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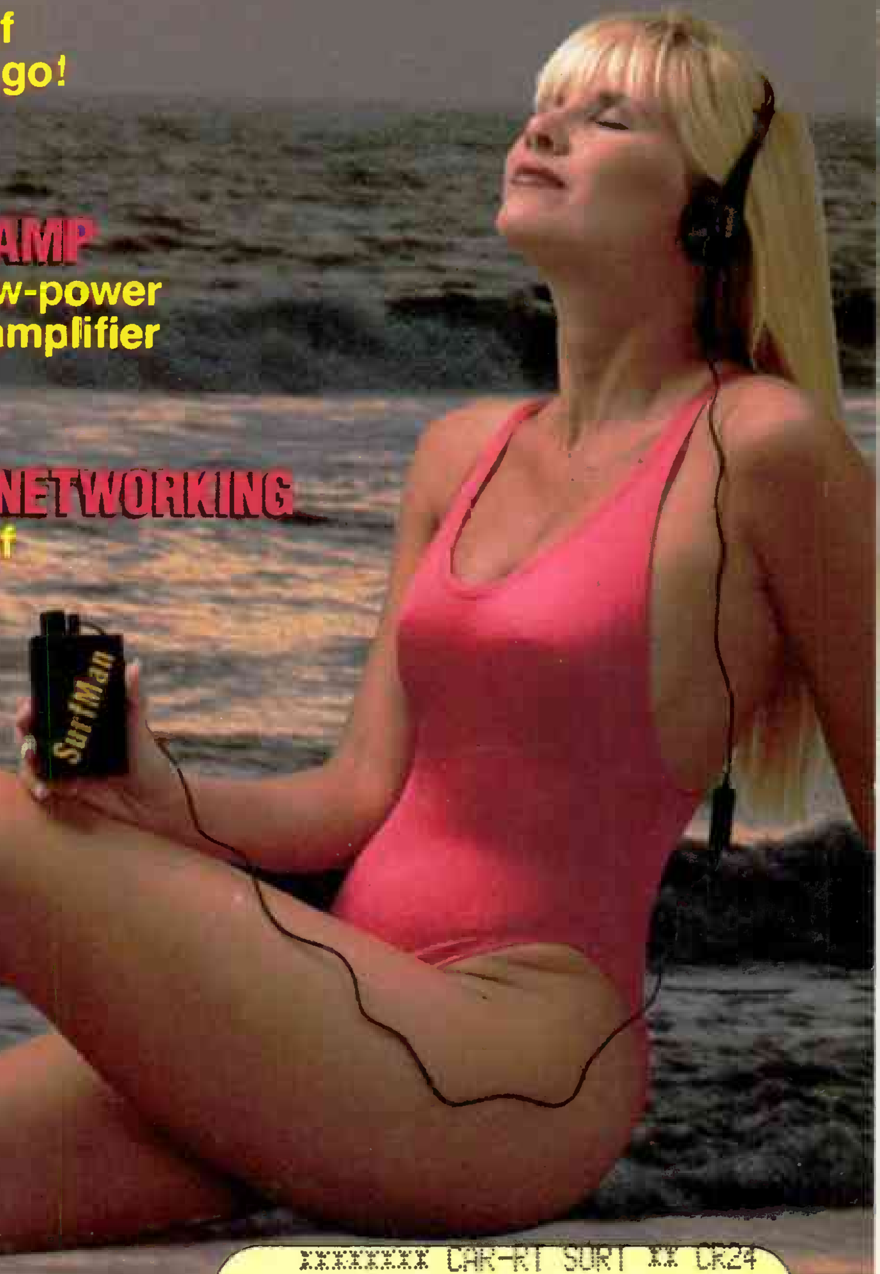

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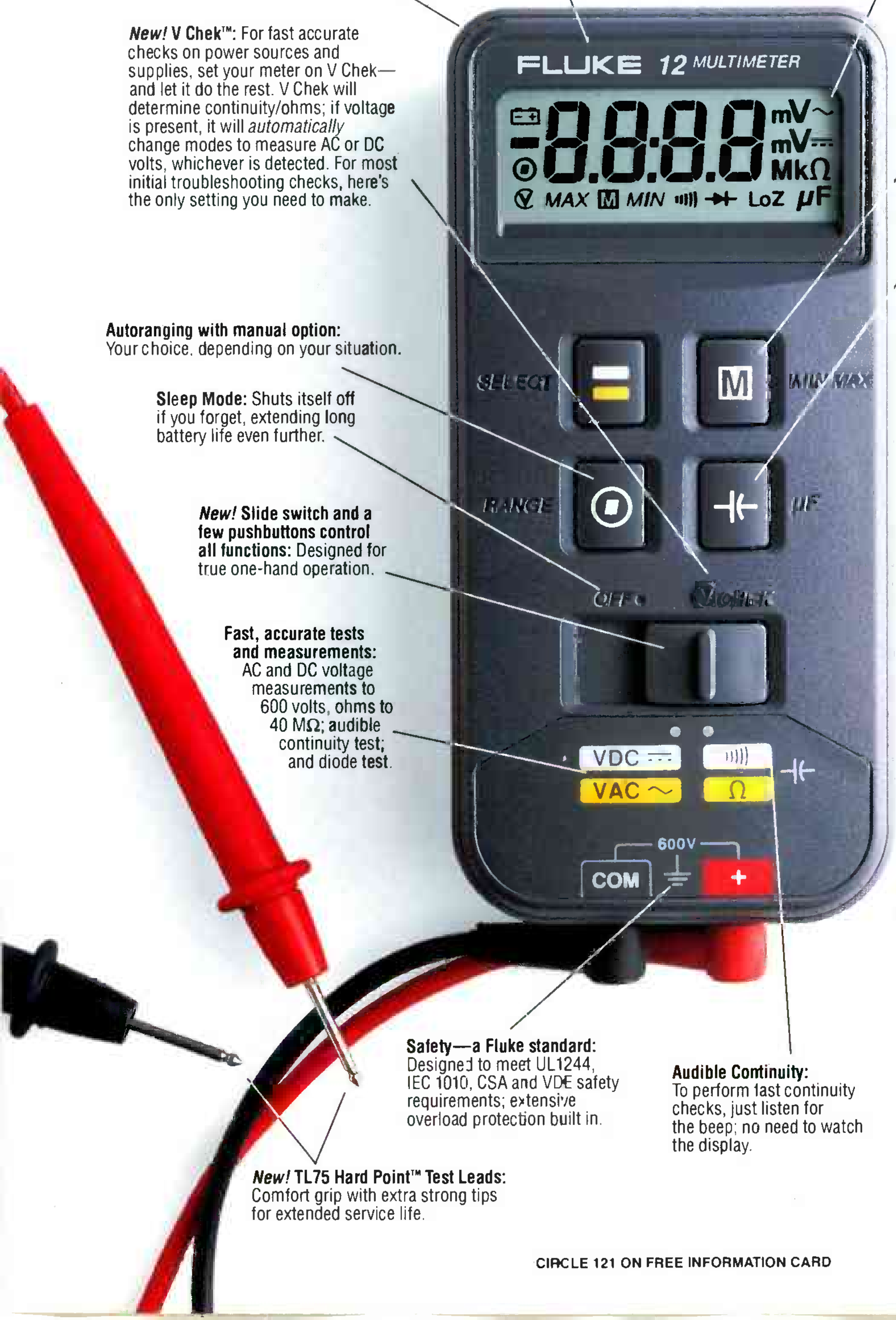

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Fast, accurate tests and measurements: AC and DC voltage measurements to 600 volts, ohms to 40 MΩ; audible continuity test; and diode test.

For high performance at Fluke's lowest price, get your hands on the new Series 10. Stop by your local Fluke distributor and feel what a powerful difference the right multimeter makes—at the right price. For a free product brochure or the name of your nearest distributor, call **1-800-87-FLUKE**.

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1.5% basic dc volts accuracy	Capacitance, .001 to 9999 µF	Min/Max recording with relative time stamp
2.9% basic ac volts accuracy	4000 count digital display	Continuity Capture™
1.5% basic ohms accuracy	0.9% basic dc volts accuracy	Capacitance, .001 to 9999 µF
Fast continuity beeper	1.9% basic ac volts accuracy	4000 count digital display
Diode Test	0.9% basic ohms accuracy	0.9% basic dc volts accuracy
Sleep Mode	Fast continuity beeper	1.9% basic ac volts accuracy
Two-year warranty	Diode Test	0.9% basic ohms accuracy
	Sleep Mode	Fast continuity beeper
	Two-year warranty	Diode Test
		Sleep Mode
		Two-year warranty

*Suggested U.S. list price.

Optional holster with tilt-stand available.

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August 1992 Electronics NOW®

Vol. 63 No. 8

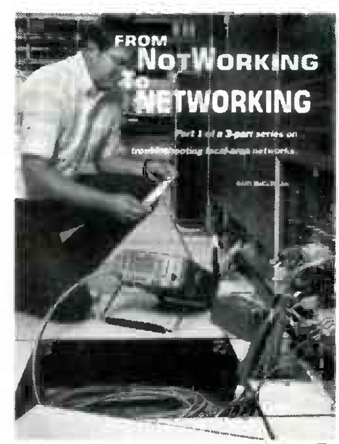
BUILD THIS

TECHNOLOGY

COMPUTERS

DEPARTMENTS

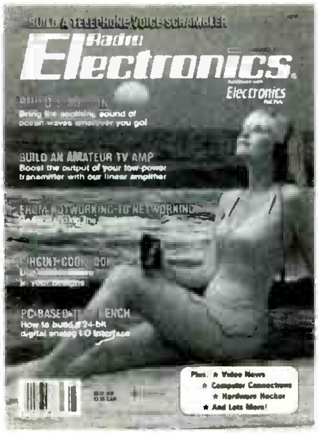
PAGE 37



PAGE 55

AND MORE

ON THE COVER



Do you often find yourself distracted and irritated by the noisy surroundings—barking dogs, screaming kids, droning lawn mowers, beeping horns, bone-shaking construction work, blaring music? One simple solution is to replace that annoying noise with one that is soothing and relaxing. You can do just that with the SurfMan, a pocket-sized gadget that lets you listen to the sounds of the sea through Walkman-style headphones, whether you're at the shore or stuck in the office. The SurfMan surrounds you with the rhythmic sound of waves crashing on the shore, while drowning out the noisy sounds of the real world. For construction details, turn to page 33.

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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

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

WHAT'S NEWS

A review of the latest happenings in electronics.

Tandy's new retail format

Tandy Corporation (Fort Worth, TX), parent company of Radio Shack and Computer City stores, will introduce a new style of retailing this fall at two of its "Incredible Universe" electronics stores located in shopping malls. The stores will sell a large selection of competitively priced products from more than 50 leading manufacturers. Included will be home-entertainment components and systems, auto electronics, appliances, computers, and software. The first two stores will be located near Portland, OR, and Arlington, TX, with others locations promised.

As stores go, these will be large—about 100,000 square feet of selling floor space at each location. The center of each Incredible Universe store will have a rotunda, a kind of arena for hands-on demonstrations, entertainment, and educational presentations by manufacturers' representatives.

Customers will have an opportunity to try out the products right in the store. Tandy will try to ovecome complaints it has heard in the past about sales personnel being either too pushy or indifferent as well as having incomplete knowledge of the product available.

Tandy said that Incredible Universe salespersons will be salaried so they won't have an incentive for being pushy to earn commissions. Moreover, the company says that the sales people will spend at least 10% of their workday in the store's training center learning about the products and keeping up with the latest in technology.

In its attempt to make shopping for electronics a "positive" experience Tandy will provide repair, installation, delivery, training in the use of the products, child-care facilities and a restaurant at each store. Customers have also been promised an advanced efficient check-

TANDY'S "INCREDIBLE UNIVERSE" mall-style stores will carry consumer-electronics, appliances, and computers.

out system. Direct computer links between each store and each manufacturer will provide daily sales information to manufacturers, enabling them to keep up with customer demand.

Self-healing integrated circuits

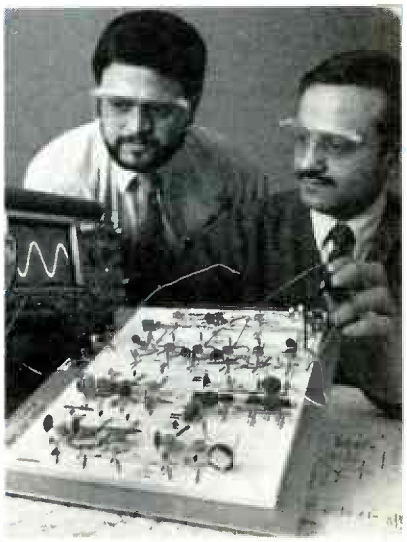
"Self-healing chips" have been developed by scientists at the GE's Research and Development Center (Schenectady, NY). According to GE, the advanced integrated circuits will monitor themselves for errors caused by any malfunctioning elements and produce signals that will compensate for those errors.

Fault-tolerant chips are seen as having applications in circuitry aboard satellites and unmanned spacecraft that cannot be repaired or replaced. Errors in processed data caused by faulty circuitry can cause failure of the mission. Intermittent errors introduced by electromagnetic interference and other transient phenomena, as well as errors caused caused by permanently damaged or destroyed components, will be detectable and correctable.

GE reports that its methodology is applicable to both digital and analog fault-tolerant IC's whose performance can be represented by state-variable equations. Included in this class of circuit are filters and controllers for diverse control and signal-processing applications.

Error detection and correction in the GE approach are carried out by a small, built-in "checking circuit." The checking circuit is coupled to the chip's primary circuitry at strategic locations.

The checking circuit computes "checksum codes"—specified weighted linear sums of the terms on both sides of the state equations that the primary circuit solves while performing its function. If there is a fault, the checksums do not agree, and an error is signalled. The check-



ENGINEERS MANUEL D'ABREU AND ABHIJIT CHATTERJEE set up a fault-tolerant circuit breadboard for testing at GE's Research and Development Center.

ing circuit then error checks itself, and if okay, it computes the error value and automatically feeds that value back to the main circuit for error correction.

GE scientists see the fault-tolerant chips as two or three years away from their first practical applications. GE is currently working to extend the technology to the design of complex fault-tolerant circuits that exhibit nonlinear behavior. Their present efforts are limited to the design of linear systems. **R-E**

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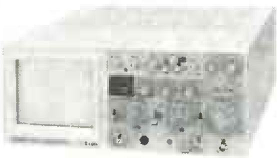

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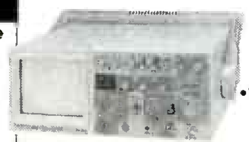
Elenco 40MHz Dual Trace



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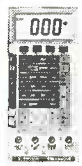

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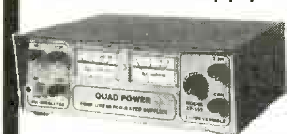

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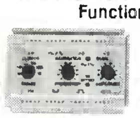

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Laser power	1 milliwatt
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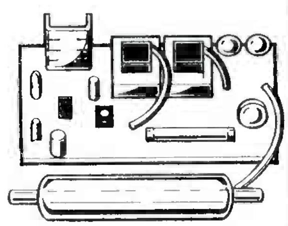

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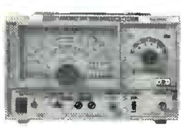

