end of the month. What makes it worse is that anyone who has access to your phone can call these numbers, forcing you to pay the bill. Most people would not leave their credit cards lying around the house for anyone to use, but in a sense, that is what you are doing if you allow others to have dialing access to all phone numbers from your phone.

The Telephone Call Restrictor described in this article can block access to any particular telephone number, or any group of numbers beginning with a certain prefix. The numbers to be blocked are entered into the call restrictor's memory from a Touch-Tone phone. The restrictor can also be programmed to block all telephone numbers *except* those which you have entered into memory. That feature is ideal for your business if you want to allow incoming calls, but only outgoing emergency calls.

The restrictor can be plugged into any phone jack in your home or office to control all the phones on that line. The restrictor can be disabled on a single-

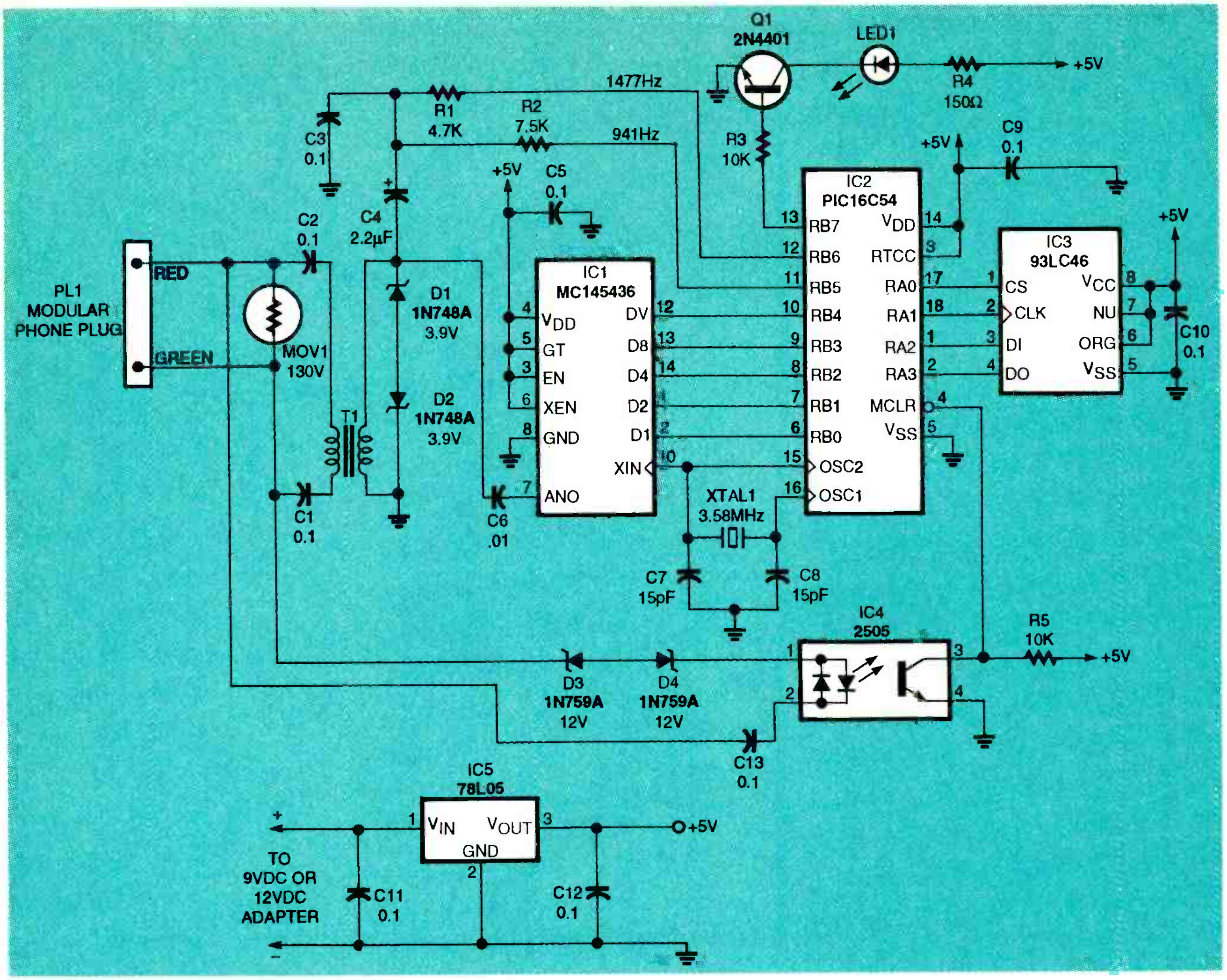


FIG. 1—THE MICROCONTROLLER (IC2) COMPARES the decoded DTMF tones from IC1 with the telephone numbers stored in the EEPROM (IC3).

call basis with a four-digit password. The password also prevents others from reprogramming the unit.

The restrictor is programmed from a Touch-Tone phone. An EEPROM provides non-volatile storage of the programmed information. Therefore, the restrictor will not lose its data because of a power failure or relocation of the unit.

Circuit theory

A schematic diagram of the call restrictor is shown in Fig. 1. Capacitors C1 and C2 and transformer T1 isolate the circuit from the phone line. Those components also couple the DTMF (dual-tone multiple frequency) tones from the phone to pin 7 of IC1, an MC145436 DTMF receiver. A metal-oxide varistor (MOV1) protects the circuit from high-voltage spikes on the line, and D1 and D2 provide protection from ringer voltages. The DTMF receiver converts the Touch Tones into 4-bit TTL-level data. The PIC16C54 microcontroller (IC2) processes the data from IC1, stores the user-entered telephone numbers in EEPROM (IC3), and generates the tones necessary to disable the telephone.

Optoisolator IC4 generates a reset pulse for the microcontroller every time the handset is picked up or put back on hook. The change in voltage from tip to ring (when the line goes from on-hook to off-hook or vice versa) causes current to flow through the optoisolator as C13 charges or discharges to the new voltage level. The current flow forward biases the transistor output of IC4, which pulls IC2's reset pin low. Diodes D3 and D4 provide a threshold voltage that is high enough so that voice or DTMF tones will not trigger a reset.

A low-current voltage regulator (IC5) drops the voltage from a 9- or 12-volt DC adapter to 5-volts DC; C11 and C12 stabilize IC5's output.

The disable tones generated by IC2 (discussed later) are attenuated by R1 and R2, smoothed out by filter capacitor C3, and then coupled to T1 by capacitor C4. Transistor Q1 turns LED1 on when pin 13 of IC2 goes high.

Microcontroller and EEPROM

The PIC16C54 is an 8-bit CMOS microcontroller manufactured by Microchip Technology, Inc. This microcontroller has one eight-bit I/O port, one four-bit I/O port, 512 × 12 bits of on-chip EPROM, and 32 × 8 bits of data RAM.

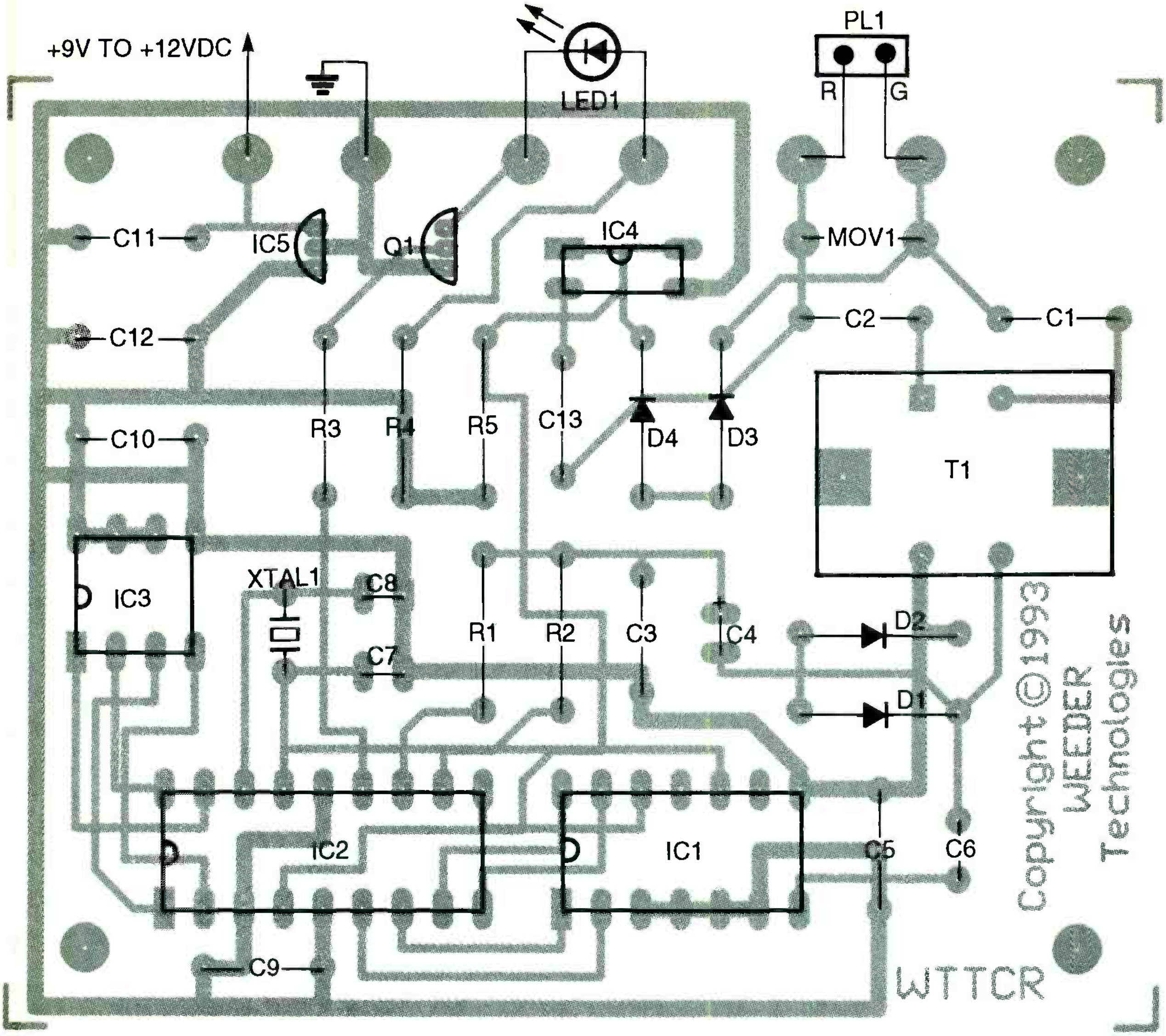


FIG. 3—PARTS PLACEMENT DIAGRAM. Mount components as shown here. Watch for solder bridges on Q1 and IC5.

The PIC16C54 contains a two-level stack, an eight-bit wide arithmetic logic unit (ALU), and a real-time clock/counter register with a prescaler. The instruction set consists of 33 single-word operations which require one cycle (four clock pulses) for execution. Instructions that force a program branch require two cycles. Each pin of the I/O ports can be configured individually as either an input or output through software. The PIC16C54 also has its own built-in "watch dog" timer (WDT) and "sleep" mode, but neither are used in this circuit because the chip is reset every time the handset is picked up. Also, the circuit is powered by an AC adapter so low-power operation is not essential.

A preprogrammed PIC16C54 is available from the source given in the Parts List. The source and object code files are available on the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) for those who wish to program their own microcontrollers. A programmer for the microcontroller was described in the January 1994 issue of *Electronics Now.*

The internal RAM of the PIC16C54 functions as working registers for the operating program. All user-entered data is stored in IC3, a 93LC46, 1K serial EEPROM, also manufactured by Microchip. The 93LC46 is connected to Port A of IC2 through four input lines: CHIP SELECT, CLOCK, DATA IN, and DATA OUT. After a high is detected on CHIP SELECT, data is then transferred to and from the 93LC46 on the positive transition of the clock signal.

Each transfer of data consists of one start bit, a two-bit opcode that identifies the function to be performed, then a 6-bit address, followed by the 16 bits of data which is being read from or written to that address. Immediately preceding and following all write operations, the microcontroller sends instructions to the 93LC46 that enable or disable the write function, thereby protecting the data.

The data in the 93LC46 is stored in 16-bit blocks, while the data output from the DTMF receiver is in 4-bits. To make

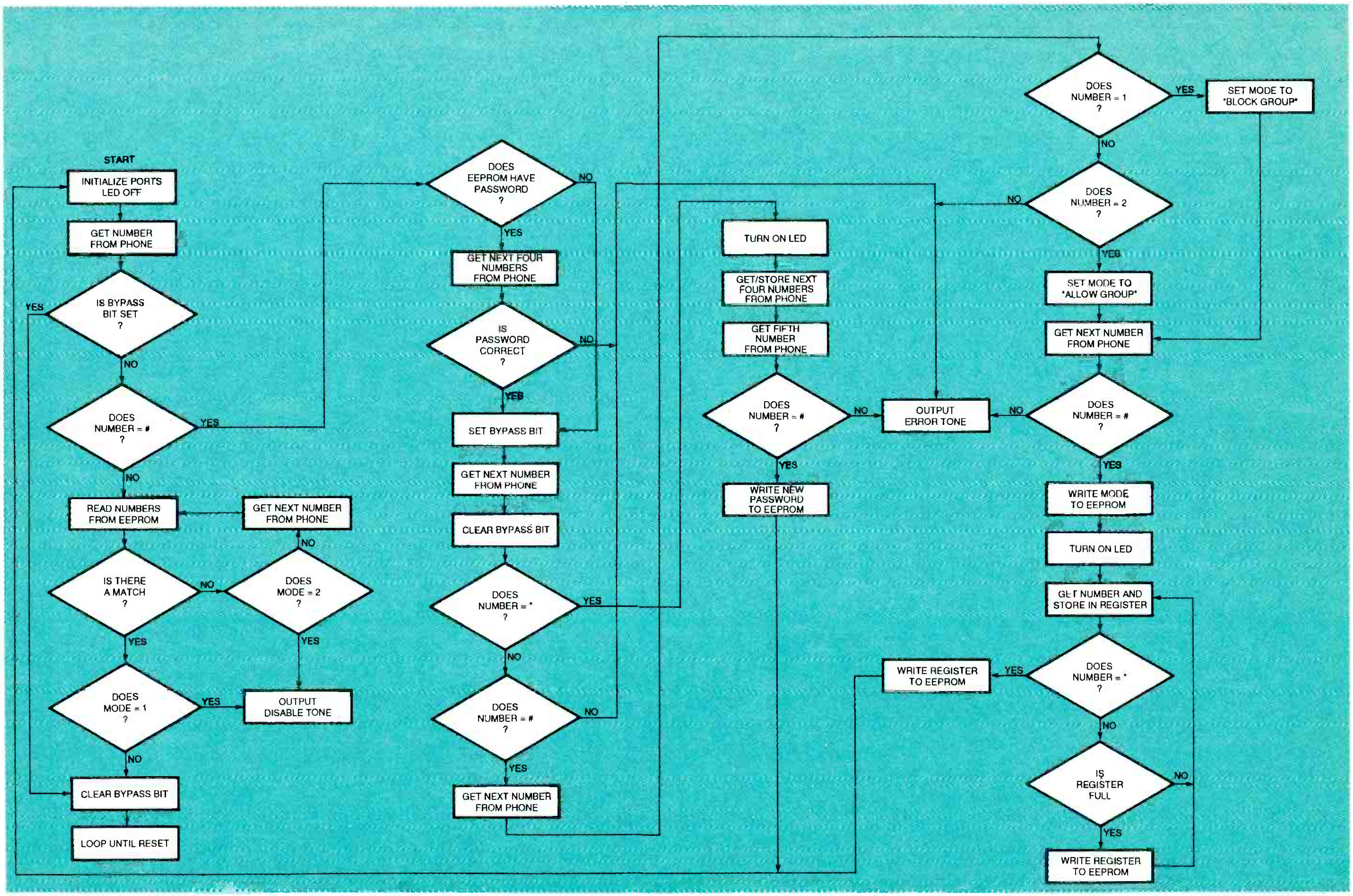
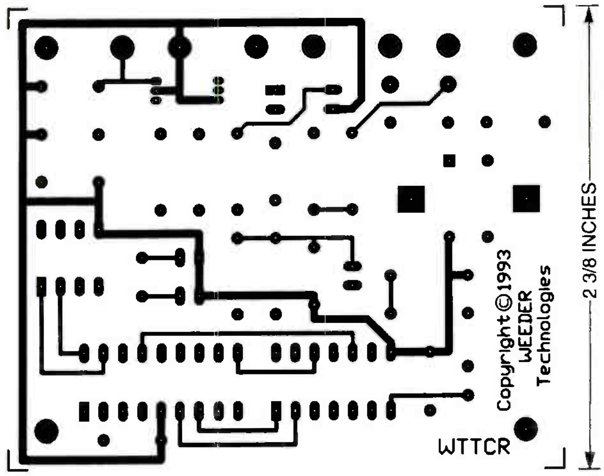


FIG. 2—FLOW CHART OF THE OPERATING PROGRAM. The source and object code files are available on the *Electronics Now BBS* for programming your own micro-controller, or you can purchase a pre-programmed chip from the source given in the Parts List.

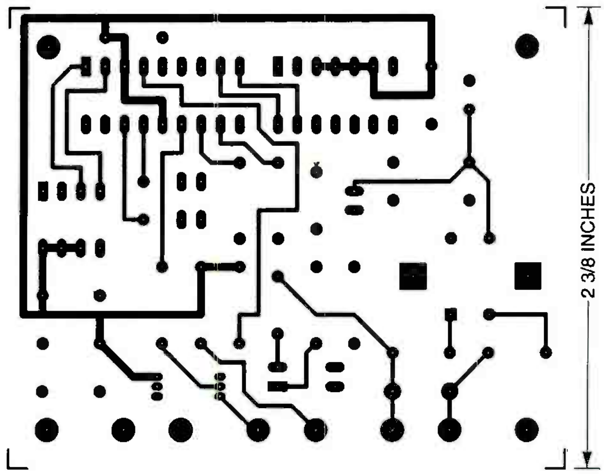
PARTS LIST

All resistors are ¼-watt, 10%, unless noted otherwise.
R1—4700 ohms
R2—7500 ohms
R3, R5—10,000 ohms
R4—150 ohms
Capacitors
C1–C3, C5, C9–C13—0.1 µF, Mylar
C4—2.2 µF, 16 volts, tantalum
C6—0.01 µF, Mylar
C7, C8—15 pF, ceramic disc
Semiconductors
IC1—MC145436 DTMF receiver (Motorola)
IC2—PIC16C54-XT/P microcontroller (Microchip)
IC3—93LC46 serial EEPROM (Microchip)
IC4—2505-1 optoisolator (NEC or equivalent)
IC5—78L05 low-power 5-volt regulator
D1, D2—1N748A 3.9-volt Zener diode
D3, D4—1N759A 12-volt Zener diode
LED1—light-emitting diode, any color
Q1—2N4401 NPN transistor
Other components
MOV1—130 VRMS metal-oxide varistor
T1—600-ohm primary, 600-ohm secondary, audio transformer
XTAL1—3.58 MHz TV colorburst crystal
Miscellaneous: Enclosure, PC board, IC sockets, wall adapter (9- or 12-volt DC), telephone cord with modular plug, hook-up wire, solder, hardware
Note: The following items are available from Weeder Technologies, P.O. Box 421, Batavia, Ohio 45103:
- **Double-sided PC board (WT-TCR-B)—$9.50**
- **Kit of all board mounted components including pre-programmed PIC16C54 (WT-TCR-C)—$25.50**
- **Pre-programmed PIC16C54 only (PIC-TCR)—$16.00**

All orders must include $3.50 for shipping and handling. U.S. and Canadian orders only. Ohio residents must add 6% sales tax.



COMPONENT SIDE of the call restrictor.



SOLDER SIDE of the call restrictor.

use of all the memory available in the 93LC46, the microcontroller's software is written so that it will stack four numbers at the same address locations when storing the numbers in EEPROM, then extract the numbers in the correct order when reading back from the EEPROM.

Software

A flow chart of the operating program is shown in Fig. 2. After IC2 resets (which occurs when the phone is taken off-hook), the chip looks for a number entered from the telephone. This microcontroller waits for a high on the DV (DATA VALID) pin of IC1, reads the 4 data lines, and then waits for a low on the DV pin. The microcontroller then checks to see if the pound (#) key is pressed. It indicates a request to program the EEPROM.

If a # is detected, IC2 looks for a password in EEPROM. Initially, a non-programmed 93LC46 EEPROM contains all 1's in its registers. Therefore, the microcontroller can determine if a password has been entered. If a password is found, IC2 reads the next four numbers from IC1 and determines if they match the password stored in EEPROM. If a valid password has been entered, the caller can then program the EEPROM. If an incorrect password is entered, or if a mistake is made in the programming sequence, an error tone is transmitted on the phone line. It continues until the phone is replaced on hook (causing a reset of IC2).

If the first number entered from the phone is not the # key (indicating that a call is being attempted), IC2 stores the number in one of its registers and then looks for a match in EEPROM. IC2 disables the telephone if there is a match, and then places the next number entered in an adjacent register and looks for a match making use of both numbers stored in its registers. The process is repeated, adding each new number to the string of numbers stored in IC2's registers and comparing this string with numbers stored in EEPROM until either a disable condition is met or the string exceeds 11 characters.

If a disable condition is met, IC2 outputs two tones on port B; 1477 hertz is output on pin 12 and 941 hertz is output on pin 11. The two tones are the same as those generated by pressing the # key on the phone. Upon detection of this tone pair by the central office, a busy signal is automatically issued so that the call cannot be completed. (The same tone pair is also indicates an error as mentioned earlier.)

In areas where the central office does not generate a busy signal when the # key is pressed, the tone generated by the restrictor will interfere with any conversation.

