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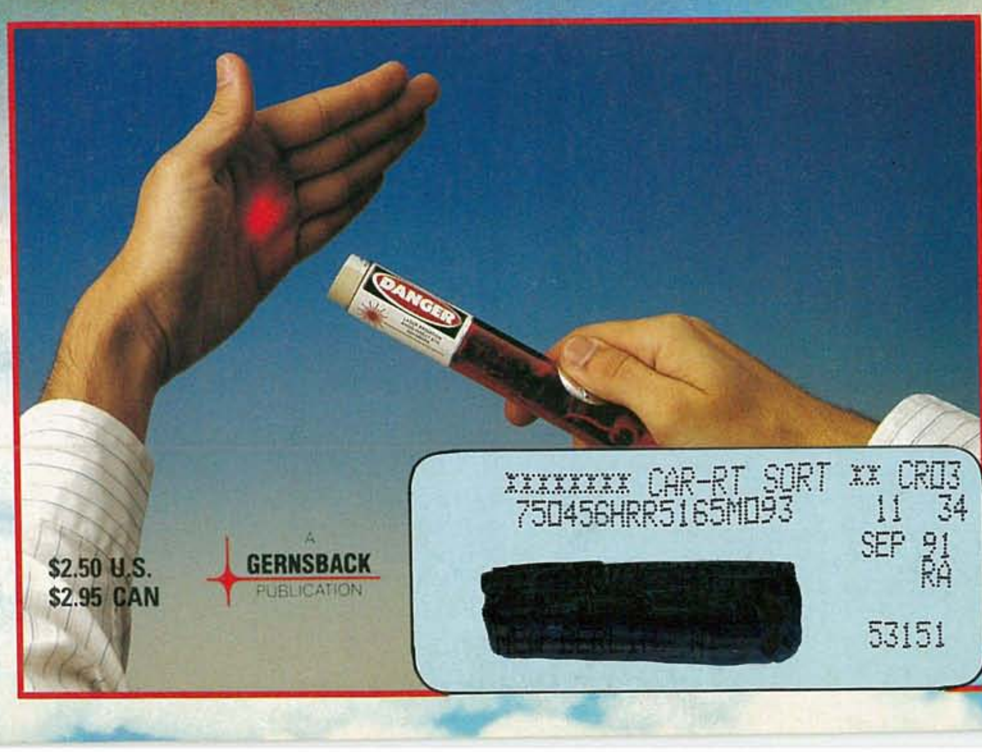

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Radio-Electronics
Vol. 61 No. 11

BUILD THIS

34 SEMICONDUCTOR LASER SYSTEM
Visible-light laser diodes are at the heart of this handheld, rechargeable, semiconductor laser system.
Robert Iannini

41 PORTABLE 146-MHz QUAD ANTENNA
Build your own 2-meter quad antenna.
Linton G. Robertson, KJ2EF

49 PHONE-CALL SCREENING SYSTEM
Build our system that puts an end to junk calls.
John C. Koller

TECHNOLOGY

58 THE CHANGING FACE OF SATELLITE TV
A look at how small, flat antennas could boost the popularity of satellite TV.
Robert Angus

COMPUTERS

63 SPICE
Can a PC-based circuit-simulation program take the place of breadboards?
TJ Byers

86 COMPUTER CONNECTIONS
SCSI/ESDI shootout, and a pair from Micropolis.
Jeff Holtzman

PAGE 63

PAGE 41

DEPARTMENTS

6 VIDEO NEWS
What's new in this fast-changing field.
David Lachenbruch

24 EQUIPMENT REPORTS
Coordinated Time Link CTS-10 Computer Time Standard

69 HARDWARE HACKER
A look at walking-ring counters, electronic dive, vortex coolers, and more!
Don Lancaster

83 DRAWING BOARD
Some final words on video, then on with our controller!
Robert Grassblatt

81 IC SPOTLIGHT
A new column debuts this month!
Mike Mullin

85 AUDIO UPDATE
What audio test reports do—and don't—tell you.
Larry Klein

AND MORE

106 Advertising and Sales Offices
106 Advertising Index
14 Ask R-E
97 Free Information Card
16 Letters
105 Market Center
32 New Lit
26 New Products
4 What's News

ON THE COVER

In the past 25 years, lasers have become an integral part of both the technological world and our every-day lives. Yet, because of fragile glass laser tubes and high-voltage power requirements, there ahve been limits to their applications, especially for hobbyists. Now, a series of laser diodes recently developed by Toshiba, which emit visible light and which don't require a high-voltage power supply, just might open up a whole new world of applications. We put the new visible-light laser diodes to work in handheld, battery-powered, rechargeable, semiconductor laser system. To find out how it works, and how to build your own, turn to page 34.

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

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Radio-Electronics is indexed in *Applied Science & Technology Index* and *Readers Guide to Periodical Literature.*

Microfilm & Microfiche editions are available. Contact circulation department for details.

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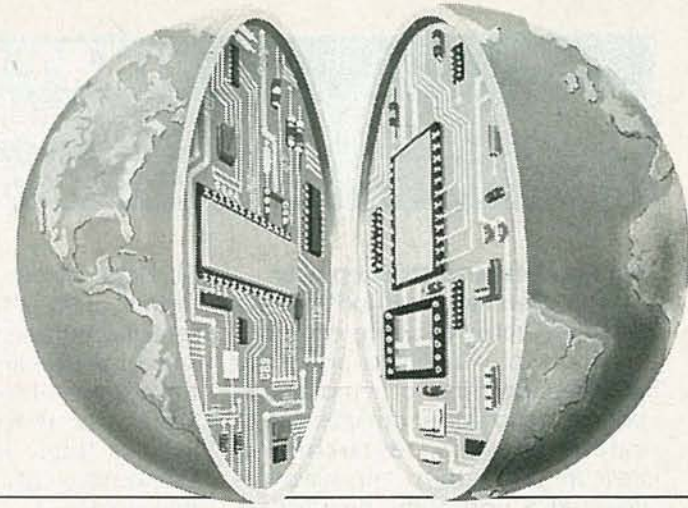

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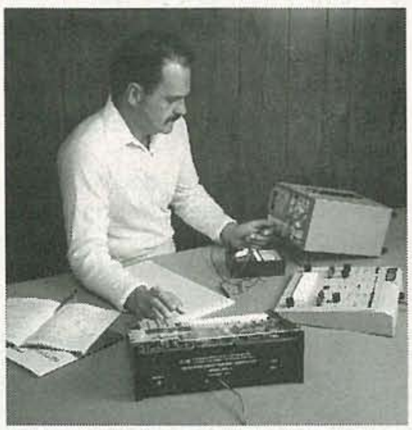

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WHAT'S NEWS

A review of the latest happenings in electronics.

Non-polluting electrical power

With alternative methods of generating electricity being explored around the world to counter the growing problems of atmospheric pollution and power outages due to natural disasters, researchers at Bellcore (Livingston, NJ), have developed a non-polluting process that might lead to smaller, lighter, more reliable, and less costly power sources. "Fuel cell" systems designed using the new method could be used in a wide range of applications, including replacing traditional rechargeable batteries as emergency backup power sources for many applications.

In small, experimental prototypes of the fuel cell, Bellcore has converted gas to electricity using a thinner-than-paper material sandwiched between two conducting metal films. Electricity is generated when hydrogen or other fuel gases are "blown" over the fuel cell's surface in the presence of oxygen or air. According to Christopher Dyer, who discovered the method while exploring new ways to improve communications power systems, no pollutants are created in this process; since the hydrogen is simply converted to water vapor.

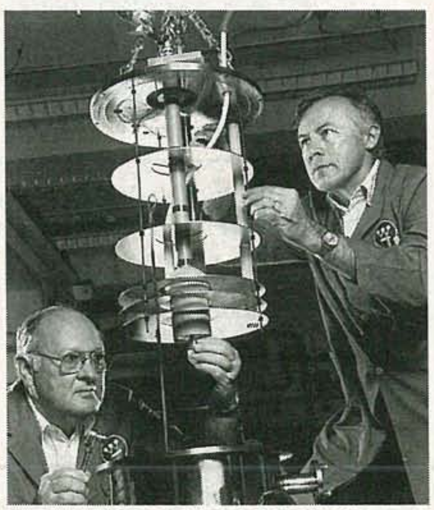
While NASA has used fuel cells in spacecraft, commercialization has been slow due to high production costs of existing designs that require separated gas intakes of pure gases. Bellcore's prototype operates in a gas mixture. Essentially, its materials "separate" the gases internally, greatly simplifying the engineering. Because those materials are so thin, practical devices could be made by depositing the materials on both sides of an inexpensive, continuously moving roll of plastic. Predetermined lengths of the processed material could then be rolled into an open spiral, through which air together with the fuel gas would be passed to give the required power.

The prototype's extremely good power-to-weight ratio—more than 50 watts of electrical power per pound of weight—means that potential commercial devices could be small as well as lightweight. The prototype generates quiet, clean power and has no moving parts, suggesting that future devices could provide users with a reliable, long-lived power source.

The next step is to upgrade power levels while retaining the attractive weight and volume, which might be accomplished by improving gas efficiency so that heat removal equipment won't be needed or, perhaps, using the heat as a benefit. Some possible future applications of devices are emergency power supplies for remote telephone terminals, refillable power supplies for portable phones, integrated-circuit power sources, home generators running off natural gas, power sources for portable computers, and power plants for electric vehicles.

Record-breaking electrical lead

An electrical lead—developed in a joint effort between Westinghouse Electric Corporations Science & Technology Center and the Superconductivity Pilot Center at the U.S. Department of Energy's Argonne National Laboratory—was used to set a world record for current (2,000 amperes) carried by a practical high-temperature superconductor. This high-current lead could become one of the first devices using superconducting materials to come into widespread commercial use. It was designed to connect room-temperature power supplies to liquid-helium-cooled low-temperature superconducting power equipment, and has the potential to greatly reduce helium refrigeration costs in applications such as magnetic resonance imaging, superconducting magnetic energy storage, or the superconducting supercollider.



WESTINGHOUSE TECHNICIANS Don Martin and Ray Malingowski make connections for a test run of the complete assembly of the electrical lead that set a world record for current carried by a practical, high-temperature superconductor.

Ten-year battery

Scientists at Sandia National Laboratories (Albuquerque, NM) have developed a battery for military and space applications that can provide power for 10 years. That longevity was achieved by making a number of modifications to existing lithium-sulfur dioxide batteries, which are primarily used by the armed forces for applications requiring long life and high energy density, and which experience failure most frequently occurs due to glass corrosion.

The major change made involved the use of a specially developed glass, CABAL 12, that eliminates corrosion in the glass-to-metal seal. Other modifications included using molybdenum as the positive terminal to inhibit corrosion by products of electrolysis, placing a nickel grid in the lithium anode for increased efficiency, and using an improved method of attaching the cathode tab to the positive terminal. In addition, by fully annealing the case and increasing the radius of curvature at the bottom of the can, stress was reduced, which eliminated cracking in the steel cell case.

The ten-year lifespan was predicted based on studies evaluating the performance, reliability, and aging characteristics of battery cells over a period of years.

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VIDEO NEWS

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

DAVID LACHENBRUCH

• 8mm vs. VHS-C. Although the 8mm format currently is ahead in the mini-camcorder war, the proponents of VHS-C (they prefer the designation "compact VHS") are striking back. As already reported (**Radio-Electronics**, September 1990), they are fielding tiny models made by Matsushita (including the Panasonic Palmcorder)—highlighted by a version with Digital Electronic Image Stabilization, which counteracts the jitters to which a lightweight camcorder is subject, and by a new series of JVC VHS-C models. Early returns indicate that the VHS-C camp is regaining some ground, although 8mm is still far ahead in the compact-camcorder race.

Several manufacturers are embracing both sides of the mini-camcorder conflict. While Thomson's RCA brand added several 8mm models, the same company's GE brand moved into the VHS-C camp with some Matsushita-made models strongly resembling the Palmcorder. Meanwhile, Matsushita itself is hedging its bets. It is making a tiny 8mm camcorder—the smallest camcorder yet—which currently is being marketed by Chinon and is being offered by Matsushita to other brands (although Matsushita's Panasonic brand currently is sticking with VHS and VHS-C models). And Toshiba, which now offers only full-size VHS camcorders, reportedly has designed an 8mm version in case necessity dictates that format.

• Another TV dropout. In August, we reported that Japan's NEC had decided to call it quits in the American TV and video market. Now another Japanese-made line—Teknika, an American brand owned by the leading computer manufacturer in Japan, Fujitsu—has "suspended" sales of video products here, although it will continue to market Fujitsu brand satellite receivers. Lately, Teknika has been buying TV sets and video recorders from companies that manufacture in the United States and Mexico, because of the high cost of procuring Japanese-made sets. More brands are expected to withdraw from the U.S. market this year, in view of the tough competition and declining TV sales in a slow economy.

• TV screen sizes. With the first-half results in, it appears that 1990 will not be television's banner year. In terms of receiver sales, here's what was up and what was down: Everything under 20 inches was down, with the biggest decline in the 8-inch-and-under mini-sizes, down almost 20%. The formerly hot 19-inch size showed a 14.4% decline. That size is being replaced by the 20-inch, which was up 1.7%. In table models, 25- and 26-inch models were down, but the 27–29-inch category rose 23% and the 30-inch-and-up sizes jumped by 103.6%. In consoles, all sizes registered declines except 30-inch-and-up, which rose 14%. All projection TV's were up, with the biggest gains in the largest 50-inch-and-up sizes (57%), followed by 45–49-inch (up 36%) and the 44-inch-and-less category (up 30.7%).

WEIGHING IN AT JUST OVER 1½ pounds, Sony's CCD-TR4 is the world's smallest and lightest 8mm camcorder

• Congress mandates captions. For many years, TV-screen captions for the hearing impaired have been an optional feature, and caption-decoding attachments have been available at about $200. A few sets with built-in decoders have been offered, but with few takes. At our press time, the Senate had passed a bill requiring that all TV sets with screens 13 inches and larger have built-in decoders to receive and display the captions, and passage by the House was expected to be routine.

The captions are carried on line 21 of the vertical blanking interval (VBI). Although the legislation originally specified the technology for the decoders, the TV industry persuaded Congress to legislate only the final result and to let TV set manufacturers decide how to bring it about. They also succeeded in having Congress extend the date for the law to take effect to July 1, 1993, to give them time to prepare. No sets manufactured or imported after that date may be sold if they don't include caption decoders. The Electronic Industries Association estimated that inclusion of decoders would add $20 to the wholesale cost of a TV at first, but some manufacturers said that amount would be the retail increment, and no one doubted that costs would come down quickly.

Teletext, which has succeeded in Europe, has been a major flop in the United States. With the universal inclusion of caption decoders in most television sets, it's a short step to universal teletext. Maybe, at no added cost, teletext will succeed. **R-E**

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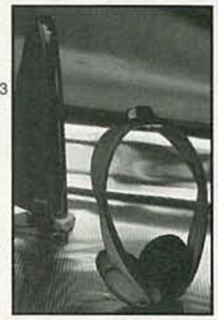

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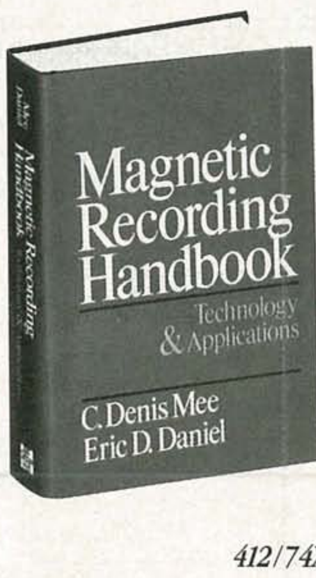

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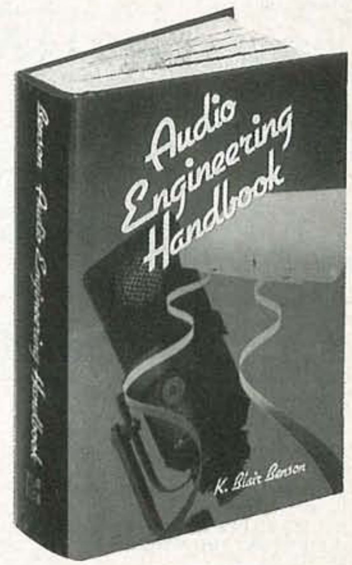

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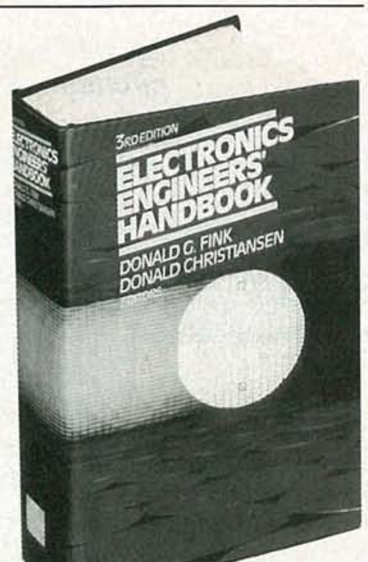

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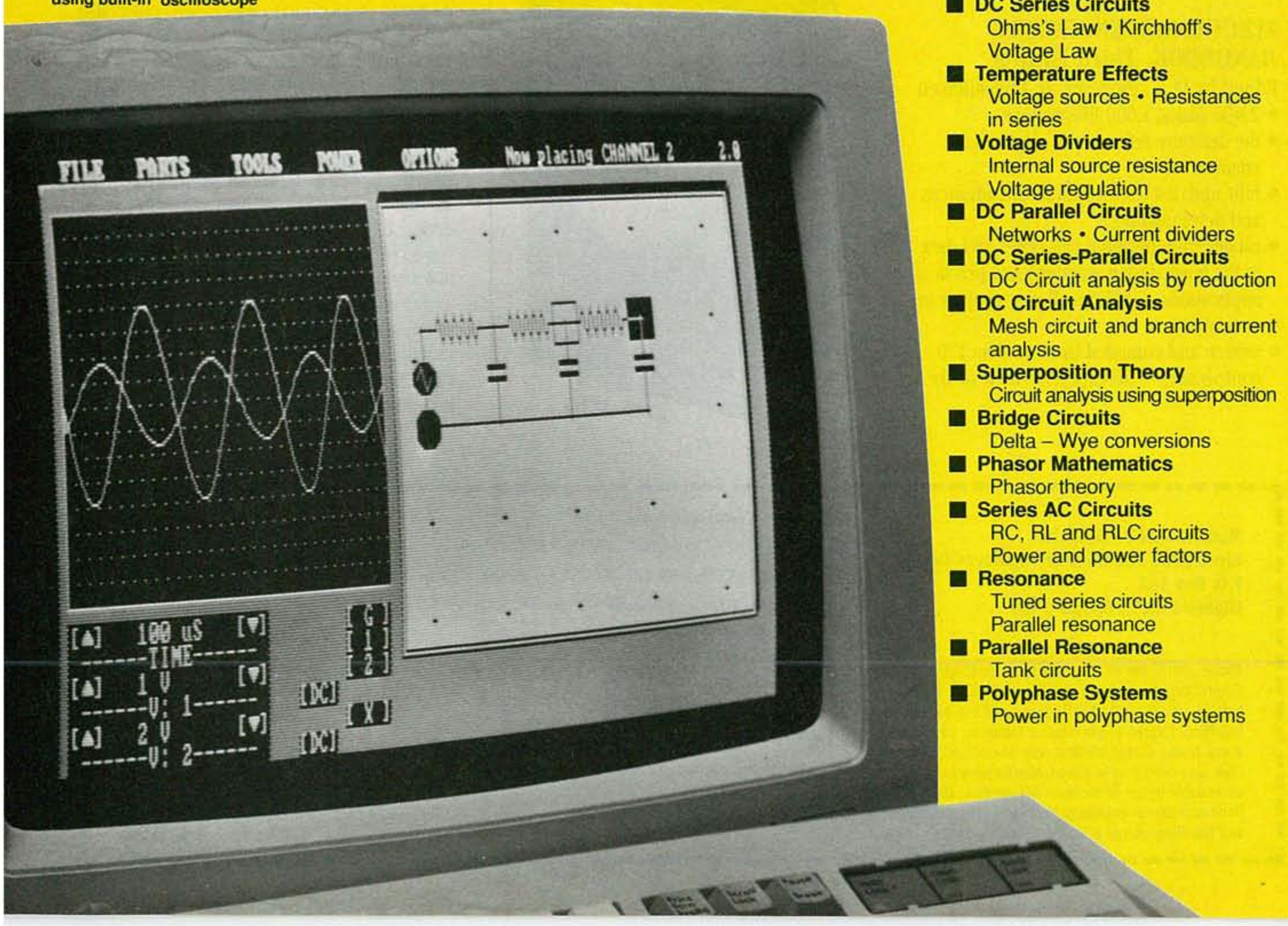

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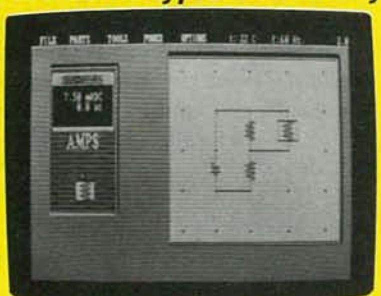

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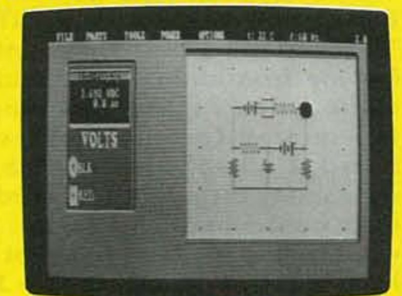

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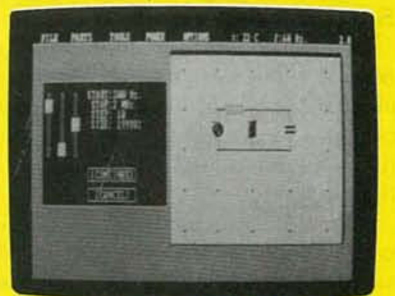
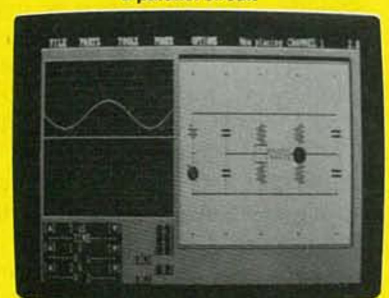


Parallel Resonance LC Tank Circuit using sweep generator to vary voltage across tank, monitoring circuit response



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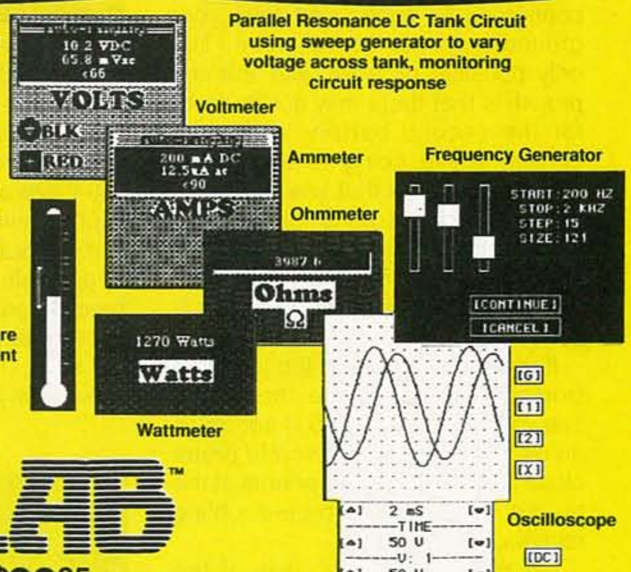

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SPLIT BATTERY

I'm building a circuit using op-amps that require a split supply. The final product is going to be powered by batteries so I've been using resistors to create a split supply from a nine volt battery. It works but I've noticed that the performance of the op-amps is much better if the circuit runs of a real split supply. Is there some simple circuit I can use to get a real negative voltage from a single battery?—J. Laberdie, Somerville, NJ

This is a problem that you run across whenever you use op-amps like a 741. They're easy to use, cheap, and available everywhere, but running them off batteries is a pain in the neck.

There are two ways you can take care of the problem. The first one is simply to use two nine-volt batteries connected in series and take your ground from the center point. The only possible problem with this approach is that there may not be room for the second battery in the enclosure you're going to use. If the only components that use the negative supply are the op-amps, then the battery that's supplying the negative voltage will last for a very long time since the draw from the op-amps is very low.

If you insist on doing the job electronically, you can use the circuit shown in Fig. 1. The 555 is set up as an oscillator with a duty cycle pretty close to 50%. The components at the output work as a voltage-doubling rectifier.

On the positive half cycle of the output wave, D1 is forward biased and C1 charges up with respect to ground. On the negative half cycle, C1 discharges through D1 and charges C2. Since D2 is reverse biased, C2 can't discharge through C1. The result is that we have a voltage at the cathode of D2 that's negative with respect to system ground and the voltage is renewed with every full cycle of the 555 output.

The 555 can supply about 200 milliamps but all you can really get from the circuit is less than half that amount. Since you're only using the negative voltage to supply the op-amps, you've got more than enough current available to do the job. The negative voltage you'll get will be a few volts below the positive voltage supplying the 555, but the exact number depends on the amount of current you're going to draw from the circuit.

XT UPGRADE

I have an XT clone and am thinking of upgrading to an AT. The only thing that's preventing me from doing so is that, while I don't mind spending the money for the motherboard, I resent having to lay out money for a new I/O card, disk controller, and so on. I want to know whether or not I have any alternatives?—J. Bendel, Bogota, NJ

The difference in performance between an 8088-based XT and a 286 AT is what is referred to in the technical journals as "mind blowing." A conservative estimate would be that you'll see at least a five-fold increase in processing speed.

If you want to keep the costs as low as possible, the only thing you'll really have to add to the motherboard is faster memory—and even that's not for sure. There's no reason whatsoever why you can't use the cards you have in your XT in an AT. You won't be getting the best performance possible out of the new motherboard, but that's a long way from saying that it won't work at all. The sixteen-bit cards made for the AT are faster than the eight-bit cards you're using in the XT but, when you actually compare things, the performance difference isn't anything like the difference you'll get by swapping the motherboards.

The only thing to be careful of is how you set up the AT since you have an XT-controller card. The AT stores in memory the kinds of drives you have, and needs that information to operate because it has drive tables built into the ROM. The XT doesn't have any of those and has to depend on drive tables stored in a ROM on the hard-drive controller card. The way around that is to tell the setup program that you don't have any hard drives installed.

Memory speed is a different problem. Most AT boards can run at two speeds. The low speed is usually about 8 MHz and the high speed can be anything up to 20 MHz. If the memory you have in your XT is rated at 12 nanoseconds or less, the AT will probably crash at high speed. Your alternative is to either run at low speed or replace the memory with 10-nanosecond RAM.

The price of memory changes every day but is usually somewhere around a hundred dollars a megabyte. Since the difference between the low and high speeds of the AT is pretty noticeable, you should really consider getting whatever memory is needed to have the motherboard run as fast as possible.

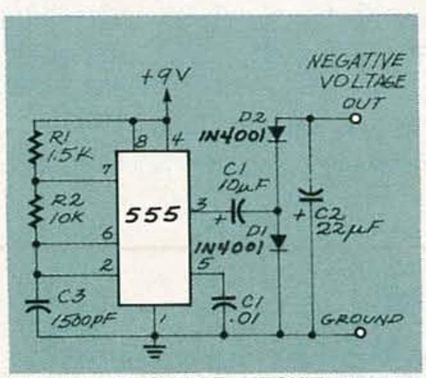

FIG. 1—THIS SIMPLE CIRCUIT can provide you with a negative voltage from a positive supply.

WASHING BOARDS

Some time ago you ran a series on how to make printed circuit boards and, in general, I've been successful following your advice. The only place I have any trouble is in developing the board. When I wash the developed board with water, the board often doesn't clear.

If I put it back in the developer for a longer period, all of the resist gets dissolved. What am I doing wrong?—G. Fischer, New York, NY

Making printed circuit boards at home is time-consuming enough, without having to seek out how-to information, as well. There are lots of books on the subject, and several companies make the supplies, but the information you get from them is often more theoretical than practical.

There are so many variables involved in producing a good board that it's almost impossible to pinpoint your problem. Mistakes that are made in pouring the resist may not be evident until you actually dunk the board in the etchant, and there's no easy way to know exactly where the mistake was made. Since you indicated in your letter that you've had some success in making boards, we can eliminate a few of the steps as the source of your problems.

The light source you're using and the exposure time are probably correct since a mistake here means that it would be impossible to have any success at all. The same sort of argument applies for the quality of the printing negatives. My best guess would be that you're either not coating the copper blank properly or you're making a mistake when you develop the board.

When you pour the resist on the board, you want to keep the actual coating as thin as possible. The best way to do that is to pour the resist on one edge of the board and then tilt the board one way and then the other to let the liquid resist flow across the entire surface. If you have a problem with this, you can use a small brush to help the resist flow around the board.

Once the board is covered, let it rest at a sharp angle on a piece of paper towel so the excess resist can flow off the board. If you let the safe light hit the board at the right angle, you'll be able to see the excess resist flowing to the bottom of the board. Keep on blotting the edge until all of the excess is off the board.

You can air dry the resist but that takes overnight. A better way is to use a hair dryer on a medium setting. That will dry the board in a few minutes but the resist can be ruined if you let it get much over 125°.

Developing the board is a pretty straightforward operation. Put the board in the developer and gently rock the tray back and forth for about 30 seconds or so. That's enough time for the first dunk. Wash off all the dissolved resist before you give the board more time in the developer.

One piece of information you won't see anywhere but in **Radio-Electronics** has to do with washing the board in water. Fill a tray with COLD WATER (about 70 degrees Fahrenheit is fine), and dunk the board in and out of the water. If you use hot water, the dissolved resist won't wash off the board.

Once you see the board clear (the foil pattern will start to show and the rest of the copper will be clean looking), take the board out of the water and shake the excess water off it. Don't wipe it because the resist is still very soft. Repeat the developing step and then wash it again. The pattern should appear clearly on the board and, once it dries, you should have no trouble etching it. **R-E**

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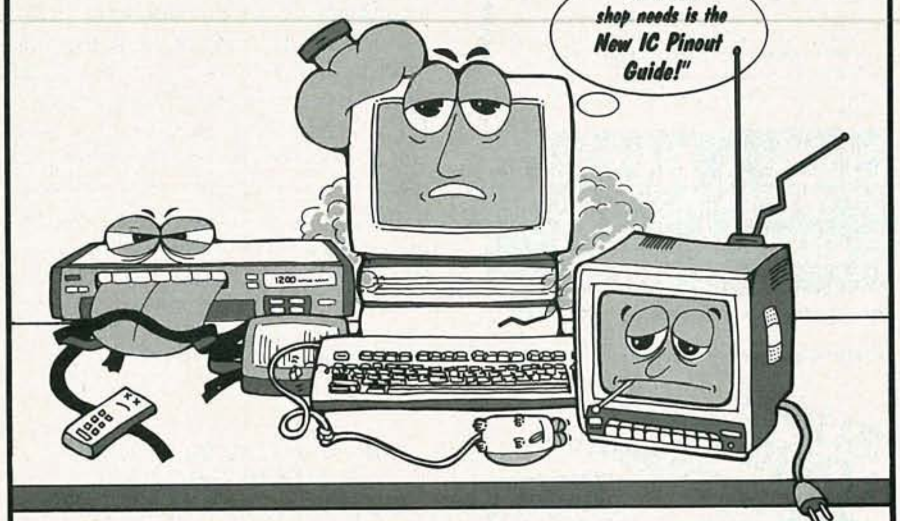

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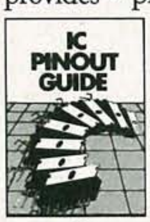

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LETTERS

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HOW TO FIND SCHEMATICS

Trying to locate information through manufacturers who have moved or gone out of business is a difficult task. One method that's worked for me is to send a short request for information on file for the patent number of the equipment, plus $0.50, to the Commissioner of Patents, U.S. Patent Office, Washington, DC 20231. Within six to eight weeks, you will receive a letter stating the additional fee needed to cover printing and shipping costs of the material or the information used to patent the equipment. (The original $0.50 is applied toward the cost, and can be refunded if you don't want to pay the fee to receive the information.) I sent for the patent information on an instrument amplifier and received schematics with detailed theory of operation. Take advantage of a little-known public service!

DARRELL W. OVERFELT
Kansas City, KS

ACCURATE OSCILLOSCOPE MEASUREMENTS

People who use digital-storage scopes based on sampling techniques speak of "bandwidth limiting." Dave Sweeney's letter in the August issue of **Radio-Electronics** stated the bandwidth needs to satisfy the Nyquist criterion, which, for faithful reproduction, requires a sampling rate at twice the highest frequency component in the signal.

By definition, a scope's bandwidth is assumed to be the −3-dB frequency response point of the scope's vertical system. When making accurate measurements, we should be concerned that the system bandwidth is adequate—that means right from the probe tip. Just as the bandwidth of a pulse is approximately the reciprocal of its length, the bandwidth of a component is approximately the reciprocal of its rise time. And, similarly, the bandwidth of a scope using a combination of components with known rise times approximately equals the reciprocal of the RMS value of their reciprocals.

Many scope users fail to remember that the −3-dB point is a power response, while the observed signal is in terms of voltage that equates to −6 dB, for the so-called Gaussian response. In actual fact, most low-cost scopes use a peaked response to obtain the rated bandwidth and are non-Gaussian. Any scope, regardless of cost, exhibits 30% error at rated bandwidth. Again, by definition, the vertical amplifier response is down to 0.707 in amplitude at the −3-dB power response point.

If you want to make accurate measurements with a scope, use one that has a bandwidth 3 to 5× that of the highest-frequency component in the input signal. Similarly, in non-Gaussian-response amplifiers, strange phase shifts sometimes occur that can distort the viewed signal, particularly as rated bandwidth is approached. Think about how many measurements can be tolerated with an uncertainty of 30%.

RALPH CAMERON
Government Accounts Manager
Tektronix Canada Inc.

HINDERING THE HANDICAPPED

As totally blind individuals, my wife and I are becoming quite frustrated with the consumer-electronics industry. In an age when LSI and other fabrication techniques could give us greater access to new and useful consumer electronics, we are encountering more and more barriers to our operation of many units. Those are the ones that contain visual-only functions or printed "keyboards" on perfectly smooth panels, which make operation without sight very difficult or impossible.

For nearly ten years, we enjoyed absolutely reliable operation of a dual-alarm GE clock radio, which cost about $80 and had direct numeric keyboard entry of times and frequencies by a keypad much like that on a push-button phone. When the keyboard became erratic, we found that the radio could not be replaced because parts were no longer available.

All the new clock radios seem to

use what I disparagingly call the "idiot data entry" method, by which you hold a key or press a spot until the desired number appears on display—a system totally unusable without sighted assistance. If data entry on clock radios—and some other electronic products, for that matter—was similar to data entry on scanners and push-button phones, a few quick keystrokes would provide absolutely reliable operation for the blind and sighted alike.

Computerized home-appliance controllers could be very helpful to us, if we could program them reliably without sighted assistance. (Many of us do not have sighted assistance easily available.)

While some of our needs are best met by special devices made for the blind, those are very expensive because they are made for such a small market. However, we could use many off-the-shelf items if their manufacturers would consider the possible sightless operation of those products. I sometimes think it would be interesting if those who design consumer electronics could be rendered totally blind for several hours, during which they would have to attempt operation of their equipment. I believe it is time for the electronics industry to examine ways in which it might provide greater accessibility to its products by the blind.

Do you know of any company that produces a good clock radio to meet our needs?

DAVID PLUMLEE
Independence, MO

We'll be presenting some projects that you should find useful in upcoming issues, including an E-Z Tune FM radio. However, it sounds as if your clock radio's keypad may simply need a good cleaning. You might want to try using TV-tuner cleaner on the switch contacts.—Editor

AC POWER AND MICROWAVES

I'm writing about two articles in the August issue of **Radio-Electronics**. First, I found the article on AC-power measurement to be well written and very informative. I would like to see more of such articles. There is one method of measuring power that is missing. That is using four-quadrant multipliers, such as one using RCA's transconductance op-amp, CA3060. I have assembled the parts for a wattmeter based on the CA3060 and have a prototype schematic, but have not gone further yet. Figure 14 in the article, using the pulse-width modulator method, interests me, and I will investigate it further. One note, though: The analog switch in Fig. 14 is drawn incorrectly so that the integrator sees the normal, but never the inverted input.