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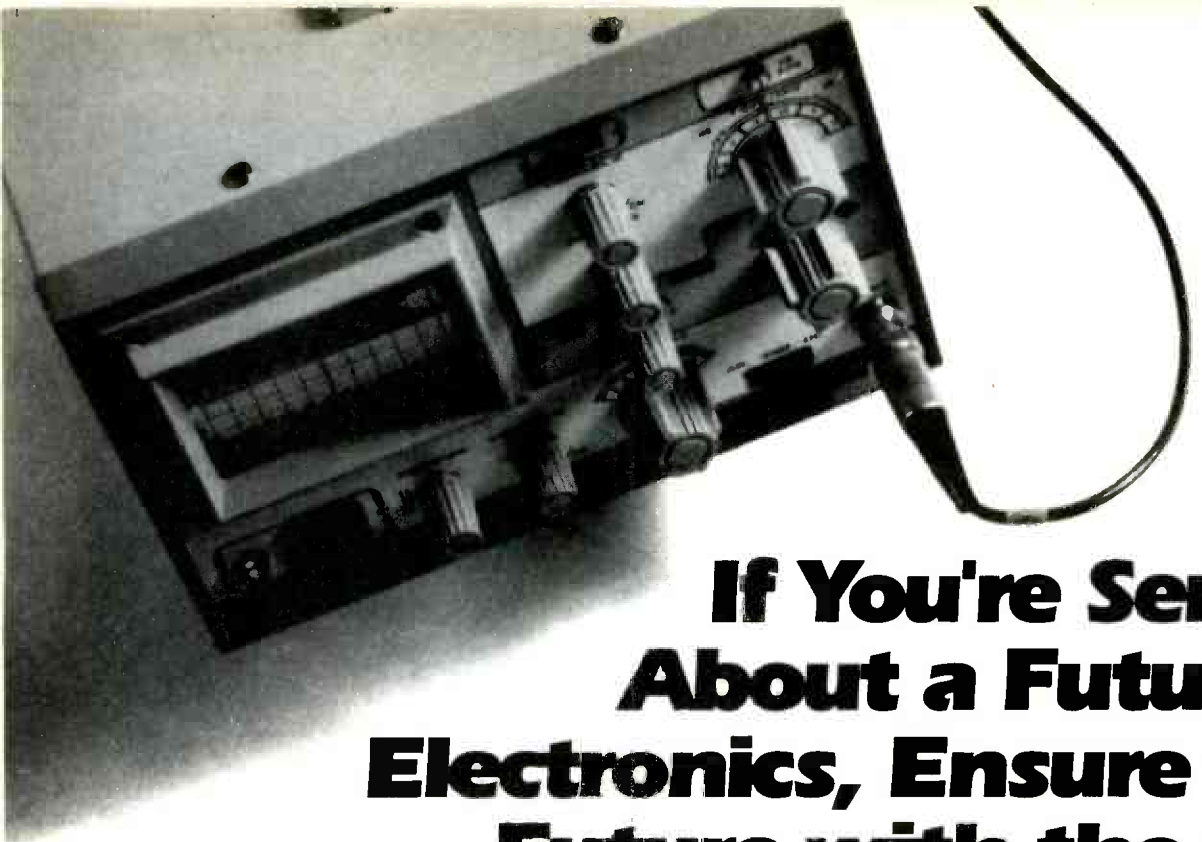

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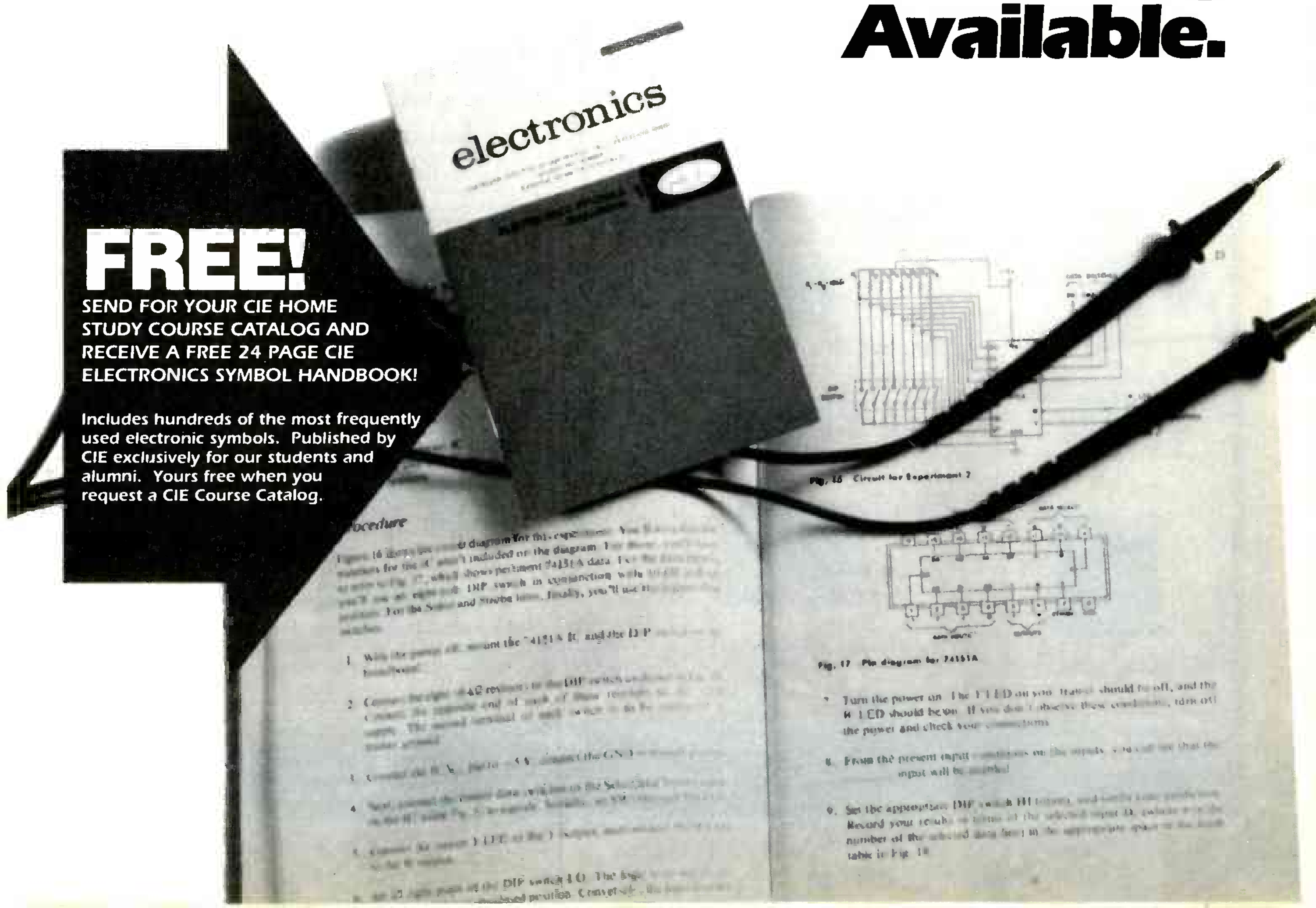

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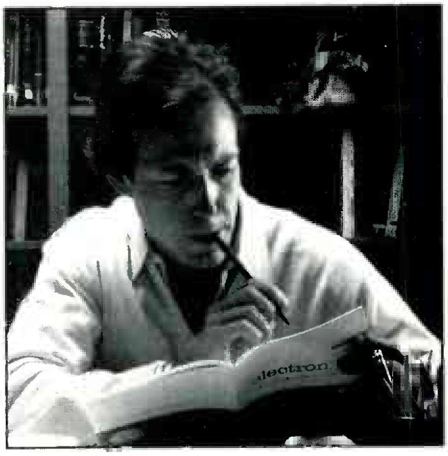

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VIDEO NEWS

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

DAVID LACHENBRUCH

• Ghostbuster compromise. There's peace at last in the ghost-busting arena. Developers of the two leading systems have gotten together and merged their systems into one that should satisfy the needs of broadcasters and cable operators alike—as well as viewers plagued with ghosting problems. Tests by the National Association of Broadcasters (NAB) had found the ghost-canceling system developed by Philips to be superior, but a rival system by the David Sarnoff Research Center and backed by Thomson Consumer Electronics was favored in tests by Cable TV Laboratories (**Radio-Electronics**, July 1992).

The Philips system performed better in eradicating the widely spaced ghosts generally found in broadcast signals, while Sarnoff's technology did better with the more closely spaced ghosts developed within cable systems. In a model cooperative effort, both proponents got together and developed a third system that combines the best elements of both. The ghost-canceling system uses a reference signal transmitted during the vertical blanking interval to direct specially equipped receivers to eliminate ghosts. Ghost-canceling circuits are expected to add at least $100 to the cost of TV sets, and will be marketed for the current NTSC system. HDTV sets are expected to use a different method of dealing with ghosts.

• Standards-converting VCR's. An answer to a common question—how to swap tapes with friends and relatives in countries with different TV standards—is in sight. Aiwa, which has been out of the video field in the U.S. for several years, this summer will start marketing a reasonably priced VCR that can play NTSC tapes on PAL receivers and vice versa. The standards-converting VCR will carry a suggested list price of about $500—far below previous standards converters—and is scheduled to be available this month. At the same time, Aiwa will offer a stand-alone standards converter, that will adapt any tape or videodisc to a different standard, at $400. That model has three input and output terminals, a stereo-mono switch, 500-kilobyte-per-second field memory, and a 7-bit A/D converter. It provides 240 lines of horizontal resolution and will operate on NTSC, PAL, and SECAM.

The first VCR model will have no tuner, but a tuner-equipped version (for tuning NTSC broadcasts) is due early next year. A model with a PAL tuner is already on sale in the U.K., where one expert judged the picture quality not as good as the original, but "quite good enough for most viewers wanting to watch family tapes from abroad."

• TV Data System. Next year's TV receivers could have vastly expanded on-screen graphic capabilities, thanks to a new "TV Data System" approved by an EIA engineering committee for submission to the FCC. The system is an expansion of the technology developed for closed captioning, which will be required by law in all TV sets 13 inches and larger made after June 30, 1993. The new data system adds a second field to the single field in the vertical interval line reserved for captioning. That additional allocation will make possible closed captions in a second language and add new options, including a variety of background colors for the captions.

It will also permit broadcasters and cable operators to develop new graphic and labeling ideas, including program identification service, which would offer on-screen labeling of program titles at the push of a remote-control button—a feature especially useful to channel browsers. With additional software in home TV's and VCR's, the system would permit such features as automatic on-screen weather warnings for emergencies. Perhaps the choicest feature would be stations' transmission of their advance program schedules. Receivers could be programmed to seek and store that information.

• VCR programming systems. While the system described above could be used to program a VCR to tune to a single channel, a multi-channel on-screen program-selection system is scheduled to be introduced next year in sets made by Zenith, which has a one-year exclusive license. This system was developed by InSight Telecast, a California firm whose backers include the cable programmer Viacom, the Japanese trading company C. Itoh, and several other communications and entertainment firms. InSight plans to use a portion of the vertical blanking interval of the PBS network (which reaches 90% of TV sets in the U.S.) to send out a detailed program guide grid. Zenith TV sets equipped with the system will be able to call up those grids, as well as detailed descriptions of each program and even listings of programs by type (sports, talk, drama, etc.). The on-screen grid would be used to set up VCR's by program name rather than time and channel. The TV set contains an "IR blaster," an infrared transmitter at the end of a cable that sets up the VCR through its remote-control receiver. Future VCR's are expected to have InSight built in. InSight plans to offer the service by subscription, and its goal is to supply it for about half the price of a subscription to *TV Guide*.

TV Guide also is experimenting with a programming system, in conjunction with major cable interests. That system apparently is similar to InSight, except that it would be carried on cable TV systems. *TV Guide's* goal is for the service to be supported by advertisers. **R-E**

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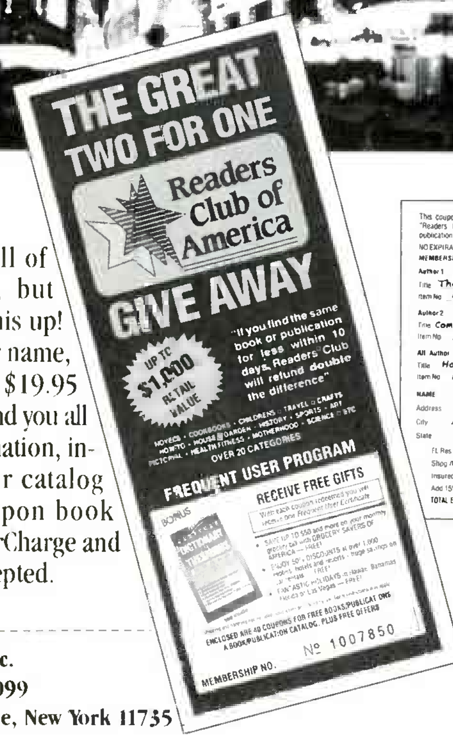

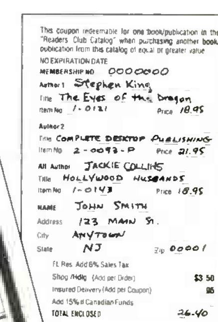

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ASK R-E

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AUTOMATIC VOLTAGE SENSING

I'm interested in learning the basic approach for designing a power supply that can be plugged into any outlet with a voltage from a low of 85 to a high of 270 volts. Those supplies, found on some TV's and VCR's, automatically sense the input voltage and supply the correct output voltages needed by the devices they're powering. How do these things work?—R. Llanes, Curacao, Netherlands Antilles

There's always more than one way to approach a problem like yours. I can't say how any one supply like that works, but I do know how I would go about designing one.

The first thing to realize is that it's much more useful to think about the output voltage supplied by the circuit than it is to think about the voltages being supplied to the circuit. What we want to design is a supply that can provide 5, 12, 24, or some other DC voltages. Once you think about the device in that way, the design of the front end that "sees" the AC outlet voltage becomes a bit simpler.

The basic block diagram for a power supply that can automatically provide the same output voltage for a wide range of input voltages is shown in Fig. 1. As you can see, the only thing that makes it different from a fixed-input supply is the box labelled "voltage limiter." The job of that section of the circuit is to take a range of DC voltages at its input and provide a constant DC voltage at its output.

This isn't a difficult circuit to design because we are really talking about a "preregulator" for the last section of the supply that generates the final output. The parts of the preregulator can include Zener diodes, fixed output regulators, or other devices. In fact, the preregulator is really the same as a standard regulator circuit.

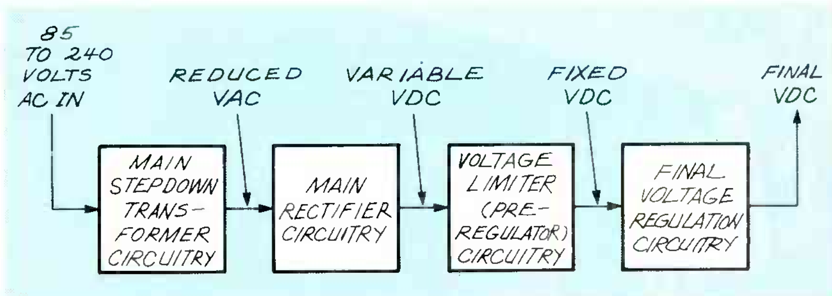

FIG. 1—POWER SUPPLY BLOCK DIAGRAM. It can automatically provide the same output voltage for a wide range of input voltages.

It is most important to know that the preregulation of the voltage is done after the input voltage from the wall outlet has been reduced to a manageable level by the front-end transformers. Trying some brute-force approach to the problem at the main input transformer is certainly possible, but it would involve a lot more circuitry.

You could have the preregulator control the input transformer so that it would switch among several secondary windings but, off the top of my head, I think this approach would result in a much more complicated circuit. A design for chopping the DC voltage is a more straightforward way.

If you start experimenting with that idea, or any other approach to the problem, don't ever forget that you're dealing with some very high voltages.

POCKET-STEREO AMP

I've been experimenting with the LM386 amplifier, and I'm wondering if it can be used as an audio amplifier. When I play my pocket stereo through the enclosed circuit, the sound is distorted—even at low volume. Do you have any suggestions about what's wrong?—R. Marcachen, Algonquin, IL

I'm really surprised at your question because the LM386 was designed specifically for use with audio. The circuit you've sent me is one that usually shows up in the data books and should work without any trouble at all. I think your problem is elsewhere—particularly with the output of your pocket stereo.

The LM386 is a virtually bulletproof IC that can put out about 300 milliwatts into an 8-ohm load. It can drive a small speaker at a respectable level, but only if you feed it with the right levels at it's input, and give it enough supply power to operate without clipping.

The overall gain of the chip is controlled by the resistance between pins 1 and 8. The LM386 has an internal 1350-ohm resistor across those pins to give the chip a gain of about 20 dB. The maximum gain you can get from the chip is about 45 dB, obtained by bypassing the internal resistor with an external 10 µF capacitor. That's what you did in the circuit you sent in.

Assuming you have enough available DC power for the LM386 to operate properly, the only thing that can be causing a problem is too much power being supplied to its input. Although you have a trimmer between the stereo's output and the input of the LM386, remember that power is a product of both current and voltage, and you have to control each of these separately. That means you need a resistor in series as well as a trimmer to ground.

To give you an idea of how easy it is to use the LM386, look at the circuit shown in Fig. 2. This is a minimum amplifier circuit built around an LM386 and, as you can see, the component count is very low. Because there's nothing between pins 1 and 8, the IC will give you a 20-dB gain at the output. Considering the signal level that usually comes out of a typical pocket stereo's headphone jack, a 20 dB gain should be more than enough to drive a speaker at what is usually referred to as a "comfortable listening level."

Notice the resistor on the input line that's in series with the stereo's output and the LM386's input. That's what cuts the current level of the signal, and it's also what's missing from the circuit you sent in. The value of the resistor to use depends on the output power from the earphone jack, but you should start your experiments with a value in the area of 10K or so. You'll know when you have a good value because you'll get a clean sound at the speaker regardless of how you set the volume control on the stereo.