Notice from the flow chart that when programming the EEPROM, the microcontroller sets the bypass bit immediately after verifying that a correct password has been entered. It then clears that bit after receiving another number from the phone. If the caller enters the correct password and then hangs up the phone without entering any additional numbers, the bypass bit will be set. Therefore, when the handset is picked up to place the next call, the set bypass bit will be detected, and the program will branch to an endless loop that keeps the blocking action of the circuit disabled until a reset occurs. Placing the handset back on-hook resets the circuit.

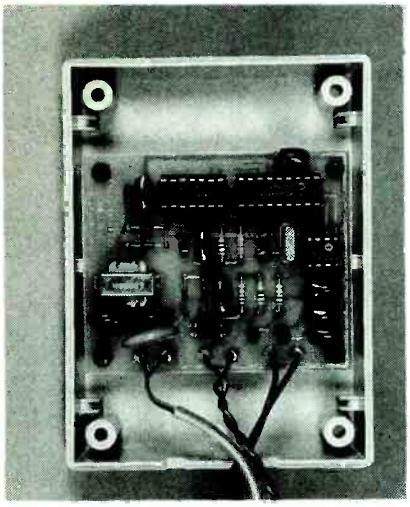


FIG. 4—MOUNT THE BOARD in the enclosure and cut two slots in the seam of the plastic case for the power cord and the phone cord.

TABLE 1—PROGRAMMING

To Change / Enter Password:
– Password – * – New Password –

To Disable for Next Call:
– Password (hang up)

To Program "Block Group" Mode:
– Password – # – 1 –
Number – # –
Number – # –
Number – # –
" (up to 248 characters)
Number – # – *

To Porgram "Allow Group" Mode:
– Password – # – 2 –
Number – # –
Number – # –
Number – # –
" (up to 248 characters)
Number – # – *

Note: "Number" can be any telephone number (1 to 11 digits long).

Construction

The circuit fits on a double-sided, 2⅞- × 2⅜-inch printed circuit board. Artwork is provided here for those who wish to make their own boards. Manufactured boards can be purchased from the source given in the Parts List. Refer to the parts-placement diagram in Fig. 3 and start by inserting and soldering IC sockets for IC1 through IC3. Mount IC4 directly to the board and then solder Q1 and IC5 to the board, carefully avoiding solder bridges between the closely spaced pads.

Next, mount the resistors, capacitors and diodes. When soldering the crystal (XTAL1), leave a small space between the bottom of the crystal and the PC board. Caution: The metal case of the crystal could short the two solder pads together if it is pushed flush against the board when soldering. Finish assembly by mounting the transformer (T1) and the varistor (MOV1).

After all components have been soldered to the board, double check for solder bridges on both the top and bottom side of the board, and re-solder them if necessary. Carefully plug IC1, IC2, and IC3 into their sockets.

The board will mount directly in a plastic enclosure available from Digi-Key (Part No. SR131G-ND), but it is not essential that you use this case. Because this unit can be operated remotely with any Touch-Tone phone on the phone line, you might want to build the circuit without a case.

LED1 can be mounted to the top of the enclosure or soldered directly to the PC board. Use a phone cord with a modular jack on one end and solder the red and green wires to the correct locations on the board—you can cut off the black and yellow wires. After determining their polarity, solder the AC adapter's leads to the points labeled POS and NEG.

Mount the board in the enclosure and cut two slots in the seam of the plastic case for the power cord and the phone cord. Figure 4 shows the inside of the

continued on page 74

BRANCO JUSTIC and
PETER PHILLIPS

NIGHT-VISION SCOPES

View a scene in near total darkness with a passive night-vision scope, or illuminate it with infrared for an active scope

NIGHT-VISION SCOPES WERE DEveloped as military surveillance devices to permit viewing enemy activities and aiming weapons at night without revealing the observer's presence. The sensitivities of their principal components, image tubes, have been improved with fiber-optic lenses, more gain stages and better photocathodes. In addition miniature, solid-state, extra high-voltage power supplies have reduced their size, weight and power needs.

Two night-vision scopes are described in this article. One is passive, meaning that it will work in faint natural light, and the other is active, meaning that it requires supplemental infrared illumination. They include surplus first-generation imaging tubes. Although they have been superseded by more advanced devices, they will, nevertheless, provide adequate sensitivity for most hobbyists and science experimenters.

The active scope will permit police to observe suspected criminal activity at night and citizens to monitor their homes or property without being detected. The scope will also permit hunting, nature study, marine navigation, and many other nighttime applications. The active scope is suitable for some of these activities, but the scene must be illuminated by an infrared source. Neither will disturb the eyes' adaptation to darkness.

The first night vision scopes were designed for use by forward observers, snipers, aviators, and tank crews. Some that were made as monoscopes to mount on rifles looked like the devices shown in Fig. 1; others were made as binoculars. The most sensitive passive units are called *starlight scopes*. *Night-vision goggles* are lightweight binoculars for helicopter crews that mount on their helmets.

Active night-vision scopes, such as the one shown in Fig. 2, depend on infrared illumination from sources such as lasers for aiming artillery, guided missiles, and "smart" bombs. Night-vision systems were considered military secrets for many years. After they were declassified, they could be sold as military surplus and commercial versions based on the technology were offered for police surveillance and as nighttime marine navigational aids at prices that often exceed $2000.

Both of the night-vision scopes described in this article are based on military surplus equipment that includes both an image tube and optics. The parts for the active unit cost $90, and parts for the active unit cost $220.

Night-vision scopes

Figure 3 illustrates a typical night-vision scope. The objective lens, positioned at the cathode end of the tube, focuses the image on the photocathode. It is selected for its intended application—long-distance or short-range viewing. The eyepiece at the anode is for viewing the enhanced image. It is a simple lens that magnifies the image on the screen. It can be removed and replaced by a television camera, camcorder, or film camera for transmitting or recording the image.

The image tubes are the hearts of the night-vision scopes. Before you start building one (or both), you might want to learn more about how they work. See the sidebar entitled "Image Converter and Intensifier Tubes."

The only electronics needed

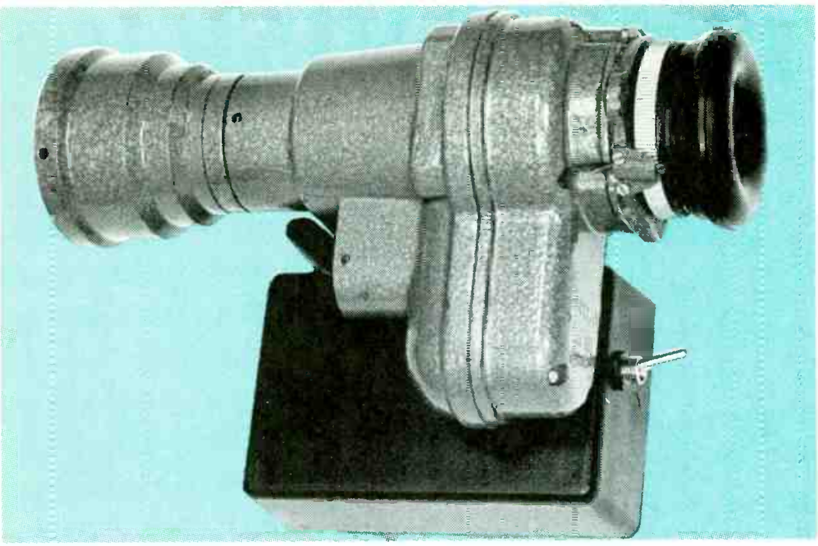


FIG. 1—A PASSIVE NIGHT-VISION MONOSCOPE made from half of a Russian night-vision binocular with an image intensifier tube and all optics.

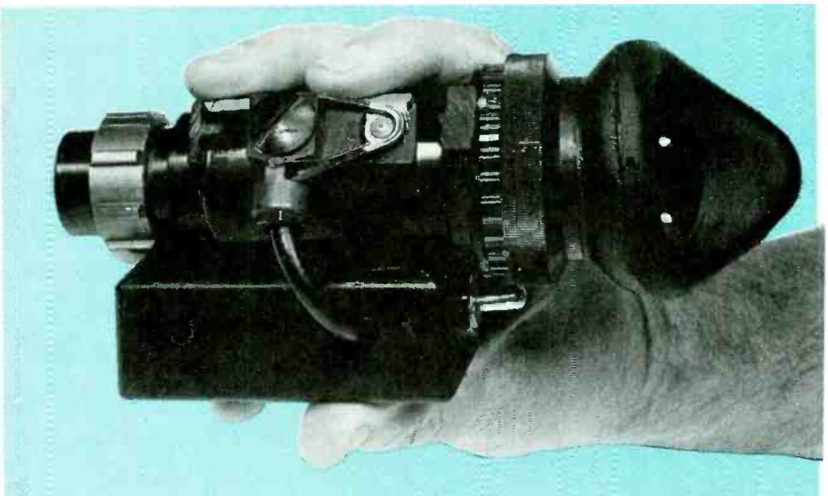


FIG. 2—THIS ACTIVE NIGHT-VISION SCOPE requires an infrared illumination source but it works from the same power supply as the scope in Fig. 1.

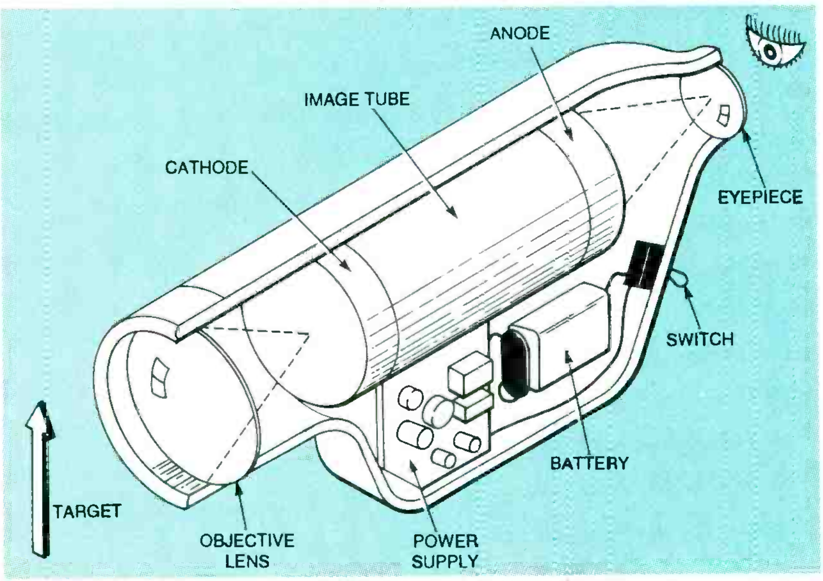


FIG. 3—ALL NIGHT-VISION SCOPES have objective and eyepiece lenses, an image tube, a high-voltage power supply, and a battery.

in both projects described in this article is a high-voltage power supply capable of providing a typical working voltage of 13.5 kilovolts. This efficient and compact regulated supply operates satisfactorily from a 9-volt, alkaline battery. The current drain of both tubes described here is small, so that their power consumption is low.

The compact power supply is built into a small plastic project case that is fastened directly to the surplus night-vision scope that contains the imaging tube. The Russian-made monocular viewer shown in Fig. 1 is actually one half of a binocular. It is complete with an objective lens and an eyepiece. This assembly includes a first-generation, single-stage *image intensifier tube*.

The active night-vision scope shown in Fig. 2 contains a single-stage *image converter tube*. Instructions on how to make several different low-cost infrared illumination sources are described in this article.

Active military night-vision weapons aiming systems typically include an infrared-emitting laser. It pinpoints the target for a heat-seeking weapon or for aiming other kinds of guns or missiles while also acting as a non-visible searchlight for the observer (bombardier or gunner) with an active scope. Various systems have been built for use on land, in the air, or on the sea at night.

Infrared-sensing missiles and "smart" bombs actually "home" on the IR-illuminated target which has been identified by the observer who directs the laser beam and watches it with the active scope. Needless to say, aiming and firing must be fast because enemy gunners with active scopes can also see the laser illumination and take evasive action or retaliate.

Power supply design

Figure 4 is the schematic for a high-voltage power supply that will power both night-vision scopes described here. It produces about 13.5 kilovolts from a 9-volt battery. The tubes draw about 20 milliamperes so about

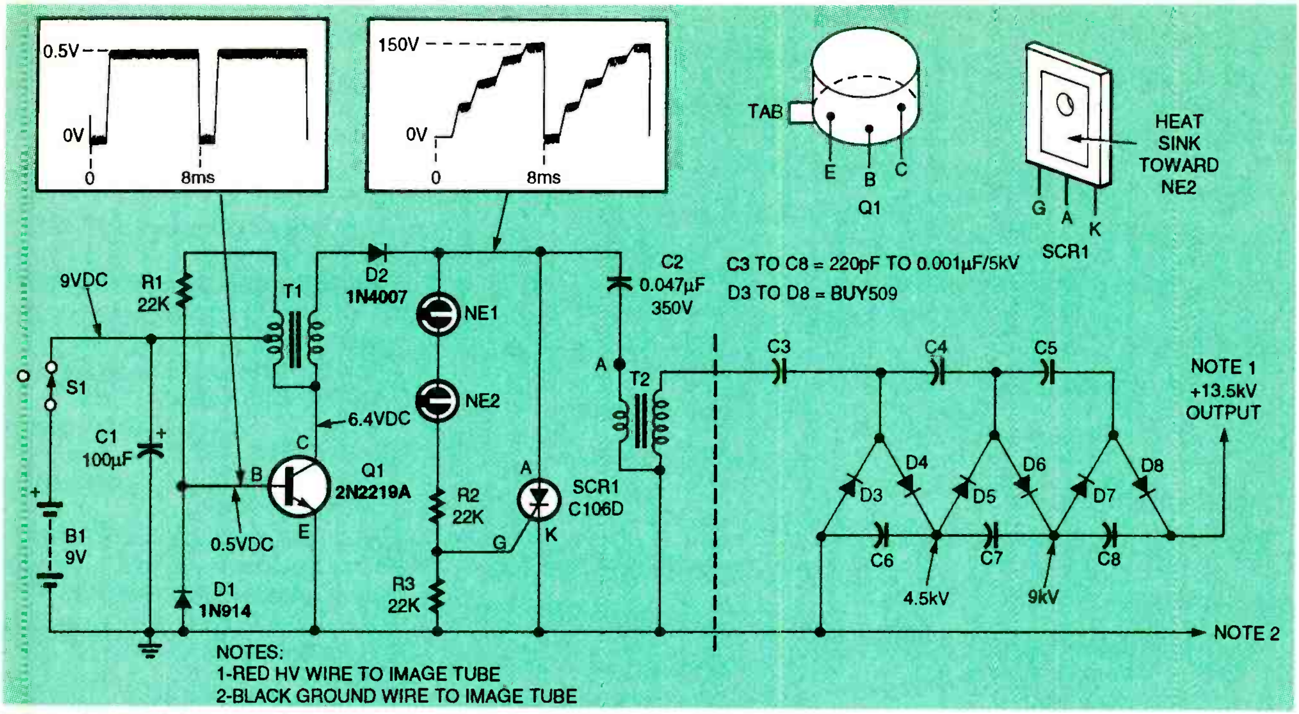


FIG. 4—THIS HIGH-VOLTAGE POWER SUPPLY has an inverter around Q1 that supplies 150-volt pulses to the converter of SCR1 and C2. The output of T2 is a 4.5 kilovolt pulse that is multiplied by the voltage-tripler network (right) to produce 13.5 kilovolts.

36 hours of useful life can be obtained from a 9-volt alkaline battery. The output voltage will remain essentially constant for battery voltages of 6 to 12 volts.

The power supply has three sections: the inverter, the converter, and the voltage multiplier. The inverter section, a ringing-choke oscillator, consists of transformer T1, resistor R1, diode D1, and transistor Q1. Resistor R1 provides bias current for starting the oscillator, and it also supplies the feedback to maintain oscillation.

Diode D1 protects the base-emitter junction of Q1 when the base voltage swings negative. The oscillator operates at about 120 Hz, set principally by the transformer. The resulting AC voltage at the primary of T1 is stepped up by the secondary turns. The secondary voltage, which is rectified by diode D2, charges C2 through the primary (low-resistance) winding of transformer T2.

When the voltage across C2 exceeds the breakdown voltage of the two series-connected neon lamps NE1 and NE2 (about 150 volts) the lamps turn on. This conduction triggers SCR1, and C2 is quickly discharged through SCR1 and the primary winding of T2. When C2 is discharged, the lamps extinguish, SCR1 turns off, and the charge cycle starts again.

During the discharge cycle of C2, a pulse with a peak-to-peak voltage of 4.5 kilovolts is produced at the secondary of trigger transformer T2. This pulse is applied to the three-stage Cockcroft-Walton or Greinacher voltage-multiplier circuit consisting of diodes D3 to D8 and capacitors C3 to C8.

The multiplier triples the 4.5-kilovolt input to provide the 13.5-kilovolt output with very low current. The capacitors and

LIGHT UNITS

The standard (SI) unit of light intensity is the lux, and a typical recommended minimum illumination level for a video camera is around 50 lux. However, some some video cameras will work with light levels as low as 1 lux. With this frame of reference, you can get a better idea about how sensitive night-vision systems are.

The recommended light level for the safe operation of these tubes is from 50 millilux down to 500 microlux (0.0005 lux)— very low light levels. Table 1 lists familiar light levels and their light intensity in lux units. By contrast, a typical first-generation image intensifier tube will not be damages if the illumination level is as high as 100 millilux (one tenth of a lux), but tube life will be reduced if it is exposed for long periods to that light level.

Sensitivity is the most important specification for of a night-vision scope. An average scope has a sensitivity of 10 millilux (mlx), a value that makes it effective in night lighting from a quarter moon. By contrast, a very sensitive night-vision scope can operate at 1 mlx, which corresponds to starlight conditions. For this reason, very sensitive scopes are called "starlight" scopes.

TABLE 1
RELATIVE VALUES OF NATURAL LIGHT SOURCES

Source	Illumination (lux)
Direct sunlight	100,000
Bright sunlight	10,000
Overcast day	1,000
Very dull day	100
Twilight	10
Deep twilight	1
Full moon	0.1
Quarter moon	0.01
Starlight	0.001
Overcast starlight	0.0001

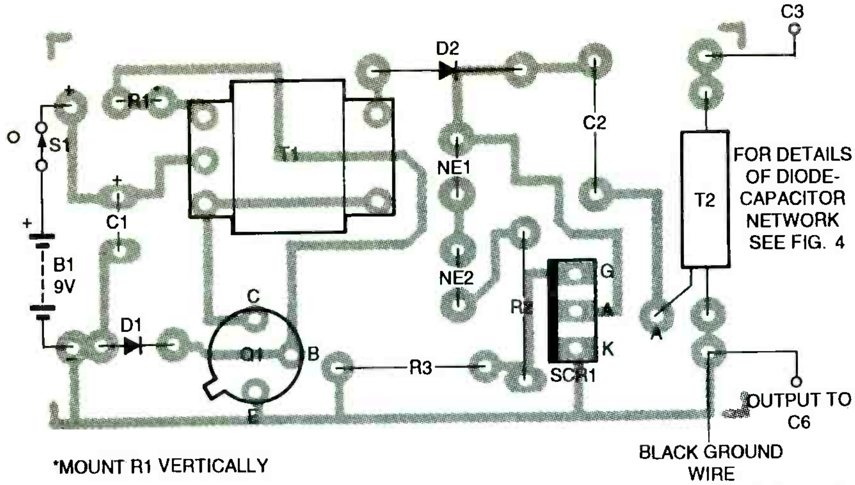


FIG 5—PARTS PLACEMENT DIAGRAM for the high-voltage power supply. Refer to Fig. 4 for the layout of the voltage-tripler network that is connected to its output.

PARTS LIST

Resistors are ¼-watt, 10%
R1, R2, R3—22 kilohms
Capacitors
C1—100 µF, 25 volts, aluminum electrolytic
C2—0.47µF, 350 volts, polyester
C3, C4, C5, C6, C7, C8—220 pF, 5 kV breakdown, ceramic
Semiconductors
D1—1N914 silicon signal diode
D2—1N4007, 1000V, 1A silicon diode (DO-41 case), Motorola or equiv.
BY509—silicon diode, 10 kV, 3 mA, Philips or equiv. (rating must be greater than 6 kV, 2 mA)
2N2219A—NPN transistor, Motorola or equiv.
MCR106-6 (C106D)—SCR, 400 V, 4 A in a T-126 package, Motorola or equiv.
Other components
NE1, NE2—neon tubes, miniature
T1—transformer, inverter, 3 kilohm CT, iron core, audio, miniature PC mount
T2—transformer, trigger type, 250 V primary, 6 kV secondary
Miscellaneous printed circuit board; passive night-vision monoscope with imaging tube and optics (see text); active night-vision scope with converter tube (see text); plastic project box (see text); 9-volt alkaline transistor battery, 9-volt transistor battery clip with wires; miniature toggle switch, PCB mounted; plastic sleeving; RTV silicone potting compound; tinned copper wire, 22 AWG; insulated hookup wire, 22 AWG, solder.

Note: The following items are available from Oatley Electronics, P.O. Box 89, Oatley, Sydney, NSW, Australia 2223: Phone 011 61 2 579 4985 (Time zones USA—East 7 PM to 2 AM, Central 6 PM to 1 AM, Mountain 5 PM to 12 AM, Pacific 4 PM to 11 PM), Fax 011 61 2 570 7910. Mastercard and Visa accepted with telephone or fax orders, International bank drafts and money orders accepted by mail. Customers please include phone and/or fax number.
- **Complete kit of passive night-vision scope and parts for the HV power supply—$220.00**
- **Complete kit of active night-vision scope and parts for HV power supply—$90.00**
- **Kit of parts for HV power supply only—$24.00**
- **Kit of non-standard parts (T1, T2, NE1, NE2, and C2)—$8.00**

Include $15.00 for shipping and handling, $6.00 for air mail from Australia.

diodes must be rated to withstand at least 4.5 kilovolts. For this reason, the capacitors are all rated at 5 kilovolts, and the diodes are high-voltage units.