The second article is the one on microwave technology by Joe Carr. In the history of microwaves he gives an erroneous view of the use of vacuum tubes and omits an important application. He says, "By World War II, operation at 200 MHz was possible, 500–800 MHz was achieved by the end of the war, and 800 MHz by the early 1950's." In truth, by the late 1940's we had triode vacuum tubes that would work up to about 5000 MHz. In 1949, I worked on path-loss measurements for proposed relay sites for bringing AT&T's TD-2 microwave-relay system into Denver. The TD-2 band is 37 to 4200 MHz. That system had already been built some distance west of New York. The fol-

continued on page 25

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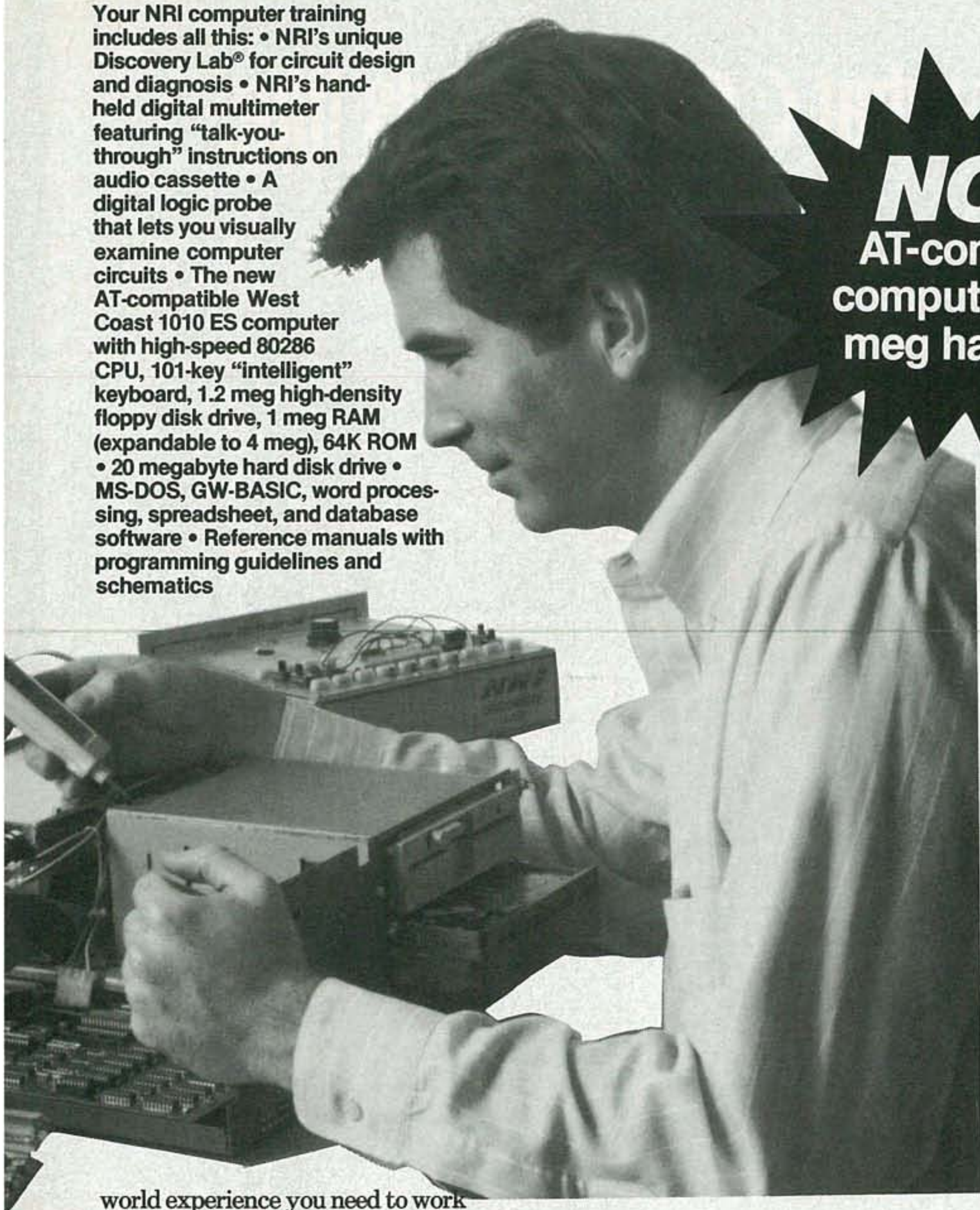

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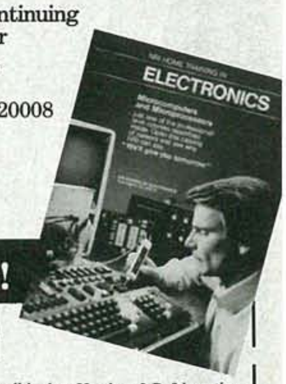

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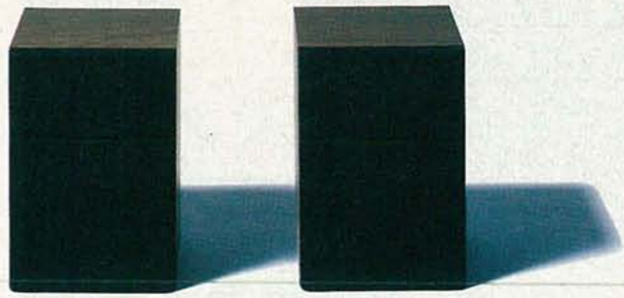

(●) is the symbol for the new *Sound Retrieval System* that lets you experience true 3-D sound from two ordinary loudspeakers. Read that last sentence again. You probably still won't believe it. But it is real.

In fact, (●) won the Grand Award for Audio Technology in the "Best of What's New", Popular Science, December, 1989.

Until now the quest for life-like 3-D sound has involved ever more sophisticated, complicated and expensive arrays of hardware.

Until now. Because the engineers at Hughes Aircraft Company began asking some new questions about sound itself. Instead of concentrating on hardware, they analyzed the way the ear processes sound. They discovered that the subtle restoration of certain frequencies in recorded audio can duplicate the way your ears locate sound. Ah ha!

Then they fiddled around with their new technology until they not only perfected it, they made it affordable for commercial applications.

To experience the uncanny realism of this new kind of sound is . . . well, uncanny. You can get up and walk around the room and the sound image doesn't change. You don't have to stay in the "sweet spot" created by delay arrays and surround-type matrices. And you won't find the "hot spots" you get with multiple speaker arrays. Will (●) replace all those speakers? Len Feldman, in the September 1989 issue of Radio Electronics wrote, "The demonstration was so dramatic and effective that people couldn't help but look for additional hidden speakers."

So forget expensive surround-type speaker matrices. You don't need to buy a roomful of speakers and sacrifice a lot of square feet of living space to house them. All you need is (●).

We'll bet you're still skeptical, and will be until you actually hear (●) for yourself. Which you can, today, on Sony TV sets. Imagine that. You can buy a Sony TV with built-in sound that will make you want to throw rocks at your stereo system. Several other major electronics companies are poised to announce (●) on their products.

So, when you do look for your new audio system, look for (●).

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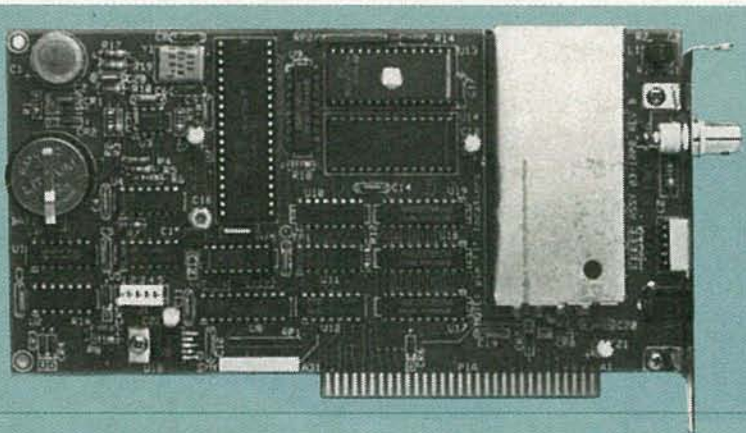
Coordinated Time Link Model CTS-10 Computer Time Standard



Link your IBM PC or compatible computer to an atomic clock for accurate, NIST-traceable time.

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It's easy to take accurate timing for granted. Today's least expensive digital watches offer performance that was available only on the most expensive watches of yesterday. The same trend has carried over to laboratory testing and data-logging equipment, but there, the demand for high accuracy is more critical.

As the personal computer takes over more and more data acquisition, logging, and automation functions, the need for higher-accuracy real-time clocks has become sorely apparent. Although the PC on which this report was prepared is not used for any laboratory functions, its internal clock keeps notoriously bad time. In a data-logging application, that would be unacceptable. For example, consider a network of several computers keeping watch on seismic activity in different parts of the country. If those computers don't share the same clock, the data they obtain can be misleading or meaningless. Fortunately, there's a solution: the *Computer Time Standard-10* or *CTS-10* from Coordinated Time Link, Inc. (3442 De La Cruz Blvd., Santa Clara, CA 95054).

The *CTS-10* is a plug-in time standard for IBM PC/XT/AT and compatibles. It decodes the time and date information from the 10-MHz radio broadcasts from WWV and WWVH, two stations operated by NIST, the National Institute of Science and Technology (formerly known as the NBS or National Bureau of Standards). Any application running on the PC automatically incorporates the correct atomic-based time—including leap-second corrections.

Installing the *CTS-10*

The *CTS-10* is reasonably easy to get up and running. The circuit board is a half-size card but, because of the width of the on-board 10-MHz radio receiver, takes up two slots (unless you can install it in the right-most slot). The rear panel of the card contains a BNC antenna connector, a 5-position DIP switch for port selection, and a DC power jack for connection to a wall transformer for backup power operation. An on-board lithium battery provides operation in the event of a power failure.

The most important part of the installation is mounting an antenna. Coordinated Time Link does have both indoor and outdoor antennas available as options, but it should be easy enough for a reader of this magazine to construct his own. A couple of caveats should be mentioned, however. The computer in which the receiver is mounted is a very noisy RF interference source. Even with proper shielding, the emissions from a PC at close range can be much stronger than the WWV signal.

Since the *CTS-10* offers neither a signal-strength meter nor an audio output, finding the correct positioning of the antenna is difficult. We found that using a separate shortwave receiver was a reliable way to find the best antenna location.

The remainder of the installation involves picking a port address that won't conflict with any other installed boards, and configuring the software.

The software supplied with the *CTS-10* is very easy to use. The configuration program is controlled by menus that allow you to select the port used, the color of the time display, the time zone you want displayed, the format (12/24 hour) of the time and date display, and whether you want automatic display of daylight savings time. The clock's update interval is adjustable from once every second to once per day. Although a short update interval offers the greatest accuracy, each update slows other processing down.

Although the software supplied with the board is adequate for most purposes, the *CTS-10* is the type of product that is bound to find itself in many custom applications. Fortunately, a chapter in the user's manual completely describes the programming interface, and appendices include routines in C and 8086 assembler that handle basic communications with the *CTS-10*.

We had an easy time getting everything operating properly—once we got our antenna far enough away from our computer. In a sense, that's unfortunate—we never got to try out the Remote Service Utility provided by Coordinated Time Link. That program allows a CTL service technician to test the *CTS-10* board in your own machine, using your own antenna. Although this is the first time we've seen such a service offered, we hope it's not the last.

We found the *CTS-10* to be a fascinating, one-of-a-kind device. With a single-unit price of $225, it should be an irresistible bargain for many laboratories and schools. **R-E**

LETTERS

continued from page 17

lowing year, I started a seven-year hitch in testing and maintaining two main routes of TD-2 systems. The tube that made the system possible was what started as the Morton triode, later coded the 416A, and still later the 416B triode tube. In the early 1950's, AT&T established a nationwide TD-2 system that allowed good TV network transmission for the first time. I think it was sometime in the 1960's that the tubes were replaced by solid-state devices. KENNETH E. STONE
Cherryvale, KS

Mr. Stone is essentially correct, and I gladly defer to the wisdom of age and "eye-witness experience." In any case, because of the importance of microwaves in beating the Nazis (especially through their use in radar), I'm darn glad that those frequencies were available!—Joe Carr.

VOR GENERATORS

Please advise P. Jamison (*Ask R-E*, **Radio-Electronics**, August 1990) that he should disregard your suggestion that he might use a 555 timer to build a VOR signal generator to test VOR course indicators used in aircraft.

As a retired Supervisory Electronic Specialist with the FAA, certified in VOR operation, I can agree with him that available VOR test-signal generators can appear to be heavily overpriced. However, closer examination shows that it's not so. The need for self-calibration and a 0.1°-limit on course error necessitates higher cost.

VOR's transmit two modulation components: a 9960-Hz component frequency-modulated at a rate of 30 Hz, and a 30-Hz component. Those signals are very clean sine waves, generated in such a way that the two recovered 30-Hz signals are in zero phase at zero azimuth, or point true north of the station. At other azimuths, the difference in phase between the two 30-Hz signals is equal to the true azimuth within a very small, allowable error. To shop-build even one such unit capable of generating such signals is feasible, but the cost would be prohibitive. For instance, the ARC type-14A VOR generator has been on the market for at least 15 years, so it should be possible to find a used one at a good price.

Approved testing of VOR equipment *requires* that some accurate signal source be used.

I suggest *Aviation Electronics*, by Keith W. Bose (Howard W. Sams & Company, 4300 West 62nd St., Indianapolis, IN 46268; 800-428-SAMS), for those who would like to learn more about any aircraft navigation equipment in easy-to-chew words.

As an aside, I've been reading **Radio-Electronics** since 1929, when it was called *Radio Craft*, and I've been a subscriber longer than I can remember.
WILLIAM L. HOY
Charleston, WV

SUPER ARTICLE

I'd like to "transmit" my thanks to Dale B. Blackwell for his excellent article, "Superdirectional Microphones" (**Radio-Electronics**, July, 1990). As an enthusiastic electronics hobbyist and an impulsive buyer of all available electronics magazines, I have collected many technical arti-

continued on page 94

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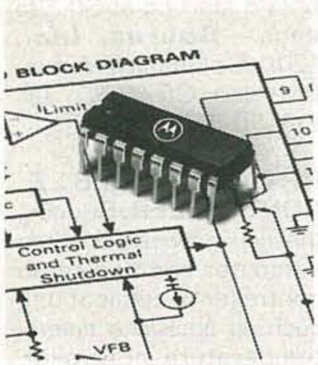

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step-up, step-down, and voltage-inverting applications with a minimum number of external components. Key features include operation from 2.5- to 40-volt input, precision 2% reference, a controlled duty-cycle oscillator capable of operating at over 100 kHz, and low standby current of 6.0 mA. The gated-oscillator control mode results in simplified, low-cost implementation of voltage-converter designs. In addition, functional features—including a programmable current limiter, bootstrap, and MPU reset—make it easy to achieve less complicated designs at lower cost. Designs using the *MC34163* do not require complex loop compensation (as do pulse-width modulated control-mode systems), which results in fewer external components, simplified IC design, and reduced die size. The devices are available in a 16-pin dual-in-line package, including a heat tab plastic power package which eliminates the need for an add-on heatsink.

The *MC34163P* (0°C–+70°C) and the *MC33163P* (−40°C–+85°C) 3A power-switching regulator devices cost $1.14 and $1.34, respectively, in quantities of 10,000.—**Motorola Inc.**, Bipolar Analog IC Division. Marketing, EL340, 2100 E. Elliot Road, Tempe, AZ 85284; Tel. 602-897-3615.

OSCILLOSCOPE PROBE KIT. A 20-piece *Master Kit* from *Probe Master, Inc.* contains three complete, heavy-duty probes and accessories. Included are a

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1×-25-MHz probe, a 1×-200-MHz probe, and a 1×/1× switchable 15-/200-MHz probe in a high-impact protective case. The four-foot probes use soft-molded strain-relief techniques that provide longer cable life. Accessories include a fully enclosed, rotating, snap-on ground lead; screw-in replaceable tips; tip insulators; IC test tips; trimmer tools; and repairable spring hooks for ease of operation and maintenance. Optional accessories include a four-inch insulated extender tip, wire wrap adapters, and pico hooks to adapt the probe tip for high-density circuit servicing.

The oscilloscope probe *Master Kit* cost $89.00.—**Probe Master, Inc.**, 4989 Ronson Court, San Diego, CA 92111; Tel. 800-772-1519.

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standard sine wave output can be converted to a square or triangle wave by changing one internal wire. Instructions are included to re-adjust or change the five

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fixed frequencies: 20 Hz, 1 kHz, 3 kHz, 10 kHz, and 20 kHz. The *125B* features a 0–20-kHz automatic sweep, and a manual frequency control that can be set from 0 to 20 kHz. Once set, the output amplitude remains flat from 20 Hz to 20 kHz (±1/4 dB). A special regulator circuit allows the two batteries to change from 9 volts to 5-1/2 volts, with no change in amplitude or frequency.

The model *125B* sweep generator costs $76.00.—**Production Devices**, 356 North Marshall Avenue, El Cajon, CA 92020; Tel. 800-824-4226.

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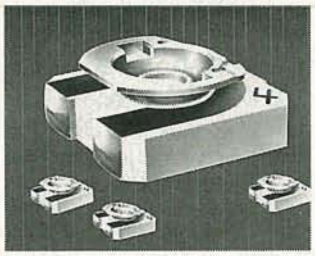

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place. The model *3363* surface-mount trimmer boasts the industry's smallest 3-mm design and meets both EIA and EIAJ standard board footprints and packaging requirements. Typical applications are in pocket and hand-held pagers, video cameras, cellular-phone handsets and base stations, office-automation equipment, computer peripherals, and home security systems. Superior termination-pad geometry results in improved wave and reflow soldering. A permanent coating over the resistor element protects it from harsh fluxes, soldering, and cleaning environments. The standard resistance range is 100 ohms to 1 megohm with 5% maximum contact resistance variation (CVR). The *3363* is packaged in an 8 millimeter embossed tape.

In low volume quantities, the model *3363* trimmer is priced starting at $0.395 each.—**Bourns, Inc.**, 1200 Columbia Avenue, Riverside, CA 92507; Tel. 714-781-5500.

PROGRAMMABLE CONTROLLER. Bridging the gap between desktop computer and dedicated controller in applications such as appliance timers, temperature controller, programmable tester, hobbyist projects, and alarms systems, the *BEaR-1FB* controller also functions as a hardware/software development tool or a micro-

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(* Source: U.S. Bureau of Labor Statistics)

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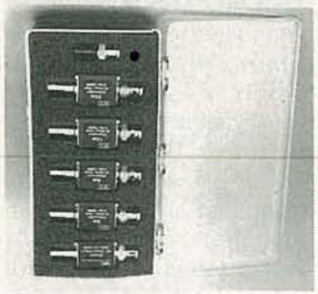
computer lab trainer. The controller, from *Blue Earth Research*, is based on the Intel 83C51FB microcontroller with resident floating point BASIC interpreter and debug monitor. The *BEaR-1FB* is simple to wire and program, requiring only a 6–16-volt power source and any terminal or PC that supports serial communications. Housed in a high-impact plastic case, the unit features 32K bytes of RAM; a real-time clock/calendar; an 8-channel, 8-bit A/D converter; a precision 5-volt regulator; a 10-year lithium backup battery; and a dual RS-232C driver/receiver for serial communications.

The *BEaR-1FB* controller costs $199.00. A complete system—including the controller, user manuals, a power supply, applications board, and serial interface cable—is available for $299.00.—**Blue Earth Research**, 310 Belle Avenue, Mankato, MN 56001; Tel. 507-387-4001; Fax 507-387-4008.

BNC ATTENUATOR KIT. Putting the proper attenuators at the fingertips of radio and TV broadcasters, RF design engineers, and mobile communications manufacturers, *Test Probes, Inc.* has introduced its model *TPI-1200* BNC attenuator kit. The kit contains one each of the four most frequently used attenuators—in 3-, 6-, 10-, and 20-dB ratios—as well as one 50-ohm feed-through and one 50-ohm BNC termination. The attenuators feature thick-film circuitry for low reactances and a frequency range of DC–1 GHz. Built for durability, the attenuators have a rectangular shape to keep them from rolling off a bench, and feature a "drop-proof" shock-resistant design.



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The model *TPI-1200* BNC attenuator kit costs $110.00.—**Test Probes, Inc.**, 9178 Brown Deer Road, San Diego, CA 92121; Tel. 800-368-5719.

CROSS-NEEDLE SWR/WATTMETER. The *MFJ-817* 114/440-MHz SWR/Wattmeter from *MFJ Enterprises* displays forward power, reflected power, and SWR at a single glance. The peak-and-average-reading instrument also provides two power scales—200 or 20 watts forward and 5 or 50 watts reflected. The *MFJ-817* is housed in a 7¼·4½·3½-inch black aluminum cabinet. It features a meter lamp and a large, two-color easy to read meter.

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The *MFJ-817* peak-reading cross-needle SWR/wattmeter, including a one-year unconditional warranty, costs $79.95. An optional 110-VAC adapter (*MFJ-1312*) for the meter lamp costs $12.95.—MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, MS 39762; Tel. 601-323-5869; Fax 601-323-6551.

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DSP ANALYSIS SOFTWARE. *Alligator Technologies' Fourier Perspective III* digital signal processing (DSP) analysis software with Data View graphics is designed to run on any MS-DOS-compatible computer (IBM PC, XT, AT, 386, 486, PS/2, and compatibles using MS DOS 3.0 or higher and equipped with a minimum of two floppy-disk drives or one floppy and a hard disk, and 512K of RAM memory). Data View provides publication-quality graphics; supports a variety of printers and plotters; and requires a CGA, Hercules monochrome-compatible, EGA, VGA, or equivalent graphics card. Fourier Perspective II uses the Prime Factor FFT subroutine library to operate on complex data sets as large as 65,520 points in one dimension. Single and double precision IEEE floating point formats and integer data format are supported. The DSP analysis software provides for high-performance calculations, and the use of on optional 8087 math coprocessor significantly increases the speed of all arithmetic operations. The software features one-dimensional Fourier transforms and graphics, digital filtering, linear systems functions, apodizing and windowing, convolution and correlations, file arithmetic and complex conjugates, media window filtering, and other mathematical operations. It also provides a Lotus 1-2-3 interface.

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Fourier Perspective III with Data View costs $695.00, with multiple use licenses available.—**Alligator Technologies**, 17150 Newhope Street #114, P.O. Box 9706, Fountain Valley, CA 92708; Tel. 714-850-9984; Fax 714-850-9987.

FOUR-WAY ELECTRICAL TESTER. An inexpensive tester from *A.W. Sperry Instruments*, the model *ET-204A*, allows technicians and hobbyists to check 110, 220, 277, and 460 volts AC/DC using just one compact instrument. The *ET-204A* four-way tester has individual resistors and bypass resistors for each voltage range.

The *ET-204A* four-way electrical tester costs $3.50.—**A.W. Sperry Instruments, Inc.**, 245 Marcus Boulevard, Hauppauge, NY 11788; Tel. 516-231-7050.

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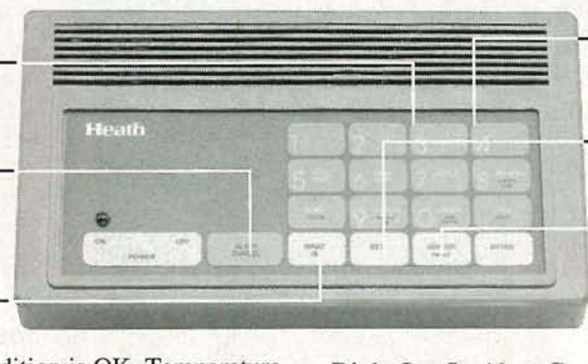

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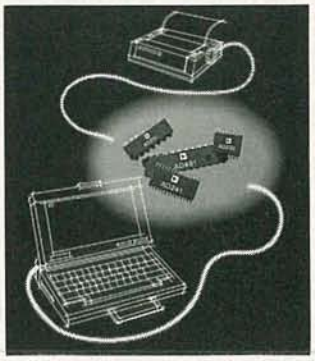
multiple lines of serial RS-232 and/or RS-422 data, replacing complicated, discrete solutions. All are manufactured in low-power CMOS or BiCMOS, require few or no external components, and are pin-compatible with existing industry products. Eleven configurations—ranging from two drivers and two receivers with the 14-pin AD231 to four drivers and five receivers with the 28-pin AD241—are offered for a variety of applications. Maximum no-load power dissipation is 50 mW with most of the devices. Nine of them require only a single +5-volt supply, and four of those feature a shutdown mode that reduces power dissipation to 5 μW for battery-powered applications.

In addition to the *AD230* line, Analog Devices introduced the *AD401* and *AD402*, which are configurable for either single-ended RS-232 or double-ended RS-422 communication standards—or a mix of both. All 13 devices are available in a variety of packages and temperature options.



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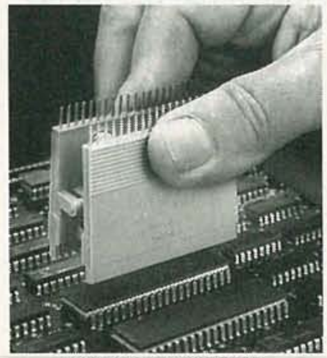
The *AD230* family of RS-232/RS-422 line drivers/receivers is priced starting at $2.70 each, in quantities of 100. Pricing for the *AD401* and *AD402* starts at $9.00 each, in quantities of 100.—**Analog Devices, Inc.**, 181 Ballardvale Street, Wilmington, MA 01887; Tel. 617-937-1428.

OXIDE-PENETRATING TEST CLIPS. Six DIP-clip test adapters from *Pomona Electronics* penetrate the oxide build-up on DIP IC's that have been exposed to contaminated environments. The devices function similarly to standard test clips, but feature a roughened, stainless-steel surface coating on their serrated contacts to provide good electrical connections on contaminated surfaces. The clips provide hands-free testing of standard 8- to 40-pin DIP IC's on high-density PC boards. The 1.02 mm (0.040 inch) contacts are separated by molded insulating barriers, allowing connection to be made on "live" boards without accidental shorting of adjacent contacts. The upper contact pins accept wire wraps or miniature test clips.

Models *5649*, *5650*, *5692*, *5694*, and *5695*, with 8, 14, 16, 20, 24, and 40 pins, respectively, range



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in list price from $9.70 to $31.00 each.—**ITT Pomona Electronics**, an ITT EMC Worldwide Company, 1500 East Ninth Street, Pomona, CA 91769; Tel. 714-623-3463; Fax 714-629-3317. **R-E**

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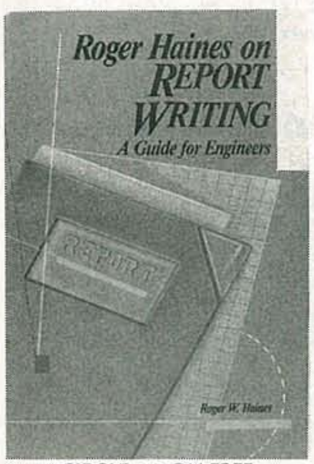
A common gap in engineers' educations is in the field of written communications. Although writing is often neglected between all the mandatory "numbers" courses, good, clear report writing is often an essential element of a career in engineering. For engineers who find it difficult to express ideas in words,



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this book demonstrates how to get ideas across to both technical and non-technical audiences. It shows engineers how to produce concise papers, using a proven approach that consists of a series of steps. The book explains how to clearly define the purpose and scope of a report, find and research information, evaluate the data, develop a writing style, choose the format and appearance of the report, effectively put graphics to use, use the advanced features of word processing, and compile appendices. A chapter on oral presentations, with advice on fielding questions, using visual aids, and using effective timing, is also included. Each topic is clearly explained and illustrated with real-life examples.

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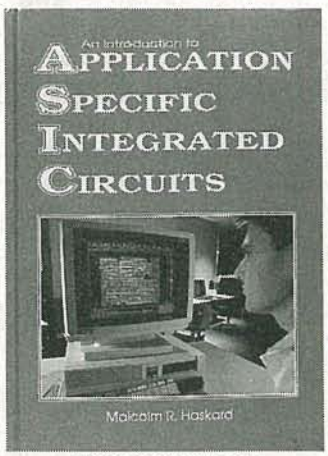
Containing specifications, drawings, and applications information for Hewlett-Packard's line of power supplies and electronic loads, this 128-page catalog provides easy-to-use informational tables to simplify selecting the right model. More than 80 models, ranging form 10 watts to 11 kilowatts, are included. Power supplies are grouped into HP-IB-controlled system, bench, lab, industrial, and special-purpose categories. Also included are HP's electronic-load products, ranging from 150 to 600 watts and offered in both stand-alone and mainframe-based configurations. The applications sections cover AC-power connections, DC-output connections, and analog-programming methods. A separate section contains a glossary of power-supply terms and their definitions.

CIRCLE 29 ON FREE INFORMATION CARD

AN INTRODUCTION TO APPLICATION SPECIFIC INTEGRATED CIRCUITS; by Malcolm R. Haskard. Prentice-Hall, Englewood Cliffs, NJ 07632; hardcover; $30.50.



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While application specific integrated circuits (ASIC's) are not a new technology, they are becoming increasing important in the world of electronics. This book provides an introduction to ASIC technology for both students and professionals. It offers a detailed overview of ASIC's, and in-depth looks at each of the major technologies, with a separate chapter devoted to arrays, standard cell, full custom, and programmable logic devices. The criteria for selecting the most appropriate silicon technology for a product are examined.

The book describes the CAD methods used in the design of ASIC's. A chapter explaining technologies that can be used to better train undergraduates in the use of ASIC's is also included.

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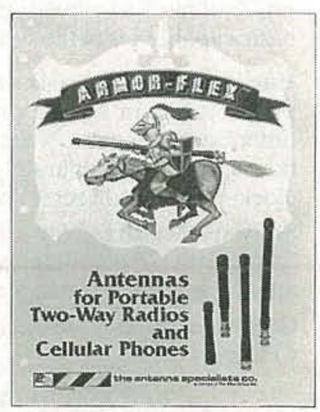

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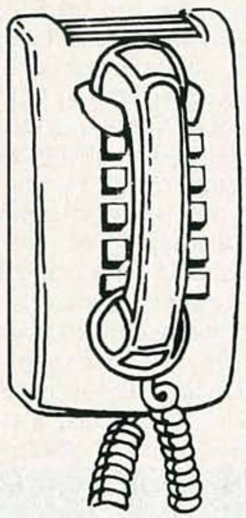

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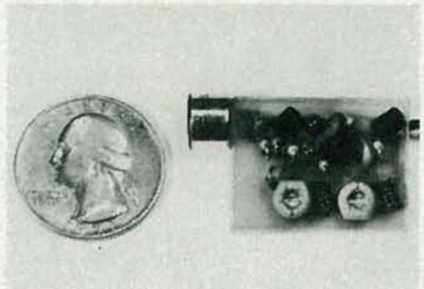

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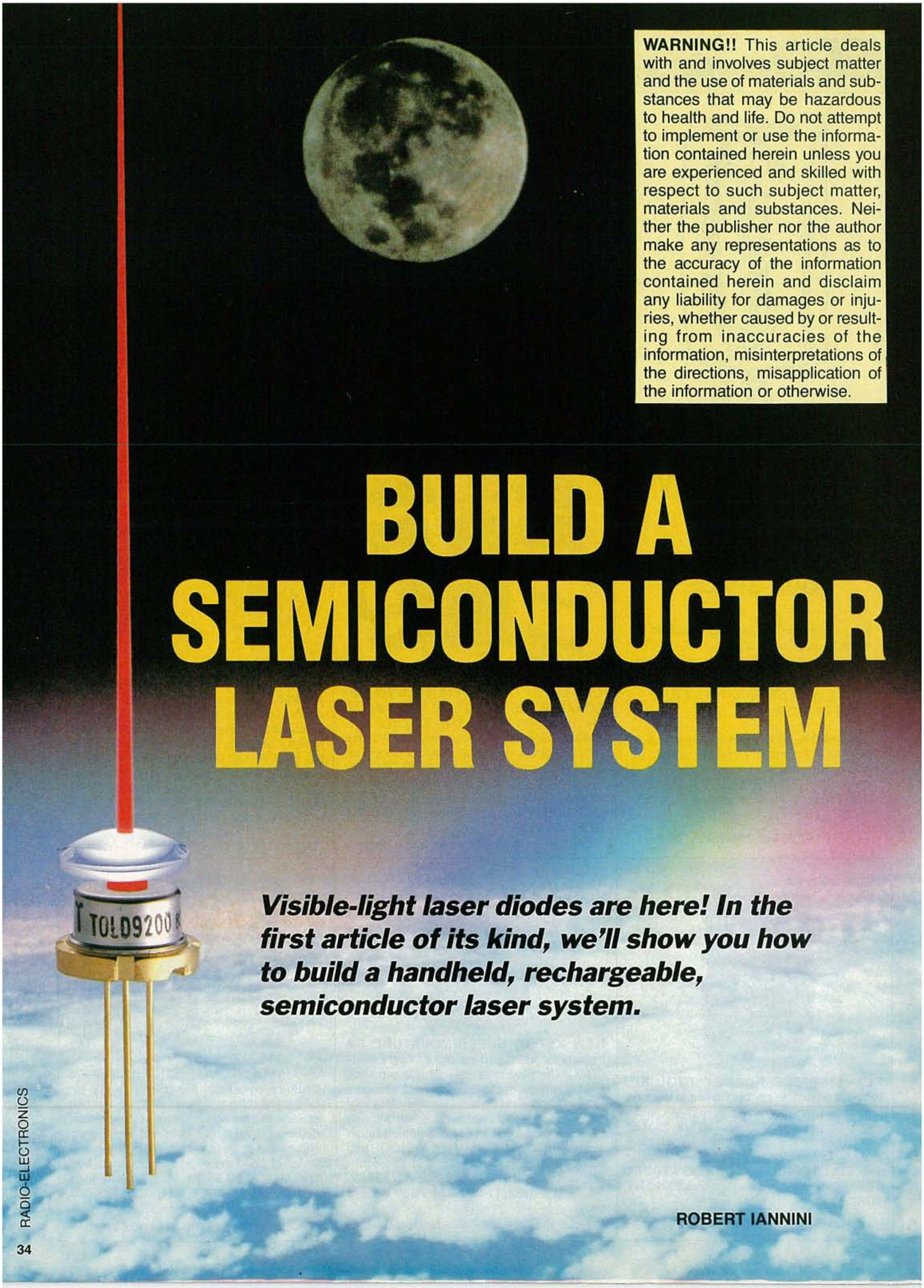

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Visible-light laser diodes are here! In the first article of its kind, we'll show you how to build a handheld, rechargeable, semiconductor laser system.

ROBERT IANNINI

THE INTRODUCTION OF LASERS IN 1963 has brought about many changes in our lives, from the supermarket check-out counter to "Star Wars" weapon technology. Very few scientific developments have had as much of an impact on both the technological and everyday world.

"Laser" is an acronym for "light amplification by stimulated emission of radiation." Lasers are used in many applications, including gun sites, pointers, printers, construction and surveying aids, compact-disc players, bar-code readers, light shows, and several others. The helium-neon gas laser is one of the most familiar types, with its bright red directional beam. It's been a workhorse for years, despite its fragile glass laser tube and its requirements for costly high-voltage power supplies. But laser diodes promise to open a whole new world of applications. To demonstrate how they can be used, we've developed a hand-held battery-powered laser that runs on four rechargeable batteries. The batteries are inductively charged using a special charger. The unit is shown in Fig. 1. How is that possible?

The recently developed TOLD-9200-series of laser diodes from Toshiba emit coherent laser light in the visible spectrum, and don't require a high-voltage power supply. Because they're small, low-cost, and fairly rugged, laser diodes are well-suited for many applications.

Before proceeding further, lets review some basic laser theory, but first we must talk about regular light for a minute. When you turn on a light bulb, light energy is emitted in what is referred to as "spontaneous" form. It is an integration of many individual atomic energy level changes, each producing its own little "packet" or photon of light energy, with each photon having a particular phase.

In the case of a light bulb, electrical energy "pumps" the filament electrons to higher-than-normal atomic energy levels (see Fig. 2). Photons are emitted when the electrons return to their initial states and give up that energy in the form of light. The frequency of the light is dependent on the difference between the previously excited and normal energy level states; the larger the difference in energy levels, the lower the wavelength of light. The light produced by the process of spontaneous emission is incoherent or random (see Fig. 3).

Unlike spontaneous emission, laser light is highly directional. The radiant energy is released in-step, or in synchronism, resulting in coherent reinforced light where all of the waves are in phase. In other words, all of the rays are parallel and at the same wavelength. To achieve that requires that the number of excited atoms in the higher energy state exceeds that of the initial or rest state. That condition, referred to as "population inversion," normally doesn't occur in nature and must be "forced" or pumped.

Given a population inversion, each energized atom is then "stimulated" to return to its lower energy state by the emission energy, or incident light of an adjacent atom (see Fig. 4). The result is coherent light waves as shown in Fig. 5. An optical cavity with mirrored ends is usually necessary to provide the right amount of stimulated energy for laser light. As shown in Fig. 6, the light is reflected back and forth within its confines until it is a powerful beam that is allowed to exit the cavity as useful laser light energy.

A laser diode is similar to an ordinary light-emitting diode (LED) in that both are composed of a semiconductor PN junction (see Fig. 7). An electrical potential causes a flow of holes and electrons that, upon recombination, emit light. The LED produces spontaneous light, while the laser emits light by stimulated emission. The laser diode also contains two reflecting mirrors that form what's called a Fabry-Perot cavity, and permit the emitted light to be highly directional, an important laser property.

In spite of a laser diode's apparent physical ruggedness, it is very sensitive to temperature changes, electrical transients, and operating-current parameters. It is totally unforgiving of errors, so our circuitry and construction techniques must take that into consideration.

Safety first

Before proceeding, you should be aware of the potential hazards associated with lasers. Laser diodes can produce a continuous power in excess of 3 milliwatts. **That energy, when collimated, or viewed near-field, can cause retinal damage, so never look directly into the laser beam or through any lenses when the system is activated.** The laser that we are building is a Class IIIa device, and must be in compliance with U.S. safety standards for laser products (21 CFR 1040.10 and 1040.11).

Our device must bear a label like the one shown in Fig. 8. It must also have a label certifying that it conforms to classification specifications. At the output it must have the following label: **"Avoid Exposure, Visible Laser Radiation is Emitted From This Aperture."** Safety glasses should be worn when working with lasing devices of this power. Laser Peripherals, Hingham, MA is a good source; their model #DO-40 is suggested.

To prevent damage to the laser diodes, be sure not to exceed maximum ratings, even momentarily; or you could destroy the diode or cause it to require more current to produce its rated output (which will quickly lead to failure). Transients or spikes from switching both on and off can also destroy the device. Heat-sinking is required; the amount depends on whether the device will be used intermittently or continuously. Keep in mind that a temperature rise reduces the output for a given current, and merely supplying more current will lead to a thermal problem.

Be aware of electrostatic discharge when handling laser diodes. Normally, assembly requires grounded irons, wrist straps, floor mats, etc. However, the hobbyist can either work on a hot humid day or use a vaporizer or humidifier to maintain a degree of moisture in the air—that will reduce the static charge.

Do not operate the unit near high-frequency or high-power pulse circuitry, an RF field, a Tesla coil, plasma, magnetic discharge, etc. Never stress the diode leads or distort the hermetically sealed case. The device

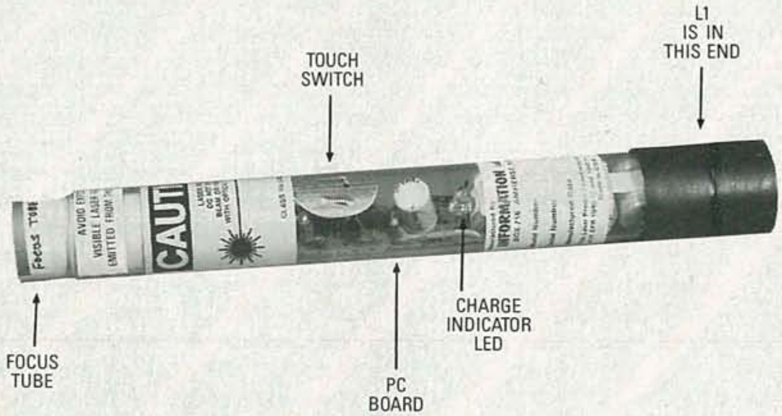


FIG. 1—OUR HAND-HELD LASER is powered from four rechargeable Ni-Cd batteries, which are inductively charged.