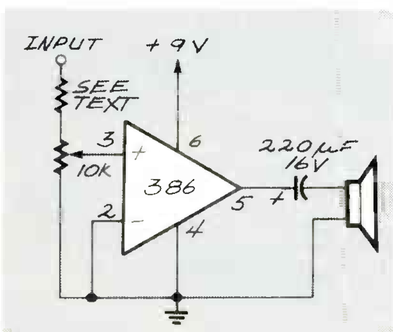

FIG. 2—THIS AMPLIFIER CIRCUIT will give you a 20-dB gain at the output.

The frequency response of the LM386 is pretty flat, but the specs show that harmonic distortion will exceed one percent THD when the input signal gets much above 12 kHz. Even with that limitation, the LM386 is the ideal chip when it comes to building a power amplifier for a small speaker. Breadboard the circuit shown in Fig. 2, and use it to determine the value of the resistor you'll need. Once you've found the right number, you can put it in your circuit.

If you decide that the LM386 circuit in Fig. 2 provides enough gain and suitable sound quality, you might consider scrapping the more complex circuit you sent in favor of the simple one. One of the goals in electronic design, as in other fields, is to keep things simple.

1-INCH RECORDER HEADS

I'm currently building a multitrack recording system and I'm putting it together by rebuilding several multitrack reel to reel recorders. I have lots of broken ones at my disposal and I'm able to steal parts from several dead machines to make a good one. The only problem I'm having is that I can't seem to find a source for the heads on the machines. Lots of people have stereo tape heads for sale but I haven't been able to find replacement heads with multiple tracks for 1-inch recorders. Any ideas?—T. Holder, Coshocton, OH

I'm always in favor of anyone who wants to turn old scrap equipment into usable products. I'm surprised you're having so much trouble getting the tape heads.

continued on page 90

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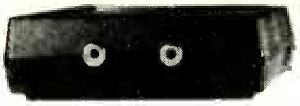
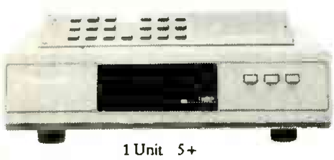




LETTERS

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

DOUBLE-BLIND AUDIO TESTS

I'd like to comment on "double-blind audio tests," that have been discussed recently in Larry Klein's *Audio Update* (**Radio-Electronics**, June 1992) column.

About 10 or 12 years ago, *Scientific American* magazine had an article on the physical processes of hearing. As I recall, the article stated that the ear generated a series of electrical pulses that were intercepted by the brain and decoded into sounds as we "hear" them. The article showed that the electrical signals were a family of short-duration pulses that varied in spacing, amplitude, and polarity. An illustration showed a sample that looked like nothing recognizable as a "signal" by electrical standards. As I recall, the article said that the complexity of the coded signal from the ear was beyond anyone's ability to understand with the state-of-the-art technology at that time.

The article also said that the signal seemed to be primarily generated by "crossings of the zero datum line" of the sounds in the amplitude realm. Time between crossings entered into the encoding scheme as well. To me, this indicates that frequency, amplitude, and phase will all contribute to the "encoding process of the ear." That being the case, it is understandable that the need for "double-blind" audio tests exists. It also explains the rather strange results between individual responses to the sounds.

There is no reason to believe that every ear "encodes" sound exactly as all other ears. Proof of that statement can be deduced from "normal aging" of the ear through life, resulting in the loss of high-frequency response in the elderly.

In view of the previous comments, it seems to me that "double-blind" tests are quite useful. In fact, in view of all of the variables involved, it would seem that ten or more tests should be duplicated to be sure that the results are correct.

I hope to see continued inquiries into the nature of audio for those of us who read and enjoy Klein's *Audio Update*."

RAYMOND H. GRIESE, K6FD
Santa Clara, CA

GET THOSE NUMBERS STRAIGHT!

I am very impressed by the quality of the "Build This ..." articles that have appeared in **Radio-Electronics** over the past decade, and I have built or adapted many of the devices that control AC power.

Yet I am annoyed by the frequent references to "110," "115," and "220." when describing household AC receptacle voltages. Although some old-timers can be forgiven for using such terms, there is no excuse for seeing them in **Radio-Electronics**!

"110/220" voltage does not exist anywhere in the United States, and has not for more than 30 years. In the mid-1950's, "115/230" was common, but changed to "117/234" briefly before becoming the now-standard "120/240" in 1970. The American National Standards Institute publishes a document entitled: "American National Standard for Electric Power Systems and Equipment—Voltage Ratings (60 Hertz)." This Standard (ANSI C84.1) specifies that the Nominal System Voltage shall be 120/240 VAC in three-wire systems commonly found in residential areas. The great majority of electric utilities try to keep receptacle voltages at 120 ± 3 volts AC.

Some appliances might carry a nameplate voltage rating of 115 or 230 volts, but that considers the wiring voltage drop under load and is correctly termed "Utilization Voltage." It is expected that the no-load voltage will be 120 or 240 volts.

ERIC G. LEMMON
Lompoc, CA

MORE ON MICROPROCESSORS, PLEASE

I'm writing to commend you on the "Build This Microprocessor Development System" articles (**Radio-Electronics**, April and May 1992), concerning the CMOS-based 1802 microprocessor. During the mid-1970's, your sister magazine, *Popular Electronics*, ran a series of articles dealing with the 1802. Many of those older articles can be photocopied at local public libraries.

The two new articles, as well as the older ones, point to a very interesting fact—namely, that the 1802, in its use of chip pins and design philosophy, is a very useful compromise between a general-purpose microprocessor and a microcontroller. Some other interesting things to note are that as a CMOS-based device it can easily be used in battery-powered projects, and it is one of the few microprocessors that will operate within the full military specification temperature range of −55 to +125°C. That last feature is also due to the processor's CMOS construction.

I would very much like to see more articles in **Radio-Electronics** about small microprocessor-based projects, especially those that use the 1802.

JIM PARSONS
Rapid City, SD

DRIVEWAY ALARM SOURCE

In *Ask R-E* (**Radio-Electronics**, May 1992), the solution given to D. Ingebright's request for a driveway alarm will work. I installed that system in my driveway about ten years ago, and it is in operation now.

The manufacturer of the Air Switch is Acme Air Appliance Co. Inc., 203 Newman Street, Hackensack, NJ 07601. Ask for Air Switch Control No. 118.

RALPH MARSHALL
The Rock, GA

CALL-WAITING SOLUTION

In *Ask R-E* (**Radio-Electronics**, May 1992) the "Call-Waiting Dilemma" was discussed.

In Houston, to defeat call waiting (for one call), you enter "*-7-4." That defeats call waiting for one call and then resets. (Other phone systems have similar features. Call your local phone company's business office for details. Some phone books also explain how to defeat call waiting) This feature is a part of call waiting, and—at least in Houston—you do not have to pay extra for it.

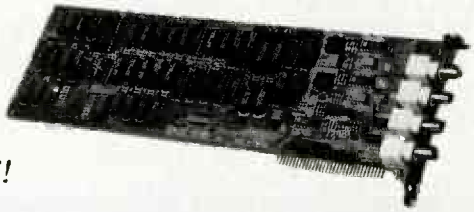
I use the modem on my PC a lot. I have programmed that "prefix" ahead of the number I want to call and have experienced no interruptions. The caller just gets a ringing with no one answering and can call back later with his voice call. That does not interrupt the data transfer via modem. If the modem call is "inbound," then the "*-7-4" command will not work to defeat the call waiting, so I always try to be the one to initiate the call.

JOHN CALLAHAN
Houston, TX

R-E

EQUIPMENT REPORTS

Gage Applied Science CompuScope Lite PC Oscilloscope



Put a DSO in your PC!

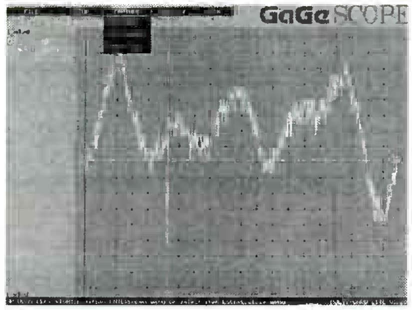
CIRCLE 10 ON FREE INFORMATION CARD

There's no question that PC-based test equipment is the leading area of growth for test and measurement. It's easy to understand why: Computers make it easy to custom-program the equipment for specific test or series of tests. And nothing beats a computer at being able to store and track measurements. Along with the benefits of programmability, PC-based equipment should have a price advantage over stand-alone instruments because there's no need to manufacture a front panel, display, or other input/output devices. Unfortunately, it doesn't always seem to work out that way. PC-based test equipment often carries a hefty price tag.

A Canadian-based company, Gage Applied Sciences, Inc. (5465 Vanden Abeele, Montreal, Quebec, Canada, H4S 1S1) is making an effort to offer the advantages of PC-based equipment at a price that's competitive with low-cost stand alone instruments. Gage's *CompuScope Lite* is priced at $595.

CompuScope Lite requires, as a minimum, an IBM XT (or compatible) with an available full-length slot, 512K RAM, a single 360K floppy disk drive, and a Hercules- or EGA-compatible graphics adapter and monitor. The scope has a full-power analog bandwidth of 7 MHz and a small-signal analog bandwidth of 50 MHz. It can accept inputs between ± 1 volt. (Larger inputs require a ×10 probe.) If used as a single-channel scope, the card can sample signals at a rate as fast as 40 Ms/s (megasamples per second). If both channels are used, a maximum rate of 20 Ms/s per channel is available. The memory depth of the card is 16 kilobytes (8K on each channel). A 64K version is available from Gage; it's priced at $995.

CompuScope Lite provides several trigger options. Either channel can be chosen as the trigger source, as can an external signal, or a keystroke. The scope uses real-time sampling. Equivalent-time sampling, where a signal is "built up" with successive samples is not used. (Equivalent-time sampling requires that the signal being measured is repetitive; transients or glitches are usually missed by digital scopes that use this sampling method.)



THE COMPUSCOPE SCREEN consists of four main areas. Along the top edge is the pull-down menu bar. The left edge contains setting information, while the bottom edge holds the command-line information. Most of the screen holds the actual scope display. The non-repetitive signal shown here could not be displayed properly on a scope that used equivalent-time sampling.

Installing CompuScope Lite

The installation of *CompuScope Lite* is relatively straightforward. The most difficult part is selecting the memory and I/O addresses that the card will use. The card uses 4 kilobytes of memory space in the PC's memory map, and two contiguous I/O addresses. Unfortunately, if you run into problems with conflicts with other cards installed in your PC, you'll have to rely on your own troubleshooting skills. The manual assumes that installing an expansion card is second nature to any user, and it does a poor job explaining what to do if something goes wrong.

Software installation requires that you simply copy files from the single diskette to a directory of your choice. Before the software and hardware can work together, you must run an installation program to enter the memory and I/O addresses that you chose for the hardware.

Using the scope

Pull-down menus are used to configure and operate *CompuScope Lite*. When making measurements, it's also possible to use the function keys to change the timebase, vertical amplifiers, input coupling, and more. The system should be easy enough to figure out for anyone who has previous experience with a digital oscilloscope and menu-driven software. That's fortunate; here also, the operating manual could use some improvement.

A host of features, too numerous to mention here, are provided by the

continued on page 90

NEW PRODUCTS

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

MACINTOSH CAD/CAM SOFTWARE SYSTEM. The easy-to-use Macintosh computer, supported by the *Douglas Electronics' CAD/CAM Professional System*, is a low-cost alternative for the design and manufacture of circuit-boards. The enhanced software package for the Macintosh consists of three separate programs covering all phases of the design of PC boards up to those with with multilayers measuring 32 × 32 inches. The package provides for schematic entry, digital simulation, component positioning, and autorouting.

The *DesignWorks* program performs schematic entry, extracts net-list and parts-list data, creates and edits custom parts, and carries out ongoing digital circuit simulation. The *Professional Layout* program does board layout, editing, and component-positioning. Editing done with Professional Layout program can be automatically merged into the DesignWorks program. The *AutoRouter* program completes circuit connections automatically. The net-list and parts-list data captured in DesignWorks, and the parts-placement data captured by the Professional Layout program provide the necessary information for routing.

CIRCLE 16 ON FREE INFORMATION CARD

The CAD/CAM Professional System includes a communications program that allows users to download their completed designs via modem to Douglas' manufacturing plant. Price quotes and order forms are provided automatically. Douglas says boards can be completed and ready to ship in as few as three days. For those who want their boards made by another vendor, the *Professional System* also provides direct output to dot-matrix and laser printers, as well as pen plotters. Utility programs are available for generating Gerber files for photoplotting and Excellon files for generating drill tapes.

The *CAD/CAM Professional System* can be purchased as a complete package or as separate modules. The price for *Professional Layout* is $1500; *DesignWorks* is $995; and *AutoRouter* is $700.

Douglas Electronics, Inc., 2777 Alvarado Street, San Leandro, CA 94577; Phone: 510-483-8770; Fax: 510-483-6453.

PC-BASED CABLE TESTER. Anyone inspecting, purchasing, installing, and troubleshooting computer cables will find that this PC-based cable tester is a valuable helpmate in analyzing and documenting RS-232C and other cables. *Cable Master* from *Houston Computer Services* sorts out and identifies the wiring in cables with up to 25 conductors and finds shorts, opens and miswires.

CIRCLE 17 ON FREE INFORMATION CARD

The manufacturer says that *Cable Master* makes it easy to "look inside" computer cables to see how they are wired so that their conductor functions can be documented. That feature eliminates the need for pin-by-pin cable testing. A complete printout of even the most unusual computer cable can be produced. The tester, which weighs just under a pound and measures 4.5 × 7 × 1.25 inches, is connected to any open serial port of a DOS-based PC with 128 to 512 kbytes of free memory. The software is menu-driven and window-oriented, providing on-line help and mouse support.

Cable Master can test any RS-232C cable with male and female DB-25 connectors at 50 points (25 per connector) in less than 4 seconds. Adapter kits are available for other cables, connector or plugs. The cable tester's software displays the cable's specifications including wire list, cable diagram, labels, and types of terminating connectors on the PC screen and permits that data to be printed out on a compatible printer.

Thousands of different cables connect terminals, PC's, printers, modems and other serial communications devices. End users, systems integrators, and service technicians frequently must find the correct wiring configuration for cables between two different devices. This tester simplifies the task of analyzing existing cables for repair and replacement or for transferring those designs to other systems.

A cable data base can be developed and kept updated on diskette or hard disk to retain information about cables as they are designed, purchased, or installed. Software is included for searching a cable data base for suitable matches.

The *Cable Master* is priced at $395.—**Houston Computer Services, Inc.** 3207 Ashfield Drive, Houston, TX 77082; Phone: 713-489-9900.

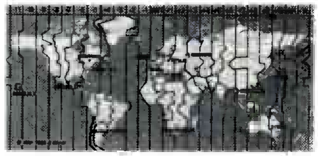
CIRCLE 18 ON FREE INFORMATION CARD

CONDUCTIVE PEN. A conductive pen from *Planned Products* has an improved tip and better silver conducting ink for drawing fine conductive traces on PC boards. The *Micro Tip 2200 Circuit Works*, intended primarily for the repair of traces on leaded-part and surface-mount circuit boards, also works on membrane and flexible circuits. The pen can also be put to use in circuit prototyping, modification, and component shielding.

The silver-based conductive liquid in the pen dries in 5 to 10 minutes at room temperature and reaches its maximum conductivity when air-dried for 20 minutes. The repair of circuit traces takes about 15 minutes. The resistance of the traces is given as 0.01 ohms or less. Maximum conductivity and adhesion occur after a heat cure at 250° to 300°F for five minutes. The cured conductors can be soldered at temperatures below 350°F with lead-tin or silver solder. The pen contains enough conductive ink to draw up to 100 feet of traces, jumpers, or shields. An unopened pen has a shelf life of 18 months.

The *Micro Tip 2200 Conductive Pen* is priced at $10.95.—**Planned Products**, 303 Potrero Street, Suite 53, Santa Cruz, CA 95060; Phone: 408-459-8088; Fax: 408-459-0426.

TIME ZONE MAP DECAL. A decal illustrating time zones of the world gives the radio amateur or anyone with a need to know local time elsewhere in the world a handy reference. *World Time Zone Map Decals* from *Time & Again*, drawn as Mercator projections are available in two sizes.



CIRCLE 19 ON FREE INFORMATION CARD

The decals, made of polyester with a self-adhesive backing, can be applied to any surface such as the front panel of an amateur radio. Sizes are 2¼ × 4¾ and 1¼ × 3¾ inches.

CIRCLE 108 ON FREE INFORMATION CARD

CIRCLE 177 ON FREE INFORMATION CARD

Large *World Time Zone* decals are priced at $2.00 and small decals are $1.50; one of each is $3.00. Payment and self-addressed stamped envelope are requested with each order.—**Time and Again**, P.O. Box 306, Dickinson, TX 77539; Phone: 713-337-5319.