The neon lamps regulate the output so that the voltage applied to the primary of T2 is constant at 150 volts, peak. Although the power supply output is nearly constant for DC input voltage from 6 to 12 volts, the operating frequency of the inverter/ oscillator increases with the DC input voltage. The waveforms and frequencies shown on Fig. 4 were obtained with a 9-volt input.

Building the power supply

All the electronic components of the power supply except the capacitors and diodes in the voltage tripler are mounted on a $1^{15}/_{16} \times 1^{1}/_{15}$-inch printed-circuit board that will fit with a 9-volt rectangular battery inside a 2 × 3¼ × 1-inch plastic project case. A foil pattern has been provided here for those who want to make their own circuit boards.

Refer to parts placement diagram Fig. 5. Insert SCR1 so that its metal heatsink faces neon lamp NE2. When inserting electrolytic capacitor C1 and diodes D1 and D2, observe their polarities. Mount resistor R1 vertically on the circuit board. Solder all components and trim excess lead lengths.

Refer back to the schematic Fig. 4, and wire the leads of capacitors C3 to C8 and diodes D3 to D8 together mechanically to form a rigid unit according to the schematic. Keep all exposed lead lengths about ¼-inch long. Then solder the network together as rapidly as possible to avoid applying damaging excessive heat to the capacitors and diodes. The cathodes of some diodes are identified with a red dot on the cathode lead.

Figure 6 shows the completed power supply with the tripler network to the right of the board. Battery B1 and switch S1, both off-board components, are not shown. Solder one lead from C3 and one lead from C6 in the tripler network to the terminal points on the circuit board, as shown in Fig. 5. (The tripler will be potted in silicone after the system has been tested.)

NOTE: The image converter tube in the active night-vision scope shown in Fig. 2 requires a positive ground. If you build this unit, reverse diodes D3 to D8 to convert the supply from one with a positive to a negative output with respect to ground.

Mechanical assembly.

Drill a hole in the body of the plastic project case for mounting the miniature toggle switch S1. The location of the switch is not critical, but it should not interfere with the other components. In the passive night-vision scope, it was positioned at the end of the case facing the eyepiece.

Drill the hole in the case for mounting it to the passive scope body with a single screw. The hole for this screw, already drilled and tapped in the body of the scope, is located under the coupling bracket. Drill another hole large enough to pass the power cable to the image tube. Its location will depend on the project you build. Mount switch S1 in the sidewall of the case. Fasten the case to the passive viewer with a screw. If you build the active viewer, cement the case to the scope body with epoxy, as shown in Fig. 2.

Cut the supply lead from the scope about 6 inches long, and strip back about 1 inch of the jacket to expose the braid and the insulated central conductor. Twist the braid into a lead and insulate it with a length of plastic tubing. Insert the cable lead into the project box, solder the braid to the ground connection of the circuit board, and solder the inner conductor to the high-voltage terminal of the tripler network, as shown in Fig. 4.

Verify that there are no short circuits in the construction of the tripler and that the leads are spaced by at least ¼-inch from each other. Wire toggle switch S1 in series with the positive lead from the battery clip. Cut the battery leads from the circuit board so they are long enough to permit lifting the circuit board out of the case. Insert the battery and wiring in the case, but leave the tripler network and circuit board outside temporarily.

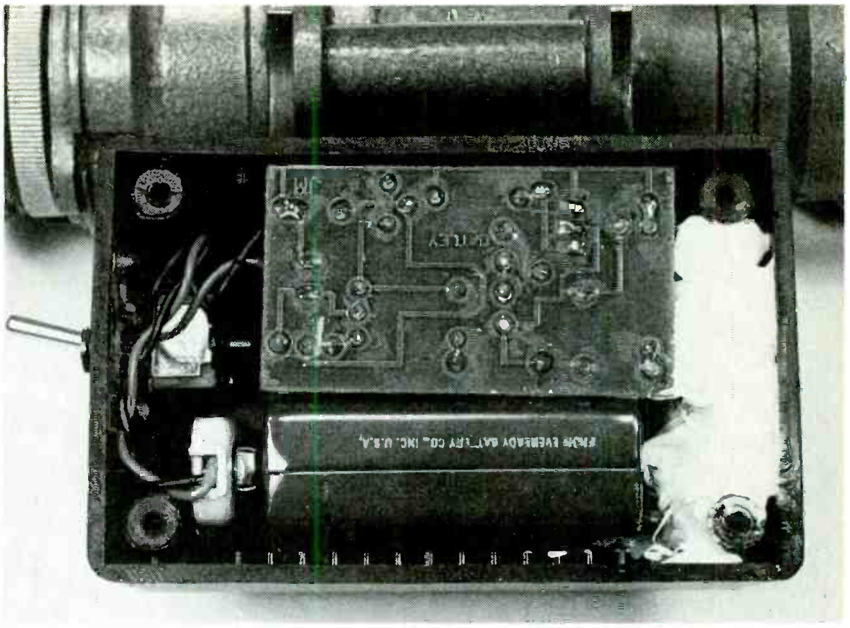
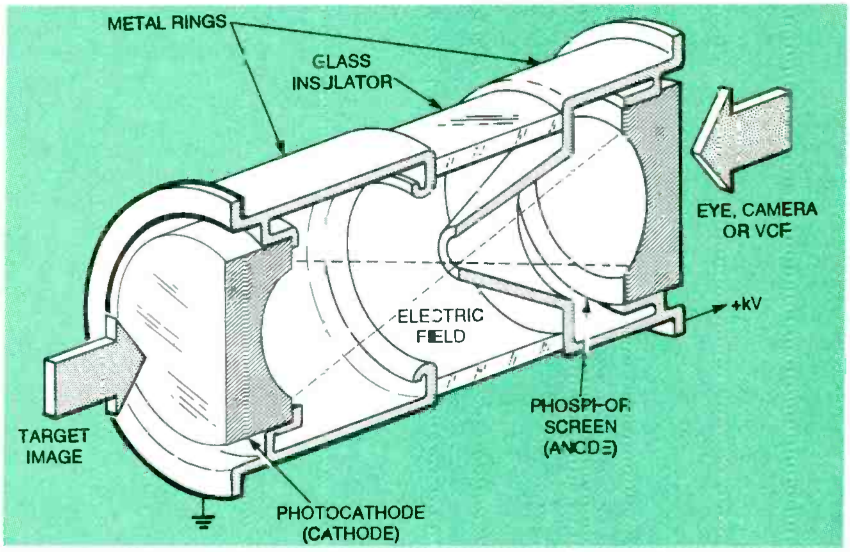


FIG. 7—POWER SUPPLY CIRCUIT, battery, and switch in the project case. The tripler network potted in silicone is shown as the white patch at right.



CUTAWAY VIEW OF SINGLE-STAGE image tube showing the position of its key parts.

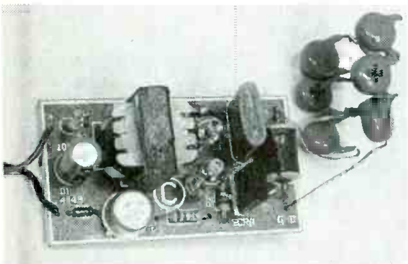
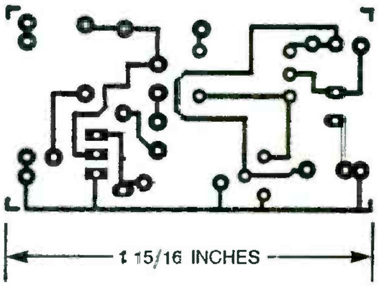


FIG. 6—COMPLETE HIGH-VOLTAGE power supply circuit board with the voltage-tripler, diode-capacitor network shown unpotted at right.



FOIL PATTERN FOR POWER SUPPLY circuit board.

Test and checkout

After rechecking your work and verifying the polarities and orientation of all components, snap the battery to the battery clip. The current drain on a 9-volt alkaline transistor battery should be about 20 milliamperesin a correctcircuit.

WARNING! The power supply described in this article produces an output voltage of about 13.5 kilovolts, and is capable of giving you a startling electric shock. While not normally life-threatening, it can have a temporarily debilitating effect. Consequently, treat it with respect and always make sure switch S1 is off and the capacitors are discharged before handling the circuit board.

When you switch on S1, a corona discharge might appear around the tripler network. This is non-destructive, but avoid electrical shock by keeping your hands away from that part of the circuit.

Alternatively, you can test the power supply by placing a wire connected to the circuit's ground bus close to the high-voltage output lead. It should produce an arc as much as ¼-inch long.

When the switch is off, connect the ground wire directly to the high-voltage output to discharge all the capacitors. Because of the short-duty cycle discharge pulses, the illumination of neon lamps NE1 and NE2 will be visible only in darkness.

If power supplies have been built and installed correctly, the phosphor screen of the image tube should emit a green glow, whether or not light is incident on the cathode. The green glow persists for a about a minute after the power has been switched off, indicating that sufficient voltage still exists between the anode and cathode to form an image.

If, after following the directions closely and checking your workmanship, the scope still doesn't work, check the voltages at the base and collector of transistor Q1 with a digital voltmeter. The values shown on the schematic, Fig. 4, are DC values expected with a 9-volt power supply.

Do not attempt to measure the high-voltage output directly unless you have a suitable high-voltage probe on your meter. The waveforms shown were also obtained with a 9-volt supply. If you don't have an oscilloscope available, measure the AC voltage at the test points shown on Fig. 4.

The reading on most digital voltmeters will be RMS values, but they will give you a valid indication if there is a signal. The AC voltage at the cathode of D2 (to ground) of the prototype measured about 45 volts RMS on a DMM. The AC voltage at the base of Q1 was about 0.45 volt RMS.

When the scope is working properly, switch off the power and wait for the tube to discharge completely. Insert the tripler section carefully inside the case as shown at the right side of Fig. 7. Encapsulate it with neutral-cure, room-temperature vulcanizing (RTV) silicone potting compound to prevent high-voltage corona and discharge, which increases with relative humidity. The compound will also fasten the tripler network inside of the case.

IMAGE CONVERTER AND INTENSIFIER TUBES

An image tube is a vacuum tube that converts an image in one part of the electromagnetic spectrum to another part of the spectrum, usually with an increase in intensity. If, for example, you want to convert a near-infrared (IR) image to a visible light image, you would use an *image converter tube*. This is the tube in the active night-vision scope described in this article. However, the scene must be illuminated by an infrared source if the scope is to function.

However, if you just want to intensify a scene in darkness you would use an *image intensifier tube*, the kind included in the passive night-vision scope described here. The figure shows a simplified cutaway view of this kind of tube. While it is also sensitive to near IR, it is still called an image intensifier.

Both tubes have photoemissive input surfaces at their cathode ends that form an electron image of the scene being viewed when a voltage of 4 to 20 kilovolts is applied between the cathode and anode. Photons from the scene or target are focused on the photocathode which triggers an avalanche of electrons. The anode accelerates the cascaded electron emission from the photocathode and focuses them on a phosphor screen to display the image.

Image tubes are now made in many different sizes with different photocathodes, electron focusing techniques, and gain mechanisms. The tubes in the night-vision scopes described here are examples of first (or zero) generation, single-stage converters that are electrostatically focused. More advanced tubes obtain higher gain by cascading two or more converter stages.

For night-vision applications, the earlier generations of image tubes had simple glass lenses and S25 photocathodes that closely match the peak sensitivity of the human eye. These tubes produce a high-definition black and green image. The latest versions now have fiber-optic lenses, gallium-arsenide photocathodes, and gain stages called *microchannel plates*.

In night-vision scopes, the image must be formed on the cathode by an objective lens similar to a camera lens, and the scene is viewed at the anode end with an eyepiece.

It is important to remember that no passive image intensifier tube will work in complete darkness. It must gain enough light from natural background sources to work. These might only be barely perceptible even to the night-adapted human eye. The sources could be faint sky glow on a cloudy night, starlight on a clear night or moonlight.

Viewing with the scope

The lens of the surplus Russian passive night-vision scope specified in this article is focused to infinity, making it useful for viewing images more than a few meters away. By loosening a small locking screw, the lens can be adjusted. This will permit viewing objects more than 100 meters away under near starlight illumination.

Imaging tubes will be damaged if they are exposed to bright light for long periods. Don't use either scope in sunlight, or even in well lighted rooms. Always cover both ends of a night-vision scope with suitable lens caps when it is not in use to keep the imaging tube in darkness. The monocular passive scope offered by the source given in the parts list has a rubber lens cap that can be snapped in place. It also has a focusing eyepiece.

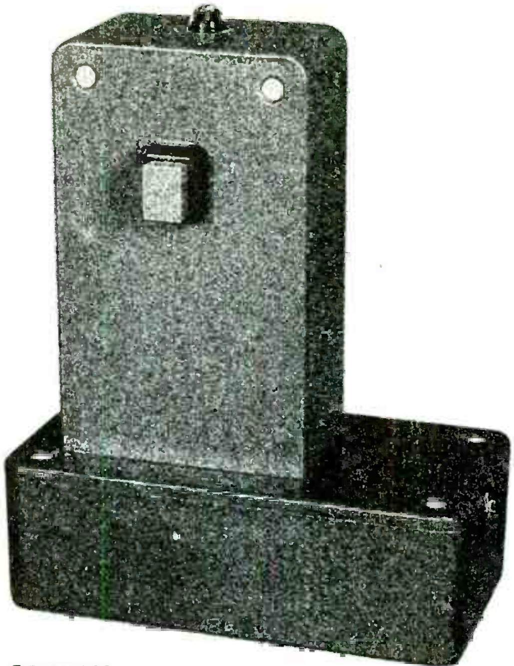
Both of the night-vision scopes will detect IR energy, so they can verify the operation of stereo and TV remote controls. In a darkened room, point the emitting face of the control at the scope. A pulsing green light will be seen when any of the remote control's keys are pressed. A TV remote control can also serve as a temporary IR illuminator.

IR light source

A better IR source can be made by covering a flashlight with an IR filter. You can pur-

Continued on page 73

AUTOMATIC RECHARGEABLE FLASHLIGHT



Build this combination rechargeable emergency light/flashlight with a bright, high-efficiency LED lamp.

MARC SPIWAK

A BRIGHT LIGHT-EMITTING DIODE (LED) with a rechargeable battery and recharging circuitry in one module and a step-down transformer for battery recharging in a second module form this unusual combination emergency light/flashlight, the subject of this article. The LED in the portable module turns on automatically when it is removed from the transformer module. Its light source is a high-intensity, aluminum gallium arsenide (AlGaAs) LED that can beam a saucer-sized red spot on a wall three feet away.

The Hewlett-Packard HLMP-8150 red, T4-size LED lamp emits a typical intensity of 15 candelas (cd) at 20 milliamperes. (This compares with about 4 millicandelas (mcd) from a typical gallium arsenide phosphide (GaAsP) red T1¾-size LED lamp.) See the sidebar "What is a candela."

The forward voltage of the LED is only 1.85 volts. It offers longer life and lower power dissipation and cooler operation than an incandescent lamp, the usual light source for most flashlights and emergency lights. Its clear, nondiffused, bullet-shaped lens focuses the light into a narrow, intense 4° beam. The LED's dominant red (637-nanometer) wavelength will not disturb the eye's adaptation to night viewing.

A flashlight with a high-intensity LED lamp would probably not be your first choice as an illumination source for exploring under the hood of your car at night to find out why it won't start. Moreover, you'd probably find the light inadequate for searching for lost objects or summoning help at night.

However, it will provide enough light for you to read a roadmap or find the circuit breaker that kicked out, darkening your house. It might also help you find your way around a campsite, or even change a tire at night.

The LED flashlight module is powered by four AA nickel-cadmium (Ni-Cd) power cells. Because each cell has a nominal output of 1.2 volts, four cells in series provide about a 4.8-volts.

Flashlight module

Figure 1 is the schematic for the flashlight module. When the battery pack consisting of the four Ni-Cd cells is fully charged (and there is no voltage at J1), 4.8-volt DC flows through trimmer potentiometer R2, the normally closed contact of relay RY1, and push-on, push off power switch S1. Trimmer R2 limits the current flowing through LED1. Switch S1 can turn LED1 on and off when the battery is not being charged. (The trimming function of R2 will be discussed later.)

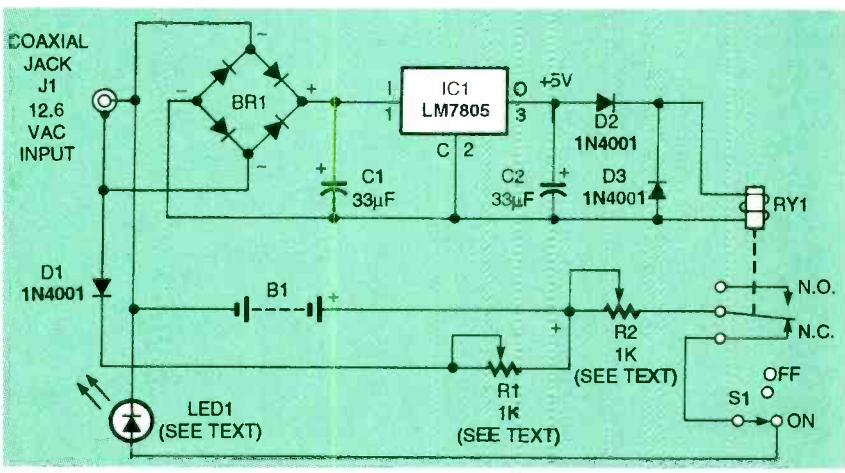


FIG. 1—SCHEMATIC FOR FLASHLIGHT MODULE. When relay RY1 is energized, it cuts the power to the LED; when power to the relay is removed, the LED lights.

If 12.6-volts AC is present at J1, it is full-wave rectified by bridge rectifier BR1. Capacitor C1 smooths the rectified AC ripple. Five-volt regulator IC1, a National Semiconductor LM7805, provides the 5-volt DC output.

This output, sustained by C2, energizes the coil of relay RY1, which opens the normally closed contacts. Diodes D2 and D3 stabilize the relay. When the NC contacts of the relay open, power to LED1 is cut off—even if S1 is in its ON position. The values of C1 and C2 in the prototype are 33 μF, but they are not critical values. Any capacitor from 20 to 40 μF would work.

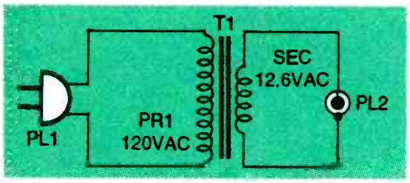


FIG. 2—SCHEMATIC for transformer module. The 12.6-volt output from coaxial plug PL2 powers the flashlight when it is mated with jack J1 on the transformer module.

When the relay is energized, AC power from J1 flowing through D1 is half-wave rectified to form a pulsed-DC output for charging the Ni-Cd cells. Potentiometer R1 limits the charging current to the cells. A voltage of 12.6 volts is enough to charge the 4.8-volt battery pack.

When the batteries are being charged, the relay is energized, inhibiting LED illumination. When charging current is removed, the relay provides a conducting path to the LED. Thus the LED turns on whenever the AC-line voltage is cut off if S1 is ON.

Transformer module

Figure 2 is the schematic for the transformer module. Line voltage taken from a 120-volt AC outlet is transformed to 12.6-volt AC by transformer T1. The line cord is terminated with plug PL1, and the 12.6-volt AC appears at coaxial power plug PL2. The plug mates with coaxial jack J1 on the flashlight module for recharging. As long as the transformer module is plugged into the AC line, 12.6-volts AC appears. When PL2 is plugged into J1, 12.6 volts appears at J1.

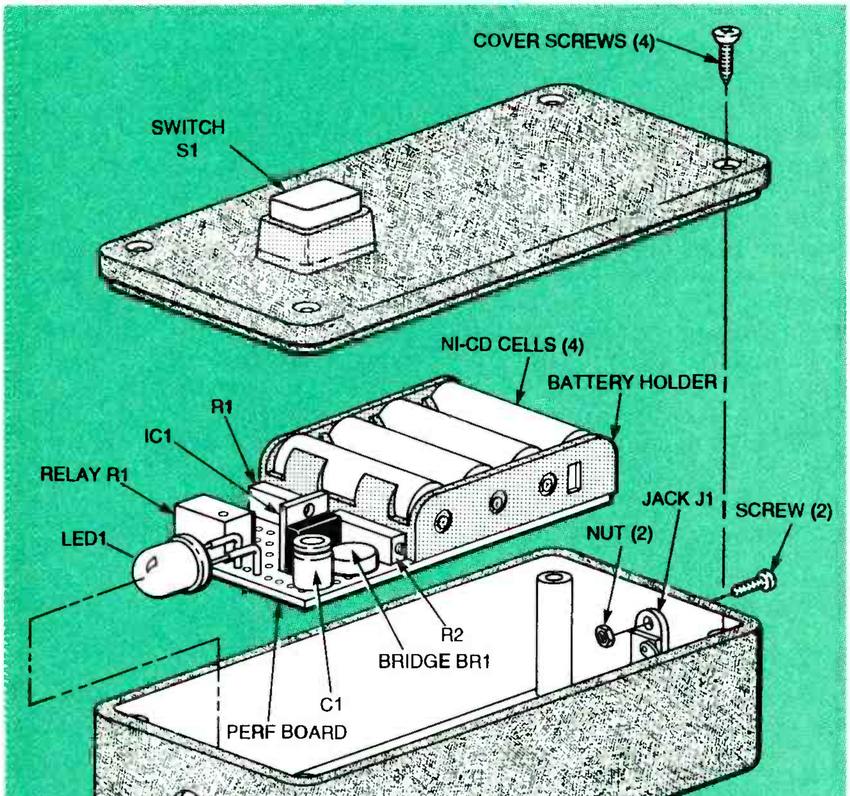


FIG. 3—FLASHLIGHT MODULE ASSEMBLY. The circuit board contains the electronic components and battery holder. The LED lens projects through a hole in the case. Jack J1 is at the other end of case, and switch S1 is on the cover.