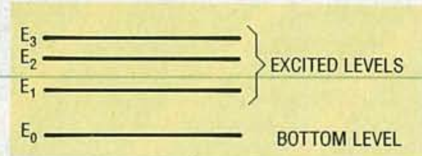


FIG. 2—LIGHT IS THE RESULT of radiation produced within an individual atom by an electron being "pumped" to a higher than normal energy level by an external energy source.

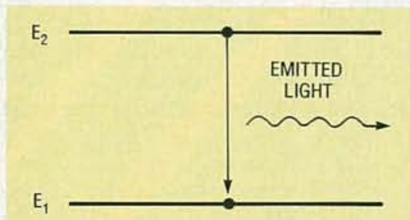


FIG. 3—A LIGHT BULB EMITS "spontaneous" light, which does not allow the energy packets to reinforce one another in phase or position.

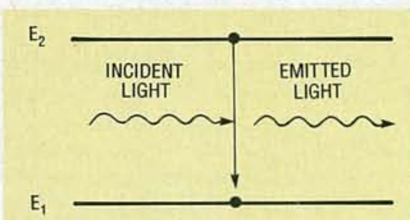


FIG. 4—WHEN MORE EXCITED ATOMS exist in the higher energy state than in the initial or rest state, each energized atom is "stimulated" to return to its lower energy state by the emission energy, or incident light of an adjacent atom.

should fit snugly into the heat sink cavity with minimal force. Never touch the window because scratches and contaminants will distort and decrease the optical output. Use a cotton swab and ethyl alcohol to clean the window.

Circuitry

A laser diode operates like an ordinary forward-biased diode and shows the operating curve in Fig. 9. The vertical axis corresponds to optical output while the horizontal axis is the forward diode current. I_{OP} is the operating current, which determines the optical output. Lasing starts at the threshold value (I_{TH}). The maximum rated input current must never be exceeded. However, anything below I_{TH} will produce the effects of a regular LED. The curve shows a very steep slope where laser operation takes place, and the input-current "window" on the horizontal axis is very narrow; consequently the driver circuit must operate within those limits or you'll end up with one of the worlds most expensive medium-powered LED's.

The schematic of the hand-held laser is shown in Fig. 10. The Toshiba 9200 laser diode (D3) is actually an assembly that contains a laser-emitting section (LD) and a photodiode section (PD). The photodiode allows the circuit to monitor the laser diode's output and to produce the feedback necessary to control the circuit and protect the diode from voltage transients.

The laser diode is connected in series with current-limiting resistor R4 and the collector of Q4. The current through Q4 is controlled by Q3. Zener diode D2 maintains the voltage across Q3, and R3 limits the Zener current. The collector current of Q3, which is also the base current of Q4, is controlled by its base which is connected across R5 and R6. Current from the photodiode develops a voltage across those resistors that is proportional to the optical output energy. That constitutes the feedback required for output stabilization. Increased output causes Q3 to conduct less base current to Q4, resulting in less laser diode current. Potentiometer R6 presets the value of quiescent current. Capacitor C5 limits transients at the base of Q4 while C4 limits them from the V_{CC} line.

The system turns on when Q2 is conducting and close to saturation. Touch-switch S1's electrodes consist of small pieces of metallic tape that, when bridged by finger contact, cause a small amount of base current to flow into Q1. The collector current of Q1 flows into the base of Q2, causing it to saturate and supply current to the laser diode. Base current to Q1 is limited by R2, while R1 and C2 reduce the circuit's sensitivity to stray AC or static fields that could cause premature turn-on.

The laser is powered by four rechargeable Ni-Cd batteries. They are charged by induction coupling to the charging module. The batteries are connected in series with rectifier diode D1, LED1, and the pickup coil, L1. High-frequency energy from the charger is coupled into the coil, and is rectified and filtered by C1. When the batteries are being charged LED1 turns on.

The charger schematic is shown Fig. 11, and a photograph of a prototype unit is shown in Fig. 12. It uses a 120-to-12 volt AC step-down transformer, T1, whose output is rectified by diodes D4–D7; capacitor C6 removes any ripples. Switch S2

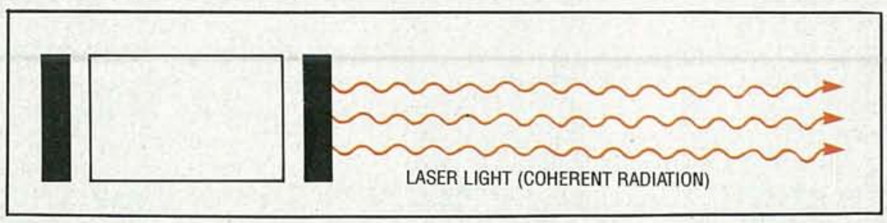


FIG. 5—A LASER BEAM IS THE RESULT of an "in lock step" train of coherent light waves.

supplies power to the circuit, and LED2 indicates when the power is on. The ground lead of PL1 is connected directly to the metal chassis of the charger.

The rectified 12–14 volts DC energizes a simple oscillator circuit consisting of Q5 in series with L2. That winding couples energy into the pick-up coil (L1) of the laser section for battery charging. To charge the batteries, the pickup coil physically slides over the coil assembly of the charger module. No electrical connections are necessary to provide the charging current.

Coil L3 (which is wound on the same ferrite core as is L2), and resistor R9 provide the necessary feedback to sustain oscillation. Resistor R8 initiates the action by turning Q5 on. A resonating capacitor (C7) is connected across L2 to adjust the frequency to approximately 250 kHz.

PARTS LIST FOR THE LASER

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—5.6 megohms
R2, R5—1000 ohms
R3—470 ohms
R4—15 ohms, ½-watt
R4-a—100 ohms (optional, see text)
R6—5000 ohms, trimmer potentiometer

Capacitors
C1—100 µF, 16 volts, electrolytic
C2—0.1 µF, 16 volts, ceramic disc
C3—0.01 µF, 16 volts, ceramic disc
C4—1 µF, 16 volts, electrolytic
C5—10 µF, 16 volts, electrolytic

Semiconductors
D1—1N4001 diode
D2—1N5221 Zener diode (2.4 volts)
D3—TOLD 9200 laser diode (Toshiba)
LED1—yellow light-emitting diode
LED3—red light-emitting diode (for the simulated laser diode)
Q1, Q3—PN2907 NPN transistor
Q2, Q4—PN2222 NPN transistor
Q5—L14G3 or ECG3036 phototransistor (for the simulated laser diode)

Other components
B1–B4—1.25-volt Ni-Cd cell, VARTA 100 R.S.
L1—pickup coil, 10 turns #18 wire, ½-inch diameter
S1—2 pieces of adhesive-backed metal tape (see text)

Miscellaneous: PC board or perforated construction board, small transistor socket (for laser diode), special aluminum heatsink and diode retainer with hardware, #24 vinyl wire, #20 vinyl wire, 7¾-inch long by 1-inch diameter by 1⁄16-inch wall thickness (transparent or colored), 13⁄16 plastic rear cap, 1⅝-inch by ⅞-inch focus tube, 1×6 mm short focal length lens, 1-inch plastic caps, ⅞-inch diameter shoulder washer (to mount lens on), warning labels, etc.

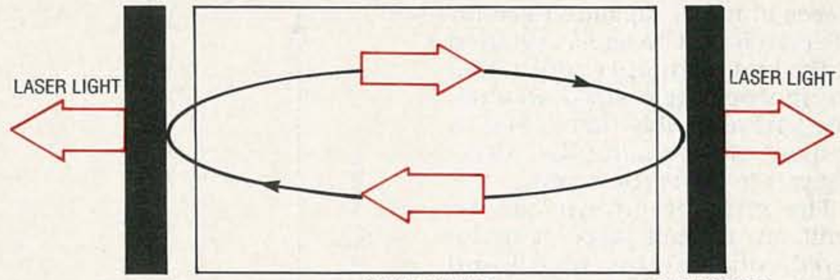


FIG. 6—AN OPTICAL CAVITY having mirrored ends provides the right amount of stimulated energy for laser light. Light is reflected back and forth within its confines until it is a powerful beam that is allowed to exit the cavity as useful laser radiation.

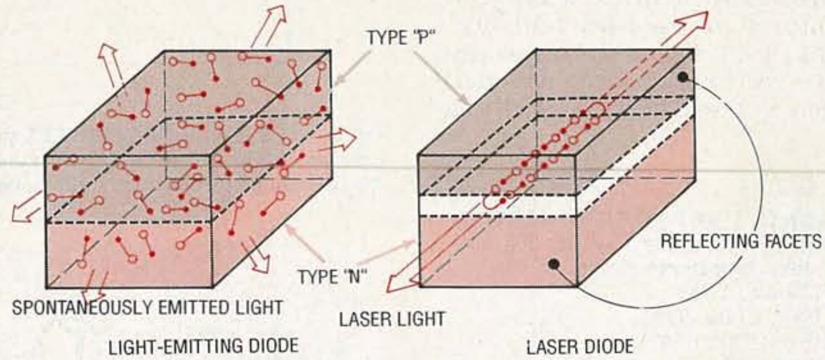


FIG. 7—A LASER DIODE IS SIMILAR to an ordinary LED, except that the LED produces spontaneous light, while the laser emits light by stimulated emission where the wavelengths and temporal relation are coherent. A laser diode also contains two reflecting mirrors that form a cavity and permit the emitted light to be highly directional.

FIG. 8—ANY LASER DEVICE must contain warning labels according to the specific type of device. Our hand-held laser must display this warning, in addition to a label stating that it conforms to specifications and a warning at the laser aperture.

Construction

All of the parts are available from the source mentioned in the parts list. A foil pattern has been provided if you wish to etch your own board for the laser unit, and a parts-placement diagram is shown in Fig. 13.

If you wish, you can certainly install the circuit in any kind of housing that you like—you don't have to follow our unit exactly. Just make sure you follow the circuitry and the precautions concerning the laser diode.

The specifications for L1 are described in the parts list. Position it as shown in the handle of the laser so that it can slide over the charging coil (L2). DO NOT install the laser diode in the circuit at this time; install only its socket. The circuit must be checked and calibrated beforehand. Don't forget to build the "simulated laser diode" shown in Fig. 10. It is used later on for testing and calibrating the laser system, without the fear of damaging the actual laser diode.

A cylindrical plastic enclosure houses the board, the batteries, and the optics. After the board is finished and checked out, it slides inside the plastic tube and the leads for S1 (the touch switch) are brought outside through two small holes. (Wait until we check out the board before installing it in the tube.) Two pieces of metal tape are used for the contacts. The lens is secured at the end of another tube using an appropriately sized washer. The lens assembly then slides in and out of the main tube, allowing you to focus the beam.

The charger circuit can be built on a small piece of perforated construction board and wired according to the schematic in Fig. 11. In the prototype, Q6 is heatsinked by attaching it to the surface of the metal cabinet. It must be insulated, so use a nylon screw and a mica washer to mount it (or use a separate heatsink). Coils L2 and L3 are wound on a ferrite core (see parts list), then wrapped with tape. The assembly is then centered in the charger tube and secured with epoxy filler (see Fig. 12).

Figure 14 shows how the laser section and the charger go together. If you don't follow the prototype exactly, simply follow Fig. 14 as a rough layout.

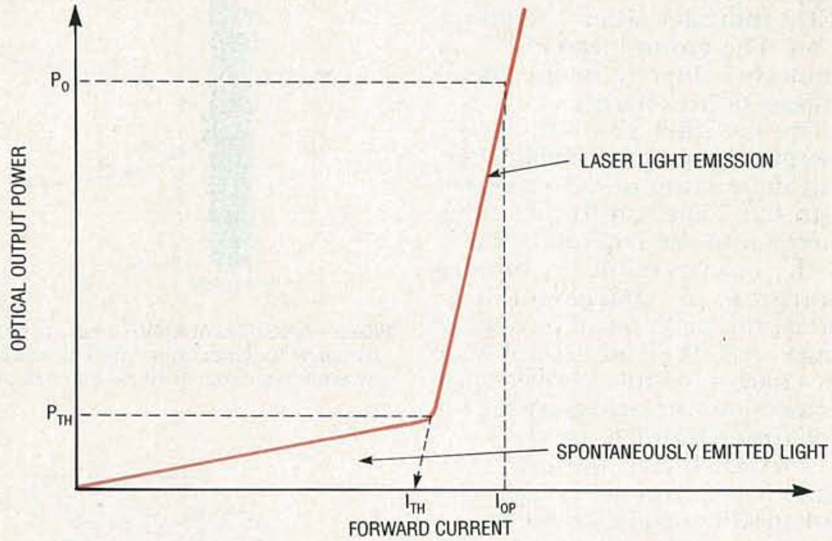


FIG. 9—A LASER DIODE OPERATES similarly to a forward-biased diode. The vertical axis corresponds to optical output while the horizontal axis is the forward diode current. I_{OP} is the operating current, and anything below I_{TH} will produce the effects of an LED.

PARTS LIST FOR THE CHARGER

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

R7—470 ohms
R8—22,000 ohms
R9—10,000 ohms

Capacitors

C6—1000 µF, 16 volts, electrolytic
C7—0.047 µF, 50 volts, Mylar

Semiconductors

D4–D7—1N4001 diode
LED2—green light-emitting diode
Q6—D40D5 or NTE210 NPN power transistor

Other components

L2, L3—coils wound on ferrite core (core is 1-inch in length, ¼-inch diameter) L2 is 10 turns #24 wire, L3 is 10 turns #30 wire.
T1—120/12-volt AC step-down transformer, 100 mA
S2—SPST switch
PL1—3-wire line cord

Miscellaneous: perforated construction board, 6-32 × ½-inch nylon screw and nut with mica washer (to mount Q6 to case), 2½-inch plastic tube to fit over laser tube, metal cabinet (or use separate heatsink for Q6), line cord bushing, LED mounting bushing, double-sided tape, hardware, wire nuts, #24 vinyl wire, epoxy, etc.

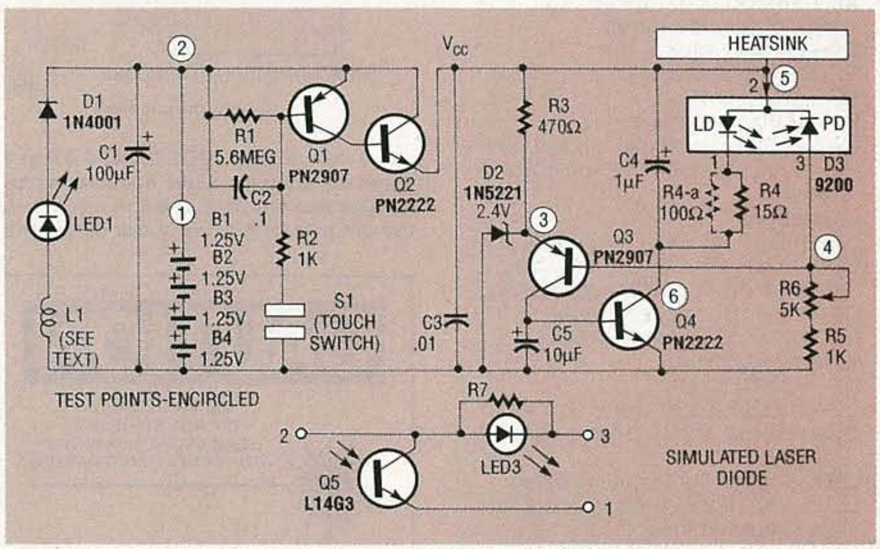


FIG. 10—HERE'S THE SCHEMATIC of the hand-held laser. The laser diode (D3) consists of the laser-diode (LD) and photodiode (PD) sections. That allows monitoring of the output energy and produces the feedback necessary to control the circuit.

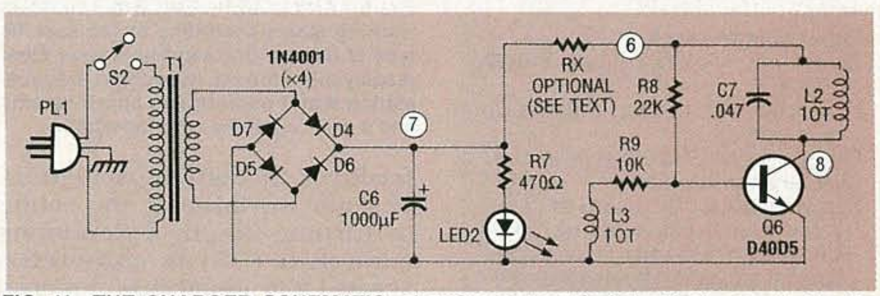


FIG. 11—THE CHARGER SCHEMATIC, charging current is inductively coupled to the hand-held laser.

Checkout

First make sure you do not have the laser diode in the circuit at this time. Plug the charger into a grounded AC outlet and check for 12–14 volts DC at test point 7 on the charger schematic. Check to see that LED2 turns on when you close S2.

Open up the lead at test point TP6 on the charger and check for a reading of 100–125 milliamps (assuming the batteries aren't already charged). In rare cases, if the current is excessively high, a resistor (RX) may be required as shown in the schematic to limit it. If a scope is available you may

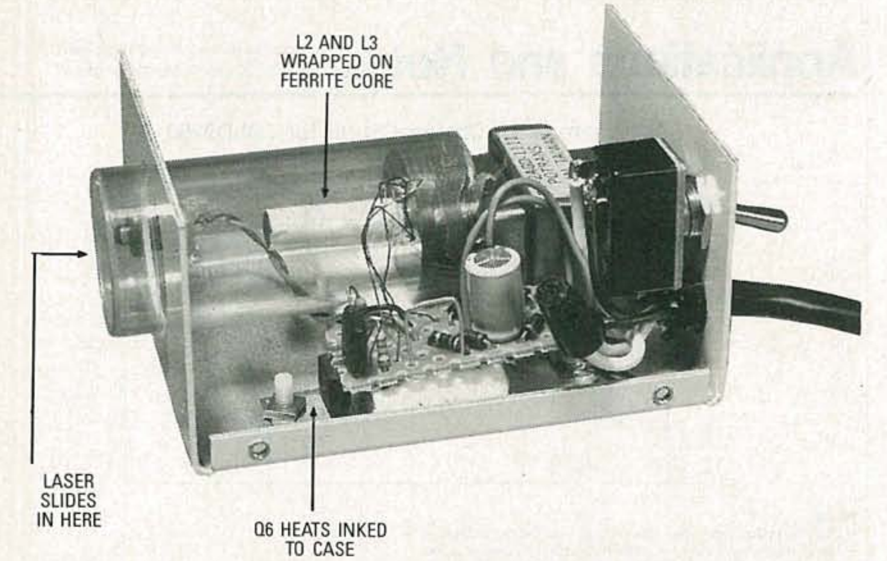


FIG. 12—**THIS IS THE CHARGING UNIT;** the amount of current coupled to it depends on how far the laser is inserted into the charger.
in the charger, more or less current is coupled to it.

ORDERING INFORMATION
A kit of all parts for the hand-held laser except the laser diode, heatsink, and retaining hardware (# VRL2-LHK), is available for $39.50. The special aluminum heatsink and diode retainer with hardware (#HS3) is $9.50. The price for the Toshiba laser diode (TOLD 9200) is continually dropping, although it is currently $74.50. A kit of all parts for the charger (#VRL2-CMK) is $34.50. A kit of parts for the entire system, including batteries and charger is $158.50. Contact Information Unlimited, P.O. Box 716, Amherst, NH 03031. FAX: 603-672-5406. Toll-free order line: 800-221-1705.

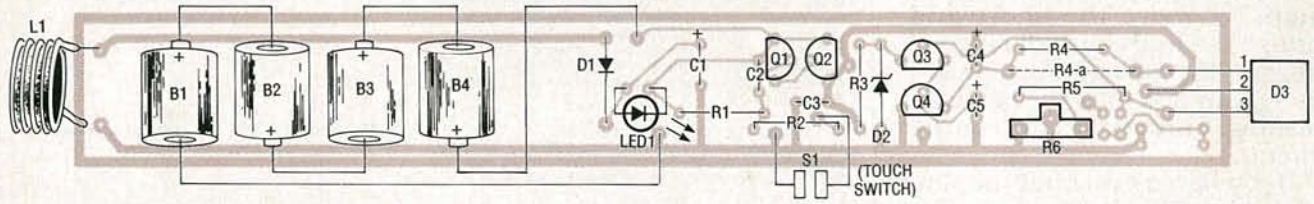


FIG. 13—**PARTS-PLACEMENT DIAGRAM** for the laser. Do not install the laser diode until everything has been thoroughly tested.

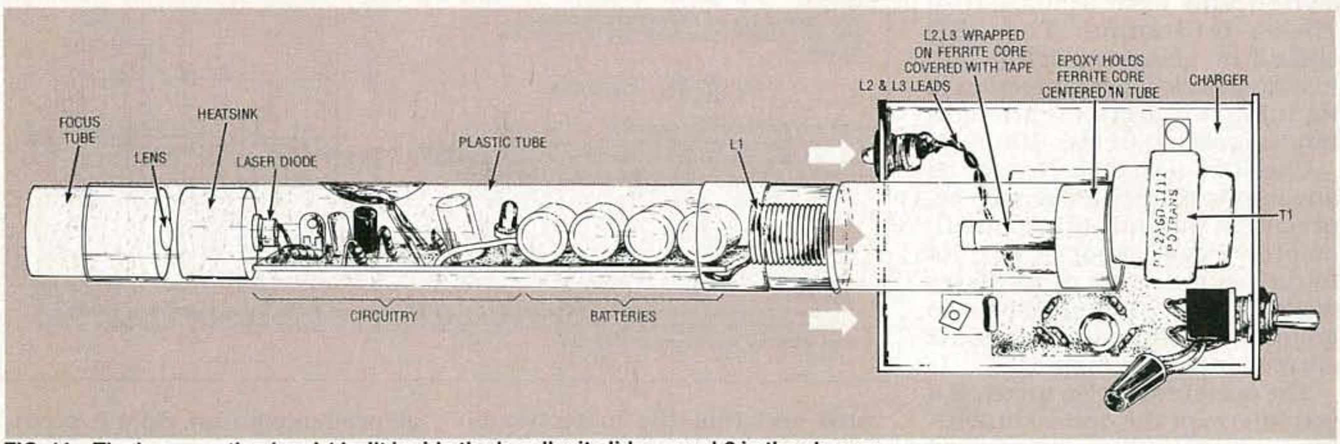
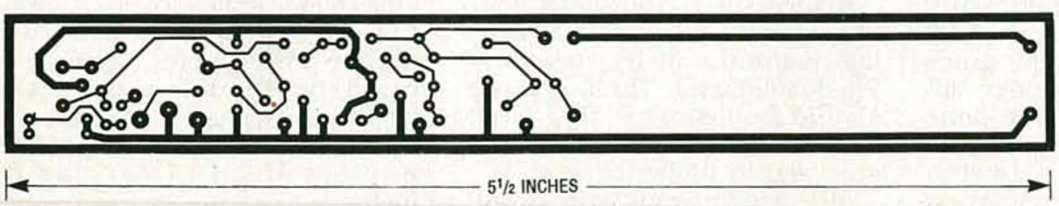


FIG. 14—The laser section has L1 built inside the handle; it slides over L2 in the charger.



THIS FOIL PATTERN for the hand-held laser can be used if you wish to etch your own board.

want to verify an approximate sine-wave shape of 25–30 volts peak to peak at a frequency of 250–300 kHz at test point TP8. This verifies proper operation of the charger.

Connect an ammeter in series with test point 1 on the laser. Slide coil L1 of the laser over the ferrite core of L2 on the charger. Check for a current reading of 10–25 milliamps and that the charge indicator (LED1) is lit.

The laser may be positioned in the charger socket for either a fast charge of 20 milliamps at a 6–8 hour rate, or the recommended 10 milliamps at a

14 hour rate. Monitor the charging current as you slide the laser in and out of the charger.

Make sure that the batteries are fully charged before you proceed with the following. Remove the laser from the charger. Note that the current goes to zero and LED1 goes out. Check on the lowest meter range; any current flowing into the circuit above a fraction of a microamp will cause premature discharging of the batteries. Check for defective components, flux paths, excessive moisture, etc., if any current is detected in this step.

Using the negative lead of B4 as a ground point, check for 5.6 volts at test point TP2. Adjust R6 to a maximum value (fully counter-clockwise in our layout). Short out the touch-switch leads and note a current of 10–15 milliamps. Remove the short and bridge the leads with dampened fingers; the current flow should be slightly less than the previous reading. This verifies the control circuit.

If you haven't yet built the simulated laser diode (shown in Fig. 10), do so now, and insert it into the circuit. Short out the touch switch and note a current of 75–85 milliamps. The LED should be glowing brightly. Adjust R6 in a clockwise direction to its midpoint and note the current increasing to over 100 mA.

Check for a smooth control, as any jumps can spell disaster, especially at the end of the potentiometer travel. Short the phototransistor section of test laser diode with a 470-ohm resistor to ground. You should note that the current increases further.

The current will also increase if you interrupt the optical link between the phototransistor and the LED. That verifies that the feedback circuit is operating properly. CAUTION: Re-adjust R6 back to maximum resistance (fully CCW). As a reminder, adjustment of R6 must be done with the batteries fully charged.

Remove the touch-switch short. With a metal screwdriver, short out all pins of the laser-diode socket. Do not go any further if you suspect a high-static electrical condition. Wait for a damp day or use a humidifier or vaporizer in your work area. Make sure the touch-switch leads are separated and that the meter reads zero current. Carefully insert the diode into the socket.

Bridge the switch with your finger and note the laser diode lighting and a meter current of 70–80 milliamps. The laser diode should be lasing at this level. Short out the touch switch and note slightly higher current.

At this point your laser is producing about 0.5 to 0.7 milliwatts—so you might want to stop here. However, the actual laser-diode current is the meter reading (70–80 mA) minus the 10–20 milliamps at the touch-switch leads, which is still well below the allowed maximum. So it is possible to get more power out of the laser diode. However, if you do decide to challenge Murphy's laws, the next step should be done with a laser power meter. That's because the output level is critical when adjusting for maximum. We used a *Metrologic* model number 45-540 laser power meter.

Couple the head of the power meter to the laser diode and set it for the 20-milliwatts range. Use a piece of clay for temporarily securing them together. Short out the touch switch and note a

continued on page 95

Applications and Notes

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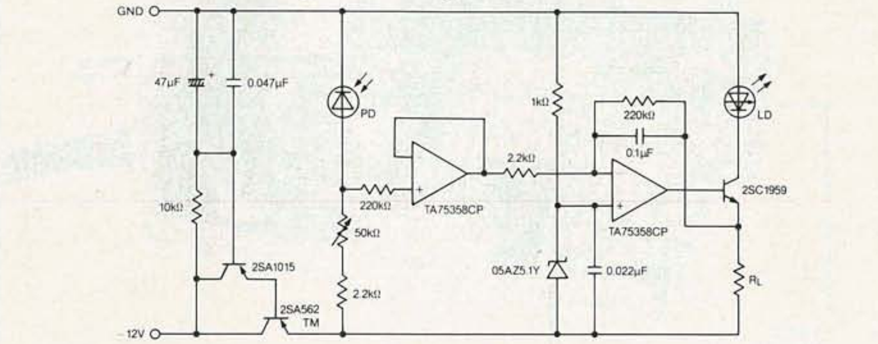
An Example of Driving Circuit for TOLD9200

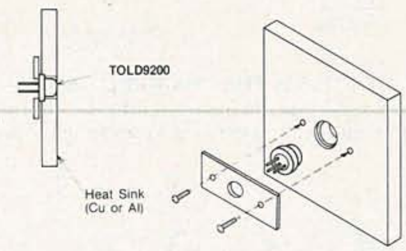


Note:

- Use the laser diode after attaching it to a heat sink. Use a larger heat sink during the evaluation stage of deciding the operating condition. A copper or aluminum heat sink is recommended.
- Set the variable resistance VR (50kΩ) for its maximum value, then turn a power supply on. And regulate VR to adjust optical output power.
- When adjusting the optical output power, monitor both the drive current and the optical output power, never exceed the maximum optical output power rating. To monitor the optical output power, use an optical power meter or a calibrated photodiode that has a large active area. In case of using the above driving circuit, the heat sink will have positive potential.
- An Example of the Design of a Heat Sink
  The relationship among the case temperature T_c, ambient temperature T_a, and the thermal resistance of the heat sink θ_f is shown in the following simplified equation:

$$\theta_f \fallingdotseq \frac{T_c - T_a}{I_{op} \times V_{op}} - (\theta_s + \theta_c)$$

θ_s: Thermal resistance of insulator sheet
θ_c: Contact thermal resistance



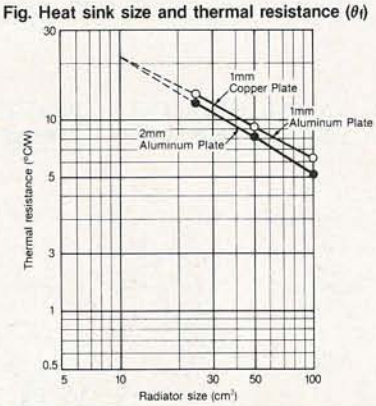
Example:

In the case of $T_c = 50°C$, $T_a = 45°C$, $I_{op} = 100mA$, $V_{op} = 2.5V$, $\theta_s = 0$ (no insulator sheet), $\theta_c = 8°C/W$, from the above equation:

$$\theta_f \fallingdotseq \frac{50 - 45}{0.1 \times 2.5} - 8 = 12°C/W$$

Heat sink thermal resistance must be 12°C/W or less. From the figure on the right, the surface area of the aluminum heat sink—assuming it is 2mm thick—must be 25cm² in order to obtain a thermal resistance of 12°C/W or less.

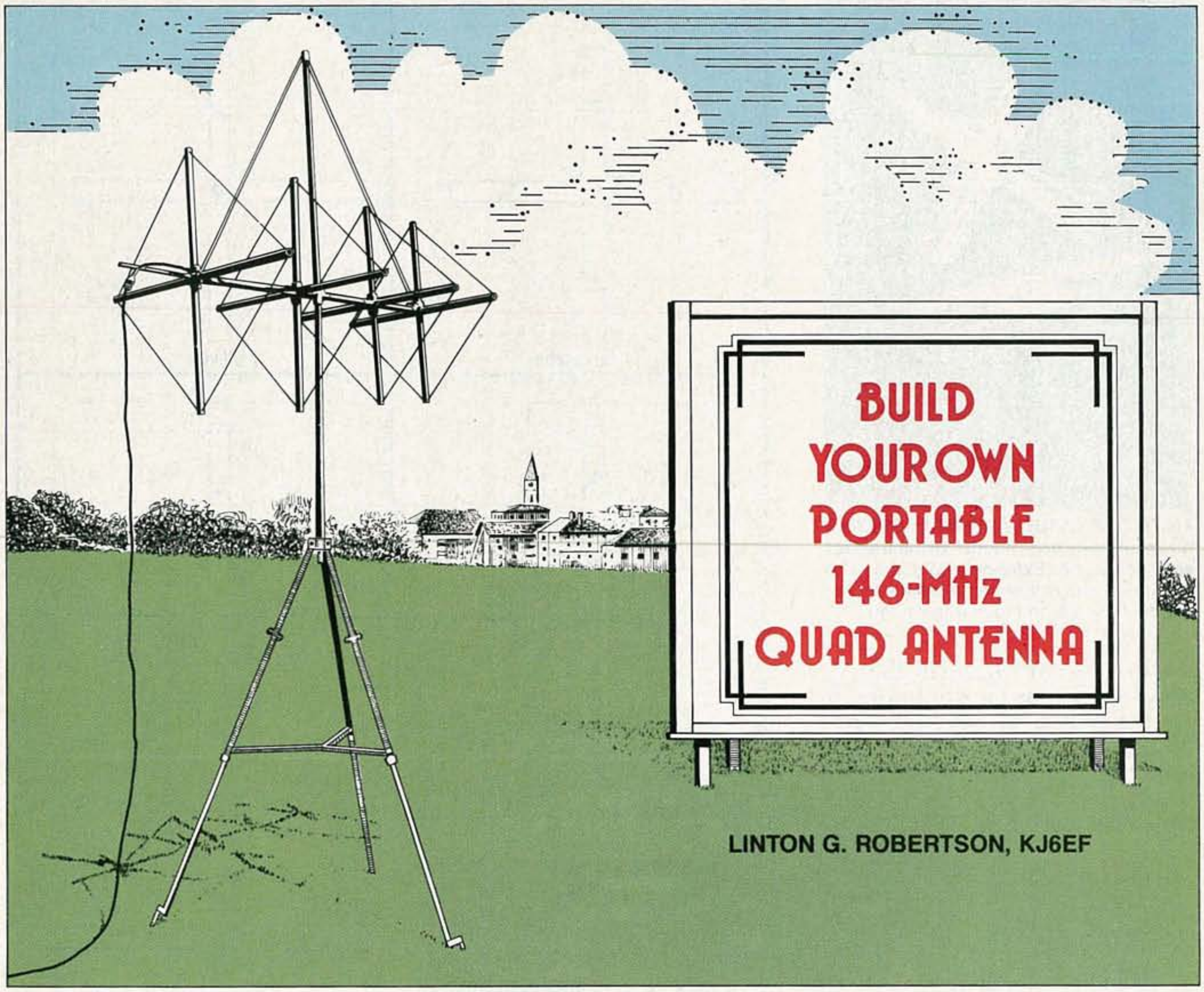
Fig. Heat sink size and thermal resistance (θ_f)



IMPORTANT NOTICES

The circuit examples illustrated herein are presented only as a guide for the performances of the applications of our products.

Keep in mind that no responsibility is assumed by TOSHIBA for its use, nor for any infringements of patents or other rights of the third parties which may result from its use, and that no license is granted by implication or otherwise under any patent rights of TOSHIBA.



BUILD YOUR OWN PORTABLE 146-MHz QUAD ANTENNA

LINTON G. ROBERTSON, KJ6EF

Build this portable 2-meter quad antenna. It offers plenty of punch to the pound for your next Field Day adventure.

IF YOU'RE AN AVID VHF HILL-TOPPER, or just thinking about becoming a "ham", you'll be interested in this inexpensive and easy-to-build antenna for the 2-meter band. Join in the spirit of public-service by taking this light, portable quad antenna into the great outdoors on Field Day, an annual event held every June. On Field Day, amateur radio operators take their equipment into the field and, using power generated at the operating site, test it to prepare for their response in the event of a disaster.

Our portable quad antenna weighs only two and three quarter pounds, and has good gain compared to a four-element Yagi. Assembly of the antenna is made simple by the use of PVC pipes and cross-tees. All the materials you need for this project are available at your local home-improvement center, and they are quite inexpensive. The author's antenna cost about fifteen dollars, including the coaxial matching section. No exotic tuning devices are required; all you need is a simple SWR (standing wave ratio) meter. Figure 1 shows a view of the antenna with the spreader elements taken apart, ready to be transported.

Construction

The quad antenna consists of four element spreaders (reflector, driver, and two director sections), four boom sections, a boom support and mast, five cross-tees and two support lines. The spreaders are four legs that hold the actual elements. The spreader elements should be assembled first. The boom support and boom sections can be assembled later. Figure 2 shows how all sections are connected.

Cross-tees C1 through C4 are used in the construction of the four element spreaders. Cross-tee C5 is used for final assembly. Four spreader legs are cemented into the four openings of cross-tees C1 through C4. The legs, which hold the antenna elements, should be cut following

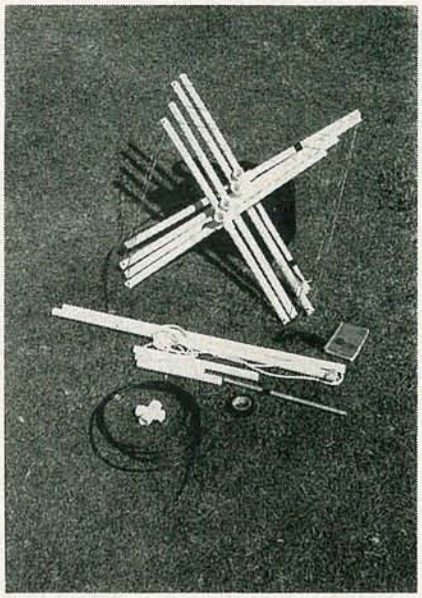


FIG. 1—THE ENTIRE ASSEMBLY BREAKS down and sets up in about five minutes for easy portability. Extremely light, it can be packed in and out of some places where two feet can go and four wheels can't.

