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Electronics NOW®

Vol. 63 No. 7

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ON THE COVER

There's no doubt that we've all become spoiled when it comes to music—we're used to having music where ever we go. But what happens if you feel like listening to a CD in your AM/FM/cassette-equipped car? Or when you're mowing the lawn but your personal portable can't pick up your favorite radio station? That's when our FM Stereo Broadcaster comes in handy. The versatile transmitter can take music from any line-level audio source and broadcast it anywhere within a 50 foot range. You can send audio from a portable CD player to your car stereo, or from your home stereo to your Walkman. Take a look at the project on page 33, and see how many other uses you can think of!

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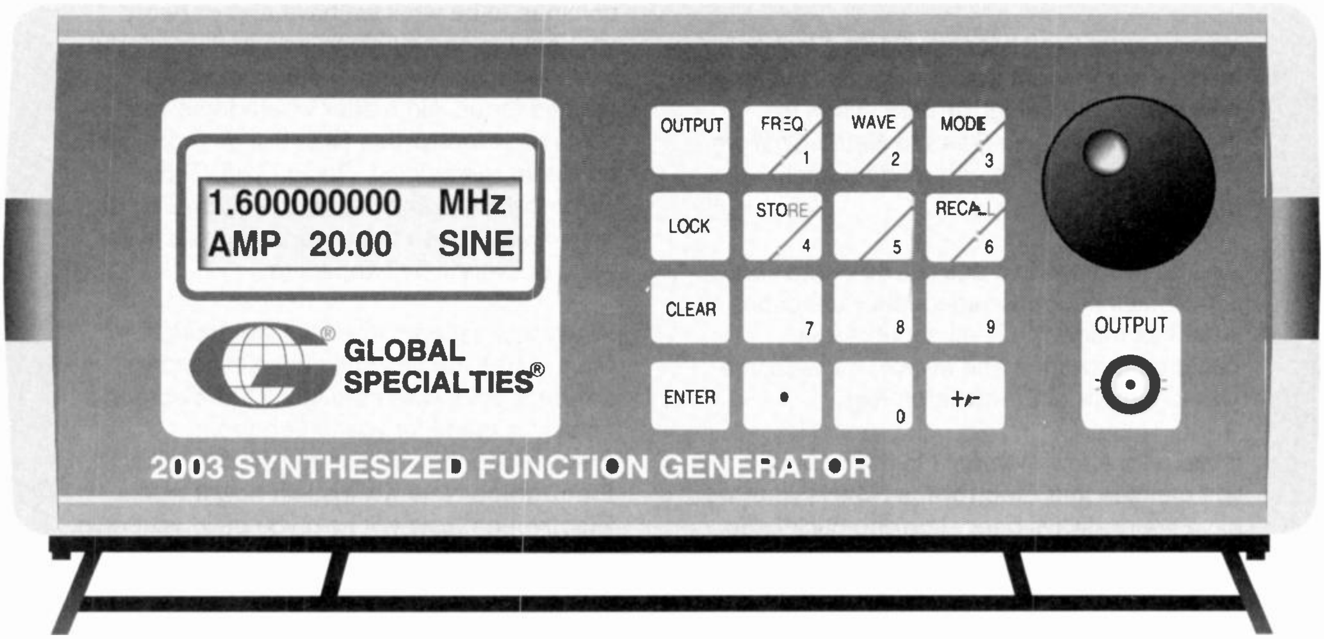

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EDITORIAL

EVERYTHING CHANGES

We live in a world of change. Nowhere is that more true than in the world of electronics. Although this magazine has always changed to keep pace with the changes in electronics, our name has remained unchanged for 44 years.

When *Radio-Craft* became *Radio-Electronics* in 1948, we thought it was a final choice for a new name. But earlier, in 1929, when we changed from *Radio News* to *Radio-Craft* we also believed that we had made a final change.

And so, we now do it again. The name *Radio-Electronics* no longer adequately describes what this magazine is all about. As we continue to change and evolve, we welcome you to the era of **Electronics Now**.

If you take a few moments to think about it, you can see that **Electronics Now** is what we have really always been. Looking back I see us having covered the very first days of radio—evolving from our start in 1908 as *Modern Electrics* to the *Electrical Experimenter* in 1912. Yes, even then we were **Electronics Now**. Even before the word "electronics" had been coined.

In 1919 we started covering the birth of commercial radio and told our readers how to build their own receivers—crystal radios with headphones, of course.

In 1927 we introduced the birth of television in the pages of *All About Television*. In 1930 Radio-Craft listed 27 experimental TV stations and in 1931, *Television News* came into being. In 1937 Radio-Craft showed readers how to build their own television receivers.

Then came FM radio, the consumer electronics revolution—color TV, computers, CB radio, high-fidelity, stereo, surround sound, satellite TV, The VCR, videodisc, CD, DAT, projection TV, cellular telephone, and *Radio-Electronics* was always there—and always will be.

Today we continue our evolution to the future. Today we become **Electronics Now**. But most important of all, even as we change, we continue to be what we have always been: your source of everything new and wonderful that the modern world of electronics has created for us. No matter where tomorrow takes us, **Electronics Now** will be there, just as *Radio-Electronics, Radio-Craft, The Electrical Experimenter,* and *Modern Electrics* have always been there—bringing you every word of every new happening.

When the first ham operator transmits from Mars, when the first solid-block electronic device is sold, when the first 3-D holographic display is ready for your video room, **Electronics Now** will bring you the news. **Electronics Now** will explain how it works. **Electronics Now** will help you build your own. **Electronics Now** will continue to be your magazine. That is my promise. That is the promise of our entire staff—the editors, artists, production, circulation, advertising and clerical people that bring this publication to life.

So join with us now and come along with us on our continuing journey into the 21st century. Adventure with us from today into tomorrow. We carry the banner of a proud new name, but we also follow the dream and tradition of the great magazines we have always been. Come along with us on our quest, our never-ending quest through the world of electronics—from yesterday, through today and on into tomorrow. Welcome **Electronics Now!**

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

WHAT'S NEWS

A review of the latest happenings in electronics.

Ghost-busters

Multipath distortion—or ghosting—has been a problem since the introduction of television. Ghost images occur when a weaker echo or reflection travels over either a longer or shorter path than the original signal and reaches the receiver out-of-phase with the prime signal. The National Association of Broadcasters recently completed field tests of ghost-canceling systems from AT&T/Zenith, the Broadcast Technology Association of Japan, David Sarnoff Research Center/Thomson Consumer Electronics, Philips Laboratories, and Samsung Electronics.

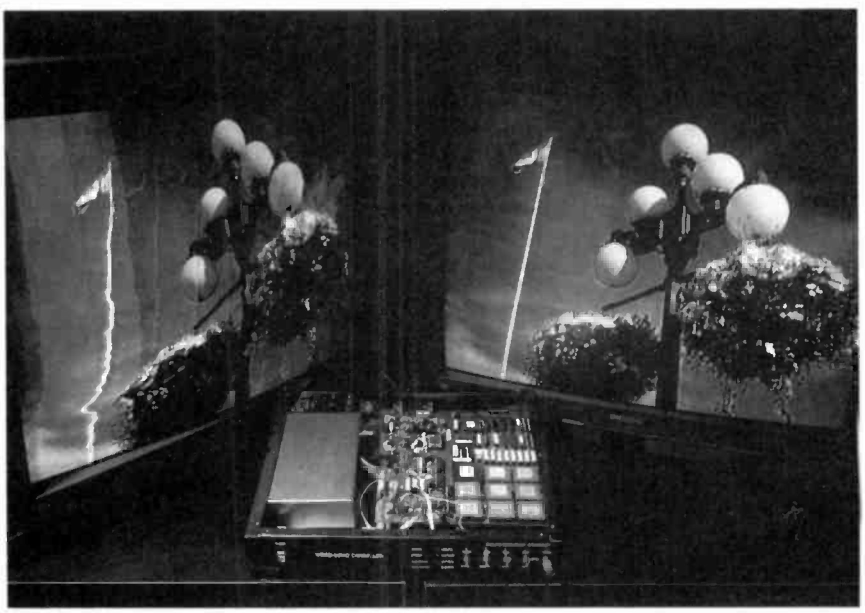
The tests were conducted by three Washington DC TV stations—one VHF and two UHF. They took place at 106 measurement sites—70% in strong-signal reception areas and 30% in weak-signal areas and 318 tests were performed. According to the NAB report, "the Philips system consistently exhibited superior performance relative to the other four systems."

Philips Laboratories (Briarcliff Manor, NY) recently demonstrated its Ghost Cancellation System, which was developed in cooperation with Philips Consumer Electronics Company (Greeneville, TN) and Magnavox CATV Systems (Manlius, NY). The system depends on a ghost cancellation reference (GCR) signal that eliminates moving ghosts as well as ghosts in weak-signal and noisy reception areas. The GCR signal is sent during the blanked portion of the TV raster. When it reaches the receiver, the reference signal has undergone the same ghosting distortions as the TV picture.

A processor integrated circuit analyzes the distortions and calculates corrections, and filter ICs perform cancellation. Two generations of ghost filter chips capable of canceling many strong ghosts simultaneously have been developed. The first generation filter chips are being produced by VLSI Technology. Second-generation chips, jointly designed by TLW, a Boston consulting firm, and Hewlett-Packard, are being manufactured by HP.

The system also includes a prototype Philips deghoster, firmware that was found to be reliable in NAB's tests. Philips' scientists developed mathematical algorithms and processing software to control the hardware.

The Advanced Television Systems Committee is scheduled to select the standard GCR for the United States in a few months. Meanwhile, Philips Consumer Electronics Company and Magnavox are working to include the Philips Ghost Cancellation System in their Philips, Magnavox, and Sylvania color TV receivers. Magnavox CATV Systems will begin selling the VECTOR video echo canceler in May. According to Magnavox CATV, it will provide ghost-free TV reception for cable TV subscribers.



PHILIPS VIDEO GHOST CANCELLER for television sets (center) eliminates the ghosts that appear on TV screen at left so they look like the sharp picture at right.

Digital major-league broadcast

CBS Radio broadcast the Cincinnati Reds' opening game at Riverfront Stadium to start its 17th season of Game of the Week coverage. However, this time there was a difference: advanced digital broadcast technology was tried. The result was crisper sound for the fans and a large savings for CBS.

Traditional satellite and long-distance voice circuits require an on-site satellite truck, an army of technicians, and as many as four satellites to complete the long-distance feeds between New York and the stadium. All this costs about $2500 per feed. By contrast, the new CBS approach depends on on MCI Communications' Switched 56 full-duplex digital service for transmission of its broadcasts from major league ball parks around the country to its New York facilities. The announcer's voice is digitized and compressed before it is sent over MCI's digital network at about the same cost as a regular phone call.

Switched 56 circuits are installed at each of the major league ball-

Continued on page 50

VIDEO NEWS

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

DAVID LACHENBRUCH

• **Movies on CD's.** In a little-noted but historic event last March, Philips demonstrated full-motion video of at least VHS quality on a standard compact disc. Spectators at the International Conference and Exposition on Multimedia and CD-ROM in San Francisco gasped at the quality of the moving images presented in the CD-Interactive (CD-I) demonstration. Philips, which is now selling CD-I players and discs without full motion, hinted that the future discs could ultimately be used for movies, music video, and full-motion games in the home.

The CD-I players currently being sold in the United States are designed to accept a plug-in adaptor for full-motion video, which is due late this year, at an unannounced price, and the next model CD-I player is expected to have full motion built in. Because the maximum playing time of a CD is 72 minutes, the CD-I's application as a movie medium would depend on the future introduction of a CD-I changer. That product is believed to be under development, but Philips won't comment on that project.

• **HDTV landmark.** The first live, over-the-air broadcast of a digital high-definition TV system was received in the United States Capitol Building, fitting for the momentous occasion. The system, DigiCipher developed by General Instrument and MIT, is one of five systems being evaluated by the FCC's Advanced TV Advisory Committee. The signal originated at WETA-TV, Washington's Public TV station, operating at about 2% of the station's normal power. One prime requirement for digital TV is low-power transmission.

The station broadcast a prerecorded program from a high-definition tape player. In the audience at the Capitol were about 50 people, including Speaker of the House Foley and four FCC commissioners. They viewed the broadcast on a 65-inch Hitachi projection set and two 28-inch Sony direct-view monitors. The broadcast was also successfully carried by the Capitol Hill Cable System. The demonstration proved that digital HDTV broadcasting is feasible. The other three proposed digital HDTV systems have been demonstrated in prototype closed-circuit operation, but not in on-the-air broadcasts. DigiCipher was the first digital HDTV system to be tested by the Advanced TV Test Center in prior to an FCC decision.

• **The timetable slips.** There was bad as well as good news on the HDTV front. In an interim report, the FCC's Advanced TV Advisory Committee said that the timetable for testing proposed systems by the Advanced TV Test Center had slipped by more than four months. Under the new timetable the committee plans to recommend the winning system, based on its lab tests, by early February 1993. The decison had been originally scheduled for September 30, 1992. The system that performs best in the test center's lab tests will be field tested in an actual broadcast from Charlotte, NC. Field testing is expected to be complete by June of 1993. The runner-up system will also be field tested if problems develop with the winning system. The FCC will make its decision shortly thereafter.

• **HDTV sets—how soon?** FCC Chairman Alfred Sikes forecast that despite slippage in its testing timetable, the public will be able to buy HDTV sets between mid-1995 and mid-1996. But the question of when and how much still remains hotly debated. Roy Pollack of Fordham University, formerly executive vice president at RCA in charge of its electronics business, told a recent seminar that such forecasts are "an unfortunate example of hype and wishful thinking." Solomon Buchsbaum, senior vice president of AT&T's Bell Laboratories, reported that he saw "no reason HDTV should cost any more than a set built with today's technology five to 10 years from now." However, he conditioned his forecast on continuing progress in the manufacture of low-cost, flat-panel LCD displays suitable for HDTV as replacements for the cathode-ray tube.

Another concern is how soon TV stations will begin adding the HDTV high-definition channels that they have been granted. A real possibility exists that HDTV will begin on cable or satellite rather than as direct TV broadcasts. Commenting on estimates that it might take five to eight years for HDTV sets to reach 1% penetration of U.S. homes, Stanley Hubbard, head of the forthcoming 50-channel U.S. Satellite Broadcasting Company, noted that no local station could afford to broadcast to only 1% of its viewing area. However, he said 1% of the viewing population would be a profitable audience for one channel of a satellite system covering the entire United States.

• **More ghost-busting.** Shortly after engineering tests by the National Association of Broadcasters proclaimed that the Philips ghost-canceling system was "superior in every respect" to its four competitors, Cable TV Laboratories reported on its own tests. It found that the rival system submitted by David Sarnoff Research Center performed best "in virtually every test." The conflict in the findings raised a question about whose tests are better. Was the Philips system better at canceling the widely spaced ghosts typical of broadcast TV, whereas the Sarnoff system fared better with the closely spaced ghosts typical of cable TV? The industry eventually expects to select a single system for both broadcast and cable. **R-E**

ASK R-E

Write to Ask R-E, Radio-Electronics, 500-B Bi-County Blvd., Farmingdale, NY 11735

PICK UP THE BEAT

What kind of pickup device would I need to display a heartbeat on my oscilloscope? I've tried a stethoscope with an electret mike and a preamp, but was unable to pick up anything.—C. Tracey, Marion, VA

A standard oscilloscope isn't really the best display device for heartbeats because the persistence of the phosphor used in most CRT's isn't very high. That's a factor because, at an average of 70 beats per minute, you'd have to have the trace speed down somewhere about one sweep per second. A digital scope would be much better because the waveform could be stored and displayed until the next heartbeat was detected.

Regardless of the kind of scope you use, designing a pickup is a common problem. I'm surprised you weren't able to use the mike-and-stethoscope approach because there's no reason why you can't amplify the audio signal enough to meet the voltage requirements of most oscilloscopes. You didn't send in the circuit you used, but I'd be willing to bet that a bit of redesign would be in order.

If you want to raise the detected signal to logic levels, you can use the circuit shown in Fig. 1. It's the front end of a pulse meter I built some years ago, and it has worked reliably since then. The circuit is interesting because it uses an infrared detector as the pickup. The detector can be put anywhere on the body, but the best places are at the body's pulse points such as the neck or wrist.

When the heart pumps, there's an increase in blood volume in all the arteries of the body—from the major ones at the pulse points down to the small capillaries under the skin. The difference in blood density causes a change in the infrared reflectivity of the skin, and that can be detected by any phototransistor

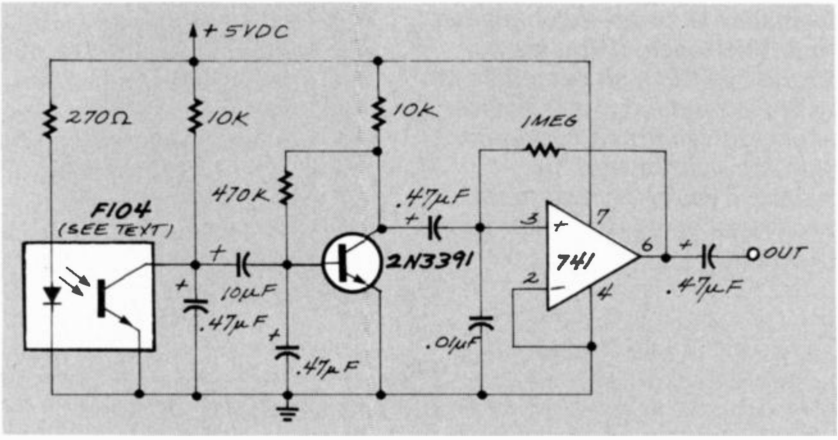


FIG. 1—TO RAISE A HEARTBEAT SIGNAL to logic levels, you can use this circuit. The infrared detector can be put anywhere on the body. When the heart pumps, the increase in blood volume causes a change in the infrared reflectivity of the skin, which can be detected by any infrared phototransistor.

whose bandwidth extends into the infrared region.

The device I used as the detector was an F104 made originally by Fairchild. It's an infrared emitter and phototransistor mounted in a single plastic package. The openings for each part of the device, as shown in Fig. 2, face in the same direction so that the phototransistor can see the emitter's light only if it's reflected off a surface. When you put it against the skin, the infrared light penetrates the skin and the phototransistor senses the reflected changes in blood density each time the heart pumps a new volume of blood into the arteries.

The output of the circuit is high enough to function as the trigger signal for a standard 555, so you

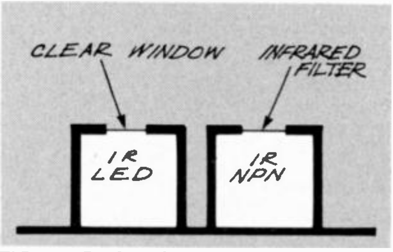


FIG. 2—BECAUSE THE OPENINGS for the infrared emitter and phototransistor face the same direction, the phototransistor can see the emitter's light only if it's reflected from a surface.

shouldn't have any trouble seeing it with an oscilloscope. If your scope's inputs are good enough, you might be able to pick up the signal off the collector of Q2 (or even right off the collector of the phototransistor), and get rid of the rest of the circuit. Good luck.

VIDEO MIXER

I have a video camera and a computer with a composite video output that I've been trying to mix together to get special effects. Is there some simple way that I can do that? I've tried several methods but haven't had any luck so far.—E. Guerard, Montreal, CA

Mixing video is very, very different from mixing audio. The video signal, as I've mentioned here on numerous occasions, is one of the most complex waveforms that exist.

Each line of video has both a data area (the picture), and a control area (the horizontal interval), as shown in Fig. 3. What you want to do when you mix two or more signals together is to combine the picture areas but still use only a single control area. Because the control area tells the TV where to turn on the electron beam on the right side of

Continued on page 72

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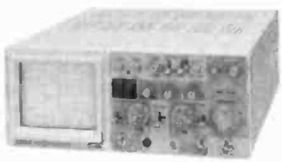

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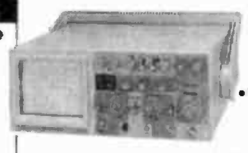

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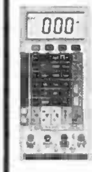

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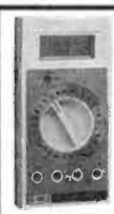

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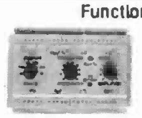

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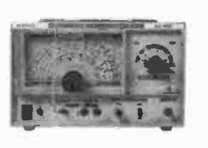

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LETTERS

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

MIDI COMPATIBILITY QUESTIONS

Judging from reader reaction, my article, "MIDI Interface For Your PC" (**Radio-Electronics**, March 1992) has been well-received and has introduced a lot of people to MIDI. But some reservations have been expressed over the interface not being MPU-401 compatible.

Maybe some readers have gotten the impression that the interface can be used only with the Voyetra software that was available packaged with the card. That is not at all the case. For example, many readers have asked if the interface can be used with Cakewalk (another popular sequencer/editor) or Music Printer Plus (a popular program for printing musical scores from MIDI data) or with numerous other programs, and the answer is yes.

Some readers may have gotten the idea that since a PCM68 interface does not appear on the set-up menu of software that they already own, the software will not support this card. That is usually a case of the PCM68 not existing at the time the software was published, and most publishers will be happy to supply the appropriate drivers for the card if asked. Some packages will list a CMS-101 interface on their menu of options; that selection will generally drive the first port of the **Radio-Electronics** card (the second port doesn't exist on a CMS-101).

Kits presently shipped by PAiA include a disk that has, in addition to shareware toys and tools, VAPI drivers for the interface. Many software packages are VAPI compatible, and those drivers allow the user to exploit both ports of the PCM68 without having to go to the publisher for revisions. By the time this letter appears in print, that disk will also include drivers that run under Windows 3.1.

It's true that software packages that can use *only* an MPU-401 or clone for an interface will not be able to drive the PCM68. Fortunately, the number of programs that are so narrow in their scope of support is a small and dwindling part of an otherwise expanding applications base. You can see why: A comparable situation would be a word processor that worked with only one kind of printer.

When you're running a program like Multi-Media extended Harvard Graphics running under Windows 3.1 with your **Radio-Electronics** interface, are you really so concerned that it's not compatible with MPU-401?

JOHN SIMONTON

ZEROING IN

The response to J. Mullane's question concerning electronic dice ("Skip the Zero," Ask R-E, **Radio-Electronics**, *April 1992) drew an avalanche of mail from our on-the-ball readers. Below is a sampling of some suggestions for improved, easier solutions to Mr. Mullane's dilemma.—Editor*

The problem *is* the 7490; it's the wrong one. Mr. Mullane simply needs to drop in a presettable counter in its place. I recommend a 74161 as illustrated in Fig. 1; others are also suitable. Simply enter the lowest or starting number on the preset inputs via grounds and pullup resistors. Then decode the outputs for the highest or ending number with simple gates to trigger the preset load pin of the counter. The following clock pulse simply starts the count over.

Although EPROM's might be cheap, this is cheaper. If the reader's skills were at the level where he might have a PROM burner, chances are he wouldn't need to write you. This solution seems more suited to his needs. Furthermore, your assertion that someone "interested in electronics" should really have a PROM burner on the bench seems inappropriate. My daily work in high-power audio, power control,

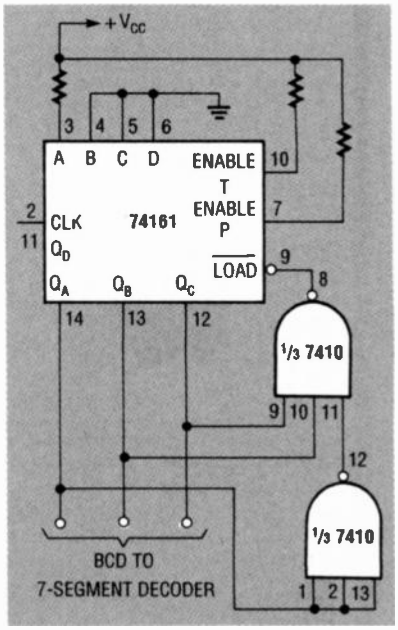


Fig. 1—One reader's 74161 solution to "Skip the Zero."

and video display seldom requires the use of ROM's, even though my interest level is high, thank you very much. There's much more to life than computers.

T.M. ENZO
East Lansing, MI

What is referred to in the fifth paragraph of your response to Mr. Mullane as a major engineering problem actually can be solved with one 7483 4-bit adder. Also, the problem of getting the 7490 to reset after a count of six pulses can be solved by using the first three stages of a 7492, as shown in Fig. 2. The idea is to add one to each count, which is easy with a 7483; without it, we would have a major engineering problem. Thanks for an interesting column.

RODGER ROSENBAUM
Seattle, WA

If Mr. Mullane could get by with six LED's instead of a seven-segment display, I suggest he use a 4017 or 4022 counter and connect the Q6 output to the clear input.

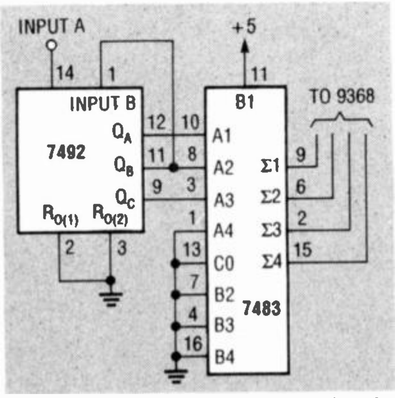


Fig. 2—A reader's 7492 and 7483 solution to "Skip the Zero" that appeared in April's Ask R-E.

Then consider Q0 to be 1 and Q1 to be 1, and so on. If he must have a seven-segment indicator, he could use a 74HC283 to increase the counter 7490 output by one.
EIICHI TAKARADA
Rockford, IL

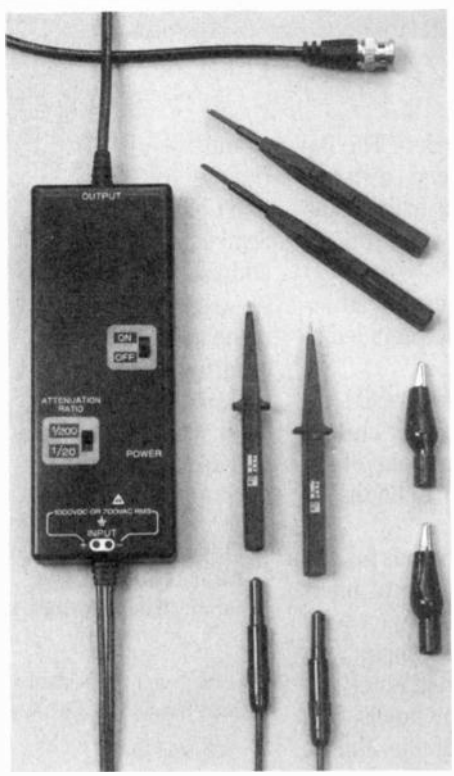
The ROM is the hard way to do it. The zero can be skipped with a 74163 counter. When it reachers the end of the count you are interested in, just pre-load a 1. Another way to solve the problem is to use a 4-bit adder between the 7490 and the 9368. I think both ways are easier than programming an EPROM.
TOM LEWIS
Ft. Lauderdale, FL

A quick trip to my trusty TTL data book revealed that there is a one-chip solution to the problem described. That chip is the 7483 4-bit adder. It is a common, inexpensive chip that's readily available from mail-order suppliers.

To use the 7483, take the outputs of the 7490 counter and use them as the A data inputs. Set the B data inputs so that bit 0 is tied high and bits 1–3 are tied low. Also, be sure to tie the CO input low. The chip will then add 1 to the 7490 count and output the sum. Then use this sum to both drive the 9386 decoder AND to provide the inputs (bits 0–2) to the AND gates used to reset the 7490. When the 7490 reaches the count of 6, the 7483 adder will output a 7, creating the needed reset pulse.
GEORGE BARBER
Fort Worth, TX

Your suggestion is overkill. If you carefully read a 7490's function table, you'd see that the chip has two R9 inputs. When both of those inputs are high, the 7490 will be set to 9. The 7490's QD is not used because the count number that the dice need is from 1 to 6. Thus, set 9 equivalent to 1. Then use a three-input AND gate to decode QA, QB, and QC. The output of the AND gate is sent to two R9's. That connection can guarantee that the counter number is always between 1 and 6.
YONGPING XIA
Torrance, CA

As an out-of-work EE, I now have the time to think up alternate solutions to the ones given in *Ask R-E*. I guess it's the equivalent of out-of-



work writers doing crossword puzzles. I came up with two alternative solutions for Mr. Mullane's dilemma.

The cheapest would be to use a 90-cent 74190 chip instead of the 7490 (Fig. 3). That would allow a 1 to be loaded at the instant a 7 is reached. The 7 would never show for any appreciable amount of time—only long enough to cause

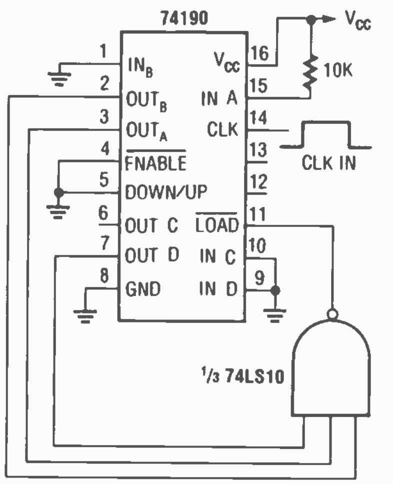


Fig. 3—A reader's 74192 substitution solution to "Skip the Zero" that appeared in April's Ask R-E.

the 1 to load. (A 30-cent, 3-input NAND would also be required.)

Another solution is a little more expensive than yours, but I feel that it would be the most elegant solution that could be accomplished with a single chip (not including clock). I'm of the opinion that this problem is screaming for a PAL solution. I thing that, unless a hobbyist were seriously into microprocessor/controllers, that a PAL programmer would be a better investment (albeit more expensive) than an EPROM programmer.

I love **Radio-Electronics**—it's both informational and educational, and I save each issue for reference.
THOMAS HOLLOWAY
Miami, FL

A DOG-GONE GOOD ARTICLE

The article "Remote Control for your Dog" (**Radio-Electronics**, April 1992) caught my attention. I am anxious to build that unit as I, too, am one of the unfortunate few who have a semi-uncontrollable ca-

Continued on page 73

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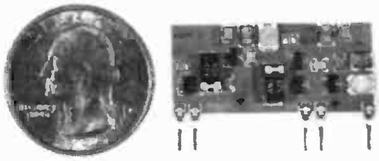

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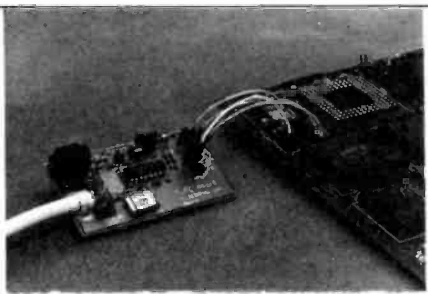

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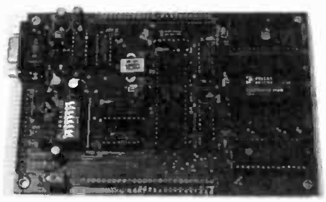

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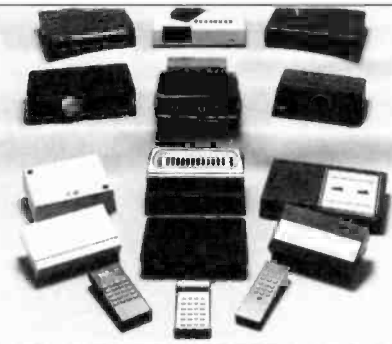

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Unlike any logic analyzer we've seen previously, the LA16PC can be expanded with both input and output pods, with either analog or digital capability. Although we didn't have the opportunity to test them, Paragon is currently developing a 16-channel digital-output pod, analog output and input pods, and a digital-multimeter pod.

To use the analyzer, you can get by with as little as an IBM XT-compatible with a single free slot and 256K free RAM. Anything better than DOS 2.0 is acceptable, and Hercules, CGA, EGA, and VGA graphics are supported. (With VGA, the analyzer can display up to 51 channels simultaneously, with each channel having its own color.)

The software is as easy to use as it is to install. Pull-down menus give you easy access to all of the boards functions. For example, the main menu lets you manipulate files, or change the display mode of the analyzer. You can select a standard timing-diagram or state display, or change to a logic-probe display or even to an event-counting (or event timing) display. Another menu choice lets you change trigger modes and trigger words. Yet another menu choice lets you select the clock source, polarity, frequency, and two qualifiers.

One of the most powerful features of the LA16PC is that channels can be displayed in user-definable groups so that data is presented logically for your application. Let's assume, for example, that you want to look at the signals on a computer bus. You could create one group that contained only the address lines, while other groups could contain data lines or control lines. You can change the color in which groups are displayed, or even hide groups—while they still remain in memory for triggering and the like.

With it impressive expansion capabilities and a suggested list price of $1099, the LA16PC promises to be a formidable competitor. **R-E**

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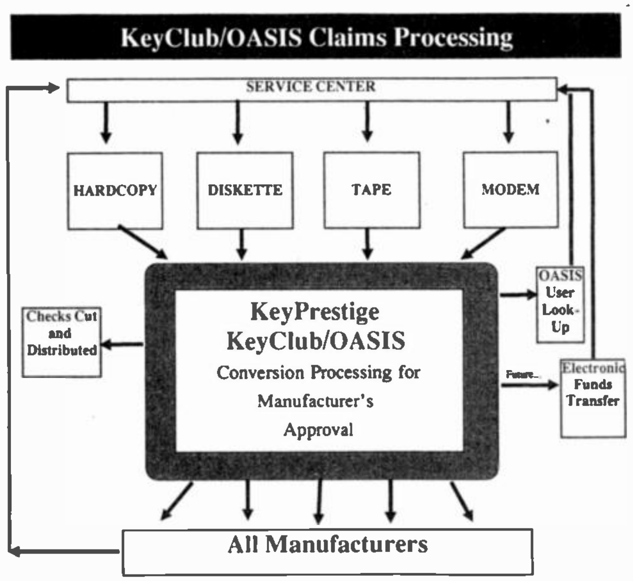

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Service shops that already use personal computers have immediate access to a considerable amount of information. That includes claims processing, warranty and parts information with descriptions, prices, and availability. Bulletins provide technical support with quick reference, print-screen, and schematic ordering capabilities, training schedules with date, time, class, location, and costs. Also included are up-to-the-minute announcements, advertisements, and news flashes. Subscribers can use their current emulation software packages such as Procom, Crosstalk, Carbon Copy, or Kermit. Alternatively they can use the program that KeyPrestige has configured for the system. When connecting to the central-source mainframe with one's user ID password, one can access all authorized information via menu-driven screens. The service provides on-line help. Information is available 24 hours a day, seven days a week, with daily electronic updates.

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The *EM-TEC 1000* is about the same size as a typical handheld TV remote control. It is powered by a single 9-volt battery.

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The *EM-TEC 1000* infrared sensor is available in kit form for $49.95, or fully assembled for $64.95. Wholesale prices and quantity discounts are available.—**O.T.I. International**, P.O. Box 194, 319 North Main, West Point, NE 68788; Phone: 402-372-5650.

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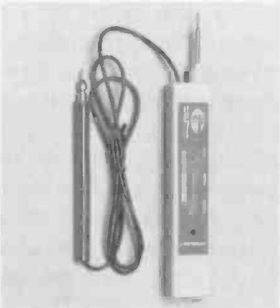


CIRCLE 18 ON FREE INFORMATION CARD

The *Shortsqueak* tone-ohmmeter costs $49.95. —**Jensen Tools Inc.**, 7815 South 46th Street, Phoenix, AZ 85044-5399; Phone: 602-968-6231.

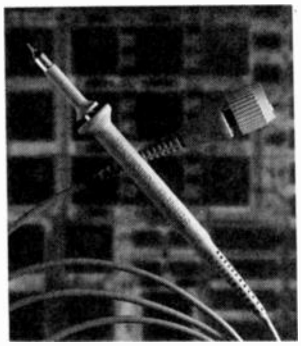
LAPTOP COLOR VIDEO CONVERTER. You can output the graphics from your monotone notebook or laptop PC to a color television or monitor with *Telebyte's Model 701 Pocket Videoverter*. Ideal for sales presentations and demonstrations, the *Pocket Videoverter* converts the VGA signals of a PC display to the NTSC/PAL format required by standard television monitors and VCR's. Most notebook and laptop computers are equipped with a VGA port connector that is compatible with an external monitor. That port connects the 2×3.5×1-inch *Pocket Videoverter* to the PC. The TV is connected to the device either by its S-video or composite-video port, or by an external RF modulator such as that built into a VCR. The device is available in two configurations: NTSC for U.S. use and PAL for European use.

CIRCLE 19 ON FREE INFORMATION CARD

The image on the TV screen can be turned on and off with a a hot key on the computer. In addition, the ALT and arrow keys can be used to move the image up or down and right or left. Other key combinations allow one to change the size of the TV image. Those features are important because a VGA display can resolve more horizontal display lines than a television receiver can produce. The converter can also be used to assemble a "desktop video publishing" capability by adding a VCR. It works with all major software packages and VGA display cards, and provides both interlaced and non-interlaced display modes.

The *Pocket Videoverter*, is supplied with an external power adapter, two eight-foot cables (one for an RCA AV input and the other for S-video), a reference manual, and a 3.5-inch floppy disc with the driver software. Its suggested list price is $399.—**Telebyte Technology Inc.**, 270 East Pulaski Road, Greenlawn, NY 11740; Phone: 516-423-3232 or 1-800-835-3298; Fax: 516-385-8184/7060.

EXTRA DURABLE PROBES. *Tektronix* says that it's *B-Series* of 1×, 10×, and 1×/10× passive voltage probes, specifically intended for the company's analog and digital oscilloscopes, are the most durable probes on the market. The probes are designed and manufactured to withstand the rigors of constant daily use and abuse, with guaranteed electrical accuracy from circuit to probe. The series includes the *P610B*, *P6103B*, *P6109B*, *P6119B*, and *P6129B* probes, with bandwidths up to 100 MHz.



CIRCLE 20 ON FREE INFORMATION CARD

Each probe is encased in a patented rubber-molded casing that gives it a comfortable, pen-like feel. The body is more resilient and is 50% lighter then previous probes that have been introduced. A probe will bounce when dropped, with its casing protecting the probe's surface-mounted components. A patented integral strain-relief protects both ends of the cable from extreme mechanical stress. Each probe tip can withstand up to 50 pounds of pressure. If the tip is exposed to extreme pressure in excess of that pressure, it is designed to break off and be replaced. This feature eliminates the vulnerability to damage of the molded-plastic probe body. Each probe is supplied with an extra replaceable tip and a set of accessories. A full range of application-specific adapters is available as an option. On these switchable probes, the miniature posi-lock switch ensures fault-free operation and eliminates unintentional switching.

The probes offer low input capacitance, which minimizes circuit loading, and provides for accurate signal acquisition. The probes also offer a compensation range of 15 to 35 pF, matched to Tektronix portable oscilloscopes. This feature allows for accurate compensation adjustment and minimizes signal distortion.

The *B-Series* probes are priced from $50.00.—**Tektronix Inc.**, Test and Measurement Group, P.O. Box 1520, Pittsfield, MA 01202; Phone: 1-800-426-2200.