Building the flashlight

Refer to Fig. 3. The modular case for the flashlight measures 4¾ × 2½ × 1⅜ inches, and has four raised round surfaces molded on its bottom surface that act as feet. Sand or file these bumps flush with the bottom surface so they will not interfere with the insertion or removal of the flashlight module from the transformer module.

Cut out an approximately ½-inch diameter hole in one end wall of the case to admit the LED lens and a second hole in the opposite end wall for jack J1, as shown in Fig. 3. When cutting the hole for the jack, be sure the center conductor rather than the body of the jack is centered on the end wall. Drill the two mounting holes for the jack.

Cut a piece of perforated construction board 3½ × 2¼ inches to fit snugly in the bottom of the case. Insert the electronic components for the flashlight on that board, and connect them by point-to-point wiring.

Mount LED1 on the end of the board, and solder it so that its leads can later be bent at right angles to permit the lens to extend through the hole in the case. Figure 3 shows the locations of the largest electronic components, but their locations are not critical.

Make only mechanical connections to potentiometers R1 and R2 so you can later put an ammeter in series with them to adjust both charging and LED forward current. Fasten the battery holder for four AA cells on the board with double-sided adhesive tape.

Cut a hole in the plastic cover,

and fasten the push-on, push-off switch S1 in position with a ring nut. Fasten jack J1 in the case with small screws and nuts.

Complete all of the wiring to the switch S1 and jack J1 according to schematic Fig. 1, allowing enough slack in the wires to permit the board to be removed for later adjustments. Fasten the circuit board to the bottom of the case with double-sided adhesive tape, and carefully bend the leads of the LED so that the lens projects through the end hole in the case.

Building the XFMR module

Refer to the transformer assembly drawing Fig. 4. Cut a ⅛-inch diameter hole at one end of a second plastic project case that measures 4¾ × 2½ × 1⅜ inches to admit the line cord terminated by line plug PL1.

Cut a rectangular hole that measures approximately 2⁹⁄₁₆

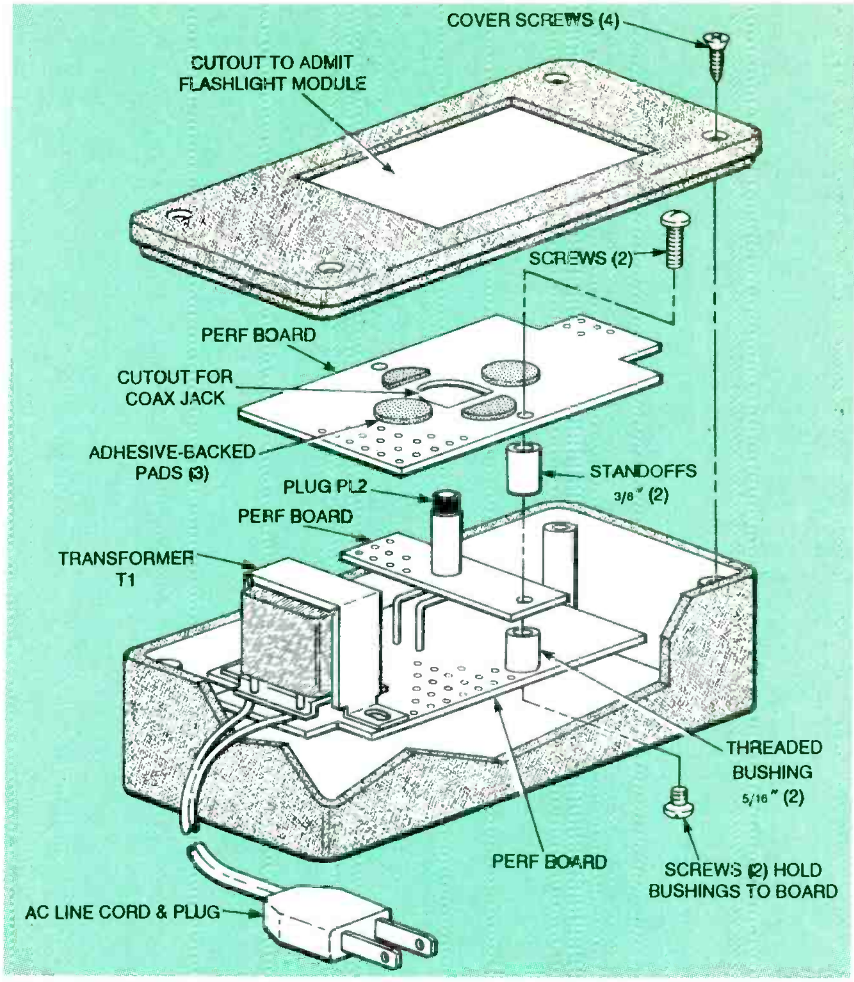
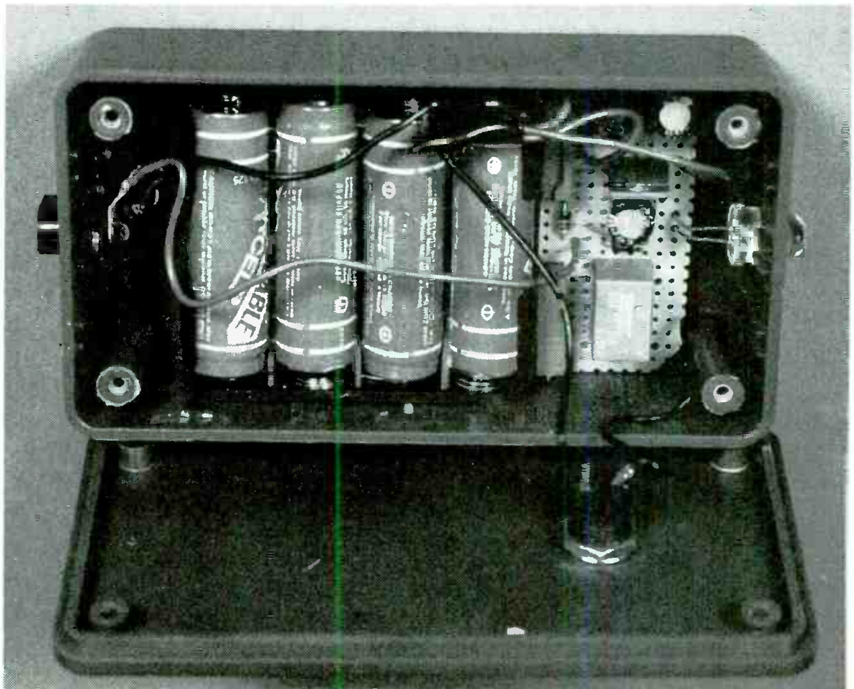


FIG 4—TRANSFORMER MODULE ASSEMBLY. A cutout in the cover admits the flashlight module. The upper board supports the flashlight when jack J1 is plugged into plug PL2 on the middle board. Transformer T1 is on the bottom board.

PARTS LIST

Resistors
R1, R2—1000 ohms, multiturn potentiometer (A 1K resistor might be needed in series. See text)
Capacitors
C1, C2—33 µF, aluminum electrolytic (see text)
Semiconductors
IC1—LM7805 5-V regulator, National Semiconductor or equiv.
D1–D3—1N4001 rectifier diode
LED1—light-emitting diode, T-4 Hewlett Packard HLMP-8150 or equiv.
BR1—1A bridge rectifier, Radio Shack 276-1161 or equiv.
RY1—SPDT relay, 5-VDC, 90 mA coil, 55-ohm, Radio Shack 275-240 or equiv.
Other components
S1—SPST switch, push on/push off, Radio Shack 275-1565 or equiv.
B1—four AA Ni-Cd cells
J1—coaxial power jack, Radio Shack 274-1565 or equiv.
PL1—AC line cord
PL2—coaxial power plug, Radio shack 274-1578 or equiv.
T1—120/12.6 VAC, 300 mA, transformer, Radio Shack 273-1385 or equiv.
Miscellaneous: two project cases (seetext); perforated construction board; holder for four AA cells; adhesive pads, double-sided ashesive tape, screws and nuts; hookup wire; solder



FLASHLIGHT MODULE with cover removed showing the four Ni-Cd cells, LED, and circuit components.

WHAT IS A CANDELA?

The amount of light produced by a light source is called *luminous intensity*. The standard for measuring luminous intensity is the *candela* (cd). It was formerly the *candle* based on the luminous intensity of a single wax candle. By comparison, a 40-watt light bulb has a luminous intensity of about 3000 candela.

The candela is the amount of light that shines out through a hole with an area of 1/60th of a square centimeter in one side of a ceramic box that has been heated to the temperature of molten platinum (1772°C). It is the basis for both the calculation of the *lumen* (lm) and the *foot-candle*(fc).

A 1-cd light source produces a 1-lm light beam that provides 1 fc of illumination on a 1 ft^2 area located on a radius of 1 foot from the source (1 fc = lm/ft^2). The intensity of light falling on a surface varies inversely with the square of the distance between the source and the surface.

× 1 9/16 inches in the cover of the case so that it will admit the end of the flashlight module. Scribe the outline of the end dimensions of the case on the top of the cover with a sharp cutting tool, leaving a pronounced rectangular mark. Drill holes in the four corners and saw an "X" diagonally across the scribed marks with a fine coping saw. Snap off each of the four triangular-shaped pieces along the scored lines.

There are three perforated circuit boards in this module. The largest is positioned at the bottom of the case to support transformer T1, the middle one supports the plug PL2, and the upper one acts as a shelf and support for "docking" the flashlight module. These three boards will be fastened together to form a three-deck assembly with threaded bushings, standoffs, and screws.

Cut the large base board from perforated board 3½ × 2¼ inches. Notch out two corners of the board so it can be positioned against one end wall of the case without interfering with the internal posts.

Cut the small board from perforated board 2¼ × 1 inch to form the plug support. Drill a central ¼-inch hole to admit plug PL2 when the flashlight module is "docked."

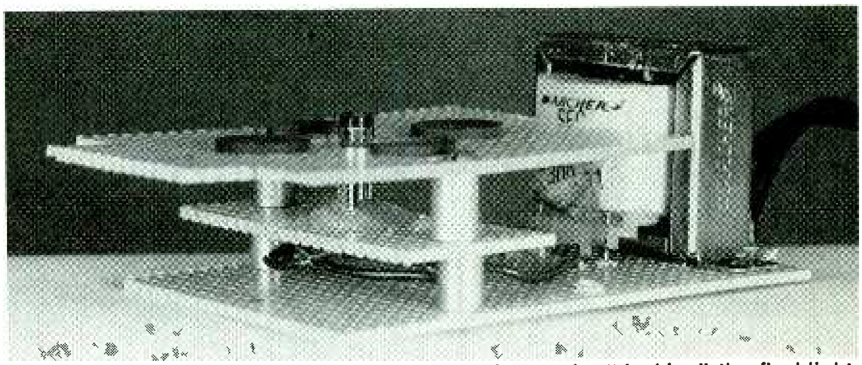
Cut the upper deck from perforated board 2¼ × 3 inches. Notch out two corners at one end so it does not interfere with the posts at the other end of the case. Cut a ½-inch diameter hole in the center of the board to admit the outer shell of jack J1 when the flashlight module is "docked."

Stack the three boards as shown in Fig.4, and drill holes on each side through all three boards to admit screws so the boards can be fastened in a three-deck stack.

of the case. Place adhesive-backed plastic pads around the central hole on the upper board to cushion the "docking" procedure.

Current adjustments

Adjust potentiometer R1 first. (Potentiometer R2 can't be adjusted accurately until the battery is fully charged.) Before you insert the batteries in the holder, set R2 so that its maximum resistance value is in series with the LED.



THREE-DECK ASSEMBLY in transformer module permits "docking" the flashlight module.

Fasten the power plug (PL1) in a vertical position in the middle of the board with hot-melt glue. Mount transformer T1 on the lower board near one end, as shown in Fig. 4.

Trim the ends of the wires in the line cord to expose about ⅛ inch of bare copper wire, and insert the cord through the hole in the case. Solder the leads to the primary terminals of T1. Cut two 5-inch lengths of insulated, stranded, hookup wire, and solder them to the secondary terminals of T1 and the terminals on plug PL2.

Assemble the three boards together to form the three-deck assembly. Fasten the lower threaded bushings to the top of the base board with screws from the underside of the board. Then assemble the second board on the bushings and place the top board in position with screws through the two standoffs.

When the assembly is complete, fasten it in the bottom of the case with double-sided adhesive tape. It can also be fastened with sheet metal screws through holes from the bottom

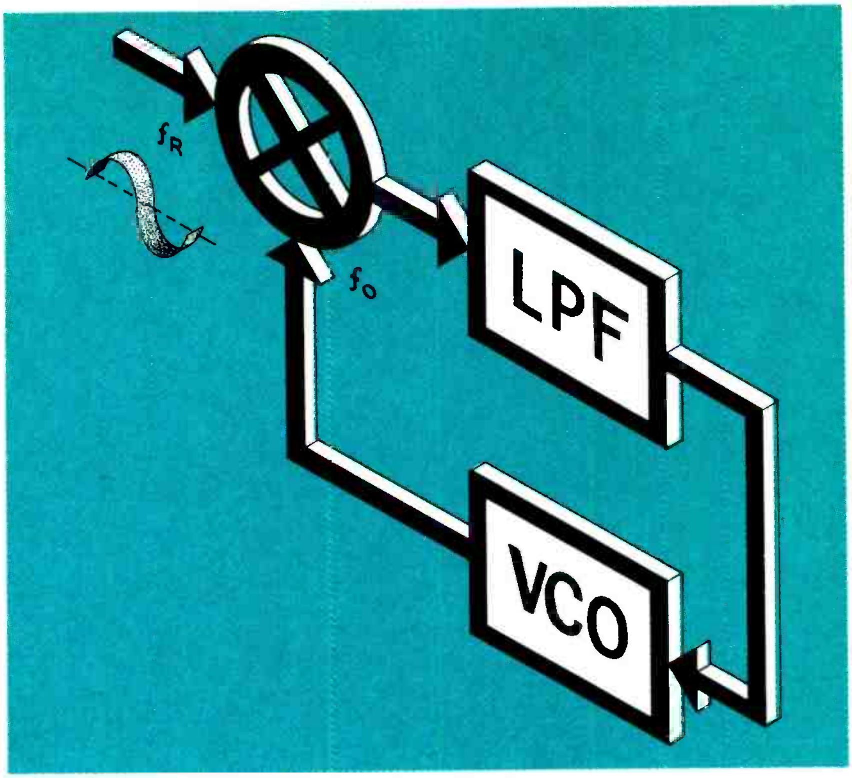
Charge the Ni-Cd cells slowly at a 45-milliampere rate for 45 hours, or fast charge them at 150 milliamperes for four hours.

Once the battery is fully charged, set R1 for a trickle charge of about 10 milliamperes by temporarily inserting an ammeter in series with R1. If the current can't be set low enough, insert a fixed 1-kilohm resistor in series with R1—or use a potentiometer with a higher resistance value. Once R1 is set, solder it permanently.

Adjust R2. The forward current through the LED should not exceed 30 milliamperes. Set the maximum forward current to 300 milliamperes and adjust R2 as was done with R1. If the current can't be reduced low enough, add a 1-kilohm fixed resistor in series with R2. Then solder R2 permanently.

Plug the charger into an outlet, and set S1 in its ON position. LED1 should light when the flashlight module is removed from the charging module and go off when it is in the charger module. You now have a nifty emergency light/flashlight. Ω

RAY MARSTON



PHASE-LOCKED LOOPS

Experiment with these phase-locked loop circuits, and put them to work in your designs.

THIS ARTICLE PICKS UP WHERE LAST month's article on phase-locked loops left off. Last month the basic principles of the phase-locked-loop were explained and the functional sections of a popular CMOS PLL IC, the CD4046B were described. The circuits presented in that article showed various ways to configure the voltage-controlled oscillator (VCO) section of the CD4046B for practical frequency-dependent applications.

Sound-effects generators

The versatility of the VCO section of the CD4046B IC was explained last month. Its operating frequency can be swept over a very wide range under the control of voltages applied to pin 9. Moreover, its output can be gated on or off with a voltage applied to pin 5. These characteristics make the CD4046B suitable as the principle component in many different circuits for sound-effects generation. Figures 1 to 6 are schematics for sound-effects generators.

The circuit in Fig. 1 can emit a conventional siren sound. It produces a tone that rises slowly to a maximum value when S1 is closed, and falls slowly from that maximum to silence when S1 is opened.

This response is caused by the voltage on C1 that is applied to voltage-control pin 9. It rises exponentially through R1 when S1 is closed, and falls exponentially through R2 when S1 is opened. Resistor R3 ensures that the operating frequency falls to zero when the voltage at pin 9 is zero. The VCO output is AC coupled to the speaker through C4 and transistor Q1.

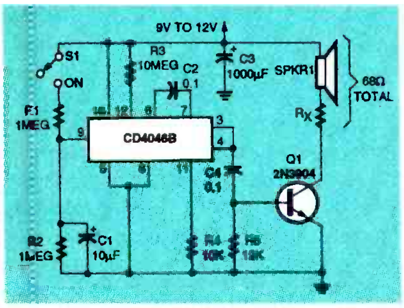


FIG. 1—ELECTRONIC SIREN CIRCUIT based on a CMOS CD4046B PLL IC.

Figure 2 shows how the Fig. 1 circuit can be modified to give a quick response in which the frequency rapidly switches to its maximum value when S1 is closed (as C1 discharges exponentially through R3). Figure 3 shows another circuit modification that generates a "phasor" sound (similar to that heard aboard the starship Enterprise in the Star Trek TV series) when pushbutton switch S1 is closed. In this circuit, the CD4011B IC is configured as an astable multivibrator that is gated through S1. It produces a chain of 4 millisecond pulses at intervals of 70 milliseconds.

Each pulse rapidly charges capacitor C2 through R3 and D2 to produce a high tone which decays slowly as C2 discharges through R5. The cycle is repeated again on the arrival of the next pulse.

Figure 4 shows a different kind of sound-generator circuit that can generate either a pulsed or warble tone, depending on the setting of S2. Pushbutton switch S1 simultaneously enables pin 5 of the CD4046B to gate on the CD4001B astable multivibrator which, in turn, applies a rectangular (alternately fully-high and fully-low) waveform to the IC's pin 9.

In the *pulsed* mode, the VCO generates zero frequency when pin 9 is low, but in the *warble* mode it generates a tone that is 20% lower than the high tone generated when pin 9 is low.

Figure 5 is a circuit that produces a special-effects *run-*

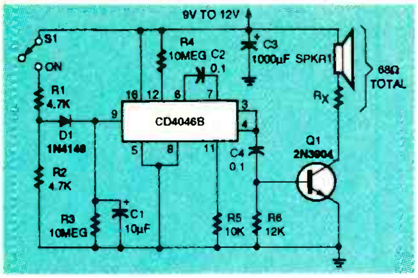


FIG. 2—QUICK-START SIREN CIRCUIT based on a CD40466B PLL IC.

down clicking sound like that of the big "wheels of fortune" seen in television game shows. The time between clicks is constant after pushbutton switch S1 is pressed. However, when S1 is released, the time between clicks increases as the "wheel" apparently slows to a standstill. The circuit operates as follows:

When PB1 is pressed, C1 rapidly charges to a high voltage through D2. Simultaneously, Q1 is biased on through the combination of D3 and R4, which connects R6 between pin 11 and ground. This makes the VCO operate at tens of kilohertz, effectively generating a random number of clock pulses.

When S1 is released, Q1 is turned off and the timing of the VCO is governed by R7. At the same time, C1 discharges rapidly to half the value of the supply voltage through R1, R2 and D1. This discharge causes the VCO to operate at about 100 Hz. Capacitor C1 then slowly discharges through R3, and the VCO frequency slowly decays to zero in about 15 seconds.

The output of the circuit in Fig. 5 can directly clock most counters. It can be directly coupled through R9 to an external crystal or ceramic transducer to produce low-level run-down sounds.

The circuit's output can settle in either the logic-zero or logic-one state when the run-down is complete. Therefore, the output should not be DC coupled to circuits such as power amplifier stages.

Figure 6 is a schematic showing how the circuit in Fig. 5 can be modified to ensure that its output always settles in the logic-zero when run-down is complete. This modification make the circuit safe for direct-coupling the output to power amplifier stages.

In this circuit, the CA3140 operational amplifier is configured as a voltage comparator. It is set up to turn the VCO off automatically and drive its output low through pin 5 when the voltage at pin 9 falls below a reference value of about 2 volts. (It is set on pin 3 of the op-amp).

Special VCO circuits

The VCO section of the CD4046B is so versatile that it lends itself to a wide variety of special-purpose waveform generator applications. Figures 7 to 9 are examples of these circuits.

The circuit in Fig. 7 is a simple *frequency shift keyed* (FSK) square-wave generator. With the component values shown in

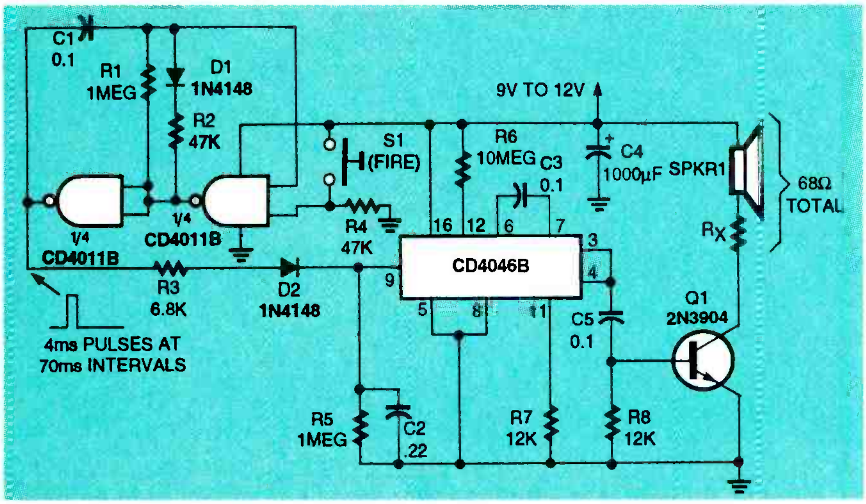


FIG. 3—PHASOR-SOUND GENERATOR circuit based on a CD40466B IC.