DIGITAL UNIVERSAL COUNTERS. These line-powered digital counters offer enhanced performance in the 1- and 2-GHz range. The *Model B-1000* and *Model B-2000* from *Protek* measure frequency, period, total event, ratio, time, and interval, and they have a self-test feature—all available with switch setting. Display hold and reset functions are also switch-activated.

The 1-GHZ *Model B-1000* and the 2-GHz *Model B-2000* have eight LED displays and LED indicators for annunciators, function selection, and gate timing. They permit the user to read results at a single glance. Key features include 10-MHz basic frequency output via a rear-panel BNC, Channel A and B outputs with 1:10 attenuators, AC or DC coupling-selection switches, and a low-pass filter for accurate low-frequency measurements. The counters are intended for design and service as well as for monitoring signals.

CIRCLE 20 ON FREE INFORMATION CARD

The *Model B-1000* digital counter is priced at $330 and the *B-2000* is priced at $425.—**Protek**, P.O. Box 59, Norwood, NJ 07648; Phone: 201-767-7242; Fax: 201-767-7343.

RECEIVER DOWNCONVERTER. This 800-MHz downconverter converts signals in the 806- to 900-MHz frequency range down to 406 to 500 MHz. *Ace Communications' DC 89* is a compact amplifier measuring 3 × 2 × 1½ inches. Frequency is stabilized by a surface-mount prescaler/ synthesizer that is referenced to a precision quartz crystal clock. The downconverter has two BNC connectors and an on/off switch. An internal battery permits it to operate on handheld receivers.

CIRCLE 21 ON FREE INFORMATION CARD

The amplifier can extend the performance of test equipment and UHF communications receivers.

The *DC 89* 800-MHz downconverter is priced at $89.—**Ace Communications**, Monitor Division, 10707 East 106th Street, Fishers, IN 46038; Phone: 317-842-7115; Fax: 317-849-8794. **R-E**

CIRCLE 176 ON FREE INFORMATION CARD

DRAWING BOARD

Let's explore the mysteries of video scrambling.

ROBERT GROSSBLATT

I've been looking around for a source for prewired LED matrixes to use in our home-made oscilloscope but, so far at least, I haven't had a whole lot of luck. A few places had them but they were fairly expensive and, to make matters even worse, there were minimum quantities and minimum orders. The problem is that the minimums for each order are usually more than you or I would normally spend on electronic parts over the next six months.

I can't believe that some supplier somewhere out there doesn't have a barrel or two full of those things hanging around. If anyone out there knows of a source for an LED matrix, please drop me a note and let me know about it so I can share it with everyone. I'll put it in the column and post the address as a message on the E-Mail section of the RE-BBS (516-293-2283), as well. (It's hard to get on the bulletin board because it's always in use, but a bit of perseverance will win out.)

I'm still waiting to hear from any of you out there who have done something terrific and ingenious with the scope we designed over the last few months. The contest is still on, and the prizes are still waiting for a few winners.

On a different subject entirely, I've been getting lots and lots of mail about video in general and scrambled video in particular. For some reason a lot of you really get enraged because some cable companies insist on scrambling certain premium channels. Before we go any further on this, let me tell you that I don't see anything wrong with it. Now, wait a minute—before you write me off as a stooge of the cable industry, let me finish.

The cable companies have every right to scramble whatever they want, although the rumors that some companies are scrambling everything they transmit—including the standard VHF channels—is going much, much too far. Premium stations and the pay-per-view shows are okay to scramble. What's not okay are some of the regulations that a lot of the cable companies insist are their God-given right to impose on you.

To begin with, hitting you with an extra fee for putting in another outlet is ridiculous. Some years ago the phone company did the same thing—anyone who added an extension phone on his own was risking life imprisonment or, even worse, being regarded as a not-nice person in the eyes of Ma Bell. That all went out the window years ago, and I think it's only a matter of time before the same thing happens in the cable-TV business. And, as far as I am concerned, the sooner the better.

The most annoying part of the cable system is the whole business of sending me scrambled signals, *and then telling me I can't do anything with them*! As I said, if the cable companies don't want me to get a particular channel (because I'm not paying for it, or some other perfectly legitimate reason), then don't send it to me. Trap it out of the line before the cable comes into my home. The additional cost of the traps has to be offset by the reduced cost of the cable box needed for the system, and the cost of installation should be the same because anyone with an opposable thumb and finger can put a trap on the line.

I agree that the signal coming into my home is the property of the cable company but, and this is important, at a certain time the real ownership of the signal becomes less clear. When the RF has been reduced to baseband video and has spent lots of milliseconds running around the inside of my TV set, I think things are a bit different and the cable companies' original claim of ownership is a lot weaker. And if I worked out a way to record scrambled signals and then descrambled them on playback, what then?

If I built a box that scrambled some of the channels currently sent to me in the clear, the cable company would look at me in a funny way, but I really doubt they'd care one way of the other.

Now that you know how I feel about this stuff, I'd like to show you how to descramble signals, but I can't because there are several ways that signals can be scrambled. It's sad but true that being able to descramble one system is no guarantee that you can descramble any other system.

The scrambling methods can be broken into two basic categories. The method you have in your home depends on the kind of cable service you have, how it's sent to you, and the economics of your viewing region. That last reason is important because the cable companies have to pay for the decoder boxes; the more sophisticated the way the signal is scrambled, the more the box costs. A cable company that has its franchise in a large city with lots of customers needs lots of boxes, and that translates into some serious numbers for the purchase of the boxes. And don't forget that the more extensive the scrambling method, the more expensive the equipment needed to scramble the signal in the first place.

Taking apart the video signal and turning it upside down and inside out is pretty simple, but putting it back together correctly is a different matter altogether. And the FCC

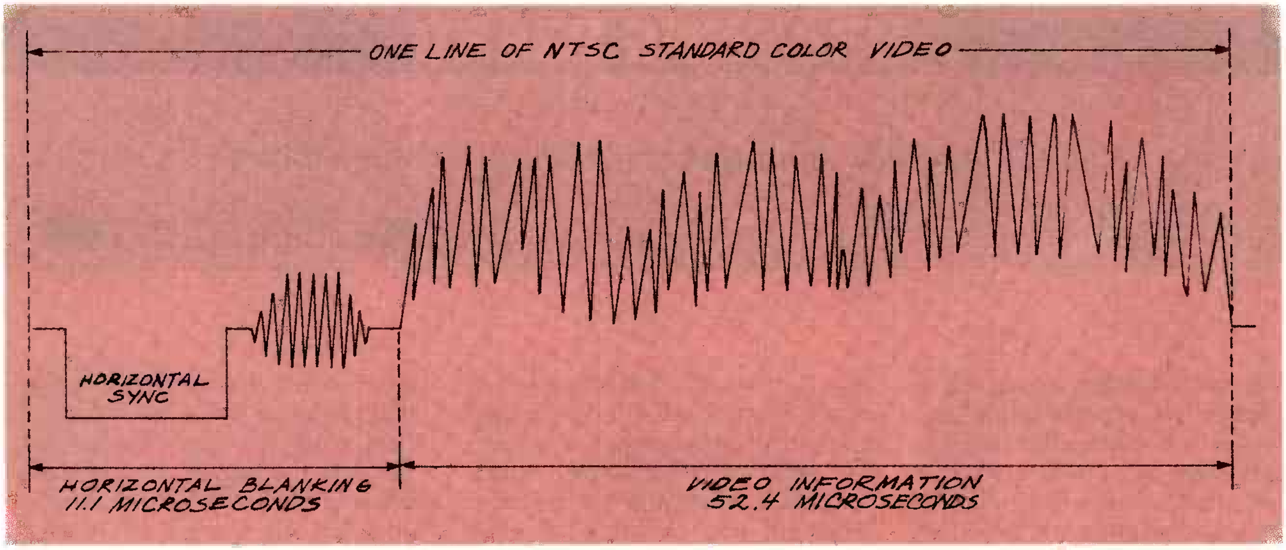


FIG. 1—THE MOST COMMON APPROACH to scrambling video involves manipulating the information in the horizontal interval. For example, without a sync pulse, the TV's horizontal circuitry will freewheel.

keeps a careful watch on how close the reconstituted signal comes to real video. If the new signal is too messy, the FCC will give it a big thumbs down.

The most common approach to scrambling video involves manipulating the information in the horizontal interval. In the beginning, every cable company used the same method—they suppressed the horizontal sync pulse, which meant that the TV had no idea where each line of video started and ended. The sync pulse can be seen in the video waveform shown in Fig. 1. Without a sync pulse, the TV's horizontal circuitry will freewheel and you'll most likely see the horizontal weaving down near the center of your screen rather than being located discreetly off to the side. That also means that the TV won't see the transmitted burst signal in the right place, and the colors will be off as well.

To descramble the video, a decoding signal was sent, buried in the audio. It would restore the sync pulse at the proper time and for the proper interval. I don't want to spend a lot of time on this because there's as much chance of seeing this as there is of seeing a mastodon. Once upon a time they were everywhere, but they're long gone today.

The best way to get a good handle on the whole business of video scrambling is to get into the theory and the circuitry needed to turn the theory into practice. I have to stress at this point that you're not going to get much out of this unless you understand how video works in the first place. Some time ago I did a series of columns on this subject. I strongly suggest that you get your hands on them, read them, and then keep them handy for reference. I'll assume that you understand the basics of a clear video signal as we go through the methods that are often used to mess it up.

Every scrambling method depends on altering some or all of the control pulses that are included in the definition of the standard video waveform. That means that the most basic operation of any scrambling/unscrambling system is the separation of the control information from the picture information. That isn't such a complex job because the NTSC standard was devised with a strictly mathematical timing relationship between every individual part of the signal. Therefore, looking at a video signal is somewhat like reading a street map—if you know exactly where you are, you automatically know where everything else is. Or, in the case of scrambled video, just where everything else is supposed to be.

Splitting the sync signal from the video waveform is, as I said, a very common job. After all, every TV does exactly that over and over as long as it's turned on. Most semiconductor manufacturers with lines of video IC's have several sync-separator chips in their catalogs, although it's usually hard to buy them in single quantities from suppliers. And they're not the cheapest IC's around either. I wonder if that means anything.

Over the next several installments we'll be looking at various scrambling methods commonly used by the cable companies. I'll go through the theory and show you how you can find out what your cable company is shipping to the back of your TV set. And yes, we'll be looking at the circuitry needed to descramble the signals—practical examples with component values.

I'll be using standard IC's that meet all our usual criteria of price (low) and availability (everywhere), but this is one area where you're really going to need an oscilloscope. If you're serious about electronics you should have one of these things anyway, because they're just about the most basic and essential piece of test equipment you can own.

When we get together next time we'll start things out by building some stuff that will scramble a standard video signal. That may seem a bit strange, but remember that the first step in defeating an enemy is to learn to think like he does. **R-E**

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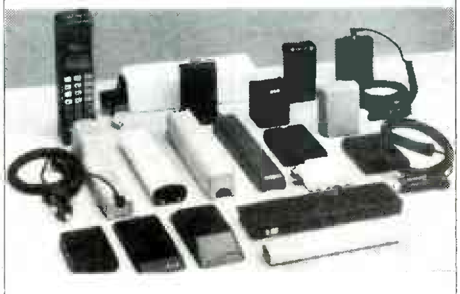

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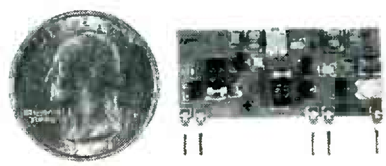

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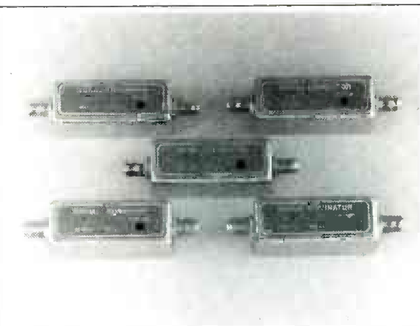

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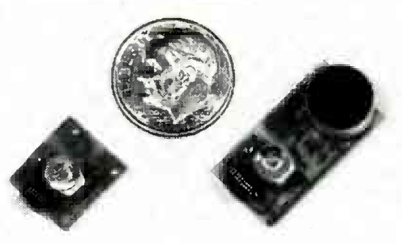

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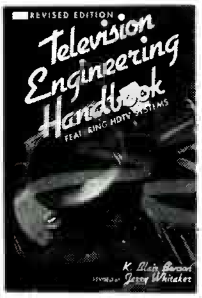
TELEVISION ENGINEERING HANDBOOK: REVISED EDITION; by K. Blair Benson; revised by Jerry Whitaker. McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020; $99.95.

Since this book was first published 35 years ago, television engineering has undergone many changes. One of the most fudamental changes was the replacement of vacuum tubes by transistors and IC's.



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Other milestones include the worldwide acceptance of color TV, the introduction of cable TV, and the use of satellites as relays. The new technologies that have impacted television engineering during that period include digital recording and transmission, hand-held video cameras, and the video cassette recorder (VCR). The video cassette and its format has been standardized and the laser disk has appeared. On the horizon is high-definition television (HDTV). What system will be selected, will it be accepted, and how will it affect existing transmission and receiving methods?

The original handbook has been completely rewritten by a team of 70 contributors, each a specialist in his field. In more than 1500 pages, the handbook provides comprehensive technical information and reference data for engineers who design, develop, service, and operate television systems.

The topics covered include the fundamentals of television, signal generation and processing, transmission, reception, and picture reproduction. Advanced TV systems are discussed and reference data is included. Opening chapters contain sufficient tutorial content to provide the reader with a background for understanding the principles involved in the subjects covered in subsequent chapters.

Those tutorial subjects include reviews of the principles of color vision, photometry, and optics as they relate to television engineering. Later chapters cover broadcasting, cable and satellite distribution, signal and image storage on videotape, video disks, and film. The latest techniques for digital signal processing and transmission are also included. Other chapters discuss graphics generation, picture manipulation, and TV standards conversion.

A thorough coverage of the TV standards in the United States and the rest of the world is presented. A chapter is devoted to data, equations, and definitions not generally found in television-engineering handbooks. Finally, a detailed survey of HDTV contains a discussion of the digital and analog HDTV proposals from competing teams of corporations and laboratories. It explains their operating principals and benefits.

THE SODER-WICK SYSTEM; from Chemtronics Inc., Soder-Wick Fine-Braid, P.O. Box 1448, Norcross, GA 30091-9931; free.

This six-page, full-color brochure explains the Soder-Wick Fine-Braid desoldering system. It is said to be useful in the removal of both leaded and surface-mount components from all boards.

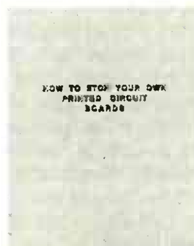
CIRCLE 38 ON FREE INFORMATION CARD

Chemtronics says its desoldering braids are made from oxygen-free, high-conductivity (OFHC) copper wire braided in a geometric pattern that efficiently wicks molten solder. The braid is cleaned to prevent the contamination of parts being desoldered. Braids are available in nine widths from 0.022 to 0.210 inch. The braid is available fluxed (pure water white rosin or no-clean) and unfluxed.

Soder-Wick Fine-Braid will remove accidental solder bridges and excess solder from all locations and correct poor solder joints. It is said to be helpful in the removal and remounting of all circuit components.

HOW TO ETCH YOUR OWN PRINTED CIRCUIT BOARDS; by Neil Petrucelli. Cover to Cover Desktop Publishing, Attn: PCB Book, P.O. Box 8064, Westfield, MA 01086-8064; $9.95.

This step-by-step instruction manual is filled with valuable information



CIRCLE 37 ON FREE INFORMATION CARD

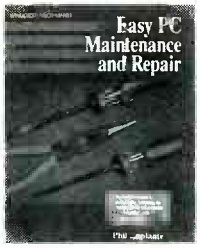
for anyone interested in etching printed circuit boards. It leads readers through the entire process from analyzing the circuit to laying out the corresponding traces and pads. A photographic process forms the circuit board mask that is then positioned against the copper-clad board and exposed to light.

The author says the process produces PC boards comparable to those from industrial vendors. He keeps the hobbyist in mind by providing a list of readily available and affordable equipment. The PC board manual is fully illustrated with computer-aided design drawings.

EASY PC MAINTENANCE AND REPAIR; by Phil Laplante. Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; $14.95.

This guide contains clear instructions that make it easy and inexpensive to troubleshoot and maintain your personal computer. No technical experience is needed to take advantage of the diagnostic advice given in this book; the only tools necessary are a screwdriver and a pair of pliers. However, the reader who wants to do his own servicing should at least have a basic understanding of how personal computers work.