MULTIPURPOSE ANTENNA TUNER. For tuning both mobile and home antennas, the *MFJ-247* SWR analyzer from *MFJ Enterprises* provides quick and easy tuning of high-frequency beams, verticals, dipoles, and mobile antennas for the lowest standing-wave ratio at your desired frequency. The fully self-contained unit displays your antenna's SWR over the entire band, and works without a transceiver, SWR bridge, or other equipment. You can observe SWR change while rotating your beam, and you can observe the effects of ice, snow or wind motion. You can even check the SWR on the input of your linear amplifier, or pretune your antenna tuner without switching on your transceiver. The device's large LCD readout provides a high-contrast display even under direct sunlight.

CIRCLE 21 ON FREE INFORMATION CARD

The *MFJ-247* is easy to use. You plug your antenna into its top SO-239 socket, and set the readout to the desired frequency. The SWR appears on the unit's meter. You can then shorten or lengthen your antenna's active element or mobile whip for the lowest SWR at the desired frequency, tune in to band edges, and read the bandwidth of the antenna.

The antenna tuner consists of a precise digital frequency counter plus a low-power signal generator and an SWR meter in one cabinet. Its weak signal on your selected frequency is fed to the antenna, and then the antenna's SWR is read directly on the MFJ-247's meter. The device has a separate BNC input connector for accurate frequency counting.

The *MFJ-247* SWR analyzer costs $189.95.—**MFJ Enterprises, Inc.**, P.O. Box 494, Mississippi State, MS 39762; Phone: 610-323-5869 (1-800-647-1800 for orders); Fax: 601-323-6551.

EXTERNAL SPEAKER/DTMF DECODER. The *Silencer Model ARE-10* from *Amateur Radio Engineering* is an external speaker with a DTMF decoder for use with VHF/UHF radios. The user-programmable, 2- to 4-digit DTMF code enables (opens) the speaker for about 10 seconds when the proper tone is received. Then an LED on the unit lights to notify the user that a call has come in. The front toggle switch can be set to MONITOR when the user wants to hear everything that's being said on the frequency. When the switch is set in its MOMENTARY position, the LED turns off after a call has been received. In addition to providing easier selective calling, the *Silencer* also screens family members or coworkers from hearing everything being said on busy frequencies. Rather than turning the radio off, the toggle switch can be set to DECODE, and the *Silencer* will eliminate all of the chatter yet still permit the user to receive calls. The accessory, which measures only 3 × 3¼ × 4⅜ inches, is easy to connect. It plugs into the external speaker jack on the radio and a 12-volt DC power source. The unit's high-quality speaker will improve the audio from most amateur transceivers.

CIRCLE 22 ON FREE INFORMATION CARD

The *Silencer Model ARE-10* costs $99.—**Amateur Radio Engineering, Inc.**, P.O. Box 169, Redmond, WA 98073; Phone: 206-882-2837.

INSIDE-MOUNT CELLULAR ANTENNA. Two common cellular telephone problems—dropped calls and noisy transmission—are said to be significantly reduced by *Terk Technologies' CFR900 Transceptor* cellular antenna. It is designed to mount on the inside of a vehicles window glass.

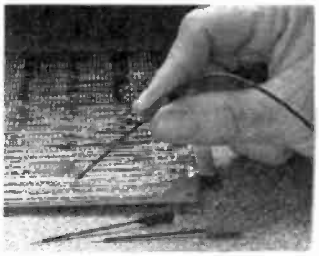
The compact modular unit is hard-wired to a cable in a single-piece unit, preventing signal loss due to

CIRCLE 23 ON FREE INFORMATION CARD

wire braid separation. The uniquely polarized *Tranceptor* radiates in a 360-degree pattern, increasing power, coverage, and efficiency with respect to conventional stick or coil antennas. The unit's voltage standing wave ratio (VSWR) is 1.0:1. This compares with the 1.9:1 VSWR of more conventional cellular antennas. Because it is mounted inside the vehicle, the antenna is less likely to attract the attention of thieves and vandals. It also is said to eliminate interference problems due to wind and inclement weather, and mechanical problems caused by car washes. Unlike other window-mounted antennas, the CFR900 can be installed even on a window that has a built-in defroster.

The *CFR900 Transceptor* cellular antenna has a suggested retail price of $79.95.—**Terk Technologies Corporation**, 233-8 Robbins Lane, Syosset, NY 11792; Phone: 516-942-5000 or 1-800-942-TERK; Fax: 516-942-TERK.

NEEDLE-POINT PROBE TIP. This spring-loaded, needle-point probe tip facilitates positive, non-slip probing of high-density lead traces.



CIRCLE 24 ON FREE INFORMATION CARD

ITT Pomona's Series 5789 probe tip is intended for scanning test points on surface-mount and other high-density circuitry. It allows technicians to work on equipment with densely populated circuit boards without fear of damaging the thinly spaced traces. The sharp, insulated, stainless-steel tip is 1.42mm (0.056-inch) in diameter and 89mm (3.5-inches) long. It can easily be attached to a range of test equipment and cable interfaces. It connects to 0.64mm (0.025-inch) diameter square or round sockets on test leads via gold-plated pins. The probe is rated at 50 volts, 1.5 amps, maximum. Weighing only 0.66 grams, the needle-point probe tip is available in red or black.

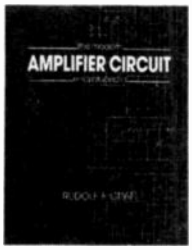
The *Series 5789* needle-point probe tip is priced at $9.65 in single quantities.—**ITT Pomona Electronics**, Customer Service, 1500 East Ninth Street, P.O. Box 2767, Pomona, CA 91769; Phone: 714-469-2900; Fax: 714-629-3317.

NEW LIT

Use The Free Information Card for fast response.

THE MODERN AMPLIFIER CIRCUIT ENCYCLOPEDIA; by Rudolf F. Graf. TAB Books, Division of McGraw-Hill Inc., Blue Ridge Summit, PA 17294-0850; Phone: 1-800-822-8138; $12.95.

Written by an author well-known to readers of **Radio-Electronics**, this encyclopedia is intended to shorten your search through the hundreds of pages of larger circuit encyclopedias to find a specific circuit. It provides fast, easy access to more than 250 ready-to-use amplifier circuits. Those range from audio, video, and radio-frequency amplifiers to operational, instrumentation, and voltage-controlled amplifiers. The circuits in Graf's encyclopedia are organized by application for easy reference. Moreover, they are presented in the same format in which they were originally published to prevent transcription errors. Each schematic is accompanied by a brief circuit explanation. A section at the back of the encyclopedia lists the publications in which each of the circuits was originally published, making it easy for the reader to obtain supplemental information.



CIRCLE 36 ON FREE INFORMATION CARD

TTL POCKET GUIDE; VOLUMES I, II, AND III. Electronics Technology Today Inc., P.O. Box 240, Massapequa Park, NY 11762-0240; $18.95 plus $3.50 shipping and handling for each book, or $50.85 plus $8.00 shipping and handling for the three-volume set.

CIRCLE 37 ON FREE INFORMATION CARD

This three-volume set of pocket-sized books provides a comprehensive listing of commonly used transistor-transistor logic (TTL) products from all major manufacturers. All current families are covered, including standard, low-power, advanced, advanced low-power, and fast Schottky. Each page is limited to the coverage of one device, and it is divided into eight sections. The first gives the device's schematic with a clear, simple logic diagram. The second contains a brief circuit description as a quick overview of the device's internal structure. The next section gives details on operating the integrated circuit, describing input signals or levels at individual pins. The fourth section lists primary applications, and it is followed by a summary of essential data. The next section includes a table listing the devices available in each TTL family. Finally, device description and type-number references are highlighted for easy reference. An index at the end of each book lists the manufacturers of each device.

RTTY DATACARD; from Tiare Publications, P.O. Box 493, Lake Geneva, WI 53147; Phone: 414-248-4845; $6.00 plus 50 cents shipping and handling.

CIRCLE 38 ON FREE INFORMATION CARD

Converting radioteletype tones into readable material can be a big hurdle for persons monitoring RTTY, even when they are using the latest decoding units. This two-sided, 8½ × 11-inch, thickly laminated datacard simplifies that process. It presents and explains the Yarbrough Matrix RTTY Tuning Method, developed by Chuck Yarbrough, a seasoned RTTY hobbyist who happens to be a columnist for the Speedx Shortwave Club. One side of the card explains RTTY emission modes and the Yarbrough system, while the other side contains the Matrix Tuning Table. A list of baud rate and various RTTY transmission methods classed under narrow, medium, and wide shifts for that tuning rate is in the table. It also summarizes the tuning method.

1992 CATALOG; from Parts Express International Inc., 340 East First Street, Dayton, OH 45402; Phone: 1-800-338-0531; free.

This 148-page catalog is filled with descriptions of electronic parts and accessories; it is geared toward consumer electronics and the technical hobbyist. The catalog includes extensive lines of electronic components such as speakers and audio accessories for home and car. Also covered are repair parts and accessories for CATV and VCR's, semiconductors, tools, and telephone-related products. Under supplies are chemical solvents, wire, and connectors. The catalog even includes books and videotapes on electronics-related subjects, and parts for arcade-games. The illustrated catalog contains product descriptions, prices, how-to-order information, and a comprehensive index. **R-E**

CIRCLE 39 ON FREE INFORMATION CARD

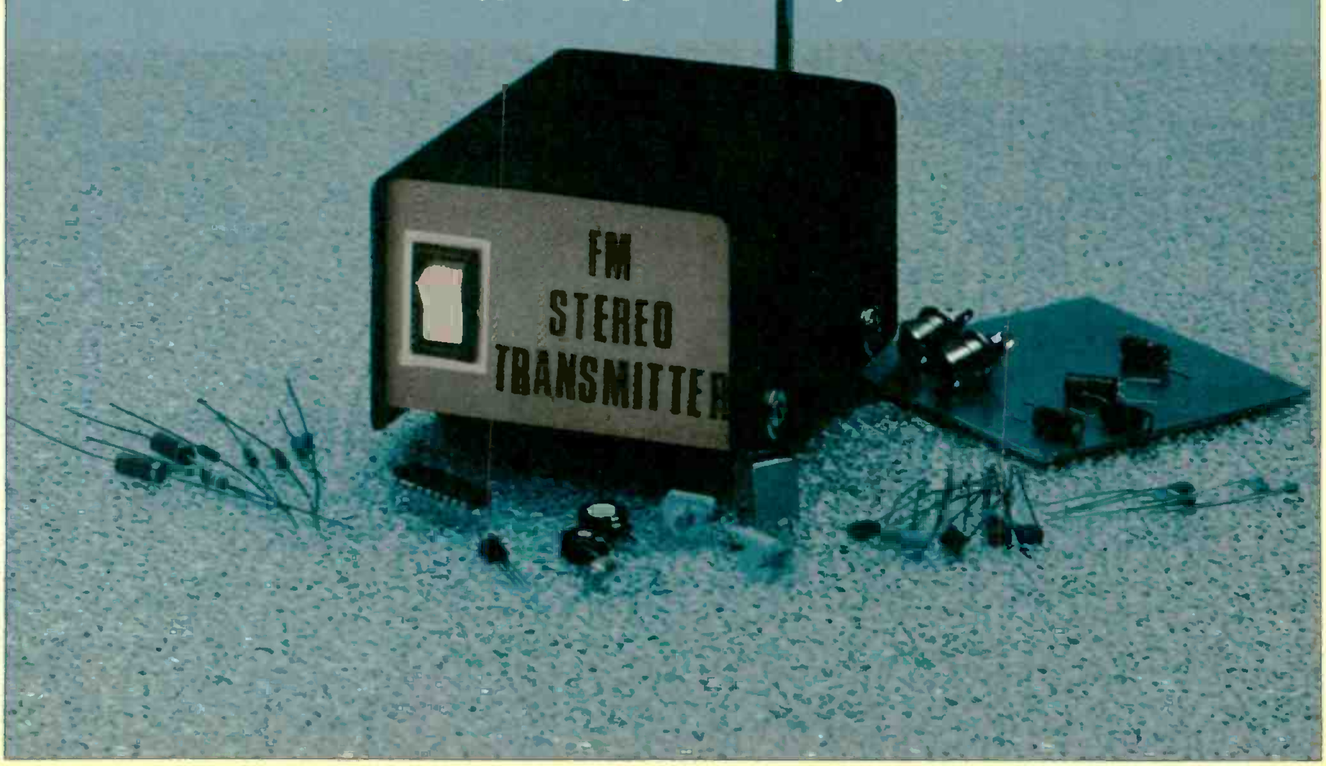
BUILD THIS FM STEREO BROADCASTER

You'll find countless uses for this versatile FM stereo transmitter!

LUTHER M. STROUD, CET N5TVY

COMPACT DISCS OR CD'S. ARE QUITE POPULAR THESE DAYS, NOT ONLY AT HOME BUT on the go, too. Personal portable CD players are popular because of their convenient size—but their disadvantage is that only someone with headphones can enjoy the music. However, if you build our stereo FM transmitter, you'll be able to listen to the CD audio on any FM receiver—whether it's in the car, at the beach, or in the yard. Since the transmitter can be used with any line-level audio source, other applications—such as a baby monitor or wireless microphone—are possible as well.

The low-power, low-cost FM-stereo transmitter that we'll build develops a signal of only a few microwatts. But that's enough power to transmit a high-quality stereo signal to any FM receiver within about 50 feet. The project uses an integrated circuit specifically designed to be a complete FM stereo transmitter. Very few support components are required.



FM basics

Many simple wireless FM transmitters are monophonic only. A stereo broadcast signal has two channels: left and right. The audio signals occupy a bandwidth of 50 to 15,000 Hertz, with the higher frequencies given a treble boost or pre-emphasis for noise-reduction. Both channels are added together and broadcast as main channel audio (L+R) so that monophonic FM receivers will be able to reproduce all of the program material for the listener to enjoy.

Along with the main channel audio, a stereo signal contains a 19-kHz pilot carrier at 10% amplitude of the main channel, and a sideband subcarrier from 23 kHz to 53 kHz containing the difference between the right and left audio signals (L−R). The stereo receiver uses the 19-kHz signal to recreate a phase-locked 38-kHz signal (suppressed at the transmitter) to decode the sideband carriers back into the right and left channels. Figure 1 shows the frequency spectrum of an FM-stereo signal. The receiver also provides a treble cut (called de-emphasis), which compensates for the pre-emphasis that was added at the transmitter.

How it works

At the heart of this project is IC1, a BA1404 FM stereo transmitter (see Fig. 2). The left-channel input signal is adjusted to proper level by R1. Treble boost (pre-emphasis) is provided by the parallel combination of C1 and R3. That tailors the audio response to the 75-microsecond standard set down by the FCC. Audio is coupled by C10 into the left-channel input of IC1 at pin 1. Stray RF signals are bypassed to ground by C2 to prevent unwanted feedback. The right-channel input circuitry to pin 18 of IC1 is identical to that of the left channel. Power-supply decoupling is done by C14, and any previous amplification to the audio input is decoupled by C12 on pin 2 of the chip.

A 38-kHz signal is needed to multiplex the incoming audio and create the pilot carrier. The internal circuitry of IC1 supports the use of a 38-kHz SX-cut crystal, as shown by the dashed line in the schematic of Fig. 2. However, the 38-kHz crystals are difficult to find, and they can be costly when you do. A more readily available crystal, manufactured by Statek, operates at 38.400 kHz. It will work in most situations; tests made during the development of this project showed that some FM stereo receivers wouldn't lock reliably to the pilot carrier derived from 38.400 kHz crystal. The solution was to use a highly stable external Hartley oscillator made from low-cost, easily obtainable parts instead of either crystal oscillator.

The 38-kHz sine wave is generated by Q1 and the surrounding components (the Hartley oscillator). High-gain transistor Q1 has a beta of over 300; lower-gain devices might not work due to the low supply voltage (1.5 volts DC) that is provided by a single AA cell. The adjustable coil used for T1 is a first intermediate-frequency (IF) transformer found in portable transistor radios, and it's designed for 455-kHz operation. The coil in T1 is loaded with enough capacitance by C23 to bring its operating frequency down to about 38 kHz. You can adjust T1's core to put the oscillator exactly on frequency. Although the oscillator might drift more than a quartz crystal, it's not a problem because receivers use phase-locked loops that can track the minor drifting. Note that the circuit won't oscillate if transformer T1's wiring is reversed. A bottom view of T1 is included in Fig. 2 to help you with the wiring.

The multiplexed audio exits pin 14 of IC1 and is mixed with the pilot carrier on pin 13 using the network of R5, R6, C22, and C13. The resulting signal is applied to the modulator input at pin 12. To prevent any RF feedback problems, pin 12 is bypassed by C6. A Colpitts oscillator, operating from 88 to 95 MHz, is formed at pins 9 and 10 with the network of C15 to C17, C20, and L3. The coarse frequency adjustment is made by varying the coil spacing of L3, and the fine adjustment is made with C20. RF energy that is generated from the tank circuit is prevented from getting back into the power supply circuitry with bypass-capacitor C7 and RF-choke L2.

The modulated signal at pin 10 of IC1 is coupled internally to the RF output amplifier consisting of C18, C19, and L4 connected to pin 7. That circuit boosts the oscillator signal to drive the antenna, and it prevents changes in antenna loading from shifting the oscillator frequency. The antenna is tapped at a point on L4 for the best power transfer. The design of IC1 is optimized for 1.5-volt operation with an absolute maximum of 3.5 volts. Early testing of this project showed that the transmit range didn't increase significantly when 3 volts was used to power the circuit, and the current drain tripled. Therefore, the increase in operating voltage is not recommended. The FM transmitter circuit draws only about 5 mA, so a single AA cell should last a very long time.

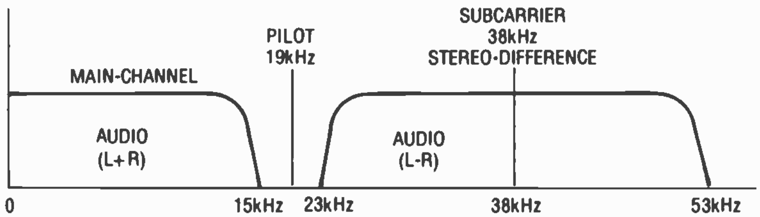


FIG. 1—THE FM-STEREO FREQUENCY SPECTRUM contains left and right channels broadcast as main channel audio (L + R), a 19-kHz pilot carrier, and a sideband subcarrier from 23 to 53 kHz containing L − R.

Construction

Any circuitry that operates at high frequencies needs proper

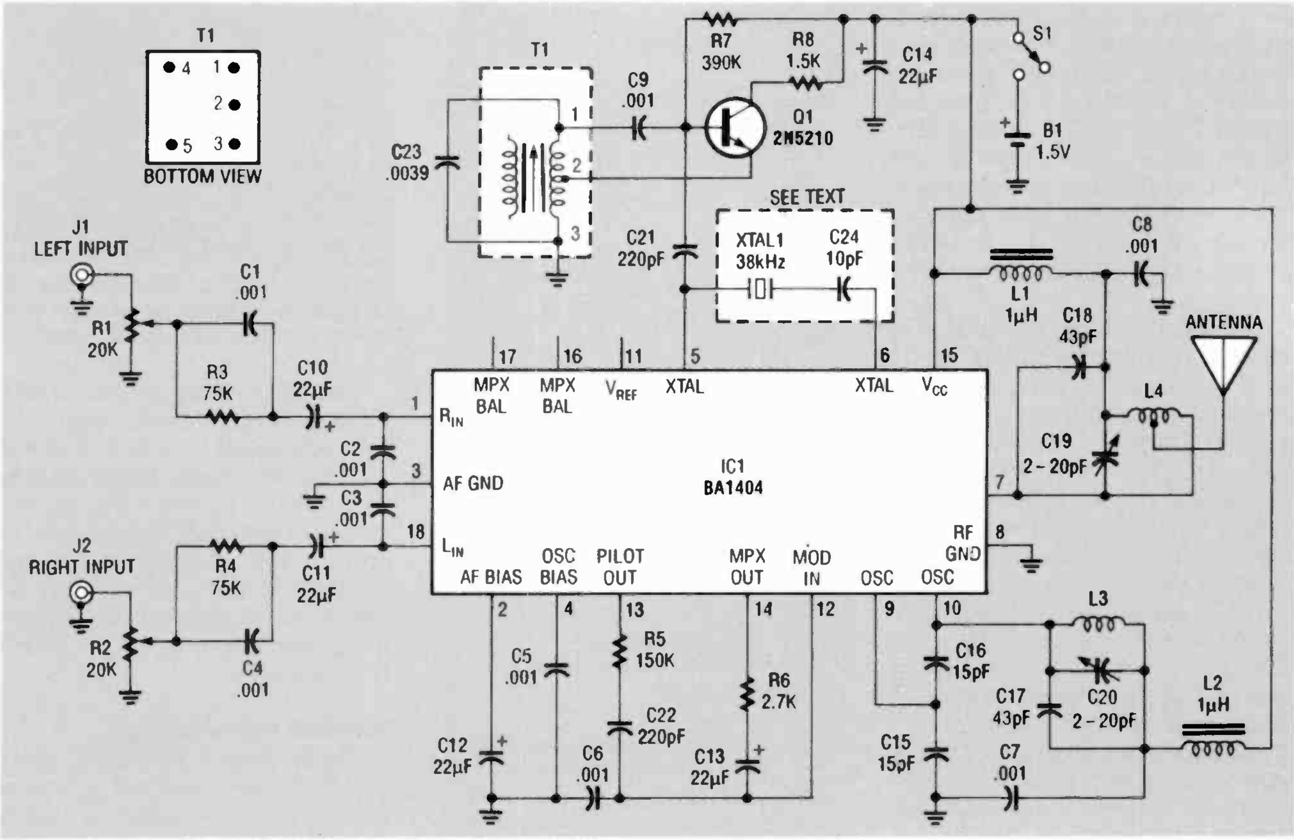


FIG. 2—THE HEART OF THE FM TRANSMITTER is a BA1404 FM stereo transmitter IC. The left input-signal level is adjusted via R1, pre-emphasis is provided by C1 and R3, and audio is coupled by C10 into the left-channel input. The right-channel input circuitry is identical.

grounding and shielding. However, to keep this project as simple as possible, a PC board was *not* used. Instead, a single-sided copper-clad blank was used, with the copper on the component side forming a ground plane, and point-to-point wiring done on the underside. You should be able to locate all of the necessary parts for this project. If you can't find some of them, they are available from the source mentioned in the Parts List.

To prepare the blank, drill four mounting holes in the corners of the board; the author used the mounting holes of the aluminum project case as a drilling guide for the copper blank. After you drill the four mounting holes, put a short screw in each hole secured with a nut. That will form a miniature "table," making it easy to drill the holes in the board for component mounting.

Next drill the 18 holes for IC1 near the center of the board—a scrap of perforated construction board makes a good drilling guide. After drilling the holes for IC1, use a 3/16-inch drill bit, twisting it between your fingers, to remove a small burr of copper around each hole except at pins 3 and 8, which must be soldered directly to the copper. That will prevent shorting any of the pins to the ground plane while still providing the circuit with near-perfect shielding.

As shown in Fig. 2, many of the parts have one lead going directly to ground. For parts like that, drill a hole through the board only for the ungrounded lead. The other lead can be soldered directly to the ground plane on top of the board. It is suggested that you drill and solder only a few components at a time. That way it's easier to lay out all the parts neatly. Try to keep all leads as short as possible. Also, it's important that decoupling capacitors be placed as close as possible to the pins of IC1, L3, and L4.

You can make coil L3 by close-winding three turns of #20 enameled wire on the shank of your 3/16-inch drill bit and spreading it out to 1/4 inch after removal. To make coil L4, close-wind four turns of #20 wire as before, and spread them out to 3/8 inch after removal. Both coils are mounted on the board 1/16 inch above the copper surface. Place the coils at right angles to each other and at least one inch apart to reduce coupling between them. The RF chokes (L1 and L2) should also be mounted at right angles to coils L3 and L4.

Checkout and tune up

Take a few minutes to review your work. Make sure the copper is removed from around all holes intended for component lead pass-through. Before applying power, make a few checks with an ohmmeter from IC1's pins to ground to see if any shorts exist where they shouldn't be. Also check for proper polarity of the electrolytic capacitors. Connect the battery and measure the current drain; it should be under 5 milliamps. Attach the antenna to the top of L4, at the first turn from the end that is connected to pin 7 of IC1. The 17-inch antenna on the prototype is the length most often found on portable radios; use only enough length of the antenna to avoid interfering with other nearby radios.

Connect a stereo audio signal to the transmitter—left at J1 and right at J2. Tune your FM receiver through the band listening for the transmitted signal. Set C19 and C20 at their midpoints and adjust L3 for about 92 MHz. You can now use C20 to fine tune the desired frequency. Although you probably have a good transmitting distance already, you can tune the circuit for maximum output by watching the signal-strength indicator on the FM receiver you're using, and adjusting the coil spacing of L4 with a plastic tool. As you get close to maximum, the coils are slightly interactive, so adjusting one will affect the other. Repeat the procedure until you reach a maximum output. With a stereo signal applied to J1 and J2, listen to the output from the FM receiver, preferably through headphones, and adjust R1 and R2 to the point just below where distortion occurs on loud portions of music. An input level to IC1 just below 200 mV is recommended.

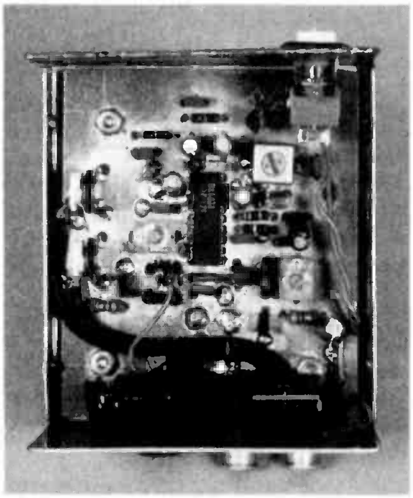


FIG. 3—A SINGLE-SIDED copper-clad blank provides a ground plane on the component side, and point-to-point wiring is used on the underside.

PARTS LIST

All resistors are ¼ watt, 5%, unless otherwise noted.
R1, R2—20,000 ohms, potentiometer
R3, R4—75,000 ohms
R5—150,000 ohms
R6—2700 ohms
R7—390,000 ohms
R8—1500 ohms
Capacitors
C1–C9—0.001 µF, ceramic disc
C10–C14—22 µF, 16 volts, electrolytic
C15, C16—15 pF, ceramic disc, NPO
C17, C18—43 or 47 pF, ceramic disc, NPO
C19, C20—2–20 pF, trimmer capacitor
C21, C22—220 pF, ceramic disc
C23—0.0039 µF, Mylar, 5%
C24—10 pF, ceramic, NPO (optional, see text)
Semiconductors
IC1—BA1404 stereo FM transmitter
Q1—2N5210 NPN transistor
Other components
XTAL1—38-kHz crystal HC-18 style (preferred) or 38.4-kHz crystal (both optional, see text)
S1—SPST toggle switch
T1—455-kHz 1st IF transformer (Sumida 1202-0042, Mitsumi 410B, or equivalent)
L1, L2—1.0 microhenry RF choke
L3—three turns of #20 enameled wire wound on 3/16-inch form
L4—four turns of #20 enameled wire wound on 3/16-inch form (tap at one turn)
J1, J2—RCA phono jack
J3—banana plug and jack for antenna
Miscellaneous: 17-inch telescoping antenna, single-sided copper-plated PC-board blank, 8 inches of 20-gauge enameled wire, drill bits, suitable metal enclosure, AA battery holder, wire, solder, hardware, etc.

Note: The following items are available from Pershing Technical, P.O. Box 1951, Fort Worth, Texas 76101-1951:
- **A kit of all board-mounted components, coil wire, 3×3-inch undrilled PCB blank, AA battery holder, and audio connectors (crystal is not included)—$19.50**

Price includes first class shipping costs. Orders outside USA add $2. Please allow from 4 to 6 weeks for delivery.

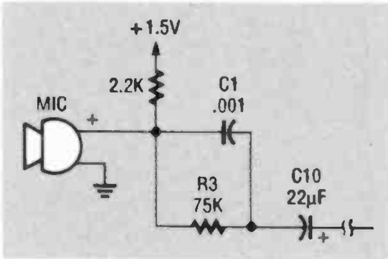


FIG. 4—A WIRELESS MICROPHONE can be made by adding an electret condenser microphone to the J1 input.

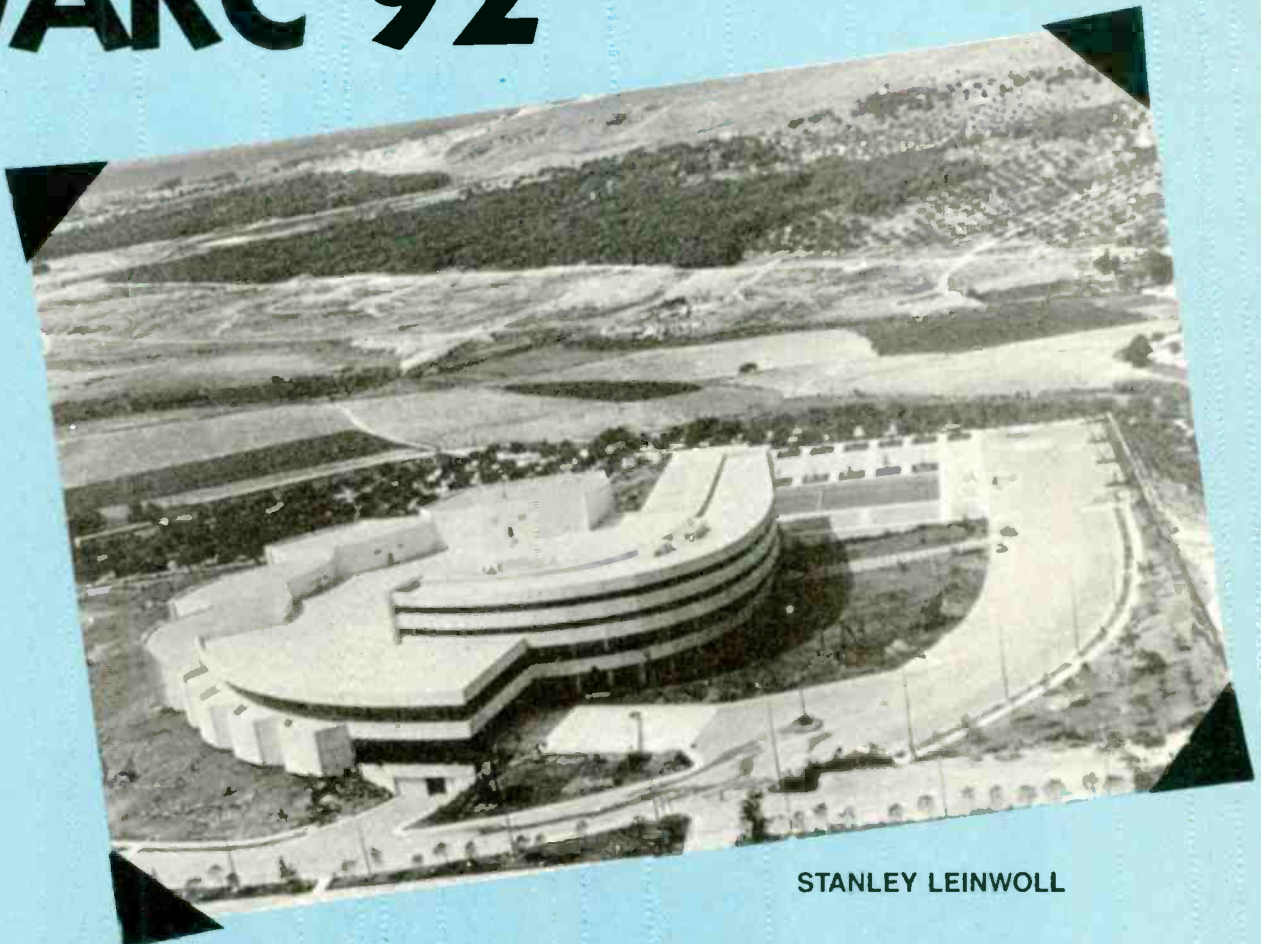
The 38-kHz oscillator is best adjusted with a frequency counter connected to pin 5 of IC1. If no counter is available, adjust the core of T1 noting the positions where the receiver's stereo-indicator light goes on and off. Adjust the core midway between those two points. Figure 3 shows the prototype stereo transmitter.

Further refinements

There might be times when you wish to transmit a monophonic signal, such as a speaker's voice to an auditorium sound system. A switch can be added to the circuit to place a 0.01-µF capacitor from pin 6 of IC1 to ground to inhibit stereo operation. If permanent monophonic operation is desired, the 38-kHz oscillator components and C5 can be omitted from the circuit.

Adding an electret condenser microphone to the J1 input with a 2200-ohm resistor connected to +1.5 volts will convert this project to a wireless microphone for baby-room monitoring or lecture-hall use. Wire the parts into the circuit in place of R1 as shown in Fig. 4. Stereo operation allows you to double up on the inputs. You might try adding vocals on one channel and an instrument on the other for broadcast through your stereo system. You could also monitor the telephone or baby on the left channel and listen to your scanner on the right channel—all while you wash your car or mow your lawn, while wearing a Walkman-type receiver. Those are just a few of the many possible uses for this simple project. We're sure you can come up many others. If you do, let us know what they are. R-E

WARC 92



STANLEY LEINWOLL

RF Spectrum Prepped for Next Century

REPRESENTATIVES OF COUNTRIES with a stake in telecommunications met recently in Torremolinos, Spain, to reallocate parts of the radio-frequency spectrum for satellite and space communications services in the 21st century. But the meeting had its share of contention as national delegations clashed over frequency redistribution.

The World Administrative Radio Conference (WARC-92), held from February 3 through March 3, allocated frequencies for many different concepts related to satellite and spacecraft to Earth communications. Some proposed systems that require special frequencies are only vague concepts, but others could be started even before the turn-of-the-century. Consider these possibilities:

- A cordless telephone system that will permit you to dial another phone anywhere on earth using a constellation of 77 low-orbiting satellites. This system would also permit you to phone, page, or send fax messages from airplanes, ships at sea, or moving cars.
- A satellite system that directly broadcasts strong, clear, non-fading radio signals to home receivers worldwide with compact-disc quality reception.
- A satellite television system that beams clear, sharp images directly to your home that are better than those received directly from terrestrial TV transmitters or cable.

WARC-92 also allocated Earth and space exploration frequencies, including those required to establish a lunar colony, and for a manned expedition to Mars. In addition, WARC-92 allocated an additional 790 kHz of RF spectrum to high-frequency broadcasting (HFBC), and adopted a resolution calling for a future conference to plan HFBC.

Nationalistic squabbles beset the conference that allocated frequencies for 21st-century telecommunications

Tough allocation decisions

Although many of WARC-92's accomplishments read like a chapter from Star Trek, they did not come easily. Participants found that attendance was strenuous, some delegations were highly contentious, and the results of certain sessions were confusing.

WARC-92 reallocated frequencies in different parts of the electromagnetic spectrum ranging from high frequency (HF—3 to 300 MHz) all the way up to the extra-high frequency (EHF—above 150 GHz).

Conference accomplishments

WARC-92's accomplishments include:

1. *High-frequency (HF) allocations.* Figure 1 shows the additional frequency allocations made for high-frequency broadcasting. Four conditions were imposed on those allocations:

- They were limited to single-sideband (SSB) only.
- Their use is subject to planning procedures of future WARC's.
- They were allocated to the *fixed* and where appropriate, the *mobile* services until April 1, 2007.
- Existing *fixed* and, where appropriate, *mobile* services can continue on a low-power, national, and non-interference basis taking into account existing HF-broadcasting schedules.

A future planning WARC will probably be scheduled for 1995 or 1996. In preparing for this important radio conference, the United States Delegation proposed the expansion of the shortwave broadcasting bands by an additional 1125 kHz in Europe, Africa, and Asia, and 1325 kHz in the Americas. But a large bloc of developing countries from Latin America, sub-Saharan Africa, and Asia steadfastly refused to reallocate that amount of the RF spectrum to broadcasting.

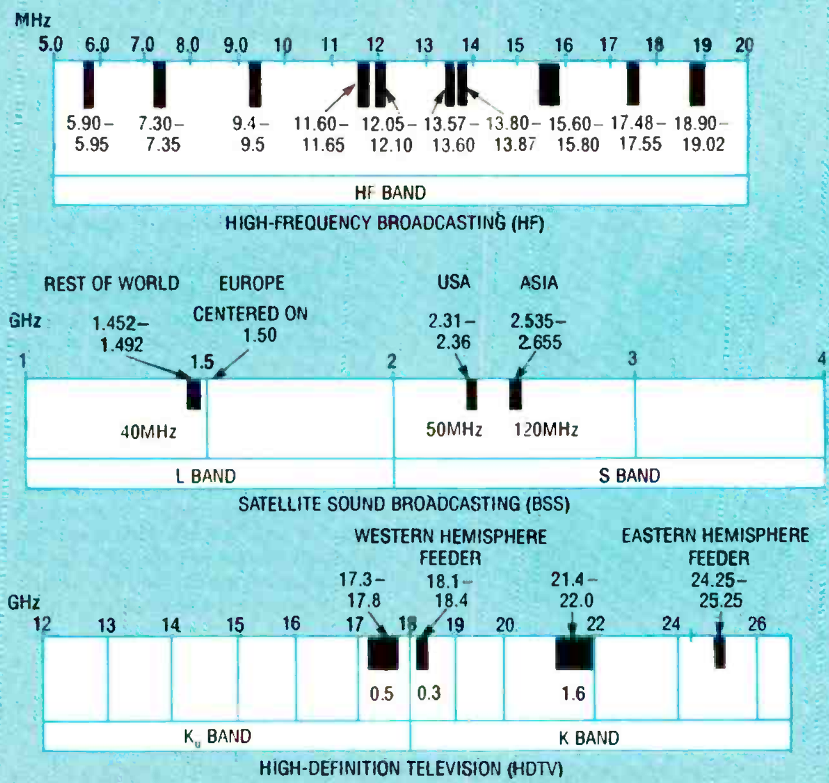
The bloc pointed out that the HF bands below 10 MHz are used extensively in their countries for internal point-to-point communication, and they are extremely congested. Consequently, those developing countries were adamant about releasing large amounts of spectrum below 10 MHz. To avoid the possibility that HF broadcasting would not get *any* additional spectrum during WARC-92, an eleventh-hour compromise was struck, and a total of 2000 kHz was reallocated in the bands below 10 MHz.

Mindful that the amount of spectrum reallocated to HF broadcasting was insufficient, the United States Delegation declared that WARC-92 failed to make adequate provision for that service, particularly below 10 MHz. The delegation announced that it "reserves the right to take the necessary steps to meet the HF needs of its [U.S.] broadcasting service."