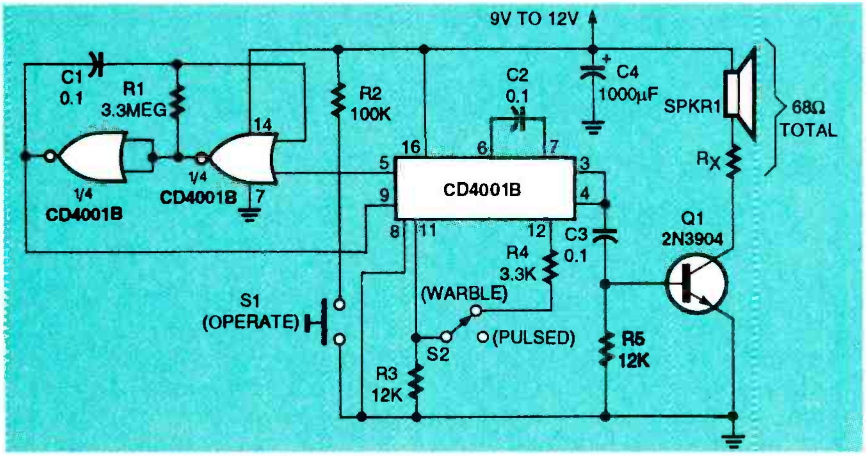


FIG. 4—COMBINED PULSED /WARBLE TONE alarm generator based on the CD4046B.

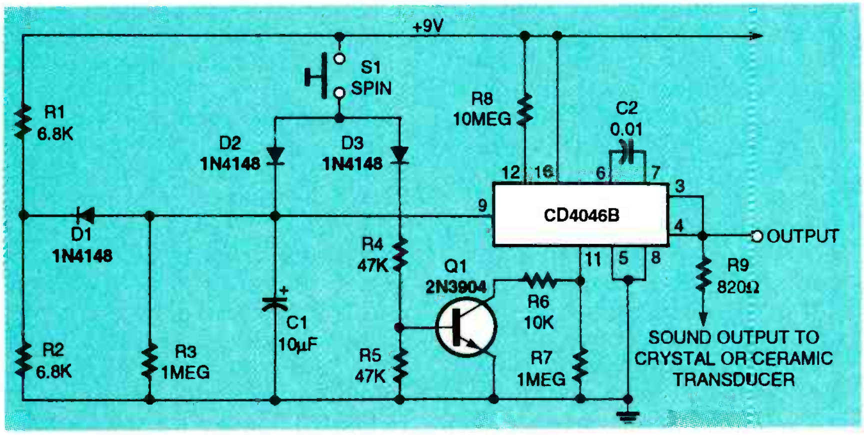


FIG. 5—RUN-DOWN CLOCK/SOUND generator circuit.

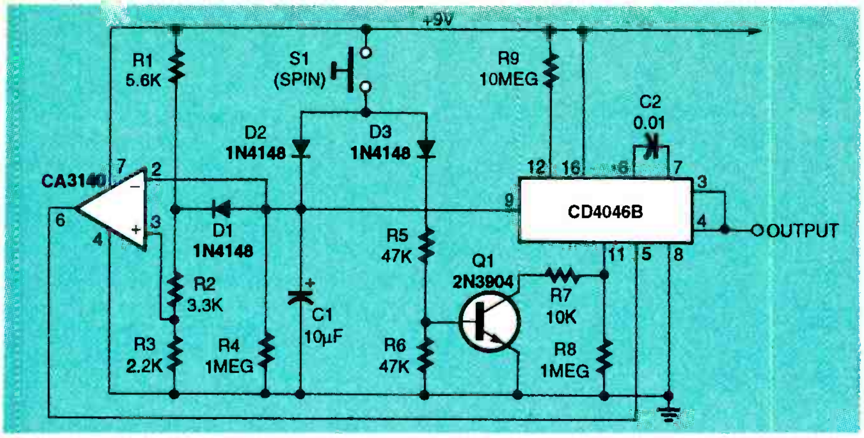


FIG. 6—MODIFIED RUN-DOWN generator circuit.

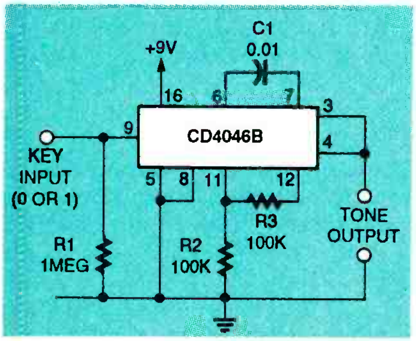


FIG. 7—FREQUENCY SHIFT KEYED (FSK) generator. Logic 0 = 1.2 kHz and logic 1 = 2.4 kHz.

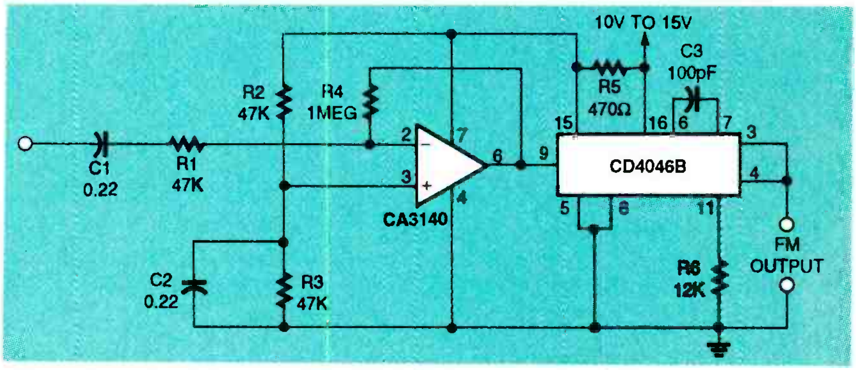


FIG. 8—FREQUENCY MODULATOR CIRCUIT generates 220 kHz.

this figure, the circuit will generate a tone frequency of 2.4 kHz when a logic-one signal is applied to pin 9. It will also generate a 1.2-kHz tone when a logic-zero signal is applied to the same point.

The high-frequency tone is set by the values of C1 and R2, and the low-frequency tone is set by the values of C1, R2, and R3. Other frequencies can be obtained by altering those component values.

The circuit in Fig.8 is a 220-kHz frequency modulation (FM) waveform generator. The internal Zener diode at pin 15 of the CD4046B provides a stable power supply for the CD3140 op-amp, which is configured as a multiply-by-20 inverting AC amplifier. It has a quiescent bias of about 2.6 volts applied to its non-inverting A input at pin 3 through R2 and R3.

As a result, output pin 6 of the op-amp produces an approximate 2.6-volt potential that is amplitude modulated with an amplified (×20) version of the audio frequency input signal. This output is applied to volt-

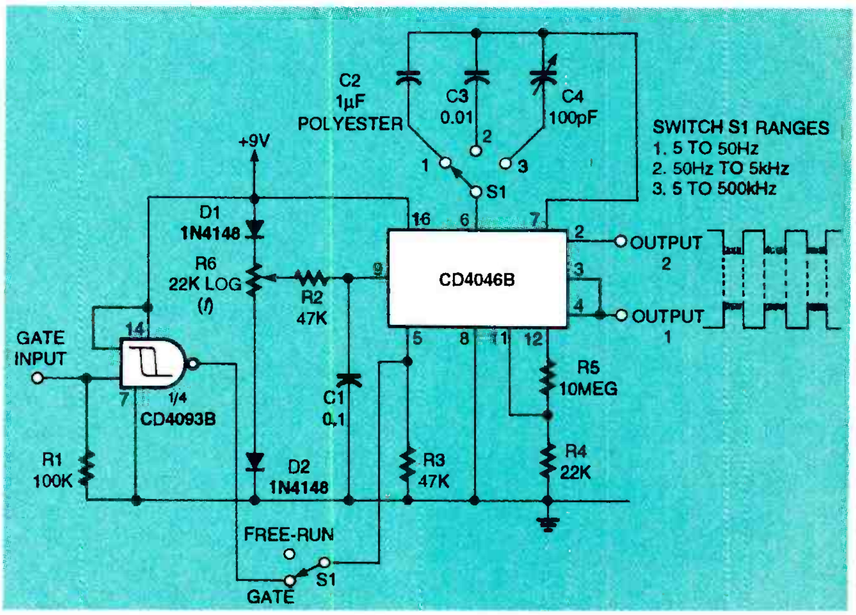


FIG. 9—UNIVERSAL CLOCK/SQUAREWAVE generator.

age-control input terminal pin 9 of the CD4046B's VCO. The component values of C3 and R6 were selected so that it generates a mean output "carrier" frequency of 220 kHz. This output frequency is modulated by the original AF input signal.

Figure 9 shows how the CD4046B VCO can be converted to a wide-range, universal, squarewave "clock" generator that covers the nominal range 0.5 Hz to 500 kHz in three switch-selected bands. This circuit can be a useful test instrument that provides a two-phase output. It can operate in either the free-funning or the gated modes.

Phase-locked circuits

The basic operating principles of the CMOS phase-locked loop (PLL) IC were explained last month. You should review that article unless you have a clear understanding of those principles before you work with the circuits presented in the remainder of this article. They will make use of all of the PLL's circuitry.

Figure 10 shows the CD4046B organized as a wide-range signal tracker. It will com-

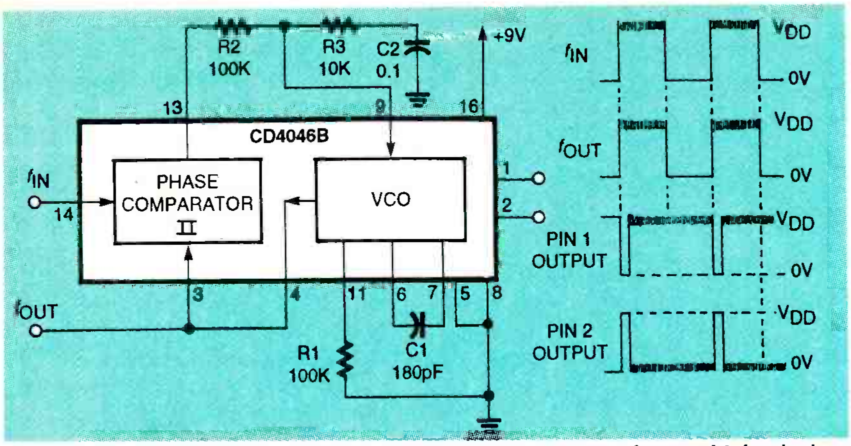


FIG. 10—WIDE-RANGE PLL SIGNAL TRACKER showing waveforms obtained when the loop is locked.

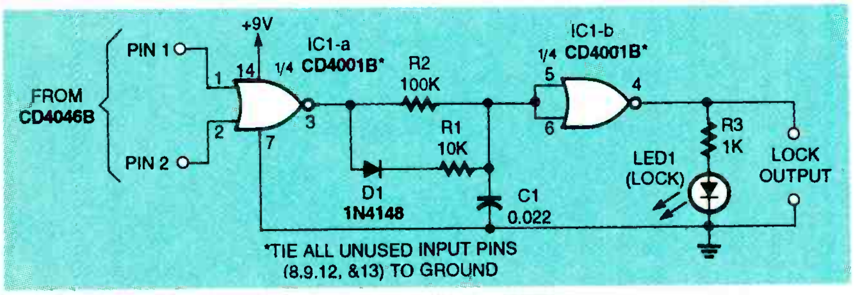


FIG. 11—PHASE-LOCKED LOOP "lock" dectector/indicator.

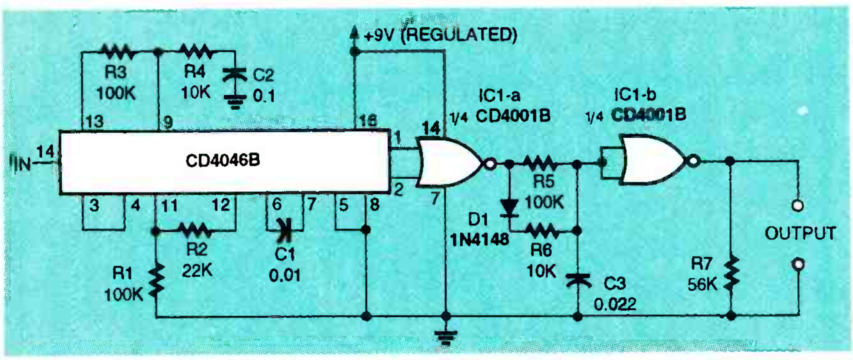


FIG. 12—PRECISION NARROW-BAND TONE SWITCH has a range of 1.8 kHz to 2.2 kHz.

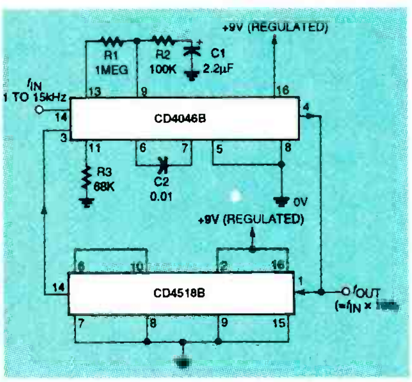


FIG. 13—A LOW FREQUENCY ×100 multiplier/pre-scaler circuit.

pute and track any input signal from 100 Hz to 100 kHz, provided that the input signal to pin 14 switches fully between the zero and one logic levels.

This circuit (and the others shown here) takes advantage of the internal wide-range phase comparator II. This circuit permits it to lock to any signal within the "span" range of the VCO. The filter formed by R2, R3, and C2 is organized as a sample-and-hold amplifier in this operating mode. Its component values determine the settling and tracking times of signal capture.

The VCO's operating frequency is determined by the values of R1 and C1 and the voltage on pin 9. The VCO "span" (and thus the capture and tracking range of the circuit) ranges from the VCO frequency value obtained with pin 9 at zero volts

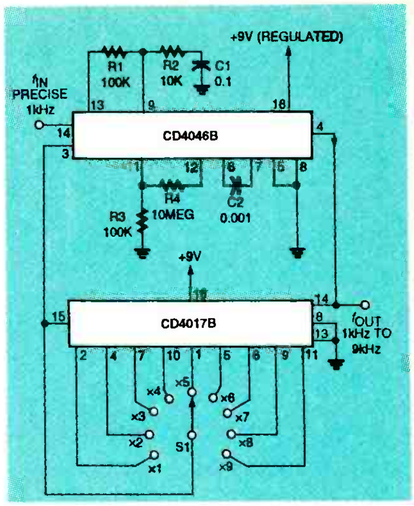


FIG. 14—FREQUENCY SYNTHESIZER covers a 1 to 9 kHz range.

to that obtained with pin 9 at the supply voltage (V_{DD}).

Figure 11 is a simple *lock detector/indicator* circuit that can be used in conjunction with the PLL circuit of Fig. 10. In the PLL, the output of each phase comparator is a series of pulses whose widths are proportional to the difference between its two input signals.

The output of phase comparator I is normally low, and that of phase comparator II is normally high, except for these pulses. When the PLL circuit is locked (see Fig. 10), the two outputs are almost perfect mirror images of each other.

In the lock detector/indicator circuit of Fig. 11, those features are implemented through two-input NOR gate IC1-a, which is driven from the outputs of the two comparators. If the loop is locked, the IC1-a output remains permanently low, thus driving IC1-b output high and turning on LED1.

If the loop is not locked, however, the IC1-a output is formed as a series of positive-going pulses that rapidly charge C1 through D1 and R1. This forces IC1-b low and holds LED1 off.

Figure 12 shows how a PLL circuit can be combined with a *lock* indicator to form a precision narrow-band tone switch. The VCO's maximum frequency is determined by R1 and C1, and the minimum frequency is determined by R1, R2, and C1.

The frequency is variable from about 1.8 kHz to 2.2 kHz with the component values shown in Fig. 12. The circuit can only lock to input signals within this frequency range.

Figures 13 and 14 are schematics for several practical *frequency multiplier* circuits. The circuit in Fig. 13 serves as a multiply by 100 frequency multiplier/prescaler that can change 1 Hz to 150 Hz input signals into 150 Hz to 15 kHz output signals.

The circuit in Fig. 14 is a simple frequency synthesizer. It is fed with a precise (crystal-derived) 1-kHz input signal, and its output is a whole-number multiple (in the range ×1 to ×9) of this signal. The CD4017B is organized as a programmable divide-by-N counter in this application. A single CD4017B can be replaced by a series of programmable decade counters to form a wide-range (10 Hz to 1 MHz) synthesizer. Ω

NIGHT VISION SCOPES

continued from page 62

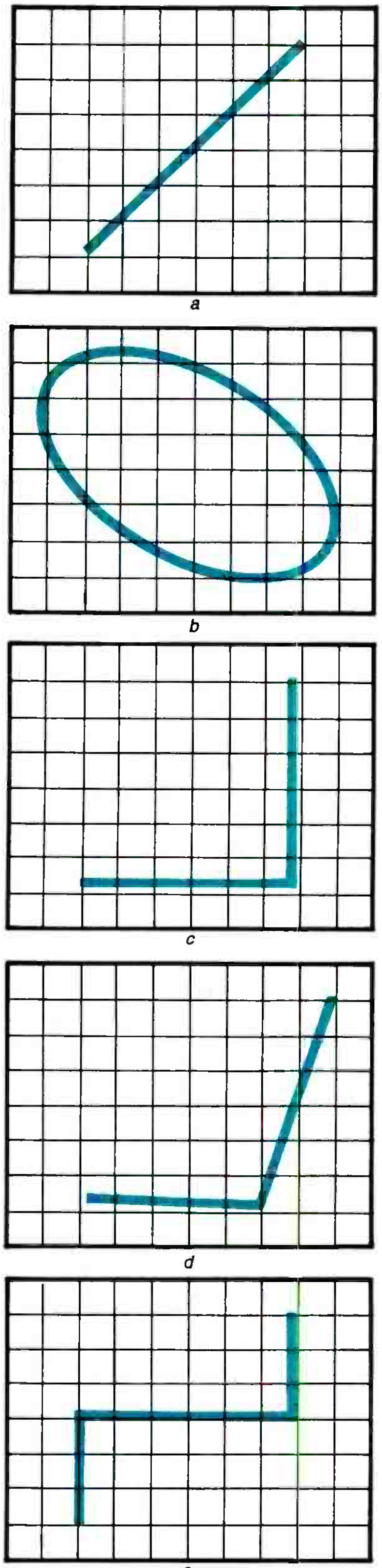
chase a suitable IR filter at most retail camera stores, or you can stack four or five layers of completely exposed, developed film negatives between the incandescent lamp and flashlight lens. This film can be obtained as scrap from local photo developing shops. Cut four or five disks from this exposed film to fit inside the plastic or glass lens cap of your flashlight.

A complete kit of parts to build both of the scopes described in this article can be obtained from the source given in the parts list. If you elect to buy a surplus image tube to make a night-vision scope from scratch, purchase or obtain a "fast" camera lens and a magnifying glass for use as an eyepiece. You can then assemble all of these parts in a suitable metal or plastic tube. The power supply described here will power most imaging tubes, regardless of their size or country of origin. Ω

FUNCTION GENERATORS

continued from page 50

Note: A copy of B&K Precision's *Guidebook to Function Generators* will be sent to any reader free of charge by addressing a request in writing to Guidebook, B+K Precision, 6470 West Cortland Street, Chicago, IL 60635.



nature represents the forward voltage drop. The vertical part of the signature represents the forward current, and the horizontal part represents the reverse voltage drop.

In the waveform for the Zener diode in Fig. 9-d, the forward current is a function of the forward voltage. But when the reverse voltage equals the PN junction breakdown voltage, reverse current increases rapidly, producing a vertical line in the lower left quadrant of the screen. This line is the *breakover point* or Zener voltage, and it is established by the knee in the signature.

The signature technique can be applied to test and explain the operation of all electronic components. It is simple to use, it can speed troubleshooting, and it works well on unpowered circuit boards. Even electronic service centers operating under tight budget constraints can afford this method.

It is worth noting that two functionally identical ICs which seem to be operating normally can have different pin signatures because of differences in chip fabrication. You might encounter this when testing functionally identical IC's from different manufacturers. Different signatures do not necessarily indicate a device fault.

With experience in the careful interpretation of signatures, signature analysis can help you to identify defective components quickly—even those with marginal problems. Defective ICs (open-circuited or short-circuited) can be isolated rapidly by persons with little or no experience doing this. Ω

FIG. 9—NORMALIZED CURRENT VS. VOLTAGE SIGNATURES for electronic components: resistor (*a*), inductor or capacitor (b), silicon signal diode (*c*), light-emitting diode (*d*), and Zener diode (*e*).

PHONE-CALL RESTRICTOR

continued from page 56

prototype unit. Run the wires through the slots and assemble the two halves of the case.

Operation

Locate a suitable phone jack in your home or business and plug in the phone cord of the Telephone Call Restrictor. Put it in a location that is not accessible to those whose phone access you wish to control, and plug the wall adapter into an AC outlet.

Refer to Table 1 for the set of programming commands that can be entered from your Touch-Tone phone. Initially, before programming, set the call restrictor to the "Allow Group" mode. Because there have not been any numbers entered into the EEPROM, all numbers that someone attempts to dial will be blocked. Pick up the phone and try to dial any number. You should hear a tone after pressing the first digit, and a busy signal will be placed on the line to prevent you from completing the call. If that does not occur, the call restrictor is not operating properly.

Make a list in advance of the telephone numbers that you want to either block or allow. If you want to add or remove numbers, that list will come in handy. When programming the unit, LED1 will light immediately prior to the input of telephone numbers and/or password, indicating thatthe curcuit is in the programming mode and that a valid password has been entered (if applicable). Until you decide on a password and have entered it into the EEPROM, omit this number wherever it appears in the programming sequence in Table 1. Be careful not to enter a password and then forget the number. If that occurs, you will have to replace the EEPROM with a blank chip.