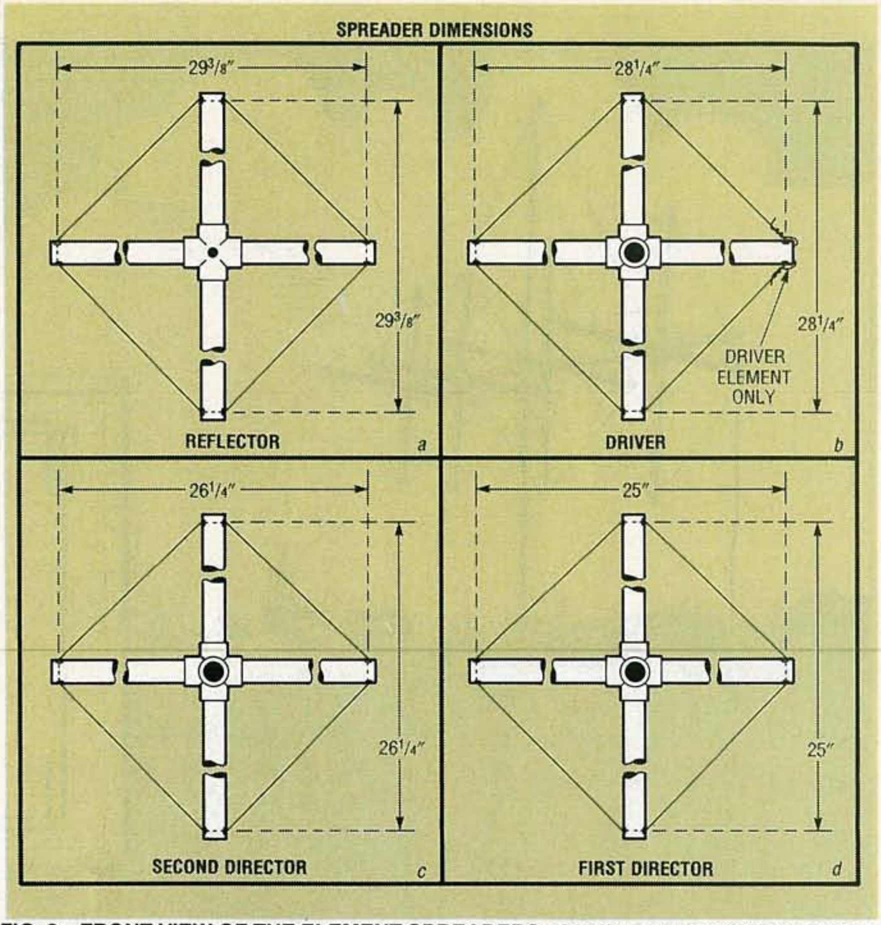


FIG. 3—FRONT VIEW OF THE ELEMENT SPREADERS with dimensions; (*a*) is the reflector, (*b*) is the driver, (*c*) is the second director and (*d*) is the first director.

the dimensions given in Fig. 3. The dimensions shown in Fig. 3 are the length of each spreader. The spreader length is measured from the drilled hole on one end to the drilled hole on the other end. Make sure you leave an extra half-inch beyond the drilled opening on the end of each leg, and an extra three quarters of an inch where the pipe fits into the cross-tee. The exact length of each spreader leg is not critical at this point; exact measurements will be taken after the legs are cemented to the cross-tees.

Glue the spreader legs into the cross-tees with a silicone sealing compound. Try to avoid using standard PVC cement—repair of an individual element may be difficult later on if it becomes damaged in field use. Cement all the remaining spreader legs into the cross-tees and let them dry for one hour. Figure 3 shows a front view of a finished spreader element.

While the four spreader elements are curing, cut boom sections B1–B4, the mast, and boom support. Measure the nylon cord that is to be used to keep the boom ends from sagging. Now, drill two holes in the support section at one end for the sag lines and attach the lines to the support piece. At this point, it might

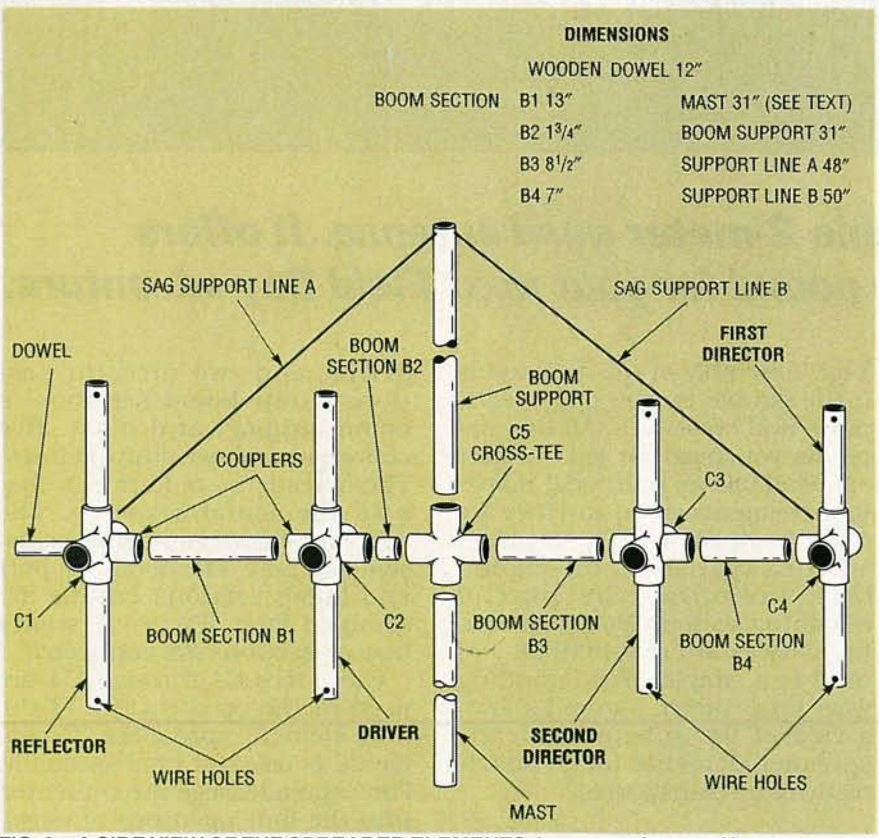


FIG. 2—A SIDE VIEW OF THE SPREADER ELEMENTS, boom sections and boom support. The driver section is where the RG59/U coaxial cable is connected.

be a good idea to label all the elements, boom sections, mast, and sag support for final and future assembly. Mark each section, according to Fig. 2 to avoid any mixups, or use different colored paint to mark mating pieces.

When all spreader sections are dry, drill two holes at the end of each spreader leg for the wires to pass through. Use a drill bit a few sizes larger than the wire you're using—stringing the wire is much faster with a larger opening. Measure as accurately as possible or the antenna will be difficult to tune. A good way to do that is to divide the spreader dimension by two, and measure from the center of the cross-tee. Mark your measurement on the end of each spreader element and then drill two ⅜-inch holes, one hole drilled directly opposite the other.

After you have finished drilling the holes on the spreader legs, take cross-tee C1, used for the reflector element, and drill a ⅜-inch hole on both sides. The wooden dowel fits into this opening and is used for suspending the feedline far enough away from the reflector element to avoid detuning it.

The next step is to glue half-inch couplings to each of the elements. Two couplings are glued on the driver and second director elements, while only one coupling is glued to the reflector and first director. Figure 4 shows a closeup view of the coupling assembly used on the driver and second director elements.

A fast-drying, two-section epoxy is the best type of bonding agent to use for gluing the couplings, just make sure you let each section cure for one hour. Lay each element down on a flat surface, and rough up the side surface of each cross-tee as well as one end of each coupler where the two are to mate. Use a ruler to determine the center of the cross-tee and mark that point with a pencil. Mix enough epoxy for *four* couplings, which is about two tablespoons. Coat the four ends of each coupling with a medium amount of epoxy. Glue the coupling to each element's cross-tee in the center. Use only one coupling per element for now. Work as quickly as you can, as epoxy sets within a few minutes. All elements should dry for one hour.

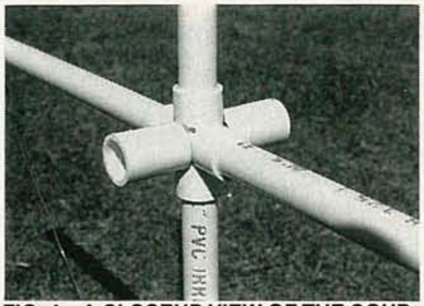


FIG. 4—A CLOSEUP VIEW OF THE COUPLING assembly used on the driver and second director elements. Note that the reflector and first director elements have only *one* coupling cemented to the cross-tee.

Turn the driver and second director elements over. Repeat the process so that those two elements have a coupling on each side of them, in the center. Let all elements dry for twenty four hours.

Stringing the wires

For the reflector, first director, and second director, pass the wires through the drilled holes and solder them together at a point between the spreader legs, making a large loop. You *must* use a heat sink on each side of the solder joint to prevent melting the plastic spreader leg. On the driver element, do not connect the wire to make a loop. Instead, pass the wire through the hole, make a loop and wrap it back on itself again a few times. Figure 5 shows a close up of that connection to the driver feed point. Again, make sure you use a heat sink, and solder as quickly as you can when you make that connection. The driver feed point is where the RG59/U matching coaxial cable will be soldered.

If you notice that there is a significant amount of slack in the wires, you can tighten the wire by doing the following: grab the wire with a pair of needle-nose pliers where it goes inside the spreader at each end of the spreader leg, one at a time. Pull gently straight outward from the center of the element. Repeat that on all four ends of each spreader leg on each element, except the driver, where you'll only have three points to grab. Don't pull too hard, or you'll warp the spreader legs out of shape.

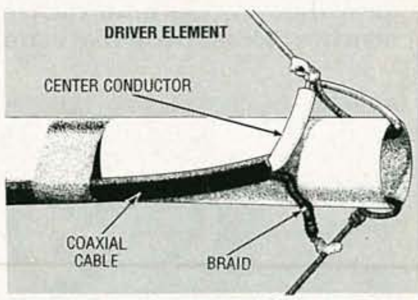


FIG. 5—A CLOSEUP VIEW OF THE coaxial cable connection to the driver feed point. Make sure you use a heat sink between the solder points and the plastic PVC pipe to avoid melting.

Next, cut back one end of the 36-inch RG59/U coaxial matching cable until you expose about 1.5 inches of braid and center conductor to work with. Solder the braid to one side of the driver loop. Don't forget to use a heat sink. Tape the first few inches of coaxial cable from the solder joint down to the spreader leg, letting the rest dangle. The cable will run down the center of the boom during final assembly.

Final assembly

For final assembly gently slide the sections of boom, elements, support, and mast together according to Fig. 2. The sections should slide freely out for disassembly. Be careful not to jam them in permanently—excessive force is not necessary as the coupling depth is only about 0.5–0.75-inch into the cross-tee.

The dowel should now be inserted into the reflector element. The dowel is used to support the RG58/U transmission line that is fed to the matching section. Route the coaxial matching section down the spreader leg away from the feed point and down the length of the boom as shown in Fig. 6. Tape the coaxial matching section to the boom with electrical tape—that's something you'll want to bring with you when you use the quad out in the field. Support the assembled unit on a tripod, if possible, or any other type of device that can hold the antenna steady while keeping it away from nearby metal objects that will distort it's field and play havoc with SWR readings.

Tuning the antenna

Tune your transceiver to 146 MHz. Trim the free end of the coaxial matching section back a couple of inches and solder it to a bulkhead SO-239 receptacle con-

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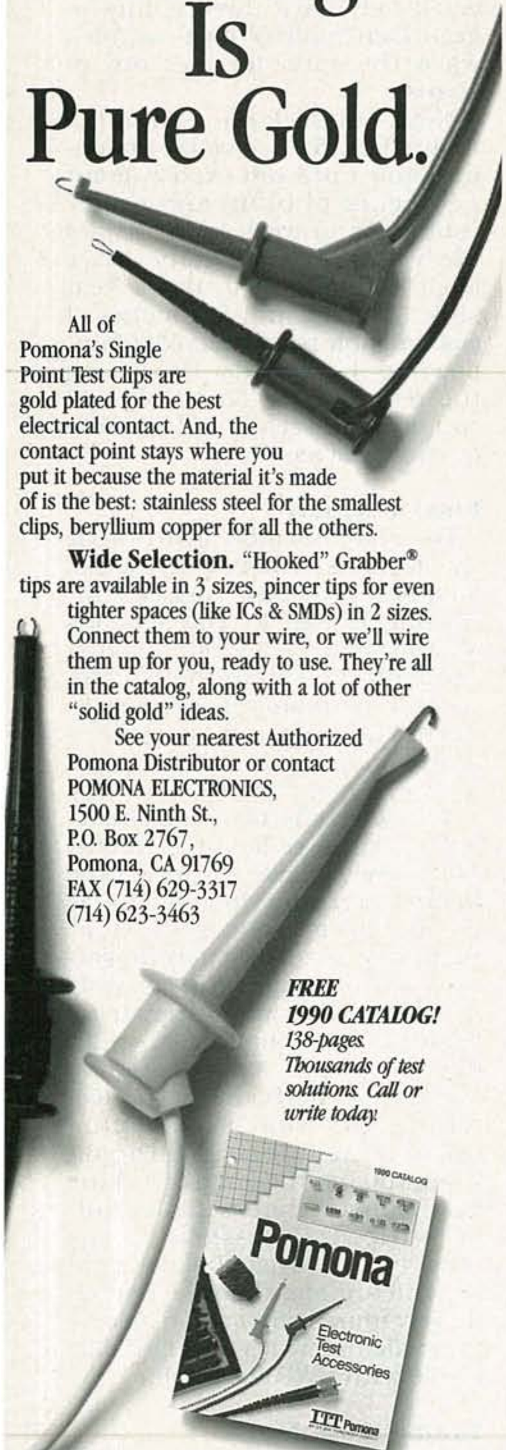

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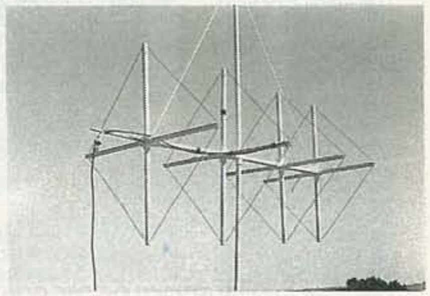

FIG. 6—A REAR VIEW SHOWS ROUTING OF THE coaxial matching line, the sag support tie points and the wooden dowel support for the antenna feedline.

nector shown in Fig. 7-*a*. That type of bulkhead connector provides a maximum adhesion surface for the silicone sealing step. Connect the coaxial matching line with a length of RG58/U cable and a PL-259 plug, shown in Fig. 7-*b*.

Use a Voltage Standing-Wave Ratio (VSWR) meter to help you tune the antenna. The VSWR is an important tool in matching impedances of a transmission system. A VSWR reading, usually called simply the SWR, indicates the ratio of the load impedance to the feedpoint impedance. For maximum power transfer to occur, the feedpoint impedance of the antenna should closely match that of the transmission line. If those impedances are mismatched, some unabsorbed power is reflected back down the transmission line. Not only is that inefficient, it can damage a transmitters output stage.

For proper tuning of the antenna, the SWR meter should measure below 1.5. If not, desolder the SO-239 connector from the matching coaxial cable, trim a quarter of an inch from the center conductor and the braid, resolder and measure again. Repeat that process until the SWR reaches at least 1.5. If that cannot

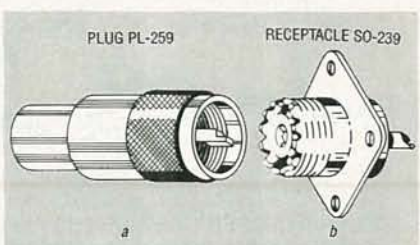

FIG. 7—A STANDARD PLUG AND RECEPTACLE used to mate two coaxial cable sections; (*a*) is a PL-259 plug and (*b*) is an SO-239 receptacle.

be achieved, you've done something wrong, probably with the driver spreader dimensions. The models the author has built come down to 1.1 at 146 MHz, and rise to 1.5 at the band edges of 144 MHz and 148 MHz. Also, you might not want to push your luck in trimming the antenna past about 1.4 or 1.3. If the SWR suddenly rises after an adjustment, you've probably passed the null. You should still be able to get the SWR reading down very low.

After you've gotten the SWR down to an acceptable level, seal the feedline connector with silicone cement for a good, weather-tight seal. Apply a heavy amount of silicone so that it completely covers the exposed area from the SO-239 connector to past the edge of the skinned coaxial cable.

PARTS LIST

- Schedule 125 PVC pipe—20 feet, ½-inch in diameter
- PVC cross tees—5
- #14 or #16 gauge wire—11 yards
- Two-part quick-drying epoxy—1 tube
- RG59/U coaxial cable—1 yard
- SO-239 bulkhead connector—1
- PL-259 plug—1
- ⅜-inch wooden dowel—6 inches
- Nylon cord—8 feet
- ½″ PVC couplers—6
- Silicone sealing compound, or RTV—1 tube
- Electrical tape—1 roll

Allow the feedline connector to dry for one day.

After the connector is thoroughly dried and cured, feed the antenna with the RG58/U cable. The cable length should be reasonably short—50-foot runs are not a good idea.

The antenna works well in the field. When tested over a one-hundred and fifty mile distance, strengths of S-9 were reported with as little as 3 watts from a hilltop locale. When we turned up the power on the quad to 30 watts, the receiving station operator said he'd send us a bill for a new S-meter! Apparently, the quad antenna does have good gain.

Mounting the antenna for field use is left to your imagination and individual needs. But try this little plumber's delight. We'll see you on a hilltop soon! **R-E**

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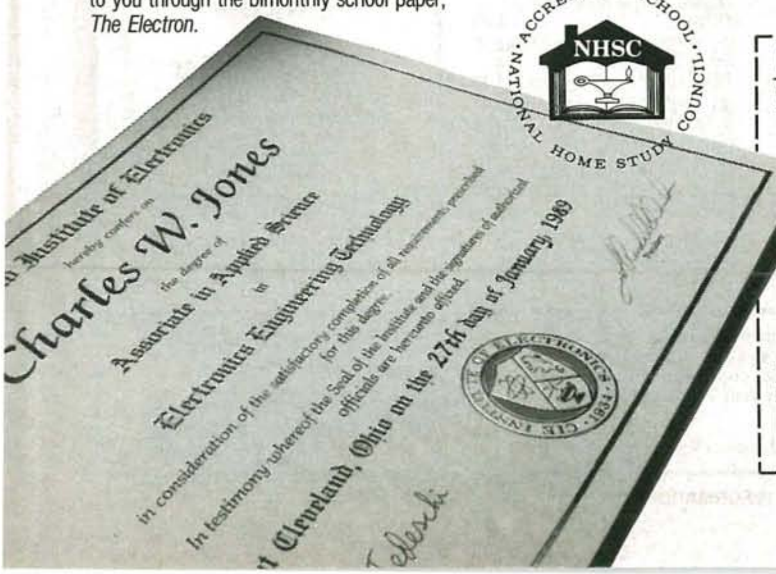

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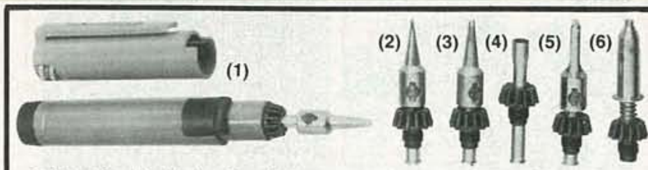

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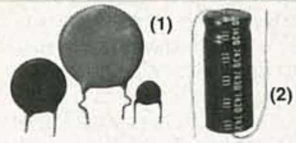

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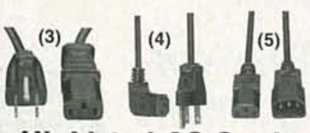

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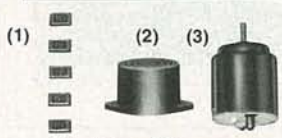

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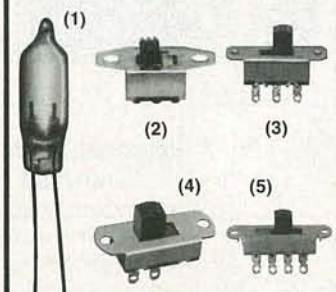

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One system that appears to offer promise is "Caller ID," which provides the called party with a read-out of the caller's telephone number before the phone is answered. Customer response to this service is reportedly very good. The problem is, of course, that the system screens only telephones, not callers. If a call is made by an "authorized caller" from another telephone, the called party will not recognize the number and might reject the call. The cost for the service is about $100 to start, with a monthly service fee of around $6.

The real solution to the problem of screening unwanted telephone calls must be one that screens callers, not numbers. It must include a security system that no accidental access such as wrong numbers or sequentially dialed numbers can breach. And the user should be spared the intrusion of having to screen his or her own calls, which is the case with an answering machine or Caller ID. The real solution should intercept incoming calls and silently and automatically screen them. When a caller is cleared, then the phone rings.

The CallScreen does all of that and more. It's easy to use, easy to install, easy to build, and relatively inexpensive. What's more, the unit can also send fax or modem calls directly to specified device. If this no-nonsense approach to call screening appeals to you and seems worthwhile, then read on because the solution is here!

Operation

The CallScreen connects to the phone line at the point where the line enters the building, and the "slave" phones connect to the CallScreen. The unit features "Limited Screen" and "Full Screen" modes, which can be selected by toggling one of two pushbuttons on the cabinet; the other button toggles "Screen On"/"Screen Off." However, the easiest way to select screen modes is with the "*" and "#" keys on any phone connected to the CallScreen. Pressing the "*" key will alternately select Screen on/Screen Off.

Actually, one version of the CallScreen doesn't even have the pushbuttons—you must use a phone to change modes. Whenever a transition to Screen On is made, a momentary tone is heard through the handset. The "#" key selects Limited Screen/Full Screen, with the transition to Full Screen producing the tone. LED indicators on the cabinet indicate the current screening mode, regardless of which method is used for selection. Should a power failure occur, the CallScreen bypasses itself so that normal telephone service is provided. We'll now describe the operation of the CallScreen in Limited Screen mode.

When the unit detects ring current on the telephone line, the line is taken off-hook and a short tone burst is injected into the phone line, to signal the caller to enter a three-digit access code. The caller then has approximately seven seconds to enter a three-digit number sequence that must match either of two codes (a primary code and a secondary code) set by the user.

Each three-digit code is set via a set of DIP switches. Allowable codes include digits "1" to "9." The digit "0" is reserved for code-entry errors. If the caller enters incorrect digits; a zero may be entered causing the CallScreen to erase the previous digits and prepare for re-entry.

When a correctly entered primary code is detected, the CallScreen begins ringing any telephone connected to its output jack with a cadence of two short rings and a pause. The secondary code cadence is three short rings and a pause. The CallScreen owner now knows, by the type of ring, that the call has been screened and has some idea of the caller's identity (family or friends for instance). If neither code is entered, a standard ring is generated, which continues until any phone is picked up, or the caller hangs up. Should the unit be set in the Full Screen mode, the completion of the seven-second entry interval, with no proper code entered, results in the line going back on-hook, disconnecting the caller.

A call-routing adapter (CRA) allows operation with telephones and a choice of either an answering machine or a modem/facsimile machine. When the CRA is set for "ANS MACH," any unscreened calls will be routed to an output jack to which an answering machine may be connected. When the CRA is set for "COMP/FAX," all primary code calls and unscreened calls (or primary code calls only if the CallScreen is set for Full Screen) will be routed to the protected phone(s), while secondary code calls will be routed to the computer modem or facsimile machine.

If the user would rather substitute other telephones for the answering machine/modem/facsimile machine in order to control where in the building a phone will ring, full answer (off-hook) and connect recognition is provided even for telephones that are not ringing. That allows any protected phone to "answer" a ring even if the ring was being routed to another phone.

When the CRA is switched off, all processed calls are passed to both CRA output jacks. Outgoing calls are unaffected by the CRA regardless of its on/off status.

The CallScreen consists of five major circuits: Phone Line Interface, Decoder, Control and Reset Logic, Ringer, and Slave Telephone(s) Interface. We'll describe each section in detail.

Phone line interface

Figure 1 shows the schematic of the CallScreen. Incoming telephone calls are detected by IC7, a Texas Instruments TCM1520 ring detector IC, which, along with the other circuitry, is protected from over-voltages by surge suppressor R8. Capacitor C12 blocks DC voltage from entering IC7, and R11 limits ring current so that IC7 operates over a typical 40–150 volts RMS ring-voltage range. The incoming ring voltage charges C13 which brings pin 4 of IC7 high with respect to pin 3. After less than one full ring, the current from pin 4 turns on the LED inside IC10, which turns on the phototransistor. That, in turn, puts a low on pin 2 of NOR gate IC3-a.

Pin 1 of IC3-a is connected to the Master Reset line which is normally low, so when pin 2 goes low pin 3 goes high and pin 4 goes low. When the first ring interval has ended, the phototransistor in IC10 switches off. But, since IC3-b pin 4 is low and is connected through R19 back to pin 2, pin 3 remains latched high regardless of the state of IC10. As long as pin 3 is high, a forward bias current, limited by R22, flows through the base-emitter junction of Q1, turning Q1 on and energizing RY1, which takes the phone line off-hook. It takes about 100 milliseconds for RY1 to be activated after pin 3 of IC3-a latches high. That allows multiple CallScreen units connected to the same telephone line to latch before any of them actually "answer" the call. The time delay is generated by a ramp voltage across C18 following the latch up of IC3-a pin 3.

When RY1's contacts close, they provide a DC path across the telephone line through BR2 and R6. The resulting DC current through R6 signals an "off-hook" condition to the central office, which then removes the ring voltage and connects the calling party to the line. Bridge rectifier BR2 ensures that, regardless of the phone-line polarity, the end of R6 that's connected to C5 is always positive with respect to the other end. If, while the CallScreen is off-hook, any other telephone on the same line is lifted, the voltage across R6 will decrease due to the additional load placed across the line.

That voltage change is coupled through C5 as a negative pulse that appears on IC8 pin 2, momentarily illuminating the internal LED. The IC8 phototransistors then conduct, placing a brief low on pins 12 and 13 of IC27-d, which is part of the Control and Reset logic. That sends a reset pulse to pin 1 of IC27-a, which, with IC27-b, normally passes reset pulses to IC3-a pin 1, to release the off-hook latch. However, during the cue interval pin 2 of IC27-a receives a logic low, which disables the passage of reset pulses during this time. That allows any phone-line transients, that could trigger the off-hook detection circuit at the moment the CallScreen raises an off-hook, to delay before enabling the Master Reset line. The cue timer interval begins just before the CallScreen goes off-hook, and continues for approximately 1 second. Diode D3 protects the LED inside IC8 from any reverse voltage transients that may be on the telephone line.

The momentary negative-going pulse develops at IC27-d pins 12 and 13 whenever a remote phone is raised off-hook appears inverted (as a momentary high) at pin 1 of IC3-a. That pulse will unlatch IC3-a/IC3-b, releasing RY1, resetting the CallScreen, which goes back on-hook to await another call.

Audio is coupled to the phone line through transformer T2, which is AC-coupled to the line at all times via C11 so that signaling

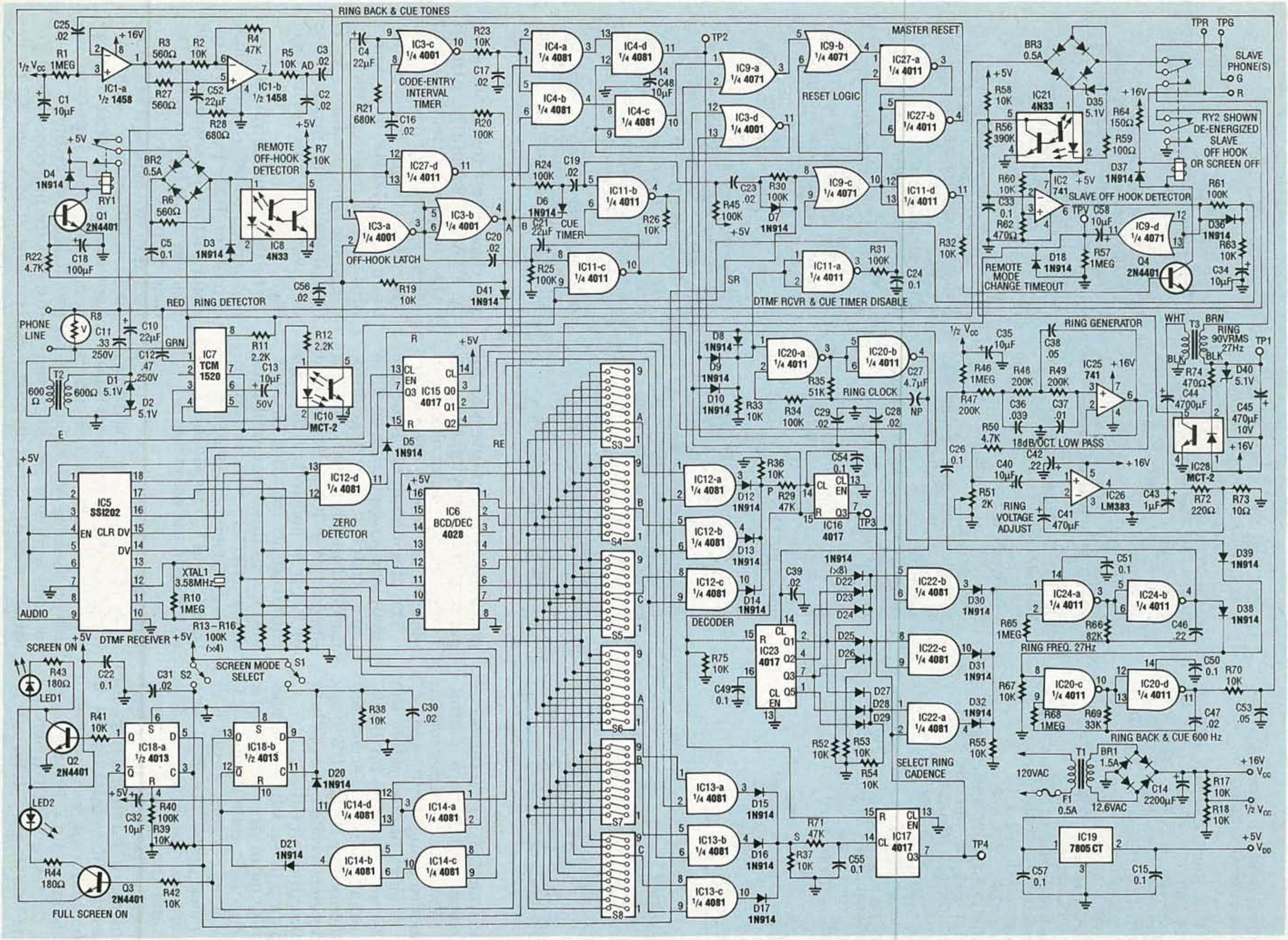


FIG. 1—SCHEMATIC OF THE CALLSCREEN. It can prevent unauthorized callers from wasting your time with "junk" calls.

CALLSCREEN PARTS

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

R1, R10, R46, R57, R65, R68—1 megohm
R2, R5, R7, R17–R19, R23, R26, R32, R33, R36–R42, R52–R55, R58, R60, R63, R67, R70, R75—10,000 ohms
R3, R27—560 ohms
R4, R29, R71—47,000 ohms
R6—560 ohms, ½-watt
R8—metal-oxide varistor surge-suppressor, 130 VRMS, 15 joules
R9–not used
R11, R12—2200 ohms
R13–R16, R20, R24, R25, R30, R31, R34, R45, R61—100,000 ohms
R21—680,000 ohms
R22, R50—4700 ohms
R28—680 ohms
R35—51,000 ohms
R43, R44—180 ohms
R47–R49—200,000 ohms
R51—2000 ohms, potentiometer
R56—390,000 ohms
R59—100 ohms
R62, R74—470 ohms
R64—150 ohms, ½-watt
R66—82,000 ohms, 1%
R69—33,000 ohms
R72—220 ohms
R73—10 ohms

Capacitors
C1, C32, C34, C35, C40, C48, C58—10 µF, 10 volts, radial electrolytic
C2, C3, C16, C17, C19, C20, C23, C25, C28–C31, C39, C47, C56—0.02 µF, 20 volts, ceramic disc
C4, C10, C21, C52—22 µF, 16 volts, radial electrolytic
C5, C15, C22, C24, C26, C33, C49, C50, C51, C54, C55, C57—0.1 µF, 20 volts, ceramic disc
C6–C9—not used
C11—0.33 µF, 250 volts, polypropylene
C12—0.47 µF, 250 volts, polypropylene
C13—10 µF, 50 volts, axial electrolytic
C14—2200 µF, 20 volts, radial electrolytic
C18—100 µF, 10 volts, radial electrolytic
C27—4.7 µF, 10 volts, non-polarized axial electrolytic
C36—0.039 µF, 20 volts, ceramic disc
C37—0.01 µF, 20 volts, ceramic disc
C38, C53—0.05 µF, 20 volts, ceramic disc
C41, C45—470 µF, 10 volts, radial electrolytic
C42, C46—0.22 µF, 50 volts, polyester
C43—1 µF, 35 volts, tantalum
C44—4700 µF, 16 volts, radial electrolytic

Semiconductors
IC1—LM1458 dual op-amp
IC2, IC25—LM741 op-amp
IC3—MC4001 quad NOR gate
IC4, IC12–IC14, IC22—MC4081 quad AND gate
IC5—SSI 202 DTMF receiver (Silicon Systems, Inc.)
IC6—MC4028 BCD-to-decimal converter
IC7—TCM1520 ring detector (Texas Instruments)
IC8, IC21—4N33 Darlington opto-coupler
IC9—MC4071 quad OR gate
IC10, IC28—MCT-2 transistor opto-coupler
IC11, IC20, IC24, IC27—MC4011 quad NAND gate
IC18—MC4013 dual D-type flip-flop
IC15–IC17, IC23—MC4017 decade counter
IC19—MC7805 5-volt regulator
IC26—LM383 7-watt power amplifier
D1, D2, D35, D40—IN5231 5.1-volt Zener diode
D3–D10, D12–D18, D20–D32 D36–D39, D41—1N914 diode
D11, D19, D33, D34—not used
LED1, LED2—red light-emitting diode
Q1–Q4—2N4401 NPN transistor
BR1—50-PIV 1.5-amp bridge rectifier
BR2, BR3—100-PIV, 0.5-amp bridge rectifier

Other components
T1—120/12VAC 950 mA power transformer
T2—600/600-ohm telephone line coupling transformer
T3—8/8K ohm 10-watt matching transformer (use 8-ohm and 0.625-watt taps on 70-volt line transformer)
XTAL1—3.58-MHz colorburst crystal
S1, S2—SPST momentary pushbutton switch
S3–S8—9-position DIP switch
RY1—SPST N.O. miniature relay, 5-volt, 70-ohm coil (or nearly any other 5-volt miniature relay)
RY2—DPDT miniature relay, 12-volt, 290-ohm coil (or with a coil between 260–400 ohms)

Miscellaneous: PC boards, cabinet, linecord, telephone wire, stranded wire, solder, hardware, etc.

to and from CallScreen can occur regardless of the hook status. That allows you to change screening modes using the "*" and "#" keys of slave phones while the CallScreen remains on-hook. Any voltages on T2's secondary are clamped by D1 and D2 to approximately 5 volts while audio is coupled through C10.

Op-amp IC1-a, which operates at unity gain, drives ring-back and cue-tone audio through R3. A coupling network to pin 5 of IC1, made up of R27, R28, and C52 approximately mirrors R3, C10, and the secondary impedance of T2. Therefore, the output signal from IC1-a appears equally across the differential inputs of IC1-b, producing very little output signal on pin 7. However, signals that are input from the phone line to pin 6 have a very small in-phase component appearing on the non-inverting input of IC1-b, so they appear at pin 7 amplified by a factor of approximately four, as set by R2 and R4.

The attenuation of phone-line input signals appearing on IC1-b pin 5 occurs by the voltage dividing of R3 and the very low output impedance of IC1-a. The output of IC1-b is connected through equalization network R5, C2, and C3 to dual-tone multi-frequency (DTMF) receiver IC5. Inputs to IC1 are biased to ½ of V_{CC} by R1, and C1 provides AC decoupling of the bias source.

Decoder

DTMF tones are coupled from the phone line to the audio input (pin 9) of DTMF receiver IC5, a Silicon Systems SSI 202 (or Sierra Semiconductor SS1202) chip set up for BCD output on pins 1, 16, 17, 18. The chip contains its own clock whose frequency is set by XTAL1. Normally, pin 15 (CLEAR DV—clear detection valid) is logic low and pin 3 (ENABLE) is logic high. Under those conditions, valid DTMF tone pairs, while being received from the telephone line, produce a BCD output and simultaneously raise the DV output (pin 14) to logic high.

The data outputs from IC5 are connected to BCD-to-decimal converter IC6. Pull-down resistors R13–R16 ensure a solid logic low at the inputs to IC6. Decade outputs from IC6 are connected to two sets of three nine-position DIP switches which are used to select two three-digit access codes. Both inputs of AND gate IC12-d bridge the BCD lines to detect the presence of digit "0." Likewise, IC14-a and IC14-c detect the "#" and "*" respectively.

When the CallScreen "answers" a call, the logic high from IC3-b pin 4, which holds the decoder circuitry inoperative until the CallScreen is off-hook, goes low and removes the reset from decade counters IC15, IC16, and IC17 through D41. At this time, IC15, IC16, and IC17 all have their Q0 outputs at logic high, and are enabled to begin counting. Because reset signals are diode-coupled, R75 is used to ensure a solid logic low on the decade counter reset line in the absence of reset logic levels. At all other times, the reset high to the decoder circuit prevents the tone-decoded ringing of slave phones, should the first three digits of a number dialed from a non-protected phone coincidentally contain a valid three-digit code.

ORDERING INFORMATION

Note: The following is available from Electronic Control Systems, R.D. 2 Box 3308, Wernersville, PA 19565. Set of two double-sided, plated-through PC boards, $39.95 (add $2.00 postage and handling); complete kit including PC boards and all parts except the cabinet, $158.000 (add $2.50 postage and handling). PA residents add 6% to all orders. Check or money order only.

For the following discussion of call decoding, we will assume a primary access code of 3-4-5, as shown by the DIP-switch settings on the schematic. Since IC15's Q0 output (pin 3) is high, primary and secondary code-enable gates IC12-a and IC13-a are enabled. The first DTMF tone pair received will be a three, and will appear as a logic high at switch position three of all DIP switches. Primary code switch digit "A" is in position three, so therefore the momentary logic high produced during the presence of DTMF-3 is passed through to IC12-a. When IC12-a is enabled, its output goes high and increments counter IC16 through D12, and 5-ms time-delay network R29-C54.

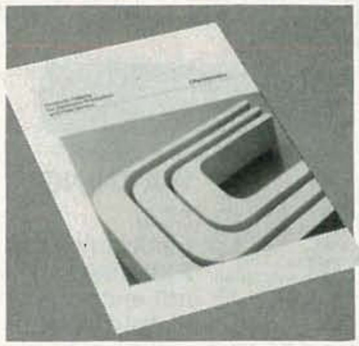
Meanwhile, when the DTMF receiver is detecting the valid tone pair representing the number 3, the DV line (IC5 pin 14) goes high. When the tones disappear, DV goes low, incrementing counter IC15 such that Q0 (pin 3) goes low and Q1 (pin 2) goes high to enable IC12-b and IC13-b for reception of the next digit.