The extension bands will become available to HF broadcasting on April 1, 2007. They will be planned, and can only be used in the SSB mode.EP

2. *Satellite sound broadcasting (BSS)*: The issues here produced a genuine tug-of-WARC. The conference was divided from the outset on allocation of frequencies. Most Europeans wanted the more economical and propagationally suitable L-Band, with an allocation around 1.5 GHz. However, the U.S. was firmly opposed to that allocation became military aeronautical services are now operating in that band. The U.S. wanted the allocation in the S-band, around 2.3 GHz. Other countries, notably, China, Russia, Japan, India, and Pakistan, wanted the BSS allocation to be around 2.5 GHz. (See Fig. 1)

In the end, BSS allocations were made in all three bands on a regional basis. In the U.S., satellite sound broadcasting is allocated in the 2.31- to 2.36-GHz band. However, China, Russia,



FREQUENCY ALLOCATIONS IN THREE REGIONS of the RF spectrum.

Japan, India, Pakistan, and several other Asian countries will use the 2.535- to 2.655-GHz band. The rest of the world will use the 1.452- to 1.492-GHz band. All of those uses will be limited to digital audio broadcasting (DAB). WARC-92 agreed that the upper 25 MHz of each band can be used immediately, provided that suitable coordination procedures are followed.

3. *High-definition television (HDTV).* This service ran into problems similar to those encountered in BSS, and there was no agreement on worldwide allocations. Instead, Europe, Africa, and Asia will use the 21.4- to 22-GHz band, and the Americas will use the 17.3- to 17.8-GHz band. Feeder links will be in the 18.1- to 18.4-GHz band in the Americas, and 24.25- to -25.25-GHz band elsewhere. (See Fig. 1) These bands will become available on April 1, 2007. Prior to that date, HDTV could be implemented, provided that existing services are protected.

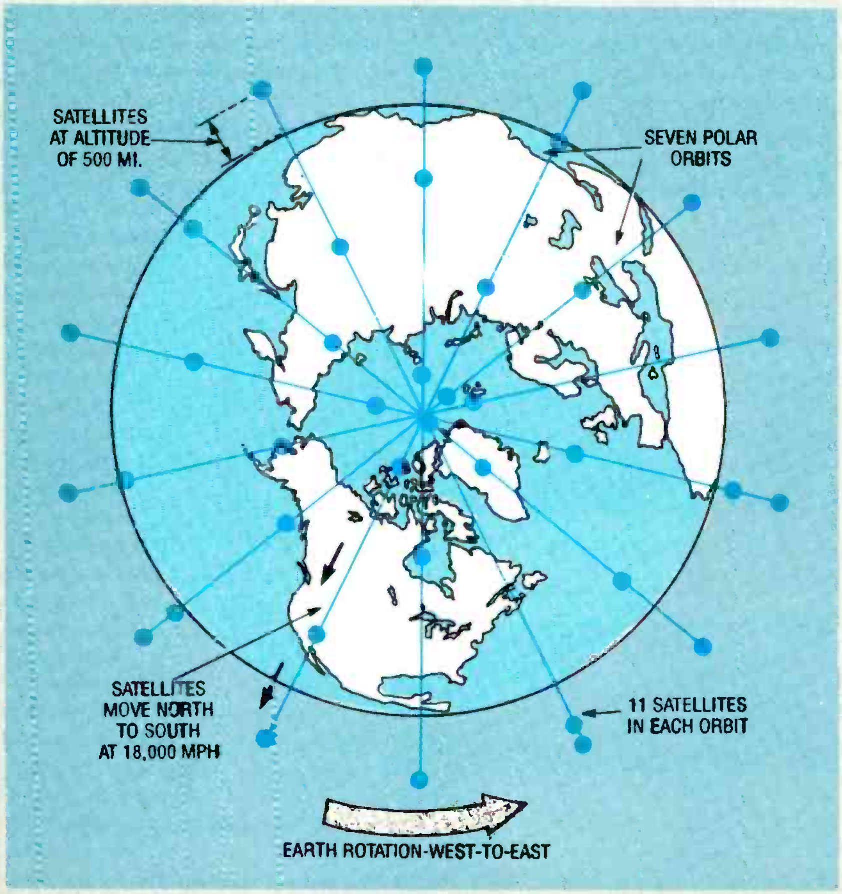
4. *Mobile satellite service, and aeronautical public correspondence (APC).* The services that most excited WARC-92 attendees occur in the frequency bands assigned for telephony, worldwide paging, and fax services using many continually orbiting rather than geostationary satellites.

In 1990 Motorola proposed a global telephone system called Iridium (see box). The APC system would enable passengers on commercial airlines to make phone calls or send FAX messages anywhere on earth. Frequencies for these services were allocated in bands between 300 MHz and 3.0 GHz, and they include allocations for a future public land-mobile telecommunications service (FPLMTS). That service would, among other services, permit anyone in a moving automobile with a car phone to call anywhere on Earth.

Although some worldwide exclusive allocations were made, the interregional jousting that took place in BSS and HDTV also affected the mobile satellite service. Once many of these systems are implemented, it will be necessary for the systems to carry dual standard equipment. For example, an airplane crossing the Atlantic must carry equipment that operates in the frequency bands allocated for the Western as well those allocated for the Eastern hemisphere. The world's electronic equipment manufacturers can expect to stay busy for years to come meeting the demand for equipment that will operate at the many WARC-92-allocated frequencies.

Continued on page 73

GLOBAL TELEPHONE NETWORK OF 77 SATELLITES



IRIDIUM TELECOMMUNICATIONS NETWORK would have 77 moving satellites in seven polar orbits at a 500-mile altitude.

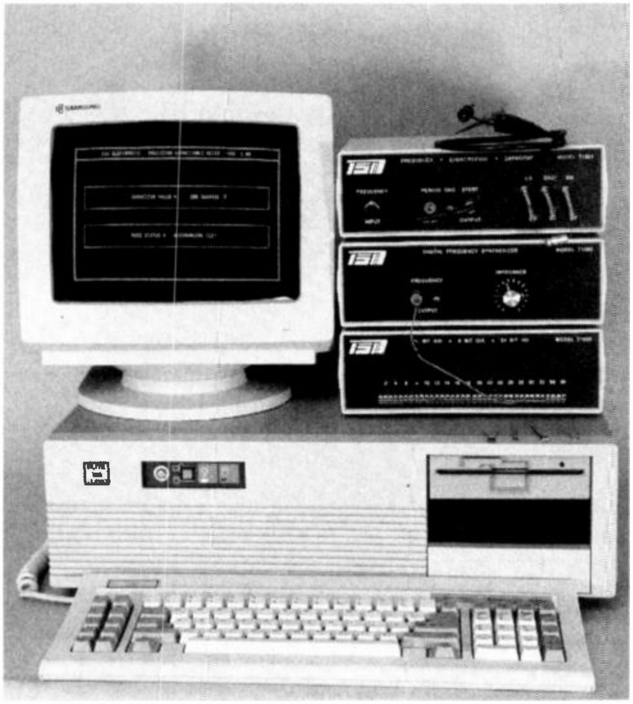
Iridium, a proposed global cellular telephone network, would put 77 relay satellites in earth orbit. Those moving transceivers or "cell sites" would be supported by 20 or more ground stations connected to terrestrial telephone lines. The system promises worldwide telephone, paging and fax service.

Unlike existing telecommunications satellites that remain in a fixed position 22,300 mile above the equator, Iridium's satellites would orbit the earth at an altitude of 500 miles. The 77 satellites would be launched and synchronized in seven polar orbits with 11 satellites in each orbit.

Moving from north to south at 18,000 miles per hour, the satellites would behave like electrons orbiting the nucleus of an atom. The earth will rotate west to east under this "shell" of satellites. As a result, at least one satellite will be in position above the horizon ready to transmit and receive calls at all times. Moreover, the low-altitude orbits will permit half-watt pocket phones to be used.

This ambitious scheme, proposed by Motorola Inc., has received frequency spectrum allocations although it has not yet been authorized by the FCC. In addition to revenues expected from telephone, fax, and paging services, Motorola envisions considerable work in making the satellites, ground station equipment, and pocket telephones. Critics, however, say that Iridium will have to play catch-up with existing cellular telephone services, and it will be too expensive to be profitable. R-E

PC-BASED TEST BENCH



The first I1000 peripheral that we're going to build, the T1001, contains a frequency counter, an event/period meter, and a capacitance meter.

STEVE WOLFE

THIS MONTH WE CONTINUE our PC-based test equipment series by completing the first of several that are compatible with the I1000 interface we built last month. We also went over the Front-End circuitry that must be contained in each I1000 peripheral. This first peripheral, the T1001, contains a 100-MHz digital frequency counter, an event/period meter, and a precision capacitance meter accurate from 1 pF to 10,000 μF.

Capacitance measurement

The Circuit Control Latch section (CCL) is made up of 16 control lines that are individually routed to every block depicted in Fig. 1. The purpose of the CCL section is to enable, disable, reset, start, and stop the major processes of the T1001. The Capacitor Pulse section, when started by the CCL section, produces a negative-going pulse whose period is proportional to the capacitor under test.

The pulse produced in the Capacitor Pulse section enables and disables the 60-MHz clock. To determine the period of the pulse, the output of the clock is connected to the Cap/Event section which contains the least-significant eight bits (byte 1) of a 32-bit digital counter, as well as a latch used to read those eight bits. The Counter section provides the remaining 24 counter bits (bytes 2, 3, and 4) as well as three more 8-bit latches that are used to read the count back into the computer.

The complete sequence is as follows: Control data is sent to the address of the CCL. The Chip-Select (CS) section enables the CCL to store the control data. The control data disables the Frequency, Event, and Timebase sections, and resets the counter and Capacitor Pulse sections. Next, the CCL is sent a byte that causes a one-shot to fire in the Capacitor Pulse section. The resultant pulse enables the clock, which enables the counters. When the pulse has ended, the final counter values are read back into the computer. The four counter bytes are then combined into a single decimal value. The resultant value is proportional to the capacitance of the component under test.

Event/period measurement

Event or period measurement uses most of the same circuitry as the capacitance meter. In this case, the CCL is programmed to deactivate the Capacitor Pulse section and to activate the Event-Pulse section. The Event Pulse section contains a CCL-controlled inverter/buffer. The 60-MHz clock is enabled and disabled by a negative-going pulse. The inverter/buffer ensures that a pulse of any polarity fed into the Event Pulse section will be negative-going upon reaching the Clock section. That allows for measurement of either negative-going or positive-going pulses. As with capacitance measurement, the counters are clocked at a 60-MHz rate for the duration of the event pulse, and are then stopped. The counter bytes are read back into the computer and combined into a single decimal value. The resultant period in seconds is equal to the final count divided by 60 MHz.

Frequency measurement

For frequency measurement, the CCL is first instructed to disable the Capacitor Pulse and Event Pulse sections, reset all the counters, and select one of eight available timebases, which are derived from the 60-MHz clock. Next, a timing period begins, and the output of the Timebase section goes low. That allows the Frequency Input section to begin counting the frequency that is being measured. The first byte of the input frequency ripple carries into the Counter section (bytes 2, 3, and 4). When the timebase period ends, the output of the timebase section returns to a high condition, disabling the Frequency Input section. The final count bytes are then read back and are combined into a single decimal value. The resultant frequency is

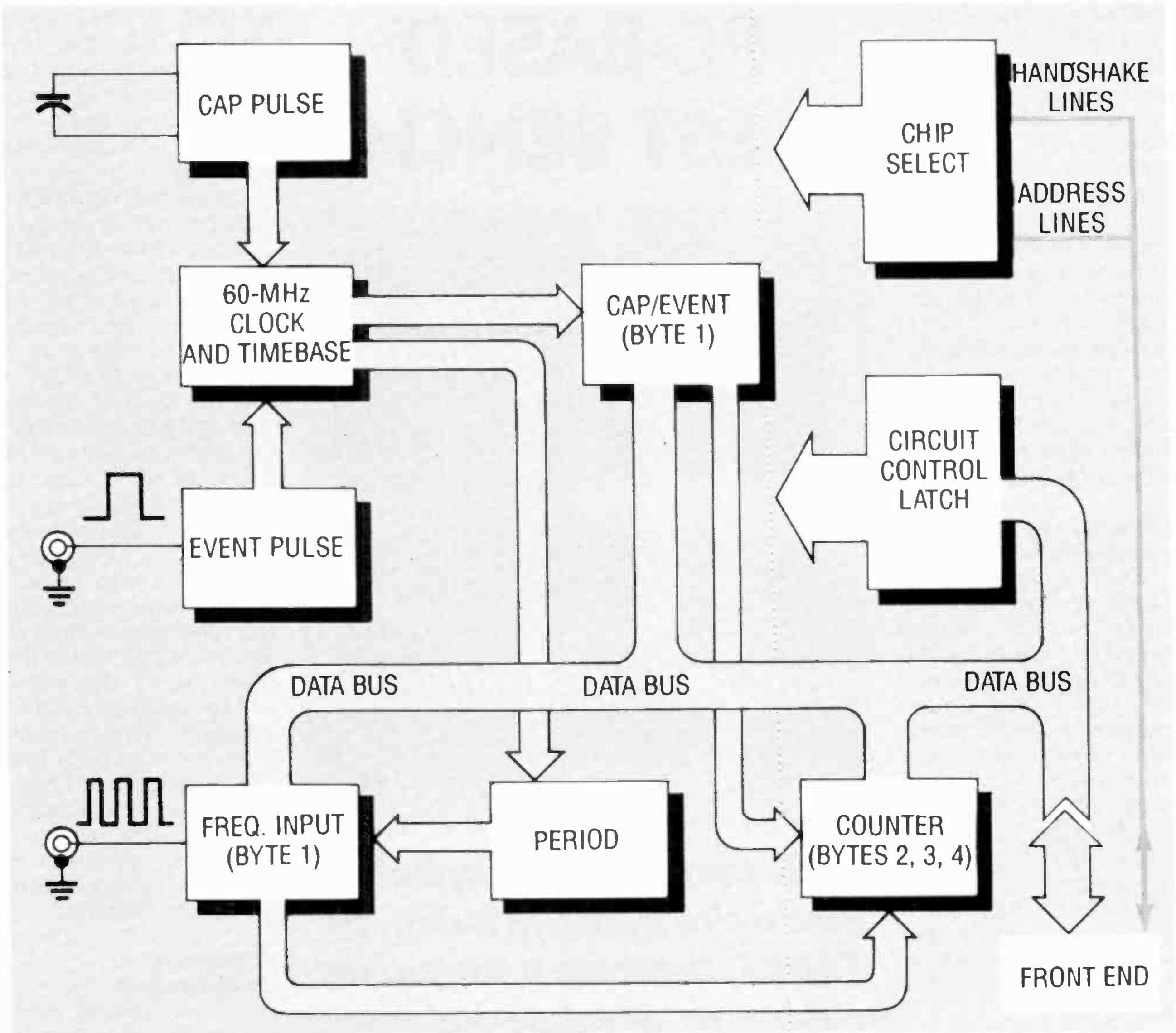


FIG. 1—T1001 BLOCK DIAGRAM. This peripheral contains a 100-MHz digital frequency counter, an event/period meter, and a precision capacitance meter.

equal to the final count divided by the timebase period in seconds.

Controlling the T1001

The first step in controlling any I1000 peripheral is to establish a base address and select the desired peripheral. The first bit of code will be:
bas = 768 : out bas + 31,1
768 (hex 300) is the factory-preset base address of the I1000. Next we have an out to bas + 31. Recall that address bas + 31 is reserved for peripheral selection. The T1001 has a unit or peripheral address of "1." Consequently, if you send an out to bas + 31 with a data byte of "1," the T1001 will be readied for full I/O operation.

Take a look at the T1001 schematic in Fig. 2. (Note that the Front End circuitry is absent—you can find that, and a description of it, in the June 1992 issue.) A 74HCT138 3-to-8 line decoder (IC21) produces the read function chip selects within the T1001: it decodes three binary lines and produces a low on one of eight output lines. The low remains active as long as the handshake lines remain active. The handshake lines that come from the Front End are $\overline{\text{SEND}}$, $\overline{\text{RD}}$, and BEN. The address information present at pins 1–3 of IC21 corresponds to A0–A2 (A3 AND A4 are not used by the T1001).

The BEN pulse is high as a result of selecting the T1001. Executing "a = inp(bas + 3)" will cause SEND and A2 lines to go low, and A0 and A1 to go high. After 500 nanoseconds, the read pulse ($\overline{\text{RD}}$) will go low, activating IC21 pin 12 for the duration of the $\overline{\text{RD}}$ pulse (1 μs). If BEN were low, IC21 would not respond to read pulses. BEN is low in every peripheral except the one addressed with the bas + 31 function. The +0 through +4 designator on the outputs of IC21 correspond to bas + 0 through bas + 4 in the software. Using that notation, it is easy to visualize the software's effect on the hardware.

A byte latched into IC9 can be retrieved using the following:
a = inp(bas + 0):a = inp(bas + 0)
A read to bas + 0 will cause IC21

pin 15 to go low, which in turn brings IC9 pin 1 low. That causes IC9 to go active and place its data onto the bus. Similarly, a read to bas+1 will bring data held within IC19 onto the data bus. Reads issued to bas+2, +3, +4, and +7 retrieve bytes from IC27, IC28, IC30, and IC25, respectively. Another 74HCT138, IC22, produces the write function chip selects within the T1001. It functions in much the same way as IC21 except that it responds to the write pulse ($\overline{WR}$) instead of the read ($\overline{RD}$) pulse.

An "OUT bas+0,170" would cause IC22 pin 15 to go low and subsequently IC20 pin 8 to go high; IC20 pin 8 controls the latch input of IC23 pin 11. You may have noticed that chip-select read-function outputs are active low, while write function outputs are inverted, or active high. That's because the 74HCT573 latches need a low on pin 1 to output their byte, and a high on pin 11 to store a byte. Components IC23 and IC24 are used to clear, start, and stop all of the processes of the T1001. The labels on the output side of IC23 and IC24 match labels at the IC being controlled.

T1001 PARTS LIST

Resistors
R1—200,000 ohms, ¼-watt, 1%
R2—5110 ohms, ¼-watt, 1%
R3—2200 ohms, ¼-watt, 5%
R4—5600 ohms, ¼-watt, 5%

Capacitors
C1, C2, C7, C8, C10, C16, C17, C34, C41—10 µF, 35 volts, electrolytic
C3, C5, C6, C12–C15, C18, C20–C30—0.15 µF, 50 volts, monolythic
C4, C9, C11, C19, C31, C35, C36, C38, C39—not used
C32—105 pF, 100 volts, dipped mica
C33, C37, C40—100 µF, 25 volts, electrolytic

Semiconductors
IC1—74LS123D dual one-shot
IC2—74HCT86D quad 2-input XOR gate
IC3, IC11—74HCT32D quad 2-input OR gate
IC4—74HCT20D dual 4-input NAND gate
IC5—74HCT74D dual D flip-flop
IC6, IC16—74F86D quad 2-input XOR gate
IC7, IC10, IC17—74ACT74D dual D flip-flop
IC8, IC12–IC14, IC18, IC26, IC29—74HCT4040D 12-stage binary counter
IC9, IC19, IC23–IC25, IC27, IC28, IC30—74HCT573D octal latch
IC15—74HCT151D 8-channel multiplexer
IC20—74HCT04D hex inverter
IC21, IC22—74HCT138D 3-to-8 line decoder
IC31–IC33—LM340T 5-volt regulator, TO-220 case
IC34—LM340K 5-volt regulator, TO-3 case
D1—1N4148 diode

Other components
OSC1—60-MHz crystal oscillator
J1—panel-mount BNC connector
J2, J4—red binding post
J3—black binding post
J5–J7—spring jacks or other type of connector, see text

Miscellaneous: project case, PC board, software, three TO-220 heatsinks, one TO-3 heatsink, sheilded cable, stranded jumper wire, hardware, ribbon cable, solder, etc.

Powering the T1001

Peripherals attached to the I1000 are powered by the +12-volt DC power line of the host PC. The +12-volts DC is filtered and regulated to +5-volts DC within the peripheral. In the T1001, the +12-volts DC is converted into four different +5-volt supply lines. There are four different supply lines because the 60-MHz master oscillator produces energy that can radiate to other parts of the circuit. (In an early T1001 prototype, the 60-MHz clock radiated enough energy to completely disable the frequency-counter section.) Giving each high-frequency section its own power supply eliminates such problems.

Measuring capacitance

To measure capacitance, you must first disable any systems not involved in capacitance measurement. Therefore, IC23 and IC24 are used to disable IC17, IC18, IC10, IC2-d, and IC5-b. That disables the Frequency Counter and Event sections. Let's assume that you are going to measure a small capacitor (less than 1 µF). Now IC23 and IC24 clear IC1-a, IC1-b, IC7-a, IC7-b, IC8, IC26, and IC29, and another byte from IC23 and IC24 releases those chips from their reset modes.

You are now ready to start IC1-a by transitioning its start line at pin 2; that causes IC1-a pin 4 to go low and IC4-b pin 8 then goes high. Flip-flop IC7-a—a 74F74 high-speed flip-flop set up as a divide-by-two—contains the least-significant bit of the 32-bit counter. When IC6-d receives a low on pin 13, IC7-a is disabled; when IC6-d receives a high on pin 13, IC7-a is enabled. Therefore, during the time that IC1-a is producing a negative pulse, IC7-a is counting at a 60-MHz rate.

The rest of the 32-bit counter section is made up of IC7-b, IC8, IC26, and IC29. Each section ripple-carries to the next. Once the one-shot pulse has begun, IC25 continually reads back IC6 pin 13 to determine if the pulse has finished. When IC6 pin 13 is found to be low, the one-shot has finished and the contents of the counters are read back from IC9, IC27, IC28, and IC30. The four bytes are recombined by the software to yield one decimal number proportional to the capacitance.

One-shot circuits cannot produce pulses that increase with capacitance in a 1:1, or linear fashion. In fact, the graph can be a curve resembling the natural log of 2. To achieve better than one percent accuracy, matrices and determinants are used in the software to overlay a correction curve and thus cancel any nonlinear characteristic. That is achieved by plugging capacitors with known values into the capacitor checker during a calibration process, allowing the checker to learn what capacitance equals what count. Therefore, the T1001 capacitance meter is accurate from 1 picofarad to 10,000 microfarads. For optimal performance, the calibration process should be repeated every six to eight months.

Measuring an event

Period measurement is accomplished with most of the circuitry used for capacitance

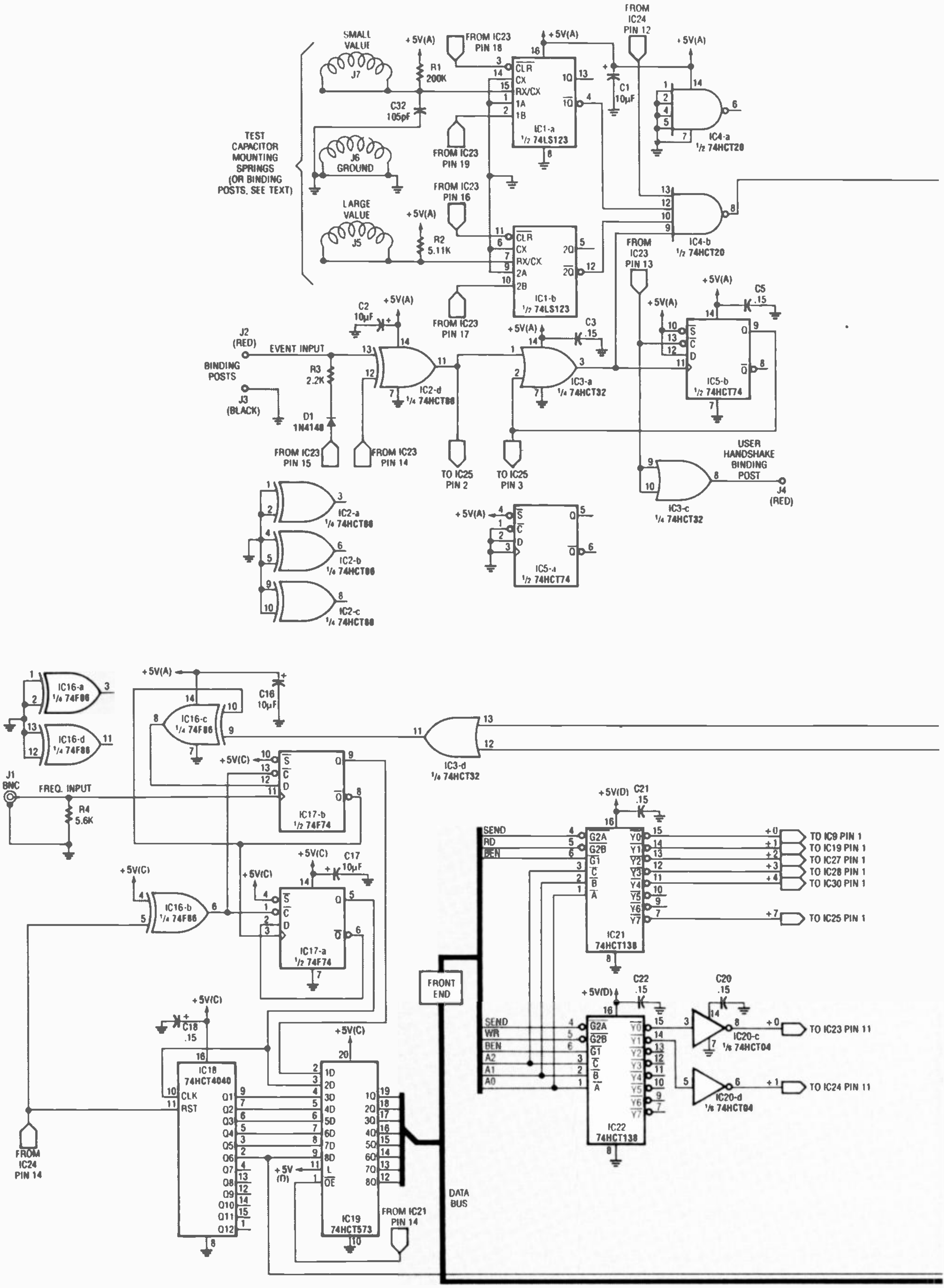
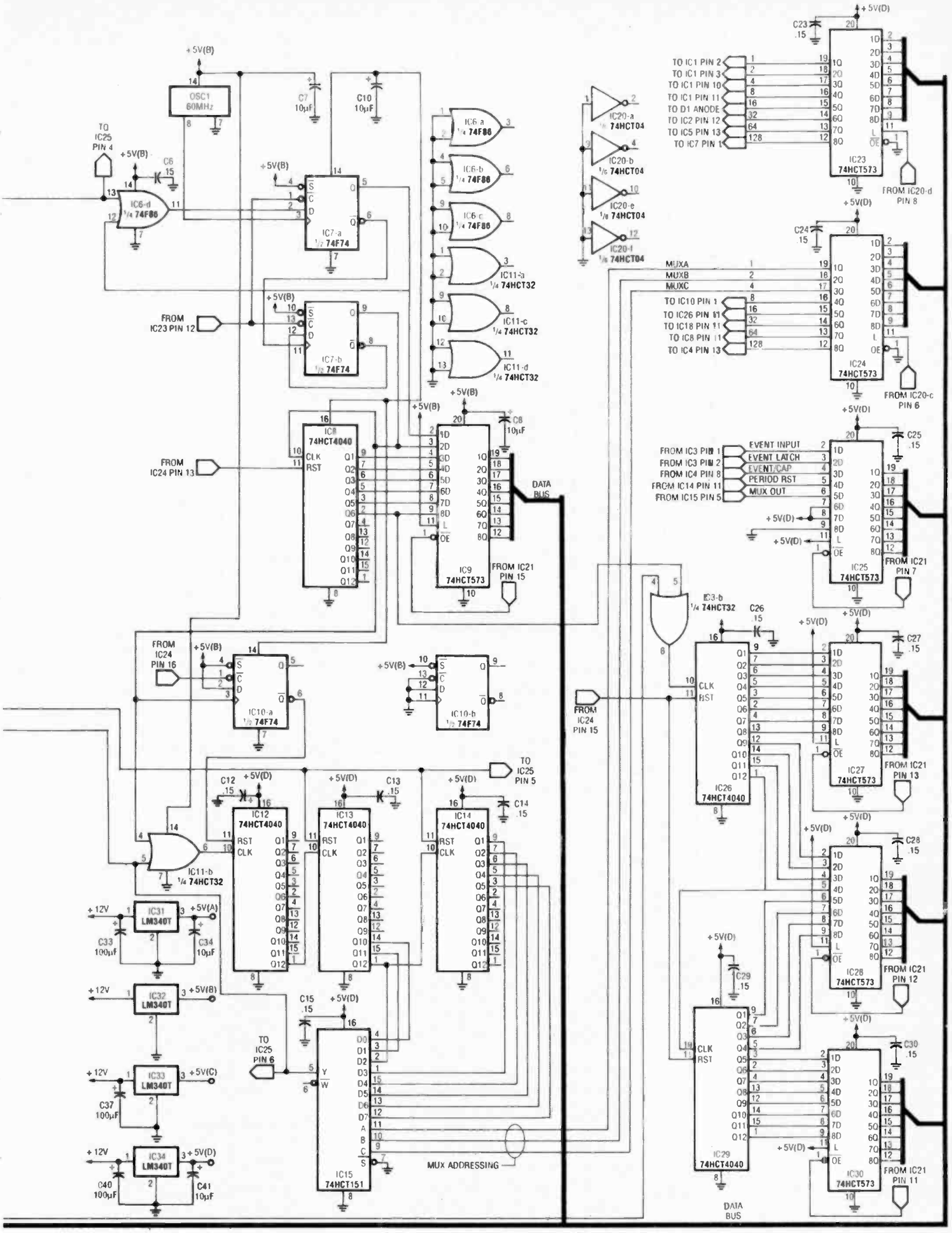


FIG. 2—T1001 SCHEMATIC. A 3-to-8 line decoder (IC21) produces the read function chip selects within the T1001 by decoding three binary lines and producing a low on one of eight output lines.


OSC1 60MHz
IC6-a 1/4 74F86
IC6-b 1/4 74F86
IC6-c 1/4 74F86
IC6-d 1/4 74F86
IC7-a 1/2 74F74
IC7-b 1/2 74F74
IC8 74HCT4040
IC9 74HCT573
IC10-a 1/2 74F74
IC10-b 1/2 74F74
IC11-a 1/4 74HCT32
IC11-b 1/4 74HCT32
IC11-c 1/4 74HCT32
IC11-d 1/4 74HCT32
IC12 74HCT4040
IC13 74HCT4040
IC14 74HCT4040
IC15 74HCT151
IC20-a 1/6 74HCT04
IC20-b 1/6 74HCT04
IC20-e 1/6 74HCT04
IC20-f 1/6 74HCT04
IC23 74HCT573
IC24 74HCT573
IC25 74HCT573
IC26 74HCT4040
IC27 74HCT573
IC28 74HCT573
IC29 74HCT4040
IC30 74HCT573
IC3-b 1/4 74HCT32
IC31 LM340T
IC32 LM340T
IC33 LM340T
IC34 LM340T
DATA BUS
MUX ADDRESSING
MUXA
MUXB
MUXC
EVENT INPUT
EVENT LATCH
EVENT/CAP
PERIOD RST
MUX OUT
TO IC1 PIN 2
TO IC1 PIN 3
TO IC1 PIN 10
TO IC1 PIN 11
TO D1 ANODE
TO IC2 PIN 12
TO IC5 PIN 13
TO IC7 PIN 1
TO IC10 PIN 1
TO IC26 PIN 11
TO IC18 PIN 11
TO IC8 PIN 11
TO IC4 PIN 13
FROM IC3 PIN 1
FROM IC3 PIN 2
FROM IC4 PIN 8
FROM IC14 PIN 11
FROM IC15 PIN 5
FROM IC20-d PIN 8
FROM IC20-c PIN 6
FROM IC21 PIN 7
FROM IC21 PIN 13
FROM IC21 PIN 12
FROM IC21 PIN 11
FROM IC21 PIN 15
FROM IC23 PIN 12
FROM IC24 PIN 13
FROM IC24 PIN 16
FROM IC24 PIN 15
TO IC25 PIN 4
TO IC25 PIN 5
TO IC25 PIN 6
+5V(A)
+5V(B)
+5V(C)
+5V(D)
+12V

measurement. All of the sections initially disabled or cleared during the capacitance test are treated the same way here. The event input is secured by D1 and R3 when it's not in use. When the anode of D1 is brought low, control is given to the Event Pulse input so that a pulse can be measured. If the pulse to be measured is positive-going, IC2-d is pulled high. If the pulse to be measured is negative-going, IC2-d pin 12 is pulled low. That ensures that any pulse leaving IC2-d pin 11 will be negative-going. Next, a byte is sent to IC23 and IC24 to release IC5-b, IC7-a, IC7-b, IC8, IC26, and IC29 from their reset modes.

A positive-going START pulse, which tells the circuit producing the event to begin, is sent out. The input pulse enters IC2-d pin 13, and a negative-going pulse leaves IC2-d pin 11 and goes to IC4-b pin 9, and the counters begin counting. Flip-flop IC5-b watches for the event pulse to end; when the pulse ends (a rising edge is detected), IC5-b pin 9 goes high, disabling the Event section. That provides noise immunity by passing only the first pulse received. Because the pulse has ended, IC6-d pin 13 goes high, indicating that it is time to read back the final count. The period can then be determined with the formula described earlier.

Measuring a frequency

As in the other two processes, a set of initial conditions must be established. First bytes will be sent to IC23 and IC24 to disable IC1-a, IC1-b, IC2-d, and IC5-b. All counters will be reset as before and IC4-b pin 13 is pulled low to ensure that when IC7 is released from the reset mode it will be free-running.

The period section consists of IC3-d, IC10, IC11-b, IC12, IC13, IC14, and IC15. Once released from reset, IC7 produces a CLOCK pulse which is applied to IC10-a and IC11-b. That part, IC11-b, is the clock enable/inhibit gate that supplies IC12 with clock pulses. A 74HCT4040D 12-bit counter, IC12, ripple-carries to another counter, IC13, which ripple-carries to the last counter in the period section, IC14.

Eight channels from a 74HCT151D 8-channel multiplexer, IC15, are connected to eight of the counter outputs. The multiplexer output channel is connected to IC11-b, IC3-d, and pin 6 of IC25, a 74HCT573D octal latch. Pin 6 of IC25 is a read-back line for determining when the period has ended.

The operation of the Period section is as follows: IC7-a, IC10-a, IC17, and IC18 are all released from reset. IC7-b produces a 15-MHz clock signal that is fed to IC10-a and IC11-b. When the first rising edge reaches the clock input of IC10-a, pin 6 of IC10-a goes low. That releases IC12, IC13, and IC14 from reset. Prior to that event, all the counter, or "Q" outputs were low due to the reset condition. At this time, IC11-b has a low on pin 5 and a clock signal on pin 4. That produces a clock signal on IC12 pin 10.

Since the counters are no longer in a reset condition, they go into a free-running mode. Eventually, the multiplexer line currently selected is fed a high condition. The high is fed to IC11-b, IC3-d, and IC25 pin 6. When pin 6 of IC11-b goes high, it inhibits IC12, IC13, and IC14. The output of IC3-d was high before the reset was removed, low after reset and before the counter went high, and high after the counter went high. If IC3-d produces a high, then IC16-c is an inverter and consequently IC17-b is inhibited. If IC3-d is low, then IC16-c is a buffer and IC17-b is enabled. In other words, during the time when the counters are not in reset, but prior to the counter output being fed back to IC3-d, the frequency being measured is allowed to clock IC17, IC18, IC26, and IC29. The length of the period is determined by the counter output, or "Q" that is allowed to pass through IC15.

The T1001 was designed to produce eight different timebases between 0.1 and 20 seconds. The period of any given timebase can be determined by calculating the amount of time it will take for the target "Q" to go high at the given clock rate. That method is not as exact as it could be, due to propagation delays. The preferred calibration method is obtained by working backwards. You input a relatively high, known frequency into the counter input and start a period. Once the count is read

FRONT-END PARTS LIST

Resistors
R1—33 ohms, 16-pin DIP resistor
R2—2200 ohms, 10-pin SIP resistor
R3—1000 ohms, 10-pin SIP resistor
Capacitors
C1–C7—0.15 µF, 50 volts, monolythic or polystyrene
C8–C11, C20–C28—1500 pF, 63 volts, polystyrene
C12–C19—220 pF, 100 volts, ceramic disc
Semiconductors
IC1—74LS573D octal latch
IC2—74LS688D 8-bit magnitude comparator
IC3—74LS245D octal transceiver
IC4—74LS02D quad 2-input NOR gate
IC5, IC6—octal buffer
IC7—74LS08D quad 2-input AND gate
Other components
J1—16-pin male header
J2—18-pin male header
J3—Right-angle PC-mount male DB25 connector
Miscellaneous: 17 shorting blocks (for J1 and J2), solder, etc.

ORDERING INFORMATION

Note: The following items are available from TSW Electronics Corp., 2756 N. University Drive, Suite 168, Sunrise, FL 33322 (305) 748-3387:

- **I1000 kit—$65.00**
- **I1000 PC board only—$35.00**
- **I1000, assembled and tested—$77.00**
- **6-foot interface cable (DB-25-6)—$12.95**
- **T1001 kit (includes PC board, all listed parts, project case, and preassembled front and rear panels—$149.00**
- **T1001 PC board only—$49.00**
- **T1001, assembled and tested—$179.00**
- **T1001 software (included free with T1001 order)—$10.00**
- **Capacitor kit (unmeasured)—$21.00**
- **Capacitor kit (measured to within 1%)—$26.00**

Add $5.00 S&H to any order. Check or money order only.

back, the period in seconds is equal to the count divided by the frequency. In that way you can determine the exact period, propagation delays included. Once you have mapped out the exact value of all eight periods, you can save them to disk and reverse the equation so that the frequency is equal to the count divided by the period.

Construction

To build the T1001 peripheral, a PC board is recommended. You can either buy a PC board from the source mentioned in the Parts List or make your own from the foil patterns we've provided. Note that the parts for the Front End are contained on the T1001 board shown with a dark line around them. There is also a separate Parts List for the Front End. Do not confuse the two lists of parts, or where they go on the board. Install parts on the board as shown in Fig. 3. Also, for many of the capacitors, notice that there are three holes on the board, with two of them electrically the same. The holes accommodate capacitors of different sizes. Use the pair of holes that best fits the capacitors you use.