The EEPROM has enough memory to hold 248 characters including the # sign which separates the telephone numbers.

You can enter full 7- or 11-digit numbers, or you can enter partial numbers such as 786, and all numbers beginning with that prefix will be considered part of the list. A prefix can be any length; entering 1-900 will add all 900 numbers to the list, while entering 1-9 will add all numbers beginning with 1-9 (1-900, 1-976, 1-905, etc.).

At any time you can bypass the call restrictor from any phone on the line simply by pressing #, your password, and then hanging up. The unit is then disabled until the next call is made, and is re-enabled upon completion of that call. With the Telephone Call Restrictor you can finally gain complete control of your phone, and your bill, whether at home or at work. Ω

HARDWARE HACKER

Major SETI developments, using binary chain codes, new shaft-encoder designs, battery-charging resources, and light-to-frequency converters.

DON LANCASTER

There seems to be another manufacturer making those programmable interconnects that I discussed several columns back. A startup company known as Atesla now offers products that it calls *programmable wiring* cross-point arrays.

These are dense chips, fairly low in cost, that offer good high-frequency performance. They can be programmed one time only, and are available in array sizes from 13 × 13 up to 101 × 101.

Any and all pins can be connected together in any combination with no limitations. They can handle digital or analog signals up to 30 volts of either polarity. Their final interconnects are strictly passive and draw zero current.

One warning on these devices: Beware of *sneak paths*. If you connect pins 2 to 6 and 6 to 7, you've also connected pin 2 to 7, whether you like it or not. Because there are low-resistance fuse links between pins, any pin can either be an input or an output. However, despite this introduction, a hacker-friendly, nonvolatile, cheap, dense, and re-programmable wiring chip has yet to be offered by anyone.

More thoughts on SETI

Some very interesting events have occurred lately in the search for extraterrestrial intelligence, or SETI.

After a number of false starts, convincing evidence exists that several planets orbit a remote pulsar. They were discovered by Pennsylvania State University's Alexander Wolszczan and published in *Nature*, February 24, 1994.

French astronomer Pierre Lagage *might* have found a different planet or two in a totally different part of the galaxy. See the article in *Science News*, June 25, 1994, entitled "Orbiting Beta Pictoris."

Both observations clearly imply that planets are *not* unique to our solar system, and that planets are as common elsewhere as they are here in our galaxy. This also shores up a weak element in the *Drake Equation* that predicts the number of intelligent civilizations lurking about.

Even more intriguing, amino acids have "most likely" been verified near the galactic center. (See page 1668 of the June 17, 1994 issue of *Science*.) At a distance of 30,000 light years, the glycine spectrum is not likely to be bread crumbs that blew away from a family picnic.

Amino acids are the key ingredients in proteins and plant and animal life itself. Should you want to build your own kangaroo, you'll start off with several key amino acids. The complete set of kangaroo plans appears in a machine language code called DNA. Free copies are available at your nearest zoo. Some skill is needed for compilation and assembly.

Meanwhile, Federal funding for a major SETI search has been dropped, but I suspect this will be beneficial in the long run. Individual

A binary chain code is a long series of ones and zeros that keeps repeating.

A chain of length "n" will have 2^n bits in it. What makes binary chain codes interesting is that any short sample of n bits will define a unique position in the chain. All possible n-bit words get used precisely once.

Ferinstance, $09AF is a four bit binary chain code. Expand it into a series of ones and zeros...

0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1

Add a few extra bits so the sequence goes round and round...

... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...

Now repeat the sequence sixteen times. Note how each n=4 bit sample defines a unique position in the sequence...

... 0 1 1 $\boxed{1\ 1\ 0\ 0}$ 0 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 $\boxed{1\ 0\ 0\ 0}$ 0 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 $\boxed{0\ 0\ 0\ 0}$ 1 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 $\boxed{0\ 0\ 0\ 1}$ 0 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 $\boxed{0\ 0\ 1\ 0}$ 0 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 $\boxed{0\ 1\ 0\ 0}$ 1 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 $\boxed{1\ 0\ 0\ 1}$ 1 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 $\boxed{0\ 0\ 1\ 1}$ 0 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 $\boxed{0\ 1\ 1\ 0}$ 1 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 $\boxed{1\ 1\ 0\ 1}$ 0 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 $\boxed{1\ 0\ 1\ 0}$ 1 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 $\boxed{0\ 1\ 0\ 1}$ 1 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 $\boxed{1\ 0\ 1\ 1}$ 1 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 $\boxed{0\ 1\ 1\ 1}$ 1 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 $\boxed{1\ 1\ 1\ 1}$ 0 0 0 0 1 ...
... 0 1 1 1 1 0 0 0 0 1 0 0 1 1 0 1 0 1 $\boxed{1\ 1\ 1\ 0}$ 0 0 0 1 ...

FIG. 1—BINARY CHAIN CODES are self-positioning. This makes them an exciting new tool for robot sensing and data base management.

and creative private research ultimately beats out the Feds every time. I expect a loose network on Internet will more than pick up the slack with a network of dishes and computers the Feds couldn't even dream about.

The major SETI setback seems to be our own fault. All of a sudden, we are a lot smarter about communications than we used to be. We've found out that 5 watts transmitted from a satellite is better than 50,000 watts transmitted from an Earth-based tower, and that a mere 5 milliwatts on a fiberoptic cable is even better yet.

At last we have decided not to reserve unique radio frequencies for a single user. Instead, we're now starting the long overdue conversion to *spread spectrum communication* in which dozens, hundreds, or even thousands of transmitters can share a single band without interference.

We have also discovered that the radio spectrum is much too valuable to waste on the direct broadcasting of unencoded information, especially in analog format. Thus, we are rapidly changing over to *data compression techniques* that cram a lot of useful information into minimum spectral segments.

BATTERY CHARGING RESOURCES

Benchmarq
2611 Westgrove Dr #109
Carrollton TX 75006
(214) 407-0011

Burr-Brown
6730 S Tucson Blvd
Tucson AZ 85706
(602) 746-1111

Dallas Semiconductor
4401 Beltwood Pkwy S
Dallas TX 75244
(214) 450-0400

Electronic Power Technology
6400 Atlantic Blvd Ste 130
Norcross, GA 30071
(404) 449-1104

EnChip
434 Ridgedale Ave Ste 11-327
East Hanover NJ 07936
(201) 328-2049

International Rectifier
233 Kansas St
El Segundo CA 90245
(310) 322-3331

Linear Technology
1630 McCarthy Blvd
Milpitas CA 95035
(408) 432-1900

Maxim
120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800

Philips/Signetics
PO Box 3409
Sunnyvale CA 94088
(800) 234-7381

Siliconix
2201 Laurelwood Rd
Santa Clara CA 95054
(800) 554-5565

Teledyne Semiconductor
1300 Terra Bella Ave
Mountain View CA 94043
(415) 968-9241

Unitrode
580 Pleasant St
Watertown MA 02172
(617) 926-0404

Spread spectrum and compression techniques greatly reduce the *entropy* of a signal, leading to the curious result that intelligent communication is now largely indistinguishable from random noise, unless you happen to know the spreading codes and the exact rules for decompression.

Assuming that extraterrestrials are smarter than we are, they have also long ago given up on high-power, single-frequency communications transmissions.

Now, you can't just tune in and receive compressed spread spectrum communications. If you don't know the rules, you have to look at subtle shifts in spectral density, signal entropy, or the timing patterns just to be able to predict that a signal exists. Thus, we might be looking for the wrong type of SETI signal in the wrong way to be able to interpret a valid intelligent message.

I'll go out on a limb and set forth this premise: A very tiny but highly significant fraction of extragalactic "noise" is actually intelligent communication from extraterrestrials.

The search is yet to begin.

Meanwhile, the television signals from our triad of goodwill ambassadors to outer space—Captain Video, Roller Derby, and Kukla, Fran & Ollie—have now swept over the better part of a thousand candidate galaxies. They originated from a minor sun that suddenly became a video star in 1949. The signals have inflated to a spherical area now 45 light years in radius, and yet they are still at signal levels that we could easily detect here on Earth today.

Should you want to participate in ongoing SETI activities, check into the *Planetary Society* or else the *SETI Institute*. If you want a good bibliography and more SETI resources, see HACK65.PS on *GEnie* PSRT or my new *Hardware Hacker IV* reprints.

Binary chain codes

A digital code is a train of pulses representing ones and zeros. In past columns I've discussed the basics of several different codes: *pseudorandom* codes, short portions of which appear as random noise, *Gray* codes whose bits are allowed to change only one at a time, and *Huffman* codes that compress data. *Cyclic redundancy check (CRC)* codes can correct many of their own transmission er-

```
2 bit binary chain code:  $6
3 bit binary chain code:  $17
4 bit binary chain code:  09AF
5 bit binary chain code:  04653ADF
6 bit binary chain code:  0218A392CD3D5DBF
7 bit binary chain code:  01061438916347932A5CD9D3EAD7B77F

8 bit binary chain code:
  0081828384858687889 8A8B8C8D8E8F929395969799A9B9D9E9FAAEB6BEDEEFF

9 bit binary chain code:
  004060503824160D0784426150B864361D0F88C4A27148AC5A2F198D46E391D8
  F47E4964D2794CAA572D974BE67359B4DE753B9ECFA7F55ABD6EBB5FB6FBBDFF

10 bit binary chain code:
  0020180A038120581A078220982A0B8320D83A0F8423094270A42B0B42F0C433
  0D4370E43B0F43F114471244B1344F14C5515C5916C5D17C6328CE348D6368DE
  398EA3B8F23D8FA3F9264A92E4D93A4F94A72ACAD2BCB32D4B72ECBD2FCCD33C
  D535CDB374DF39D6769DE7A9EE7D9FA7FAABAB6AFAD6F5DD7B5FDB76FDDF7BFF

11 bit binary chain code:
  00100601403809016034078110260540B8190360740F82104609413829056 0B4
  17831066 0D41B8390760F41F84308A11C2484B09A13C288530AA15C2C85B0BA1
  7C318650CE1A43586D0DE1C4398750EE1E43D87D0FE2244588D11E24C4A89713
  226C4E89F146294538A91562B4578B316A2DC5C8BB17A2FC638C9196334678D3
  1AA35C6C8DB1BA37C728E71D23AC768EF1E63D47B8F91F63F47F92524E4AC969
  2F2664D49B93B27A4FCA594D29E54CAA9572B6574AF9672D65B4B79732EA5DCB
  D97D2FE66CCE99F34E6ACD69AF36A6DCDD9BD37E73CEA9D73B6774EF9EB3DA7B
  CFA9F73F67F4FFAAB55EADD5DABF5AEB6D6FAEF5EEBED7FB6F6EEDFDDFBDF7FF

12 bit binary chain code:
  00080180280380480580680780880980A80B80C80D80E80F8108118128138148
  1581681781881981A81B81C81D81E81F8208608A08E09209609A09E0A20A60AA
  0AE0B20B60BA0BE0C20C60CA0CE0D20D60DA0DE0E20E60EA0EE0F20F60FA0FE1
  0A10E11211611A11E12212612A12E13213613A13E14614A14E15215615A15E16
  216616A16E17217617A17E1862863864865866867868869 86A86B86C86D86E86
  F871872873874875876877878879 87A87B87C87D87E87F888988A88B88C88D88
  E88F891892893894895896897899 89A89B89C89D89E89F8A28E29229629A29E2
  A62AA2AE2B22B62BA2BE2C62CA2CE2D22D62DA2DE2E62EA2EE2F22F62FA2FE31
  A31E32632A32E33233633A33E34A34E35235635A35E36636A36E37237637A37E
  38E48E58E68E78E98EA8EB8EC8ED8EE8EF8F28F38F48F58F68F78F98FA8FB8FC
  8FD8FE8FF924B24D24F25325525725B25D25F26526726B26D26F27327527727B
  27D27F29529729B29D29F2A72AB2AD2AF2B32B52B72BB2BD2BF2CB34B3CB4CB5
  4B5CB6CB74B7CB9CBACBB4BBCBCCBD4BDCBECBF4BFCCCD4CDCCECCF4CFCD34F3
  5535735B35D35F36736B36D36F37537737B37D37F39D39F3AB3AD3AF3B53B73B
  B3BD3BF3CF54F5CF6CF74F7CFACFB4FBCFD4FDCFECFF4FFD55755B55F56B56F5
  7757B57F5AF5B75BB5BF5D76D77D7BD7DD7ED7FDB6FB77B7BB7FBBBFBDFBEFFF
```

Longer codes appear in #899 BINCHAIN.TXT on GEnie PSRT.

FIG. 2—SOME EXAMPLES of shorter binary chain codes.

rors, and the rarely used *Barker* codes can autocorrelate perfectly. And, of course, the ASCII code allows the storage and transmission of letters and numbers. There are many other codes.

I recently ran across an odd class of digital codes called *binary chain codes*. They are inherently *self-locating*. This property leads to all sorts of exciting new hacker opportunities ranging from greatly simplified robotic position encoders to self-organizing geographic and topographic map data bases.

A binary chain code is said to be of length n if its total number of ones and zeros equal 2^n. Thus, a six-bit chain code will have a total of 64 ones and zeros in it. Binary chain codes are normally joined serially, often continuously connected end-to-end. There is no beginning or end to a binary chain code.

Figure 1 shows what's unique about a binary chain code: any n bit sample can immediately determine the exact position in the total sequence. Thus, if you know only six recent bits in the code, you will know exactly and uniquely where you are in the 64-bit-long sequence.

Figure 2 shows some sample binary chain codes for some lower n values. Check any of these, and you will find that any sample that is n bits long is uniquely positioned. A simple table lookup is all you need to find where you are at any particular time.

The binary chain codes are neither very rare nor very common.

Surprising as it might be, there are 18,446,744,073,709,551,616 total possible unique code sequences with a length of six, but only 67,108,864 of those are binary chain codes. It is not likely that you will randomly stumble into a chain code.

Some properties of simple chain codes include: 1) The number of ones and zeros are equal. 2) There will be one *n*-bit run of zeros and one *n*-bit run of ones. In a basic six-bit chain code, there will be:

1 - six-bit run of zeros
0 - five-bit runs of zeros
1 - four-bit run of zeros
2 - three-bit runs of zeros
4 - two-bit runs of zeros
8 - one-bit runs of zeros

There will also be an identical number of runs for ones in the same pattern. The total number of runs of zeros will be *one quarter* of *n*—so will the total number of runs of ones. The 1-0-1-2-4-8-16-32... sequence will continue for a higher number of bits.

Now for some fun. Turn the zeros and ones into black and white stripes. Figure 3 shows the PostScript code that will generate any radial pattern of ones and zeros on a disk. All you do is introduce a string of ones and zeros to it, and it builds the pattern for you. The code

NAMES AND NUMBERS

Adhesives & Sealants Industry
PO Box 400
Flossmoor IL 60422
(708) 922-0761

Aldus
411 1st Ave S #200
Seattle WA 98104
(800) 685-3614

Apple Computer
20525 Mariani Ave
Cupertino CA 95014
(408) 996-1010

Atesla
2890 N Frist Street
San Jose CA 95134
(408) 428-6250

Black Range Films
Star Rt 2 Box 119
Kingston NM 88042
(505) 895-5652

Computer Telephony
12 West 21 Street
New York NY 10010
(212) 691-8215

DynaArt Designs
3535 Stillmeadow Ln
Lancaster CA 93536
(805) 943-4746

GEnie
401 N Washington St
Rockville MD 20850
(800) 638-9636

HP/Peripherals Group
16399 W Bernardo Dr
San Diego CA 92127
(619) 592-8333

Hitachi
2000 Sierra Point Pkwy
Brisbane CA 94005
(415) 589-8300

Home Systems Network
Box 3006
Edmond, OK 73083
(405) 330-0718

Internet World
11 Ferry Lane West
Westport CT 06880
(203) 226-6967

Motorola
5005 E McDowell Rd
Phoenix AZ 85008
(800) 521-6274

Photocraft Inc
PO Box 408
Geneva IL 60134
(815) 786-2885

Planetary Society
65 N Catalina Ave
Pasadena CA 91106
(818) 793-5100

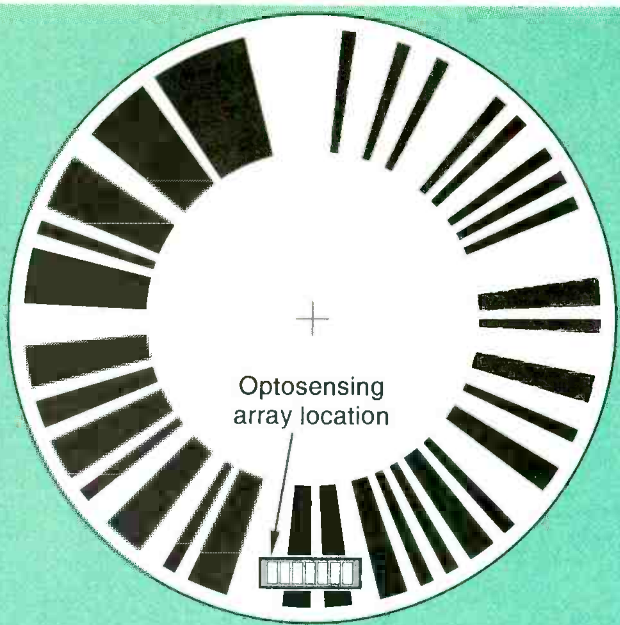
Raytheon
350 Ellis St
Mountain View CA 94043
(800) 722-7074

Sensors
174 Concord St
Peterborough NH 03458
(603) 924-9631

SETI Institute
2035 Landings Dr
Mountain View CA 94043
(415) 961-6633

Synergetics
Box 809
Thatcher AZ 85552
(602) 428-4073

Texas Instruments
PO Box 809066
Dallas TX 75380
(800) 336-5236




```
% This draws an arbitrary pattern of ones and zeros as radial spokes...

/inches {72 mul} def /outsidediskdia 4 inches def /outdatadia 3.8 inches def
/indatadia 2.2 inches def /xcenter 3 inches def /ycenter 3 inches def

/encoderpattern  (0000 0001 0000 0110 0001 0100 0011 1000 1001 0001 0110
0011 0100 0111 1001 0011 0010 1010 0101 1100 1101 1001 1101 0011 1110
1010 1101 0111 1011 0111 0111 1111) def

xcenter ycenter translate -8 0 moveto 16 0 rlineto 0.5 setlinewidth stroke
0 -8 moveto 0 16 rlineto 0.5 setlinewidth stroke 0 0 outsidediskdia 2 div
0 360 arc 1 setlinewidth stroke    % draw the disk

/patangle 360 0 encoderpattern {dup 48 eq exch 49 eq or {1 add} if} forall div def

gsave encoderpattern {dup dup 48 eq exch 49 eq or {48 sub setgray 0 indatadia
2 div moveto 0 0 indatadia 2 div 90 dup patangle sub arcn 0 0 outdatadia 2 div
90 patangle sub  dup patangle add arc closepath fill patangle rotate}{pop} ifelse}
forall grestore showpage quit   % draw the pattern and print
```

FIG. 3—A BINARY CHAIN CODE ENCODER DISK and the PostScript code you'll need to generate it. Despite having only 32 stripes, this is an absolute position sensor that can provide as much as 12-bit accuracy.

is even smart enough to ignore spaces and carriage returns. You can route the code to almost any PostScript printer or view it with *GhostScript* shareware. This is yet another example of the general-purpose computing that is trivial with PostScript.

As an example, Fig. 3 also shows a simple seven-bit binary chain-code encoder disk. Unlike conventional absolute encoder disks, the photo sensors are placed *tangentially* along the disk. By reading seven bits, you will know the position in the sequence at all times. Despite the seemingly simple pattern, this is an *absolute* encoder that tells you exactly where you are—not an *incremental* encoder that only counts pulses.

Certain refinements can be made to the process. You can deliberately *oversample* to produce ten to twelve bits of position accuracy from a seven-bit wheel. Part of this can be the result of simple interpolation as the pattern moves across the sensor face. Oversampling can also solve those "hairy edge" problems that are common to all "non-Gray" encoders.

A wheel with only 32 stripes on it can measure an absolute position to an accuracy of one part in 1024, or even one part in 4096.

Compared to the usual Gray code position encoder, the binary chain encoder is simpler and cheaper; it permits much looser tolerances. Its main drawback is that a binary chain encoder takes more

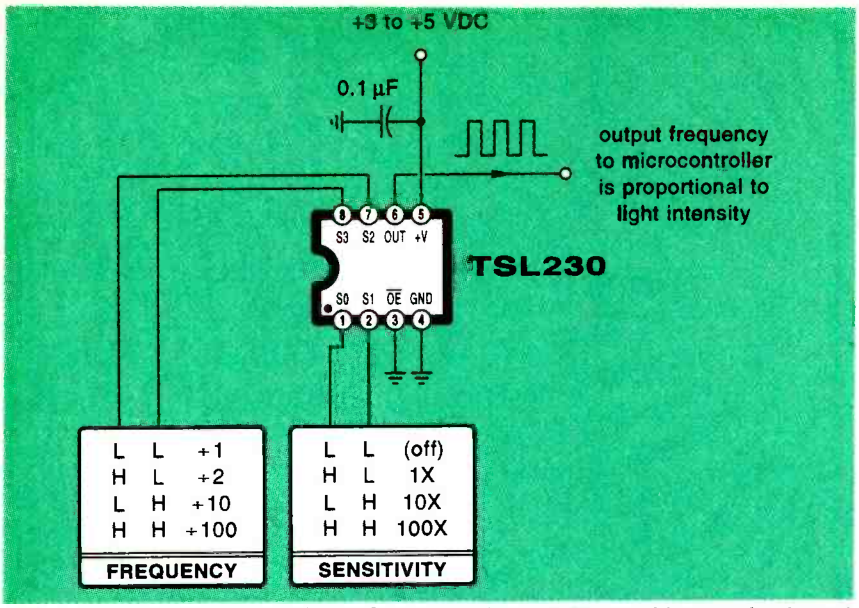


FIG. 4—TI's TSL230 LIGHT-TO-FREQUENCY CONVERTER providees a simple and low-cost way to interface light intensity with any microcomputer or microcontroller.

processing time. One possible sensor would be the new TSL230 from Texas Instruments. You can also dream up *linear* position sensors that use binary chain codes or some variant of them.