The next digit will be a 4, and the logic high produced by it will pass through any DIP switches in position 4, incrementing counters IC16 and/or IC17 if the switch in position 4 is for digit B. In this example, IC16 will be incremented and two correct digits for the primary code will have been counted. Again, the transition of DV from logic high to low increments counter IC15 by one count, now enabling IC12-c and IC13-c. Next, a third DTMF tone pair is received representing a 5. It passes through IC12-c and D14 incrementing IC16 again, now producing a logic high on Q3 (pin 7) of IC16. As soon as three correct digits are counted by either counter, the ringer circuitry is activated to begin the ring.

Whenever the CallScreen rings the slave phones, pin 1 of IC20-a is at logic high through either D8, D9, or D10. The logic high is also coupled to IC11-a (which is connected as an inverter) whose output (pin 3) is then a logic low. Through R31, that low disables DTMF-receiver IC5 via pin 3 (ENABLE), making the CallScreen ignore any further DTMF input.

The detection of a correct code, by the Q3 output being high on either IC16 or IC17, is also coupled to the reset logic through NOR gate IC3-d pins 12 and 13. When either input to IC3-d goes high, its output goes low, disabling any control action resulting from the seven-second time-out of the code-entry interval timer IC3-c.

Counter IC15 accumulates the total number of digits input; when three have been entered, the Q3 output (pin 7) goes high. The Q3 high output is connected to IC5 pin 15 (CLEAR DV), freezing the counter at three by disabling the DV output on IC5. The only valid tone pair that the CallScreen can now recognize to use is digit "0." Tone pairs 1–9 are ignored since none of the gates are enabled. The "*" and "#" tones for remote mode-selection are also ignored because the remote-select gates are enabled only when one of the slave phones is off-hook.



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If the caller enters "0" now, or at any time during the code dialing sequence, both inputs of IC12-d go high from IC5's BCD lines, and a logic high appears at pin 11 of IC12-d. That high is coupled through D5 to the reset (pin 15) of each of the decoding counters IC15, IC16, and IC17. Since the reset is blocked by reverse-biased D41, it does not affect any other circuitry, and the seven-second interval timer continues to run. Still, if the three digits counted by IC15 represent a valid code, then the entire DTMF receiver is shut down as discussed above, via IC5's ENABLE input.

Both flip-flop sections of IC18 are used for screen-mode selection latching. Local selection is made via push buttons S1 and S2. A momentary closure of S1 raises a momentary logic high on CLOCK pin 11 of IC18. That transfers the logic state of DATA pin 9 to the Q output pin 13. Since $\bar{Q}$ (pin 12) is connected directly to pin 9, Q and $\bar{Q}$ both change state and remain latched upon each momentary closure of S1. The Q and $\bar{Q}$ outputs are used to control circuitry in the reset logic to place the CallScreen in either Full-Screen or Limited-Screen mode, so the mode changes occur in a toggle fashion using S1. When Q (pin 13) is high, the Full-Screen mode is active and Q3 is turned on lighting LED2.

The selection of Screen On/Screen Off is made independent of Full- or Limited-Screen selection. However, IC18-a is toggled by S2 in a similar manner as IC18-b. Screen-On status is indicated by LED1, where R43 and R44 are current-limiting resistors. Transistors Q2 and Q3 are connected in a series arrangement such that LED1 will be turned on any time the screen mode is "on." However, LED2 cannot be turned on by Q3 unless Q2 is also on.

Resistors R38 and R39 ensure a solid logic-low at the CLOCK inputs of IC18 in the absence of positive pulses. Capacitors C30 and C31 prevent the outputs of S1 and S2 from bouncing, which would produce multiple transfers of the flip-flops. The connection of reset pins 4 and 10 together through C32 to +5V and through R40 to ground causes both flip-flops to be reset whenever power is applied. That ensures that the operating mode will always initialize to Screen Off/Limited Screen in case of a power failure.

The MASTER RESET line is constantly held high by IC18-a from $\bar{Q}$ (pin 2) through OR gates IC9-c and IC9-b whenever the CallScreen is in the Screen Off mode. Limited/Full Screen is controlled by IC18-b by enabling/disabling AND gates IC4-a and IC4-b in the reset logic.

Remote mode selection can be made through any Touch-Tone type telephone connected as a slave. The "*" and "#" BCD outputs from IC5 are detected by IC14. When IC5 receives a "*," D1, D2, and D8 (pins 1, 18, and 16) go high. That places a logic high on pins 8 and 9 of IC14-c and on pin 2 of IC14-a. Pin 1 of IC14-a is connected to remote mode-change timer IC9-d, which holds a logic high on pin 1 of IC14-a for 7 seconds after any slave phone goes off-hook. Such a combination of logic levels causes pins 3 and 10 to go high, causing pin 4 to go high, which toggles the state of IC18-a through D21. When IC5 receives a "#," D4 and D8 (pins 16 and 17) go high. That places a logic high on pin 2 of IC14-a and pin 13 of IC14-d. If pin 1 of IC14-a is also high from IC9-d, pin 3 of IC14-a will go high, toggling IC18-b through D20.

Control and reset logic

There are two reset conditions used by the CallScreen. One is a constant logic high on the MASTER RESET line which disables the off-hook latch (IC3-a and IC3-b), effectively shutting down the unit. The two signals that can hold the MASTER RESET line high are slave-off-hook (IC9-c pin 9) and screen off (IC9-c pin 8). The other reset condition occurs as an intermittent logic high delivered to the MASTER RESET line when the CallScreen is off-hook and is ending the process of screening a call. Any one of the following inputs will result in a momentary reset high:

a) Code-entry interval time-out when the CallScreen is in the Full-Screen mode and successful code entry is not made.

b) The calling telephone transitions to on-hook and local loop current momentarily drops.

c) Any other telephone on the CallScreen telephone line (local loop) transitions to off-hook.

During the one-second cue-tone interval that occurs while the CallScreen goes off-hook for an incoming call, pin 10 of IC11-c provides the enable gate (IC27-a and IC27-b) with a logic low on pin 2. That prevents any reset signals from reaching the off-hook latch during the off-hook time when line switching transients could trip the remote off-hook detector.

The code-entry interval timer (IC3-c) is initiated when pin 4 of IC3-b goes low. Pin 9 of IC3-c is normally low while pin 8 is normally high. When pin 5 of IC3-b goes high, pin 9 also goes high through C4. At the same time, pins 4 and 8 go low so that pin 10 remains low. Any transients that might disturb the transition of input states to IC3-c are filtered by R20 and C16.

As C4 charges, the voltage across R21 decreases; when it falls below approximately 1.5 volts, pin 9 sees a logic low and, since pin 8 is also low, pin 10 now goes high. That represents the end of the seven-second code-entry interval.

The output of IC3-c is coupled through RC filter R23-C17 to AND gates IC4-a (Limited-Screen logic) and IC4-b (Full-Screen logic). When the CallScreen is set to Limited Screen, IC4-a is enabled through pin 1 from pin 12 ($\overline{Q}$) of IC18-b. The IC4-a output is coupled to AND gate IC4-d. Gates IC4-c and IC4-d are normally enabled through IC3-d, whose inputs come from the number of correct digits that enter counters IC16 and IC17. When either a primary or secondary code entry is correct, either pin 12 or pin 13 of IC3-d will go high, placing pin 11 low and disabling both IC4-c and IC4-d. That prevents the generation of a standard ring, or the trigger of a master reset after a seven-second time-out, whenever a valid code is entered. If a valid code is not detected, the logic high produced by the seven-second time-out appears on pin 11 of IC4-d and is coupled to the ringer for generation of a standard ring to indicate an unscreened call.

If IC4-b is enabled for Full-Screen operation (pin 13 of IC18-b is high), the seven-second time-out produces a logic high on IC4-b pin 4. If a valid code has not been received, that high appears on pin 10 and is passed through IC9-a and IC9-b to the MASTER RESET line, releasing the off-hook latch.

The MASTER RESET is used only to enable or disable the off-hook latch. The MASTER RESET will also disconnect the CallScreen from the phone line whenever the remote off-hook detector (IC8 pin 5) couples a momentary low to IC27-d. That logic level is inverted by IC27-d, which then appears, through various gates, on the MASTER RESET line. Pin 2 of IC27-a receives a low from IC11-c pin 10 during the cue interval. That prevents the resetting of the off-hook latch during the cue interval when the CallScreen is going off-hook and the loop current is changing.

There are two conditions that will hold the MASTER RESET high indefinitely: pin 9 of IC9-c receives a continuous high whenever any slave phone is off-hook, and pin 8 receives a continuous high whenever the screen mode is off. Either of those conditions will hold the off-hook latch inoperative, disabling ring detection and the decoder. A high on pin 10 of IC9-c is inverted by IC11-d and coupled to the base of Q4; that causes relay RY2 to drop out, connecting the slave phone(s) directly to the telephone line, bypassing the CallScreen.

The cue timer one-shot, made up of IC11-b and IC11-c, operates as a monostable multivibrator, triggerable by either positively or negatively transitioning logic levels. The outputs of the cue timer perform two functions during the timing interval: first, to turn on the 600-Hz cue-tone oscillator and, second, to disable the MASTER RESET line. The first function is operated from IC11-b pin 4, which is normally low and goes high. The second is operated from IC11-c pin 10, which is normally high and goes low.

The cue timer one-shot monostable multivibrator is triggered by a high pulse through C20 to IC11-c pin 8 when the CallScreen goes off-hook; the other input to IC11-c is normally high. The cue

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timer is disabled by IC11-a whenever the ringer is enabled and the CallScreen is ringing the slave phones. RC network R31-C24 delays the re-enabling of the cue timer when the ring-enable signal returns to logic low. That delay allows any ring transients—that could develop should a slave phone transition off-hook at a moment when the instantaneous ring voltage is high—to decay before re-enabling the cue timer. The cue timer must be disabled during a CallScreen-generated ring, because of the high input impedance of the timer trigger circuits and their sensitivity to stray pickup from the high ring voltage.

There are two other input triggers to the cue timer. Each input is capacitively coupled so that either input can produce momentary low levels on pin 5 of IC11-b, which is normally held high through R45. These inputs come from the screen-mode select flip-flops of IC18. Whenever the mode transitions from Screen Off to Screen On, the reset level at pin 8 of IC9 goes low. Before pin 8 goes low, C23 has no charge on it.

The transition of pin 8 to low forward biases D7 allowing C23 to charge from the +5 volt supply through R45. The initial charging current causes a large momentary voltage drop across R45 effectively reducing the voltage at pin 5 of IC11-b to logic low, triggering the cue timer to inject a tone into the telephone line. At the same time, D6 is either momentarily reverse biased or has zero bias depending on the status of Limited/Full Screen selection. That effectively presents a high impedance (100K set by R24), preventing swamping of the logic low pulse developed by C23/D7.

When IC9-c pin 8 transitions high (screen mode is being set to off), C23 is fully charged to +5V, and D7 is reverse-biased. Resistor R30 discharges C23 by bringing both of its terminals to a +5V potential. The transition from Limited to Full Screen also triggers the cue timer in a manner similar to that described above, but uses R24, C19, D6 and R45.

With the cue timer enabled (pin 9 of IC11-c is high), and pin 8 normally low through R25, pin 10 is at logic high and therefore pin 6 of IC11-b is also high. Since pin 5 of IC11-b is normally high through R45, pin 4 is then low, which represents the quiescent state of the cue timer.

When the off-hook latch operates, a logic high differentiated by C20 to a momentary high appears at IC11-c pin 8. Since pin 9 is also high, pin 10 transitions low as does pin 6. With pin 6 low and pin 5 high, pin 4 now goes high. That high also appears at pin 8 through the charging action of C21 and, for the time being, the timer output (pin 4) remains latched high.

As C21 charges through R25 and R26, the voltage on pin 8 decreases. When the voltage diminishes to approximately 1.5V, IC11-c sees a logic low and pin 10 transitions high as does pin 6. With pins 5 and 6 both high, pin 4 goes low and the timing interval ends. The same timing action is triggered if a momentary logic low appears on pin 5 of IC11-b. This would occur upon operation of the screen-mode select logic as discussed earlier.

Ringer

The CallScreen ringer circuitry essentially takes a logic high on one of three inputs and produces one of three ring cadences which is delivered to the slave phone(s) as a 27-Hz, 90-volt RMS ringing voltage. The ringer also includes the 600-Hz cue oscillator which, along with cue timer functions, is keyed by the 27-Hz ring frequency oscillator to produce the "ring back" signal that the caller hears.

The three ringer input lines are coupled through diodes D8, D9 and D10 to ring clock NAND gate IC20-a pin 1. When any one of the lines goes high, indicating the need to ring the slave phone(s), IC20-a is enabled and the ring clock begins to run. An astable multivibrator, made up from IC20-a and IC20-b, produces gating pulses at pin 4 of IC20-b at 600 ms intervals when enabled by pin 1 of IC20-a being high. The repetition interval is determined

continued on page 62

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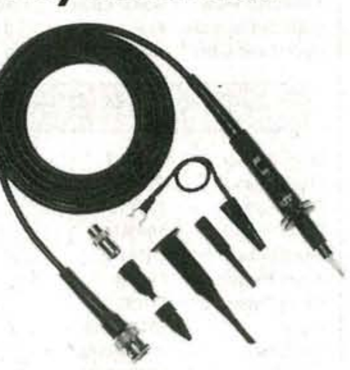

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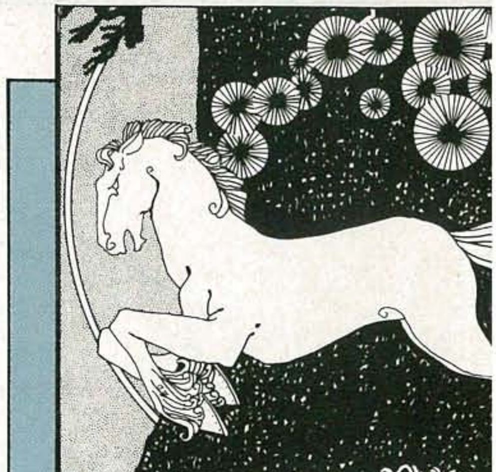


Satellite television, received on small, flat antenna panels, promises to give cable TV a run for the money.

ROBERT ANGUS

SATELLITE TELEVISION, DELIVERED to antennas as small as a table napkin, is about to become a reality. You might be saying to yourself, "So what's the big deal?" Futurists have been talking about that for as long as they've been talking about large-screen TV receivers thin enough to hang on the wall like pictures. And haven't Europeans and Japanese been watching TV using tiny flat-panel antennas for a year or more?

Well, yes. But this time the talk is for real, with technology letting a single satellite deliver as many channels as a large cable system. Indeed, within three years, there could be at least six major programmers broadcasting directly from satellite, offering up to 400 channels of pay-per-view (PPV) movies, premium sports events, concerts, and general entertainment programs.

The first, TVN, was scheduled to start in September, with 10 channels of movies and three of basic cable. TVN isn't truly a small-dish service, since it uses an existing low-powered satellite (Telstar 303) and a full-sized C-band satellite antenna, but it shows how such services will operate. Scheduled to be launched in October is K Prime, a 10-channel service that also uses an existing satellite (Satcom K1), but transmits to dishes 3–4 feet in diameter.

The first satellite specifically designed for direct-broadcast by satellite (DBS) service will be SBS-6, scheduled for launch later this year. It'll carry 10 channels of PPV movies and special events beginning early next year. In late 1993, Sky Cable, the real biggie, should have 27 transponders on three Hughes high-powered satellites capable of transmitting pictures to a flat, square antenna measuring a mere 14 × 14-inches, called a "squarial." The same antennas will be able to pick up an additional five channels from United States Satellite Broadcasting's bird located nearby.

By 1993, however, all the programmers listed above expect to offer many more than the 65 channels they plan to start with. Using digital signal compression, they expect to multiply their capacity some 2–8 times, enabling Sky Cable to promise a total of 108 channels. TVN President Stu Levin boasts that he'll have enough channels to be able to start feature movies every few minutes, so viewers can enjoy their choice of flicks virtually on demand.

Large-dish satellite antennas are able to choose programming from 18 C-band and six Ku-band satellites, with well over 200 channels. In theory, they can also receive all the new channels. To do so, however, the nation's two-plus million dish owners will need new decoders—separate ones for TVN, SkyPix, K Prime, and Sky Cable—since each firm plans to use different, incompatible, scrambling systems.

The assumption of most DBS programmers is that viewers will select one of the competing sys-

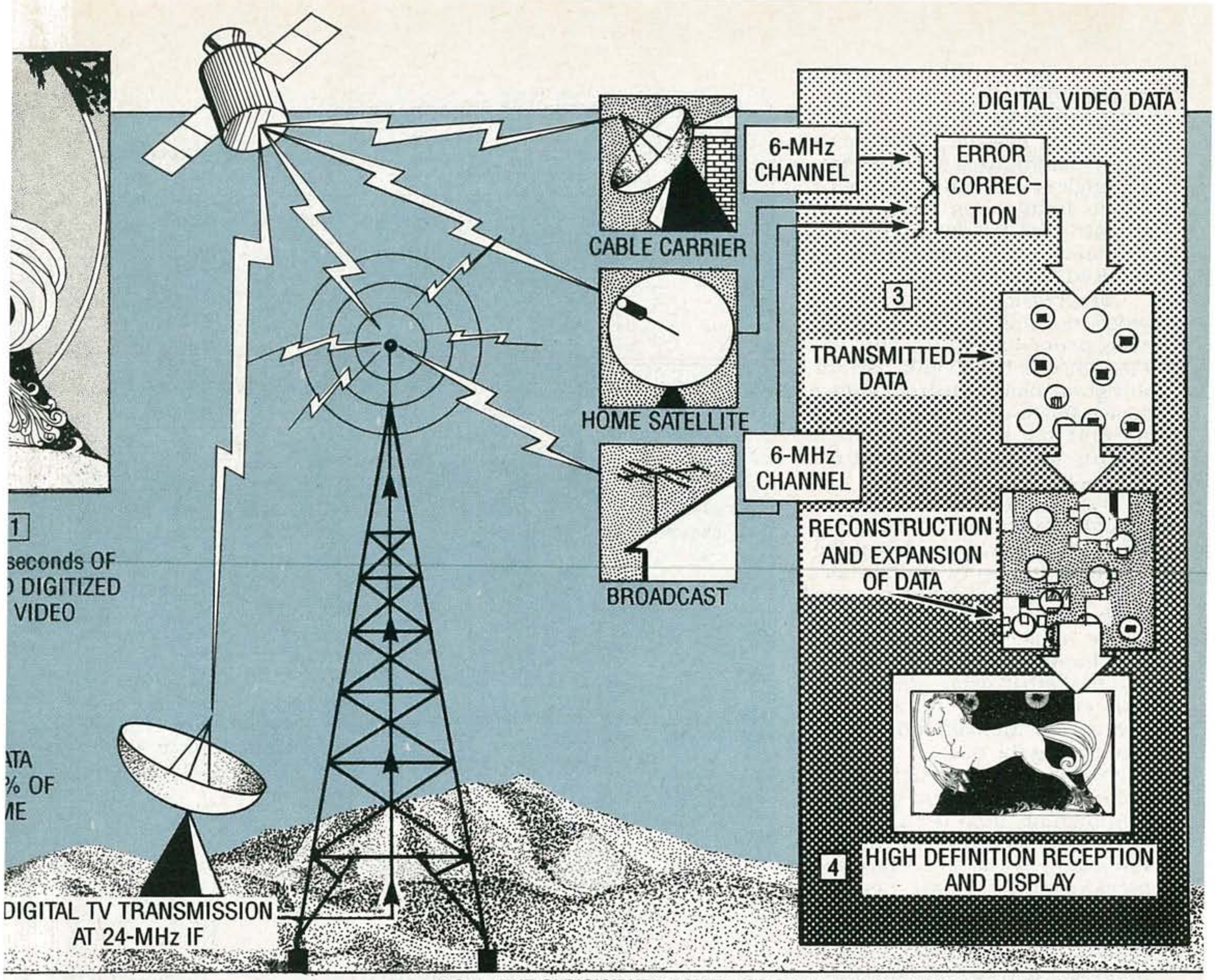


FIG. 1—THE GI DIGICIPHER COMPRESSION METHOD. SOURCE material is digitized at the broadcast station or uplink site (step 1). An encoder extracts essential data from a frame. The 1.2 gigabits per second of digital HDTV is compressed by motion-estimation and compensation methods (step 2). Only 2% of the bits are transmitted between frames; DigiCipher HDTV's receive the signal, and error-correction methods reconstruct the digital video (step 3). It's converted to analog, with no resolution loss (step 4). The improvement is like comparing CD's to vinyl records.

tems, erect a small, fixed-position antenna to receive it, and rent or buy a dedicated integrated-receiver-descrambler (IRD). K Prime, for example, plans to charge $12 a month for a package with basic programming and reception equipment; PPV movies will cost $5 each. Sky Cable and SkyPix plan to sell hardware packages for $500–600, with viewers paying $5 each for new flicks.

Uniden Corp. of Indianapolis, IN, has provided a glimpse of the potential satellite future. Their new Model 4800 receiver ($2499) uses not only the standard VideoCipher II Plus decoding used by most C-band programmers, but also D-Code decoding for TVN. To keep track of the 120 movies TVN plans each day, as well as big-dish program listings, the Model 2400 has a built-in electronic program guide.

Instead of selecting a satellite and transponder, the viewer calls up the schedule for an appropriate viewing time, picks a program, hits "ENTER" on his remote control, and the receiver automatically sets the correct satellite and transponder. You can even program a whole night's viewing this way.

Of all the technical miracles, the most important is digital signal compression. It not only makes possible capturing several channels on a small fixed-position dish, but provides the bandwidth for everything from high-definition television (HDTV) to multichannel interactive video and specialized narrowcasting. It digitizes the information in a video frame, removes extraneous information (so that what's left is compressed), and the data is transmitted. The only new data transmitted thereafter are frame-to-frame updates. Current video, by contrast, uses the National Television Standards Committee (NTSC) format, transmitting full, uncompressed video frames at 60 Hz.

Suppose the program were the Talking Heads on the Tonight show; difference signals make up only about 2% of the total. However, when there's lots of action and rapid movement in a program, the frame-to-frame changes can be up to 50%. Greater compression without visible artifacts is possible when movement is minimized and the camera angle is constant. And when a video image has been compressed, the bandwidth needed to transmit it is correspondingly reduced.

Compression basically makes video transmission into an adaptive process, where the instantaneous bandwidth used at any given moment to transmit an image fluctuates as the amount of motion between frames changes. Such a procedure makes for the most efficient use of bandwidth, since it continually varies and updates according to the video needs of the moment. In theory, it's possible to multiplex 10 such programs in the bandwidth used by a normal, single, broadcast, cable, or satellite channel. But if one program is a basketball game, its viewers may complain of streaks and fishtails as the ball and players move along the court.

If you've ever watched rebroadcasts of older black-and-white (B/W) programs from the 1950's or early 1960's (like the Honeymooners), you can often see streaks and fishtails as the characters move or the camera pans, since the image orthicon tubes in TV cameras of the period lacked adequate resolution. Such streaks were quite common on bright metallic objects that tended to reflect excess light into the camera, saturating the tube phospor. Or, a nature program with closeups of flowers and insects may lack detail and appear washed out, making viewers complain.

By reducing the total number of channels, broadcasters can improve the resolution of those that are left, since there's more available bandwidth. The ultimate extreme this way would be a true HDTV channel with digital surround sound, needing 1.5–5 uncompressed cable channels, but which can fit into a single cable or broadcast channel, using compression techniques. When compression becomes a reality—maybe by late 1991—a DBS firm might have one or two HDTV channels. They may use two or three more channels for sports or movies (where high resolution would be most appreciated), and have several 4:1 compressed channels for weather, business, children's programming, and family-type series reruns.

MAJOR HOME-SATELLITE BROADCASTERS

Company Name	Services	Start date	Satellite Longitudes	Comments
Comsat Video	Multiple narrowcast channels	Unavailable	Unavailable	Has compression system; developed 14 × 14-inch "squarial" antenna
Directsat	2 medium-power satellites	1992	101°W, 148°W	None
Dominion Video	8 transponders on 2 medium-power satellites	Unavailable	119°W, 148°W	Educational and religious programming
Echostar	3 PPV movie channels, 3 premium movie channels, 10 basic-service channels, and 2 medium-power satellites	Unavailable	61.5°W, 148°W	Basic-service channels include religious, children's, and adult programming; will air 6–7 Pay-Per-View movies per month
EMC²	Movies on demand on C-band satellite using digital technology	Late 1990	Unavailable	Over 4000 feature films
K Prime	10 channels on Sat-com K1 include 3 PPV channels	Oct 1990	85°W	Package available from cable operators through Netlink for about $12; includes 4-foot dish and proprietary IRD
	Plan compression to increase capacity	1992-1993		

The DigiCipher system

There are almost as many ways to compress video signals as to scramble them, which may explain why every DBS firm has its own compression and scrambling methods. General Instrument GI Corp. plans to introduce the DigiCipher system next fall; it's likely to be first out of the box, and has already been used for Sky Cable's business plan.

A spokesman for GI Corp., Mike Walker, says that set-top black box decompressors on the market by then could run $200. When Sky Cable begins, DigiCipher could be built into a TV for HDTV purposes. Fig. 1 shows the DigiCipher process, and Fig. 2 shows the major staff members at the GI Video Cipher Div. in front of a sample image. The DigiCipher process itself works as follows:

- The source material (like video movie or computer-generated art) is digitized at either the broadcast station or the cable satellite programming uplink site (step 1). A DigiCipher encoder sorts non-essential data out of each video frame.
- The 1.2 gigabits per second generated for digital HDTV is compressed by proprietary mo-

MAJOR HOME-SATELLITE BROADCASTERS

Company Name	Services	Start date	Satellite Longitudes	Comments
SkyPix	10 transponders on SBS-6	Jan-Feb 1991	Unavailable	$500 package complete with 3-foot dish and proprietary IRD, PPV movies every few minutes, sports, and concerts
	Expandable to 80 channels with proprietary compression technique	1992-1993		
Sky Cable	27 transponders on 3 Hughes high-power satellites	Late 1993	101°W	$500–600 for system to include 14–35-inch dish, as well as PPV movies and sports; sold through cable services, in basic and premium versions
	Plans to expand to 108 channels using compression	1993-1994		
TVN	10 PPV channels on Tel star 303, and 3 basic channels	Sep 1990	125°W	D-code descrambling, $25/month for basic service and IRD; available through Uniden dealers
	2 added channels	Jan 1991		
	Expects to add capacity using compression	1993-1994		
USSB	5 high-powered Ku-band channels, expects to add capacity using compression	Late 1993	101°W	None

FIG. 2—THE MAJOR STAFF MEMBERS AT THE GI VIDEO CIPHER DIV. From left to right, Dr. Jerry Heller, Exec. Vice-President, Dr. Woo Paik, Asst. Vice-President, and Larry Dungham, President.

tion-estimation and compensation methods (step 2). Thus, only 2% of the bits are transmitted between successive frames (for minimal interframe motion) via broadcaster satellite to cable system head ends, and home satellite systems.

- DigiCipher-equipped HDTV's receive and demodulate the signal, and use potent error-correction methods to reconstruct the transmitted digital video (step 3).
- The reconstructed digital video is converted to analog for a crisp HDTV picture, with no subjective loss in resolution (step 4). The improvement in DigiCipher HDTV over NTSC format is like comparing audio digital compact discs (CD's) with vinyl records.

Perhaps the most interesting application of digital signal compression applied to DBS is by Entertainment Made Convenient² (EMC²), a Denver, CO, company that hopes to offer a library of 400 movies virtually on demand by late 1990. They propose to compress movies in time *and* bandwidth, letting a full-length feature film be downloaded to a VCR in about 12 minutes.

The VCR would allow two viewings per movie before erasing a tape automatically. To receive the programs, transmitted via an as yet-unnamed C-band satellite, a viewer would need a small napkin-sized antenna and VCR with a dedicated, built-in satellite receiver. The VCR would tape films digitally, so the tapes can't be played back on conventional VCR's. The catch is that digital VCR's don't yet exist, and major manufacturers aren't planning on them anytime soon.

Since the same pool of feature films should be available to all the PPV hopefuls, and the majors promise to offer basic programming comparable to current basic cable and C-band DBS packages, there may not be much variety among various systems. All the PPV firms promise to have the top 10 box-office attractions when they appear in video stores. Hence the race by K Prime, TVN and others to be first, even if they have to recall receivers in a year or two when they start using newer, more powerful satellites.

One feature TVN hopes to offer to distinguish itself from the competition is interactive video.

SATELLITE TV

continued from page 61

so the viewer can choose a camera angle on sports events, interact with contestants on a game show, or determine the plot of an action series. TVN has an exclusive agreement with ACTV, a Canadian company that's developed a seamless way to switch between four video channels to provide interactive video.

Until digital compression became a reality, interactive TV made no sense, since few cable operators and no terrestrial broadcasters had the needed channel capacity. TVN Vice-President Stuart Jacob says his company hopes to offer sports fans interactive coverage of major sporting events like the Indianapolis 500, the 1992 Olympics and major-league hockey and baseball.

Does all this mean the large dish is dead? No way. The programmers who form the backbone of cable TV and today's satellite viewing—HBO, Showtime, CNN, ESPN, MTV and the rest—are committed to large-dish transmission through the year 2015. Over the next few months, they'll be joined by some 20 newcomers with everything from want ads and programs in Tamil, to sci-fi and American Lawyer (a 24-hour channel for Perry Mason addicts). What signal compression can do for small-dish DBS services, it can also do for large-dish owners. **R-E**

CALL SCREENER

continued from page 56

by C27 and R35, and R34 provides the feedback path to IC20-a. Gating pulses from pin 4 of IC20-b begin clocking decade counter IC23 whose ten outputs (they're not all shown) then begin sequencing, one at a time, to logic high. At a 600-ms clock rate, the counter will sequence through all ten outputs in 6 seconds, which is the standard ring cycle of the U.S. telephone systems. Steering diodes D22–D29 are connected from the Q outputs of the decade counter to assemble the three different ring cadences.

Diodes D22, D23, and D24 are connected to the Q1, Q2, and Q3 outputs of IC23. As soon as the ring clock is enabled, Q1 goes high for 600 ms, followed immediately in sequence by Q2 and Q3 for 600 ms each. The input of IC22-b (pin 5), therefore, sees a logic high for approximately 1.8 seconds (Q1 + Q2 + Q3) out of every 6 seconds, thus producing a standard telephone-company like ring if IC22-b is enabled by pin 6 being high. In a similar manner, IC22-c and IC22-a are supplied with logic levels corresponding to cadences as follows:

IC22-c—high 600 ms, low 600 ms, high 600 ms, low 4.25 seconds (two short rings and pause).

IC22-a—high 600 ms, low 600 ms, high 600 ms, low 600 ms, high 600 ms, low 3.5 seconds (three short rings and pause).

Each of the three ringer input lines is connected to one of the ring-cadence enable gates of IC22. Gate IC22-b is enabled via pin 6 from IC4-d pin 11 when the CallScreen is in the Limited Screen mode and the code-entry interval timer times out; this produces a "standard" ring, signaling an unscreened call. Gate IC22-c is enabled via pin 9 from IC16 pin 7 when the correct primary code is detected; this produces a double ring and pause. Gate IC22-a is enabled via pin 2 from IC17 pin 7 when the correct secondary code is detected; this produces a triple ring and pause.

The outputs of the ring-cadence enable gates are connected through diodes D30–D32 to the ring-frequency generator (pin 1 of IC24-a). Resistor R55 ensures a solid logic low in the absence of ring. Whenever pin 1 is high, the 27-Hz ring oscillator is running. Gates IC24-a and IC24-b are configured as an astable multivibrator producing approximately symmetrical square waves of logic-low and -high levels. The frequency is determined by C46 and R66, and R65 is a feedback resistor. Steering-diode D38 is used to enable the 600-Hz cue oscillator thus gating its output at 27 Hz. Resistor R67 ensures a solid logic low in the absence of enable signals.

The ringback and cue oscillator is an astable multivibrator consisting of IC20-c and IC20-d along with frequency-determining components C47 and R69, and feedback resistor R68. R70 and C53 form a low-pass filter which sets the 600-Hz output level correctly for input to IC1-a. Enabling of the oscillator occurs on IC20-c pin 8 through either D38 for ringback or D39 for cue signaling tones.

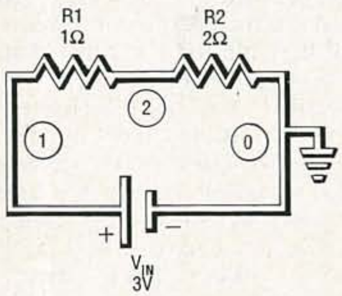
The output of the ring-frequency oscillator (IC24-b pin 4) is also coupled, through C26, to the input of op-amp IC25, which is configured as an active low-pass filter whose center frequency is set to 20 Hz. That setting provides a frequency-proportional attenuation of the 27-Hz square wave supplied from the ring-frequency oscillator at an 18dB/octave rolloff rate. The output of IC25 is very nearly a 27-Hz sine wave. Components R46 and C35 provide AC decoupling of ½ V_{CC} bias voltage to operate IC25 without a split power supply. Voltage divider R50 and potentiometer R51 set the input level to IC26 for a 90–95 volts RMS ringer output voltage.