The frequency-input BNC connector (J1) must be wired to the board as shown in Fig. 3 with shielded cable. Binding posts J2–J4 are connected to the board with insulated stranded wire. For testing capacitors, "spring jacks" (J5–J7) allow quick insertion and re-

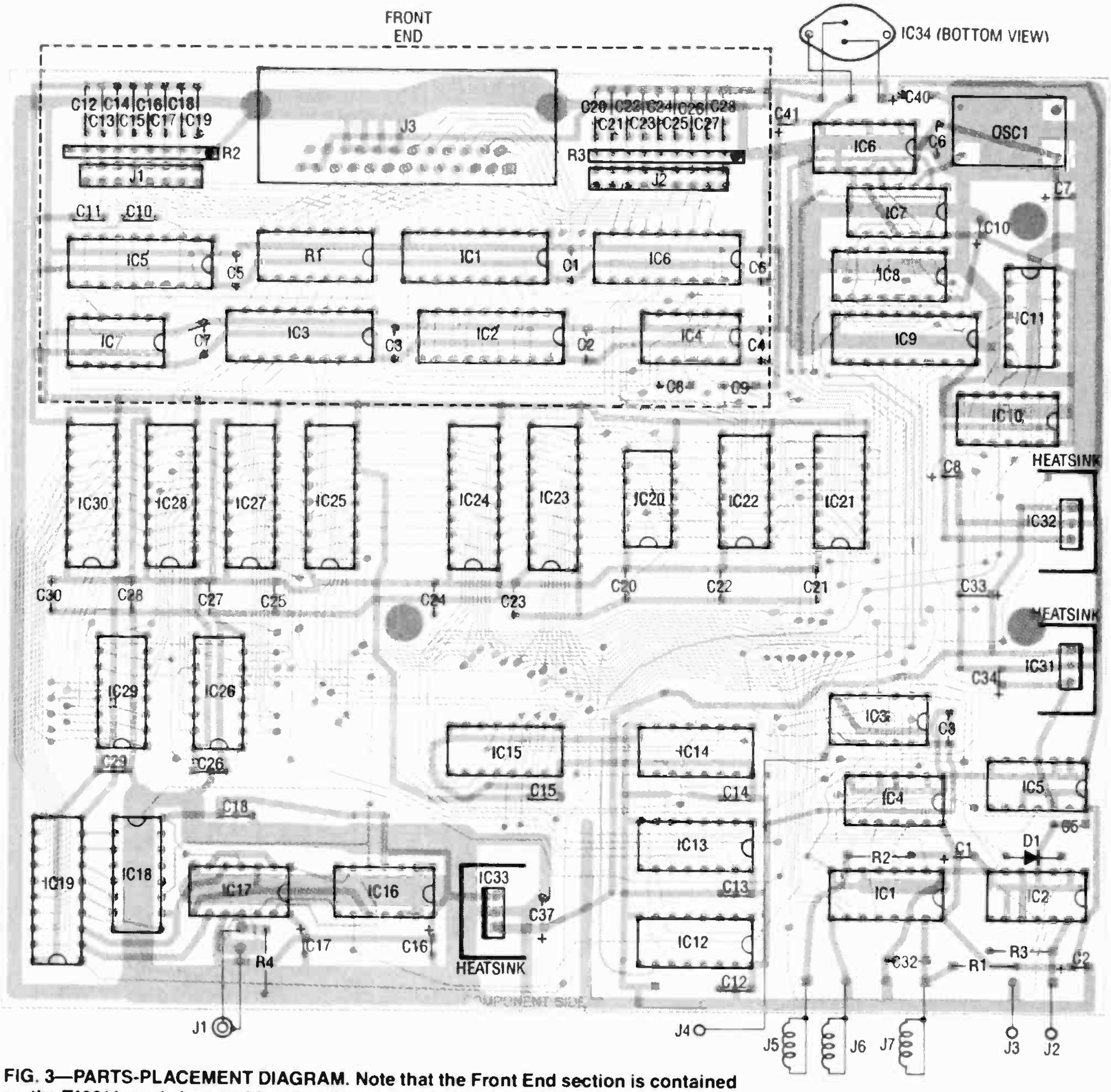


FIG. 3—PARTS-PLACEMENT DIAGRAM. Note that the Front End section is contained on the T1001 board shown with a dark line around it. There are separate Parts Lists for the sections, so be sure not to confuse them. (The extra holes where capacitors are mounted are for accommodating capacitors of different sizes.)

moval of test capacitors, as well as easy paralleling of capacitors to achieve any desired value. The spring jacks are simple springs bent in a semicircle, attached to the front panel with a screw at both ends, and connected to the PC board with insulated stranded wire. There is one spring jack for large-value capacitors (J5), one for small-values (J7), and a common one for ground (J6).

However, a problem with the spring jacks is that a spring is an inductor, and the measured capacitance would vary depending on how the capacitor is inserted into the springs. Therefore, a fine-gauge shunting wire must be "woven" around the back edge of each spring and soldered to the jumper wire that connects the spring jack to the board.

Making spring jacks can be difficult and tedious for the average do-it-yourselfer. Therefore, anyone who purchases a complete kit for the T1001 will receive a preassembled front panel—it's drilled, silkscreened, and all the jacks, including the three springs, are mounted on it. To save yourself a lot of hassle if you're not buying the kit, you can use any kind of capacitor test jacks such as binding posts or alligator clips.

Four voltage regulators are used in the T1001: IC31–IC34. Three of them (IC31–IC33) are LM340T's in a TO-220 case, and the proper heatsink should be attached to each of them. The fourth regulator (IC34) is an LM340K in a TO-3 case. That regulator must be mounted on the back panel of the T1001 case, also with an appropriate heatsink, and hardwired to the board. Figure 4 shows the completed T1001 board.

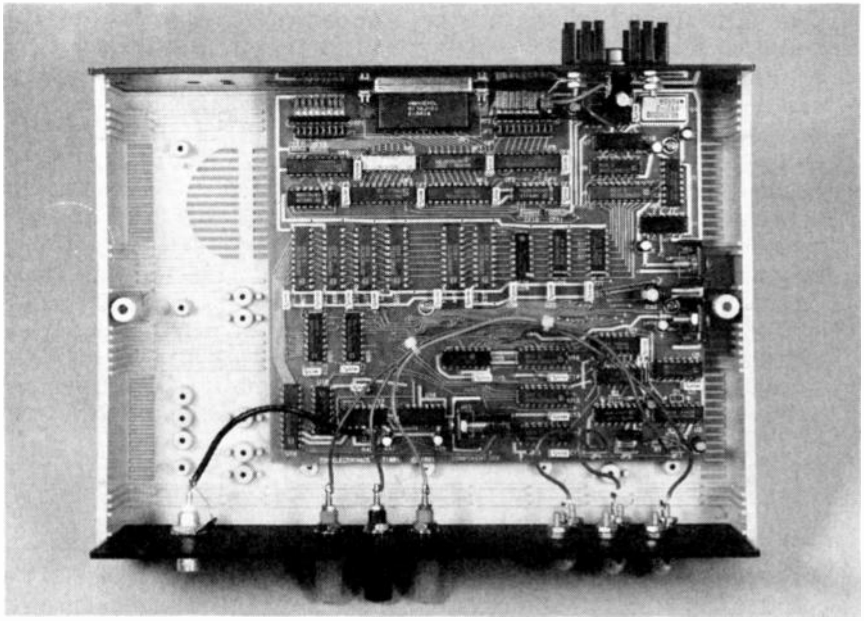


FIG. 4—COMPLETED T1001. A preassembled front panel is included with the purchase of a T1001 kit.

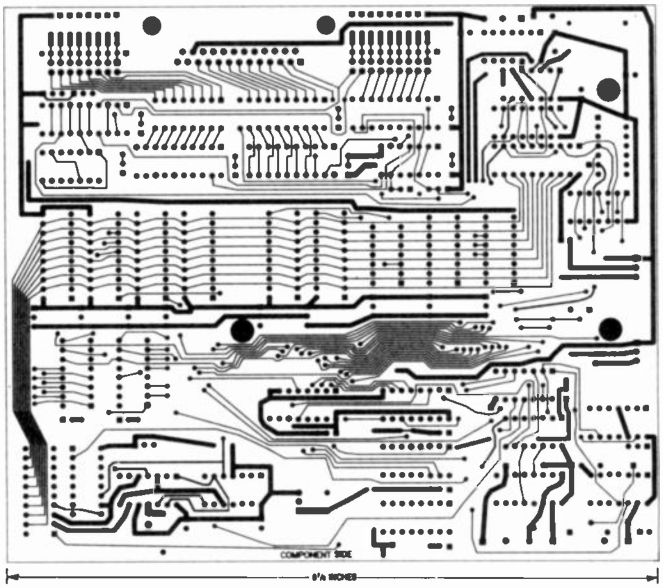
Software

Each peripheral, including the I1000 itself, has its own software program to control its own operation. All of the programs end up in one directory as you add more peripherals. Software for the I1000 and the entire series of peripherals, including the T1001, can be downloaded all at once from the RE-BBS (516-293-2283, 1200/2400, 8N1) as a self-unarchiving zip file called I1000.ZIP. Both compiled and uncompiled software is included. Software is included free with the purchase of any peripheral from the source mentioned in the Parts List. (Software can also be purchased from that source if you're not buying anything else from them and you have no way of downloading it from the RE-BBS.) Before you can do anything with the I1000 system, the software must be installed in your computer. To do that, type "install" and then hit Enter, and follow the instructions you are given.

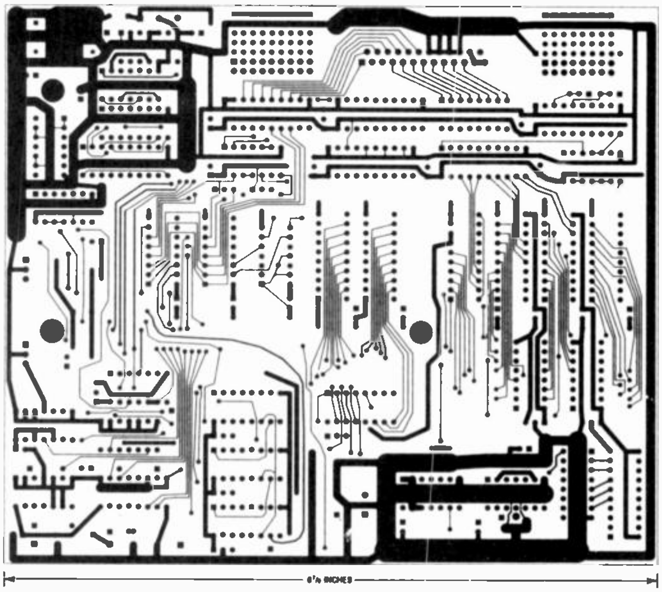
Operation and calibration

Before installing the I1000 card in your computer, the card must be calibrated. To calibrate the I1000, you'll need a dual-trace oscilloscope capable of measuring a 400-nanosecond pulse, two ×1 probes, and a non-metallic alignment tool. Set both oscilloscope channels to 2 volts/division, the timebase to 0.2 microseconds/division, the trigger slope to negative (−), and then set the sync source to channel 1.

Power down your computer,



COMPONENT SIDE of the T1001 board.



SOLDER SIDE of the T1001 board.

install the I1000 card, and connect the scope's ground lead to the I1000's metal mounting bracket. Attach the channel-1 probe to TP11 and channel 2 to TP5. Boot your computer and change directories to \TSW. Type "CALI1000" and press Enter. Press the space bar until the status line indicates "WRITING." Adjust the trigger level of your scope until you are in sync with channel 1. Adjust R12 until the waveform on channel 2 is centered within the waveform on channel 1. Move the channel-1 probe from TP5 to TP7. Press the space bar until the status line indicates "READING." Adjust R13 until the waveform on channel 2 is centered within the waveform on channel 1. Move the channel-2 probe from TP7 to TP9. Adjust R14 until the waveform on channel 2 is centered within the waveform on channel 1. Power down the computer and remove the probes; the I1000 is now fully calibrated.

All three functions of the T1001 peripheral must also be calibrated. When the system is up and running, the main, or "TSW" menu allows you to choose between the different functions of the peripheral. First choose the frequency-counter option, and you'll then be presented with the frequency-counter menu as shown in Table 1; pressing the keys shown on the right side will execute the functions shown on the left side.

TABLE 1—FREQUENCY

Function	Press
Units (Hz, etc.)	U
Quit	Q
Main menu	M
Direct	D
Timebase	↑ ↓
Calibrate	C

Connect the counter input to a known reference frequency, and make sure that frequency is displayed on the screen. Press "C," and answer "Y" to activate the calibration. After you are asked what frequency (in hertz) you are using for calibration, type it in and press Enter. The computer will take care of the rest.

The event/period menu is shown in Table 2. Again, pressing "C" activates the calibration mode. You will be asked to enter the number of nanoseconds needed to calibrate the period being displayed. The value you enter will be saved to disk and used in all subsequent readings. To remove the calibration offset, press "C" and enter a zero.

The capacitance-meter menu is shown in Table 3. Pressing "C" and answering "Y" from that menu activates the capacitance calibration process. You will then be asked to insert various known-value capacitors and press a key. The calibration capacitors required are shown in Table 4. The more precise the values of the calibration capacitors, the more precisely calibrated the T1001 will be. A package of the capacitor listed in Table 4 is available from the source mentioned in the Parts List.

TABLE 2—FREQUENCY

Function	Press
Units (μs, etc.)	U
Quit	Q
Main menu	M
Positive	P
Negative	N
Handshake toggle	H
Calibration	C

TABLE 3—CAPACITANCE

Function	Press
Units (uF, etc.)	U
Quit	Q
Main menu	M
Large cap test	L
Small cap test	S
Zero	Z
Direct	D
eXit zero or direct	X
Calibrate	C

TABLE 4—CAPACITORS

5 pF	.47 μF
10 pF	1.0 μF
47 pF	4.7 μF
100 pF	10 μF
470 pF	47 μF
1,000 pF	100 μF
4,700 pF	470 μF
.01 μF	1,000 μF
.047 μF	4,700 μF
.1 pF	10,000 μF

The I1000/T1001 pair should now be completely calibrated. With that and your computer, you're well on your way to having a versatile computer-controlled test bench. R-E

WHAT'S NEWS

continued from page 6

parks. Several days before the broadcast, a portable Switched 56 "traveling case" is sent to the ballpark's technician. Somewhat larger than a briefcase, the case contains a modem, a codex, a digital service call-up unit, the power supply, and a power cord. The unit's AC power line and input and output connections are plugged in, and a MCI's phone number is dialed.

The equipment converts the analog voice signal to digital data for transmission to the CBS studios in New York where the broadcast is mixed and commercials are added. The finished product is than digitally transmitted (uplink) to a satellite for retransmission (downlink) to all CBS network and affiliate stations, which convert the digital data back to an analog broadcast signal. Because the equipment is full duplex, the Switched 56 also carries two-way communication between New York and the broadcast site.

CBS made use of the Switched 56 system at the NCAA Basketball Tournament, the Masters Golf Tournament, and for live news coverage of the New Hampshire presidential primary. CBS affiliate, KMOX in St. Louis, will broadcast half of its Cardinals games with the system.

Correcting soil contamination

According to Sandia National Laboratories, heavy-metal contamination of soil and ground water is a widespread problem for the nation. Sandia says the problem is particularly serious at the Department of Energy's weapons complex. The Albuquerque, NM, laboratories are studying electrokinetics as one possible technique for the direct removal of such contaminants from soil waters.

In the electrokinetic technique, electrodes are implanted in the soil, and a direct current is passed between the electrodes. This has two effects: First, ions in the soil-water solution begin to migrate toward the oppositely charged electrode—a process called electromigration. Second, and at the same time, soil-water begins to flow toward the cathode—a process called electro-osmosis.

The combination of those two effects can cause contaminant ions to move toward one electrode or the other, promising in-place removal of contaminants from the soil. The contaminants are actually removed by one of sseveral methods, including electroplating at the electrode. Thje other methods are precipitation or co-precipitation at the electrode, and pumping or ion-exchange of water near the electrode.

Both electrokinetics and electoosmosis have been tried for increasing the density and solidifying slurries, and to to extract water from liquefied soils, paper mats, and concrete. More recently electro-osmosis has removed heavy metals and soluble organic contaminants from saturated clays in laboratory experiments.

Sandia is now trying to learn more about electrokinetic remediation and to evaluate the kinds of contaminants and soil conditions that are appropriate candidates for that remediation. The issues being evaluated are: the removal of heavy metals with complex redox chemistry, the effectiveness of the process in partially saturated soils, the effects of mixed soils on the process, and methods for scaling the process up to practical field applications.

FCC allocates radio-spectrum space for interactive TV

The Federal Communications Commission on January 16 voted unanimously to allocate a portion of the radio spectrum for interactive video and data services (IVDS) use, paving the way for a new wireless broadcast industry in interactive television, which will allow consumers to shop, bank, and pay bills directly through their television sets, without requiring a telephone line or computer. The action was a result of a petition filed in 1987 by TV Answer (**Radio-Electronics**, February 1992).

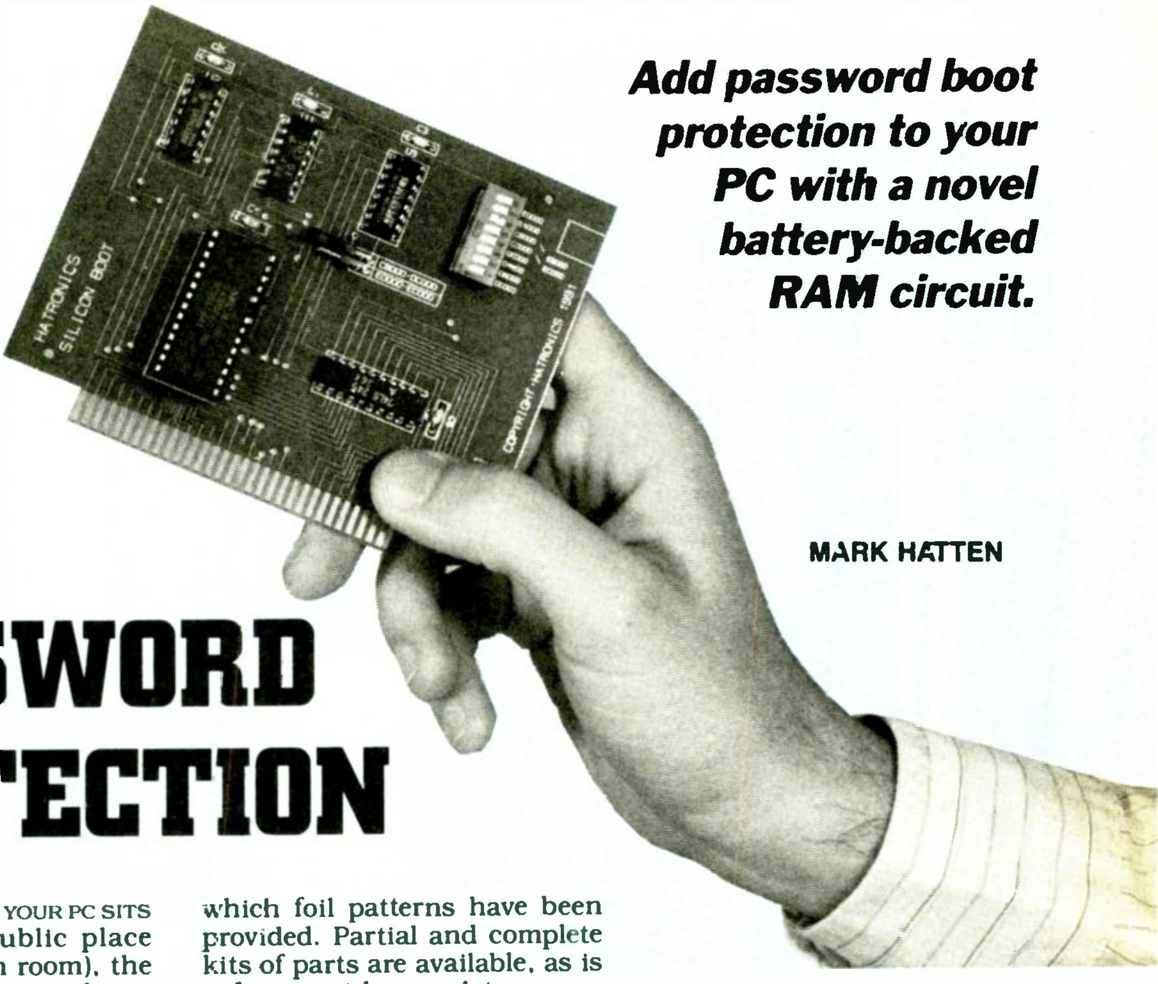
The FCC, which will allocate one megahertz in the 218–219-MHz band for use by companies providing IVDS services, is expected to issue the first IVDS licenses by the end of this year.

Updated area-code plan

Since area codes were first introduced in 1947, they've had "0" or "1" as the middle digit, indicating to the switch that a long-distance call is being made. With only two of the original 144 codes still available, we're in imminent danger of "running out" of area codes in the near future. A plan mapped out by Bellcore's North American Numbering Plan (NANP) Administration (Livingston, NJ) describes how new area codes can be distributed. The proposed two-part strategy is designed to meet telecommunications numbering needs at least through the first quarter of the 21st century by allowing the numbers "2" through "9" to be used as the middle digit.

The plan is the backbone of the NANP Administration's long-range "Proposal on the Future of Numbering in World Zone 1," which has been distributed to more than 3000 telephone companies, manufacturers, governments, and other interested parties in the World Zone 1—the United States, Canada, and 16 Caribbean countries—where Country Code 1 is the international-dialing designation. Under the plan, 300 new area codes will be assigned to specific geographic areas, tripling the number now available. Ninety more codes will be reserved for non-geographic uses: 80 for personal communications and 10 for special-purpose service access codes such as today's 800 or 900 codes. The remaining codes will be allocated for future growth and as-yet-unidentified future needs. The plan predicts that eventually all calls made in World Zone 1 will require ten digits.

Bellcore's NANP Administration, a small group that has the responsibility for administering the scarce telecommunications numbering resources for all countries in World Zone 1, works closely with local telephone companies that manage local telephone exchanges. After hearing industry comments, the NANP Administration will reissue the proposal by the end of the year. Once consensus has been reached, further study of the steps needed to achieve the plan's long-term goals will begin. **R-E**



Add password boot protection to your PC with a novel battery-backed RAM circuit.

PC PASSWORD PROTECTION

MARK HATTEN

IS YOUR DATA SAFE? IF YOUR PC SITS unsecured in a public place (your office or dorm room), the data in it is liable to theft—or destruction. Network servers and some new PC's contain built-in password boot protection. But what do you do if you've got an older, unprotected machine?

This article presents a simple, inexpensive circuit that allows you to add password boot protection to any PC with an empty 8-bit expansion slot. Every time you boot with the board installed, software on the board gives you three tries to enter the correct password. If you don't guess correctly in three tries, you'll have to perform a cold reboot and try again.

An interesting feature of the circuit is that it is built with a battery-backed static RAM (SRAM), rather than an EPROM, to hold the code. A benefit of that arrangement is that you can use the circuit to develop and test your own PC BIOS extensions much more conveniently than with a traditional EPROM burn/test/erase cycle.

All circuitry fits on a short 8-bit PC expansion card, for which foil patterns have been provided. Partial and complete kits of parts are available, as is software with complete source code. A tested and assembled unit is available for less than $60.

Circuit theory

A well-known feature of common static RAM's (SRAM's) allows them to maintain their contents when power goes off. If the $\overline{CS}$ line is held within 0.2 volt of V_{CC} when power goes down, and a suitable battery is connected to $\overline{CS}$, RAM contents will be maintained. Design of the switching circuitry can be tricky, but a special device called a *SmartSocket* has both the necessary smarts and a built-in backup battery. A static RAM, a SmartSocket, some simple address decoding circuitry, and a few software tricks can thus add password protection to your PC.

Figure 1 shows the complete circuit. Jumper JU1 selects either the inverted on the non-inverted address line, A17, which in turn selects a base address for the circuit of either C000 or E000, respectively. Decoder IC3, a 74LS138, then chooses one of eight 16K starting addresses within that range (e.g., C000, C400, C800, . . . EC00). The selected output of IC3 then drives the SmartSocket's $\overline{CS}$ line directly. Other than that, IC2-a, IC2-b, and IC1-d buffer memory-read and -write lines $\overline{MEMR}$ and $\overline{MEMW}$, respectively, determine the direction of data through 8-bit bidirectional buffer, IC5. Writing data to the device at a given address is as simple as exercising the $\overline{MEMW}$ line. (For additional security, you might wish to add a "write-protect" jumper between pin B11 of the PC expansion bus connector and pin 6 of IC2-b.—*Editor*)

ROM BIOS extensions

The software is a little bit trickier, but still straightforward. When a PC is turned on, it executes a program in ROM called the Power-On Self-Test, or POST. Depending on the type of BIOS in your machine, the POST can test various systems

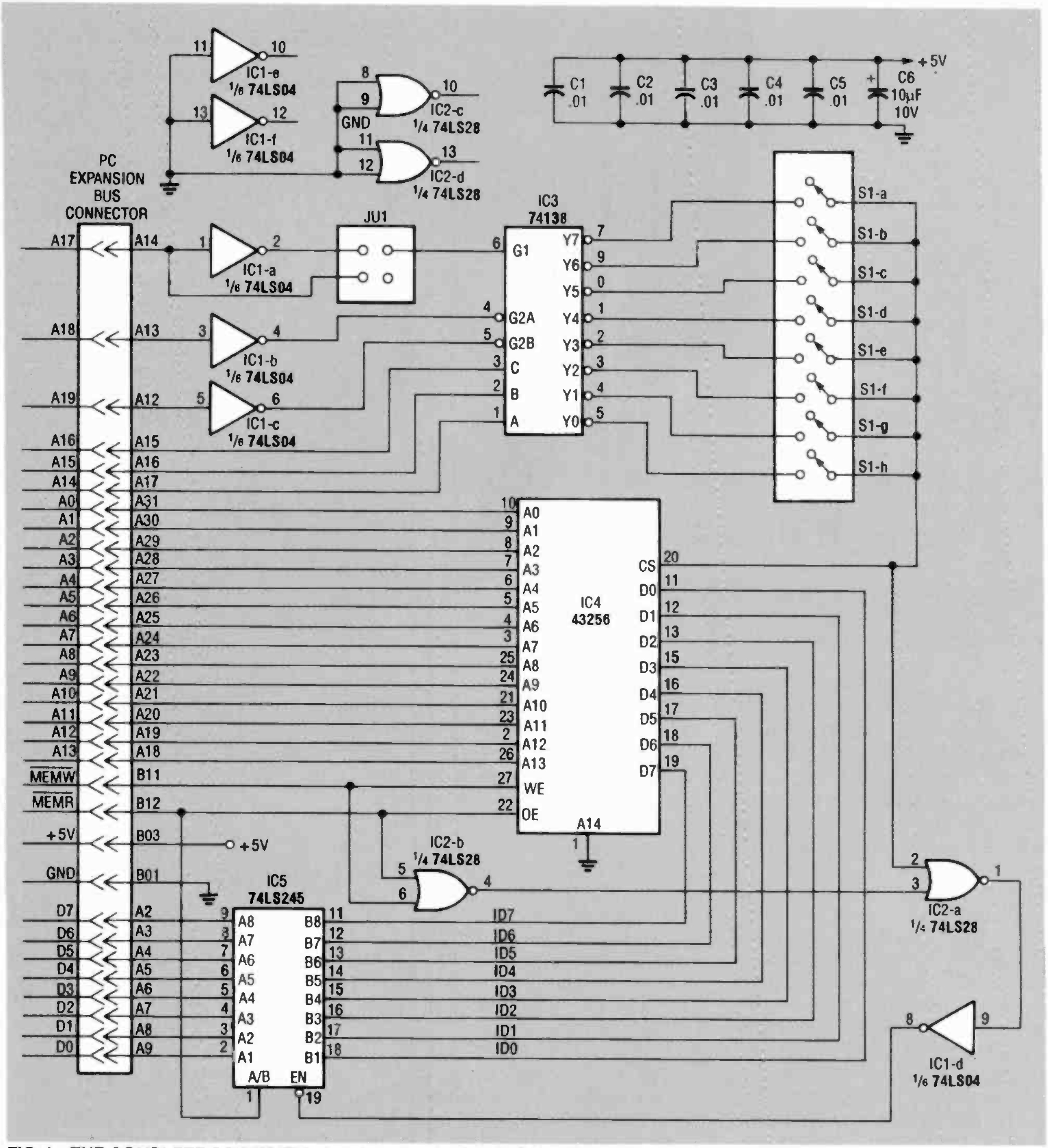


FIG. 1—THE COMPLETE SCHEMATIC reveals a simple circuit. Gates IC1-a, IC1-b, and IC1-c, along with 1-of-8 decoder IC3, and jumper JU1 decode a 16K address space for IC4, a 32K static RAM. The SRAM mounts in a "SmartSocket," which provides battery backup with automatic switchover.

such as RAM, DMA, and timers. The POST also does something called a *ROM scan*. The purpose of the ROM scan is to locate peripheral devices with on-board ROM, give them a chance to initialize themselves, and link themselves into DOS. Many video adapters and hard-disk controllers link ROM's in that manner.

The PC BIOS identifies a ROM extension by way of a two-byte "signature" (55h, AAh) that appears in the first two ROM addresses. The third byte indicates the number of 512-byte blocks in the ROM that contain code. (The number of blocks can be smaller than the overall size of the ROM.) The last byte in the specified number of blocks contains a checksum of all bytes contained in those blocks. The PC calculates the checksum by summing all the bytes in the specified blocks, then subtracting the result from 100h. If the calculated value equals the value stored in the last byte, the BIOS makes a far call and begins executing code at byte four. Typically, code there initializes some attached peripheral device, "hooks" itself into DOS via one or more interrupts, and

PARTS LIST

IC1—74LS04, hex inverter
IC2—74LS28, quad dual, input NOR gate
IC3—74LS138, 1-of-8 decoder
IC4—43256-100, 32K × 8 static RAM, 100 ns
IC5—74LS245, octal transceiver
S1—8-position SPST DIP switch
C1–C5—0.01 μF, bypass
C6—10 μF, 16 volts, electrolytic
Miscellaneous: SmartSocket for IC4, header pins, IC sockets, PC board.
Note: The following parts are available from Hatronics, 145 Lincoln St., Montclair, NJ 07042:
- **Bare board—$17**
- **Kit of parts (not including SmartSocket)—$27**
- **Assembled and tested unit—$55**

All orders include software on floppy disk. Add $3.00 shipping and handling to all orders. NJ residents add appropriate sales tax. COD, money order, or personal check only.
Note: The SmartSocket is available from Dallas Semiconductor (4401 South Beltwood Parkway, Dallas, TX 75244-3292, 214-450-0448), and from American Design Components (400 County Avenue, P.O. Box 2601, Secaucus, NJ 07096-2601).

then returns control to the BIOS by means of a far return instruction.

There are several ways to write a ROM BIOS extension. Probably the simplest is to use assembly language. One catch is that a normal .EXE file precedes a file with a 512-byte header that is not used in ROM extensions. So, before dumping code to our device, the first 512 bytes of the file must be removed, and then the modulo-100h checksum must be calculated from the result.

Utilities

All software discussed in this section is contained in a self-extracting archive file (PASSWORD.EXE) that you can download from the RE-BBS (516-293-2283, 8N1). You'll need about 100K of disk space to unpack the file. Software is also available from the author. All source (in Microsoft C and assembler) and executable files are included.

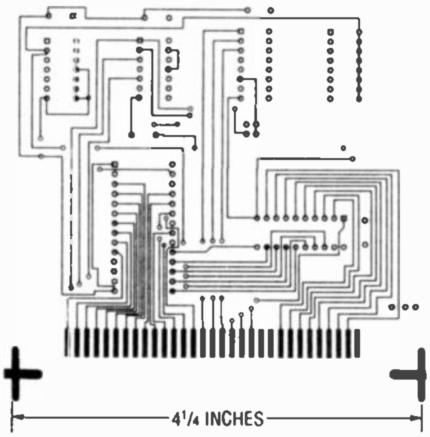
The software includes several utilities; most have a command-line interface of the form:

```
C>UTILNAME HEXADDR
```

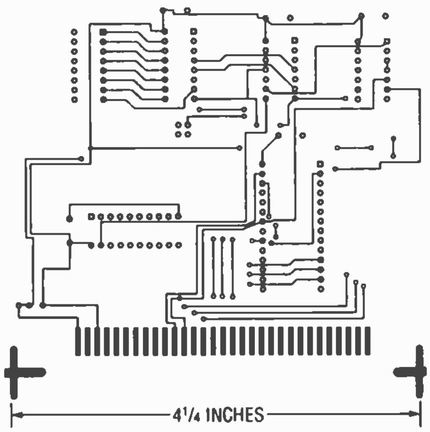
where UTILNAME is the name of the utility, and HEXADDR is the hexadecimal segment address at which the board is installed (C800, CC00, . . . EC00). Note that although the decoding circuit supports addresses starting at C000, to avoid potential conflicts the software only allows starting addresses of C800 and higher.

The utilities all work in a similar manner. Typically, a program first verifies that the user has entered a valid address on the command line. If not, the program terminates; otherwise, it reads some data from the keyboard or a disk file one byte at a time, then writes that data to the appropriate area on the board using normal C pointer arithmetic.

The first two utilities allow you to enable and disable the board. DISABLE.EXE works by overwriting the first byte of the ROM with 00h, which prevents



COMPONENT SIDE shown half size.



SOLDER SIDE shown half size.

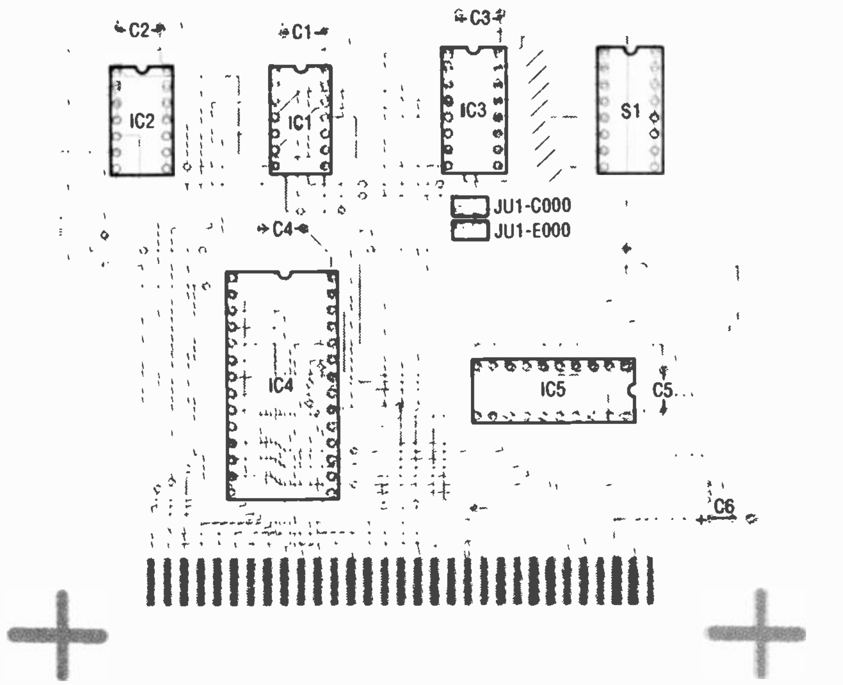


FIG. 2—MOUNT ALL COMPONENTS as shown here. Mount the SmartSocket at IC4; use header pins and a jumper at JU1.

the BIOS from recognizing the remainder of the ROM. Conversely, ENABLE.EXE works by restoring the first byte of the ROM to 55h.

SETPASWD.EXE allows you to set the password that must be entered when booting your PC. The password can have a maximum of 15 characters. After obtaining a new password from the user, the program writes it to the SRAM, then calculates and installs a new checksum.

INSTROM.EXE enables you to install the contents of a disk file in the SRAM board. Syntax for the command is:

```
C>INSTROM FILENAME.TYP
HEXADDR
```

where FILENAME.TYP represents a file and HEXADDR again represents the installation address.

Of course you can't install just *any* file; it must conform to the format outlined above. Listing 1 shows how the password protection software works. Note first that the software is ORGed to byte 03h of the program. At location 03h, the program calls the main routine. Following that call is a far return, coded as a define byte (CBh). Following the far return comes the password, then a byte (COUNT) that specifies the number of tries the input routine will accept.

Then comes the main routine. First, it sets up the keyboard, then it checks whether the first byte of the password equals 00h. If so, the routine simply terminates; otherwise it continues by displaying a sign-on message. It then goes into a loop that collects a CR-terminated password from the user, and checks it against the stored password. If the user does not enter the correct value within three tries, the program disables the keyboard and goes into an endless loop, forcing the user to reboot.

LISTING 1—ASSEMBLY SOURCE

```
        PAGE    ,132  ;@ (CTRL-OH)   IBM PC PRINTER CONDENSED MODE

        TITLE   security password

CSEG    SEGMENT PARA PUBLIC 'CODE'

        ASSUME CS:CSEG,DS:CSEG,SS:CSEG,ES:CSEG ;ALREADY SET BY DOS LOADER

        INCLUDE                 DISPLAY1.MAC
              org  03h
;BIOS ROM SIGNATURE

TOP:                    call main
_RETFAR                 DB   0CBh


PASSWORD                DB      'avento',0Dh,'          '; password


NEWWORD                 DB      16 DUP(?)
count                   DB      3

MAIN                     PROC near

                STI
                MOV AL,00h                              ;set keyboard int
                OUT 21H,AL                              ;
                MOV AL,20h                              ;
                OUT 20H,AL                              ;
                MOV DX,0                                ;zero dx
                mov CX,0050h                            ;zero cx
                MOV DS,CX

                MOV BYTE PTR DS:count,03h               ;number of attempts var
                MOV AL,BYTE PTR CS:PASSWORD  ;GET FIRST BYTE OF PASSWORD
                CMP AL,00h                              ;CHECK FOR ZERO
                JE OKOUT                                ;IF SO CONTINUE WITH POST
                JMP OVERIT                              ;IF NOT CONTINUE WITH THIS bios EXT
OKOUT:          RET



OVERIT:
    PRINTB<'********************************************',13,10>
    PRINTB<'*         PC SECURITY PASSWORD UTILITY         *',13,10>
    PRINTB<'*            COPYRIGHT HATRONICS               *',13,10>
    PRINTB<'*                 1991                         *',13,10>
    PRINTB<'********************************************',13,10>
    PRINTB<' ',13,10>
    PRINTB<'  PLEASE ENTER YOUR PASSWORD              ',13,10>
    PRINTB<'  FOLLOWED BY THE ENTER KEY              ',13,10>


 LOOP1A:        MOV BX,00h                              ;zero bx
 LOOP1:         CALL CI                                 ;get keyboard data
                CMP AL,0Eh                              ;
                JNE GOOD                                ;
                DEC BX                                  ;
                JE LOOP1                                ;
                                                        ;
                                                        ;
 GOOD:          CMP AL,0Dh                              ;check for CR
                JE  CHECK                               ;
                MOV BYTE PTR DS:NEWWORD[BX],AL          ;add to entered string
                INC BX                                  ;bump pointer
                JMP LOOP1                               ;more input
CHECK:          CALL CHECK1                             ;lets check password
                CMP DX,1                                ;if 1 then good passwd
                JE OK                                   ;continue bio scan
                CMP CL,0                                ;if zero no more
                JE loop3                                ;chances
                JMP LOOP1A                              ;
                                                        ;
                                                        ;
loop3:          MOV AL,0FFh                             ;
```

Construction and use

We recommend using a PC board for this project. Use sockets for all IC's. You might want to use one for the SmartSocket (IC4) but doing so increases overall board height so it could interfere with adjacent cards.

After mounting all components, (Fig. 2) select a base address (C000 or E000) and install the appropriate header pin. Then select a starting address on S1 as shown in Table 1.