Many thanks to mathematician Jim Fitzsimmons for his help in finding those codes and understanding their unique properties. More information on generating and using your own binary chain codes appears in both #899 BINCHAIN.TXT and #902 MORCHAIN.TXT up on *GEnie* PSRT, including programs to generate your own. More information on digital codes in general is included in my *Micro Cookbook I*—only a scant few copies of this book are left.

One source of ready-to-go chain encoders is *Photocraft*. Additional encoder construction details appeared in the April 1994 issue of *Sensors* magazine. More on the subject of geodata chain code applications appears on the *Dialog* information service.

Light-to-frequency converters

Texas Instruments has offered a real "sleeper" product for over two years that has outstanding hacker potential: the TSL230 light-to-frequency converter. Its output frequency is proportional to the intensity of the light input. This device can greatly simplify optoelectronic-to-computer interfacing. The TSL230 is packaged in a clear plastic 8-pin minidip case and sells for less than $5 for single units—and half that in quantity.

This chip can be used for nearly any task involving light. Measuring its output frequency can give you a dusk-to-dawn control, a colorimetry system, an auto brightness control, or an exposure meter. Integrating (or counting) the output pulses yields total light dosage. You can use the TSL230 for such tasks as measuring total solar irradiance at a site or automating a photo development procedure. Differentiating (or monitoring changes) in the output pulse rate can perform light-to-voice or light-to-music translations, and solve light-beam telemetry problems.

Figure 4 shows how simple the circuit is. Provide a +3 to +5-volt power supply, choose some hardware jumper options, and route the output to a computer port. For quick experiments, a headphone or audio amplifier will work on the outputs. Even a speaker with a 100-ohm series resistor will work.

Jumpers let you change the sensitivity and frequency range. There are three silicon photodiodes in the device, with relative areas of 1, 9, and 90. That gives you four sensitivity options of zero (off), one, ten, and one hundred.

Similarly, the device has four output frequency options. The fastest one produces 1-megahertz pulses at maximum light input. Typical pulse width is a third of a microsecond. You can also get output square waves that divide the output by 2, 10, or 100.

The choice of photodiode can give you an electronic shutter or a variable F-stop. The choice of output scaling gives you the equivalent of variable shutter speed.

There are normally two different ways to measure frequency. If you introduce a high frequency, you can count cycles for a specified time interval, say one-tenth of a second. This gives you *events per unit time* and directly measures frequency. This works well for fast signals, but lower frequencies might require hundreds or thousands of seconds to produce accurate results.

For lower frequencies, one cycle of the frequency starts and stops a high-speed reference. This is known as the *pulse period* or *stopwatch* method. You can precisely measure a 5-hertz square wave in a tenth of a second by using this pulse period method.

But the pulse period method has a price. Its result is *not* a measure of frequency. Instead, it is a *time period*, or the *inverse* of frequency. Instead of 440 hertz, you get 0.00227 seconds. A division or lookup table will be required when you want to know the actual frequency. Note that any inverse is always a nonlinear curve.

The pulse-period method is also noise-sensitive. Any deviations on the particular cycle being measured can invalidate the results. One trick to overcome this is to average the

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Phone or write your Hardware Hacker questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(602) 428-4073

For fast PSRT access, modem (800) 638-8369, then an HHH. Then JOINGENIE. On keyword prompt, enter DMD524.

Internet email access link:
SYNERGETICS@GENIE.GEIS.COM.

pulse period method over several input cycles. This is a trivial task with any microcontroller these days.

Supply current for the TSC230 is 2 milliamperes when the device is active and 10 microamperes when its output-enable pin is high. Accuracy varies from 5 to 20 %, depending on device options. You can do custom calibration if you need higher accuracy.

The spectral response is the standard Gaussian silicon response curve that is weak in the blue region of the spectrum and very strong in the infrared region. Temperature compensation is good over the visible light range, but any near-IR heating of the chip causes severe frequency errors. Installing a fan or a heat filter on the host equipment is a good idea for solar applications.

The dark current produces about half a hertz at full area, compared to saturated light at 1 megahertz. This gives a 66-dB dynamic range. The jumpering options let you center the dynamic range on the intensity range you need.

Battery charging resources

There are some really exciting new products being introduced in the battery-charging arena these days—mostly new ICs that allow faster and safer charging of high-tech cells and batteries. For this month's resource sidebar, I gathered together the major sources.

One of the bigger players here is *Dallas Semiconductor*, which is offering a new battery-charging data book. The book discusses a lot of sophisticated, yet quite low-cost chips, some fully programmable. You also might want to pick up a copy of the *NiMH and Ni-Cd Battery Management* application note from Philips.

Research so far on electric car batteries has been mostly "smoke and mirrors" hype. It is crammed full of hidden agendas, wishful thinking, and suffers from limited funding.

But the laptop-computer makers have an immediate new multi-billion dollar market begging for new rechargeable cells. What's needed are cells that pack energy into small volume with minimum weight. Solve the laptop energy problem and the electric car power problem becomes a trivial sideshow.

My own guess right now is that a polymer-based, fast rechargeable lithium system will end up with all the marbles. Lithium is light and cheap and provides high energy density. Lithium's reactivity is fast becoming manageable through brand new developments. Lithium can be obtained from seawater. More as the drama unfolds.

This month's contests

Let's have a really far out contest this month. Assume you are a high-tech hardware hacking native of some fairly laid-back planet orbiting *Gamma Gallinas*. Your specialty is radio astronomy, and you have been observing a third rate star some 40 light years away that suddenly became a video source.

So far, you've discovered suspicious spectral distributions in the VHF region and have applied the latest in PDSP (psychic digital-signal processing) techniques to them. Suddenly a twelve-second clip of Roller Derby pops up, superbly clear, on your virtual monitor wall from your latest run. For our contest send me a copy of the report you will send your supervisor, along with a copy of your next Intergalactanet post. Yes, you do have witnesses and archival backup copies.

There will be the usual dozen or so *Incredible Secret Money Machine II* books going to the best entries, plus an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the finest of all. Be sure to send all your *written* entries to me here at *Synergetics*, rather than to *Electronics Now*.

Now for a second and more down-to-earth contest this month: just tell me about a new and hacker-friendly application for Texas Instrument's TLS230.

New tech lit

Raytheon is offering its 1994 data book on fancy video and multimedia chips. *Hitachi* is offering a new *Semiconductor Technology for Wireless Communication* book. Ask *Apple Computer* for its *Power Macintosh Software Directory*. *Motorola* is offering a *Power Scene* newsletter on MOS devices.

And from *Texas Instruments* again, there's a new $98 digital signal processing breadboard. It is called the *TI DSP Starter Kit*. For more specifics, call TI at (800) 477-8924, extension 3651.

Several helpline callers have asked about TIFF files. These are simply an older way to describe a bitmap image, and TIFF is short for a *Tag Image File Format*. Copies of the Revision 5.0 specification are available from *Aldus*. A *Guide to the Tag Image File Format* is also offered by *HP Peripherals*.

Adhesive & Sealants Industry is a trade journal that's not afraid to deal with sticky subjects. *Computer Telephony* is a new magazine on phone modem networking, and *Internet World* is a publication on Internet access and its use.

Three unique videos on straw bale home construction are now being offered by *Black Range Films*, and a half hour home automation video titled *Living with an Intelligent Home* has been released by *Home Systems Network*.

Frank Miller of *DynaArt Designs* just sent me a selection of his new tools and materials for making direct-toner printed circuit boards. I'll have more on this when I complete testing it. Meanwhile, you can pick up free details on this exciting new method for quickly and simply making your own printed circuit boards by giving Frank a call.

To pick up the fundamentals of digital integrated circuits, check into my CMOS and TTL Cookbooks, also available as part of my *Lancaster Classics Library*.

Here is a reminder that electronic reprints of all my columns, along with instant technical help, are available on *GEnie* PSRT. I've managed to arrange ten free *GEnie* hours for your use, as shown in the help box.

Free catalog requests and technical questions you want answered here or on PSRT can also be sent to me directly through my own SYNERGETICS@GENIE.GEIS.COM Internet address.

As usual, most of the resources I've mentioned appear in the *Names & Numbers* or the *Battery Charging Resources* sidebar. Be sure to check here before calling our no-charge technical helpline. Ω

AUDIO UPDATE

Sound-off's, CSICOP, and audiophilia

LARRY KLEIN

I've endorsed *Car Audio and Electronics* as a publication that provides the straight scoop—and impressive test reports—on the fast-changing world of car stereo components, alarms, and other automotive devices. My present relationship with the publication involves the technical editing of its audio-equipment test reports. The magazine is a classy looking, technically authoritative journal catering to a readership that (to put it gently) seems a little weird.

Besides the mostly dim-witted letter-column exchanges among the self-labeled "bass-heads" and others, there are also articles on outfits such as the United States Autosound Competition (USAC). For those who are not *au courant* with recent car-audio craziness, I should explain that ghetto blasters have, in effect, gone very much upscale, and are now to be found installed in all manner of vehicles. As you might be aware, the rumble and boom of the vehicular-bass-obsessed is heard day and night on both the streets of the city and the winding roads of suburbia.

American entrepreneurs, ever alert to the opportunity to make a buck, have organized "sound-offs" at which the owners of sonically customized vehicles vie with each other for prizes. The original perpetrator of the format—the International Auto Sound Challenge Association (IASCA)—has, over the years, injected some rationality into its rulebook by de-emphasizing decibels in favor of balance and quality. As a matter of fact, the "92 Finals" even had "dB police" armed with sound pressure level (SPL) meters to restrain those contestants overeager to demonstrate the ear-shattering capabilities of their vehicles.

According to the March issue of *Car Audio & Electronics*, the newly competing USAC operates under no such constraints. At one point during USAC's recent sound-off, there was a planned SPL competition between Cerwin-Vega's professional demo van and a consumer SPL champ from previous contests. Much to the disappointment of the 5000 spectators, the USAC officials canceled the event. The reason offered was that "vehicles with projected SPLs of over 153 dB could not be fairly and accurately judged." (Incidentally, 140 dB is at the threshold of pain; 150 dB is twice as loud!) However, it wasn't that the judges feared spectator ear damage, it was just that their SPL meter wouldn't read that high! But fear not; there are plans to stage an "SPL shoot-out" between the two vehicles "as soon as possible." Can you stand the wait?

Cable redux

In my December 1993 column, I wrote about a somewhat surprising article that appeared in *Audio* magazine. The surprise lay in the article's up-front discussion of the fads and fallacies rampant in the high-profit—if not high-fidelity—speaker-cable market. Author-engineer Fred E. Davis described, measured, and auditioned 12 speaker cables ranging in price from 24 cents to over $130 (!) a foot.

Davis concluded that cables made from exotic conductor and/or insulation materials will provide minimal (if any) enhancement of your system's fidelity, but maximal erosion of your bank account. I lauded Davis' approach, but chided him gently for his decision to delete brand names "in the interest of not adversely affecting the business of any manufacturer."

After my column appeared, Davis wrote to me saying how pleased he was with my discussion of his article, but he corrected me on a significant point. He writes that the decision to delete manufacturers' names was not his, but *Audio's*. He explained that the magazine had lost big bucks from advertising cancellations provoked by a previous speaker-cable article, and it didn't

want to repeat the experience.

I'm aware of the problem of advertiser sensitivity. While I was at *Stereo Review*, I was directly responsible for a major speaker manufacturer's cancellation of about $50,000 worth of advertising. It seems that in reply to a question at an audio club meeting, I stated that room placement of direct/reflective speakers, omnidirectional speakers, and dipolar speakers is particularly critical because so much of their output is bounced directly off the rear walls.

My words got back to the manufacturer, and he took direct action without much reflection; he canceled his advertising contract with *Stereo Review*. After a month or so, the manufacturer finally explained to our publisher that he saw no reason to support a magazine whose technical director (me, that is) did not support his product.

No one told me to recant, although *Stereo Review's* publisher did ask me to explain to the unhappy sales staff (who had lost their commissions) how random phase cancellations can result when strong rear radiation causes reflections that impinge on a speaker's direct wave. The manufacturer ultimately started advertising again, satisfied, I guess, that we had learned our lesson. To put it in fortune-cookie format: "Big Mouths Can Cost Big Bucks," or "The Truth Shall Make You (almost) Fired."

To return to Fred Davis, I phoned him at home, and we had a nice mutual-admiration-society kind of chat. I mentioned that I had recently come across an article he had written in one of my favorite publications, *Skeptical Inquirer*, the journal of The Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP). Among the topics Fred discussed were the digital alarm clock that has "a smoothing effect" on audio electron flow, a green felt-tip marker that when applied to the edges of a CD "improves clarity, definition, and ambience," and replacement power line cords from five different manufacturers (selling from a low of $99.95 to a high of $249.95) that provide "increased transparency, improved spatial coherence, seamless tonal balance," and so forth. Such blather finds fit company among the topics normally discussed and debunked by the *Skeptical Inquirer*, such as flying saucers, psychic revelations, channeling, telepathy, dowsing, astrology, and other weird topics.

I shouldn't give the impression that CSICOP consists of cynics and mechanical materialists. The Fellows of the Committee listed on the journal's masthead read like a Who's Who of the universities and sciences. The organization's intention is to encourage critical analysis and clear thinking in all areas where heavy applications of scientific methodology are needed to illuminate the issues.

Readers who would like to know more about CSICOP and the *Skeptical Inquirer* should write to: Barry Karr, CSICOP, Box 703EN, Buffalo, NY 14226-0703. Ω

DRAWING BOARD

Our alternate tachometer design takes shape.

ROBERT GROSSBLATT

Figure 1 is the block diagram I came up with last month for the counter-based tachometer. The circuit requires 2-hertz pulses so that the tachometer updates its display twice a second. The simplest way to get accurate timing pulses is to use the National Semiconductor MM5369 oscillator/divider. The basic 5369 circuit is shown in Fig. 2. The EST version of the chip will provide a 100-hertz output and the AA version will provide 60 hertz. In this case, the more common AA version is a better choice because it's easier to divide by thirty than it is to divide by fifty.

As shown in Fig. 2, the signal can be divided by thirty with a CD4520B bit binary counter to count the pulses from the 5369. I had to use both halves of the 4520 because it takes five bits to count up to thirty in binary. If you have a CD4040B ripple counter around you can use that as well, but other ripple counters in the family (such as the CD4020B and CD4060B) don't have a complete set of outputs for all the counts and might not be suitable.

The reason I prefer the 4520 to the 4040 is because I like to use a synchronous counter rather than a ripple counter whenever I have a choice. Ripple counters are a string of sequential counters, and each counter gets its input from the preceding one in the chain. The pulses at the clock input feed only the first stage of the counter. As the count progresses, the setup in the counter causes each stage to change output in sequence rather than all at once in step with the pulses at the clock input.

This daisy chain procedure will result in an incorrect count being present briefly at the outputs. How brief depends on the propagation delay of the counters, the supply voltage, and the length of the count.Basically it's pretty hard to predict. In general, a ripple counter is acceptable when you can afford to wait for the counter to settle down before checking its output. Synchronous counters don't have this drawback because each of the counting stages in the IC is triggered directly by the pulses at the clock input, so the output count is always in step with the clock. One of my golden rules is to avoid using ripple counters unless they're the only way to get the job done.

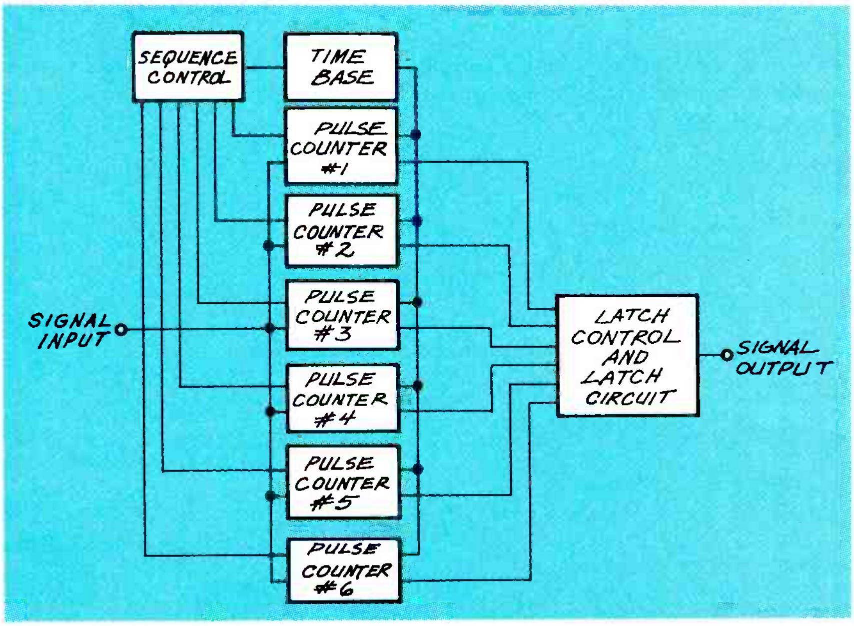


FIG. 1—BLOCK DIAGRAM of the counter-based tachometer. The heart of the circuit is the time base.

Cascading two halves of a CD4520B usually calls for gating because you must detect a full count of 15 (1111 binary) and use that state as the clock input to the second half of the chip. In this case I'm luckier than that because the number I'm detecting is 30, which is an even multiple of 15. Since each half of the 4520 can operate independently, the first half of the chip can divide the 60-hertz input signal in half, and that can be used to clock the second half of the chip. By using the Q0 (divide by two) output of the first half of the 4520 as the clock input for the second half, the second half of the IC can be clocked at 30 hertz. Then I can get the 2-hertz signal I need by detecting a count of 15 at the outputs of the second half of the 4520.

The count of 15 corresponds to a division of the 60-hertz signal by 30, and is detected by half of a CD4012B dual four-input NAND gate. When the count in the 4520 reaches 30, the output of the gate will go low, and that low is inverted by the second half of the 4012 which, because all the inputs are tied together, operates as an inverter. I need a low-to-high transition of the 2-hertz pulse later on, and the second half of the 4012 will provide.

Once you have this part of the circuit operating, you can check the output frequency with a simple watch. Just connect the cathode of an LED to the output of IC3-a, and connect its anode through a 200-ohm resistor to the positive side of

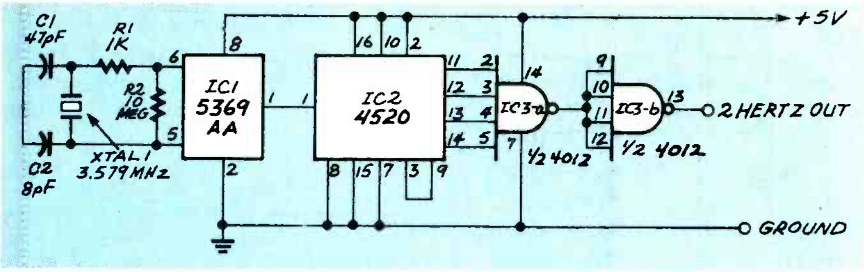


FIG. 2—YOU CAN DIVIDE BY THIRTY with a 4520 to count the pulses from the 5369.

the power supply. You can time the pulses for about 10 seconds and verify that you're getting two pulses per second at the output.

The next part of the circuit to tackle is the pulse counter. There are six pulse counters shown in the block diagram, but you can have as many as you want. The more counters you have, the less susceptible the circuit will be to display "bobble," or fluctuation. An optimum number of counters seems to be six. Less than that, and the result will be a "glitchy" display. At least twelve counters are needed to make a noticeable improvement over the results you can get with six. Once the tachometer is operating, you can experiment with this yourself.

The choice of counters here is dictated by the number of pulses you want to count. With an update period of half a second and six counters on line, each counter must handle three second's worth of input pulses. While there's no way of knowing exactly what that number is going to be, I can estimate it by looking at the worst case. A 12-cylinder engine running at 6000 rpm will produce 600 sparks per second at the coil. That's 1800 sparks in a three-second period.

Converting a count of 1800 to binary yields 11100001000, which means I need a counter with at least eleven sequential outputs to handle the worst-case scenario. It seems that this is one of those places where a long-chain ripple counter is needed. While you can certainly use one, a bit of thinking about the rest of the circuit is in order before you make a final decision.

Even though I haven't talked about the latch and display yet, you should realize that when each pulse counter has to dump its count to the latch for processing, it must have access to the latch inputs. This means that the outputs of all the counters must be connected in some way to the latch inputs. It's clear that some kind of three-state arrangement (chips with outputs that can be high, low, or floating) is necessary because only one counter can be actively connected at any one time.

None of the counters I've been discussing have the ability to float their outputs, so an IC with three-state outputs must be put between the counters and the latch control section. However that present, certain problems when more than eight counter outputs are involved.

Three-state buffers come in eight-bit widths, and while some of them allow sections of the IC to be enabled separately (six and two, for example), there's no avoiding the fact that having to handle 11 bits at a time is going to require at least two buffer ICs per counter. With six counters, this is going to require a minimum of a dozen buffer ICs. Chips might be cheap, but price has nothing to do with circuit complexity and keeping things simple. There are several ways to handle this problem:

1. Reduce the update period to a quarter of a second, which would also reduce the size of the maximum spark count because pulses would be counting for only about one and a half seconds.
2. Cut down the number of pulse counters and reduce the total chip count needed to handle the counter outputs. This would keep the full eleven-bit width.
3. Make some compromises in the range of revolutions per minute the tachometer can handle.
4. Increase the number of pulse counters to count spark pulses for a longer period. This would let us keep the half-second update and

the loss of three bits would become much less significant.