The LM383 7-watt power amplifier (IC26) has its gain set by R72 and R73. Feedback for the inverting input is coupled through C41, while low-level ring voltage is connected to the non-inverting input via C40. Capacitors C42 and C43 stabilize IC26 against high-frequency oscillation. C44 couples high-current ring signals to the 8-ohm primary of T3. High ring voltages appear across the 8 kilohm secondary of T3. The ringer configuration is capable of reliably

continued on page 77

CALL ROUTING ADAPTER PARTS
All resistors are ¼-watt, 5%, unless otherwise noted.
R101—150 ohms, ½-watt
R102, R103—10,000 ohms
R104—330 ohms
R105—1000 ohms
Semiconductors
D101–D106—1N914 diode
Q101, Q102—2N4401 NPN transistor
Other components
RY101, RY102—SPDT miniature relay, 12-volt, 320-ohm (nominal) coil
S101, S102—SPDT miniature switch (or use single DPDT center-off switch)
J1, J2—modular phone jack

SPICE SPICE SPICE



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```
* Resistor divider circuit
VIN 103.0volt
R1  121.0ohm
R2  202.0ohm
.END
```

TJ BYERS

Breadboards are giving way to PC-based circuit simulation.

IF YOU'RE LIKE MOST ELECTRONICS hobbyists, you love to design and build circuits. Unfortunately, one of the hazards of the hobby is that many projects never get beyond the breadboarding stage because of design or debugging problems.

Sure, you can spend countless hours troubleshooting a circuit using a plethora of test instruments, but wouldn't it be nice if you didn't have to touch a component until you were ready for the final assembly? Now you can, using the power of your PC and a growing number of circuit-simulation programs.

Circuit-simulation programs are not new either to the computer or to the PC. What is new is that now these programs are affordable. Simulation programs that sold for $20,000 ten years ago can be obtained today for less than $100, and that low cost makes it cheaper and faster to simulate a circuit than to breadboard it.

Another advantage of circuit-simulation programs is that they give us the ability to do "what-if?" simulations. For example, what if you were to substitute a 0.01 µF capacitor for the 0.015 µF unit specified in a circuit design? Using circuit-simulation software, you could learn the answer in seconds.

This is the first article in a two-part series that will look at circuit-simulation programs for personal computers. This part discusses a venerable analog simulation program called SPICE, and the second part discusses a powerful digital simulation program called SUSIE. Our bias is toward the IBM family, but versions of the programs we'll discuss are available for other platforms; we'll discuss prices and availability later.

The SPICE of life

SPICE (simulation program with integrated circuit emphasis) is far and away the most popular analog circuit-simulation program in use today. SPICE was developed by the University of California at Berkeley in the late 60's, and was released to the public in 1972.

Over the years, SPICE has gone through many upgrades. The most important change came with SPICE2, in which the kernel algorithms were upgraded to support advanced integrated system methods, many of which relate to IC performance. SPICE2 has all but replaced SPICE1 as the SPICE of choice by industry. SPICE2 has been ported to numerous types of computers and operating systems, including the Macintosh and the IBM PC family, and is sold under several different brand names by several software companies.

Recently, SPICE2 was upgraded to SPICE3. In the new version, the program was converted from FORTRAN to C for easier portability, and several devices were added to the program library, including a varactor, semiconductor resistor, and lossy RC transmission lines. However, the kernel algorithms were not changed, and the added components aren't that significant because SPICE2 can simulate all the devices built into SPICE3 using external device modeling. But more on that later.

Creating a SPICE circuit

One reason for SPICE's popularity lies in its programming simplicity. Unlike many circuit-simulation programs, which require special programming tools to create simulation files, all you need to produce a SPICE file is an ASCII text editor. Moreover, because SPICE files are pure ASCII, files created on a Macintosh are identical to those used by a PC and a Sun workstation. That file compatibility allows you to exchange SPICE designs among vastly different computers without file modification.

SPICE files are nothing more than a list, called a *netlist*, of the components used in the circuit; Table 1 summarizes the contents of a netlist. When describing a SPICE component, it's a simple matter of listing the component's value and its physical connections to other components in the circuit. If you wish, you may optionally include qualifying parameters such as temperature coefficient, tolerance, etc., but they're not required.

To illustrate how a SPICE file is written, refer to the circuit in Fig. 1. That circuit is an RLC bridge-T bandpass filter, often used in audio equalizers. For the sake of argument, let's bias the network at 10-volts DC and specify a 1-volt AC input signal. The design questions are: What is the bandpass frequency, what is the bandwidth, and what are the AC and DC output voltages? Let's see how we could use SPICE to solve the problem.

After drawing a schematic of the circuit, you label each component. SPICE nomenclature is consistent with accepted schematic labels—R represents a resistor, C a capacitor, L a coil, Q a transistor, and so forth.

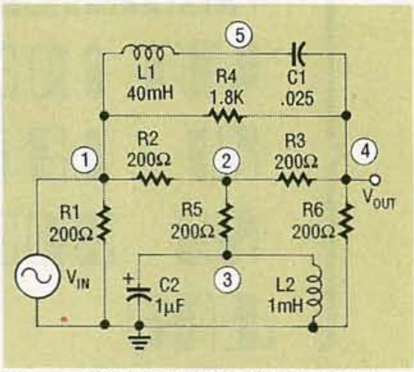

FIG. 1—SAMPLE CIRCUIT 1. This is a Bridge-T bandpass filter; the circled numbers represent the nodes that SPICE will analyze.

Next, you must number the circuit nodes. A node is any point where two or more wires connect. There is no required order to the numbering; you can assign node numbers at random, and even skip numbers. The exception is ground, which has a reserved value of 0. Just be wary that you don't assign separate numbers to opposite ends of a wire because SPICE will think you're talking about two different nodes and not make the connection.

The next step is to create a list of all components by label, node, and value (in that order), and store the list in an ASCII file with a .CIR extension (FILTER.CIR). There are three restrictions on the file format: The file must begin with a file name, end with an .END statement, and it must contain only uppercase letters. SPICE syntax is very inflexible (what programming language isn't?), and unless each component is described explicitly with all the parameters in the right order, the simulation won't work. The SPICE file for the circuit in Fig. 1 is shown in Listing 1.

TABLE 1—NETLIST CONTENTS

Title Line
Analysis Control Statement
Output Control Statement
Circuit Topology
Signal Or Power
.END Statement

LISTING 1
BRIDGE-T BANDPASS FILTER NETLIST

```
BRIDGE-T BANDPASS FILTER
.AC DEC 20 1KHZ 10KHZ
.PRINT AC V(4) VDB(4)
R1 1 0 200
R2 1 2 200
R3 2 4 200
R4 1 4 1.8K
R5 2 3 200
R6 4 0 200
C1 5 4 .025UF
C2 3 0 1UF
L1 1 5 40MH
L2 3 0 1MH
VIN 1 0 DC 10V AC 1V
.END
```

Although we listed the resistors in ascending order, there's no set order to a netlist. All voltage sources, resistors, and other components may be listed at random, because SPICE first reads the netlist in its entirety, organizes the contents to its liking, and only then compiles the circuit into a run-time file. The process is quite similar to the way a Pascal or C compiler compiles an ASCII source file into an executable program.

Circuit analysis and simulation

After SPICE compiles a run-time version of the file, it uses its kernel algorithms to analyze the circuit, first for DC parameters, and then for AC performance, if requested. The result is a computer simulation of the circuit under the specified operating conditions. The simulated circuit parameters are then recorded in an ASCII file. The SPICE simulation of our circuit is shown in Listing 2.

SPICE simulation occurs in stages. First SPICE analyzes the netlist to see if there are any errors. It can't check for all errors, simply because it can't read your mind, but it does check the syntax of every entry, and makes sure that every node has two or more connections. If an error occurs, an error message is inserted below the line that caused the error, which greatly simplifies the debugging process.

If no errors are detected, SPICE does a DC analysis of the circuit, calculating the bias voltage for every node, and the total current drain from the power sources. SPICE also measures the total power dissipation of the circuit. From this analysis, we find that the DC output is 2.5 volts.

Next SPICE does an AC analysis of the circuit using simulated signal generators. SPICE is quite adept in this area, in that it's able to emulate several kinds of signal generators, including sine, sweep, pulse, and others.

For our tests we need a sweep generator, which we describe in the second line of the netlist. The .AC label is a special SPICE command called a control statement. (Note that all SPICE control statements begin with a period.) The statement says that we want a sweep generator with a logarithmic sweep of 20 points per decade (DEC 20) beginning at 1 kHz and ending at 10 kHz. We could just as easily have selected a linear (LIN) or octave (OCT) sweep rate, and set the sweep to occur between any two frequencies, ranging from sub-audio to gigahertz.

Next we need to monitor the output signal. This is done using the .PRINT control statement on line three. .PRINT simulates a variety of measuring instruments, including several types of voltage and current meters. For our simulation we need both an RMS AC voltmeter, V(4), and a decibel voltmeter, VDB(4). The numbers in parentheses indicate which node is to be measured. As it turns out, our simulation looks at only one node, but we could have specified any number of nodes.

The .PRINT statement generates a table of values for each point on the generator's sweep. The results of our circuit simulation are shown in the AC ANALYSIS section of Listing 2. Notice that the filter peaks at 5 kHz with a voltage output of 750 mV and an attenuation factor of 12 dB. For the final answer, look at the VDB(4) portion of the table, which shows that the signal is down 6 dB at 4.5 kHz and 5.5 kHz, giving the filter a bandwidth of 1 kHz. Problem solved.

SPICE could just as well have provided more measurements, including transient response time, noise factor, distortion, and phase shift of any or all nodes in the circuit, over a wide range of operating conditions and temperatures. That type of analysis is extremely valuable for seeing how the circuit behaves under extreme environmental conditions.

LISTING 2—SPICE OUTPUT

BRIDGE-T BANDPASS FILTER

SMALL SIGNAL BIAS SOLUTION TEMPERATURE = 27.000 DEG C

(NODE) VOLTAGE

(1) 10.00 (2) 4.1667 (3) .00 (4) 2.50 (5) 10.00

VOLTAGE SOURCE CURRENTS

NAME	CURRENT
VIN	− 8.333D − 02

TOTAL POWER DISSIPATION 8.33D-01 WATTS

FREQ	V(4)	VDB(4)
1.00000E + 03	2.509E − 01	− 1.201E + 01
1.12202E + 03	2.511E − 01	− 1.200E + 01
1.25893E + 03	2.514E − 01	− 1.199E + 01
1.41254E + 03	2.519E − 01	− 1.198E + 01
1.58489E + 03	2.524E − 01	− 1.196E + 01
1.77828E + 03	2.532E − 01	− 1.193E + 01
1.99526E + 03	2.544E − 01	− 1.189E + 01
2.23872E + 03	2.561E − 01	− 1.183E + 01
2.51189E + 03	2.587E − 01	− 1.174E + 01
2.81838E + 03	2.629E − 01	− 1.160E + 01
3.16228E + 03	2.706E − 01	− 1.135E + 01
3.54813E + 03	2.862E − 01	− 1.087E + 01
3.98107E + 03	3.254E − 01	− 9.752E + 00
4.46684E + 03	4.662E − 01	− 6.628E + 00
5.01187E + 03	9.983E − 01	− 1.499E − 02
5.62341E + 03	4.882E − 01	− 6.228E + 00
6.30957E + 03	3.303E − 01	− 9.622E + 00
7.07946E + 03	2.879E − 01	− 1.081E + 01
7.94328E + 03	2.714E − 01	− 1.133E + 01
8.91251E + 03	2.634E − 01	− 1.159E + 01
1.00000E + 04	2.589E − 01	− 1.174E + 01

Device modeling

SPICE can also analyze circuits that use diodes, transistors, and other active devices. Of course, you must provide substantially more information about active components. To avoid redundancy, SPICE lets you describe a device in detail, using a method called device modeling, and then reuse the same device specification at will.

With device modeling, the equations needed to describe the device are in a library within the SPICE program. The only thing you have to do is fill in the blanks. After you define a device, you can use it as many times as you wish in a netlist.

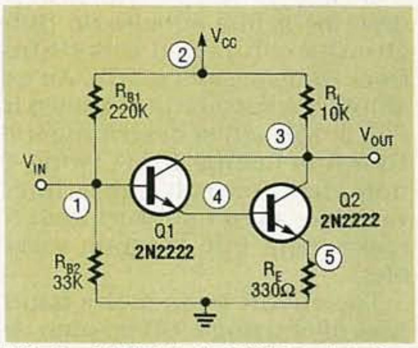

FIG. 2—SAMPLE CIRCUIT 2. This is a Darlington amplifier; like Fig. 1, the circled numbers represent the nodes that SPICE will analyze.

Let's use the circuit in Fig. 2 as an example. In this circuit two 2N2222 transistors are cascaded to create a Darlington amplifier. Resistors R_{B1} and R_{B2} are the

LISTING 3—DARLINGTON AMP DEVICE MODELING

```
DARLINGTON AMPLIFIER
VCC 2 0 DC 10V
RB1 1 2 22OK
RB2 1 0 33K
RL 2 3 10K
RE 5 0 330
Q1 3 1 4 QN2222
Q2 3 4 5 QN2222
.MODEL QN2222 NPN(IS=1.9E-14 BF=150 VAF=100
+IKF=.175 ISE=5E-11 NE=2.5 BR=7.5 VAR=6.38
+IKR=.012 ISC=1.9E-13 NC=1.2 RC=.4 XTB=1.5
+CJE=26PF TF=.5E-9 CJC=11PF TR=30E-9
+KF=3.2E-16 AF=1.0)
.END
```

biasing resistors, R_L is the load resistor, and R_E is the emitter resistor; V_{IN} and V_{OUT} are the input and output voltages, respectively. Examining the circuit, it is apparent that the SPICE netlist must contain four resistors, two transistors, and six nodes (including ground). A complete netlist is shown in Listing 3.

Notice that the transistors are treated exactly like resistors or capacitors, with the node connections listed first, and then the part value. In this case, the part value refers to the QN2222 transistor model at the end of the netlist. The .MODEL label is a control statement that tells SPICE to plug these values into its transistor equations. For each different type of transistor (or other modeling device) used in a circuit you must provide a separate model description.

Subcircuits

To model a complex device, you describe it in a *subcircuit*. Subcircuits can model everything from transformers to IC's. An example of a subcircuit is shown in Fig. 3; the netlist describing it is shown in Listing 4. In Listing 4, note that normally subscripted variables aren't subscripted, to make them into program variables.

The circuit is an active bandpass filter using a 741 op-amp. As in the case of a regular circuit, you begin by drawing the schematic, labeling the components, and assigning numbers to the circuit nodes. Note that the IC is drawn in conventional style as a single element with five external connections.

The description of the 741 begins with the line .SUBCKT UA741 and ends with .ENDS. In the 741 subcircuit netlist you'll find the usual assortment of resistors and capacitors used to specify input and output impedance characteristics. For example, R_L and C_L describe the resistive and capacitive factors of the 741's output pin.

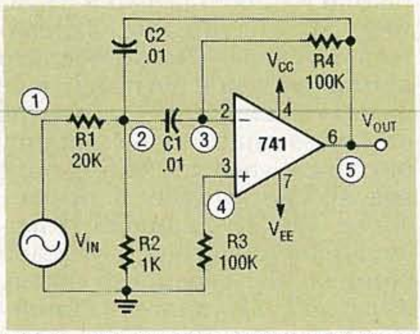

FIG. 3—SAMPLE CIRCUIT 3. This is an active filter built around a 741 op-amp. Again, the circled numbers represent the nodes that SPICE will analyze.

You may find that diodes and transistors are used to describe the inner workings of some subcircuits, but more often than not voltage and current sources are used to emulate the collective actions of these components. In our model, for example, V_{OFST} is a voltage source that sets the IC's input offset voltage at one millivolt, and I_{BN} is a current sink that sets the bias current of the inverting input at 100 nanoamps. Further, notice that the non-inverting input bias current, I_{BP}, is set at 80 nanoamps, giving the op amp an offset bias current of 20 nanoamps, a typical value for that IC.

The node numbering within a subcircuit is independent of the node numbering of the main netlist, and in no way do the two sets of numbers conflict. Furthermore, you can nest subcircuits; that is, you can call another subcircuit into your subcircuit as an element of its design. As with device modeling, you only have to define a subcircuit once, but you must have a separate subcircuit for each different device type. For example, the 741 subcircuit model will not work for an LM3900 quad op-amp.

Digital modeling

SPICE can also perform digital simulations. As a rule, you're better off using a purely digital simulator to measure time sequences and logic levels, but there are times when the two technologies come together. Analog-to-digital (A/D) converters are a prime example; the simulation must run on an analog simulator.

Performing digital simulations with SPICE requires special modeling because of the sheer number of subcircuit elements. The obvious way to model a digital device would be to describe it in a subcircuit using the actual transistor circuit. However, that approach uses large amounts of

USING SCHEMATIC CAPTURE SOFTWARE TO CREATE NETLISTS

If you find creating SPICE netlists for large circuits more than you can handle, or if you just want to make life with SPICE a little easier, there are several schematic-capture programs that can generate SPICE netlists, including the popular programs, Schema and OrCAD.

The procedure is as simple as drawing a schematic using the capture software, then requesting a netlist. Using the points that you identify as nodes, the capture software generates a SPICE netlist with the node connections and device values in the proper order.

You'll probably have to touch up the netlist, adding the opening and closing lines. In addition, most schematic-capture software lacks device and subcircuit modeling, which means that you'll have to go into the netlist and manually insert the missing lines and models. Even so, that process is better than doing the whole thing manually, and it reduces the chance for error.

One exception is SpiceNET, a schematic-capture program from Intusoft ($295) that does generate a functional SPICE netlist. Circuits created by the program can also be used as subcircuits and added to model libraries. **R-E**

LISTING 4
OP-AMP BANDPASS FILTER SUBCIRCUIT

```
OP AMP BANDPASS FILTER
.AC DEC 20 1 100KHZ
.PRINT AC V(5)
X1 3 4 5 7 6 UA741
R1 1 2 20K
R2 0 2 1K
C1 2 3 .01U
C2 2 5 .01U
R4 3 5 100K
R3 0 4 100K
VEE 6 0 -15
VCC 7 0 15
V1 1 0 SIN 0 1 AC 1
-IN
+IN
OUT
VCC
VEE
.SUBCKT UA741 2   3   6   7   4
*PINOUTS    -IN +IN OUT VCC VEE
RP 4 7 10K
RXX 4 0 10MEG
IBP 3 0 80NA
RIP 3 0 10MEG
CIP 3 0 1.4PF
IBN 2 0 100NA
RIN 2 0 10MEG
CIN 2 0 1.4PF
VOFST 2 10 1MV
RID 10 3 200K
EA 11 0 10 3 1
R1 11 12 5K
R2 12 13 50K
C1 12 0 13PF
GA 0 14 0 13 2700
C2 13 14 2.7PF
RO 14 0 75
L 14 6 30UHY
RL 14 6 1000
CL 6 0 3PF
.ENDS
.END
```

```
******* 2/19/90 ******* IS SPICE  1.41 12/12/87*******20:30: 6*****

BANDPASS FILTER

****     AC ANALYSIS                        TEMPERATURE =   27.000 DEG C

************************************************************************



 LEGEND:

*: V(5)
+: VDB(5)

     FREQ        V(5)

(*)------------ 1.000D-01    3.162D-01    1.000D+00    3.162D+00 1.000D+01
                        - - - - - - - - - - - - - - - - - - - - - - - - - -

(+)------------ -1.000D+01   -5.000D+00    0.000D+00    5.000D+00 1.000D+01
                        - - - - - - - - - - - - - - - - - - - - - - - - - -
   1.000D+03  4.773D-01 .        +   .   *       .            .           .
   1.100D+03  5.978D-01 .            .+     *    .            .           .
   1.200D+03  7.661D-01 .            .      + *  .            .           .
   1.300D+03  1.016D+00 .            .           X            .           .
   1.400D+03  1.406D+00 .            .           .   *  +     .           .
   1.500D+03  1.996D+00 .            .           .      *     . +         .
   1.600D+03  2.481D+00 .            .           .         *  .     +     .
   1.700D+03  2.182D+00 .            .           .       *    .   +       .
   1.800D+03  1.641D+00 .            .           .    *     + .           .
   1.900D+03  1.260D+00 .            .           .  * +       .           .
   2.000D+03  1.013D+00 .            .           X            .           .
   2.100D+03  8.475D-01 .            .       + * .            .           .
   2.200D+03  7.296D-01 .            .    +  *   .            .           .
   2.300D+03  6.420D-01 .            . +    *  . .            .           .
   2.400D+03  5.743D-01 .            .+    *     .            .           .
   2.500D+03  5.206D-01 .          + .    *      .            .           .
   2.600D+03  4.768D-01 .        +   .   *       .            .           .
   2.700D+03  4.404D-01 .      +     .  *        .            .           .
   2.800D+03  4.097D-01 .    +       . *         .            .           .
   2.900D+03  3.834D-01 .   +        .*          .            .           .
   3.000D+03  3.605D-01 .  +         .*          .            .           .
                        - - - - - - - - - - - - - - - - - - - - - - - - - -
```

FIG. 4—SPICE GRAPHIC. This crude graph uses ASCII characters, so it prints on any printer.

computer memory and requires lengthy run times, even for simple circuits.

A better way is to use threshold logic theory. With this method, the input gates of a device appear as analog voltages that are multiplied by weighting constants, and the resulting analog voltages are compared to a threshold value. If the sum is greater than the threshold, the output of the gate is treated as a logical one; if the sum falls below the threshold, the output is treated as a logical zero. The weighted values and threshold point are usually determined by polynomial algorithms. The problem is that the algorithms aren't easy to work with, and are beyond the expertise of most SPICE users.

Fortunately, however, there's a huge inventory of ready-made SPICE models for many different types of components, including transistors, optoelectric devices, and analog and digital IC's. Most versions of SPICE come with a library of popular components, and you can usually obtain additional libraries at extra cost. Device manufacturers are another source of SPICE models. For not-so-popular or oddball devices, you can buy specialty models from third-party vendors, or roll your own in a subcircuit. The maker of IsSPICE, Intusoft, publishes a free newsletter that contains information and modeling tips for various types of electronic devices.

Plotting SPICE's output

Like most simulation programs, SPICE generates a lot of data, and analyzing that data can be a chore. Like the netlist, all SPICE output files are in ASCII, which means you can transport them from one computer to another without conversion, or make a hardcopy of the file using just about any printer. Data is stored in the output file in the same order that SPICE performs its operations: the netlist, followed by the DC analysis, followed by the AC analysis.

There are several ways to display SPICE output in graphical form. The easiest is to add a .PLOT control statement to your netlist. SPICE then provides you with a tabular listing, similar to that generated by .PRINT, plus a crude graphical representation, as shown in Fig. 4. If you request more than one measurement within the same .PLOT statement on your netlist, you get a multi-line graph, which is handy for comparing two or more sets of measurements.

However, .PLOT graphics leave a lot to be desired. Fortunately, however, SPICE's tabular format is accepted by most database, spreadsheet, and graphics programs, including Lotus 1-2-3. The best way to prepare a SPICE output file for data import is to use a text editor to remove everything but the desired tables, and then import the data into the desired program. Figure 5 shows a 1-2-3 plot of the data in Fig. 4.

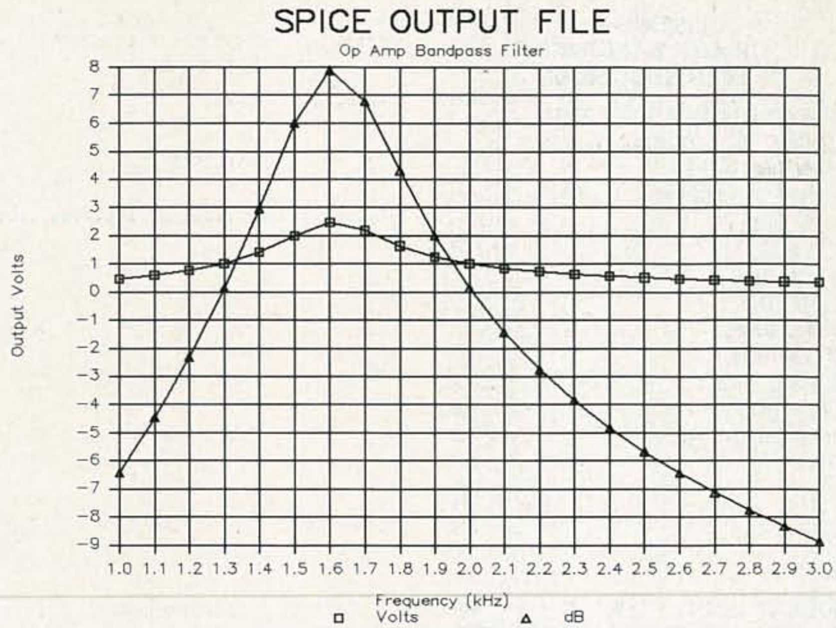

FIG. 5—1-2-3 PLOT. It's simple to import SPICE data into Lotus 1-2-3 and get a decent plot.

Choosing a SPICE program

When choosing a SPICE program, there are several factors to consider, not the least of which is cost. A SPICE package can cost anywhere from $100 to more than $20,000.

The cheapest SPICE simulation package that we know of is IsSpice from Intusoft, which sells for $95. An accessory for IsSpice that lets you draw schematics and create netlists is shown in Fig. 6. By comparison, the popular PSpice program from MicroSim goes for $950. The digital-simulation option for PSpice is shown in Fig. 7. The reason for the large difference in price between the two is due mostly to the number of device models included. IsSpice comes with only a handful of transistor models, whereas PSpice comes with a transistor library containing more than 1500 devices, plus numerous other device models.

Program prices also vary according to the type of computer the program runs on. The IsSpice and PSpice prices mentioned above are for the 8088 version. If you want to use the additional power offered by a 286 or 386 PC, corresponding versions of the program will cost more. PSpice for the Macintosh costs a hefty $1,450.

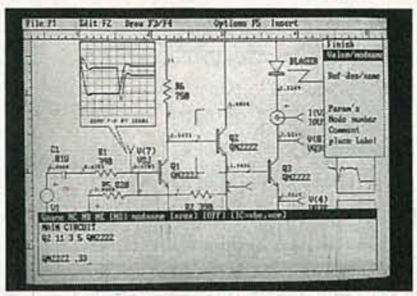

FIG. 6—SPICENET ADD-ON FOR IsSpice.

The type of PC also determines the size of the circuit the SPICE program can support. For example, the PC-only version of SPICE can only simulate circuits of fewer than 200 nodes (about 100 transistors, including subcircuits). For larger simulations, you need to buy a more powerful (and more expensive) version of the program.

Most SPICE packages offer a variety of utility programs that make SPICE easier to use. The most popular utilities are SPICE editors, Monte Carlo simulators, and graphics processors. But get ready to raise the ante again. For example, a fully-loaded IsSpice package goes for $790, and an equivalent PSpice package tips the scales at $1,750. Fortunately, most SPICE makers have demo packages available so you can try before you buy.

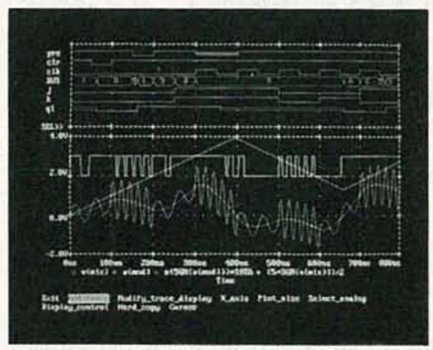

FIG. 7—DIGITAL SIMULATION FOR PSpice.

Next time we'll look at the world of digital circuit simulation, and examine a digital simulator called SUSIE. **R-E**

ITEMS DISCUSSED

- IsSpice ($95), Intusoft, P.O. Box 6607, San Pedro, CA. 90734. (213) 833-0710. **CIRCLE 41 ON FREE INFORMATION CARD**
- PSpice ($950), MicroSim Corp., 20 Fairbanks, Irvine, CA 92718. (714) 770-3022. **CIRCLE 42 ON FREE INFORMATION CARD**

HARDWARE HACKER

This month we'll take a look at walking-ring counters, electronic dice, vortex coolers, and lots more.

DON LANCASTER

Some of you hardware hackers seem to make a big deal out of getting one or two pieces of newer electronic parts. As a general rule, if a chip house has a stiff minimum order, they often will be rather liberal with free evaluation samples. All you usually have to do is ask for them in a professional manner.

other times, some other hacker will recognize a need and fill it for you. For instance, Mike Giamportone of his *Thumb Electronics* is stocking the LSI melody chips for you at $1.50 each. Many of the other great LSI hacker chips are available in small quantities from *Belco Electronics*.

My new PostScript 4BBS is already going great guns on *Genie*. Yes, all of the "lost" Guru columns are here, as is much of the *Midnight Engineering* stuff. You'll find my insider hacker secrets brochure available as library downloads #112 and #113. You can also reach me here for email and such at SYNERGETICS.

All this is on Genie's PSRT, short for the *PostScript Roundtable*. For local connect info, call *Genie* (voice) at (800) 638-9636.

While I was wandering around a few of those other RoundTables on *Genie*, I did find a great radio and electronics board up at M345. These folks are heavily into monitor and scanner listings, satellite stuff, unusual receiver circuitry, general communications, and bunches more. They have thousands of downloads available for you.

Let's start off with some unique circuits known as...

Walking-ring counters

I have always been attracted to *elegant simplicity*, circuits or software that does more with less in some superb or unique manner. In these days of FASTER CPU'S! and MORE MEMORY!, any elegant simplicity seems to have fallen by the wayside.

For instance, the game paddle port on an Apple IIe runs a LaserWriter *twice* as fast as the Mac IIcx and *three times* as fast as any other Mac. Yet for some strange reason, Apple does not appear to be shouting this fact from their Cupertino rooftops.

Since no good deed will ever go unpunished, elegant simplicity will *always* get ruthlessly stomped upon whenever and wherever it occurs in the real world.

One older and classic example of elegant simplicity is the walking-ring counter. This is a hardware circuit or a software routine which generates a unique count sequence in a simple, unusual, and quite sophisticated manner. When used in the right place at the right time, walking-ring counters can provide very clean solutions to electronic problems that otherwise are often sloppily or klutzily done.

Walking-ring counters are also sometimes called Johnson counters. To build a walking-ring counter, take a string of type D flip-flops or adjacent bits in a software word. Cascade the flip flops as an ordinary serial shift register, but connect the $\overline{Q}$ output of the last stage back to the D input of the first stage. Then you clock all of the flip flops from a common source.

Figure 1 shows you a three stage walking-ring counter we'll be looking at shortly in more detail. For now, pretend that this is a *five-stage* counter instead of being only three stages long. Furthermore, assume we have reset the counter to its 00000 state.

As you clock a five-stage walking-ring counter, the following sequence is generated...