TABLE 1—PASSWORD ADDRESSING

JU1 Jumper	IC3 Output	IC3 Pin	PC Address
E000	Y0	15	E000
E000	Y1	14	E400
E800	Y2	13	E800
EC00	Y3	12	EC00
C000	Y4	11	D000
C000	Y5	10	D400
C000	Y6	9	D800
C000	Y7	7	DC00
C000	Y2	13	C800
C000	Y3	12	CC00

Remove power from your PC, insert the card in an empty expansion slot, then reboot. You haven't installed the software yet, so the board will not ask you for a password.

Copy the software to a directory on your hard disk. Then run INSTROM.EXE, specifying GENERAL.IMG as the file, along with your selected address. Then reboot. This time you should see a sign-on message and a request to enter your password. Enter the default password ("avento"), and you

```
                PRINTB<'  SORRY !!',13,10>       ;
                 OUT 21H,AL                       ;disable input
                 MOV AL,20h                       ;from keyboard
                 OUT 20H,AL                       ;
 FOREVER:        JMP FOREVER                      ;loop forever
                                                  ;
OK:             printb<'  Thank you',13,10>      ;
                ret                               ;
                                                  ;
                                                  ;
MAIN            ENDP                              ;
                                                  ;
                                                  ;
CHECK1          PROC  NEAR                        ;
                inc bx                            ;bump BX
                mov byte ptr DS:NEWWORD[bx],al    ;ADD CR to string
                lea di,DS:NEWWORD                 ;point to new
                lea si,cs:password                ;point to fixed passwd
                XOR AX,AX                         ;CLEAR  AX

loop2:          mov al,byte ptr DS:[di]           ;get byte newword
                mov ah,byte ptr cs:[si]           ;get byte password
                cmp ah,0Dh                        ;check for end of string
                je okword                         ;must be ok
                cmp al,ah                         ;do bytes match
                jne badword                       ;bad password
                inc si                            ;cycle password
                inc di                            ;cycle newpasswd
                jmp loop2                         ;check next byte
okword:         MOV DX,1                          ;a 1= success
                ret                               ;
badword:        PRINTB<'  TRY AGAIN !',13,10>    ;
                DEC BYTE PTR DS:COUNT             ;dec try count
                MOV CL,BYTE PTR DS:COUNT          ;get try count

                MOV DX,0                          ;a 0 = fail
                ret                               ;
CHECK1          ENDP                              ;
                                                  ;
                                                  ;
                                                  ;
                                                  ;
                                                  ;
;*********************************************************************
; Copyright (c) FOSCO 1989 - All Rights Reserved
;
; Module Name: Objex Library console input function
;
; Version: 1.00
;
; Author: FOSCO
;
; Date: 5-1-89
;
; Filename:ojci.asm
;
; Language: MS MASM 5.1
;
; Functional Description:
;
; Version History:
;
;*********************************************************************


; unsigned ci(void);

;       .model   small,c
;       .code

ci      proc  NEAR
        xor     ax,ax
        int     16h
        ret
ci      endp



CSEG                    ENDS
```

should be able to continue the boot process.

To use the board for your own BIOS extensions, use Listing 1 as a model; GENERAL.ASM is the corresponding source file. Assemble your code to create an EXE file. Then read that EXE file into memory using DEBUG. Determine the number of bytes the ROM image should contain, then write the file to disk starting from address 0100h. Listing 2 shows how to create a 2048-byte (0800h) ROM image by reading in a file called GENERAL.EXE and writing out a file called GENERAL.IMG.

LISTING 2—DEBUG SCRIPT

```
C>DEBUG GENERAL.EXE
-N GENERAL.IMG
-RCX
CX 0351
:0800
-W 0100
Writing 00800 bytes
-Q
C>
```

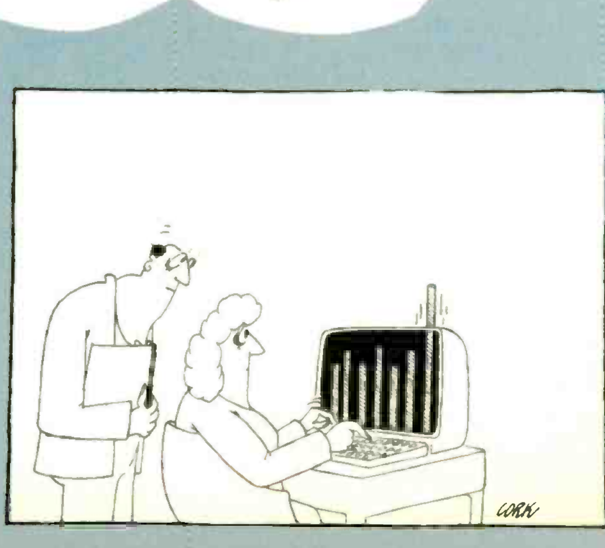
Creating ROM BIOS extensions is not easy. The techniques described here can greatly simplify the mechanics, enabling you to concentrate on the real programming task. **R-E**

THE FUNNY PAGE

"Well, it wasn't an antique radio when you started on it. You've just got to learn to work faster!"

"The question isn't what it does, it's what it's supposed to do."

"We'll never misplace the cordless phone again!"



CAR BATTERY TESTER

Build this simple meter to estimate your car battery's cranking amps.

THOMAS R. FOX

EVEN THE LATEST AND MOST SOPHISTICATED automobiles have an Achilles heel—the battery. Improvements in lead-acid batteries have been glacial compared with advances in the rest of the car—regardless of the country of origin. Recent advances in electronics have improved engine and emission control, made anti-lock braking affordable, and have put high-quality entertainment systems into the passenger compartment. Unfortunately, all of these improvements have added to rather than decreased the battery load.

If your car fails to start in your garage, it's usually just an aggravating situation. But if you stall out or can't get started at a vast shopping mall or, worse yet, out along an interstate, the situation becomes more serious. And if you're unfortunate enough to be caught in a crime-stricken urban area or on any highway at night, you could be facing danger. Getting help takes time and can be expensive even under the best of conditions. The point is that it pays to know that your battery is in top form—even more if it's not!

A weak battery is the most common cause of an automobile's failure to start. The battery remains the most failure-prone component in any automotive (and boat, for that matter) ignition system. A properly maintained engine can last for hundreds of thousands of miles, but few lead-acid storage batteries are at top performance for more than about three years. Even that time will be shortened if you live in a northern climate where your car is exposed to long winter cold "soaks" and hard starts.

Don't think that just because you bought a new battery last month that it's immune to failure. However, batteries rarely fail without such warning clues as occasional slow cranking. Unfortunately, many drivers are either unaware of these clues or, if they are aware, they put off recharging or replacing the battery until it is too late.

CRAE to the rescue

The CRanking Amp Estimator (CRAE) described here is a test instrument that will give you a reasonable estimate of your battery's power capacity. While CRAE is not a precision instrument, it will save you from being stranded in a hostile environment.

Both the graph of relative power vs. temperature (Fig. 1) and the GW BASIC listing (Listing 1) will, with a knowledge of the ambient temperature, give you a reliable estimate of your battery's cold-cranking ampere (CCA) rating. The BASIC program is capable of estimating the CCA of a battery at all normal ambient temperatures if the CCA at one temperature is known. Both Fig. 1 and the

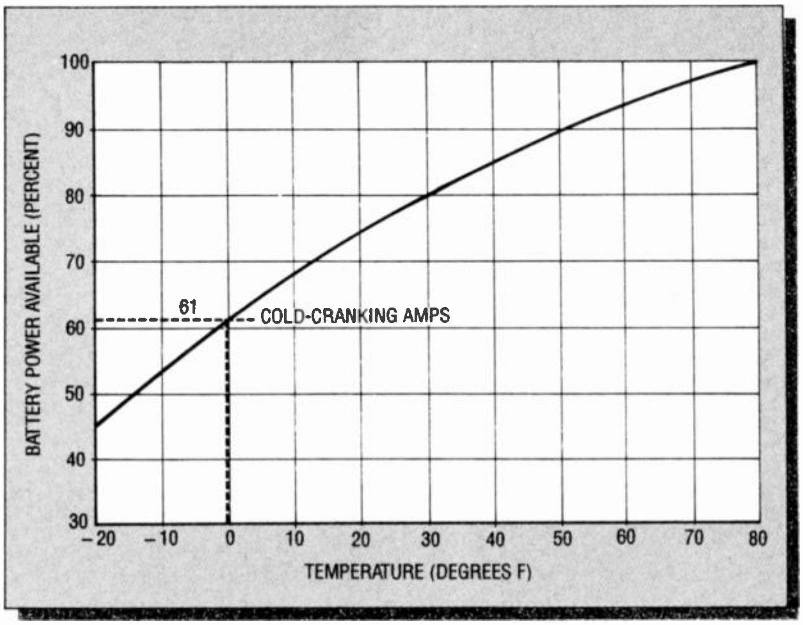


FIG. 1—RELATIVE POWER CAPACITY in a battery at temperatures from −20°F to +80°F where 100% available power is assumed. Cold-cranking amps (CCA) are read at a temperature of 0°F.

BASIC program are based on General Motors Corp. studies.

CRAE's drain on your battery is only a slight 2.5 amperes, so it is much safer to use than instruments that test the load. Also, CRAE will not significantly discharge your battery if it is used as directed. Remember that CRAE is *not an ammeter* so its readings will only give you an intelligent estimate of the *potential* CCA of your battery without actually measuring it.

After you have learned how to use CRAE, all you need is a digital voltmeter and a thermometer to keep you informed on the condition of your 12-volt car or boat battery—if it has a CCA rating from 150 to 1000.

Cold-cranking amps

Cold cranking amps (CCA) is the value for the amount of current a battery can deliver for 30 seconds at 0°F without dropping below a specified cutoff voltage. Figure 1 shows that the battery power output increases significantly from 0°F to 80°F. In fact, a battery rated at 600 CCA (at 0°F) should be able to deliver 1/0.61 × 600 or 984 cranking amps at 80°F!

An approximate guide in determining the CCA rating for a battery that will start an engine reliably at 0°F depends upon engine displacement, typically measured in cubic inches. However, If your engine displacement is specified in liters, multiply that figure by 61 to get cubic inches before using the following guide:

- An eight-cylinder engine requires one cranking ampere per cubic inch of engine displacement. For example, to start an eight-cylinder 350 cubic-inch engine, the battery must deliver 350 CCA.
- A six-cylinder engine has a CCA rating that is eight times the cubic-inch displacement *per cylinder*. For example, if a six-cylinder engine has a displacement of 231 cubic inches, the displacement per cylinder is approximately 39 cubic inches. Therefore, the battery must deliver 39 × 8 = 312 CCA.
- A four-cylinder engine has a CCA requirement that is twice the engine's displacement in cubic inches. For example, if a four-cylinder engine has a displacement of 180 cubic inches, the battery must deliver 360 CCA.

If the ambient temperature is consistently below 0°F, the battery should have a CCA rating that is 20% higher than that which would be calculated for warmer conditions.

In addition to CCA, there are other battery ratings in use today. For example, the MCA, for marine cranking amps, is a rating developed for boat batteries that is based on 32 °F instead of 0°F for CCA. An MCA rating for the identical CCA-rated battery is typically 25 to 30% lower.

Another specification is reserve capacity, given in minutes. It describes a battery's ability to continue supplying power to the engine and accessories if the car's charging system fails. That test drains the battery at a 25 ampere rate until the battery voltage drops from more than 12 volts to 10.5 volts.

A 12-volt battery model

Most text books show a 12-volt storage battery equivalent circuit either as an ideal 12-volt source or as that source in series with a small resistance, perhaps 20 milliohms or less. An ideal voltage source provides a constant voltage regardless of current flow. It can deliver infinite current and infinite power. Unfortunately, there is no such thing as an ideal voltage source.

The equivalent circuit for a battery shown in Fig. 2 is a satisfactory model for the design of a CCA meter. However, the more realistic equivalent circuit shown in Fig. 3 includes a large capacitor and an additional resistor. That model accounts for changes in battery output with respect to time.

An even more elaborate model would include a time- and current-dependent voltage source as well as time-dependent resistors and capacitors. However, accounting for all of those additional variables would complicate the design of a simple, easy-to-use meter. Moreover, taking into account all of those additional variables would add little to the accuracy of the meter.

How CRAE works

CRAE's objective is to estimate the size of R_{INT} as shown in Fig. 4. There is an inverse relationship between this resistor and battery capacity: the

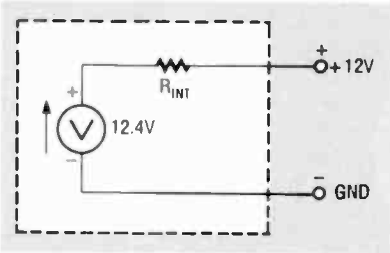


FIG. 2—EQUIVALENT CIRCUIT FOR a 12-volt lead-acid storage battery. R_{INT} limits the battery current.

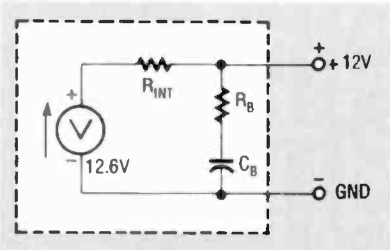


FIG. 3—CRAE EQUIVALENT CIRCUIT for a 12-volt lead-acid battery. The one-minute test reduces the measurement error caused by C_B and R_B.

smaller the value of R_{INT}, the higher the battery's capacity. In the absence of C_B and R_B, R_{INT} could easily be estimated by applying a load to the battery, measuring voltage and current, and making a few calculations. (CRAE does this for you automatically.) However, it is first necessary to discharge C_B, the reason that CRAE has a timing circuit.

There are three basic parts to CRAE: The first, the voltage-measuring circuit, is a sensitive voltmeter that measures an adjustable voltage from 11.9 to 12.5 volts. The second is a solid-state, constant-current load that is adjusted to draw 2.5 amperes load regardless of the voltage. The third is a one minute timer that lights an LED to indicate measurement readiness.

The voltage-measuring circuit consists of op-amp IC1-a (¼ LM324) connected in a differential amplifier circuit. The voltage reference for this circuit is the 5-volt regulator IC2 (LM2931Z). Resistor R13, the MAX ADJ potentiometer, trims this reference voltage to maximize voltage readings under no-load conditions. Resistor R3 is a PC-mount trimmer that adjusts current flow through the meter and is a sensitivity control on Fig. 4.

Resistor R20 is a 1K PC-mount trimmer that sets the meter's zero point (0.05 milliampere). Resistors R5 and R6 raise the meter's negative terminal above ground level, allowing the meter to be zeroed. Diodes D2 and D3 protect the meter, and D1 protects other sensitive parts of the circuit from accidental damage when the test leads are first connected to the battery.

The primary component of the constant-current load is Q2. When momentary two-position toggle switch S1 is switched to the TEST position, current flows through Q1's emitter circuit because IC1-c provides base current. That emitter current also flows through Q2's base circuit, resulting in considerable current flow. Resistor R17 both directly and indirectly controls the constant current.

As in any transistor with an emitter resistor, Q2's current is essentially constant because, as emitter current increases, emitter voltage follows. This means that V_{BE} and V_{CE} are smaller, thus tending to reduce emitter current. Nevertheless, this effect is not sufficient to provide a constant-current load. Op-amp IC1-c completes that task. Moreover, IC1-c helps to provide a near ideal constant current load, and it also simplifies load-current adjustment.

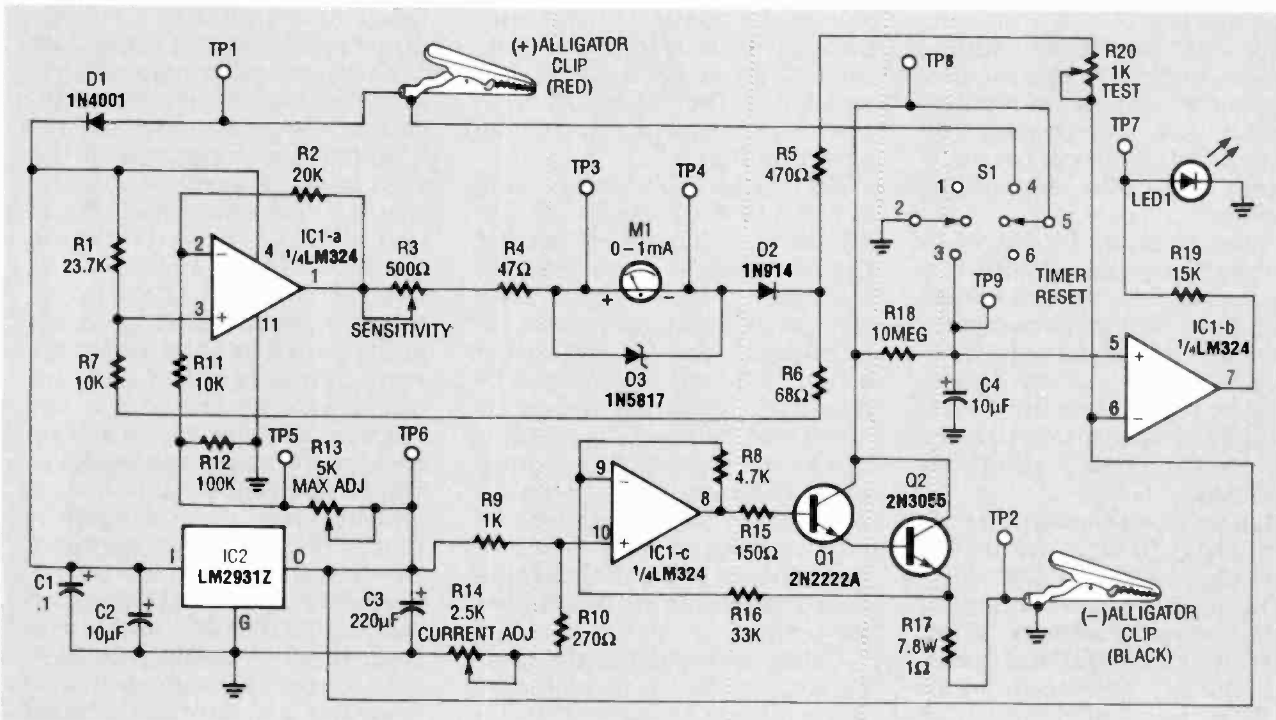


FIG. 4—SCHEMATIC FOR CRAE showing contact points for external connections.

Examination of the schematic reveals that the inverting input is connected through R16 to Q2's emitter. As Q2's emitter current increases, the voltage at the inverting input of IC1-c increases, resulting in a lower voltage output at pin 8 and less current at Q1's base. That causes a reduction in current at Q2's base and the resulting decrease in Q2's collector and emitter current. R14 adjusts the voltage on IC1-c's non-inverting input, and thus provides adjustment for the current through Q2's emitter.

The timing circuit was designed so that the timing period would vary with voltage. (Low readings on CRAE's meter are related to low battery voltage and longer timing periods.) This, in part, compensates for a fully charged (high open-circuit voltage) battery's tendency to show somewhat smaller CCA values than if it were slightly discharged.

The timing circuit consists of IC1-b, C4, and R18. When S1 is in the TEST position, C4 starts to charge through resistor R18. When the voltage across C4 exceeds 5 volts, the op-amp's output switches "on" and lights LED1.

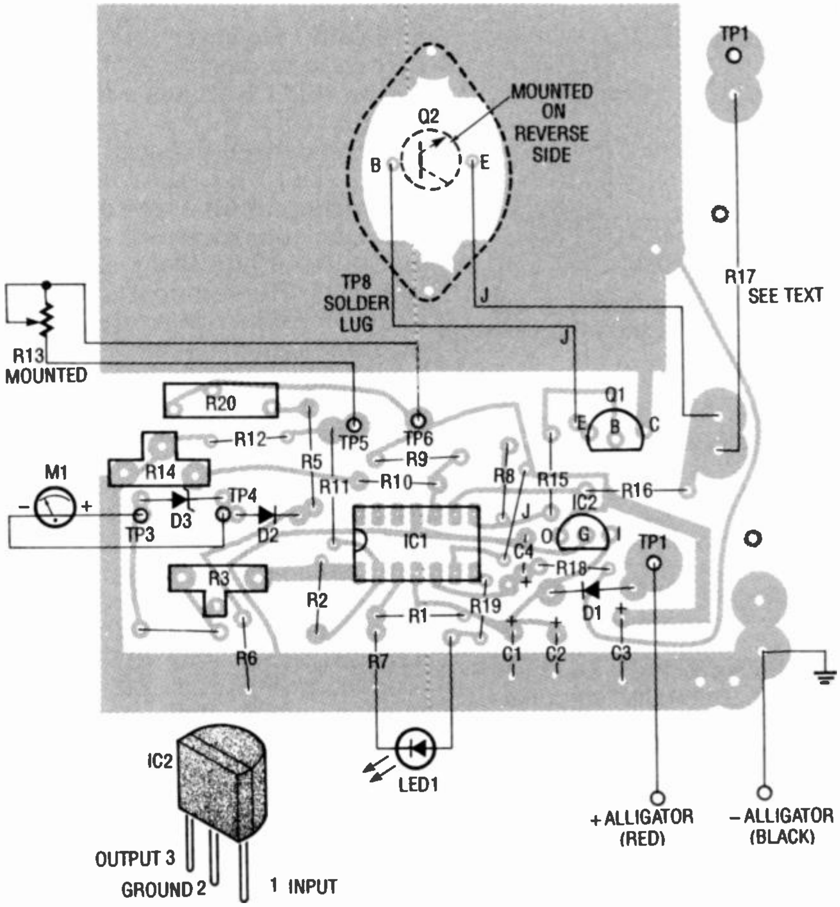


FIG. 5—PARTS-PLACEMENT DIAGRAM for printed circuit board of CRAE.

Construction

The most expensive component in CRAE is the moving-coil ammeter M1, capable of reading 1 milliampere. A meter with this rating could could cost from $10 to more than $50, depending upon size.

A custom-made PC board is not required because CRAE is a simple low-frequency instrument, but it will make assembly easier and faster, perhaps in as short a time as a few hours. However, if you assemble CRAE rapidly, be sure to allow extra time for thorough testing and calibration.

Figure 5, the component-mounting guide, should be used together with the schematic in Fig. 4 when building CRAE to avoid problems. Meter M1, switch S1, LED1 and potentiometer R13 are mounted on the front panel of the case; all other parts are mounted on the PC board. Be sure that the heat sink is in place when soldering Q2. The heat sink with Q2 attached is mounted on the foil side of the board. On the component side, wires are connected from Q2's base and emitter to the PC board with insulated jumper wires as shown in Fig. 5.

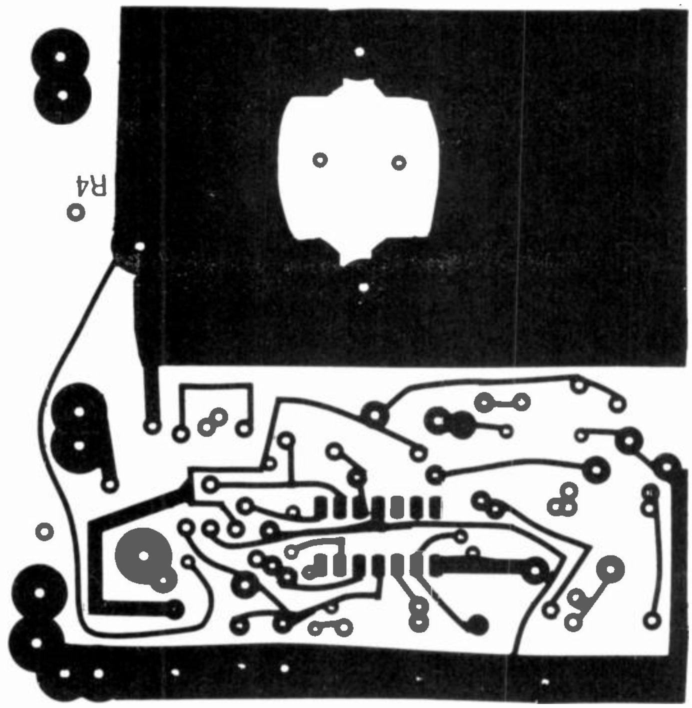
Notice that R17's power rating is listed in the parts list as 5 to 7.5 watts. Calculations indicate that the resistor must dissipate 6.25 watts. However, because the current generally flows intermittently only for a minute at a time, a 5-watt resistor can be used. (An effective 1-ohm resistor can be made by winding 40 feet of 24-gauge copper magnet wire around the outside of a large-value power resistor.) Be sure to leave at least a ⅜-inch gap between R17 and the circuit board to permit air to circulate for cooling.

Crimp and solder flexible two-conductor electrical lamp cord to each large alligator clip. One conductor from each clip is attached to the voltage-measuring circuit, and the other conductor is attached to the load circuit. That 4-wire arrangement prevents a voltage drop on the test lead wires from causing measurement errors. Those conductors should be 18-gauge or larger stranded copper.

Solder one conductor of the cord from the positive alligator clip to TP1 on the circuit board and solder or crimp the second conductor to pin 4 of switch S1 as shown in Fig. 4. (Refer to Fig. 6 for the pin numbering system of the switch as shown from the rear.) Similarly, solder one conductor of the cord from the negative alligator clip to TP2 on the circuit board, and solder or clip the second conductor to a circuit-board ground such as that at the lower right corner of the foil on the circuit board. Connect a wire from the "+" terminal of M1 to TP3 and a wire from the "–" terminal to TP4. Also connect some hookup wire from the left terminal (viewed from the rear) of R13 to TP5 and a wire from the center terminal to TP6.

In performing the following steps refer to Fig. 6 , switch S1's pin-numbering guide. (The pin numbering shown is for the switch in the Parts List.) Connect a wire from pin 2 of S1 to a circuit board ground. Also, connect wires from pin 3 to TP9 and pin 5 to TP8. Finally, connect a wire from the LED's anode (long lead) to TP7, and a wire from LED's cathode (short lead) to a circuit ground. (The LED should be a high-efficiency GaAsP or GaP lamp that draws minimal current because the circuit is sensitive to small voltage changes.)

You'll want to calibrate the meter and, perhaps relabel the meter's face with the term "Estimated Cranking Amp" markings, for a more professional appearance. Table 1 is a set of data for guidance in calibrating the meter. The photograph shows the end result.



SOLDER-SIDE FOIL PATTERN for PC board shown actual size.

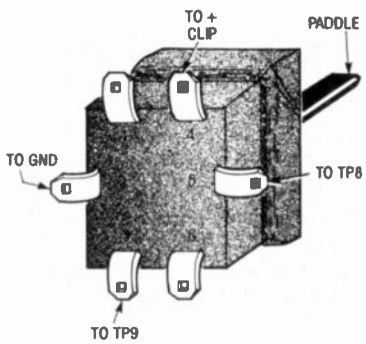


FIG. 6—REAR CONNECTIONS for S1, a 3-way toggle switch.

There are several ways to label a meter face. In one you can use a PC and an appropriate computer-aided design program to relabel the graduations and set up the estimated cranking amps legend. That can be printed out on adhesive-backed paper or plastic with a laser printer for direct application. The only drawback to this method is that the paper might be thick enough to interfere with the meter's moving needle.

Another method is to erase the numbers on the meter face with a pencil or ink eraser, and then use dry-transfer lettering to relabel it. However, you can simply use a soft pencil to add the cranking amp markings to the meter's markings.

Double-momentary toggle switch S1, the MAX(INF)ADJ potentiometer R13 and LED1 should be mounted on the front panel. Potentiometer R13 can be a stock single-turn potentiometer, but a multiturn potentiometer with dial makes CRAE easier to use. In labeling this potentiometer on the panel "max" stands for maximum, "inf" means infinite and "adj" means adjust. See the photograph of the front of the instrument.

TABLE 1—GUIDE TO LABELING AMMETER

Milliamps	Cranking Amp Markings
0.00	150 (or below)
0.30	200
0.48	300
0.60	450
0.70	650
0.80	800
0.94	1000
1.00	Infinite

LISTING 1—PROGRAM FOR ESTIMATING CRANKING AMP CAPACITY

```
1 'THIS GW BASIC PROGRAM ESTIMATES THE CRANKING AMP CAPACITY OF A 12V LEAD-ACID
2 'STORAGE BATTERY AT MOST PRACTICAL TEMPERATURES ASSUMING YOU SUPPLY IT DATA OF
3 'THE CRANKING AMP CAPACITY AT A SPECIFIC TEMPERATURE.  IF ALL YOU KNOW IS THE
4 'MANUFACTURER'S "CCA" RATING, MAKE SURE YOU ENTER "0" WHEN ASKED
5 ' "What is the temperature of the battery, in degrees F?"
10 INPUT "What is the temperature of the battery, in degrees F";TFOT
15 IF TFOT>120 GOTO 100
16 IF TFOT>80 THEN TFOT=80
20 INPUT ;"Estimated Cranking Amps at this temperature";CAOT
30 PRINT "What temperature due you want the new estimate for cranking amps?"
40 INPUT "PRESS RETURN FOR 0 F.(This will give you the CCA)";TFNT
45 IF TFNT>120 GOTO 100
46 IF TFNT>80 THEN TFNT=80
50 LET KTFOT=.61+.0082*TFOT-.0000417*TFOT*TFOT
60 LET KTFNT=.61+.0082*TFNT-.0000417*TFNT*TFNT
70 LET CANT=KTFNT*(CAOT/KTFOT)
80 PRINT "Estimated Cranking Amps at ";TFNT;"F is "; CINT(CANT)
90 END
100 PRINT "Storage batteries should not be exposed to this high a temperature!";
110 END
```

Testing and calibration

First, preset all potentiometers (R3, R13, R14, and R20) to their center positions. Next, set the output of a regulated power supply capable of at least 12.6 volts with a digital voltmeter (with minimum 0.5% DC voltage accuracy.) If a regulated power supply is not available, substitute a fully charged 12-volt storage battery with a 100-ohm potentiometer across the terminals. The desired voltage can be taken from the center wiper arm. Connect the positive alligator clip (red) to the supply's positive terminal and the other clip to the negative terminal. *Do not use the test switch at this time!*

Slowly increase the supply's voltage for a 12.5-volt reading on the DC volts scale of a digital multimeter. Set R3 for a maximum (1 milliampere) reading on meter M1. Now lower the voltage to 11.9V and adjust R20 for a 0.05 milliampere reading. Again apply 12.5 volts and adjust R3 and/or R20 to obtain a 1.0 milliampere reading. Repeat this step for 11.9 volts. After several adjustments of R20 and R3, M1 should register 1.0 milliamperes when the voltage at the alligator clips is 12.5 volts and 0.05 milliamperes when the voltage is 11.9 volts.

The DMM should then be used to set R14 for a 2.5 ampere current flow through R17. Connect CRAE's alligator clips to a 12-volt storage battery or a 12-volt source that can deliver at least 5 amperes. (Be sure the red clip is connected to the plus terminal and the black clip to the negative terminal.) Next place the DMM's leads across the 1-ohm power resistor R17 and adjust R14 for a 2.5-volt display on the DMM. (You are actually adjusting the current for 2.5 amperes flowing through R17.). This completes the basic calibration of CRAE.

If the meter faceplate conversion table in Table 1 is used, CRAE should have an accuracy better than 20%. The prototype CRAE was calibrated and tested with four different batteries of known CCA capacity. Two batteries were new (600 CCA and 165 CCA ratings, respectively), one was of average age (410 CCA), and one was older but still functional (400 CCA). The batteries were tested with commercial test equipment which confirmed the battery manufacturers' ratings for the three newer batteries.

PARTS LIST

All resistors are 1/4-watt, 5%, unless otherwise indicated.

R1—23,700 ohms, 1/4-watt, 1%
R2—20,000 ohms, 1/4-watt, 1%
R3—500 ohms PCB trimmer
R4—47 ohms
R5—470 ohms
R6—68 ohms
R7, R11—10,000 ohms
R8—4700 ohms
R9—1000 ohms
R10—270 ohms
R12—100,000 ohms
R13—5000 ohms potentiometer (panel-mount)
R14—2500 ohms PCB trimmer
R15—150 ohms
R16—33,000 ohms
R17—1 ohm, 5.0 to 7.5 watt
R18—10 megohm
R19—15,000 ohms
R20—1000 ohms, PCB trimmer, 15 turn

Capacitors

C1—0.1µF, 25 volts
C2—10µF, 25 volts, electrolytic
C3—220µF, 16 volts , electrolytic
C4—10µF, 25 volts +/- 10%, tantalum

Semiconductors

IC1—LM324 quad op-amp
IC2—LM2931Z 5-volt voltage regulator
Q1—2222A NPN transistor
Q2—2N3055 NPN transistor
LED1—Light-emitting diode (High-efficiency GaAsP on GaP)D1—IN4001 silicon rectifier
D2—IN914 silicon diode
D3—IN5817 schottky barrier rectifier

Other components

S1—DPDT momentary action with off at center
M1—Panel meter, moving coil, 0 to 1 mA.

Miscellaneous: two alligator clips (1-inch jaw length), two lengths of two-conductor parallel flexible 18 AWG stranded copper lamp cord with PVC or rubber insulation (approx. 3 feet long), PC board, case—Radio Shack Cat. No. 270-232 or equivalent, control potentiometer knob, aluminum heat sink, LED mounting hardware insulated hook-up wire, solder, etc.

The old 400-CCA battery tested 420 CCA at 50° F with commercial equipment. This suggests that its true rating is about 280 CCA and that its service life is probably at or very close to its end. While only four batteries were in the test sample, CRAE was more extensively tested than this would imply because the tests were made at different ambient temperatures on each battery.

The accuracy rating of CRAE can be increased if you calibrate it with the output of three batteries of known capacity. Accuracy of calibration can also be improved if CRAE's results are compared to those of a commercial battery tester and adjusted accordingly.

You can also increase CRAE's accuracy by connecting it to a battery whose cranking amp capacity is known, and then adjusting trimmer R14 so that CRAE's meter reading equals that a battery's of the battery. Remember that cranking amp capacity changes with temperature.

How to use CRAE

CRAE's reading will be most accurate when the open- circuit battery voltage is between 12.4 and 12.6 volts. *Do not use CRAE on an uncharged battery (open-circuit voltage below 12.2 volts) or a new, freshly charged battery (open-circuit voltage above 12.65 volts). because the readings will be erroneous.* To avoid starting problems, replace any battery whose open-circuit voltage falls below 12.2 volts within minutes of charging. Open-circuit voltages should be taken under no-load conditions. That usually requires that the ground cable be disconnected from the terminals of the battery before it is tested.

If you want to test a new, recently charged battery, discharge it slightly for a few hours at a discharge current of a few amperes. A safe way to do this is to make up a simple load by soldering insulated wires to the

Continued on page 71

RAY M. MARSTON

PHOTOSENSITIVE DEVICES

Learn to use photoconductive cells, photodiodes, and phototransistors in practical light-controlled circuits.

WE WILL LOOK AT LIGHT-SENSITIVE devices in this article and find out how they can be used in various practical control circuits. Light-sensitive devices include photocells, photodiodes, and phototransistors. Visible and infrared light (or the absence of that light) can trigger many different kinds of circuits for the control of alarms, lights, motors, relays, and other actuators. Light-sensitive devices, sometimes called photoelectric transducers, alter their electrical characteristics in the presence of visible or infrared light.

Photocell basics.

Photocells are also called by many other names including photoconductive cells, light-dependent resistors (LDR's), and photoresistors. They are variable resistors with an extremely wide range of resistance values (up to hundreds of orders of magnitude) that are dependent on the level of incident light. Resistance in photocells varies inversely with the strength of light that falls on them. In other words, resistance is very high in the dark, but low under bright light.

Figure 1 is a cutaway view of a typical photocell showing the pattern of photoconductive material deposited in the serpentine slot separating the two electrodes that have been formed on a ceramic insulating substrate. This pattern maximizes contact between the crystalline photoconductive material and the adjacent metal electrodes.

The photoconductive material is typically cadmium sulfide (CdS) or cadmium selenide (CdSe). The selection of the material and the thickness and width of its deposition determine the resistance value and power rating of the device. The two-terminal assembly is enclosed in a metal or opaque plastic case with a clear glass or plastic window over the photoconductive material. Figure 2 is the schematic symbol for the photocell.

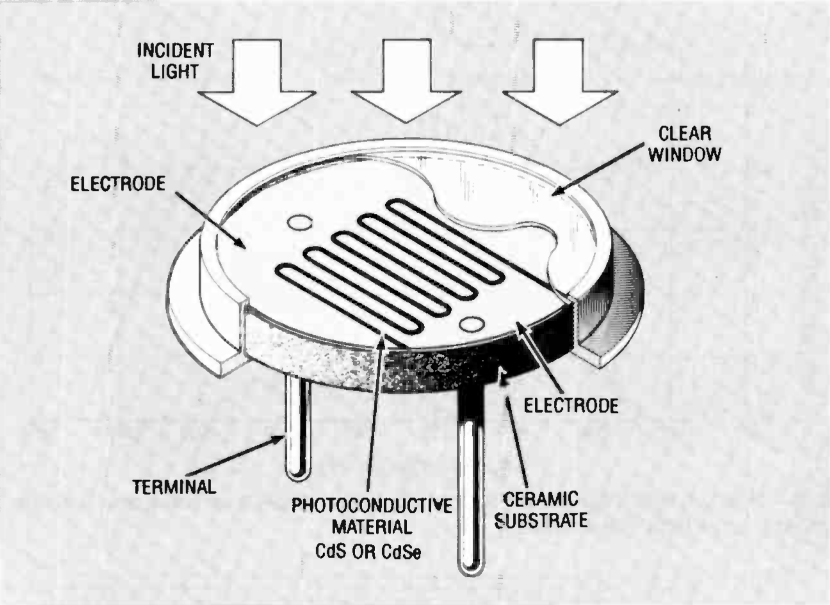


FIG. 1—CUTAWAY VIEW of a photocell or light-dependent resistor (LDR).

Photocells are made with diameters from about one-eighth inch (3 mm) to over one inch (25 mm); the most popular devices have diameters of about three-eighth inch (10 mm). The smaller units are suitable for applications where space is limited, such as in card-reading applications, but they have low power-dissipation ratings. Some photocells are hermetically sealed to withstand the effects of demanding environments.

Figure 3 compares the response of photosensitive devices characteristics with that of the human eye. Relative spectral response is plotted against wavelength from 300 to 1200 nanometers (nm). The bell-shaped human eye response curve shows that the eye is sensitive to a relatively narrow band of the electromagnetic spectrum, between about 400 and 750 nm. The curve peaks in the green light region at about 550 nm and extends down into the violet region (400 to 450 nm) at one end, and up into the dark red light region (700 to 780 nm) at the other end.

Figure 3 shows why cadmium sulfide (CdS) photocells are so popular for light-controlled circuits: the CdS spectral response curve peaks near 600 nm, and it

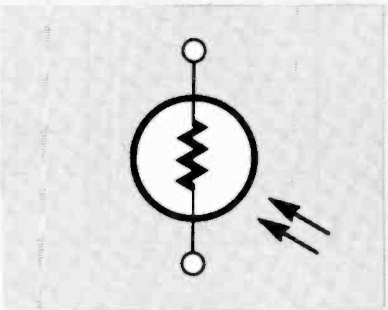


FIG. 2—SCHEMATIC SYMBOL of a photocell.

closely matches that of the human eye. By contrast, the response curve for cadmium selenide (CdSe) peaks further out at about 720 nm. However, CdSe is also sensitive to most of the visible-light region.