The book applies to all IBM-compatible PC's

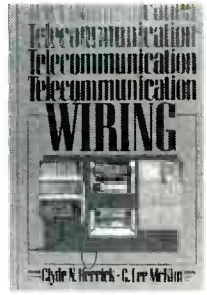


CIRCLE 40 ON FREE INFORMATION CARD

based on Intel 8088, 80286, 80386, and 80486 microprocessors. Laplante's book explains the fundamentals of computer architecture and introduces PC terms and concepts. It explains how to perform the most frequently needed repairs and carry out routine maintenance procedures. Those procedures are illustrated with many helpful photographs, drawings, and tables. The book tells you how to prevent common hardware failures, discusses the latest upgrade options, and reviews vital software tools that can help you to optimize your PC's performance.

TELECOMMUNICATION WIRING; by Clyde N. Herrick and C. Lee McKim. Prentice Hall, Englewood Cliffs, NJ 07632; $34.00

Written for the telecommunications professional, this book covers the important issues of wiring systems. It is a valuable reference for decision making in cable design, materials, writing the job proposal, documenting existing systems, and establishing maintenance procedures. Topics include



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specialized wiring for computer installations.

Wiring design, power sources, alternative power supplies, and expansion of existing facilities are discussed, and maintenance, and troubleshooting procedures are given. A tutorial guide to the 1990 National Electric Code is included. This book gives the reader an outline for successful planning, installation, and testing of cable systems. **R-E**

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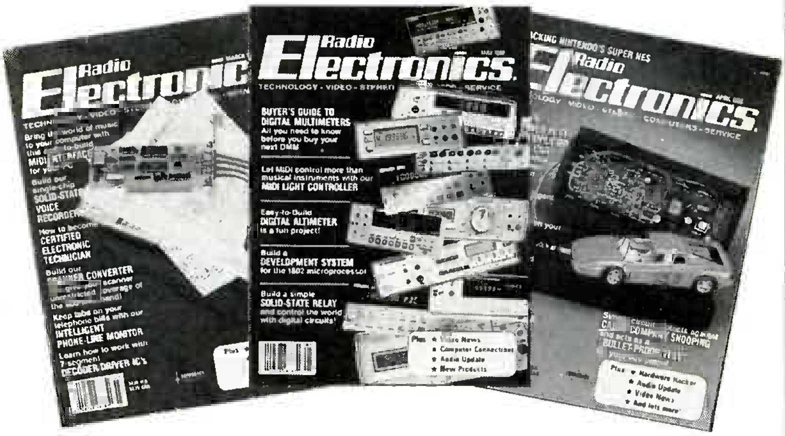

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5REH4

Battered by a noisy world? Create your own soothing sound background with SurfMan.

SURF MAN

JOHN SIMONTON

LISTEN. IT'S A NOISY WORLD. WHEN THE KID'S TV IS GOING UPSTAIRS, AND THE HI-fi is on in the living room, it can be hard just trying to think. If you'd like something to block out irritating, distracting sounds, here's something you'll like: SurfMan. It's a gadget that's small enough to fit in your shirt pocket and uses Walkman-style headphones to provide a soothing personal audio ambiance of rain, crashing surf, or unmodulated pink noise. We like to think that the surf sound is something like Hawaii's Waimea with the Banzai Pipeline thundering in the background, and we hope that you agree.

Fighting noise with noise

For a casual definition of unwanted noise, let's say that it is random sound occurring in the background which, despite your best intentions, still grab your attention from time to time. You can however, mask unwanted noise with another kind of noise.

Noise comes in colors. White noise, such as the hiss heard between FM stations has a uniform distribution of all audio frequencies mixed together—just as white light contains all colors. Pink noise, like the color pink, is weighted toward the lower-frequency end of the spectrum.

Noise has interesting psycho-acoustic properties. Experiments have shown that exposure to pink noise increases learning under certain controlled conditions, but the effects are transient and learning soon returns to

the base rate observed without the noise. White noise has also been used instead of local anesthetic by dentists, but whether positive results were from actual analgesic properties or simply placebo effects is debatable.

In the old spy movies the heroes/villains would discuss their plans to save/control the world in the bathroom with the shower running. You might think that this was just some kinky quirk that accompanies the Bond mentality, but in reality the sound of water from a shower is a kind of pink noise, and its uniform distribution of frequencies is quite effective at masking speech and disabling hidden electronic bugs.

A lot of natural sounds are essentially noise—rain on a roof, for example, is white noise. And others, like wind and surf, are "voiced" noise, which means that their amplitude and frequency spectrum are modulated over time.

Generating noise

A number of methods have been commonly used to produce random noise. SurfMan depends on the noise produced by electronic components for truly random noise generation. All electronic components produce some noise, mainly because they're not working at absolute zero temperature, and the heat-induced movement of electrons through the part results in random voltage and current fluctuations. In most components, the noise level is just enough to be a source of aggravation in critical circuits, but not enough to be useful for what we're doing.

When its reverse-voltage tolerance is exceeded, a semiconductor junction breaks down and produces just the kind of noise that we're looking for. Zener diodes do that, but some are specifically designed to minimize the random fluctuations. The base-emitter junction of a silicon transistor that has been reverse biased to the point of avalanching produces the kind of noise we're after, and it hasn't been designed out. So that's what we'll use.

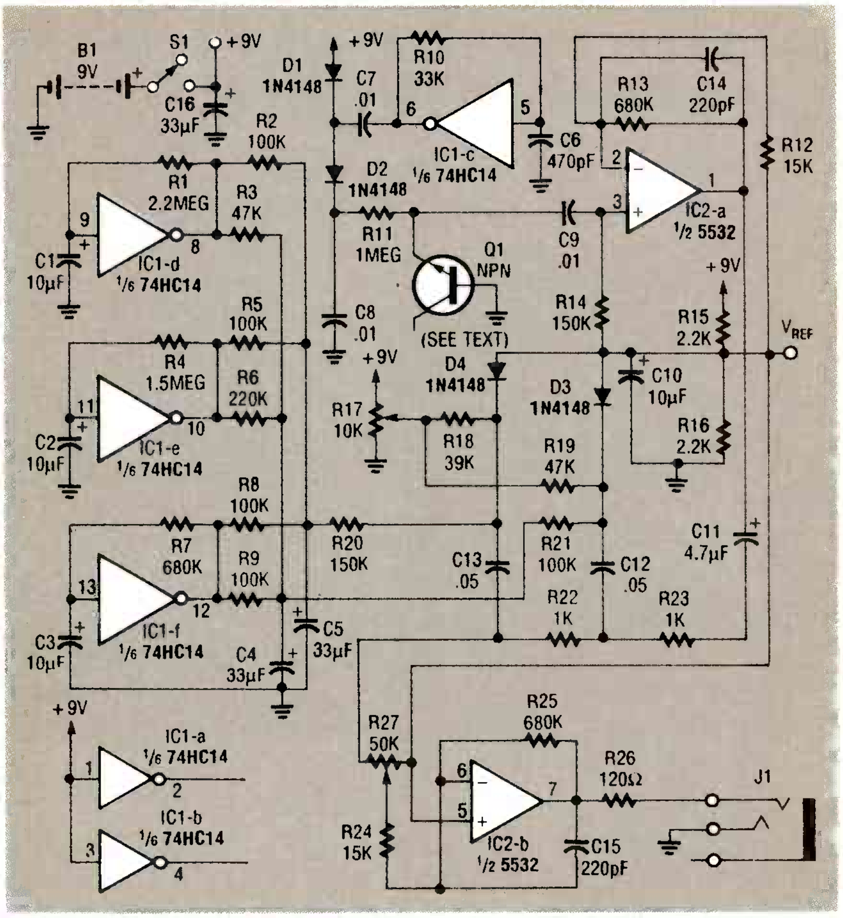


FIG. 1—SURF MAN SCHEMATIC. The circuit produces relaxing surf-like sounds.

How it works

A minor complication with using a transistor for the noise source is that it's rare to find a base-emitter junction that will avalanche at less than about 10 volts—not quite low enough to be produced reliably with a 9-volt battery. We could use two batteries of course, but then the battery size would get to be a problem. The solution is to use a voltage doubler.

Look at the schematic in Fig. 1. One stage of a 74HC14 hex Schmitt trigger inverter (IC1-c) is configured as a square-wave oscillator whose frequency is set to about 40 kHz by feedback resistor R10 and capacitor C6. When the output of the oscillator is low, C7 charges through D1 so that the junction of the diode and capacitor is positive with respect to the output of the amplifier. When the output switches high, the voltage on the capacitor is added to the output, and the resulting voltage charges C8 through D2 to roughly 18 volts. When that voltage is applied to the reverse-biased base-emitter junction of Q1 by way of R11, the junction avalanches and noise appears across the resistor. The 18-volt supply only biases the noise source and does not power any other circuitry.

The low-level noise is coupled by C9 to the non-inverting input of op-amp IC2-a, a 5532 dual low-noise op-amp. Because the op-amp is billed as a low-noise component for audio applications, it might not make much sense to use it in an application where noise is our objective. But the part was chosen for its drive capabilities because it will drive low-impedance headphones.

The 5532 is intended for bipolar operation, but here we have only a single-ended supply, the 9-volt battery. To compensate for the lack of a bi-polar supply, we provide a 4.5-volt reference using voltage divider R15-R16. Every point that would normally be connected to ground is returned to that refer-

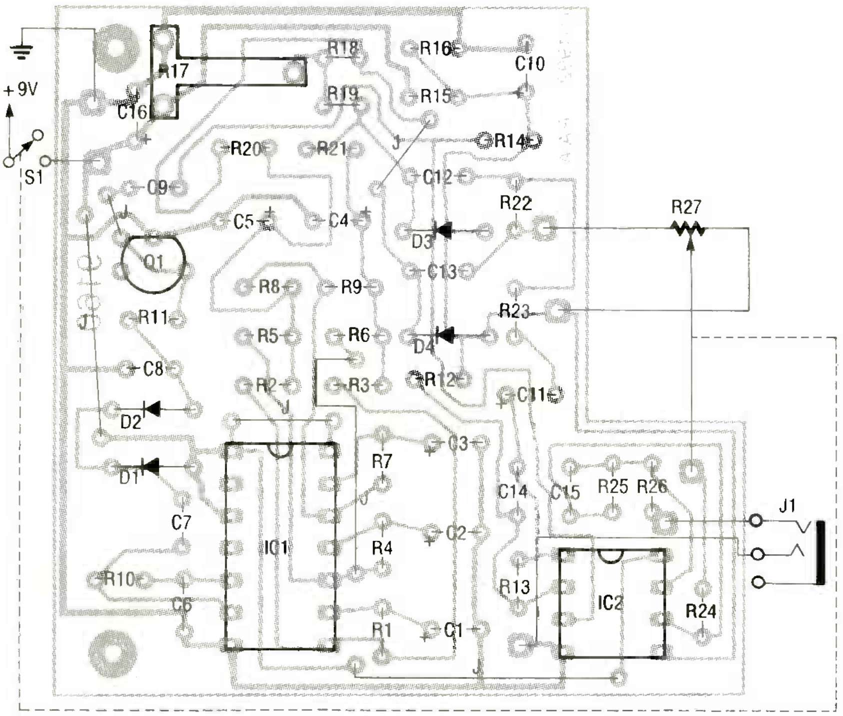


FIG. 2—PARTS PLACEMENT DIAGRAM. To conserve space, stand resistors on end and mount tall electrolytic capacitors on the solder side of the board so they lie flat.

ence point, thereby fooling the amplifier's inputs into thinking that there are positive and negative supply rails. Capacitor C10 bypasses the reference voltage source so that it appears as a ground for audio signals.

SurfMan's "wave action" sound effect is produced by three separate low-frequency oscillators running asynchronously. The oscillators are similar to the one that drives the voltage doubler, but their operating frequencies are set at a only one cycle every few seconds with larger resistor values (R1, R4, R7) and capacitors (C1, C2, C3). When added together, the three oscillator outputs form chaotic voltages that are an electronic approximation of surf sounds.

Two separate control voltages are generated. The first is through resistors R2, R5, and R8. Because those resistors are of equal value, only four different control-voltage levels can be generated. The voltage level depends on how many of those outputs are high, and not which outputs they are. You can think of this voltage as representing the "sets" of ocean waves. The second voltage is produced through R3, R6, and R9, whose values were selected as powers of two to produce eight different control-voltage levels. They can be thought of as representing the individual waves within the set. The voltages produced are smoothed by integrating them with capacitors C4 and C5.

Two voltage-controlled filters (VCF's) convert the control voltages into a changing frequency spectrum. Ordinarily, VCF's use transconductance amplifiers, FET's, or optocouplers as control elements, but here we use diodes. It's not common to see diodes used this way in audio, but they function very well and they're hard to beat when low cost and a small size are important. The basic idea is to control the effective impedance of the diodes with a DC current while AC coupling the signal of interest to them. As long as the AC signal level is much less than the DC controlling current, the current works well.

The filter consists of two "L" section circuits comprising R22, R23, C12, and C13, with D3 and D4 as the tuning elements. Notice that the anodes of the diodes are returned to the reference voltage source mentioned earlier so that the controlling voltages can both forward- and reverse-bias them. Control voltages are coupled to the diodes through R20 and R21 with potentiometer R17 and fixed resistors R18 and R19 providing a control of their fixed bias. As the control voltages forward bias their respective diodes, the decrease in impedance pulls the corner frequencies of the filters back so that higher frequencies are bypassed to ground.

Finally, the output of the filter appears across volume-control R27, which sets the amount of signal applied to the final output amplifier that includes IC2-b. The output of the amplifier is current-limited by R26 before appearing at the headphone jack J1. While the wiring of J1 might look strange, it is done that way so that the two headphone elements are in series. This is not a stereo system and doubling the impedance of the headphones makes it easier for the op-amp to drive them.

Building SurfMan

If you're not concerned about the size of the finished unit, only the standard construction precautions apply: be careful about orientation of polarized components such as IC's, diodes, electrolytic capacitors, and transistor Q1. The 74HC14 is a CMOS part and subject to damage by electrostatic discharge. Avoid shuffling along on a nylon carpet while handling the part. There are no particularly high frequencies involved, so any construction technique will work just fine. Because of some fairly high-gain stages, keep wire lengths as short a possible to prevent hum pickup.

If you're interested in building a compact SurfMan such as the one you see in the photos, you're going to have to pack a good number of components in a relatively small space. Figure 2 is the parts placement diagram. To make maximum use of the circuit board area, stand resistors on end and mount all tall electrolytic capacitors on the

PARTS LIST

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

R1—2.2 megohms
R2, R5, R8, R9—100,000 ohms
R3, R19—47,000 ohms
R4—1.5 megohms
R6—220,000 ohms
R7, R13, R25—680,000 ohms
R10—33,000 ohms
R11—1 megohm
R12, R24—15,000 ohms
R14, R20—150,000 ohms
R15, R16—2200 ohms
R17—10,000 ohms, trimmer potentiometer
R18—39,000 ohms
R21—100,000 ohms
R22, R23—1000 ohms
R26 120 ohms
R27—50,000 ohms, audio taper potentiometer with on/off switch (S1)

Capacitors

C1, C2, C3, C10—10 µF, 16 volts, electrolytic
C4, C5, C16—33 µF, 16 volts, electrolytic
C6—470 pF, ceramic disk
C7, C8, C9—0.01 µF, ceramic disk
C11—4.7 µF, 16 volts, electrolytic
C12, C13—0.05 µF, ceramic disk
C14, C15—220 pF, Mylar or polystyrene

Semiconductors

IC1—74HC14 hex Schmitt trigger inverter
IC2—NE5532N dual op-amp
D1–D4—1N4148 silicon diode
Q1—NPN silicon transistor selected for noise (see text)

Other components

J1—miniature stereo phone jack
S1—SPST switch (part of potentiometer R27)

Miscellaneous: 9-volt battery and connector, case, PC board, knob, headphones, wire, solder, etc.

Note: The following are avaialble from PAIA Electronics, Inc., 3200 Teakwood Lane, Edmond, OK 73013 (405) 340-6300:

- **Etched, drilled and silkscreened PC board (9160pc)—$6.95**
- **Complete SurfMan kit including PC board, case, and selected noise transistor (no headphones) (9160K)—$27.75**

Please add $3.50 shipping and handling to each order.