I think the best solution is the last one. Once the range of the tachometer is limited to eight bits, the question then becomes which eight bits to use. Table 1 gives the numbers you need to decide which bits should be dropped. Remember that the numbers in the table mustbe multiplied by three because the final circuit will be counting the pulses for three seconds.

If the three lowest bits are dropped to reduce the lower range of the tachometer, a total of seven pulses will be ignored for the three-second count at the tachometer. For a four-cylinder engine running at 1000 rpm, the worst case would be a count of 92 sparks instead of the real count of 99 sparks. Simple arithmetic says that would translate into a reading of 920 rpm instead of the actual number of 1000 rpm. A six-cylinder engine at the same speed would give a reading of 947 rpm, an eight-cylinder engine would give one of 955 rpm, and a twelve-cylinder engine would give one of 973 rpm. The higher the number of cylinders and the higher the rpm, the less statistically significant the lower three bits will be. Dropping the higher three bits would be disastrous because it would limit the maximum three-second count to 255.

TABLE 1

# CYL	SPARKS/SEC AT 1000 RPM	SPARKS/SEC AT 6000 RPM
2	16	100
4	33	200
6	50	300
8	66	400
12	100	600

If you experiment with dropping some bits from the top and bottom ends, you might decide that the resulting range is adequate for your engine size and expected rpm range. Dropping only the bottom two bits would give a tremendous boost to accuracy at idle (973 rpm instead of 947 rpm for a six-cylinder engine at an actual speed of 1000 rpm) and it would cut the maximum rpm down to 6800 rpm. That might not seem too bad, but this choice of bits would also drop the maximum reading for an eight-cylinder engine down to 5100 rpm.

Do the calculations and make your decision based on the size of your engine and the weight of your foot on the accelerator pedal. I'm going to drop the bottom three bits because, for my needs, that's the best solution. From a design point of view, the circuit is basically the same regardless of which bits are dropped. Ω

COMPUTER CONNECTIONS

Why Microsoft will win and IBM will lose the OS war.

JEFF HOLTZMAN

I started this story by describing important new features of Chicago, Microsoft's follow-on to Windows 3.x. As my writing progressed, it became more clear that the real story is why Microsoft will succeed, and why IBM, Novell, and Apple will fail as competitors for that product.

Chicago, the next major revision of Windows, is a full 32-bit operating system that should provide a more robust environment for running software than Windows 3.1. It is a complete, bootable operating system with no underlying DOS.

Microsoft's primary goals for Chicago include good performance on modest machines, high compatibility with prior DOS and Windows applications, and greatly improved ease of use. Microsoft hopes to release Chicago by the end of 1994, although a widely deployed beta program was launched much later than expected.

Why IBM will lose

In the August issue, I discussed IBM's massive new long-term strategy for consolidating its vast product lines around a single architecture, which is fascinating, technically. IBM's strategy is ambitious, even dramatic. Unfortunately, the drama to be played out is less likely to be a success story than a tragedy—or maybe even a comedy.

Why? Because IBM's strategy says a lot about how it intends to solve its problems, and absolutely nothing about solving the user's problems.

The architecture will allow IBM to merge product development, manufacturing, and support operations across all lines, from mainframes to personal computers. By doing this,the company expects to gain tremendous cost savings, and this should, in the long run (if successful), benefit users whose needs cross platform boundaries.

However, after considering the problem at some length, I now believe that IBM is doomed to failure as an operating system vendor.

IBM's history in the PC business is punctuated by failed top-down approaches. Probably the best example is the Microchannel Architecture (MCA), introduced with the PS/2 Model 80 in 1987. IBM rightly recognized that the AT bus, now called the Industry Standard Architecture (ISA), was nearing the end of its useful life, and it realized that something offering higher performance was needed. IBM's mistake was in assuming that users would drop ISA and go wholesale for MCA. They didn't.

IBM's Token-Ring network protocol is another example. Token Ring has theoretical and architectural superiority to Xerox's Ethernet, but Ethernet gobbled up the lion's share of the market by being good enough—and a heck of a lot cheaper. Both will soon be supplanted by much higher-performance protocols; the point once again is that top-down imposition of theoretically superior standards without sensitivity to bottom-up grass-roots needs seldom succeeds.

OS/2 is another example of top-down thinking that failed. IBM didn't get it right until version 2.1. By that time the company had blown its grass-roots credibility. Unfortunately, IBM's new cross-platform strategy resonates strongly with the PS/2 and OS/2 debacles of the past.

OS/2 and the various incarnations of the Workplace Operating System (IBM's cross-platform OS) will probably live on for some time in market niches where the "No one can be fired for buying IBM" mentality still thrives. The vocal minority with strong convictions about the superiority of MCA, Token Ring, or OS/2 might continue to convince

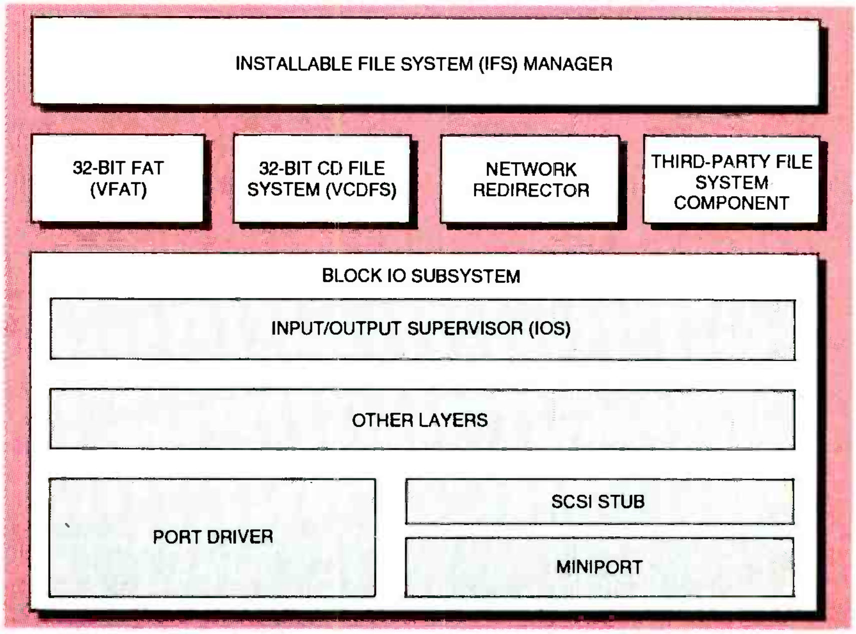


FIG. 1—CHICAGO'S INSTALLABLE FILE SYSTEM ARCHITECTURE provides 32-bit protected-mode access to all devices such as CD-ROMs, networks, and hard disks.

top IBM management of the value of pursuing system software. But eventually the bottom line will show something else.

Why Microsoft will win

Microsoft will win because it views the marketplace in a totally different perspective. Whereas IBM sees architecture as the fount from which user benefits can emerge, Microsoft sees it as an organizing principle or process. Out of that process a structure emerges for building something that meets user needs. Let's put it a different way. Microsoft asks users what they want, then figures out a logical way—an approach—to build products to meet those needs. By contrast, IBM designs an architecture, then goes about asking how that architecture can meet user needs.

Microsoft likes to keep its architectural strategy vague, but not undetectable. As I have said here numerous times in the past, I believe that all roads lead to Cairo. For the mainstream PC marketplace, the sequence is Windows 3.x to Chicago to Cairo. For the workstation and network server markets, the sequence is a jump from Windows NT (perhaps several successive versions) to Cairo. Cairo will unite and run all the major APIs, and provide a migration path toward a single, highly efficient native API. That would finally put to rest, once and for all, the "My API's better than yours" wars. It seems to be what IBM is doing with WorkPlace OS, doesn't it?

Microsoft seldom comes right out and talks about architecture directly; the company always hedges its bets and leaves its options open. For example, many people, including some influential members of the computer press, mistakenly assumed that NT was designed to be the successor to 3.x. They pointed to NT's lack of mainstream success as an excuse for some gratuitous Microsoft bashing. NT was never aimed at the mainstream market, but rather at the Unix and server markets.

Microsoft's bottom-up approach makes long-term corporate planners and strategists nervous. Nevertheless, it gives Microsoft tremendous flexibility in adapting to market changes. As a friend puts it, "Gates builds something, puts it out in the market, gets a reaction, fine-tunes it, puts it back out in the market, and so on." This is precisely what is happening now with NT.

Microsoft is bottom-up in many ways. Look at its Visual Basic. Although it has some features of an object-oriented development environment, it is essentially "flat," and thus open to criticism. But despite its theoretical or architectural impurity, VB is a huge market success. In its current state VB could become more object oriented, or it could remain flat. Either way, Microsoft's bets are covered.

Another extremely important difference between IBM and Microsoft is in marketing. IBM has long been criticized for poor marketing in the personal computer market; as far as I can tell the so-called "new IBM" has not improved a whit. IBM's OS/2 advertisements say "Operate at a higher level," an intellectual approach bound to turn off the mass market. What's the benefit of "operating at a higher level?" How does it compare with what I'm doing now? Without forthright, explicit answers to those questions, why are users going to bother with OS/2 at all? In another marketing snafu the company has scored a few kudos for OS/2 in the computer press, but has failed to capitalize on them.

Meanwhile, during the first two quarters of 1994, there have been approximately a half dozen magazine cover stories on Chicago—still closer to vapor than real product. In addition, Microsoft has publicly circulated a 300-page *Reviewer's Guide* outlining features and architecture of Chicago (on CompuServe GO WINNEWS).

Figure 1 illustrates key features of Chicago's file system architecture. For example, Chicago allows long (255-character) file names without obsoleting the existing FAT file system. This means that hard disks do not have to be reformatted to upgrade to the new file system. It also means that existing operating systems can read Chicago diskettes directly.

The document is fascinating in many ways. Among other things, it lists tons and tons of nifty new features, things to excite grass-roots interest, things that make people eager to get their hands on the software and try it out. If the software lives up to the promotional statements in the document, Chicago is going to be a killer; I think it will be. I should be getting a beta copy of Chicago in the next few weeks, and I hope to report my impressions of it in my next column.

Conclusions

All of that is marketing. It serves to heighten user awareness and anticipation. Regardless of whether Microsoft is beating IBM at the technology game, it is winning the marketing game.

Both Microsoft and IBM undoubtedly do strategic planning. The difference is that Microsoft continually refinines its understanding of user needs as an essential part of its strategy, and that's (still) nowhere to be found in IBM's strategy.

IBM should stick to what it does best: hardware. IBM has much to offer across the hardware spectrum: components (e.g., the Intel-compatible microprocessors it is building for both Cyrix and NexGen), subassemblies (e.g., the Mwave sound/modem boards and the recently introduced, highly competitive hard-disk drives). It should also stick to systems, although they still tend to be overpriced and are lacking in value compared with Gateway's 2000 and a few other brands. PowerPC is interesting, but so far there are no Power PCs, only Power Macs. Nevertheless, PC software will still be run in emulation. This almost guarantees problems with performance and compatibility in the future.

I have long suspected that the IBM-Microsoft war (primarily due to Microsoft's dumping OS/2 development) has been exaggerated. Recent statements confirm this view. In a recent interview, Bill Gates said that "Microsoft and IBM are perfectly complementary companies with the exception of one small group IBM has that does PC system software... IBM is our best customer. It's porting a lot of its key software into the Windows environment. Every month we find out more and more things we can do together" (*Playboy*, July 1994, p. 64).

News bits

As I predicted here in the June issue, Stac Electronics and Microsoft have ironed out their differences. Microsoft avoids its $120 million fine, Stac avoids its $13 million fine, and both share compression technology for the next five years. Microsoft now has a 15% stake in Stac, and Stac will receive a $1 million payment once a month for the next 43 months. It's better than winning the lottery.

TCP/IP is a network protocol originally designed to link government and research computers across what is now called the Internet. TCP/IP's popularity grew slowly during the 1980's and early 1990's. Now, with intense mass-market interest in the information highway concept generally, and the Internet specifically, its popularity is zoomingupward.

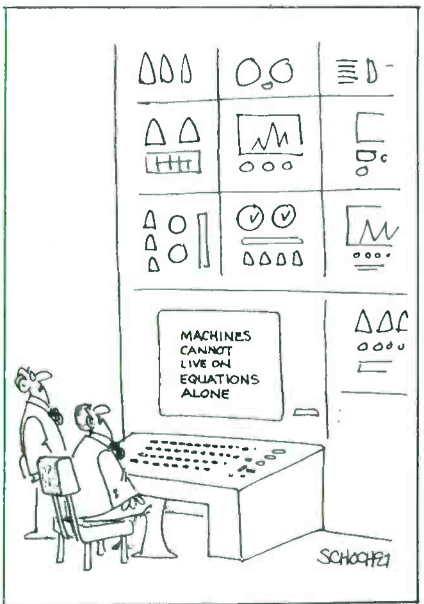
TCP/IP fits in the middle layers of the OSI stack, above the hardware drivers, but beneath applications like E-mail. TCP/IP competes with other protocols such as Novell's IPX/SPX, IBM's NetBIOS, and Microsoft's NetBEUI and Server Message Block (SMB) formats.

Because of TCP/IP's rising popularity, Microsoft has taken an interest in it. In fact, according to one recent article in the trade press, MS is getting *very* serious about it. In the past, getting TCP/IP to run on a PC was rather expensive and ranged from tricky to difficult. Microsoft has freely released a beta version of the protocol stack that runs on Windows for Workgroups 3.11; it's available on CompuServe for those interested.

Microsoft intends to include basic TCP/IP functionality in Chicago. This is bad for the small but competitive TCP/IP stack industry, but good for end users. This kind of software really belongs in the operating system, assuming it's done right.

As for TCP/IP-based applications, Microsoft includes a few basic examples for file transfer (FTP) and terminal emulation (TELNET), but the commercial vendors have little to fear here. If they're smart they'll quickly turn their efforts from network plumbing to concentrate on improved user applications.

Amiga fans will have to look elsewhere for low-cost yet hot video-processing hardware and software. As I predicted here long ago, Commodore has liquidated. As with so many other computer industry pioneers, Commodore became enamored with its vision of the way the world should be, and lost track of the way it is. It then lost its ability to compete, and in the end did a great disservice to its extremely loyal customer base. The lesson? In the computer industry (perhaps in life generally), complacency kills. Ω



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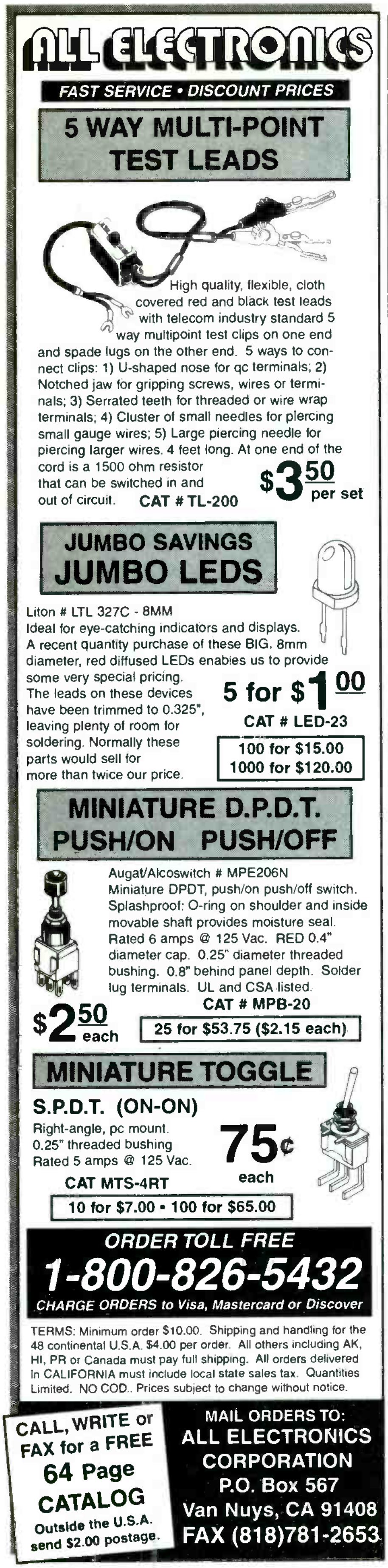

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Established 1945
M/C & VISA $20 Minimum Order
KELVIN CATALOG $3
Stock No. 650412


150 LE - Student 200 LE - Technician 300 LE - Auto-Range 400 LE - Engineer

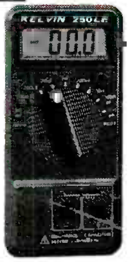
Standard Features ● AC & DC VOLTAGES ● DC CURRENT ● RESISTANCE ● CONTINUITY TESTER - Buzzer ● DIODE TEST ● 10M ohm INPUT IMPEDANCE ● ACCURACY +/- 0.5% RDG

150 LE	200 LE	300 LE	400 LE
TRANSISTOR BATTERY TEST DC CURRENT 10 Amp	FREQ COUNTER up to 20MHz CAPACITANCE from 1pF to 20uF TRANSISTOR AC/DC CURRENT 10 Amp	AUTO RANGE with 3200 counts AC CURRENT DC CURRENT ANALOG BAR 10 Amp	INDUCTANCE Resolution 1uH FREQ COUNTER up to 20MHz CAPACITANCE from 1pF to 200uF AC/DC CURRENT TRANSISTOR DUTY % 20 Amp
Stock # 990122	Stock # 990123	Stock # 990125	Stock # 990124
$29.95	$49.95	$49.95	$79.95

KELVIN 100 Basic
\# 990087 $19.95

- AC & DC VOLTAGES
- DC CURRENT
- RESISTANCE
- 3 1/2 Digit LCD
- CONTINUITY TEST -Buzzer
- LOW BATTERY INDICATOR
- DIODE TEST ● BATTERY TEST

CAPACITANCE METER
KELVIN 250 LE
\# 990126 $59.95



- 0.5% ACCURACY
- RANGES: 20mF, 2000uF, 200uF, 20uF, 2uF, 200nF, 20nF, 2000pF, 200pF
- Zero Adjust
- Safety Test Leads
- Test Socket for Plug-in Components

Designed to meet IEC-348 & UL-1244 safety specifications.

Protective Cases
For Models 100 Basic, 150LE, 200LE, 300LE .... $4.95 (#990088)

Case For Model 400LE .... $9.95 (#990116)

2 Year Warranty (Parts & Labor)

The Ultimate Meter
TRUE RMS - LCR - Hz - dBm

Popular Electronics (Reviewed • May 1993)

"Not only does the *Kelvin* 94 boast alot of features ... the features go the extra distance."

"If we had to run into a burning building to do some emergency trouble-shooting and could carry in only one piece of equipment, the *Kelvin* 94 would be it!"

12 INSTRUMENTS IN ONE -
DC VOLTMETER, AC VOLTMETER, OHMMETER, AC CURRENT, DC CURRENT, DIODE TESTER, AUDIBLE CONTINUITY TESTER, dBm, FREQ COUNTER, CAPACITANCE METER, INDUCTANCE METER, LOGIC PROBE

- **0.1% ACCURACY** ON DC VOLTAGES
- **TRUE RMS** ON AC VOLTAGES & CURRENT
- **FREQUENCY COUNTER** TO 20 MHz
- **LARGE EASY-TO-READ** 3 3/4 DIGIT LCD DISPLAY
- AUTO SLEEP & AUTO POWER OFF BUILT-IN TO SAVE BATTERY LIFE with Bypass
- SHOCK RESISTANT HEAVY DUTY CASE WITH YELLOW RUBBER HOLSTER & TILT STAND
- WATER RESISTANT SEALED CASE
- 30 DAY MONEY BACK SATISFACTION GUARANTEE

$199.95 MODEL 94 #990111

COMES COMPLETE WITH YELLOW HOLSTER, PROBES, BATTERY, FUSE, STAND

0.1% ACCURACY on DC Voltages | Water Resistant

Freq Counter to 20 MHz

Protective Cases for Model 94
Regular Padded Zippered .... $9.95 (#990116)

Deluxe Padded Zippered .... $14.95 (#990115)

Meter is designed in accordance with safety requirements specified in IEC-348, UL-1244 VDE-0411.

DC-2000 MHz

AMPLIFIERS

25th Anniversary Celebration
25%* DISCOUNT
* Prices Shown Only
Expires 12/1/96

In plastic and ceramic packages, for low-cost solutions to dozens of application requirements, select Mini-Circuits' flatpack or surface-mount wideband monolithic amplifiers. For example, cascade three MAR-2 monolithic amplifiers and end up with a 25dB gain, 0.3 to 2000MHz amplifier for less than $4.50. Design values and circuit board layout available on request.

It's just as easy to create an amplifier that meets other specific needs, whether it be low noise, high gain, or medium power. Select from Mini-Circuits' wide assortment of models (see Chart), sketch a simple interconnect layout, and the design is done. Each model is characterized with S parameter data included in our 740-page RF/IF Designers' Handbook.

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Mini-Circuits' monolithic amplifiers...for innovative do-it-yourself problem solvers.

Models above shown actual size

from **99¢** Unit price $ (25 qty)

PLASTIC SURFACE-MOUNT			++VAM-3 1.45		+VAM-6 1.29	++VAM-7 1.75		
add suffix SM to model no. (ex. MAR-ISM)	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				MAV-11 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-11 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

designer's kit, KH-1 available only $59.95 includes:
40 AMPLIFIERS* 10 MAR-1, 10 MAR-3, 10 MAR-4, 10 MAR-8
150 CAPACITORS* 50 100 pf, 50 1,000 pf, 50 10,000 pf
740 page RF/IF DESIGNER'S HANDBOOK

- MIXERS • POWER SPLITTER/COMBINERS • AMPLIFIERS • ELECTRONIC ATTENUATORS
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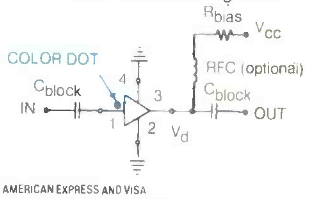
- FILTERS • LIMITERS • FREQUENCY DOUBLERS

*values or models may be substituted without notice, depending on supplies.

Typical Circuit Arrangement



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