A typical CdS photocell characteristic curve is shown in Fig. 4. Its dark resistance is about five megohms. This value falls to about 600 ohms at a light intensity of 100 lux, typical of a well illuminated room and to about 30 ohms at an intensity of 8000 lux, typical of bright sunlight. (The lux is the SI unit of illuminance produced by a luminous flux of 1 lumen uniformly distributed over a surface of 1 square meter.)

Commercial photocells have good power and voltage ratings, similar to those of conventional resistors. Power dissipation ratings could be between 50 and 500 milliwatts, depending on detector material. Their only

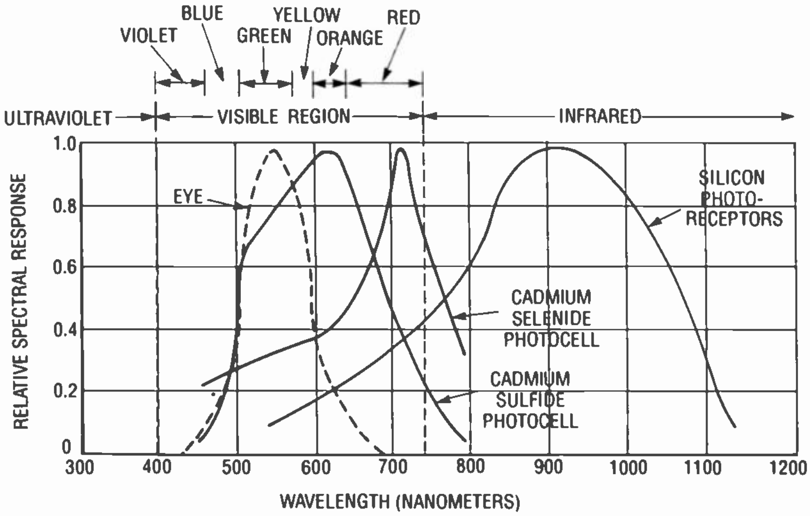


FIG. 3—CHARACTERISTIC CURVES of photosensitive devices compared with the response curve of the human eye.

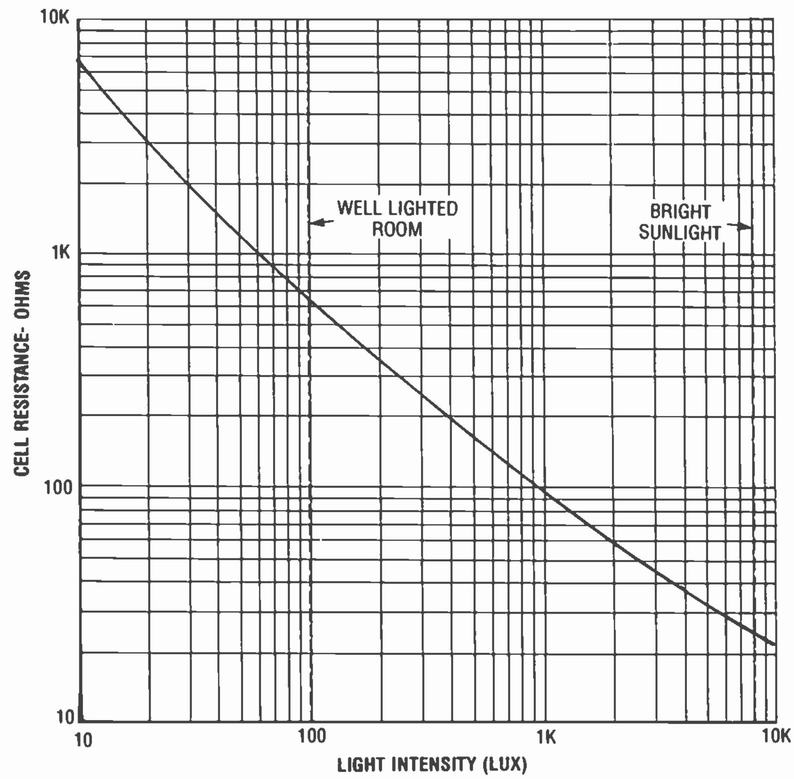


FIG. 4—CURVE OF RESISTANCE versus light intensity for a typical photocell with a 10-mm face diameter.

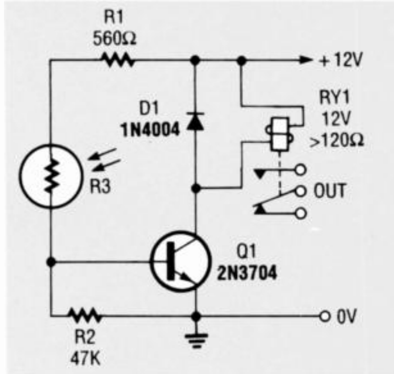


FIG. 5—SIMPLE NON-LATCHING light-activated relay switch.

significant drawbacks are their slow response times. Cadmium-selenide photocells generally have shorter time constants than cadmium-sulfide photocells (approximately 10 milliseconds versus 100 milliseconds). They also offer lower resistance values, higher sensitivities, and higher temperature coefficients of resistance.

Photocells are included in photographic exposure meters, light- and dark-activated switches for controlling safety lights, and intrusion alarms. Some light-activated alarms are triggered by breaking a light beam. There are even light-reflective smoke alarms based on photocells. Figures 5 to 20 show practical photocell circuits; each will work with almost any photocell.

Photocell light switches

Figures 5 to 10 illustrate practical light-activated switch circuits with relay contact outputs that are based on the photocell. The simple circuit shown in Fig. 5 is designed to react when light enters a normally dark space such as the inside of a cabinet or closet. The photocell R1 and resistor R2 form a voltage divider that sets the base bias of Q1. Under dark conditions, the photocell has a high resistance, so zero bias is applied to the base of Q1; in this state, Q1 and the relay RY1 are off. When a sufficient amount of light falls on the photocell, its resistance drops to a low value, and bias is applied to the base of Q1. That bias activates RY1, and its contacts can control external circuitry.

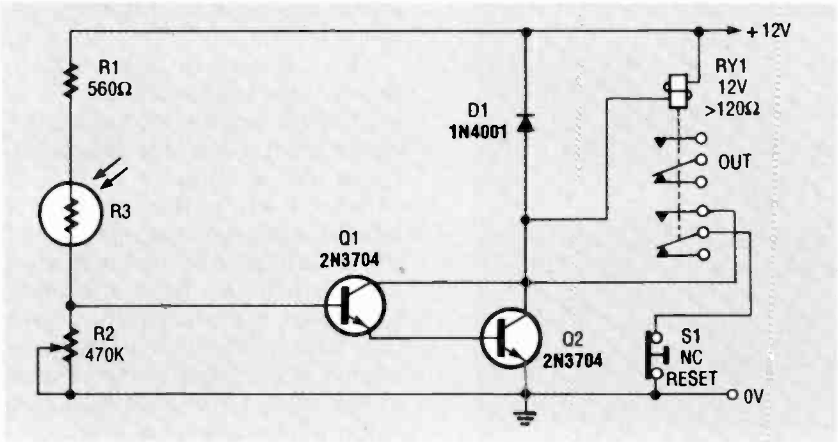


FIG. 6—SENSITIVE SELF-LATCHING light-activated relay switch.

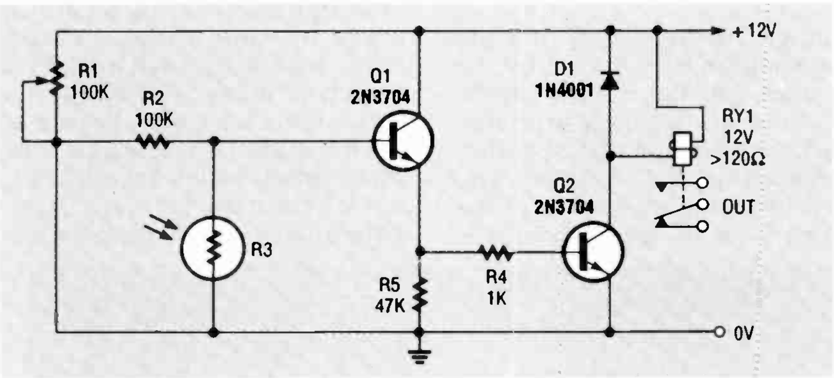


FIG. 7—SIMPLE DARK-ACTIVATED relay switch.

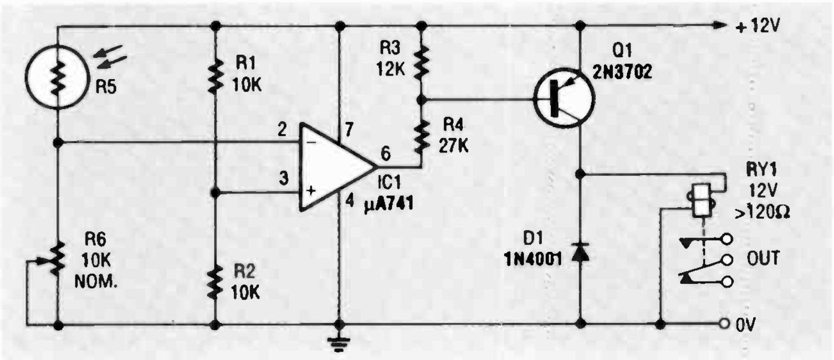


FIG. 8—PRECISION LIGHT-sensitive relay switch. R5 equals R6 at normal light level.

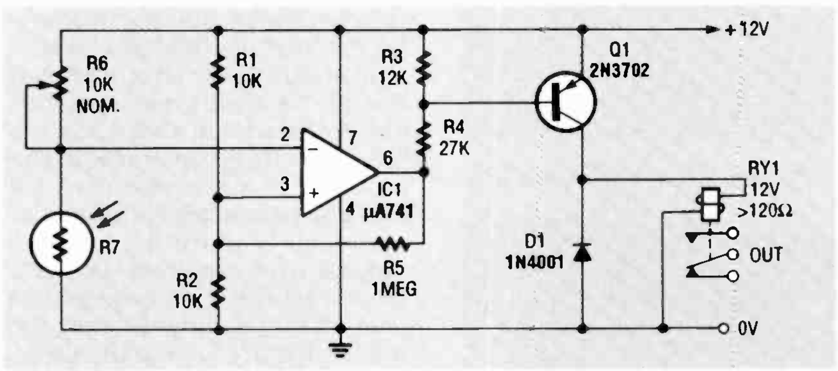


FIG. 9—PRECISION DARK-ACTIVATED switch with hysteresis. R6 equals R7 at normal light level.

The simple Fig. 5 circuit has low sensitivity and no provision for sensitivity adjustment. Figure 6 illustrates how these drawbacks can be overcome with Darlington-coupled transistors Q1 and Q2 replacing Q1, and the use of a potentiometer R2 for sensitivity control, replacing fixed resistor R2. The diagram also shows how the circuit can be made self-latching with the second set of relay contacts. Normally-closed pushbutton switch S1 permits the circuit to be reset (unlatched) when required.

Figure 7 shows how a photocell can form a simple dark-activated relay that turns on when the light level falls below a value preset by potentiometer R1. Resistor R2 and the photocell R3 form a voltage divider. The voltage at the R2-R3 junction increases with falling light. That voltage, buffered by emitter-follower Q1, controls relay RY1 with common-emitter amplifier Q2 and current-limiting resistor R4.

The light trigger or threshold levels of the circuits shown in Figs. 6 and 7 are susceptible to variations in supply voltage and ambient temperature. Figure 8 shows a very sensitive precision light-activated circuit that is not influenced by those variables. In this circuit the photocell R5, potentiometer R6, and resistors R1 and R2 are connected to form a Wheatstone bridge, and op-amp IC1 and the combination of transistor Q1 and RY1 act as a highly sensitive balance-detecting switch. The bridge balance point is independent of variations in supply voltage and temperature, and is influenced only by variations in the relative values of the bridge components.

In Fig. 8, the photocell R5 and potentiometer R6 form one arm of the bridge, and R1 and R2 form the other arm. Those arms can be considered as voltage dividers. The R1-R2 arm applies a fixed half-supply voltage to the non-inverting input of the op-amp, while the photocell-potentiometer divider applies a light-dependent variable voltage to the inverting pin of the op-amp.

To use this circuit, potentiometer R6 is adjusted so that the voltage across the photocell and the potentiometer rises

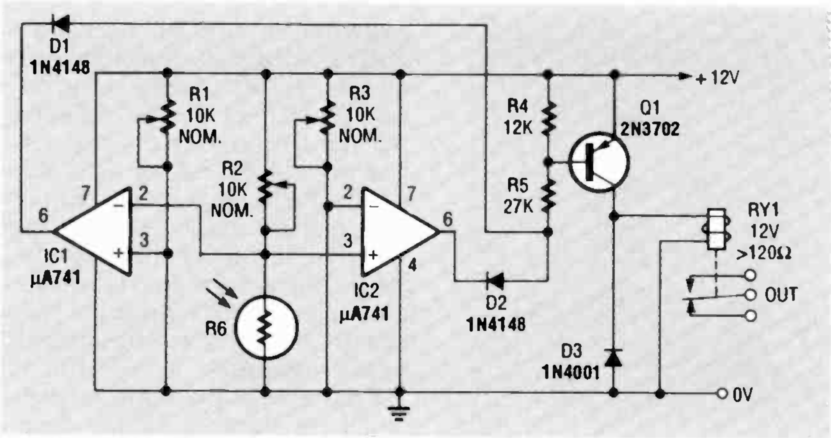


FIG. 10—COMBINED LIGHT/DARK-activated switch with a single relay output. Value of R2 equals R6 at normal light level.

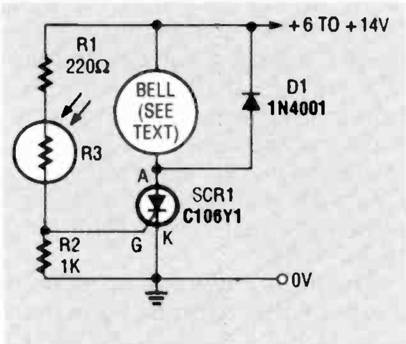


FIG. 11—SIMPLE LIGHT-ACTIVATED alarm bell.

fractionally above that across R1 and R2 as the light intensity rises to the desired trigger level. Under that condition, the op-amp output switches to negative saturation, which turns on Q1 and thus RY1. When the light intensity falls below that level, the op-amp output switches to positive saturation, and Q1 and the relay are turned off.

The circuit in Fig. 8 is so sensitive that it is able to respond to changes in light-level that are too small to be detected by the human eye. The circuit can be modified to act as a precision dark-activated switch by either transposing the inverting and non-inverting input pins of the op-amp, or by transposing the photocell and the adjacent potentiometer.

The circuit in Fig. 9 also shows how a small amount of hysteresis can be added to the circuit with the feedback resistor R5 so that relay RY1 is actuated when the light level falls to a preset value. However, the relay is not de-actuated again until the light intensity increases substantially above that value. The hysteresis magnitude is inversely proportional to the value of R5, but it is zero when R5 is open circuited.

Figure 10 shows how a precision light/dark switch can be made by combining op-amp light and dark switches. The switch activates relay RY1 if the light intensity rises above one preset value of falls below another preset value. Potentiometer R1 controls the dark level, potentiometer R2 controls the supply voltage, and potentiometer R3 controls the light level.

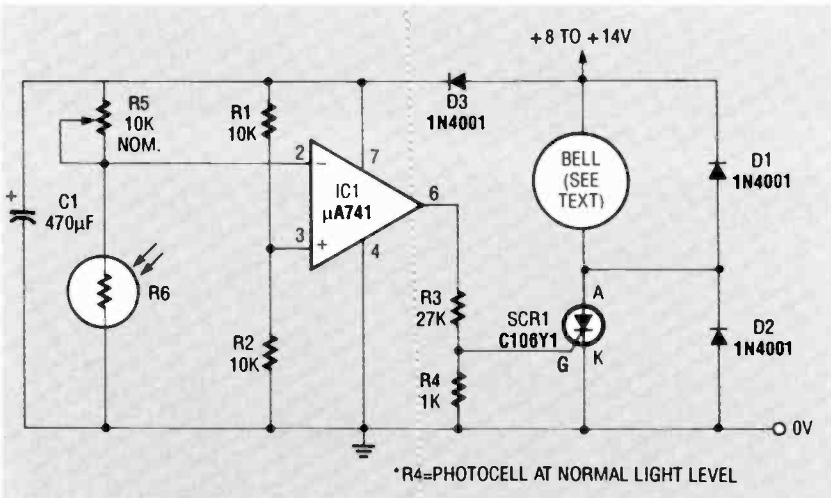


FIG. 13—PRECISION LIGHT-ACTIVATED alarm bell. Value of R5 equals R6 at normal light level.

To organize the circuit shown in Fig. 10, first preset potentiometer R2 so that about half the supply voltage appears at the junction between photocell R6 and potentiometer R2 when the photocell is illuminated at its normal intensity level. Potentiometer R1 can then be preset so that RY1 is actuated when the light intensity falls to the desired dark level, and potentiometer R3 can be adjusted so that RY1 is actuated at the desired brightness level.

In the circuits shown in Figs.

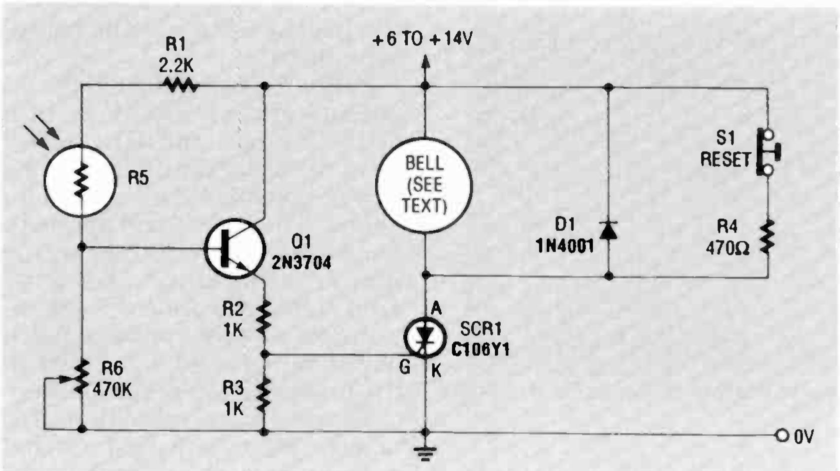


FIG. 12—IMPROVED LIGHT-ACTIVATED alarm bell with self-latching.

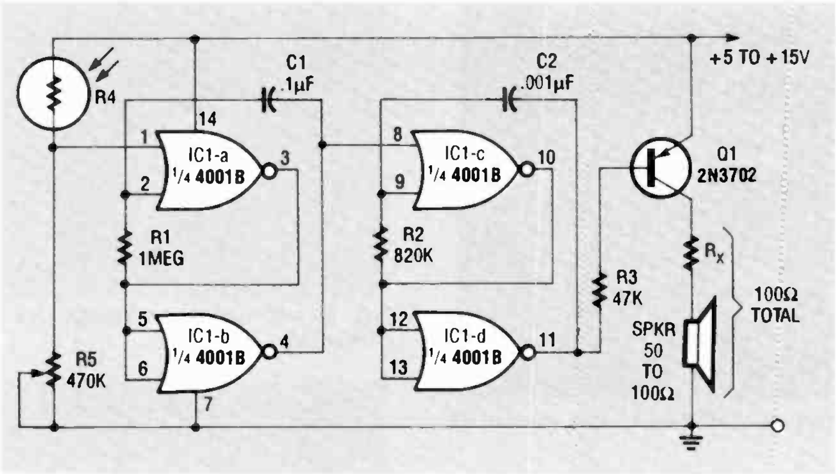


FIG. 14—DARK-ACTIVATED ALARM with pulsed-tone output.

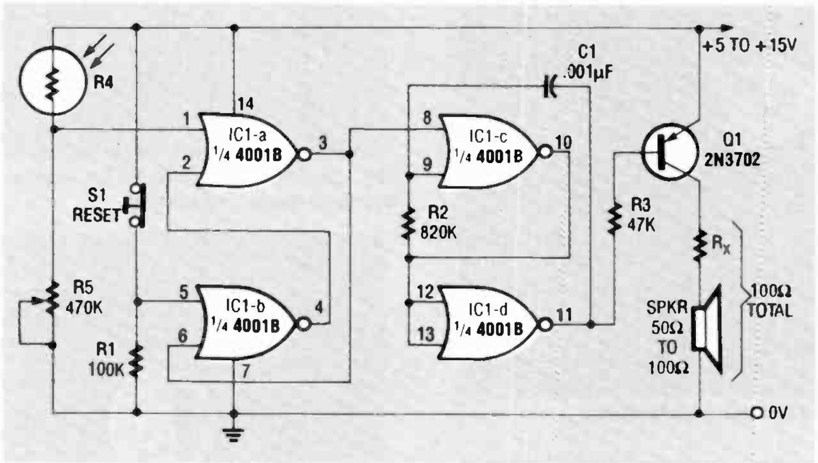


FIG. 15—SELF-LATCHING LIGHT-activated alarm with monotone output.

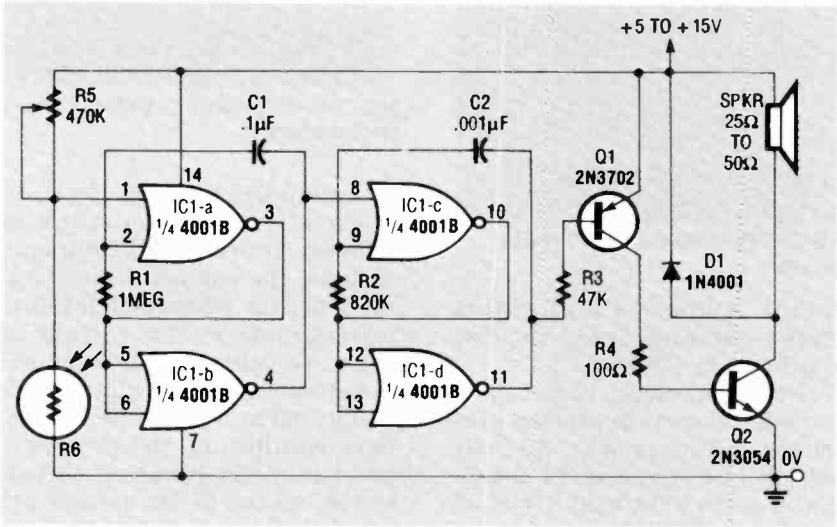


FIG. 16—BOOSTED-OUTPUT PULSED-tone light-activated alarm.

8 to 10, the resistance values of the series potentiometers should equal the photocell's resistance values at the normal light level of each circuit.

Bell-output photocell alarms

The light-activated photocell circuits in Figs. 5 to 10 all have relay outputs that can control many different kinds of external circuits. In many light-activated circuit applications, however, the circuits must trigger audible alarms. This response can also be obtained without relays as shown in Figs. 11 to 17.

Figure 11 shows a simple light-activated alarm circuit with a direct output to an alarm bell or buzzer. The bell or buzzer must be self-interrupting and have an operating current rating less than 2 amperes. The supply voltage should be 1.5 to 2 volts greater than the nominal operating value of the bell or buzzer. Photocell R3 and resistor R2 form a voltage divider. Under dark conditions, the photocell resistance is high, so the voltage at the junction R3 and R2 is too small to activate the gate of the silicon-controlled rectifier SCR1. Under bright light conditions with the photocell resistance low, gate bias is applied to the SCR which turns on and activates the alarm.

In the circuit of Fig. 11, keep in mind that although the SCR is self-latching, the fact that the alarm is self-interrupting ensures that the SCR repeatedly unlatches automatically as the alarm sounds. (The SCR anode current falls to zero in each self-interrupt phase.) Consequently, the alarm automatically turns off again when the light level falls below the circuit's threshold level.

The circuit of Fig. 11 has fairly low sensitivity and no sensitivity adjustment. Figure 12 shows how that drawback can be overcome: Potentiometer R6 replaces a fixed resistor and Q1 is inserted as a buffer between photocell R5 and the SCR1 gate. The diagram also shows how to make the circuit self-latching by wiring R4 in parallel with the alarm so the SCR anode current remains above zero as the alarm self-interrupts. Switch S1 permits the circuit to be reset (unlatched) when required.

Figure 13 shows how to make a precision light-alarm with an SCR-actuated output based on a Wheatstone bridge formed by the photocell R6, potentiometer R5, and op-amp IC1. The op-amp balance detector provides precision control. That circuit can be converted into a dark-activated alarm by simply transposing the photocell and potentiometer. Hysteresis can also be added, if required.

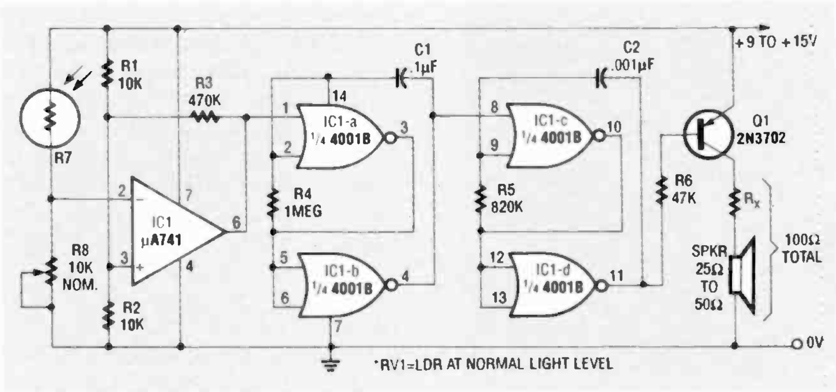


FIG. 17—PRECISION LIGHT-activated pulsed-tone alarm with hysteresis. Value of R7 equals R8 at normal light level.

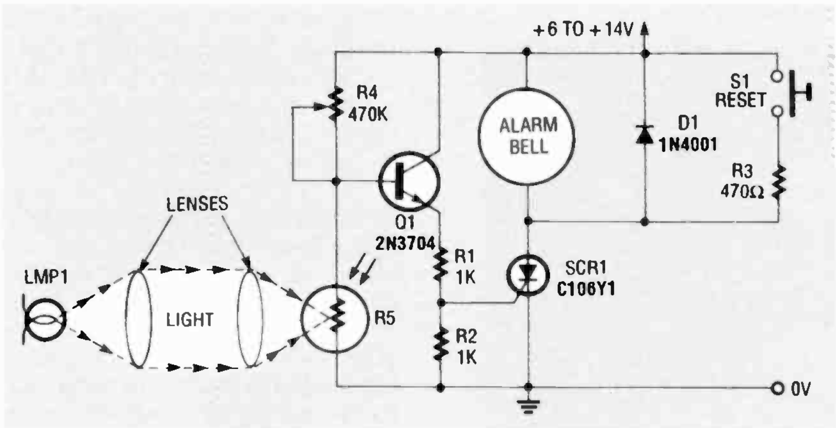


FIG. 18—SIMPLE LIGHT-BEAM alarm with self-interrupting bell output.

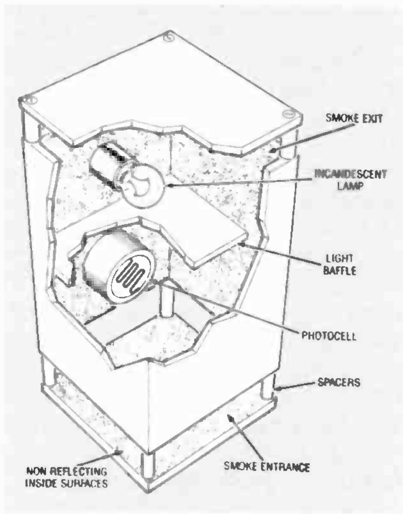


FIG. 19—CUTAWAY VIEW of a light-reflection smoke detector.

Speaker-output alarms

Figures 14 to 17 show different ways of using CMOS 4001B quad 2-input NOR-gate ICs to make light-activated alarms that generate audible outputs with loud speakers. The 4001B is available as the CD4001B from Harris and from Motorola, National Semiconductor, Signetics and others under various designations that include 4001B.

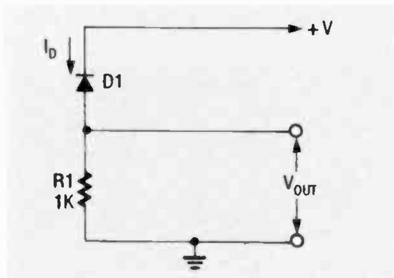


FIG. 20—REVERSE-BIASED DIODE circuit.

The circuit of Fig. 14 is a dark-activated alarm circuit that generates a low-power 800-Hz pulsed-tone signal at the speaker. NOR gates IC1-c and IC1-d are wired as an 800-Hz astable multivibrator that can feed tone signals into the speaker from Q1. It is gated on only when the output of IC1-b is low. NOR gates IC1-a and IC1-b are wired as a 6-Hz astable circuit that is gated on only when its gate pin 1 is pulled low. (Pin 1 is coupled to the voltage divider formed by photocell R4 and potentiometer R5.)

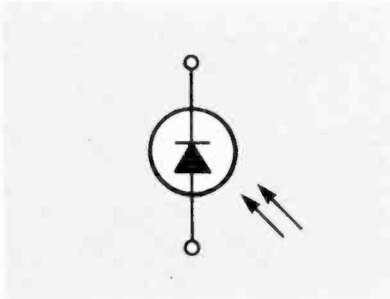


FIG. 21—SCHEMATIC SYMBOL for a photodiode.

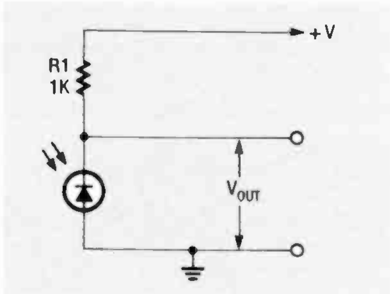


FIG. 22—PHOTODIODE WITH resistor between diode and supply.

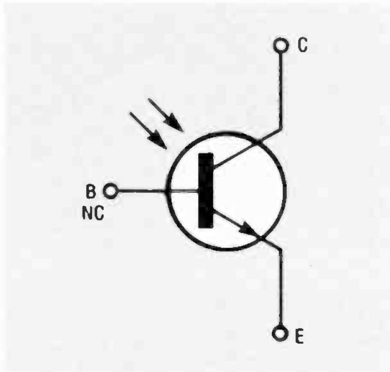


FIG. 23—SCHEMATIC SYMBOL for a phototransistor.

The action of the circuit is as follows: Under bright light conditions, the voltage at the junction of the photocell R4 and potentiometer R5 voltage is high, so both astable circuits are disabled and no output is generated at the speaker. Under dark conditions, the photocell-potentiometer junction voltage is low, so the 6- Hz astable circuit is activated, gating the 800-Hz astable circuit on and off at a 6-Hz rate. As a result, a signal from Q1 produces a pulsed-tone in the speaker.

The precise gating level of the 4001B IC is determined by its threshold voltage value, which is a fraction of the supply voltage—nominally 50%. That val-

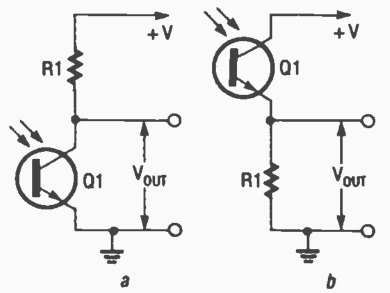


FIG. 24—ALTERNATIVE PHOTOTRANS ISTOR circuits.

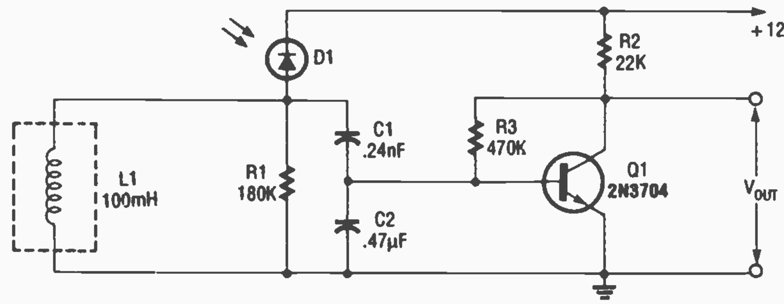


FIG. 28—SELECTIVE INFRARED preamplifier for 30-Hz operation.

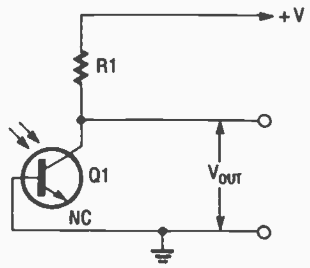


FIG. 25—PHOTOTRANSISTOR used as a photodiode.

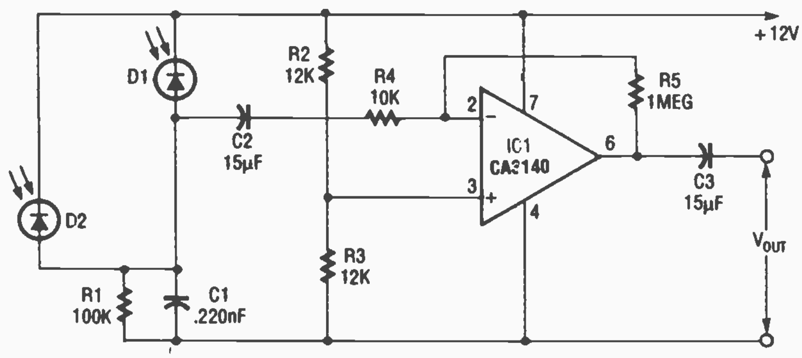


FIG. 29—SELECTIVE PREAMPLIFIER for 20-kHz light-beam alarms.

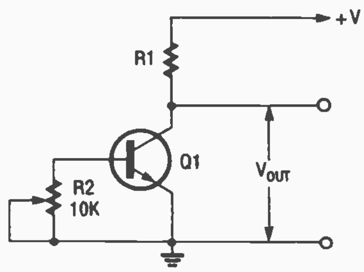


FIG. 26—VARIABLE-SENSITIVITY phototransistor circuit.

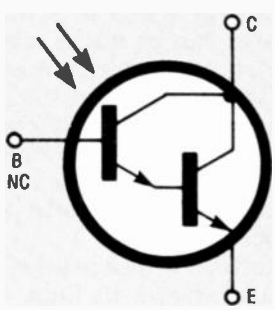


FIG. 27—SCHEMATIC SYMBOL for a photodarlington.

ue might vary from 30% to 70% in individual devices, but gating points of these IC's are generally stable. The Fig. 14 circuit provides sensitive dark-activated alarm triggering.

Figure 15 is a schematic of a self-latching light-activated alarm with an 800-Hz monotone output. In this circuit, IC1-c and IC1-d are also wired as a gated 800-Hz astable circuit, but IC1-a and IC1-b are wired as a bistable multivibrator with a normally high output. Under bright light conditions, the photocell-potentiometer junction goes high and latches the bistable circuit into its alternative state. As a result, the 800-Hz astable circuit is gated on to generate the monotone alarm signal. The circuit remains in that state until dark conditions return, and the bistable circuit is simultaneously reset with S1.

The light/dark operation of the circuits in Figs. 14 and 15 can be reversed by transposing the positions of the photocell and potentiomenter. Each circuit produces only a few milliwatts of output power. Figure 16 shows how the operation of the dark-operated circuit of Fig. 14 can be reversed to become light-operated by switching the positions of the photocell and potentiometer. The output power can be boosted with an additional output transistor Q2. This circuit can operate from a 5- to 15-volt supply and with 25- to 50-ohm speakers. The output power can vary from 0.25 to 11.25 watts, depending on the voltage and impedance values.

The circuits shown in Figs. 14 to 16 have adequate sensitivity levels for most practical applications. However, if required, both sensitivity and trigger-level stability can be increased. That's done in Fig. 17 by inserting an op-amp voltage comparator between the voltage divider junction formed by photocell R7 and potentiometer R8 and gate pin 1 of IC1-a. Resistor R3 controls the hysteresis of the circuit, but it can be removed if hysteresis is not needed.

Selection of photocell circuits

Photocells are widely used in alarms that are triggered by interrupting a visible light beam. They are also used in smoke alarms that are actuated when smoke particulates reflect light back to the photocell. Figures 18 to 20 show self-interrupting alarm-bell versions of those warning circuits.

The interrupted light beam-activated alarm circuit of Fig. 18 acts like a dark-operated alarm. Normally, the photocell is illuminated by the light beam so its resistance is low and only low voltage appears at the junction of potentiometer R4 and photocell R5. Consequently, both the SCR and bell are off. When the light beam is broken, photocell resistance increases and a significantly higher voltage appears at the potentiometer-photocell junction. Under this condition SCR1 conducts and the alarm bell rings. Resistor R3 in series with switch S1 self-latches the alarm.

Figure 19 is a cutaway view of a reflective-type smoke detector. The lamp and photocell are mounted on one wall of the box whose open ends are covered with lids mounted on spacers. The openings provided by the spacers permit smoke to pass through the detector while while ambient light is excluded. An internal baffle prevents incandescent lamp light from falling directly on the photocell.

The lamp acts as both a source of light and heat; the heated air in the box rises, creating air convection currents that draw air in at the bottom of the box and expell it from the top. The inside of the box is painted matte black to eliminate reflections.

If the air currents moving through the detector box are free of smoke, no light will fall on the photocell, and its resistance will be very high. However, if the air contains smoke, the particulates of that smoke reflect light from the lamp back onto the photocell face, causing its resistance to decrease sharply. That resistance drop can trigger an alarm. Figure 12 is a practical control circuit that can be used in the smoke alarm shown in Fig. 19.

Photodiodes put to use

If a conventional silicon diode is connected in the reverse-biased circuit of Fig. 20, only leakage current will flow through the diode and no voltage will be developed across resistor R1. However, if the case is removed from a conventional silicon diode to expose its PN junction, and the diode is then replaced in the same circuit, its photosensitive properties can be observed.

When the diode is exposed to light, its current could rise to as much as one milliampere, producing a voltage across R1.

All silicon PN junctions are photosensitive. Thus a photodiode is essentially a conventional silicon PN-junction diode in a case with a transparent cover to permit light to reach its junction. Figure 21 shows its standard schematic symbol.

In Fig. 22 the photodiode is reverse biased and its output voltage is taken across a series-connected load resistor R1. That resistor could also be connected between the diode and ground as shown in Fig. 20. Photodiodes also have spectral response characteristics, which are determined by the doping of the semiconductor material.

Figure 3 shows a typical response curve that applies for all silicon photoreceptors, a category which includes both photodiodes and phototransistors.

While silicon photodiodes have lower visible-light sensitivity than either cadmium-sulphide or cadmium-selenide photocells, they respond faster to changes in light level. As stated earlier, cadmium-sulfide and cadmium-selenide photocells are best suited for applications in visible light in which they are directly coupled and where relatively slow response time is acceptable. By contrast, photodiodes are better suited for applications in the infrared region in which they receive AC signals and where fast response is required.

Photodiodes are typically used in infrared remote-control circuits, beam-interruption switches and alarm circuits. However, lead-sulfide (PbS) photocells have characteristics that are similar to those of visible-light photocells except that they function only in the infrared region.