```
00000
10000
11000
11100
11110
11111
01111
00111
00011
00001
00000 (repeats)
```

Since we repeat after ten counts, we apparently have built a *decade*, or divide-by-ten counter. In fact, it turns out that the count length of a walking-ring counter is normally *twice* the number of stages in use. Thus, three D-flops give you a divide-by-six, four a divide-by-eight and so on.

This is a *synchronous* counter, since all stages are clocked simultaneously. There are none of the glitches that get produced by a ripple counter.

Note that there are no intermediate frequencies. You have your input frequency and an output square wave of frequency *input/2n*, where "n" is your number of stages. That makes the walking-ring counter ideal for very high frequency use, especially as UHF and VHF prescalers.

Another unique property is that *all* of the counter states can be decoded using only a single two-input NAND gate per state. Furthermore, a full decode uses *all* of the Q and $\overline{Q}$ outputs in a balanced and symmetrical manner. Back in the days when you worried about the *fanout* of a logic block, that was a really big deal.

I'll save the details on this for you to ponder over on your own, but most states decode using the Q output of one stage NANDED with the $\overline{Q}$ output of an adjacent one. Again, this is a very clean layout that is superb for high frequency use.

What is wrong with the walking-ring counter? Elegantly simple or not, it does have two bad habits. The first is that you need half as many flip flops

NEED HELP?

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

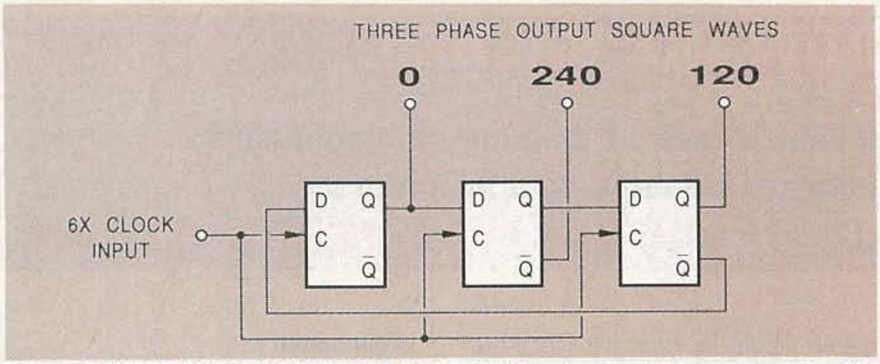

FIG. 1—A THREE PHASE REFERENCE GENERATOR using a walking-ring counter. The three-output square waves produced are at one sixth the clock frequency and are precisely shifted by 120 and 240 degrees.

or word bits as your count module. Using five flip flops to divide by ten seems like no big deal. However using 32 of them for a divide-by-64 gets old in a hurry. Thus, walking-ring counters are rarely used beyond a divide-by-twelve.

Any flip flop counter of any length can get into 2^n possible states. Thus, a five flip flop walking-ring counter can get into 32 possible states, only ten of which are legal and allowed. If you inadvertently get into one of those "wrong" count states, you can get into a *disallowed sequence* that can cause you grief.

For instance, the three stage, divide-by-six counter of Fig. 1 normally provides this sequence...

0 0 0
1 0 0
1 1 0
1 1 1
0 1 1
0 0 1
0 0 0 (repeats)

But if you ever get into the 0 1 0 sequence, here's what results...

0 1 0
1 0 1 (repeats)

All of a sudden you now have a divide-by-two counter instead of the divide-by-six, which could really be bad news. Thus, you somehow have to guarantee that a walking counter *never* gets into its disallowed state sequence!

Resetting the counter or else preloading your software registers are two good ways to prevent disallowed sequences. A sledgehammer cure is to always force internal 1 states whenever the two ends of the counter are also both set to 1. For instance, you could AND decode the outside Q outputs and use these to preset all the internal stages to their 1 state. That will quickly find any disallowed sequence and repair it on the fly.

Let's look at three uses for walking-ring counters. I can't believe how many really dumb circuits have been published in the trade journals that were intended to generate three-phase power control signals.

As Fig. 1 shows us, all you really need is a divide-by-six walking-ring counter. Provide six times your desired frequency, and you get three square waves out, all phase shifted by precisely 120 degrees.

You can obviously change your number of stages for a quadrature output, for quad-phase, five-phase, and so on. More details on all of this is in my *CMOS Cookbook*.

Another great place to find lots of really klutzy circuits is in an electronic dice game. Figure 2 shows you the elegant simplicity of a walking-ring die.

To understand this circuit, you first define your die spot count sequence as 1-3-5-6-4-2. This gives you a "free" even-odd decoding for the middle spot, and a "free" 4-5-6 decoding for two diagonal outside spots.

Use a NAND gate to decode "not 1" for the other two diagonal outside spots. Use an AND gate (or else two diodes) to decode "six" for the two outside middle spots. A medium frequency-gated oscillator clocks the die, and a second die can be cascaded off the first one. Additional details can be found in the *CMOS Cookbook*.

Finally, Fig. 3 shows you a digital-sine wave generator that produces a pair of sine waves that are frequency shifted precisely by 90 degrees. That circuit is based on stuff we looked at back in the 1989 January issue of **Radio Electronics**. See my *Hardware Hacker II* reprints for the full details.

I've purposely left the part numbers off all our figures this month, to encourage you to experiment on your own. Your best choices will be such chips as a 4013 or 74HC74 dual-type D flip flop. Most any parallel out shift register could also be used, as can software shift commands applied to any old alterable byte.

For our contest this month, either (1) Show me an unusual use for a walking-ring counter, or (2) show me some other circuit, tool, or technique that is elegantly simple.

There will be all of those usual *Incredible Secret Money Machine* book prizes for the dozen top entries, with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

As usual, do send all of your written entries directly to me here at *Synergetics*, rather than over to the people at **Radio Electronics** editorial.

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More on magnetic refrigeration

The stuff is finally starting to pour in on *magnetic refrigeration*, our exciting breakthrough topic from two months ago. Yes, this is all very legit and real. It is just being kept *very* quiet as all the insiders scramble for real world product introductions. Some of the insiders include Hughes, MIT, and Sandia Labs.

So far, very strong magnetic fields are involved and, while useful at room temperature, most of the research is aimed at reaching very low cryogenic temperatures.

The best paper I've seen so far is the *Magnetocaloric Effects in Rare-earth Magnetic Materials*, by A.S. Andreenko and crew in Soviet Physics Usp 32 (8), August 1989. This dude is both current and has an extensive bibliography.

Since an all solid state cooler would involve switching extremely strong magnetic fields, the chances are that some motion will be involved in most of the practical magnetic coolers, at least the early ones.

Figure 4 shows you a *shuttle* type cooler. Gadolinium is moved to an area free of a magnetic field where it picks up heat from the object to be cooled. It is then moved into a very strong magnetic field where it dumps energy to a suitable heat sink. This cycle is repeated at an optimum rate for the quantities of heat involved.

Vortex coolers

This is another type of "gee whiz" type of cooler that is useful for cooling electronic enclosures and doing such specialized things as preventing needle breakage in heavy duty sewing machines. A vortex cooler has no moving parts. While it looks and feels like a perpetual motion machine, it is quite real and rigorously obeys the laws of thermodynamics.

As Fig. 5 shows us, a vortex cooler is nothing but a specially designed nozzle. The input is connected to a source of compressed air, as is commonly found in most production areas. There are two outlets. Hot air comes out the hot end and cold air comes out the cold end.

Leading manufacturers of vortex coolers are *Vortec* and *Exair*. They both have lots of catalogs, cassette tapes, data sheets, and application notes available.

How does it work? The air enters

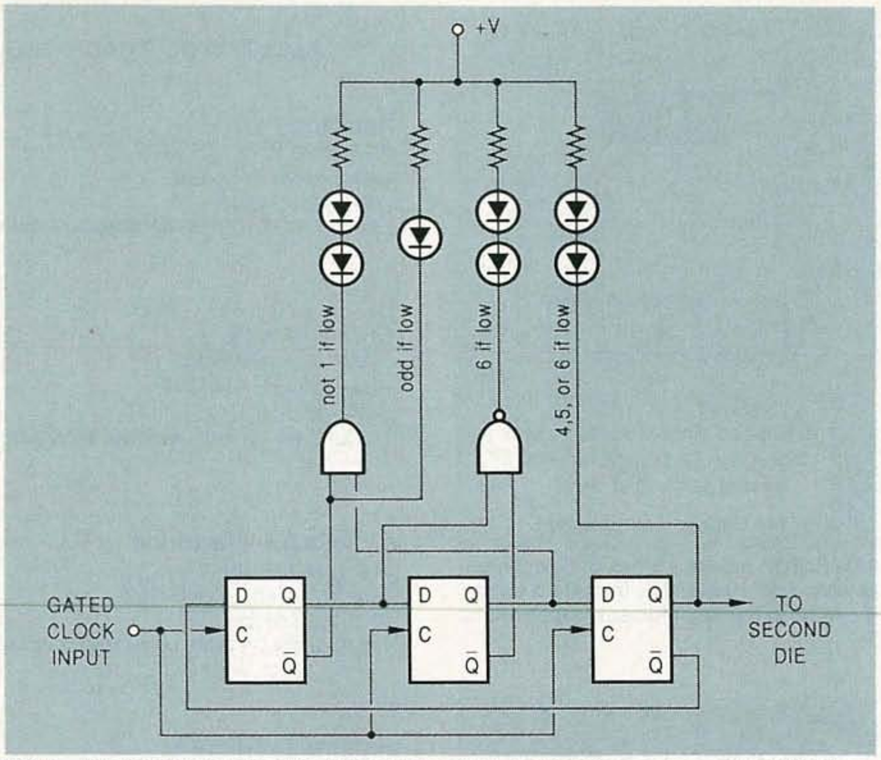

FIG. 2—ELECTRONIC DICE USES A walking-ring counter in an unusual 1-3-5-6-4-2 sequence to greatly simplify the spot decoding.

tangentally faster than the speed of sound and forms a rapidly spinning hollow vortex cylinder having a very high angular velocity. When it gets to the hot end, some of it is released to ambient, and the rest of it spirals back *inside* the spinning hollow inlet air vortex cylinder.

Now for the tricky part. The inlet air and the outlet air are both spinning at the same radial velocity, since they are in contact with each other. But the *momentum* of the inside air has to be less since it has a smaller radius of rotation, and since angular momentum is inversely proportional to the spinning radius.

Because the momentum must be preserved, energy is transferred from the inside spinning air cylinder to the outside one. That cools the cold end exit air at the same time that it heats the inlet air.

Full details appear in the *Vortec* application notes.

There is usually an adjustment screw that lets you vary the ratio of hot to cold exit air. One setting gives you the lowest possible exit temperature, which routinely can go as low as −40 degrees. A different setting gives you the most efficiency and the maximum cooling at a higher exit temperature. The air consumption and the overall efficiency are acceptable for most current uses.

What are the limitations to vortex cooling? Obviously, you do need an air supply. And your air has to be extremely clean and extremely dry if the cooler is not going to freeze or jam. That can be a noisy situation. And the pricing in single quantities often approaches $100 for industrial units.

Question: Could you put a vortex cooler in a car vent? Let's have your thoughts on this.

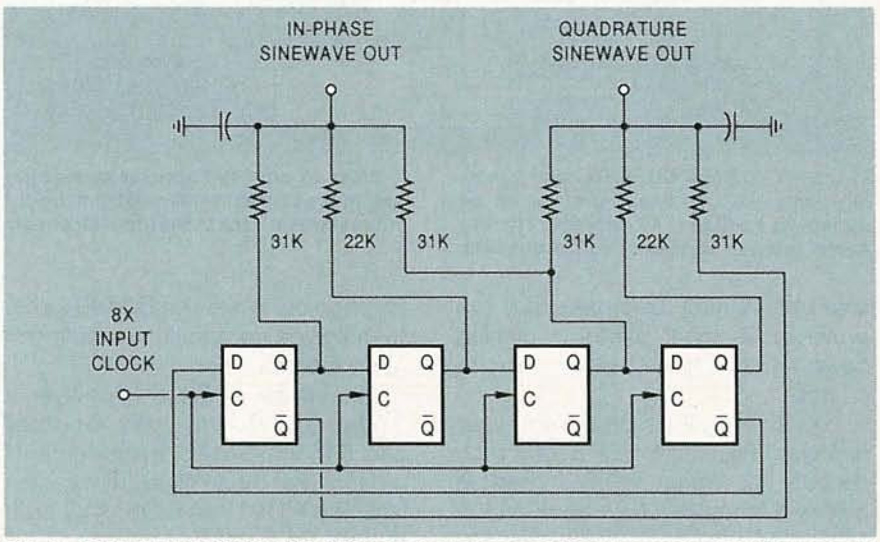

FIG. 3—QUADRATURE SINE WAVES which are phase shifted by precisely 90 degrees are easily generated with a walking-ring counter. The uses include single sideband communications and synchronous demodulation.

Electronic trade journals

As we've seen a number of times in the past, there's simply no way you can be serious about hardware hacking if you do not aggressively subscribe to the industry trade journals. For our resource sidebar this month, I have gathered together a few of what I feel are the more interesting and more important electronic magazines for you.

Most of those are free to "qualified" subscribers. You usually can qualify by using your PostScript business letterhead and your company name, and then telling them what they want to hear on their qualification card. The whole reason for the qualification process is so the magazines can get a special *controlled circulation* postage rate. As long as you are genuinely interested in what their advertisers have to offer, you're wanted as a subscriber.

To find other magazines that are not on this list, you'll want to once again refer to the *Hacker's Holy Grail*, which is otherwise known as the *Uhlrichts Periodicals Directory* that can be found on the reference shelf of your local library.

Let's see. I guess the three "best" and most useful of those would be *E.E. Times*, *EDN*, and *Electronic Design*. But all of those others are certainly worth a look.

Once you get a subscription, you use the bingo cards, fax sheets, and mail coupons to pick up data books, samples, application notes, and the whole bit. Many of the magazines

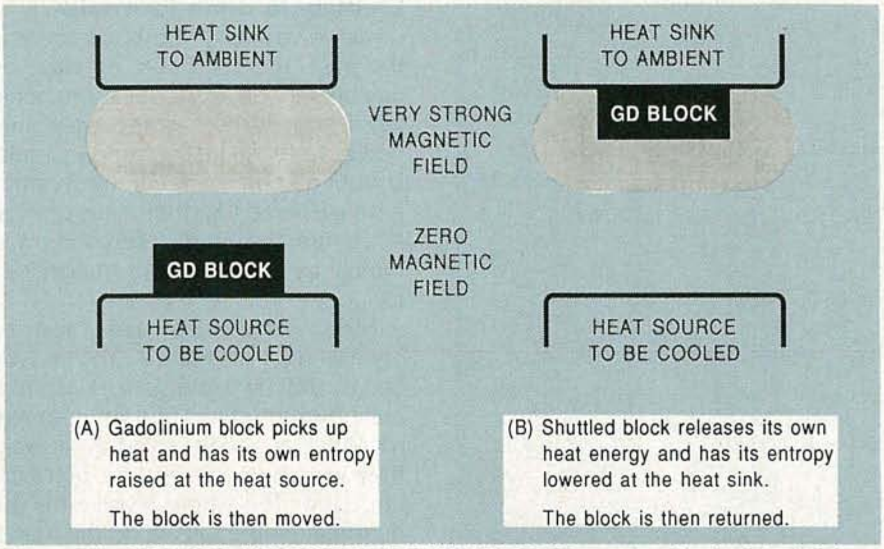

FIG. 4—THE SHUTTLE TYPE MAGNETIC REFRIGERATOR moves a block of Gadolinium between a heat source in a magnetic field free area and a heat sink in quite a strong magnetic field area. This type of heat pumping can be extremely efficient, especially at cyrogenic temperatures.

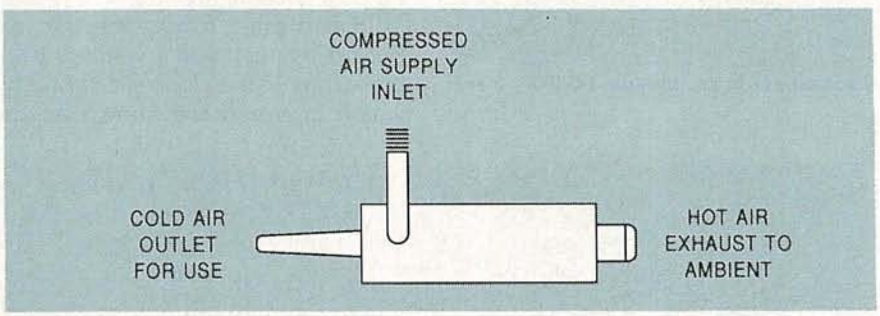

FIG. 5—A VORTEX COOLER has no moving parts, yet can easily provide an air stream as cold as −40 degrees. The key secret is a pair of coaxial vortex streams. In order to preserve angular momentum, heat energy gets transferred from the cold output stream back to the input air stream.

also offer annual directories that can prove to be most useful in pinning down an oddball part or an obscure source.

Lots more details on making your hardware hacking into a useful tech venture do appear in my *Incredible Secret Money Machine* book and in *Midnight Engineering*. If you have any favorite trade journals not already on this list, please let me know some more about them.

New tech literature

A pair of data books and a postcard sample order form from Maxim includes *Analog Product Highlights* and their *New Releases Data Book*. From PMI, a humongous *Analog Integrated Circuits Data Book #10—four pounds and several thousand pages. Included are all of the old SSM* (solid state music) circuits.

One additional source for the FM stereo broadcaster kits is *Ramsey Electronics*, while the BA1404 chips themselves do remain available from Ohm Electronics.

The latest *All Electronics* flyer includes $6.50 strip chart recorders and $15 COSMAC microcomputer trainers. For those of you that came in late, the CDP1804 COSMAC architecture gave totally new meaning to the term *bizarre*. A most wondrous beast.

Three other interesting surplus catalogs this month include *Johnson Shop Products*, *Windsor Distributors*, and *Consumertronics*. Neat stuff.

Our new magazines for this month include 8/16 on Apple programming from Ariel Publishing, and World Cogeneration, a generate-your-own-power magazine that can be found at the extreme opposite end of the spectrum from the great folks at Home Power.

Turning to mechanical stuff, free

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ergonomic foam samples are available from EAR Composites, while Wale Apparatus is where you really should go if you are at all serious about industrial glasses and the process of glass blowing.

For more details on working with walking-ring counters, check out my *TTL Cookbook* and *CMOS Cookbook*. And for more details on making all of your hardware hacking appear far more professional, you should look into my *Incredible Secret Money Machine*.

Finally, I do have a new and free mailer for you which includes dozens of insider hardware hacking secret sources. Write or call for info.

Our usual reminder here that most of the items that have been mentioned appear either in the *Names and Numbers* or in the *Electronic Trade Journals* sidebars.

As always, this is your column and you can get technical help and off-the-wall networking per that *Need Help?* box. The best calling times for that number are weekdays 8–5 in Mountain Standard Time. Let's hear from you. **R-E**

CALL SCREENER

continued from page 62

ringing telephones with a combined ringer equivalence number (REN) of 5.0.

Slave phone interface

The primary function of the slave phone interface is to immediately detect when any slave phone is off-hook and to establish a MASTER RESET high, as long as the phone is off-hook. When the slave phone is placed back on-hook, the reset is removed.

Whenever the CallScreen is in the Screen-On mode, RY2 is energized, connecting the slave phones to the secondary of ringer transformer T3. The secondary of T3 provides the ring voltage when a ring is required from incoming calls processed through the CallScreen. The phone connection to T3 is made through the series connection of the +16V power supply, and the series/parallel combination of IC28, R74, D40, and C45.

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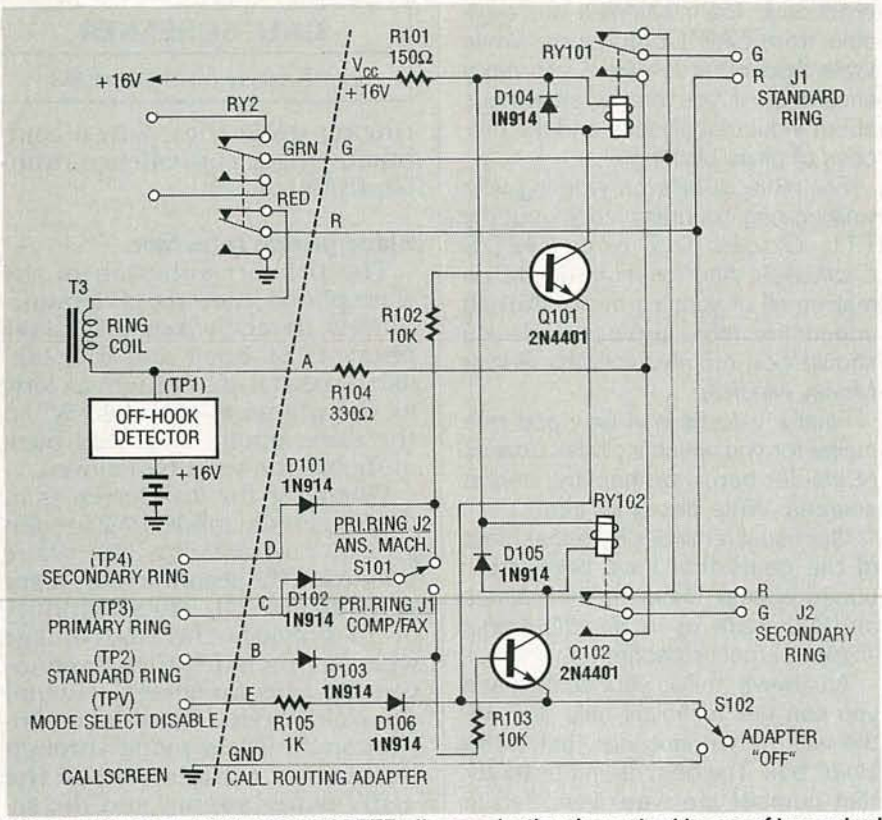

FIG. 2—THE CALL ROUTING ADAPTER allows selective ring output to one of two output jacks. While the circuit is optional, there is space for the components on the main PC board.

Standard telephones have their ringer devices coupled to the telephone line through very high DC resistances. In practice this coupling is usually capacitive, so that while on-hook, there is essentially no DC current path. When off-hook, a DC resistance of up to several hundred ohms is placed across the line. Any slave phone, when raised off-hook, causes DC to flow from the +16V power supply, forward biasing the IC28's internal LED, through R74 and the secondary of T3, through the DC resistance of the off-hook phone, and back to power supply ground. The forward-biased opto-coupler diode turns on the phototransistor whose collector is connected in parallel with the collector of the Darlington pair in IC21 and through R58 to +5V. When IC28 is turned on, the voltage at the lower end of R58 goes to nearly zero. That is coupled to pin 2 of comparator IC2 which causes IC2 pin 6 to go high.

The reference voltage for IC2 is developed by voltage-divider R60-R62; it is set to approximately 224 millivolts. When the voltage at pin 2 goes lower than 224 millivolts, the output of IC2 goes high. That output is coupled to pin 9 of IC9-c which, as part of the reset logic, sets a MASTER RESET high and also causes RY2 to release. A MASTER RESET high will unlatch the off-hook latch. The result of these actions is that the slave phones now bypass the CallScreen and are connected directly to the phone line, and the CallScreen is returned to on-hook. The output of IC2 is also connected to timer IC9-d which enables screen-mode changes for a period of approximately seven seconds after a slave phone is placed off-hook. That prevents screen-mode changes from inadvertently occurring during normal telephone calls in the event that the "*" and "#" keys are used.

Buffer IC9-d drives timing components R57 and C58. When any slave phone transitions off-hook, IC2 pin 6 goes high as does IC9-d pin 11. That high appears through C58 on IC14-a pin 1, which enables remote screen-mode changes. As C58 charges, the voltage across R57 decreases. When R57 reaches approximately 1.5 volts, pin 1 of IC14-a sees a logic low and remote screen mode changes are disabled.

As soon as IC2 pin 6 transitions high, C34 begins charging through D36 and R63; R63 limits the inrush current to C34 preventing a momentary voltage collapse at the cathode of D36. When RY2 drops, the slave phone connections are transferred from the CallScreen ringer transformer to the telephone line. When the transfer occurs, IC28 turns off and IC21 turns on. The LED inside IC21 is connected in series with the phone line through BR3 which ensures a correct polarity for forward bias regardless of actual phone line connections. Current for the LED comes from the telephone company central office.

Since the collector of the Darlington pair in IC21 is connected in parallel with IC28, the bottom of R58 remains low and the MASTER RESET remains high. At this time, the slave phone has been connected and the CallScreen is held reset and is effectively transparent on the line.

If a slave phone is raised off-hook to make an outgoing call, the process is the same as described above except that when the slave phone is transferred to the telephone line, there is a momentary interruption of the central office DC current from the time the central office detects a phone off-hook until a dial tone is returned superimposed on the restored DC current. During that interval, IC2 pin 6 transitions low, but the now-charged C34 maintains a high on pin 9 of IC9-c for approximately one second. That delay provides a ride-through capability that prevents RY2 from pulling in and eventually rocking the off-hook slave phone back and forth to and from the telephone line. The discharge of C34 takes place through R63, R61, and the low output impedance of IC2. Diode D36 is reversed biased during this interval. The arrangement of R61, R63, and D36 is designed to allow C34 to charge quickly, but to discharge slowly.

Resistor R59 limits current through IC21's LED while a forward-biased D35 eliminates any reverse voltages from appearing across the LED. When D35 is reversed biased, the voltage across the combination of R59 and

IC21's LED is limited to 5.1 volts, thus placing an absolute limit on the forward current through the LED. These precautions are necessary to protect IC21 in the presence of telephone-company ring voltage when the screen mode is off, and also to protect against electrical transients that appear on the phone line.

The detection of a slave phone off-hook while a ring voltage is being developed across the secondary of T3 requires that RC filtering be used to track the average DC voltage level on the collector of the phototransistor in IC28. While the ring voltage is present, IC28's LED will be forward biased during a portion of each half cycle of ring current. Zener-diode D40 protects the LED in the same manner as D35 protects IC21. Capacitor C45 bypasses a major portion of the AC ring current around the off-hook detection circuitry, but some short-duration pulsing of the IC28 collector to ground does occur. The combination of R56 and C33 act as a low-pass filter to reduce the ringing pulses to an average DC level across the input of IC2. The DC level is above the comparator reference voltage so that ring pulses will not trip the slave-phone off-hook detector. When the slave goes off-hook and the IC28 collector transitions to solid low, the comparator output goes high.

Call routing adapater

The call routing adapter (CRA), shown in Fig. 2, allows selective ring output to one of two output jacks. A switch (S101) on the CRA allows user selection of either answering machine or computer/facsimile machine operation. When S101 is in the "ANS MACH" position, all un-screened calls ring through J1, while all screened calls ring through J2. When S101 is in the "COMP/FAX" position, all secondary-code calls ring through J2, while all un-screened and primary-code calls ring through J1. Another switch (S102) allows the user to de-activate the feature permitting all CallScreen processed calls to be available on both CRA output jacks. The CRA derives all control signals and power from the base CallScreen unit.

With the CallScreen in a standby condition, both RY101 and RY102 are de-energized and both output jacks (J1 and J2) are connected in parallel through to the CallScreen output poles on RY2. This permits normal processing of outgoing calls generated by an off-hook condition on J1 or J2.

When an incoming call is determined to be un-screened, TP2 (in the main circuit) goes high simultaneously with the activation of the CallScreen ringer. When TP2 goes high, Q102 is turned on through D103 and R103, closing the contacts of RY102. The contacts on RY102 transfer the output on J2 from the CallScreen ringer directly to the CallScreen off-hook detector. That prevents CallScreen ring voltages from reaching any telephone(s) connected to J2. RY101, however, remains de-energized and the standard ring (for an unscreened call) is delivered to J1. Assuming that S101 is in the "ANS MACH" position, it is apparent that a logic high on either TP3 or TP4 will similarly energize RY101 preventing screened-call ring signals from reaching J1, while J2 receives screened-call rings. In this mode, the answering machine is connected to J1 and the telephones to J2.

When S101 is in the "COMP/FAX" position, the same ring lockout technique described above is used so that primary and un-screened call rings are prevented from reaching J2 and secondary rings do not reach J1. In that mode, the computer or facsimile machine is connected to J2 and the telephones to J1.

Resistor R101 reduces the 16-volt supply from the CallScreen to a nominal 12 volts for operation of the CRA relays. R102 and R103 are current limiting resistors while R104 protects the CallScreen off-hook detect circuit from excess current, should a short to ground occur across J1-J2. Diodes D101–D103 are steering diodes, while D104 and D105 act as back-EMF surge suppressors. When S102 is closed, a logic low is placed through D106 and R105 across the screen-mode select line which disables remote screen changes.

That's all we have room for this month. Next time we'll go over the assembly and provide parts-placement diagrams. R-E

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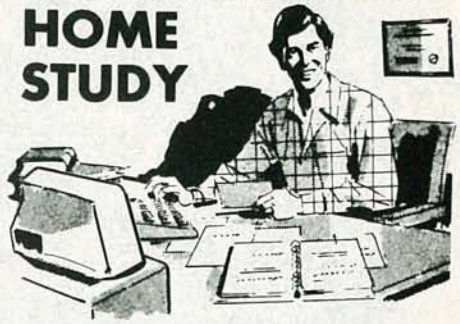

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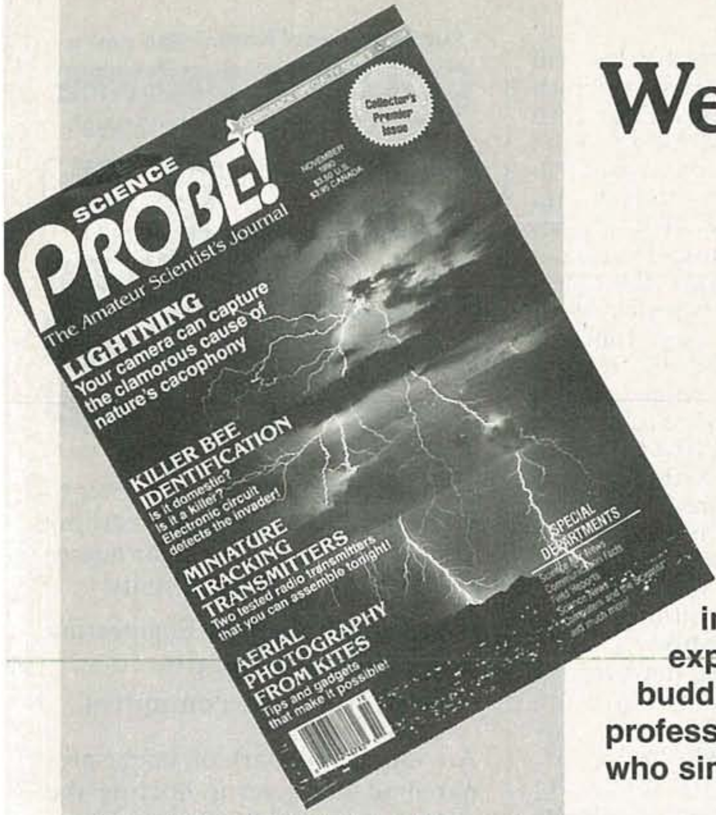

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Once simple page buffers, today's graphics coprocessors provide powerful display muscle for sophisticated, high-end graphics systems.

MIKE MULLIN

With graphics subsystem technology progressing at such a fast rate, it can be difficult to keep track of all the latest trends. We'd like to illustrate those trends by giving you some insight into the internal operations of some of the newer power-packed graphics coprocessors.

Graphics subsystems of the past were simply dedicated multi-ported memories with high-speed digital-to-analog (D/A) converters. Those coprocessors provided CRT control, screen storage, display, and refresh operations without loading down a host processor. However, the host processor still had to perform all the complex graphics operations in the computer, including raster and vector manipulation, pixel-color and intensity-control, pan and zoom functions, and so on.

Graphics subsystems of today can execute higher level transformation and rendering tasks than those of the past. These more advanced processors can perform rotation, moving and zooming, as well as vector-to-raster conversion and color and dithering calculation to express image depth.

Even though a graphics processor doesn't have to handle all of the usual central processing unit (CPU) functions, it does require a great deal of throughput for the tasks it performs. Simply refreshing a megapixel (1K × 1K pixels or more) screen with 24-bits of data per pixel (for color, intensity and depth) requires a throughput of 90 megabytes per second in non-interlaced (30 screens per second) mode.

Texas Instruments (TI) has entered the market with their widely used TMS340XX and TMS320XX series of "Application-Specific" dedicated graphics processors. Cut from the same basic core, those processor families provide a wide range of graphics and digital signal processing (DSP) functions for a diverse range of system complexities—the 34010 and 34020 are aimed at the PC and low-end workstation markets, while the 320XX series is aimed at DSP, super-high-resolution (4K × 4K pixels) and 3-D graphics markets.

The 34010's internal structure uses a 32-bit general-purpose integer processor with clock speeds up to 50 MHz. On-chip, host-interface logic allows the target system's host CPU to access the 34010 and to map it's memory into that of the host processor, thus providing a fast way to swap data commands and status information between the 34010 and the host. There is a 256-byte instruction buffer on chip, as well as two register files that contain 15 32-bit registers each.

The 340XX and 320XX series use an on-board arithmetic logic unit (ALU), which enhances their computation. Most register-to-register operations are done in a single clock cycle, and two operands can be loaded into the ALU in a single cycle. In that same cycle, the ALU can process the last-loaded pair of operands and transfer those results back to the register files. The result of that arrangement is that ALU operations seem to occur on one cycle. Bringing further flexibility to that scheme is a 32-bit barrel shifter that shifts or rotates 32 bits of data any number of positions (up to 32) in a single machine cycle.

To further customize the 34010 to graphics applications, a part of its instruction set is dedicated solely to graphics functions. Among those 23 instructions are commands for drawing and filling lines, arcs and polygons and for manipulating single pixels and blocks of pixels.

Last year, TI introduced the 34020, which has similar architecture to the 34010, but several improvements. For example, its data path is 32 bits wide, twice the width of the 34010. The on-chip buffer is 512 bytes, also twice the size.

In addition to a host-processor interface, the 34020 adds interfaces for a floating-point coprocessor (the 34082) and for multiprocessor operation. The 34010, which TI will still produce, but will target towards low-cost, high-volume applications, can be used with a math coprocessor. Instead of a direct connection, memory mapping techniques are used.

Now that you've gotten an idea of what the TI 340XX and 320XX graphics processors can do, let's look at how another manufacturer's device handles graphics applications.

Intel's "superchip"

Like their general-purpose counterparts, graphics processors are evolving to RISC (reduced instruction-set computer) architectures and parallel processing. A good example of this trend is the Intel's i860. Released by Intel as a supercomputer on a chip for general-purpose computing, it quickly became the coprocessor of choice for high-end graphics systems designers.

The i860 has a 64-bit RISC integer processor at its core, and allows programmer control over pipelining, buffering and parallel processing, including synchronization and interlock operations, for optimum instruction sequencing.

In addition to that feature, the i860 uses a floating-point processor with parallel adders and multipliers, for more efficient execution of common tasks such as fast Fourier transforms (FFT's), graphics transforms and linear equation solutions.

Three on-chip buffers—instruction, data and translation lookaside—allow single-cycle access of data and code at high clock speeds. The instruction buffer holds 4 kilobytes and can transfer 64 bits at a time. Since instructions are 32 bits wide, two instructions can be transferred along the bus with each cycle. The 8 kilobyte data buffer passes data to the CPU 128 bits at a time, so 16 bytes

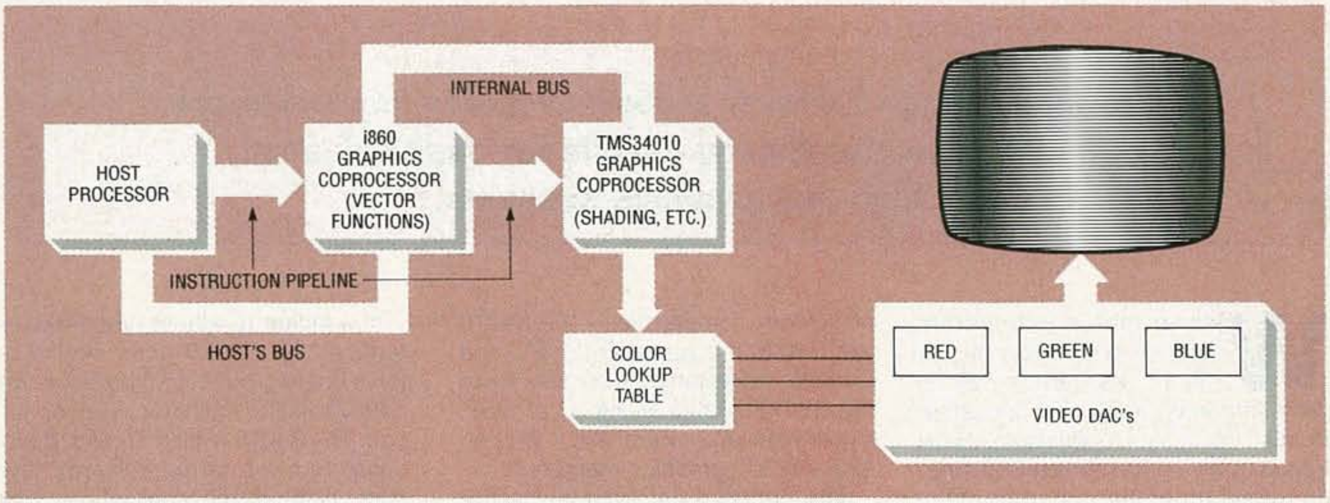

FIG. 1—FOR VERY SOPHISTICATED SYSTEMS WITH high throughput and 3-D shading, a second coprocessor is often used, as shown here. Intel's i860 performs vectorizable tasks such as panning, zooming and rotating. The Texas Instrument's 320C30 does floating-point tasks such as clipping and shading.

can be transferred in one clock cycle. As you can see, the i860 is not only efficient, but quick as well.

With the data buffer, vector data can be read from the external memory at the same time as vector results are read into the data buffer. The translation lookaside buffer stores mapping information on the 64 most recently used pages for use by the memory management unit, which saves overhead in page lookup and translation.

When it comes to graphics-specific hardware, the i860 shows its muscle with a 3-D graphics unit that provides pixel interpolation and Z-buffer checking as well as color-intensity shading and hidden surface elimination through the use of Z-buffer algorithms.

Color lookup tables

A basic problem in megapixel displays is the amount of memory used to describe the screen—especially since high-performance graphics displays need to provide a very large and accurate range of colors for a realistic display. Those displays usually need one byte of data to control the intensity of each of the three guns in a color CRT. Because of that requirement, a 1K×1K pixel screen uses three bytes for each pixel, so three megabytes of data need to be stored for each screen image that is manipulated or stored. That takes its toll not only in memory cost, but in throughput demand on the graphics processor.

Color lookup tables (CLUT's), such as those from Inmos, are interfaces between the output of graphics controllers and the analog input to the high-speed displays which they control. A typical 8-bit CLUT chip lets the user select 256 colors from a possible 16 million (24 bits) and map an address in that 16 million for each. The user can select just the 256 colors from a 16-million item palette, without addressing all 16 million. Those colors don't have to be evenly spread or related to each other, so the user has a good selection of flesh tones for example, and uses only three or four blues or greens for their application.

Tying it together

Now that we've seen how the IC's work, lets take a look at how they can be connected to one another in a typical system. Even though we're examining a high-end system, you should be aware that only specific portions of that system would be necessary for less complicated specification requirements.

If resolution is you're only concern, then an off-the-shelf graphics coprocessor, such as the 34010, can provide all the features you need. However, a high-resolution, full-color system using the 34010 needs 24-bit color data. Three million bits of data, therefore, have to be transferred for a megapixel display (1024×1024 or 1152×900).

To reduce the size of the color-defining word, a color look-up table is added at the output of the system. The CLUT translates the output byte to one of 256 24-bit addresses, defining a color as if it was called with a 24-bit word from the coprocessor.

For very sophisticated systems that require the highest throughput, where 3-D shading is involved, a second coprocessor is sometimes used in a graphics-pipeline configuration, as shown in Fig. 1. The latest group of graphics workstations made by Hewlett Packard and Apollo uses Intel's i860 IC for vectorizable transform tasks such as panning, zooming and rotating. The TI's 320C30, with an advanced 34020 core, handles floating-point tasks such as clipping and shading.

For that type of high-end system, data first passes to the i860 from the host CPU over the host bus, and then passes to the next processor at much higher speeds over an internal bus designed specifically for the graphics subsystem. The results of the last processor on the pipe pass to the lookup table and then through the DAC's to the display.

The configuration we have just described represents the highest resolution system possible. Simple CGA, EGA or VGA boards that drive TTL monitors, such as those on a standard PC, can be built from parts kits made by several vendors, including Chips and Technologies. There's not too much challenge in building from those kits, and they do provide savings and flexibility. However, if you want to push the limit of graphics capabilities, the IC's we've discussed here will let you do it. In fact, they can be used to developed systems that are so fast that you might be hard pressed to find a monitor that can keep up with them! **R-E**

DRAWING BOARD

After some final words on video, we'll continue with our controller.

ROBERT GROSSBLATT

A few months ago I did a series on video that ran over several issues of the magazine (**Radio-Electronics**, January 1990–August 1990). As with most of the stuff done in this column, the general idea I had was to go through the basics of video theory and production. Since it would be wrong to assume that any of you have a real familiarity with any of the subjects discussed here, I have to be sure and lay a good theoretical foundation before I start developing hardware designed to demonstrate the theory we're talking about.

Every time we start a new subject, there's a conflict between the scope of the subject and the amount of space I have to cover it. The column space is limited and, to be fair to everybody, I can spend only a certain number of columns on any one particular subject. Remember that not everybody is interested in everything.

When I started the series on video, I fully intended to take it a bit further and describe the theory and design of circuitry that would put images up on the screen. It seemed to me to be a good way to end the subject. But, as with a lot of things in life, it just didn't turn out that way.

In the first place, it took longer than I thought to go through the theory of the video standard, and designing circuitry to generate the video waveform was complex enough to fill several consecutive issues of the magazine. It doesn't do anyone any good to dump schematics on the page unless they're well documented. Since the purpose behind all the stuff I do is to have people learn, complete descriptions of the hardware we develop here is every bit as important as the hardware itself.

By the time I finished the basic video hardware I had already spent several months on the subject and I realized there would be no room to go into producing images as well. But there's more to it than that. If you followed the video series you should realize that the circuitry needed to generate things like bars and dots really has nothing to do with video. As I mentioned in the series, all you need to put these type of images up on the screen is a regularly produced stream of highs and lows whose timing is locked to the sync signals generated by the circuitry we designed.

This certainly isn't a trivial thing to do and, while there's all sorts of stuff you can learn by designing something like that, it's also a fact that it's not video circuitry either. Even though it would have been great to do it here, it would have taken too much room to do properly. And since we had gone over all the necessary theory, I decided to use the subject as the basis of a contest. If you've seriously followed the video series, understood the theory and built the hardware, there's no reason why you can't work out the image-producing circuitry yourself. It's a good exercise in design, and figuring out how to lock it to sync is the best way I know of to see if you really understand the video circuitry we developed together.

I've already gotten some contest entries in the mail, and I'm amazed at some of the schemes used to put images on the screen. My hat's off to everyone.

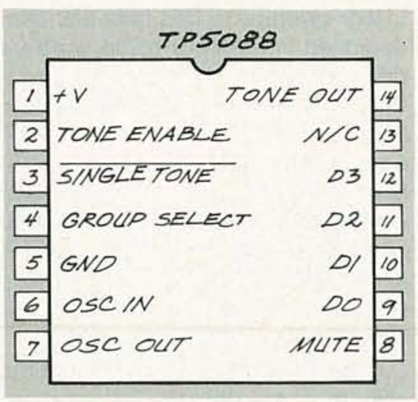

FIG. 1—THE 5088 DTMF GENERATOR is designed to be used under microprocessor control and, instead of the eight lines normally needed for keypad control, the digit is sent as four-bit binary information to the four data inputs.

Before we get back to the hardware stuff we were talking about last month, there's one more thing I want to get off my chest. A lot of people have written in asking me to show them how to beat scrambling and to put the circuit details in the column. I went through the basics of video scrambling at the end of the series and, if you read it, you know that there are lots of scrambling schemes in use across the country. There's no way for me to do it—it's just not going to happen here. You can't design circuitry to beat scrambled video without understanding how unscrambled video works. Once you've got a good handle on video, you should be able to throw the scrambled signal on a scope, figure out what's being done to mess it up, and work out what you have to do to straighten it out.

I've said this lots of times before but Grossblatt's twelfth law is worth repeating: You have to know the rules to be able to break the rules. So, the only way you're going to be able to correct a scrambled signal is to know what's being done to scramble it in the first place. Enough.

Latches and more latches

The last time we left our controller design, we were talking about latches. So, before we go any further, you should have enough latches on your breadboard to cover all the port lines you plan on using. When I design circuitry, I have a real aversion to unused silicon. I can't tell you why, but it really bugs me to have unused gates and IC halves sitting on the board that do nothing other than draw current. It may have something to do with my toilet training, but I'll spend a lot of time making sure that everything on the board has a purpose.

It's impossible to know how many latches to add to the board unless you know what you're designing, so the time has come to decide what we

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want the circuit to do. Now everybody has their own ideas but since I have no way of finding out what's in your mind (columns are written several months before publication), it seems that a neat thing to design would be a telephone dialer.

Everybody uses a telephone and having a circuit that hangs off a parallel port and talks to the phone line can open a wide range of design possibilities. Lots of bells and whistles can be added to it and, if the software is well written, the circuit can be the basis of a really useful product.

The heart of any telephone dialer is the generation of DTMF tones and that's something we've done several times in the past. It's worth your time to hunt through the back issues of RE and find the ones in which we designed our remote control system since those issues contain a good description of the entire DTMF standard (**Radio-Electronics**, January, March, and April 1987). If you don't keep any back issues around (although you really should), you might be able to find copies of those months in your local library.