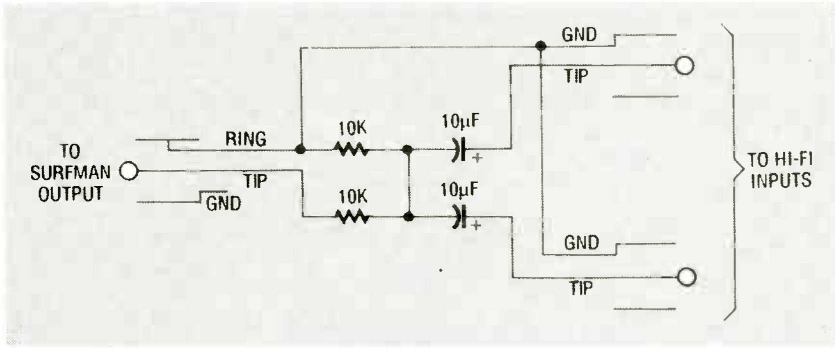
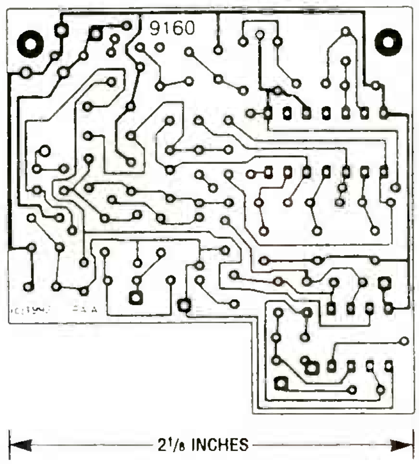


FIG. 4—TO CONNECT SURF MAN to your hi-fi setup, use this capacitively coupled voltage divider. The "Y" connector lets SurfMan drive stereo inputs.

solder side of the board to allow them to lie flush with the board. Capacitors that are short enough to stand up on the component side of the board and still allow the board to fit into the case are available, but they're more expensive and they are not really necessary.



USE THIS FOIL PATTERN to make your own PC board for SurfMan.

You can etch your own board with the foil pattern provided or buy a ready-to-use board from the source given in the Parts List. Even if you skip the circuit board and build the SurfMan on a piece of perforated construction board, it is recommended that you follow the general component layout in Fig. 2. (A lot of effort went into minimizing trace length and placing components, so you should take advantage of this work.)

Fully assemble the circuit board by mounting all resistors, diodes, capacitors, and IC's. Do not install the noise transistor (Q1) yet. Use 22-gauge or smaller stranded wire to make connections from the circuit board to the volume control (R27), power switch (S1, which is part of R27), and phone jack (J1). The five jumpers on the circuit board should be made with insulated wire to keep them from shorting against adjacent component leads.

Snap a 9-volt battery into the connector and plug a pair of headphones into J1. The generally less expensive 32-ohm headphones are preferable to 8-ohm phones because their higher impedance is more eaisly driven by the output amplifier. Turn on the unit transfer by rotating the shaft of the volume control fully clockwise. You won't hear any noise because Q1 has not been installed, but you can perform a quick test by touching your finger to pin 3 of IC2. You should hear a fairly loud buzz as environmental electromagnetic fields are coupled into the amplifier. If there is no hum, you have a clear indication that something is wrong.

With that test successfully completed you're ready to install the noise transistor. Almost any NPN silicon transistor, such as a 2N2712, 2N2222, or 2N3904, is a good candidate for Q1. You might not like the first transistor you pick because smooth noise is what we're after. You may run into a device that emits a lot of "popcorn" noise, which you'll recognize if you hear it.

Turn on the unit and set R17 fully clockwise. Press the emitter and base leads of the transistor that you're testing against the pads on the PC board. You might have to hold the device in place for a second or two so that voltages can stabilize. Also be careful not to touch any of the transistor

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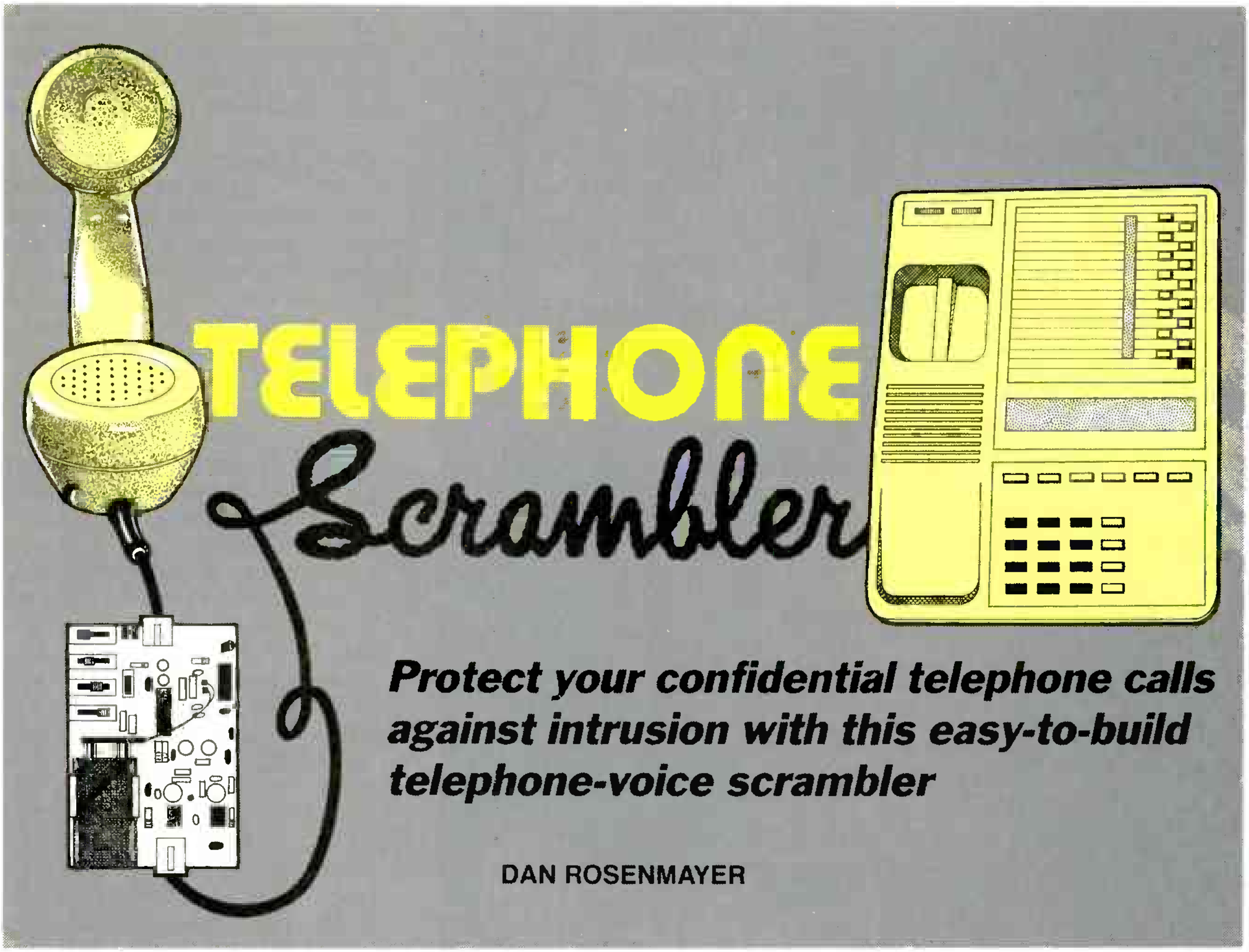


TELEPHONE Scrambler

Protect your confidential telephone calls against intrusion with this easy-to-build telephone-voice scrambler

DAN ROSENMAYER

TELEPHONE-VOICE SCRAMBLING IS the most effective method for eliminating unwanted eavesdropping on your confidential phone calls. It should be considered if you have reason to believe that unauthorized persons are or could be listening in on your telephone conversations. A system consisting of two compatible telephone-voice scramblers will permit normal conversation between you and your intended listener, while making all speech unintelligible to anyone listening on extensions at either end of the line. Only a person with a compatible unscrambler will be able to understand what is being said.

Many circuits are available that can monitor your phone line and detect intentional or unintentional removal of handsets from their hooks on any extension. Because they're easily defeated, those circuits could lull you into a false sense of security. Even if you detect an unauthorized listener "horning in," you have only two choices: hang up or be on guard against saying anything that you don't want to be heard by an unauthorized third party.

Matched telephone voice scramblers enable you to carry on conversations without guarding your speech. They also eliminate the threat of wiretapping and covert tape recording, unless the intruder has the necessary circuitry to unscramble your garbled conversations.

In the past, factory-made telephone voice scramblers were expensive and difficult to find. Today scramblers are more readily available and their prices have fallen because of the availability of low-cost voice scrambler/descrambler IC's. However, those scramblers might include certain features that you don't want such as a briefcase housing. This article will permit you to build inexpensive, compact, and effective voice scramblers in the form of loaded circuit boards.

Figure 1 shows the TVS250 voice scrambler coupled between the headset and base of a standard telephone. It is half of a complete telephone security system. Connections between the scrambler circuit and telephone are easily made with standard telephone cords terminated with standard modular plugs. A second voice scrambler would be similarly connected to another telephone to form the secure telephone system shown in Fig. 2.

Theory of operation

The heart of the TVS250 is the COM9046, a voice scrambler/descrambler IC made by Standard Microsystems Corp. Figure 3 is a simplified block diagram of that dedicated chip. The IC contains two identical speech channels that permit full-duplex operation when connected between two telephones. Each channel is capable of scrambling and descrambling voice communications.

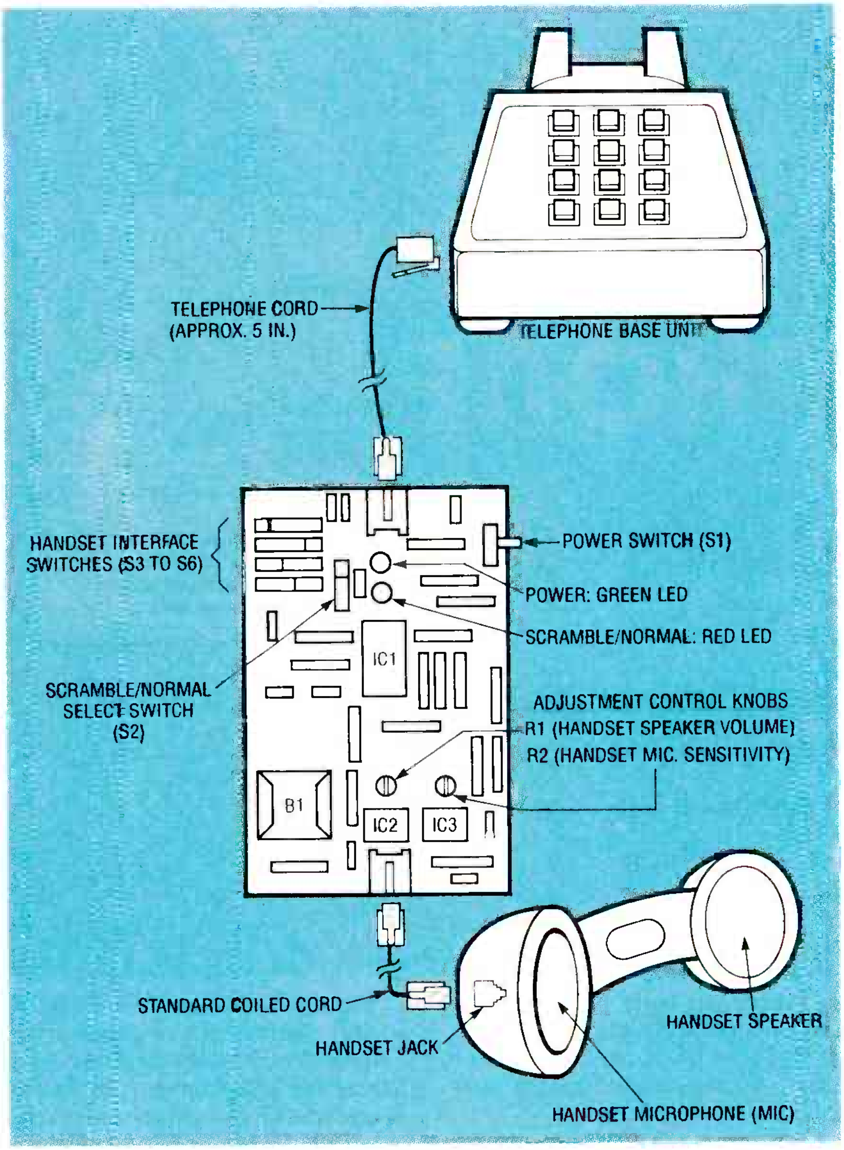


FIG. 1—ONE END OF A SECURE TELEPHONE SYSTEM, a TVS250 scrambler circuit coupled between the handset and the base of a telephone with standard jacks and cord.

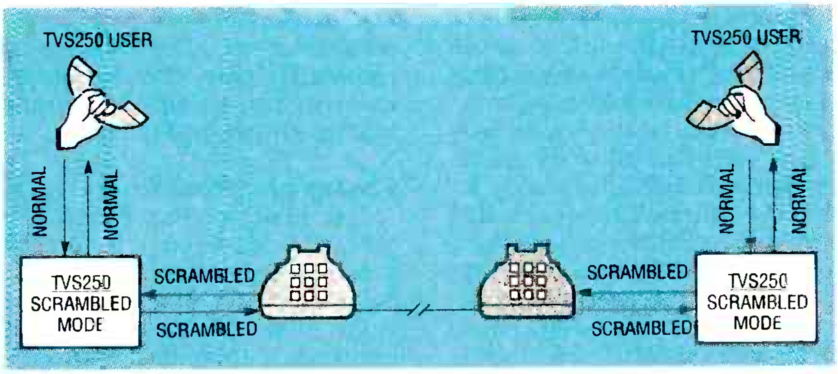


FIG. 2—COMPLETE TELEPHONE SECURITY is obtained with a TVS250 at both ends of the phone line forming a duplex scrambler/descrambler system.

To render the speech channels unintelligible, the incoming audio signal is inverted by the IC's internal double-sideband modulator. While one channel accepts the normal frequency spectrum from the handset microphone, inverts and transmits it, the other channel accepts the incoming inverted signal, normalizes and sends it to the handset speaker.

Circuit design

The COM9046 voice scrambler/descrambler IC contains a crystal oscillator that controls system timing. The on-chip oscillator requires an external 3.58-MHz crystal that is commonly used in TV color-burst applications. The chip also contains switched-capacitor filters, so input speech must be filtered by an anti-aliasing single-pole, low-pass filter before it is applied to the audio input at pins 5 and 11.

The filter's 3-dB cutoff point is determined by the resistors and capacitors connected to pins 5 and 11. The values of those components were selected so that the cutoff point is less than 20 kHz. As shown in the schematic, Fig. 4, both R5 and R6 have values of 3.9 K, and both C11 and C12 have values of 2200 pF. Applying those RC values to the equation for filter cutoff frequency, $F_O = (2\pi RC)/2$, yields a 3 dB cutoff frequency of about 18.5 kHz.

The COM9046 was designed to operate on ±2.6 volts (+2.6 volts at pins 9 and 7, and -2.6 volts at pins 3 and 8). This operating voltage is measured with respect to a ground reference at pin 4 of the IC. However, the TVS250 operates from a single 9-volt transistor battery so it is necessary to obtain the required ±2.6 volts from a unipolar 9-volt transistor battery. Those voltages are measured with respect to the IC's analog reference at input pin 4.

The 9 volts can be reduced to 5 volts by IC4, a 78L05A low-voltage regulator, as shown in schematic Fig. 4. The 5-volt input is applied to a voltage divider consisting of R16 and R18. Pins 7 and 9 of IC1 are connected to the 5-volt source. Pins 3 and 8 are connected to the supply ground (0 volts). The midpoint of the two resistors R18 and R16 is connected to pin 4 of the IC. Because the two resistors are of equal value, their junction produces +2.6 volts.

the telephone base passes IC1, it drives the handset speaker. The audio output signal from pin 6 of IC1 is filtered by an active low-pass filter consisting of IC3-b, R14, R15, C13, and C14.

Inserting those RC values in the low-frequency cutoff equation given earlier will show that the filter can pass all frequencies below 3.1 kHz. The filter greatly reduces high-frequency noise, especially that produced by clock feedthrough from IC1's internal oscillator.

The output from this low-pass filter is applied to the audio amplifier IC2 which acts as a low-power differential driver connected to the handset speaker. Potentiometer R1's resistance value of 100 K will permit volume adjustment of the handset speaker.