Phototransistors

Figure 23 shows the standard phototransistor symbol. The phototransistor is a silicon bipolar NPN transistor in a case with a transparent cover that allows light to reach its PN junctions. The device is normally used with its base pin open-circuited as shown in both parts of Fig. 24. In Fig. 24*a*, the base-collector junction of the phototransistor is effectively reverse-biased so it acts as a photodiode. The light-generated currents of the base-collector junction feed directly into the base of the device, and the normal current-amplification of the transistor causes collector current to flow as the output. That amplified current across R1 produces the output voltage.

Phototransistor collector and emitter currents are usually similar because the base connection is open circuited, and the device is not subjected to negative feedback. As a Consequence, the alternative circuit shown as Fig. 24*b* offers about the same performance as the circuit shown in Fig. 24*a*. The output voltage appears across R1 which is connected between the emitter and ground.

The sensitivity of a phototransistor is typically one hundred times greater than that of a photodiode. However, its useful maximum operating frequency of a few hundred kilohertz is proportionally lower than that of a photodiode's tens of megahertz. A phototransistor can be converted into a photodiode by connecting it as shown in Fig. 25.

Alternatively, the sensitivity and operating speed of a phototransistor can be made variable by wiring a potentiometer between its base and emitter, as shown in Fig. 26. With R2 open circuited, phototransistor operation is obtained; with R2 short circuited, a photodiode response occurs.

In practical applications of the circuits shown in Figs. 24 through 26, the R1 load value is usually selected as a compromise because voltage gain increases but the useful operating bandwidth decreases with the value of R1. Also, the value of R1 value must, in many applications, be chosen to bring the photosensitive device into its linear operating region.

Darlington phototransistors consist of two transistors coupled as shown in the schematic symbol of Fig. 27. Typical sensitivities of photodarlingtons are about ten times greater than those of standard phototransistors, but their useful maximum operating frequencies are only tens of kilohertz.

Preamplifier circuits

Photodiodes and phototransistors are used as lightwave signal receivers or detectors in fiberoptic transmission lines. The light traveling in the optical fiber can be modulated by either analog or digital methods. Photodiodes and phototransistors are also detectors in optocouplers and infrared lightbeam interruption switching and alarm-control systems.

In those applications, the signal reaching the photosensor could either be very strong or very weak. Moreover, the photosensor could be subjected to a lot of noise in the form of random, unwanted visible or infrared emissions. To minimize interference problems, optical links are usually operated in the infrared range, and the optosensor's output is then processed with a low-noise preamplifier having a wide dynamic operating range. Figures 28 and 29 illustrate typical examples of preamplifier circuits with photodiode sensors.

The Fig. 28 circuit is designed for use with a 30-kilohertz carrier. The tuned circuit, consisting of L1, C1, and C2, is wired in series with D1 and damped by R1 to provide the necessary frequency-selective low-noise response. The output signals are tapped off at the junction between C1 and C2 and then amplified by Q1.

The 20-kilohertz selective preamplifier shown in Fig. 29 is intended for an infrared lightbeam alarm. The alarm sounds when the beam is broken. Two IR photodiodes, D1 and D2, are wired in parallel so that the optical signals are lost only when both photodiode signals are cut off. Register R1 is shunted by C1 to reject unwanted high-frequency signals. The output signals across R1 are fed to the inverting op-amp through C2, which rejects unwanted low-frequency signals. R-E

BATTERY TESTER

continued from page 62

base terminals of a standard #1157 automotive incandescent lamp and crimping alligator clips to the other ends of the wires. This load can then be clipped across the battery's terminals for several hours. (The assembly is also a handy, inexpensive trouble-shooting light that you can use for working under the hood of your car.) After disconnecting the load, wait until the voltage stabilizes before doing the CCA test. Ideally, the open, circuit voltage of a new battery should be 12.6 volts ($\pm$0.02 volt).

CRAE test procedure

When using CRAE to test a battery, follow these steps:

1. Determine the manufacturer's CCA rating for the battery. This information is a reference that will help you to determine if the battery should be replaced. Also, estimate the ambient temperature of the battery by taking the air temperature of the battery's location immediately before you begin the test.
2. Disconnect the ground cable from the battery if it is connected to the electrical system of a vehicle before doing the test.
3. Using an accurate digital multimeter with a basic DC-voltage accuracy of at least 0.5%, measure the open-circuit voltage of the battery. If the voltage is below 12.25 volts, recharge the battery and recheck the voltage.
4. Under some conditions the battery voltage will exceed 12.65 volts. In that case, discharge it slightly as explained earlier in the text. Because CRAE itself is a light (2.5 ampere) load, it can be used to discharge the battery. However, *Do not use CRAE for sustained periods of more than two minutes because it is not designed for continuous use !* To measure the output of the battery most accurately, the battery's open-circuit voltage should be between 12.4 and 12.6 volts.
5. Connect CRAE's positive (red) alligator clip to the "+" terminal of the battery and the negative (black) clip to the "–" terminal. Adjust the MAX(INF)ADJ knob on the panel so that the needle points to the maximum deflection. Be sure that all connections are *secure*. A poor alligator clip connection will cause CRAE to give an erroneous reading.
6. Throw switch S1 to the TIMER RESET (left) position and then let it snap back to the center "off" position. Remember that S1 has three positions: center is "off" and the others are momentary action.
7. To test the battery, hold S1 in the TEST position until the LED lights in about 1 minute. When that occurs, take the reading and let S1 return to the center "off" position.
8. For the most accurate retest the battery. Any difference between the first and second readings on a satisfactory battery is insignificant. However, expect that the second reading on a weak battery will be lower than the first. The second reading is the *most accurate*. If you want to retest the battery a third time, be sure to wait at least two minutes between the tests to avoid stressing CRAE.
9. *Do not use the MAX(INF)ADJ knob for the second or subsequent readings on the same battery.* (The 1-minute, 2.5-ampere load of the initial test has changed the battery's open-circuit voltage.) However, if you want to test another battery proceed as stated originally. Also, if the subsequent test on the same battery occurs an hour or more later, reset the meter needle to the INF position. A general rule is that if the open-circuit voltage voltage of the battery is constant—no matter when tested—use the MAX (INF) ADJ knob to set the meter needle to the INF position.

After determining the cranking amp capacity and temperature, use either the GW BASIC program in Table 1 or the graph in Fig.1 to determine the battery's CCA capacity. *Replace the battery if the calculated CCA is substantially lower than the manufacturer's rating.* R-E

ASK R-E

continued from page 10

screen and where to turn it off on the left, you can see why there's no room for more than one set of control signals—no matter how many images you want to mix together.

There are two standard ways to mix video signals. The first is to separate the picture and control information from each signal and then to combine them with a single set of control information from one of the video sources. The second method is similar, but instead of using the control information from one of the original sources, you generate it separately.

Remember that the picture information in each line has a start and end point. Before you mix the pictures together, you have to be sure that all of them are lined up accurately. The circuit that does everything necessary to mix video signals is called a timebase corrector. It's a fairly complex piece of equipment and, as you might expect, it carries a fairly serious price tag as well.

Nothing would make me happier than being able to give you a *simple* circuit to do the job but, unfortunately, I can't. I can tell you, however, that it's worth your time to try to come up with one because, if you're successful, you'll have something that can lead to a lot of profit and an early retirement.

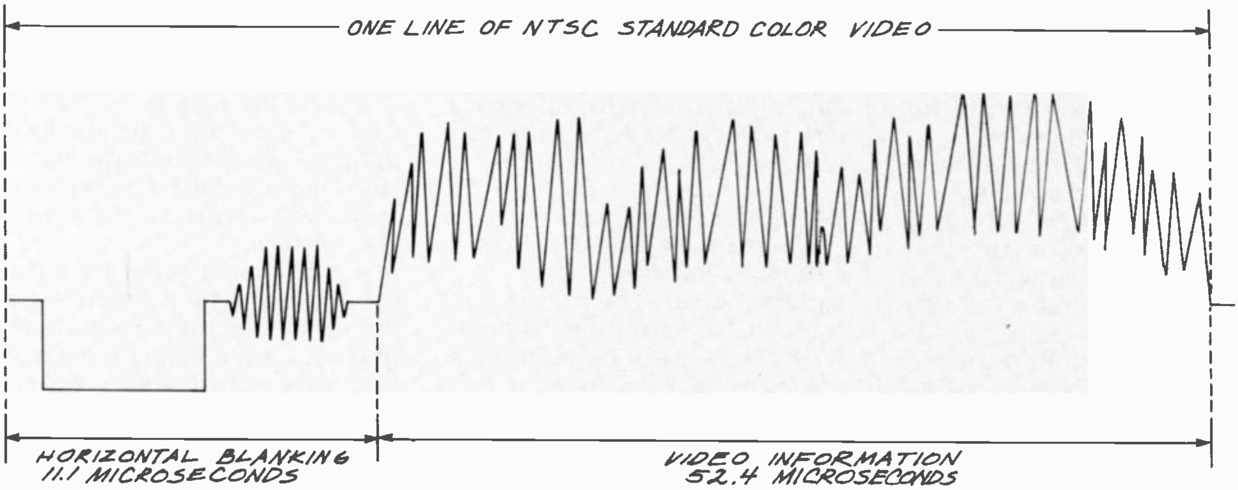


FIG. 3—TO MIX TWO OR MORE VIDEO SIGNALS you must combine the picture areas, but use only a single control area.

HARD-DRIVE LED

I have an AT-class computer with an IDE hard drive and I just recently added a second hard drive. The equipment works fine, but the LED that indicates hard-drive activity lights only when the first drive is active. The second drive works fine, but the LED doesn't come on. Can you tell me what's wrong?—G. Fishben, Enterprise, NY

Since both hard drives are working correctly, I have to assume that the question is academic—interesting, but not vital. The LED activity indicator is a nice thing to have, but we'll both agree that it's a lot better to have the drive working and the LED messed up than having it the other way around.

The reason for the problem is not with the drive but with the IDE controller card. The people who made the card in your computer, or the circuitry on the motherboard if your computer has a built-in IDE controller, cheaped-out when they designed the circuit. For some reason, the IDE standard isn't quite as "standard" as some of the earlier hard-disk encoding schemes such as MFM, RLL, or even SCSI.

The hard-disk activity LED is usually triggered by decoding several of the control lines connected to the cable. The exact method varies from card manufacturer to card manufacturer, but it's generally some combination of READ, WRITE, and other lines. The real answer to your question can be found by looking at the pinout of the standard IDE connector. If you're lucky, that can be found in the instruction manual you got with the controller card. You'll see that pin 39 is marked as "SLV ACT"—which, in plain English, means "slave drive active."

That line goes low when your second drive is selected, and it should be connected to the hard-drive activity LED along with whatever other control lines are used for the first drive. If you put a meter on that pin and access your second drive, you'll see that the pin becomes active. The manufacturer should have used an OR gate (or a resistor-combination equivalent) when the card was designed. You can do it yourself by tying pin 39 to the LED connector with a resistor of about 1000 ohms.

One side of the LED is connected to 5 volts and the other can be the output of a gate or a node on a resistor network. You want to connect the 1K resistor from pin 39 of the IDE connector to the pin of the LED that's not connected to 5 volts. Since you probably don't have schematics for the controller card, it's a good idea to use a small diode such as a 1N914 to isolate pin 39 from the LED. Since you have to take your computer apart to do that, you have to figure out if the final result is worth the effort. Should you decide to do it, you might consider using a second LED (triggered by pin 39) as an indication that the second drive is active. **R-E**

WARC '92

continued from page 40

WARC-92's notable statistics

WARC-92 was attended by more than 1400 delegates from 127 countries, and there were several hundred observers from 31 regional and international organizations. The conference produced six million pages of text weighing 28 tons. There were two all-night sessions on the last two days of the conference, and when the conference concluded, most of the participants weren't clear about what decisions had been made, particularly in the sound-broadcasting satellite service, BSS.

A total of 81 declarations were made at the end of the conference. A declaration is a statement by a country's delegation that is appended to the Final Acts of the Conference, calling attention to an issue of particular concern to that delegation. Perhaps the most telling declaration was entered by the French Delegation; it set the tone for the conclusion of WARC-92. It expressed reservations about the number and complexity of the texts adopted within the short time of WARC-92, and it was concerned about possible interpretations which would not conform with the final consensus of the conference.

[Editor's Note: Stanley Leinwoll, director of engineering in U.S. for RFE/RL, was a member of the United States Delegation to WARC-92.] **R-E**

LETTERS

continued from page 15

nine beast whose barking can become quite a nuisance.

About a year ago I built a magnetic field meter that was featured as a kit in **Radio-Electronics**. After completing the unit, I was checking around the house for relatively high sources of EMF's when I noticed that my dog, Sparky, had a very intense field surrounding him. I initially thought that was due to a high static charge accumulated from rolling around on the carpet or brushing against the TV screen. I tried discharging him to a water pipe and even rubbing him on the carpet, with no measurable effect on the field. Sparky is a very large dog and somewhat hyperactive. I believe that might coincide with his high electrical potential.

My concerns are with the micro-receiver-resonator module. That is obviously a very low power unit using the dog's own bio-magnetic field as a power source. I am afraid that Sparky's unusually strong magnetic field could quite possibly interfere with, or completely inhibit, the operation of this unit. With it's cost in mind, I would hate to think that it could be damaged or even rendered useless after it's installed. I am hoping that you can provide me with a source for detailed specifications concerning power requirements and EMF shielding of this unit.

If everything works out okay, I'm planning to use multiple resonators at various locations on Sparky in combination with an extensive training program in hopes of teaching him some very advanced tricks. That might also prove to be the long-awaited edge we need to take the blue ribbon at this summer's dog show. Although this might sound far-fetched, I'm even thinking of adding a module to my home-automation system that would allow complete control over Sparky's behavior.

Thanks for your continued efforts in bringing the latest in innovative, entertaining, and exciting projects—and your best April Fool's kit yet!

JOHN SLADE
Hillsdale, MI

Kudos to the author of "Remote Control For Your Dog" (**Radio-Electronics**, April 1992). The best April Fool's article yet. Incidentally, for those readers who might be having trouble with the high price of the actuator module, I went to work right away in my basement. I'm proud to say that I can make available the same at a price of $4.95 per unit.

BYRON HODGES

Thank you for the article "Remote Control for Your Dog." It is yet another star in **Radio-Electronics**' glittering firmament. However, it seems that Mr. Canino failed to realize the true potential of his device. The applications need not stop at simple behavior suppression. A dog is an intelligent animal and can be taught very complex behaviors. Why not use the subcutaneous receiver to initiate a behavior, for instance, fetching your slippers. Why stop there? Several receivers could be implanted in different locations and their control could be consolidated in one transmitter. A buzz in the left thigh would make the dog lick-shine your boots, a tickle behind the left ear to answer the door, and a tingle in the tail to fetch you a beer from the fridge—all for the fraction of what it would cost for a butler or personal robot.

I personally have trained my dog so that at the receipt of my summons he leaps onto a treadmill that provides electrical power for the "Low-Cost Laser Printer" that I built from an article in last year's April issue.

Mr. Canino failed to address the potential for abuse of this technology. For example, what if your dog was kidnapped by a hostile intelligence agency or an estranged family member, who subjected him, unbeknownst to you, to a receiver implant and intensive aversion therapy. He returns seemingly unharmed, but ready at any moment to receive the tear-your-throat-out signal from a waiting agent. The last place the secret service would look for a threat to the President would be his dog!

I have obtained evidence that this may already be happening to the pets of many high-ranking officials. The implant is small enough to use in all sorts of animals—cats, parrots, lions, tigers, bears, and even farm animals are no longer above suspicion. This may very well create a totally new arena for military escalation among the major world powers.

I, for one, will never look at my pet turtle in quite the same way ever again.

JAMES SENTMAN
Lake Bluff, IL

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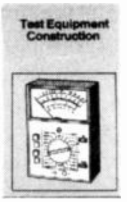

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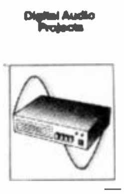

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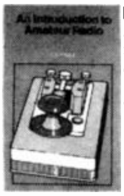

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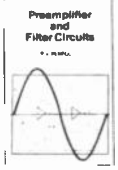

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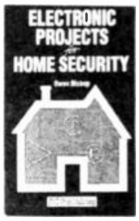

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HARDWARE HACKER

Dye-based solar energy, Neo-Geo interface cables, another sad patent story, micro-avionics newsletter, and RGB monitor fundamentals.

DON LANCASTER

Uh whoops. Back in April (page 65, Fig. 2), one of my last minute "improvements" to the PC layout for the sync stripper and universal video interface left one extra trace from pin 9 to the SYNC output line. Sorry about that. If you have already etched your board, just cut that tiny run out. Figure 1 had it correct.

Moral: It is always the things that you *thought* you triple checked that are certain to return to haunt you.

We will see several other possible changes to the sync stripper in just a moment when we look at some new *Neo-Geo* interface ideas below.

An update to the crystal-stabilized FM stereo broadcaster circuit that we looked at last month: I've now had a brief chance to check into that new *Sony* XA7A unit. While it uses pretty much the same circuit we looked at, it seems more costly, klutzier, and far harder to hack.

The BA1404 has a surface mount package. There are some tight and tiny shields, and some awkward "3-D" component arrangements. *Sony* appears to be getting two channels by pulling its crystal an astounding 200 kilohertz in either direction. I'd bet its stability isn't as good as in a *Pioneer* CD-FM-1.

Speaking of which, it should be possible to significantly improve the CD-FM-1's range by replacing the SAW filter load used by Q4 with a simple tapped resonant tank located *outside* of the existing shield. That would switch Q4 from class-A over to class-C operation. Some bypassing on R19 could also help, as might lowering its value somewhat.

More details when I get a chance. Meanwhile, do let me know what you come up with on your own.

Patents again

The morning mail had yet another sad example of a hardware hacker done in by the patent system. Or more correctly, done in by the outlandish popular myths and all the gross misconceptions surrounding patenting. One more time: *Any hardware-hacker-based small-scale involvement in the patent system is absolutely certain to result in the net loss of time, energy, money, and sanity.* Your state lottery is a vastly better investment.

This example involved an Oregon inventor who sent me a copy of his new patent and asked for my help in marketing it. The patent is intended to recover electrical energy from a steam line by impinging the steam onto a piezoelectric generator. The patentee admitted he lived in a very "remote area" where all research was difficult. And he did specifically ask me for comments, so here goes.

Well, it must have been my kind of remote area. There was obviously no telephone available to call the *Dialog Information Service*, and no postal or UPS service to receive *UMI* reprints. Their local library had to be so small that they had no *Uhlricht's Periodical's Dictionary* which included the EPRI *Electric Power Research Institute Journal*.

And, of course, no *Encyclopedia of Associations* which would include the *Association of Energy Engineers* with their great conference publications on this type of cogeneration device.

I felt the patent was rather weak. I think I could personally find all kinds of prior art way back in the 1890–1930 time frame. And I do think the idea would be so totally obvious to any "practitioner in the field" that prior art would not even be required to quickly bust this patent. In fact, attempting to defend it could easily lead to a nasty old frivolous litigation countersuit.

"Outside of that Missus Lincoln, how was the play?" Well, I do not know of any high-power electricity-producing piezo generators. Piezo tends to be grossly inefficient and involves frequencies and impedance levels that are hard to elegantly deal with at higher power. Piezo transducers tend to have lousy power factors, since they are often very capacitive. The optimum working temperatures are well below that of live steam.

Further, we obviously have a heat engine here that has to obey the laws of thermodynamics. The best possible efficiency (called the *Carnot* efficiency) would be rather low. Which is why we don't have too many steam engines these days. And I feel the P-V (pressure-volume) diagram for the proposed impingement system would be absurdly far away from the best possible. It is clearly not adiabatic.

I would be quite surprised if the overall electrical recovery efficiency could ever exceed 0.1 percent. Thus, I feel this product would *never* be able to pay for itself or for the time value of the money used. Let alone recover any useful power.

So, I'd guess my answer on any marketing of this product would be "Uh, to whom?"

Now, there are all sorts of exciting steam recovery developments going on. They involve *bottoming* and *scavenging* cycles and can use exotic fluids other than water vapor. And they are revolutionizing commercial electric-power production

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by sharply improving efficiencies. And the pulse-combustion furnace folks are playing lots of neat games in super efficient *latent heat* (gas to liquid) recovery. So there are bunches of new possible opportunities in this area. Some of them eminently hackable.

By the way, one ancient but quite readable book on thermodynamics is Sanford's *Heat Engines*, found in the *Doubleday Science Series*. No hacker can afford to ignore the fundamental laws of thermodynamics.

Where to go from here? First and foremost, *avoid any and all involvements with the patent system in any way, shape, or form*. Do so religiously.

Second, get yourself a fresh copy of *The Case Against Patents*, either in my *Blatant Opportunist* reprints or as our *GEnie* tutorial PSRT textfile #162 NOPATENT.TXT. Rumor has it that this reprint may also shortly appear in the *Whole Earth Review*.

Third, there is a unique magazine known as *Midnight Engineering* that specifically supports the small-scale developers, product prototypers, and startups. With proven and realistic help. Free samples on request.

Inventing, of course, is a highly reprehensible and incurably addictive social disease that is simply not talked about in polite company. So, fourth and finally, you might want to join some AA-type support group. A typical example group would be the *Zimmer Foundation*, associated with the *Michigan Inventor's Council*. Just be certain that your selected group isn't a marketing scam in disguise.

Another solar breakthrough?

Lots of credibility has been newly given to *dye methods* of solar energy conversion. As we have seen in past issues, certain dye molecules can act as both an antenna and rectifier, converting any incoming photons into an electron current. The dye method is potentially very cheap, very efficient, and should end up quite easy to mass-produce. Only low-cost and low-tech materials are involved.

Do check out the October 24, 1991 issue of *Nature* (vol. 353 #6346). Especially Thomas Mallouk's *Bettering Nature's Solar Cells* (on pages 698–699) and also Brian O'Regan and Michael Gratzel's *A Low-Cost High-Efficiency Solar Cell Based Upon Dye-Sensitized Collodial Titanium Dioxide Films* (on pages 737–739).

Some librarians appear to have lots of trouble finding *Nature*, possibly because it is British. Which is a real mystery, since *Nature* is regarded by most of those in the know as the finest and most significant science publications anywhere in the world.

Obviously, any magazine that gets up to weekly issue #6346 must be doing something right. If you get any static picking up any *Nature* copies locally, scream and holler and stamp your feet. Or use the address found in our *Names & Numbers* sidebar.

Figure 1 shows you the general idea behind any dye-based solar cell. The cell uses liquids and is related to a wet-cell battery. An elec-

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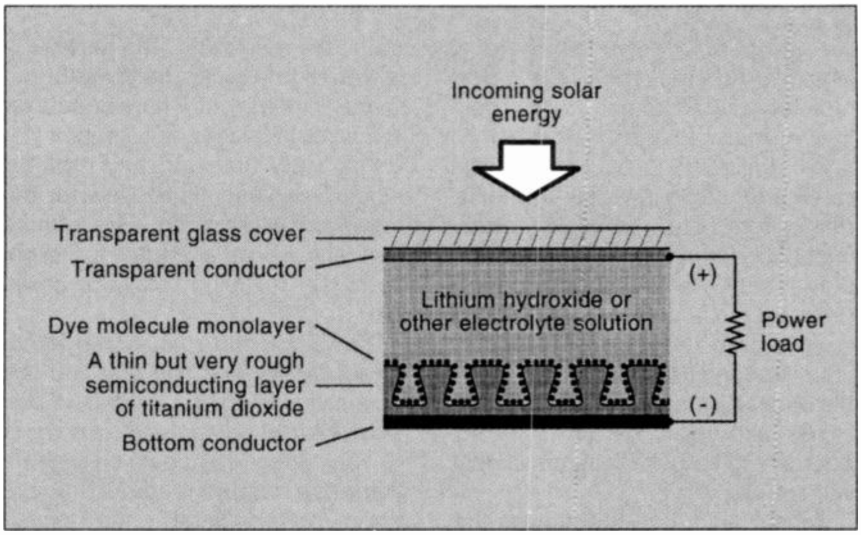

FIG. 1—ANOTHER SOLAR BREAKTHROUGH? The dye-based solar method uses a large-area monolayer of individual dye molecules to act as optical antennas and rectifiers. An electron "borrowed" from the electrolyte by the dye gets its energy level raised by an incoming photon, jumps the rectifying semiconductor gap, delivers useful load power, and then returns to the electrolyte. The high-efficiency process is related to the first stage of plant photosynthesis. All the materials used are cheap and fairly low tech.

trolyte of a lithium salt or something similar is used. The uppermost terminal is a conductive metal film under a layer of clear glass. The bottom terminal is also a conductive metal film. Onto this film, a very thin and very rough layer of a titanium dioxide semiconductor is deposited. Together they form the metal barrier diode.

The semiconductor film is made as rough as possible to greatly increase its surface area. The present effective areas are in the 2000:1 range. A one-molecule thin *monolayer* of *trimetric ruthenium* dye then is deposited on the semiconductor surface.

The single-dye molecules can act as both an antenna and a rectifier. An existing electron in the electrolyte solution will have its energy level increased by the incoming optical photons. These high-energy electrons jump the semiconductor junction, go through the load delivering useful power, and return via the top electrode, creating a self-rectifying and light-induced photocurrent.

So far, the actual efficiencies are only slightly better than polysilicon cells. But all of the materials are far cheaper (titanium dioxide is used to make white house paint; only small amounts of dye are used). They also lend themselves to larger area, high-volume processing.

There are several remarkable similarities between dye-based solar and plant photosynthesis. In fact, the biggest difference is that dye-based photosynthesis stops with its generated electrons, while plant photosynthesis will go on and use the high-energy electrons to drive the intermediate chemical reactions, which can ultimately create sugars, cellulose, and other tasty stuff.

Dye-based solar-energy conversion is already more efficient than the most efficient plants known today. On the other hand, plants can create and repair themselves.

RGB video fundamentals

I have recently been working with Dennis Carper of *Redmond Cable* in interfacing all sorts of video games to all types of leftover surplus computer monitors. So, I guess it might be a good time to review some of the fundamentals of RGB monitors.

The reasons we go to the separate *red-green-blue* route in the first place are for *picture quality* and for *picture resolution*. Regardless of how much trouble you go to, it is simply not possible to glomp onto the antenna terminals of an ordinary TV set and display anything even *remotely* near what is needed as a bare minimum for all of today's color computer displays or premium arcade video games. The needed bandwidths and scan rates are simply not there.

Unlike broadcast signals (such as NTSC, PAL or SECAM), there are *no* universal standards being used for RGB monitors. If it has three separate video lines on it, it is an RGB system. Period. Thus, you will have to be *very* careful about what your video source and your video monitor are capable of before you try to connect them.

The simplest RGB system uses "TTL" monitors. It does not accept video as such. Instead, it receives digital logic signals that turn its red, green, and blue beams *entirely* off or on. Thus you can get only *eight* possible colors. All eight of which are *always* fully saturated. Some TTL monitors include a fourth *brightness* line that gives you a choice of "full" or "half" bright, increasing the apparent color total to sixteen.

Instead, on a *linear* RGB monitor, all shades of all colors are possible. Linear monitors need much more in the areas of video amplification and linearization (or *gamma correction*) circuits. Obviously, linear monitors are required for "real" video from a cable or broadcast source, or whenever you need a very wide range of hue and saturation values.

Most linear monitors are not too fussy over accepting *interlaced* scans, used on standard TV, or the *noninterlaced* scans, as *must* be used on most data displays.

But linear monitors are extremely fussy about their *horizontal scan rates*. Ordinary TV uses the horizontal scan rate of 15.735 kilohertz for color or 15.750 kilohertz for black and white. Most computer scan rates are double that, up in the 32-kilohertz range. And premium systems can have scan rates of 80 kilohertz or higher.

Unless your monitor is carefully designed to be a *multisyncing* type, it will accept only a *very* limited horizontal scan rate range. Thus, *there is no way you could use an ordinary broadcast RGB monitor to display a Mac or VGA output*. It flat out can not operate at the higher scan rates.

One of the ruder surprises to Apple IIgs people downgrading to a Mac LC is that their old color monitor will no longer work. Their IIgs monitor is a broadcast-only style, while those LC video scan rates are up in the 30-kilohertz range. Fortunately, a simple jumpering option (which we saw a few columns back) lets the LC use an ordinary and cheaper VGA monitor.

Thus, you have to be sure that your intended RGB monitor is capable of accepting the horizontal scan rates provided by your video source. Some combinations simply will not work.

A final major consideration is the monitor's *resolution*. The resolution is set by the video bandwidth and the pitch of the color bars or dots on the screen. Images will smear if you try to view them on any monitor whose resolution is too low for the intended application. The results can end up as a cause for slight eyestrain to being totally unviewable.

So, a second rule: *Make absolutely certain that you test and use any monitor for its intended purpose before you actually pay for it.*

Your video lines could be *high impedance* cables if the runs are short, or *terminated* ones (usually

NAMES AND NUMBERS

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(408) 524-1400
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Dialog
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Palo Alto, CA 94304
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Rockville, MD 20850
(800) 638-9636
CIRCLE 314 ON FREE INFORMATION CARD

Kepro
630 Axminister Drive
Fenton, MO 63026
(800) 325-3878
CIRCLE 315 ON FREE INFORMATION CARD

Lighting Dimensions
135 Fifth Avenue
New York, NY 10010
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Sunnyvale, CA 94086
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Ringoes, NJ 08551
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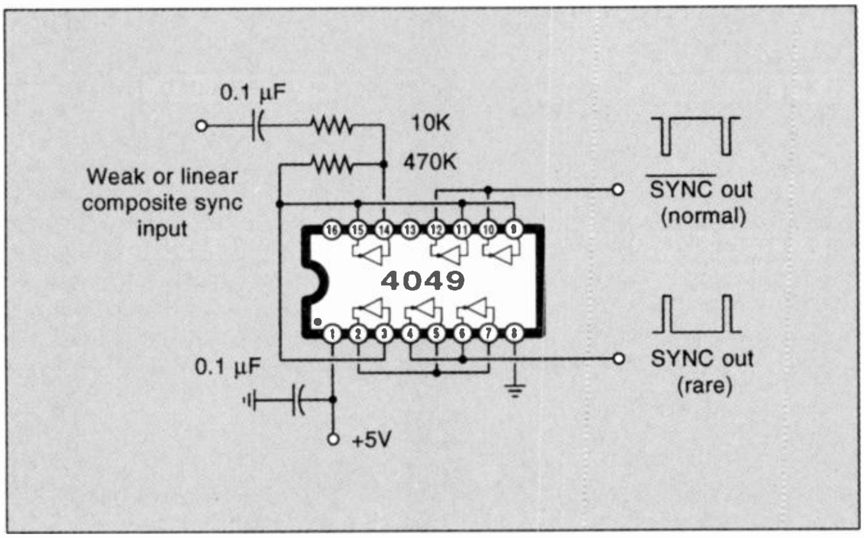


FIG. 2—THIS SYNC AMPLIFIER can take "linear" or "weak" RGB composite sync signals and make them CMOS- and/or TTL-compatible. It also gives you an optional and rarely needed active-high sync output.

75 ohms) for longer distances. A fair amount of power is required to properly drive a terminated video cable. *Maxim* is one good source for video drivers. Video cables are best made either as fully shielded, or, at the least, as twisted pairs. If any separate grounds are provided, they should be used as they were intended.

If your video source has any DC offset present (such as the emitter-follower outputs of a *Super Nintendo*), then you *must* provide for a capacitor coupling between the source and the monitor. Very large capacitors are recommended, at least 220 microfarads or more. But they might already be built in, so check first.

There are several synchronizing options used in RGB systems. Some systems tack sync signals onto the green channel and later strip them off. But most systems have separate sync line(s) that deliver horizontal, vertical, or composite sync signals.

To further confuse matters, sync lines can be smaller one-volt signals at analog levels, or they can be TTL- or CMOS-compatible. Others can be at TTL levels, but end up too small for CMOS and too weak for TTL. We saw a *Super Nintendo* workaround for this last month with a simple 680-ohm resistor to ground.

Typical sync lines are *active-low*, meaning that the sync tips are at ground. But a few (especially earlier *Commodore* products) demand an *active-high* composite sync.

Figure 2 shows you how to use several inverters to amplify low-level sync signals into full CMOS and TTL compatibility giving you a choice of either active-low or active-high sync tips. The first stage can be a biased inverter amplifier having a gain of twenty or more. The second inverter further cleans up the now-digital waveform, while the third and fourth stages act as inverters or drivers.

If you try that linear amplifier stunt with other CMOS gates or inverters, be sure to use "single stage" unbuffered (UB) versions; other buffered ones might have too much gain and could oscillate. More details in my *CMOS Cookbook*.

Our sync separator and universal video interface from the April column is easily modified to provide suitable sync amplification for the Neo-Geo or Super Nintendo.

Sound is dealt with separately in an RGB system. Sometimes, there will be no sound at all. One clue here is the absence of any volume control. *Radio Shack* makes a neat little $11 lab amplifier that can sit in for you. Other options are monophonic sound, stereo sound, or a *multiplexed stereo sound* accepting R+L and R−L inputs. Super Nintendo uses a multiplexed sound output.

If you forget to demultiplex, one channel will sound monophonic, and the other might sound awfully tinny and just plain "wrong." To demultiplex properly, you *add* the two signals together to get the right channel and *subtract* them to get the left one.

Regardless of your sound system, *totally shielded audio cables are a must.* Ideally, they should be *totally* separate from all your video cables, due to the strong "hum" and "buzz" induced by vertical rate signals.

So, what can you interface to what? Use your oscilloscope to view all the normal outputs of your video source run in its intended way. Then do the same for the "normal" inputs to the monitor.

Some hints: To tell if a source is capacitor-coupled, briefly connect a 470-ohm resistor between it and ground or +5 volts. If the scope display bounces around and slowly drifts back, you are AC-capacitor coupled. If it stays in the initial position (or possibly gets slightly smaller), then you are DC coupled. Be sure to take note any fixed offset voltage.

To determine your source impedance, note that any resistive load *equal* to your source impedance will drop your output signal level to *one half* of the open-circuit value.

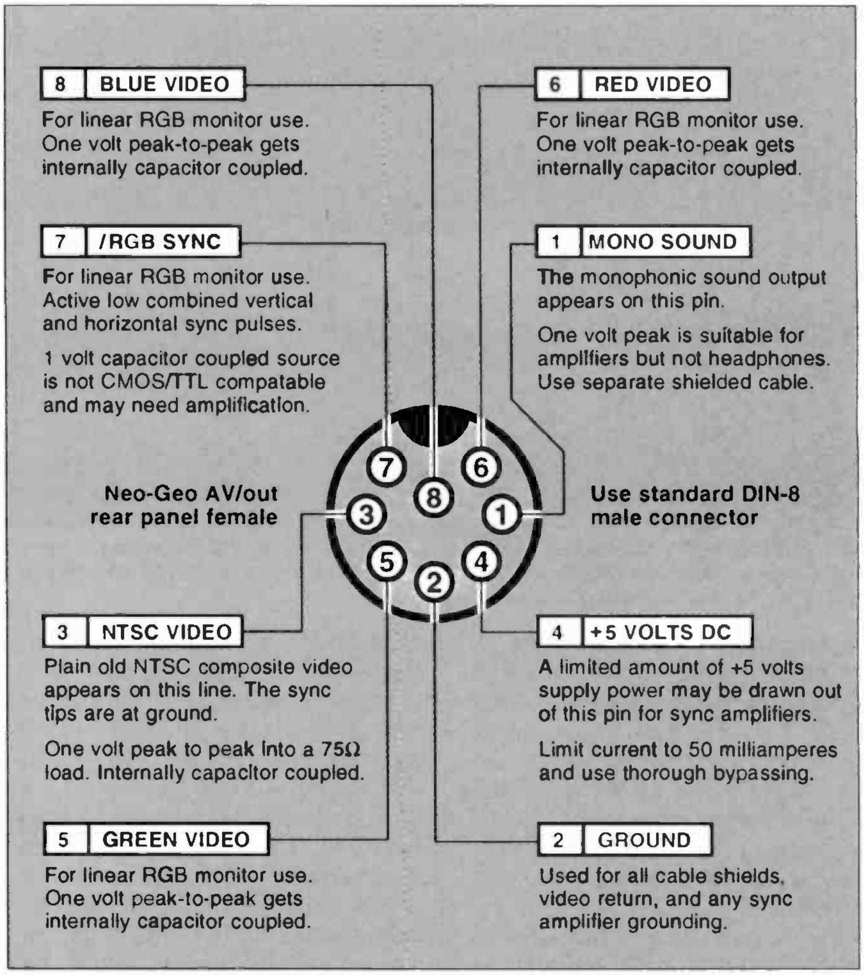


FIG. 3—THE NEO-GEO AV-OUT rear connector has both NTSC and RGB output pins available. Here are the key details.

Neo-Geo interface ideas

Sorry, but our renowned experts (the munchkin division of *Special Editions*) were not at all impressed with the new *Neo-Geo* game system. Their preerence for *Super Nintendo* was totally overwhelming, and I will certainly defer to their expertise. But, if you happen to like the Neo-Geo system, Fig. 3 shows you the rear A/V output interface connector pinouts.

There are several interesting interface options here. Present are the usual NTSC composite video on pin 3, a ground on pin 2, and a +5-volt supply on pin 4. You could use that supply for such low-current needs as modulators or sync amplifiers. For RGB use, there is a red line on pin 6, a green line on pin 5, and a blue line on pin 8. Those are capacitor-coupled video with a 70-ohm source impedance.

Their RGB active-low sync line appears on pin 7. It is also in the form of capacitor-coupled video at a one-volt amplitude. Thus, the sync line is *not* presently TTL/CMOS logic compatible, and you might need the sync amplifier of Fig. 2.

Figure 4 shows you a baseline RGB interface for the *Neo-Geo*. The connector is a standard DIN-8 that is *Radio Shack* stock. As with our previous *Super Nintendo* interface, stock and custom cables, connectors, and any and all individual parts are obtainable through *Redmond Cable*.

Surplus resources

As our resource sidebar for this month, I decided I would gather together what I feel are only the best of the very best in hacker surplus stores. These are the ones I have used consistently over the years and can personally recommend.

The best surplus store anywhere, of course, is *Jerryco*, which has recently become *American Science & Surplus*. It is strong in electromechanical parts and unusual materials.

For genuine World War II vintage surplus, *Fair Radio Sales* is the preeminent place to go. For heavier iron stuff, especially motors, steppers, or hydraulics, try either *C&H Sales* or *Burden's Surplus Center*. And for the best prices on a wide variety of components, try *Surplus Traders*.

Several other outfits I have found useful include *Herbach and Rademan* (infrared people detectors), *Marlin Jones* (power supplies and steppers), *Circuit Specialists* (for harder-to-find hacker integrated circuits), *Time Line* (solid-state imaging chips), and either *All Electronics* or *R&D Electronics* (generally good electronic buys).

Finally, for totally outlandish plain old weird stuff, *Archie McPhee* is it, claws down. Where else can you get a three-foot rubber iguana?