Generating DTMF tones used to be a real pain in the neck but things got better several years ago when semiconductor manufacturers saw the problem as a hole in the market. As things stand today, there are a slew of DTMF generator chips around and once you've worked out exactly what your needs are, you can be sure there's a chip available with all the ins and outs you're looking for.

Since we're going to drive the chip off the parallel port, one of the overriding considerations for us to keep in mind is that we should conserve lines. Most of the DTMF chips want to see the row and column inputs produced by keypads. This means that eight lines have to be devoted to selecting the tone you want to generate. We have eight data lines at the output of the parallel port but it's a good idea to be stingy with them since using them all to control tone generation will limit what we can do later on.

Fortunately for all of us, National Semiconductor (and possibly other manufacturers), makes the 5088 DTMF generator. This chip has been designed specifically to be used under microprocessor control and is driven with straight binary. Instead of the eight lines needed for keypad control, the digit is sent as four-bit binary information to the four data inputs of the 5088. The pinouts of the 5088 are shown in Fig. 1 and, if you're at all familiar with DTMF generators, you should be able to recognize the rest of the controls on the chip.

If you have a hard time finding this chip, or if you decide—for whatever reason—to use a different one, you'll have to modify the circuitry we'll be developing. This is especially true if your chip has to be driven with eight data lines. As an alternative, it doesn't take a lot of circuitry to convert the four lines I'll be using to the eight lines needed by other DTMF generators. Probably the easiest way to do something like that is to program an EPROM to do the conversion for you. It wastes a lot of EPROM space but it's quick.

Aside from the weighted binary inputs, the 5088 has a TONE ENABLE input that, besides inhibiting the generation of tones, also puts the chip into a low-power state that drops the current requirements to only 55 microamps. That isn't really such a big deal since even while the chip is active it draws only 1.5 milliamps.

Pins 3 and 4 allow you to separately generate the high and low group tones that make up the DTMF standard. That's handy when you're setting things up since you can check the frequencies. The MUTE pin is an output that becomes active when the chip is generating tones. It's generally used to turn off the telephone handset to prevent the tones from being heard while they're being generated. The main use for that is in the design of telephones, but most of the phone designs I've seen don't bother doing that.

Using the chip is easy since it only takes the addition of a cheap colorburst crystal to make things work. When we get together next month, we'll put it in the circuit, write some minimal software, and add some bells and whistles to the design. **R-E**

AUDIO UPDATE

Audio Test Reports: What they do and don't tell you

LARRY KLEIN

In a recent column on the Audio Engineering Society's "Sound of Audio" conference, I mentioned that the session on hi-fi product testing drew a surprisingly wide range of interested—and interesting—questions from the audience. As the person who for two decades was in charge of the testing program at *Stereo Review*, I was asked to provide some personal insights into the special problems of audio-product evaluations. Although I didn't do the actual lab testing, I selected and scheduled the products for evaluation. And, more important, I dealt with the problems, both technical and political, that inevitably arose.

LISTENING TESTS should be validated by laboratory tests, and vice versa.

Test-report results

Obviously, any successful magazine—audio or otherwise—must serve the interests of *both* its readers *and* its advertisers. If a magazine fails its readers, it loses circulation; if it fails its advertisers, it loses money. (Most magazines more or less break even on circulation; their income is almost totally dependent on advertising revenues. The higher—and more specialized—the circulation, the more the advertisers are willing to pay to be part of the action.)

In other words, a magazine with a substantial readership interested in quality audio components provides the best sort of marketplace "bulletin board" for those seeking to sell such products. So far so good. But if product evaluations are popular among the readers (and they are), how does a test report tell the readers that something is wrong with a specific product without upsetting its manufacturer? In fact, isn't there a contradiction between keeping the manufacturers happy—and continuing to advertise—and serving the reader by exposing a product's faults? Editors deal with such problems in the same way that porcupines are said to make love—*very* carefully!

Test-report policies

Magazines differ in the way they handle product test reports. Some publications automatically send out the edited, but not published, report to the manufacturer of the product. The manufacturer is allowed to point out factual errors, but is not permitted to change the evaluation. If the manufacturer really has problems with the test report, he might be given the option of requesting that it not be published. Other magazines keep their reports close to the vest until it appears in print. When it appears, the manufacturer might throw a party and order several thousand reprints, shake his head and say it could have been worse, or cancel his advertising and call his lawyer. Having worked for three different magazines over a 25-year period, I've encountered all three reactions.

Some audio manufacturers tend to blow a gasket if *any* fault, however minor, is found with their equipment. Others express hurt feelings by phone or letter, and a few are happy as long as you get their brand name and model numbers right. Although editors have a lot of day-to-day autonomy, the ultimate policy maker is the publisher, who is responsible for the magazine's overall editorial policy *and* income—two not-unrelated areas.

One of my "unfavorite" stories illustrating the sensitivity of a manufacturer goes back to the time when I was giving a talk before an audiophile society. One of the members asked me about a speaker system designed to achieve a special spatial effect by bouncing most of its sound off a rear wall. I said that like other speakers that radiate a significant portion of their sound away from the listener, it was somewhat sensitive to room positioning. Apparently, someone from the audience subsequently asked the manufacturer about my comment, because within a week he had canceled his advertising contract with my magazine. He ultimately returned to the fold, but not before our publisher had lost perhaps $50,000 in advertising revenues. That sort of manufacturer behavior tends to keep editors from expressing themselves freely, but fortunately, during my 30 years or so as an editor, only three of four cases of such blatant attempts at intimidation occurred.

My personal policy was to check with the manufacturer on anything that seemed askew with the product. Because of scheduling exigencies, most components tested were early or pre-production models and sometimes would not be as bug-free as the units that would ultimately reach the consumer. As a result of our tests, we were frequently able to alert the manufacturer to needed design changes—and everyone benefited as a result. The product would be retested after it was reworked.

Occasionally there would be a question of the significance of some high touted special circuit in the evaluated product. If the product worked well, but the special virtues of its, say, "double-alpha lateral feedback" circuit or the use of Litz wire in its internal wiring were not apparent, we said so.

continued on page 92

COMPUTER CONNECTIONS

SCSI/ESDI Shootout and a pair from Micropolis

JEFF HOLTZMAN

Disk performance remains one of the chief bottlenecks in PC performance today. The venerable ST-506 interface, introduced in 1980, provided adequate performance for early DOS machines, but today's generation of fast 386 and 486 CPU's far outstrips the ST-506's ability to keep up. For that reason, two more recent disk-interface standards have been gaining increasing acceptance over the past few years: SCSI (small computer system interface) and ESDI (enhanced small device interface). The two are similar in that they allow increased performance, but there the similarity ends. Currently, ESDI holds the heavyweight title for high-performance PC systems, but SCSI is coming on strong. This month I'll give an overview of the differences between the two technologies, along with my experiences using drives of both types.

Different strokes

Probably the single most important difference between SCSI and ESDI is that SCSI is a high-level, intelligent interface, whereas ESDI is a low-level interface that in some ways resembles a plain old ST-506, albeit a significantly faster one.

The basic data-transfer rate (DTR) of an MFM hard disk connected via a standard ST-506 interface is about 5 MHz; with an RLL drive, DTR increases 50%, to 7.5 MHz. By contrast, the typical ESDI system has a DTR of 10 MHz, but the ESDI spec supports a maximum DTR of 24 MHz, and systems that approach that speed are becoming available.

ST-506 and ESDI interfaces deliver data in serial fashion. By contrast, an SCSI system delivers data in parallel form across an eight-bit bus. The theoretical maximum transfer rate of that bus is 4 megabytes/second, but eight bits are transferred at once, so the overall rate is 32 MHz; quite a bit higher than ESDI's maximum. Of course, the actual throughput achievable in the real world depends on a number of factors, including the hard disk drive, the controller, the computer bus, software drivers, and host operating system.

An ST-506 drive is relatively stupid; at the other extreme, a SCSI drive must have a microprocessor to interpret and execute commands. An ESDI drive fits somewhere in the middle. The extra intelligence required by ESDI and SCSI drives is part of the reason for their high cost, relative to ST-506 drives. Lack of volume is probably the main reason for the cost differential; but as the market moves toward graphical operating environments, high-performance disk drives will become increasingly popular, so prices will fall.

An ESDI controller connects to a hard disk (or other device) by means of cables that are physically identical to ST-506 cables, including a 34-conductor control cable and a 20-conductor data cable. Many of the signals carried on an ESDI cable have names and functions that are similar to the corresponding ST-506 interface. However, there are definite differences, so you cannot connect an ST-506 drive to an ESDI controller, or vice versa. The functions of the signals on those cables include drive-select, head-select, status, clock and data lines, etc.

By contrast, a SCSI interface consists of a fifty-conductor cable that looks more like the expansion bus of a computer than a set of control signals. In fact, the SCSI interface really is a bus with eight data lines, a parity bit, and nine control signals that arbitrate which device gets to talk at any given time. A new SCSI bus standard, SCSI-II, is due to be complete soon; it will allow 16- and 32-bit transfers and will also provide better definition of software standards.

Both SCSI and ESDI interfaces allow a theoretical maximum of eight devices. However, most ESDI controllers for PC's allow only two devices. By contrast, SCSI really has almost unlimited expansion potential, because as many as seven of the eight devices may have as many as eight *logical units*, each of which may have 256 *logical subunits*, allowing a maximum total of 14,336 devices connected to one bus. SCSI clearly has a great advantage over ESDI in this respect.

The ESDI interface has several signals for selecting a particular device and exchanging data with it. By contrast, SCSI has a data bus and signals for controlling the flow of information on that bus. However, SCSI has little to say about the *contents* of that information, and that leads to a good-news/bad-news situation.

The good news is that because the SCSI interface doesn't know anything about the underlying hardware, it is theoretically possible to connect several different types of devices to a single SCSI bus simultaneously. In fact, the SCSI interface was conceived from the beginning as providing a flexible means of connecting devices of all types, including hard disks, tape backup units, CD-ROM drives, writable optical drives, laser printers, scanners, and even network interface adapters. With some computer systems (notably the Macintosh), that is indeed the case.

The bad news is that, in the PC

ITEMS DISCUSSED

- 1674-7 SCSI PC-Pak ($1895), 1654-7 ESDI PC-Pak ($1895), Micropolis Corporation, 21211 Nordhoff Street, Chatsworth, CA 91311. (818) 709-3300.
  CIRCLE 41 ON FREE INFORMATION CARD
- *Alfred Glossbrenner's Hard Disk Handbook* ($39.95), Alfred Glossbrenner and Nick Anis, Osborne McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710.
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world, that type of bus sharing is difficult to achieve at the present time. The reason is that, although the electrical standards for the SCSI bus are well defined, the software commands that tell the hardware what to do are not. In fact, the original SCSI standard specified only a single command. The result is that different manufacturers implement their software in different ways, which means that to run different SCSI devices in the same PC, you'll probably need different SCSI adapters for each type of device. For example, if you install a SCSI hard disk, you should have no trouble adding a second hard disk. But if you wanted to add a CD-ROM drive, you'd probably have to interface it via a separate adapter card, and that defeats the purpose of a bus-type interface. Similarly, although it should be possible to unplug an SCSI drive from your friend's Mac and plug it right into your PC, that type of compatibility is a long way off. By the way, that scenario is not as far-fetched as it may sound. Suppose you had prepared a long technical document in Ventura on a PC, and wanted to get it typeset. Most typesetting houses are Mac-based, so how do you transfer a 30-megabyte PostScript file of text and graphics in an efficient manner?

However, SCSI compatibility is improving. With the increasing spread of networks, high-speed high-capacity drives are becoming increasingly popular, and manufacturers are realizing that they have to get off their proprietary horses. It will undoubtedly take a few years for the dust to settle, but when it does, we'll all benefit.

Micropolis

To get a feel for real-world differences between the two competing standards, I examined a pair of what you might call fraternal twins made by Micropolis: the 1674-7 SCSI drive, and the 1654-7 ESDI drive. Each came as part of a "PC-Pak," which includes the drive, cables, mounting hardware, and partitioning software. The SCSI kit includes a host adapter, and the ESDI kit, a full controller; both have on-board floppy controllers, making each a plug-n-play replacement for a standard ST-506 setup. The SCSI setup also included drivers for Novell NetWare and SCO Xenix. Either drive has a formatted capacity of about 160 megabytes, and will co-exist with a standard ST-506 unit.

I measured the performance of both drives under DOS using Coretest; results are shown in Table 1, along with comparative data for a standard ST-251. All tests were run on a Dell System 300 (16-MHz 386 with 7 MB of RAM).

Installing both drives is straightforward and well documented. In both cases, the controller/adapter card requires an 8K space in the upper memory area; that space contains a BIOS extension that allows the drive to hook itself into DOS automatically. You must set several jumpers and switches that specify the BIOS address, IRQ, etc. Install the card, connect cables, power up, and fly.

I used each drive for several weeks with a variety of software (including many DOS programs and Windows 3.0) and hardware (including an inter-

TABLE 1—COMPARATIVE PERFORMANCE

Model No.	Technology	DTR (Kbyte/sec)	Avg. Seek Time (ms)	Seek Time (ms)
1674	SCSI	508	7.6	4.3
1654	ESDI	831	16.8	7.5
ST251	ST-506	243	44.3	6.8

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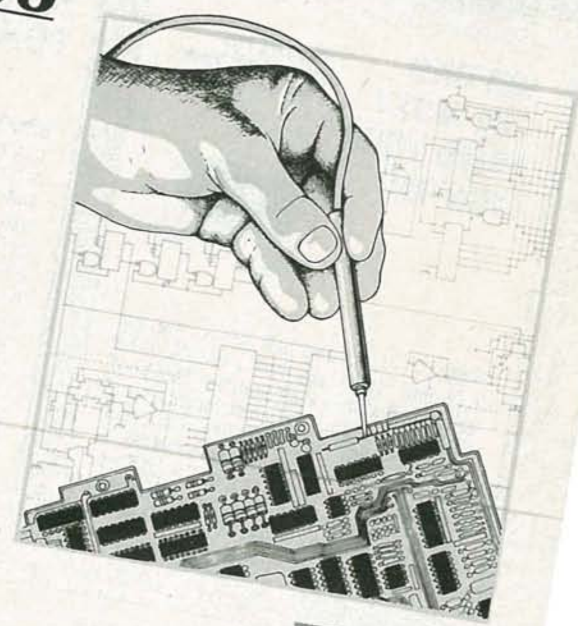

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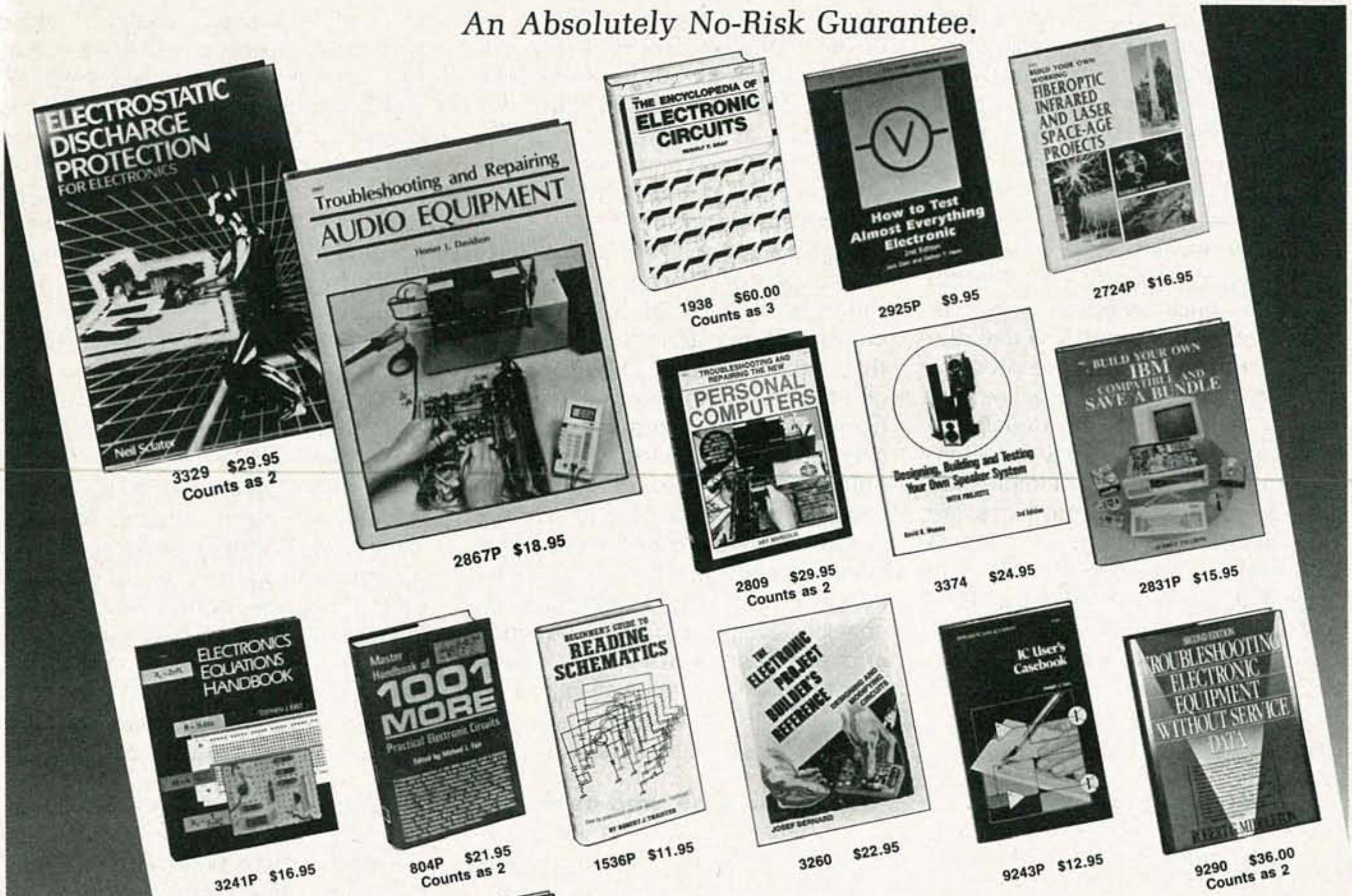

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Valid for new members only. Foreign applicants will receive special ordering instructions. Canada *must* remit in U.S. currency. This order subject to acceptance by the Electronics Book Club. RE1190 nal modem and an Irwin external tape drive). I thought I had a problem with the tape drive, which interfaces via the floppy-disk controller, and the SCSI disk, but after much fiddling with switch and jumper settings to no avail, reinstalled the Irwin software, and everything worked fine. I think that in doing the mass-transfer of software from one machine to the other LapLink must have lost a bit along the way.

Both drives are 5.25" units made by Micropolis, and are built like the proverbial brick outhouse, with die-cast aluminum frames, and use surface-mount technology. The interface cards are made by third parties, but appear to match the high quality of the drives. Based on my brief encounter, I have to say I'm impressed with Micropolis. The products are easy to install, function well, are built well, and are documented well.

PC-Pak versions of either the SCSI or the ESDI drive list for $1895; the drives list separately for $1470 and $1365, respectively. I've seen the PC-Paks listed by reputable mail-order houses for less than $1200.

ESDI or SCSI?

Based on performance alone, it would be hard to choose either of the drives I looked at. The SCSI drive has faster seek time, but the ESDI drive has a better data transfer rate.

Looking at the larger scheme of things, SCSI has much more potential than ESDI, regarding both performance and expandability. Even though it's not possible at present to do the type of device sharing that is theoretically possible, there is increasing clamor from the market for that capability. ESDI disks are more common on the market, and seem to command slightly better prices. However, disk-drive vendors can usually obtain SCSI units on request. In a few years, we should be able to connect multiple SCSI peripherals via a single interface card, but that may not be the card we would or could purchase now. However, due to its performance and expansion potential, SCSI seems destined to earn an important spot in the PC landscape.

Hard disk handbook

Regardless of the type of hard disk you use, take a look at *Alfred Glossbrenner's Hard Disk Handbook*. It contains almost 800 pages of information on selecting and maintaining your hard disk, and it comes with two disks of public domain and shareware programs that help you maximize performance of not just your hard disk but your entire system. Topics covered include selecting and purchasing a disk drive, installing it, adding a second drive, partitioning and formatting, network considerations, backup, security, disaster prevention and recovery, and quite a bit more.

The utilities include several extremely useful programs: List, Coretest, several disk caches (made by Golden Bow Systems), several head-parking programs, PKZIP, several virus scan programs, a file-recovery (unerase) program, and numerous others that have been utility staples for years. If you're a beginning or intermediate hard disk user, the *Hard Disk Handbook* can help you get much more out of your system. **R-E**

AUDIO UPDATE

continued from page 85

There are times when magazines kill a report because in the editor's judgment the product suffers from a gross defect or a major flaw in its design.

That policy has led many audiophiles to complain that the components evaluated by most magazines always test good; the implication is that either problems have been glossed over or data has been falsified. My tongue-in-cheek answer to such complaints is that the products don't all test good, some of them test really excellent.

Audiophile readers eager to learn the "real dirt" about hi-fi components are left unsatisfied when the dynamic range of product reports in the mainstream audio press extends only from merely okay to really excellent. That might be the reason for the proliferation of underground audio magazines that purport to provide the straight scoop—for better or for worse—unadulterated either by advertising pressures or the insensitivities of the reviewers in the mainstream audio test labs.

Astrology, wine, and cars

In my view, the reports in the audiophile "tweek" magazines are neither as "truthful" nor as accurate as those found in the mainstream magazines—among which I include *Consumer Reports*. Reviewers who find sonic faults, major and minor, with virtually every electronic product that they evaluate are usually expressing their inner feelings, rather than objective truth. Inner feelings are fine, but are likely to be unreliable guides for critical buying decisions, particularly when unsupported by careful lab tests. Despite the claims of the esoteric reviewers, their special hearing ability (and the product choices based on it) has never been validated by dozens of objective double-blind test procedures!

Those who purport to hear artifacts in audio components inaudible to ordinary mortals are likely to steer the unwitting reader toward the latest audiophile fads and follies. Audio cables costing up to several hundred dollars a foot (!) and a variety of esoteric components priced at perhaps ten times what their mainstream equivalents cost—these are typical of the product recommendations of the esoteric reviewers.

In general, the talents of the underground press reviewers—and most mainstream British reviewers—seem to combine the approaches and attitudes of wine tasters, astrologers, and sports-car enthusiasts. The faulty science of astrologers and the unreliability of the wine tasters are well known, but the sports-car-buff approach is worth a few words. One can easily justify a love for fine machinery, state-of-the-art engineering,and the ability to go from 0 to 60 mph in 50 milliseconds. In other words, along with the flash and the leather upholstery, your money buys special performance that can be both seen and measured.

The super-expensive electronic components usually look beautiful and are carefully made with top quality parts, but unfortunately for the true believers, they sound no better than most mass-produced products. If devout audiophiles derive special pleasure from owning *very* expensive electronic components (and wires), they are certainly entitled to do so. But better sound—except possibly from the speakers—is not what they've bought, despite what the underground reviewers might have told them. **R-E**

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You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

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

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

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

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

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

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

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LETTERS

continued from page 25

cles on that subject (among others). Mr. Blackwell's article is outstanding in that it covers the many different approaches to superdirectional microphone construction, showing the main features, advantages, and problems of each type—which is especially interesting for prospective builders and experimenters.

The article made me recall a military application of the superdirectional horn microphone that I saw as a small boy in Russia during World War II. The horn microphone, mounted on a small truck, was stationed in a field near our school and, as explained by its soldier-operator, was used to detect the sound of approaching enemy planes. I suppose that its large mouth diameter was necessary to improve directivity and also to obtain response at low frequencies, in order to catch the sound of motors and propellers turning at a few thousand RPM.

Although much was written on World War II radar and submarine sonar, I have never seen any references to acoustic aircraft detection. The system was probably phased out because it did not have a useful range. In fact, it was often surpassed by the usual method that employed advanced observers linked by telephone wires to the potential target zones. In any case, it is interesting to note that such a system was actually built and tested!

HEINRICH PARFIJANOWITSCH
Rio de Janeiro, Brazil

BRAIN POWER

I had to laugh at the letter in the May 1990 issue from Jon Rolph, who could not believe Don Lancaster's claim that the human brain had a capacity of only about four billion memory bits. Mr. Rolph is obviously not aware of what an incredible data-compression device the brain is. It is able to get by with such a small amount of memory because it can transform information into a very compact form before storing it away.

Let's use his CD analogy to demonstrate the point. If we had to remember music the way it is recorded on a CD, as tens of thousands of amplitude samples per

CORRECTION

In our "Build This Ion Meter" construction article (**Radio-Electronics**, March 1990), we are sorry to report that there are a couple of errors need that to be corrected:

- In Fig. 3 on page 37, labels a and c of S1 should be reversed. A jumper wire should go from the lower right terminal of S1 to the open hole in the pad at the juncture of D1–C2, which is located immediately beneath switch S1.
- In the Parts List on page 36, R9 is listed as 150 ohms. It should be 1.5 ohms.

second, we certainly would run out of memory after remembering only a few hours of music. But the brain has a much better way of storing music—as notes. A quick back-of-the-envelope calculation indicates that if you listened to four-part harmony continuously for 16 hours a day (allowing some time for eating and sleeping) every day for seven years, then you would completely fill your four billion bits of memory only if you could remember every single note you heard in those seven years. Even Mozart, with his incredible musical recall, could not have achieved such a feat.

A similar argument can be made for all the rest of the senses—the brain stores remembered images, smells, and other sensations more efficiently than we can with our most sophisticated electronic equipment.

Mr. Rolph is right on target, however, when he attacks Don Lancaster's claim that computers would be able to think (and be even smarter than humans) if they had enough bits of memory. It is not memory that makes the mind work the way it does; it is the incredible way the brain cells are interconnected. How the brain "processes" the information in memory is what makes it "come alive."

Yes, we probably will be able to produce a computer that can outthink us sometime in the future, but not until the current research on neural computers, which are structured somewhat like a biological brain, has progressed significantly.
ROBERT WALRAVEN
Davis, CA

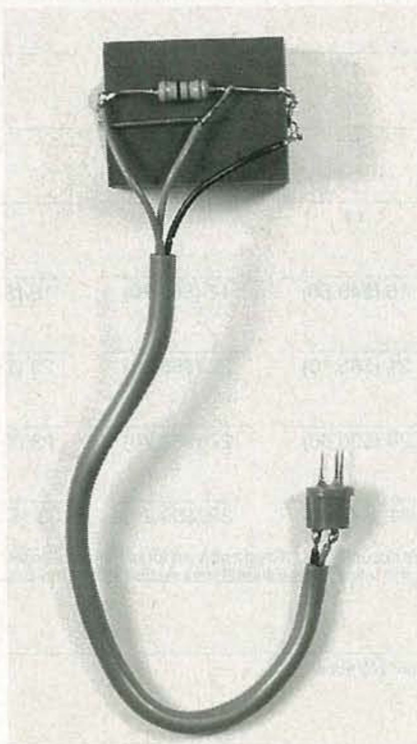
R-E

SEMICONDUCTOR LASER

continued from page 40

power output of 0.5 milliwatts or so. *Slowly* rotate R6 noting the "indicated output" on the power meter increasing. Note how "slope" sensitive it is when comparing it to the change on the current meter. That is a direct indication of the slope efficiency of the device as shown in Fig. 9.

Adjust to an output of 2.4 milliwatts—any more would constitute a more severe optical hazard, and would require a "DANGER" label. An output below 2.4 milliwatts requires only a "CAUTION" class IIIa label. **Safety glasses should be worn at this point.**



PROTOTYPE VERSION of the simulated laser diode. A hole drilled in the block provides a light path.

Remove the touch-switch short and bridge it with damp fingers; Note the power still going to 2.4 milliwatts, but the current reading on the meter is lower. This verifies the power-control circuitry is functioning properly.

This completes the electronic testing. It is suggested that you return R6 to its lower output adjustment before proceeding. And, again, always make sure that the batteries are fully charged before re-adjusting R6.

R-E

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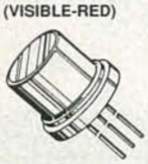

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1702	24	256 x 4 1us	3.99	3.79	3.41
2708	24	1024 x 8 450ns	6.49	6.17	5.55
2758	24	1024 x 8 450ns	3.99	3.79	3.41
2716	24	2048 x 8 450ns (25v)	3.29	3.13	2.82
2716-1	24	2048 x 8 350ns (25v)	3.79	3.60	3.24
TMS2716	24	2048 x 8 450ns	6.29	5.98	5.38
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2732	24	4096 x 8 450ns (25v)	3.79	3.60	3.24
2732A-2	24	4096 x 8 200ns (21v)	3.79	3.60	3.24
2732A	24	4096 x 8 250ns (21v)	3.69	3.51	3.16
2732A-4	24	4096 x 8 450ns (21v)	3.19	3.03	2.73
TMS2532	24	4096 x 8 450ns (25v)	5.79	5.50	4.95
TMS2532P	24	4096 x 8 450ns (25v-One Time Programmable)	1.99	1.89	1.70
27C32	24	4096 x 8 450ns (25v-CMOS)	4.19	3.98	3.58
2764-20	28	8192 x 8 200ns (21v)	3.99	3.79	3.41
2764	28	8192 x 8 250ns (21v)	3.79	3.60	3.24
2764A-20	28	8192 x 8 200ns (12.5v)	3.99	3.79	3.41
2764A	28	8192 x 8 250ns (12.5v)	3.29	3.13	2.82
TMS2564	28	8192 x 8 250ns (25v)	6.79	6.45	5.81
27C64	28	8192 x 8 250ns (21v-CMOS)	4.19	3.98	3.58
27128-20	28	16,384 x 8 200ns (21v)	5.79	5.50	4.95
27128	28	16,384 x 8 250ns (21v)	5.09	4.84	4.35
27128A	28	16,384 x 8 250ns (21v)	5.79	5.50	4.95
27C128	28	16,384 x 8 250ns (21v)	5.79	5.50	4.95
27256-20	28	32,728 x 8 200ns (12.5v)	5.29	5.03	4.53
27256	28	32,768 x 8 250ns (12.5v)	4.79	4.55	4.09
27C256	28	32,768 x 8 250ns (12.5v-CMOS)	5.29	5.03	4.53
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27512	28	65,536 x 8 250ns (12.5v)	6.99	6.64	5.98
27C512	28	65,536 x 8 250ns (12.5v-CMOS)	6.99	6.64	5.98
27C1024	32	131,072 x 8 200ns (12.5v-CMOS)	17.99	17.09	15.38
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TA-50C	Multi-Purpose Melody Generator ▲.	13.65	18.71
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TA-300	30W Multi-Purpose Single Channel Amp ▲.	20.00	29.00
TA-302	60W Stereo Power Booster (w/case) ▲▲.		70.00
TA-323A	30Wx2 Stereo Pre-main Amp ▲.	29.50	38.35
TA-377A	Hi-Quality FET Stereo Pre-Amp ▲▲▲.	59.95	75.00
TA-400	40W Solid State Mono Amp ▲.	28.00	34.93
TA-477	120W Mosfet Power Mono Amp ▲▲.	68.00	85.00
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TY-35	FM Wireless Microphone	10.22	
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- 101-Key Enhanced Keyboard
- 150 Watt Power Supply & Case
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- 12" Amber Monochrome Monitor

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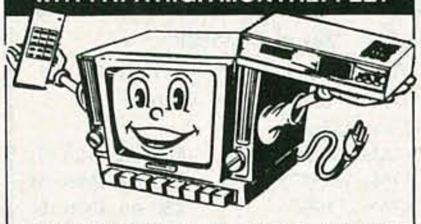

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Soho# GBL 35-DH-21080-10Y
Powerful little gearhead motor.
40 RPM @ 12 Vdc.
0.5 amps (no load).
32 RPM with load.
Operates at lower voltages with reduced speed and torque. 6.3 pound inches torque. Stall: 27 pound inches. 3.1" long X 1.375" diameter. Shaft: 0.187" dia. X 0.75" long.
CAT# MOTG-14 $11.50 each
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150 microamp full scale.
2.165" X 1.875" X 0.96" deep
Face is 1.965" X 1.1".
White background with black and red scale.
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This white box with a blue button will drive you crazy. Box measures 3 1/4" square X 2" high. When the button is pressed 4 LEDs light and a beeper pulses. Every 15 seconds one led goes out and the speed of the beeping increases. At the end of 60 seconds the unit gives off a long beep followed by a low squelch, all LEDs shut off and the unit stops. Unit requires a 9 volt transistor battery (not included) to operate.
CAT # TMR-1 $2.25 each • 10 for $20.00

SWITCHES

SPDT PUSHBUTTON

Marquardt# 1843
Rated 6 amps @ 125/250 Vac.
Black plastic pushbutton.
Switch body: .92" X .94" X .65".
CAT# PB-18 $1.65 ea. • 10 for $15.00

PUSHBUTTON SWITCH

GC/Thornsen# 35-420
S.P.S.T. normally open momentary pushbutton switch. Red plastic actuator 0.57" diameter. Chrome bezel 0.68" diameter. Threaded bushing mounts in .50" diameter hole. Rated 3 amp @ 250Vac. Solder loop terminals.
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1 pole 10 position decimal encoded switches which interlock to make up desired number or digits. Terminates to 11 pc pins (1 common and 10 poles). Each section measures .31" wide X .20" high X .78" deep. End plates can be added to form a .94" high bezel.
CAT# SWTH-9 $1.25 each
10 for $10.00
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MINIATURE TOGGLE SWITCH

Rated: 3 amps @ 120 Vac
S.P.S.T. (ON-ON) solder lugs
CAT# MTS-4 $1.35 each
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CAT# MTS-4PC $1.00 each

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ALL PLUG DIRECTLY INTO 120 VAC OUTLET
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Output: 12 Vdc @ 5 amps.
Open frame power supply.
7" X 4 3/4" X 3" high. Regulated.
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AAA SIZE $1.50 each
1.2 volts 180 mAh
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AA SIZE $2.00 each
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AA SIZE $2.20 each
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6 VOLT D.C. - S.P.D.T.

Aromat # RSD-6V
Super small relay.
Rated: 1 amp @ 30 Vdc, TTL direct drive possible. Operates on 4.3 to 14 Vdc. Coil: 220 ohms. 1 3/16" X 13/32" X 7/16". **CAT# RSD-6V**
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12 VOLT D.C. D.P.D.T. DIP RELAY

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CAT# CRLY-12 $2.50 each

24 VOLT D.C. COIL

KUP style
11 pin base can be socketed, direct soldered or quick connect terminals can be used. 1 3/8" x 1 1/2" x 2". 3.P.D.T. • 5 amp contacts • 470 ohm
CAT# RLY-3524 $2.25 each

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Timer fits standard 3" deep wallbox. Rated 20 amps @ 125 Vac. Turn knob to desired time. Includes hardware, beige wallplate, and knob. UL and CSA listed. **CAT# TMC-6**
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23.25 ohm coil. 7.5 degrees per step.
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Please specify color.

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DIFFUSED T 1-3/4 size (5 mm)
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with built in flashing circuit
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CAT# HLED 10 for 65¢

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TRW/ Optron # OPB5447-2 Rectangular w/ 28" wire leads
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CAT# OSR-3 75¢ each

TRW/ Optron# OPB711 Rectangular with PC pins.
CAT# OSR-2 75¢ each

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Two L.E.D.'s flash in unison when a 9 volt battery is attached. This kit includes a p.c. board, all the parts and instructions to make a simple flasher circuit. A quick and easy project for anyone with basic soldering skills.
CAT# LEDKIT $1.75 per kit

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421000A9B-10	100ns, 1 Megx9	$89.95
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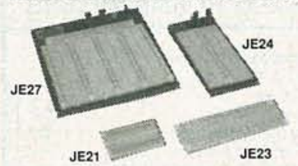

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JE23	6.5 x 2.125	830	0	$6.95
JE24	6.5 x 3.125	1,360	2	$12.95
JE25	6.5 x 4.25	1,660	3	$17.95
JE26	6.875 x 5.75	2,390	4	$22.95
JE27	7.25 x 7.5	3,220	4	$32.95

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- Attenuation: x1 / x10
- Capacitance: 180pF / 22pF
- Bandwidth: 3MHz/40MHz
- Length: 60"

LF180 40MHz Oscilloscope Probe.................... $19.95

GoldStar 20MHz Oscilloscope

- Large 6" rectangular display
- High sensitivity: 1 mV/div

GS7020 Oscilloscope................$499.95

Metex Digital Multimeters

General Specs:
- Handheld, high accuracy • AC/DC voltage, AC/DC current, resistance, diodes, continuity, transistor hFE
- Manual ranging w/ overload protection

M3650 & M4650 only:
- Also measure frequency and capacitance

M4650 only: • Data hold switch • 4.5 digit

M3610 3.5 Digit Multimeter.................$59.95
M3650 3.5 Digit Multimeter w/Frequency & Capacitance............................$74.95
M4650 4.5 Digit w/Frequency, Capacitance and Data Hold Switch $99.95

Multimeter Specials

M80:
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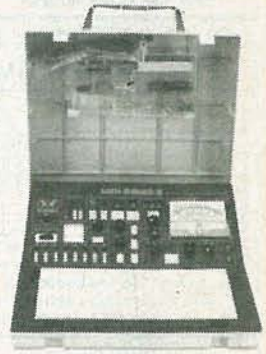
M80 3.75 Digit Multimeter $59.95

M3900:
• AC/DC voltage, AC/DC current, resistance, diodes, continuity, dwell angle and engine RPM • High surge voltage protection

M3900 3.5 Digit Multimeter $59.95

Prototype Design Stations



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UVP EPROM Eraser

• Erases all EPROM's • Erases 1 chip in 15 minutes and 8 chips in 21 min. • UV intensity: 6800 UW/CM[2]

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Jameco Universal IC Programmer

Memory Devices: EPROMS, EEPROMS and PROMS
Logic Devices: PALs, GALs, RALs, EPLDs, EEPLDs and FPLDs

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Jameco 16MHz 80386SX Desktop Computer Kit

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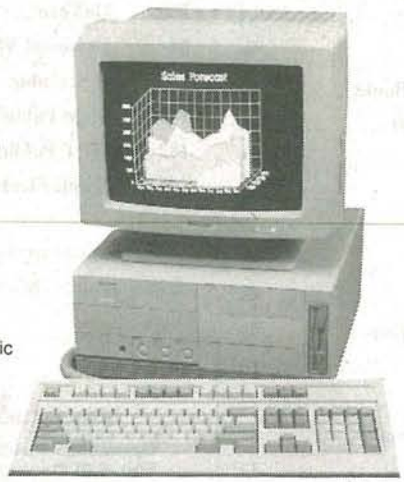
Building your own computer provides you with a better understanding of components and their functions
In-depth assembly instructions included
Have your new computer assembled and running in three hours, using common tools
Software included
Purchase computer kits configured by Jameco or design your own

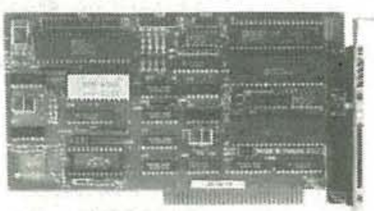


Jameco 16MHz 80386SX Desktop Computer Kit

Includes:
- 80386SX Motherboard with 2MB RAM (expandable to 8MB)
- 101-key enhanced keyboard
- Multi I/O Card
- Toshiba 1.44MB, 3.5" DSHD floppy disk drive
- Baby sized desktop case
- 200 Watt power supply
- DR DOS by Digital Research and Diagsoft's QAPlus diagnostic software

$1199.95
JE3816 monitor extra

Jameco IBM PC/XT/AT Compatible Cards



JE1077

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JE1060	I/O Card w/ Serial, Game, Printer Port & Real Time Clock (PC/XT)	$59.95
JE1062	RS232 Serial Half Card (PC/XT/AT)	$29.95
JE1065	I/O Card w/ Serial, Game and Parallel Printer Port (AT)	$59.95
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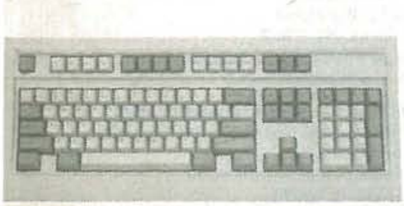

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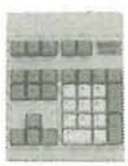

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Free Information Number		Page
108	AMC Sales	16
184	Ace Communications	95
75	Ace Products	33
107	All Electronics	103
—	Amazing Concepts	99
84	Appliance Service	33
196	Avex Probes**	56
67	Banner Technical Books	25
98	Beckman Industrial	25
109	C & S Sales	CV3
70	CEI	102
—	CIE	3, 47
50	Caig Laboratories	26
54	Chemtronics	53
—	Command Productions	95
58	Cook's Institute	16
194	D&D Electronics	77
—	Damark International	7
127	Deco Industries	33
178	Electronic Goldmine	106
—	Electronics Book Club	5, 88
—	Electronic Tech. Today*	57
121	Fluke Manufacturing	CV2
—	Global Engineering	15
185	Global Specialties	12
—	Grantham College	79
86	Heathkit	30
192	Hughes Aircraft Co.	22
193	I.S.S.C.	31
—	ISCET	94
—	Info. Unlimited	106
114	Jameco	104
115	Jensen Tools	33
179	Jinco Computers	102
—	King Wholesale	98
89	MAT Electronics	55
87	MCM Electronics	97
53	MD Electronics	101
93	Mark V. Electronics	101
—	McGraw Hill Book Club	8
61	Microprocessors Unltd.	87
117	Mouser	94
—	NRI Schools	18
189,190	Optoelectronics	17, 29
56	Parts Express	100
188	People's College	28
101	Pomona Electronics	44
197	Probemaster	94
191	RCA**	57
78	Radio Shack	48
186	SCO Electronics	54
176	Sencore	27
—	Star Circuits	26
92	Tektronix	CV4
180	Unicorn	99
64	Universal View	98
187	U.S. Cable	54
181	Viejo Publications	53
182	WPT Publications	84
183	Xandi Electronics	33

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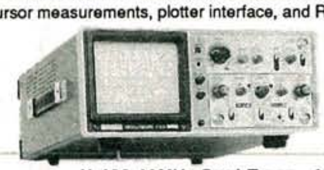

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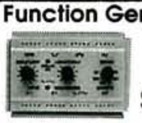

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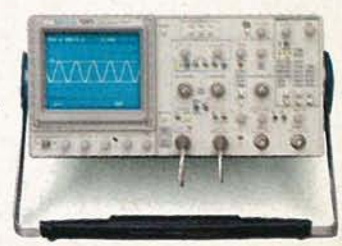

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