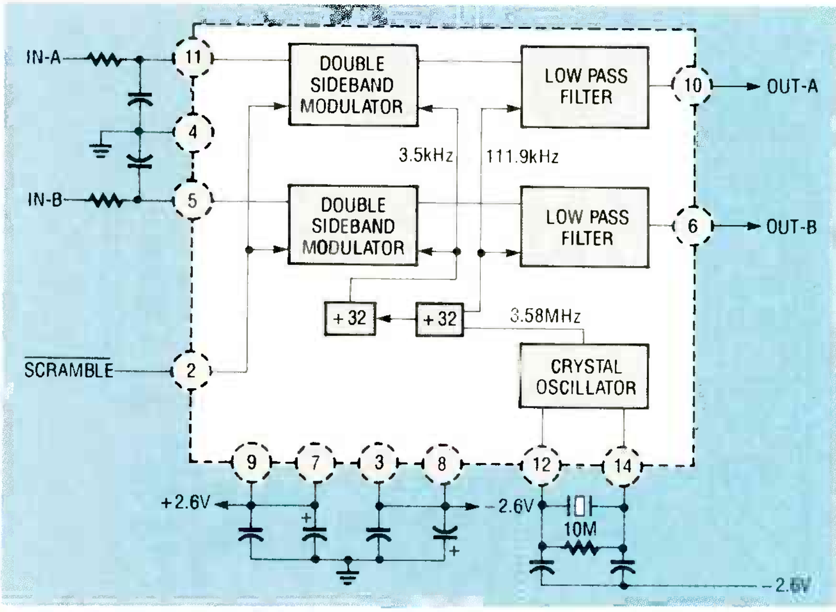


FIG. 3—SIMPLIFIED DIAGRAM OF THE COM9046 SCRAMBLER/ DESCRAMBLER IC and some peripheral components that are the heart of each TVS250 voice scrambler.

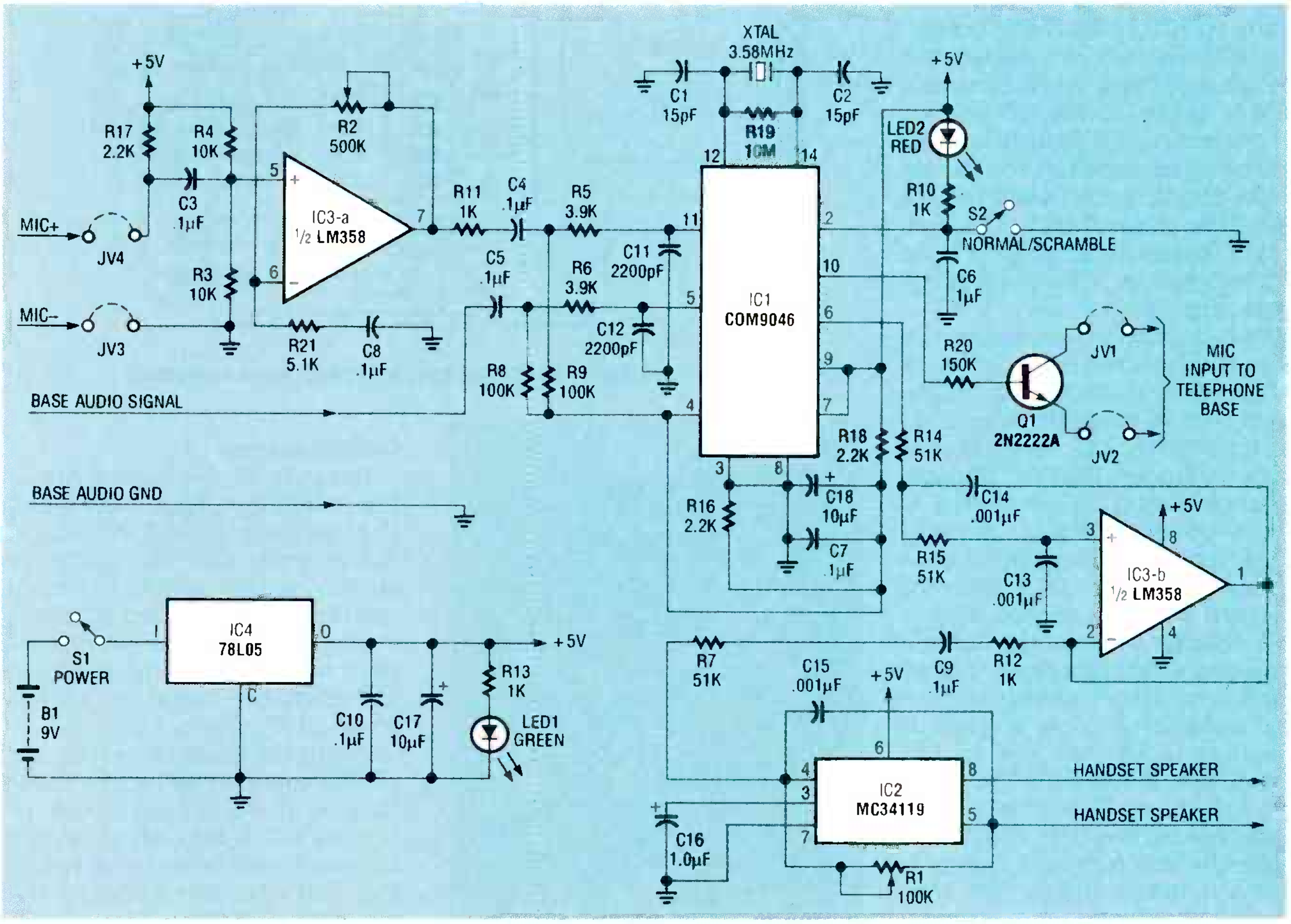


FIG. 4—SCHEMATIC DIAGRAM FOR THE TVS250 voice scrambler.

Now, with respect to pin 4, pins 9 and 7 are at +2.6 volts, and pins 3 and 8 are at -2.6 volts as shown in Fig. 3. Both of those values are within the acceptable limits for IC1.

The scrambler/descrambler IC1 can be interfaced with a standard telephone. The audio output from the base of the telephone is AC coupled to IC1 via C5. After the audio signal from

The equivalent circuit for the handset microphone is a potentiometer that changes its resistance with applied input audio signals. In quiet periods, its effective resistance is constant, but when audio input is applied, its resistance changes linearly with the varying input frequencies.

Because the microphone can be considered as equivalent to a potentiometer, a voltage divider can be formed with R17 as one resistor and the handset microphone as the other one. As the microphone's resistance changes, the voltage at JU4 will follow. That voltage is AC coupled by C3 to the amplifier circuit that includes IC3-a.

Filter resistor R21 and capacitor C8 form a high-pass RC filter for the amplifier circuit that will attenuate low-frequency noise and prevent DC bias amplification. Applying the values of this filter to the cutoff frequency equation yields a high-frequency cutoff point of 312 Hz. Below that frequency C8 will act as an open circuit, effectively removing R21 so that the signal will not be amplified. At frequencies higher than 312 Hz, C8 will act as a short, and amplification will be determined by the values of feedback potentiometer R2 and filter resistor R21. The output of the amplifier stage is then AC coupled to IC1 via coupling capacitor C4.

The audio input from the handset microphone goes to IC1, and the output audio at pin 10 of that IC must be interfaced with the telephone base. This is done by applying it to the base of transistor Q1. The current to Q1 is limited by R20 to prevent saturation. As the applied base voltage changes, Q1's collector current will vary accordingly.

A change in collector current causes a direct change in collector-to- emitter voltage across the transistor. This voltage is similiar to the voltage at JU4 which was derived for the handset interface. Lines from both collector and emitter of Q1 connect the microphone input to the telephone base. The telephone base sees transistor Q1 as a microphone.

The resistance of potentiometer R2 was selected as 500 K to permit varying the amplification of the audio input. That potentiometer varies the audio applied to the base of Q1. The circuit permits the user to adjust the transistor drive as well as compensate for internal circuit differences in telephones.

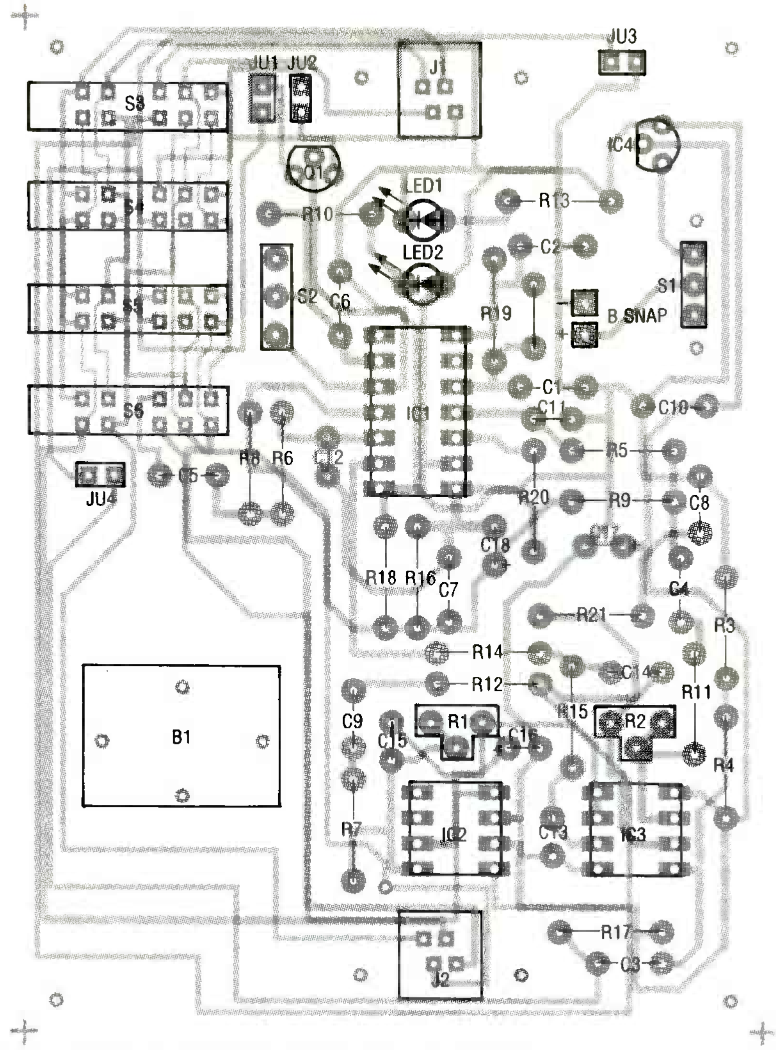


FIG. 5—PARTS PLACEMENT DIAGRAM for the TVS250. voice scrambler.

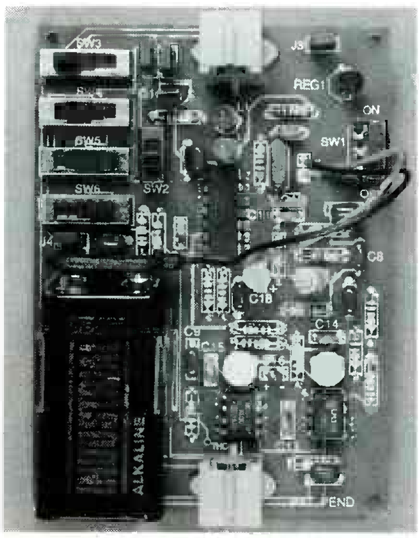


FIG. 6—PHOTOGRAPH OF LOADED BOARD for the TVS250.

Construction

Because of the complexity of the telephone voice scrambler, the double-sided PC board made with the foil patterns shown in this article is recommended. The finished PC board is available both as a separate item or as part of the complete kit available from the source given in the Parts List.

Begin the assembly of the telephone voice scrambler by inserting and soldering fixed resistors R3 to R21 where shown on parts placement diagram Fig. 5. (Figure 6 is a photograph of the loaded circuit board.) Insert and solder potentiometers R1 and R2. Do the same for nonpolarized capacitors C1 to C15. Next, insert and solder polarized capacitors C16 to C18, noting their polarity. Trim all excess lead lengths.

PARTS LIST

All resistors are ¼-watt, 5 %, unless otherwise noted
R1—100,000 ohms, PC-mount potentiometer, screwdriver adjust
R2—500,000 ohms, PC-mount potentiometer, screwdriver adjust
R3, R4—10,000 ohms
R5, R6—3900 ohms
R8, R9—100,000 ohms
R10–R13—1000 ohms
R7, R14, R15—51,000 ohms
R16–R18—2200 ohms
R19—10,000,000 ohms
R20—150,000 ohms
R21—5100 ohms

Capacitors
C1, C2—15 pF, ceramic disc
C3–C10—0.1 µF, metal film
C11, C12—2200 pF, ceramic disc
C13–C15—0.001 µF, ceramic disc
C16—1µF, 35 volts, tantalum
C17, C18—10 µF, 16 volts, electrolytic, polarized

Semiconductors
IC1—COM9046 voice-scrambling IC, (Standard Microsystems)
IC2—MC34119, audio amplifier driver (Motorola or equiv.)
IC3—LM358 dual operational amplifier, single supply
IC3—78L05A, 5-volt regulator (Texas Instruments or equiv.)
Q1—2N2222A, NPN transistor
LED1—green light-emitting diode, T1, 5mm
LED2—red light-emitting diode, T1, 5mm

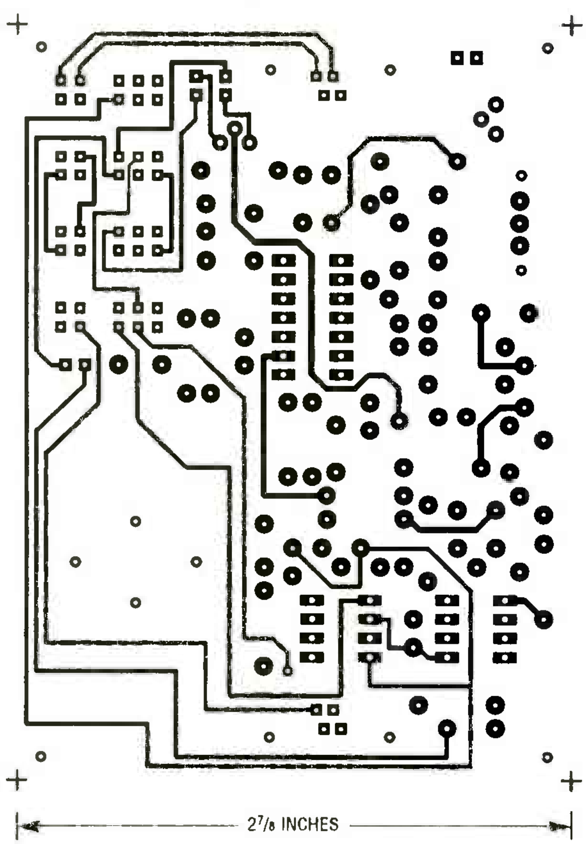
Other components
S1—SPST slide, PC-mount, side-actuated switch
S2—SPST slide, PC-mount, top-actuated switch
S3–S6—STS2400 PC, 2P4T slide, PC-mount, top-actuated (Augat/Alcoswitch or equiv.) switch
J1, J2—telephone jack, 4-4, Type 616, PC-mount
JU1–JU4—two-post jumper, 3/32-inch-on-centers with insulated shorting clips(see text)
XTL1—crystal 3.579545 MHz, metal case (ITT 4183 or equiv.)
B1—9-volt transistor battery, alkaline, standard

Miscellaneous: TVS250 PC board, 5-inch length of telephone cord terminated with standard telephone plugs, 9-volt transistor-battery clip-type holder (Keystone No. 79 or equiv.) with two 2-56 screws and nuts, 9-volt transistor battery terminal snap with leads, four rubber or plastic PC board feet (see text), and solder.

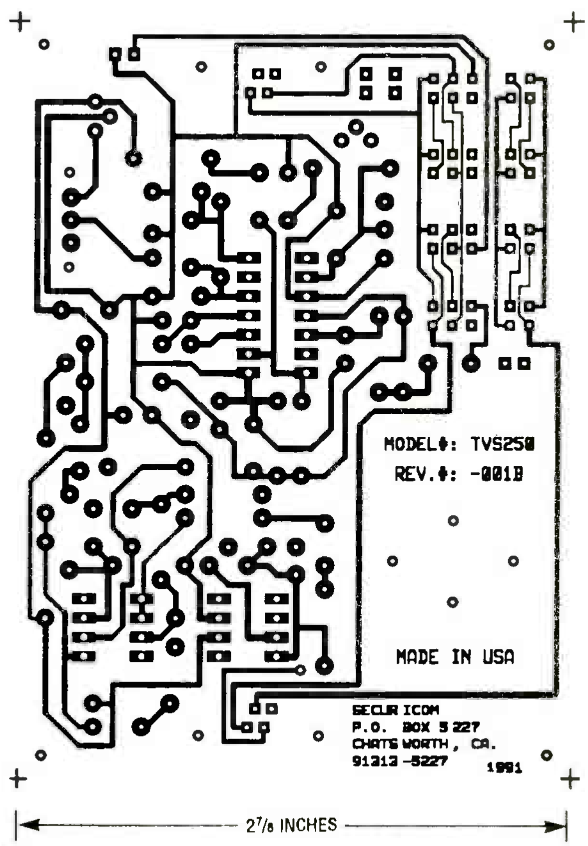
Note: The following parts are available from Securicom, P.O. Box 5227, Chatsworth, CA 91313-5227 (818)-710-0110

- **COM9046 scrambler/descrambler IC only—$18.00**
- **Double-sided, silk-screened and drilled PC board—$20.00**
- **A complete kit including PC board, all components, and 5-inch plug-terminated phone cord—$59.95**
- **Assembled and tested TVS250 with user's manual—$79.95**

Check, money order, and Mastercard orders accepted. Please add $3.75 for postage and handling. California residents must add 8.5% sales tax.