For our contest this month, just tell me about your favorite surplus or any other hacker-friendly and rea-

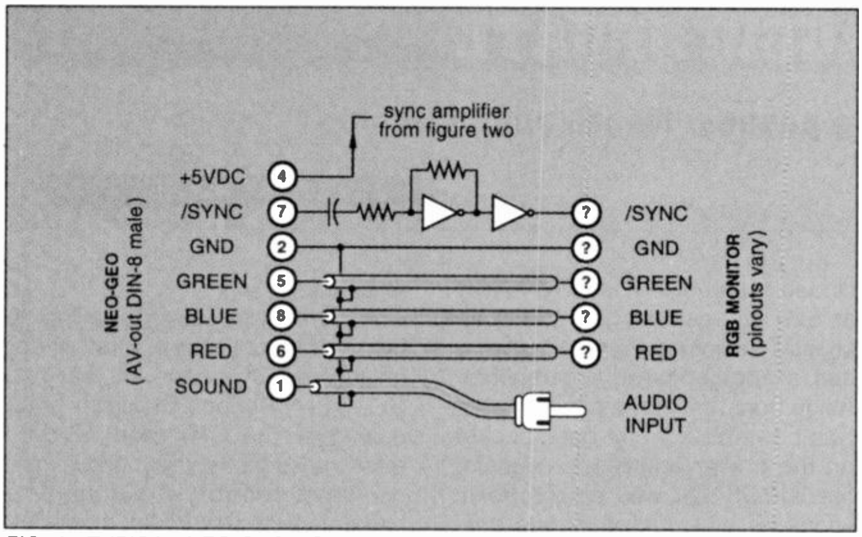


FIG. 4—TYPICAL NEO-GEO RGB INTERFACE connections. The details and pinouts vary with your choice of monitor. The sync amplifier shown might or might not be needed. Custom cables and individual parts are available from Redmond Cable.

sonably priced source of unusual goodies. There will be several of my *Incredible Secret Money Machine II* book prizes, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the best of all.

If possible, include a catalog or put me on their mailing list. Be sure to send your *written* entries directly to me here at *Synergetics* rather than to **Radio-Electronics**.

New tech lit

The *Ashtech* folks now offer some really great and reasonably priced ($100) four-day courses on those GPS navigation systems, besides offering free notes.

From *OKI Semiconductor*, some *speech application notes* on the solid-state speech-synthesis chips.

The *Micro-Avionics Newsletter* is a brand new and sorely needed labor-of-love hacker publication. It focuses on the remote controls, navigation, autopiloting, and the television links used on low-end and amateur radio-controlled R/C models, and other aerial platforms. Sample issues are $5.

Another very interesting magazine is *Lighting Dimensions*, a slick and well-done publication intended for a readership of stage, theater, television, and rock-concert lighting specialists.

It's been a while since I mentioned the *Society for Optical Engineering*. Their freebie *SPIE Technical Publications* lists all sorts of unique books and reprints on such goodies as solid-state gyros, high-speed photography, robot vision, lasers, liquid crystals, and even on *binary optics*.

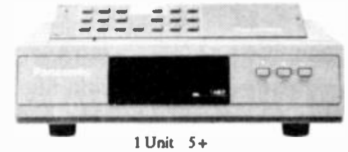
There are several exciting new developments in hacker printed circuits these days. The *Kepro* folks now offer a new *How to make printed circuit boards* booklet. A product called PCBTF-1000 is a brand new transfer film for their direct-toner method, newly available by way of *Techniks Incorporated*.

And I've just posted my shareware printed-circuit layout package over to *GEnie* PSRT as our file #401 PRNCRCT.GPS. Plus our summary tutorial on new hacker printed-circuit techniques as file #419 NUTS3.PS.

You will also find lots of wavelet info, caller-ID news, and unique tech tutorials over on PSRT. Your average downloading costs are around 21 cents each.

If you are at all interested in the PostScript language, I stock the *blue* book tutorial from Adobe; my own *LaserWriter Secrets* book/disk combo whose insider secrets apply to most printers; and *The Whole Works*, one each of everything worthwhile by *all* of the major PostScript authors, at an unbeatable price.

As usual, we've gathered many of the resources mentioned together into the *Names & Numbers* or the *Surplus Resources* sidebars. Be sure to check these out *before* using our helpline. **R-E**



AUDIO UPDATE

The kit era passes: Heath pulls the plug

LARRY KLEIN

A front-page article in a recent issue of *The New York Times* was headlined "Plug Pulled on Heathkit, Ending a Do-It-Yourself Era." I won't say that the story brought a tear to my eyes, but it certainly did send me on a trip down memory lane. In late 1947, I was in the U.S. Army Signal Corps assigned to White Sands Proving Grounds, in New Mexico. We used liberated German V-2 rockets as part of a space-flight research program. I served as an electronics technician who manned a Doppler tracking station during launches and did electronic construction and maintenance work for the Doppler Lab between "shots."

On a weekend pass in El Paso, TX, I picked up a copy of *Radio Craft* and settled down in the local YMCA for a good read. (Yes, I was truly a wild and crazy guy during my Army days!) A Heath Company ad caught my eye. The ad offered an oscilloscope kit with top-quality war-surplus parts for only $39.95. Despite the fact that the cost of the kit far exceeded my Technician, Fourth Grade's monthly pay, I felt I had to have it. My plan was to store the kit behind my bunk (it wouldn't fit in my footlocker), and work on it during my free hours. As I might have predicted, it caused a major hassle during the next barracks inspection, and I was persuaded to finish its construction in the Doppler Lab.

In any case, using the single blueprint sheet provided, I successfully completed the kit and fired it up. It didn't compare very well with the Mil-Spec Dumont scopes in the lab—but it was all mine! The trace was a little thick, and the sweep slightly nonlinear, but I now owned a real live oscilloscope.

Let's take a quick jump to the early 1950's. Encouraged by its success with a basic scope kit, Heath ultimately developed a full line of test-equipment and hi-fi kits that included separate AM and FM tuners at $29.95 each, single- and dual-chassis Williamson-type amplifiers, and a sophisticated preamplifier. Aside from the fact that the preamp was powered from an octal socket on the power amplifiers' chassis, the $19.95 unit was an electronic knock-off of a top-of-the-line self-powered Fisher preamp that sold for about $100. (In general, the kit companies that proliferated during the next decade freely borrowed from each other's designs and those of the factory-wired units. For example, I recall seeing several H-P instruments lifted wholesale into kit equipment.)

Customer problems

By now I had gone to work as a troubleshooter/technician for Heath's major competitor, the Electronic Instrument Company, better known as Eico. A large part of my job involved correspondence with kit buyers who couldn't make their completed units work.

The problems mostly came down to careless wiring errors, but anyone who has worked in the kit business has accumulated a collection of funny stories. During my five years at Eico, I came across at least one oscilloscope and one audio generator whose novice builders had, as instructed, carefully used spaghetti (never defined in the construction manual) on all the long insulated component leads. In truth, it wasn't spaghetti they used, but rather elbow macaroni of the appropriate length and diameter. The only reasons the kits didn't work were wiring errors.

A more common blunder was the use of "liquid solder," a now-extinct commercial concoction apparently composed of airplane glue and silver paint. Needless to say, those hundreds of glued "solder" joints didn't conduct very well, although at a casual glance they really did look legitimate.

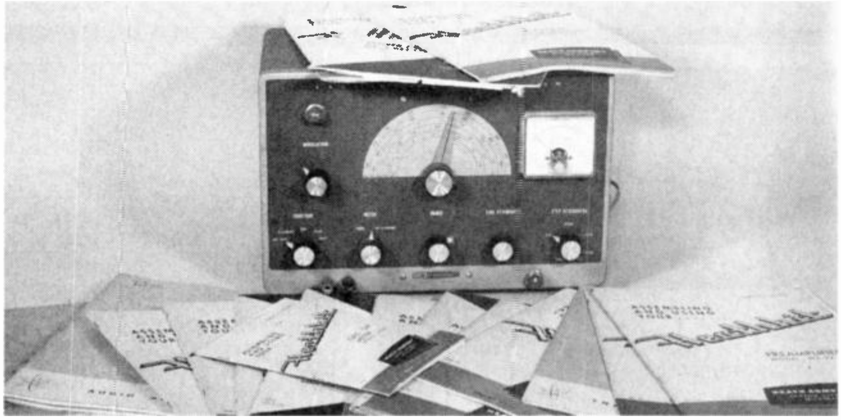
Another story is worth telling. In Eico's product line was a rather sophisticated DC-scope kit that had an edge-lit scribed Plexiglas graticule over the CRT face. Shortly after the scope hit the market, I began to get mail from kit-builders who had completed their kits, complaining that the CRT trace was dim and blurred. I wrote back with appropriate suggestions, but to no avail. I wondered whether we might have shipped out a bad batch of CRT's, and I asked one kit-builder to send back his CRT for test and possible replacement. When his CRT checked out fine, I asked him to ship the entire scope back to my attention. Less than a minute after the scope arrived at my desk, I diagnosed the problem. We had sent out the Plexiglas CRT graticule screen with a protective brown paper covering, which he had not removed before installation. Turning up the intensity made the trace visible through the paper coating but, of course, completely defocused the beam. (The ultimate solution was a stamp that said: "Peel off protective paper before installing graticule.")

To return to my involvement with Heath, my early years at *Stereo Review* coincided with Heath's heyday. A typical issue in 1964 might have six pages of Heathkit product advertising compared with Fisher's four pages. You have to understand that the Heath power amps were *the* audiophile product of the day. Heath's success didn't go unnoticed by the conventional hi-fi manufacturers. In 1962, high-quality kits were available from dozens of companies including Dynaco, Fisher, Harman-Kardon, plus many speaker, turntable, and tone-arm manufacturers.

Kit costs

During the 1970's, I wrote several "Joy of Kit Building" articles wherein I dealt with the question of kit economics. Although the early Heath power amps were not available factory-wired and there were no exact commercial equivalents available elsewhere, many components from other manufacturers *were* available in both kit and wired forms. I calculated that the average kit-builder was saving the equivalent of about 50 cents for each hour invested—not bad for having fun.

Eico produced both factory-wired and kit equipment. Knowing what I do about the complexities of producing a kit and its manual, I'm surprised, in retrospect, that kits were usually about 30% cheaper than the physically and electrically identical wired units. For example: An excellent 60-watt power amplifier cost $72.95 in kit form and $99.95 wired.

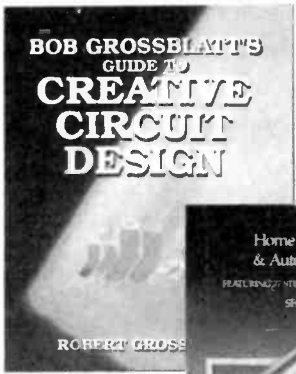


A HEATHKIT TEST GENERATOR and manuals from some of the many kits built at Radio-Electronics over the years.

Death knell

What killed Heath and the other companies involved in kit production? It seems to me that as soon as factory-wired equipment became as good as the kits and (thanks to the Japanese) just as cheap, then kits were in trouble. My earlier point about having fun still stands, but competing computing and video fun was now available to the electronic hobbyist. As the readers of **Radio-Electronics** demonstrate, there are still those who relish the smell of bubbling solder flux—and I'm one of them—but apparently our numbers are not sufficient enough anymore to support large kit companies.

Perhaps it is symbolic that my family's Heath H-89—an 8-bit, 64K microcomputer that my wife spent 52 hours (!) building in 1981—finally also died this year. Since I can't bring myself to put it out at curbside for Thursday trash pickup, anyone interested in providing it with a good home—or using the parts it contains—can drop me a note in care of this magazine. **R-E**



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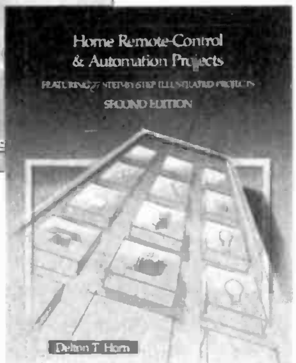

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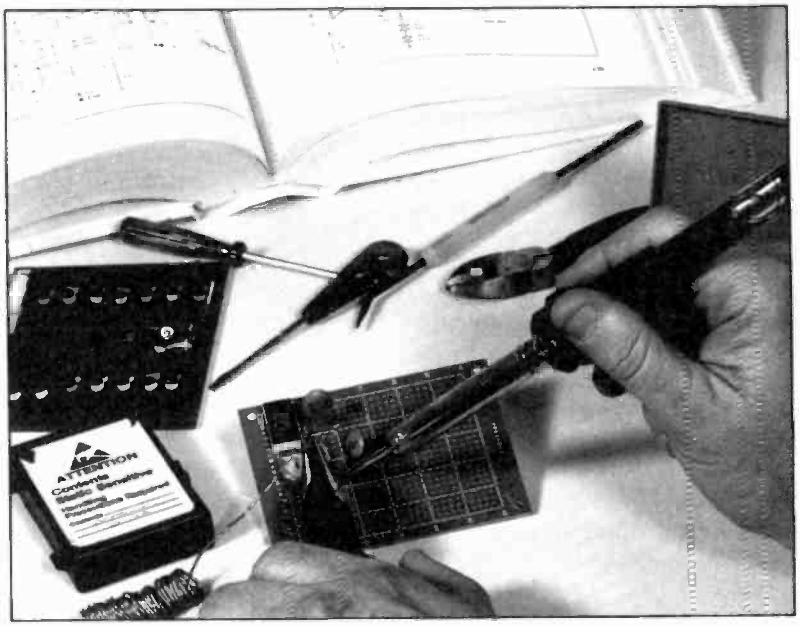

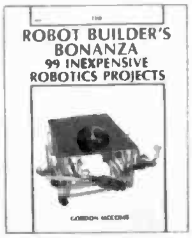

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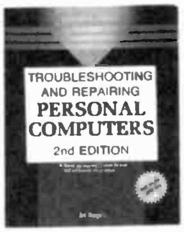

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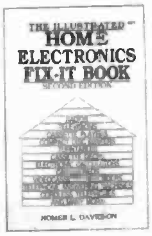

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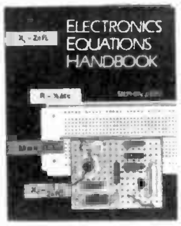

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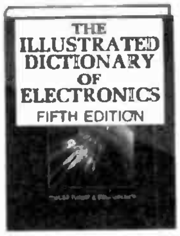

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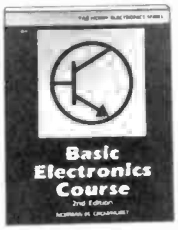

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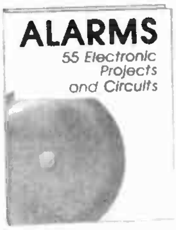

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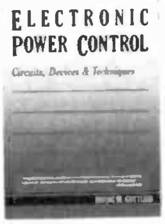

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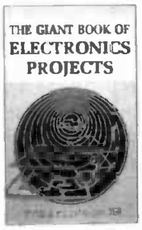

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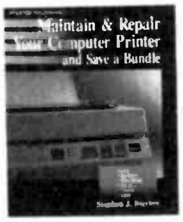

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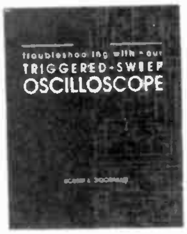

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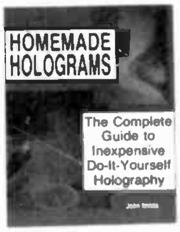

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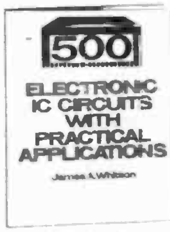

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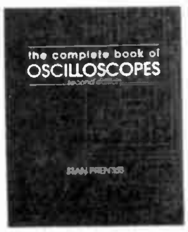
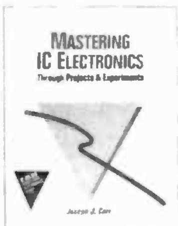


3825 $26.95



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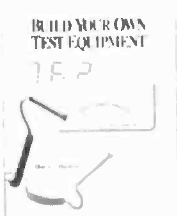

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DRAWING BOARD

Let's add the final touches to our oscilloscope

ROBERT GROSSBLATT

We've finally come to the point where we almost have a complete working scope on the bench. I say "almost" because even though it can display waveforms on the LED's, we have very little control of the input, and have no easy way to get it to trigger on an external signal. Those things, however, are minor details that we'll clean up this month.

As things stand now, the scope is set to display a full-scale input signal swing of 0 to 2.4 volts. Those aren't bad numbers, but it's more than likely that the signals you're interested in measuring are somewhere outside that range. What you have to add to the circuit to take care of that depends on whether you plan on looking at signals that are usually below 2.4 volts, or if you're one of those people who are into high voltages. Not too high, though.

An amplifier should be added in front of the 3914 input; the particular amp depends on the kinds of signals you expect to look at on the scope. Remember that the circuit we're working on, although useful and educational, is not really intended to replace a good CRT-based oscilloscope. The twenty-by-twenty resolution we have is high enough to distinguish a sine wave from a square wave from a triangle wave, but unless you have a lot more than four hundred dots, all you'll be getting is a rough idea of what the waveform looks like.

For most applications, a front-end amp based on a single op-amp is a good choice. Since we're not asking a whole lot from the amplifier, you can use just about any op-amp you happen to have around. The only thing you should keep in mind is that if the op-amp works best with a bipolar supply (as in the case of a 741), you should give it one. We're not looking for hi-fi here, but we do want the scope's display to bear as much resemblance as possible to the input signal, and running a 741 off a single-ended supply isn't going to help.

If you're absolutely determined to use a 741-type amplifier, there are ways to get a true negative supply from the single-ended five-volt supply we're using for the rest of the circuitry. We've shown how to do that numerous times here, but if you don't remember and don't have access to back issues, drop me a note and I'll go through it again. For the rest of us, the two most likely candidates for the op-amp are the LM324 or the LM3900. Both are quad op-amps designed specifically to work off a single-sided supply, making our job much easier.

The general circuit for the amplifier is shown in Fig. 1. I used an LM3900 simply because that's what I had on hand. The gain of the amp is determined by the ratio of R7 (the feedback resistor) to R8 (the input resistor). With the values shown, the amp has a maximum gain of 10.

The 3900 will accept signals in the range normally supplied by line-level audio—from about 100 mV to 1 volt or so. Signals above that can be padded down to size with the input potentiometer but if you plan to be looking at signals with levels way down in the basement you'll have to add a preamplifier to the front end of the circuit. That can be as simple as the one-transistor amp shown in Fig. 2.

Another preamp possibility is the three other amps in the 3900 package; while the interchannel

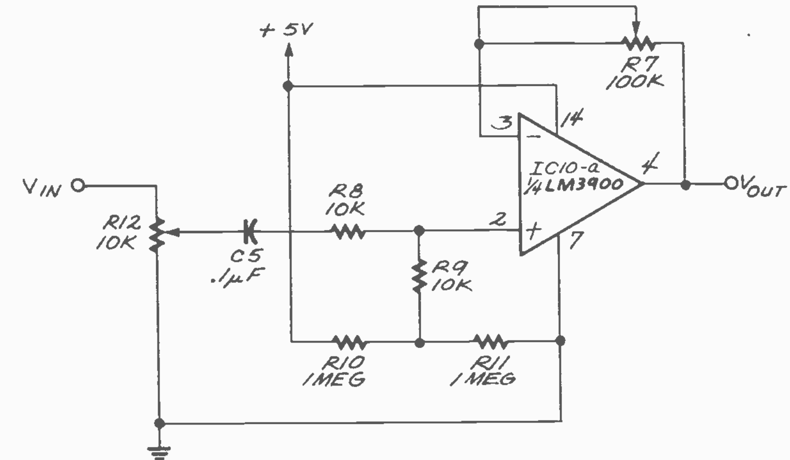

FIG. 1—A FRONT-END AMP based on a single op-amp is a good choice for most applications. The general circuit for the amplifier is shown here. The gain of the amp with the values shown is a maximum of 10.

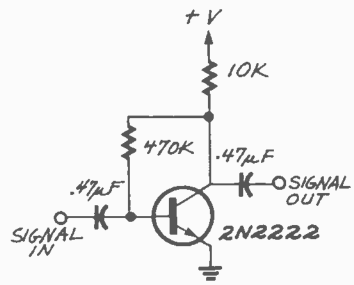

FIG. 2—THE LM3900 CAN ACCEPT line-level signals from about 100 mV to 1 volt. If you plan on looking at very low-level signals, you'll have to add a preamplifier to the front end like the one-transistor amp shown here.

crosstalk in the chip isn't down in the electron-noise range, it's certainly low enough to cascade the individual amps in the IC. Once you have the amp wired up on the board, set the feedback potentiometer at mid range and leave it there. That will give you a gain of about five, which should be enough for most of the signals you'll be measuring on the scope. The general settings can be done with the potentiometer on the input.

Since any good test instrument has to be calibrated before it can be used, you should feed the amplifier input with known signal levels and then trim the input potentiometer to a point where a particular LED on the display just starts to light up. If you use a signal source of one volt, for example, rotate the input potentiometer to the point where the next-to-last LED of the first 3914 (pin 11) comes on, and mark that point on the potentiometer. Once you have that done, use a two-volt signal and you'll see the seventh LED on the second 3914 (pin 13) come on.

When that happens, turn the input potentiometer clockwise and, because you're increasing the resistance, the signal seen by the scope will drop and the LED's will drop as well. When the LED's driven by pin 11 of the first 3914 come on, mark that spot on the potentiometer as well, since you've found the point where the full-scale reading of the scope has been doubled. By doing that several times and measuring the resistance of the potentiometer at those points, you'll come up with a table of resistor values that can be used with a selector switch to change the range of the scope.

The choice and number of ranges is up to you since you're the one using (and building) the scope. Unless you have some special need for it, I can't see why you'd want more than three or four of them—but hey, it's your instrument, and this is America, so you're the one who makes the decisions.

We also have to take care of the scope's trigger. Switch S1 lets us choose between freewheeling and external triggering but it would be nice to have a trigger control that's tied to the input signal. If you've been following the development of the scope over the last few months, I'd be very surprised if you haven't

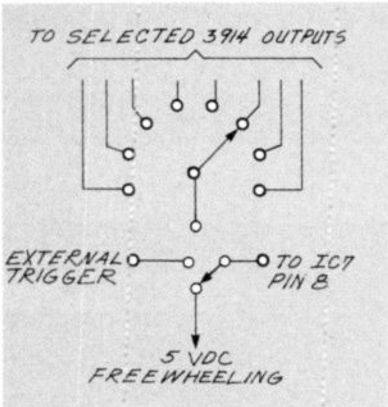

FIG. 3—IF WE REPLACE S1 with a single-pole, three-position switch, we can have the scope trigger whenever the input signal reaches a particular level.

already done that part of the job on your own.

If we replace S1 with a single-pole, three-position selector switch, we can do an interesting addition to the circuit. The third position we're adding can be used to have the scope trigger whenever the input signal reaches a particular level. We need a multiposition, single-pole switch (the number of positions depends on how many steps you want) to tap the outputs of the 3914's as shown in Fig. 3. I've shown only an eight-position switch, but the choice is yours. It's a handy addition to the circuit because it will trigger the scope on selectable voltage levels of the input signal.

That feature is extremely useful and is just one of the many features you can add to the circuit. Variable sensitivity for the input, trigger level, and even for the sweep speed are only a few of the additions you can design on your own. None of them are difficult and all they require is a good bit of careful thought.

Let me know what additions you've made to the scope and how you designed them. I'll print the most interesting ones and the top few will get their name in print and a year's subscription to the magazine. Next month I'll give you a list of sources for the matrixed LED's and start something new. **R-E**

COMPUTER CONNECTIONS

Russian dolls and the virtual PC

JEFF HOLTZMAN

Microsoft—$2.5 billion software giant—has issued a challenge to the hardware side of the industry. In the process, Gates and Co. have fundamentally altered our entire conception of a personal computer.

Figure 1-*a* shows how we've all been thinking about personal-computer hardware and software since 1981. The hardware base includes CPU and memory, video system, floppy- and hard-disk systems, and the Direct Memory Access (DMA), timing, and bus-interface circuitry that holds it all together.

Sitting on the hardware is the BIOS, which attempts to provide applications programs with some independence from the specific hardware installed on a given machine. Thus, within certain tightly proscribed limits, the same application can run on various display adapters and disk systems.

Above the BIOS are device drivers, installable modules of code that provide a clean way of seamlessly integrating new hardware devices unsupported by the original BIOS. Typical device drivers support SCSI hard disks and CD-ROM's, high-resolution display adapters, mice and graphics tablets, test and measurement instruments, network cards, and fax adapters.

Above the device-driver layer is DOS itself. Note that DOS does not communicate directly with the hardware; it does so only through the device-driver and BIOS layers. In theory, this allows DOS to run on various hardware configurations, but in practice, the zone of potential variation is very small.

At the top is the application layer. Ideally, an application would communicate only with DOS, which would in turn communicate with device drivers and the BIOS, and ultimately the hardware. Unfortunately,

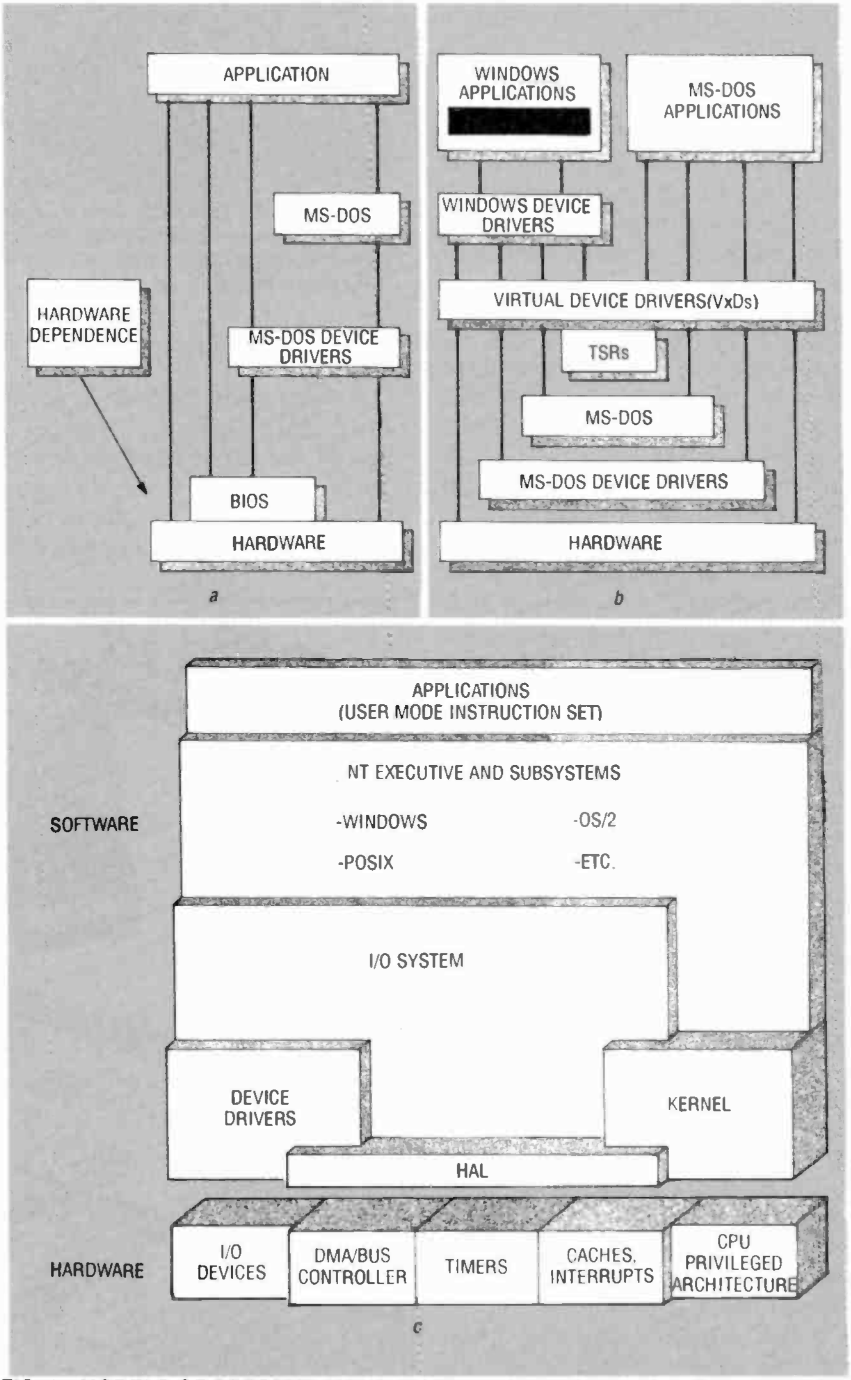

FIG. 1—MODELS OF PRESENT AND FUTURE PC'S: (*a*) shows what the present-day DOS-based architecture looks like, (*b*) shows how Windows creates a "virtual" PC through the use of several layers of device drives, and (*c*) shows the Windows NT model, which will bring compatibility with all major UNIX derivatives and mainframe operating systems.

for the sake of better performance applications long ago developed the habit of communicating directly with device drivers, the BIOS, and even the hardware foundation. Doing so gained short-term performance benefits, but has created a morass of compatibility issues that, to this day, haunt every PC manufacturer, software developer, and end user.

For several reasons it would be nice to sever the direct connections between applications and the underlying hardware. Doing so would give developers the potential to develop device-independent applications that would run on multiple hardware platforms. It would give users a wider variety of choices in making hardware purchase decisions. It would give hardware vendors freedom to innovate, which would, in turn, inspire developers to develop more sophisticated applications. That would, in turn, ultimately benefit end users.

Enter Windows. And a clever new marketing strategy from the guys in Redmond, Washington.

The virtual PC

When the industry made the transition from CP/M to DOS, several products allowed users to run CP/M applications right on their PC's. There were hardware products that amounted to complete CP/M engines on expansion cards, emulators that created an 8080 processor and the CP/M operating system in software, and (with 8088-compatible V20's from NEC), emulators that ran the CPU in an 8080-compatible mode and emulated CP/M under DOS. (In fact some of those software emulators are still available.) As a class, emulators were slow, quirky, and buggy, but they allowed users to run their old software and make a fairly smooth transition to DOS.

Running that kind of emulator put a "virtual" CP/M machine inside the PC. Ever since Intel introduced the 386, we've been putting multiple "virtual" DOS sessions on the PC. DESQview and OmniView did it for us in a nongraphical environment. Windows 3.0 and higher does it in a graphical environment. So does OS/2 2.0.

Windows 3.0 popularized the virtual PC with its 386 Enhanced Mode, which does a good job with the video system by emulating text and simple graphics modes. Windows 3.1 extends the concept with an optional 32-bit disk, access mode for ST-506-compatible disk controllers. The next version of Windows will extend the concept even farther, perhaps to include emulation of all hardware subsystems. (We'll come back to that idea in a moment.) OS/2, which has already taken the DOS virtualization concept further than Windows, also provides the user comprehensive and reliable video and DOS file system emulation services.

Microsoft outlined its vision of the virtual PC, shown in Fig. 1-*b*, last spring at a conference to inspire hardware vendors to start building multimedia features into the next generation of PC's. (If all goes well, the fruits of these efforts will start appearing this coming fall.) Note in the figure that both DOS and Windows applications are completely insulated from the underlying hardware. That architecture will make it possible to run identical applications on totally dissimilar CPU's. Microsoft's initial targets include Intel X86 and MIPS R3000/R4000 RISC chips. Full cross-platform Windows support won't happen until Windows NT (New Technology) is released, possibly as early as 1993. Nevertheless, the seeds are there now, as evidenced by the increasingly reliable DOS sessions in Windows 3.1.

Ironically, Windows is often panned for being slow, especially compared with the Macintosh. The response has always been that whereas the Mac had very few hardware variations (e.g., display adapters) to contend with, Windows had to be designed in a general enough manner to run on continually evolving systems from a multitude of vendors. And that made it slow. Now, however, Microsoft's marketing has skillfully turned that "weakness" into a strength. It's not that Windows is slow because it has to support such a wide variety of hardware. Windows is powerful, scalable, and adaptable because it *can* run on *all* that hardware—plus new platforms barely a glimmer in the eyes of the designers.

Russian dolls

Take a good look at Fig. 1-*b*. Now draw a box around it, and label the box "OS/2 2.0" (which as we speak does "contain" both DOS and Windows). Now draw a box around that, and label it "AIX" (IBM's UNIX dialect for its RS/6000 workstations). (Actually, you could replace AIX by offerings from Digital, HP, and others, all of which are based on OSF/1, and all of which will be compliant with the IEEE's POSIX spec.) Draw a box around that and label it "Taligent" (the joint operating-system company set up by IBM and Apple). To be sure, the last few boxes are speculative—but not by much. Even Windows NT will have a POSIX-compliant Application Programming Interface (API), as shown in Fig. 1-*c*. (For historical fun, draw a small box inside the one labeled MS-DOS. That box represents the CP/M file calls and data structures still present in DOS after more than ten years.)

At the beginning of this harangue, I said that Microsoft has issued a challenge to the hardware manufacturers. The challenge can be stated simply: Innovate! Build exciting new capabilities into your systems to attract new users, and get present users to upgrade. Windows' vast memory space, extendibility, and ability to virtualize underlying hardware together provide an environment in which it is safe to innovate. That's in stark contrast to the DOS years, in which any significant hardware innovation was risky to develop and expensive to support. Now, under Windows (and the same applies to OS/2), innovations can be accommodated and integrated into the environment.

This fall we will start seeing the first wave of X86 personal computers with innovative built-in multimedia capabilities, particularly in the area of sound. We'll also see rapid advances in miniaturized machines. If you thought the first ten years were exciting, hold on to your pants—you ain't seen nothin' yet. I can't wait!

They're off!

As expected, IBM unwrapped OS/2 2.0 on March 31, and Microsoft released Windows 3.1 a week later. Microsoft has gathered a tremendous amount of market energy behind its efforts; IBM has so far played it much cooler. Big Blue released OS/2 with weak support for everything but standard devices (VGA video and ST-506 compatible hard drives); Windows comes with built-in support for a wide range of devices. OS/2 requires 18–36 megabytes of disk space, and will not work with disk-compression utilities (e.g., Stacker). Windows requires about 9 megabytes and will work with Stacker and the like. Windows has extensive support for running DOS and Windows applications, but not for OS/2 applications. However, compelling native OS/2 applications are still rare. Initial tests indicate that OS/2's Windows support is nowhere near the "better Windows than Windows" that IBM has been aiming for.

IBM promises to release a much wider range of device drivers over the next few months, and is reportedly evaluating the Stacker technology to reduce disk-space requirements. Meanwhile, Microsoft will continue to add momentum.

New X86's

The good news is that Intel has finally released several models of its clock-speed doublers. The bad news is that the technology is not quite as universal as we had hoped. These chips use a phase-locked loop (PLL) to run internally at twice the speed of the clock signal fed into the device. So a machine with a 25-MHz bus would run the CPU at 50 MHz, 33 would go to 66, 50 would go to 100 . . . maybe. The problem is that the initial wave of ×2 chips are only for 486SX motherboards with "vacancy" sockets, not regular 486DX's. Intel is planning to release ×2 486DX's eventually (possibly by the end of the year), but not as user upgrades. It appears that there are several difficulties, including problems with heat dissipation and BIOS incompatibilities due to timing loops written around specific clock rates. This means that the 486DX2 might not be an end-user upgrade. Even if it is, don't expect twice the performance; Intel claims an average increase of 70%. Initial list pricing will probably be in the $600 range.

Intel also plans to release the 586 by the end of the year; we hope to run a detailed technical description of it when it is released.

Meanwhile, IBM has developed a few speed-multiplying tricks of its own. You might recall the 386SLC processor discussed here in the past. The 386SLC is a souped-up 386SX that achieves about 80% better performance than a plain 386SX running at the same speed. Now IBM says it will release, by the end of the year, a line of 486-based devices that runs not only twice as fast as the bus clock, but three, four, and even five times as fast. Running the processor faster than the bus clock doesn't make much difference if the processor ends up waiting on slower memory devices, so look for large on-chip caches.

For years there were persistent rumors that Intel would release a 16-bit 386 that would plug into a 286 socket. No such luck, but Cyrix has done something similar. The Texas-based firm, known for X87 math coprocessor clones (and bitter legal disputes with Intel) has released several CPU's that claim to provide 486 performance at 386 prices—and that fit in 386 sockets. One, the Cx486SLC, fits in a 386SX socket, but is compatible with the 486SX. The other fits in a regular 32-bit 386 socket, and is also compatible with the 486SX. The Cyrix CPU's have small caches (1K vs. 8K in all Intel 486's to date), and do not support burst-mode memory access. Nonetheless, published reports indicate preliminary findings of 75% performance increases over 386SX's running at the same clock speed, probably due to a single-instruction-per-clock-cycle execution unit. Although pin-compatible with the 386 devices, they will not be user upgrades. Both part name and performance data suggest a perhaps coincidental kinship with IBM's enhanced CPU. **R-E**

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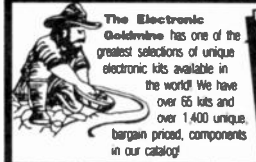

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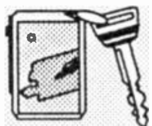

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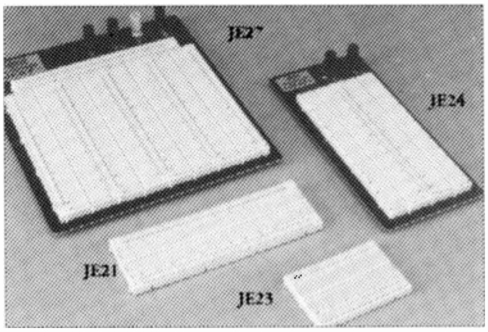

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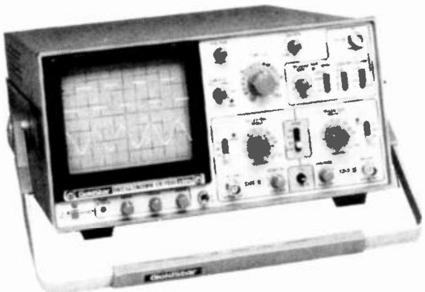

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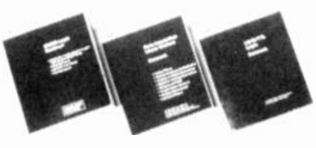

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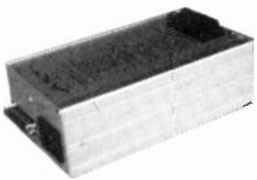

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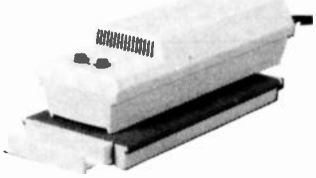

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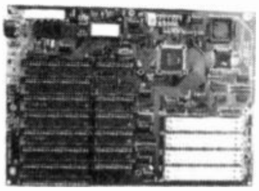

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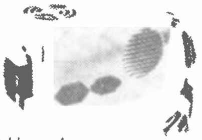

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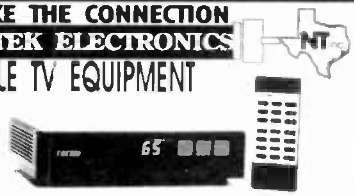

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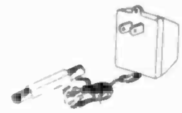

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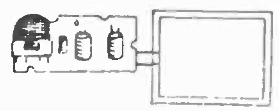

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