TOP LAYER (COMPONENT SIDE) of telephone voice scrambler PC board shown actual size.



BOTTOM LAYER (SOLDER SIDE) of telephone voice scrambler PC board shown actual size.

Then insert the jumper posts, switches, LED's, crystal, and telephone jacks where shown on Fig. 5. (Place the shorting clips (see Fig. 7) on the jumper posts JU1 to JU4 to prevent losing them.) All switches can be inserted in only one position. Orientation is not critical for inserting the crystal XTAL1. Note that the flats at the base of LED1 and LED2 are next to their cathodes. Solder all leads or wires and trim excess lengths.

Assemble the 9-volt battery holder to the PC board with screws and nuts. Insert the red and black insulated wires of the battery terminal snap in the PC board with the black wire in the hole marked "-" and the red wire in the hole marked "+" as shown in Fig. 5. After soldering the wires, trim their ends.

Insert all semiconductor devices (IC1 to IC4 and transistor Q1) where shown in Fig. 5 last. Be sure to note the dots or notches that indicate the pin 1 positions on IC1 to IC3, and the orientation of IC4 and Q1. Observe all precautions necessary to prevent electrostatic discharge damage of these devices. Solder their leads and trim excess lengths.

Make a careful visual examination of the soldered side of the PC board to be sure that all connections are sound and clean and that no stray solder has shorted any of the traces together. Remove any unwanted "bridging" by standard desoldering techniques or a sharp knife blade.

Connecting the scrambler

Connections to the telephone line are well defined and standardized, but there are no standards for the wiring that connects a specific telephone handset to its base. The TVS250 was designed to adapt to a variety of telephones. The four wires inside the retractile telephone cord that connects the handset to the base are usually color coded black, red, green and yellow. Two of these wires go to the handset speaker, and two go to the handset microphone. Unfortunately, telephone manufacturers have not agreed on

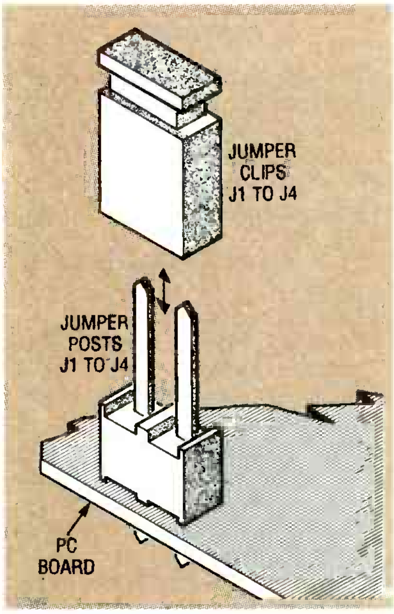


FIG. 7—SHORTING CLIPS ON JUMPER POSTS are removed while adapting the TVS250 to a specific telephone.

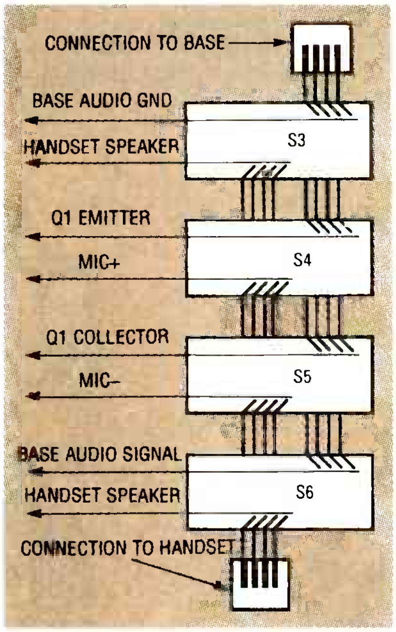


FIG. 8—FUNCTIONS OF THE FOUR SWITCHES S3 to S6 that adapt the TVS250 to a specific telephone.

either the color coding or function of those wires.

The four two-pole, four-throw switches (S3 to S6) control the handset wiring order. By changing the actuator positions of these switches, any cord wiring configuration can be accommodated by the TVS250. Figure 8 shows the functions of each of those four switches.

After some experimentation, it should take only a minute or so to arrange the switch actuators to accommodate variations in cord wiring. The easiest method for connecting the TVS250 to your particular telephone is as follows:

1) Set the midpoints of potentiometers R1 and R2 by turning their control knobs with a screwdriver so that their arrows point toward the bottom of the PC board.

2) Switch S1 to its OFF position. Attach the terminal clip to the 9-volt transistor battery and snap the battery into its spring holder on the circuit board.

3) Connect the TVS250 to your telephone by plugging one end of the five-inch phone cord into the telephone base and the other end into phone jack J1. Then plug the retractile cord that normally connects the handset to the base into jack J2 and hang up the phone.

4) Remove the shorting clips from posts JU1 to JU4. This removes switches S4 and S5 from the circuit (see Figures 4, 5, 6, and 7).

5)*Caution: Be sure that none of the actuators of the four switches S3 to S6 are in the same positions (see Fig. 9).* If the jumper post shorting clips remain in place and two of the switches are in the same position, the unit will malfunction. Moreover, power indicator LED1 (green) might not light. The removal of the four shorting clips prevents this.

6) Move S1's actuator ON and green LED1 should light. Move S2's actuator back and forth and red LED2 should turn on and off. When red LED2 is illuminated, the scrambler is in the *scrambled mode*. Before continuing, be sure red LED2 is off (*normal mode*). When configured properly, the actuators of S3 to S6 will be in one of four possible positions as shown in Fig. 9. *Remember that no two switch actuators should be set in the same position.* Switches S3 and S6, which control the handset speaker connection, should be adjusted first. To find the proper switch settings for the handset speaker, listen for the phone's dial tone.

7) Set S3's actuator to position

1, pick up the phone, and listen normally. Now move S6's actuator in sequence to positions 3, 4 and then 5. If you hear a dial tone in any of those actuator positions, leave it there. If no tone is heard, move S3's actuator to position 2 and again try S6's actuator in the other three positions. Continue this procedure until the dial tone is heard.

While the complete procedure should take only about a minute, remember that if a handset is left off of its base (hook) for more than about 15 seconds, the dial tone will automatically turn off. Hang up the phone between actuator settings to be sure that a dial tone is present when the right combination is found.

8) With the dial tone present, adjust potentiometer R1 to the desired volume.

9) Turn the TVS250 off (green LED1 is off). Place the shorting clips on all four jumper posts. After the dial tone is heard, the handset microphone switches S4 and S5 can be adjusted. For this step ask someone to assist you by listening in on an extension to your phone.

10) Set the actuator of S4 to one of the positions not used by S3 or S6, and set S5's actuator to the last available position. Turn the TVS250 on after making sure that it is set for *normal mode* (red LED2 is off). Ask your assistant on the extension to pick up the handset and key in any number to eliminate the dial tone before proceeding. Then speak normally into the handset. Your assistant can tell you if the sound volume is within normal limits. Then adjust potentiometer R2 for the best speech quality.

If, after adjusting R2, you cannot obtain quality speech, it is probable that the actuators for switches S4 and S5 are in reversed positions. (This can be determined if your assistant's voice seems distant or incomprehensible even after you have turned R2 both completely clockwise and counterclockwise. A screeching sound might also be heard.) If this is the case, simply switch the actuator positions of S4 and S5 and repeat the adjustments to R2 while speaking to your assistant.

The positioning of actuators of S3 and S6 is critical. If you still cannot get quality speech from your phone after performing the previous procedure, the positions of actuators of S3 and S6 are reversed. Exchange their positions and repeat step 10.

Although the TVS250 is rugged and will not require special handling, the unprotected circuit board must not be placed in any position where conductive surfaces could short out unprotected soldered connections on the underside of the board. The insulating feet at the corners of the PC board's underside will help to prevent damage from this cause by elevating it above any flat surface on which it is positioned. However, you might also want to enclose your scrambler in an insulated protective case for more protection.

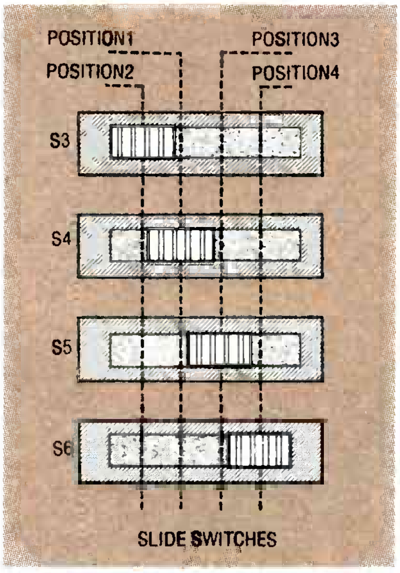


FIG. 9—FOUR POSSIBLE ACTUATOR SETTINGS of the two-pole, four-throw slide switches S3 to S6 that adapt the TVS250 to a specific phone.

After the fine adjustments have been made, your voice scrambler will be ready for use, but, of course, two scramblers are needed to form a system. Make the following simple test:

- Turn on the TVS250 with S1 noting that green LED1 is on.
- Pick up the handset and listen for the dial tone.
- Switch S2 to the scrambled mode (red LED2 is on).
- Listen for the scrambled dial tone.
- Change back to normal mode and phone someone.
- Speak normally into the phone with the scrambler mode off (green LED1 is always on when using the phone).
- Switch the unit into the scrambled mode (red LED2 is on).
- As the other party speaks, you will hear his scrambled speech and he will hear yours.
- Switch back and forth from the scrambled to the normal mode as often as necessary to check out a single unit.

When two tested scramblers on the same line are in the scrambled mode, both your voice and that of the person you called will sound normal. Anyone listening on extensions to either phone will only hear garbled speech.

Scramblers should be turned off when a call has been completed to conserve battery power. In continuous operation, a 9-volt alkaline battery will provide about 30 hours of scrambler operation.

Answering and call waiting

The scrambler can leave secure messages on an automatic answering machine. Turn on your scrambler and speak normally to any telephone with both a compatible scrambler and answering machine. When a receiving party plays back your message and hears the garbled speech, he turns on his scrambler and listens to your normalized speech through his handset.

The TVS250 can be switched back and forth from scrambled to normal mode at any time during a conversation. If you have call waiting, you could be in a secure conversation with another party whose telephone has a compatible scrambler when you are interrupted by another caller. To answer the call waiting signal, simply switch your scrambler to its normal mode and answer the call as usual. After the call is completed, return your unit to the scrambled mode and continue your secure conversation. **R-E**

OPTOCOUPLER DEVICES

Learn to use optocouplers in circuits that require high electrical isolation between input and output.

RAY M. MARSTON

OPTOCOUPLERS OR OPTOISOLATORS have applications in many situations where signals or data must pass between two circuits, but high electrical isolation must be maintained between those circuits. Optocoupling devices are useful in changing logic levels between the circuits, blocking noise transmission from one circuit to another, isolating logic levels from AC-line voltage, and eliminating ground loops.

DC level as well as signal information can be transmitted by an optocoupler while it maintains the high electrical isolation between input and output. Optocouplers can also replace relays and transformers in many digital interfaces. Moreover, the frequency response of optocouplers is excellent in analog circuits.

Optocoupler basics.

An optocoupler consists of an infrared-emitting LED (typically made from gallium arsenide) optically coupled to a silicon photodetector (phototransistor, photodiode or other photosensitive device) in an opaque light-shielding package. Figure 1 is a cutaway view of a popular single-channel, six-pin dual-in-line-(DIP) packaged optocoupler. The IR-emitting LED or IRED emits infrared radiation in the 900- to 940-nanometer region when forward biased current flows through it. The photodetector is an NPN phototransistor sensitive in the same 900- to 940-nanometer region. Both IRED and phototransistor are in chip or die form.

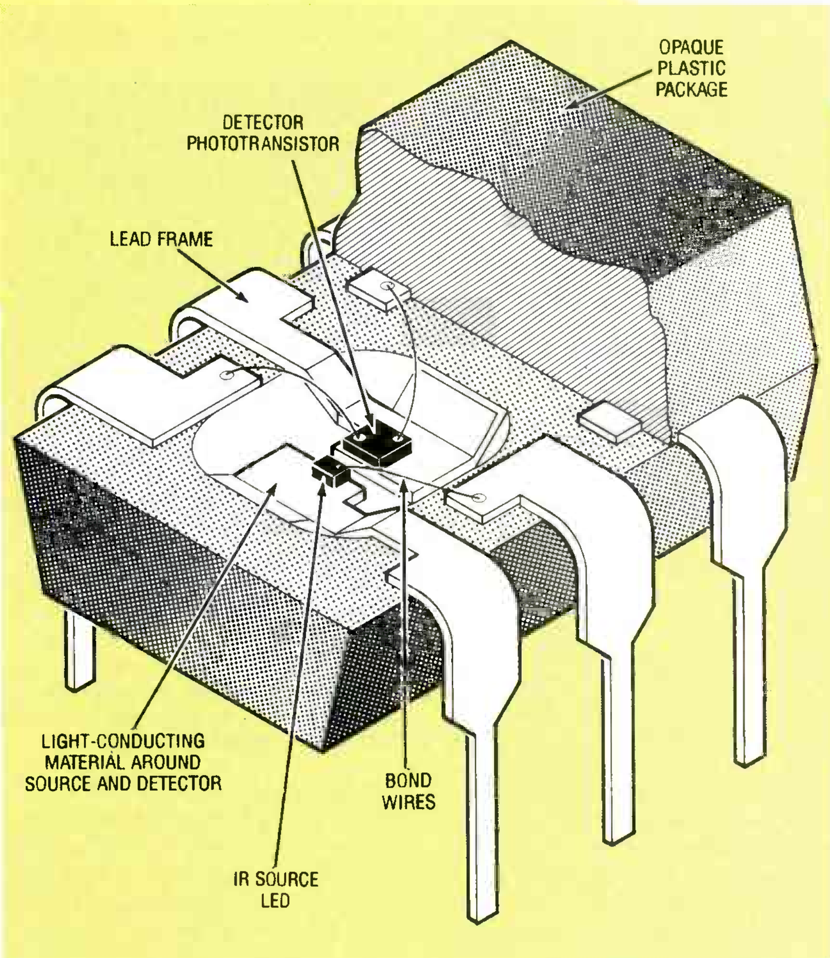


FIG. 1—CUTAWAY VIEW OF AN OPTOCOUPLER with a phototransistor output.

Most commercial optocouplers are made by mounting the IRED and phototransistor on adjacent arms of a leadframe, as shown. The leadframe is a stamping made from thin conductive sheet metal with many branch-like contours. The isolated substrates that support the device chips are formed from the inner branches, and the multiple pins of the DIP are formed from the outer branches.

After the wire bonds are made between the device dies and appropriate leadframe pins, the region around both devices is encapsulated in an IR-transparent resin that acts as a "light pipe" or optical waveguide between the devices. The assembly is then molded in opaque epoxy resin to form the DIP, and the leadframe pins are bent downward.

Figure 2 is a pin diagram of the most popular single-channel, 6-pin phototransistor optocoupler DIP. It is called an

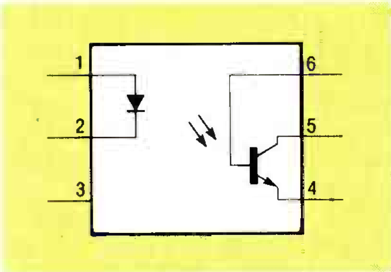


FIG. 2—TOP VIEW SCHEMATIC of a phototransistor-output optocoupler.

optocoupler because only infrared energy or photons couple the input IRED to the output phototransistor. The device is also an optoisolator because no electric current passes between the two chips; the emitter and detector are electrically insulated and isolated. These devices are also known as photocoupler or photon-coupled isolators.

The base terminal of the phototransistor is available at pin 6 on the six-pin DIP, but in normal ues it is left open-circuited. Also, no connection (NC) is made to pin 3. The phototransistor can be converted to a photodiode by shorting together base pin 6 and emitter pin 4. That option is not available in four-pin optocoupler DIP's and multi-channel optocouplers. There are, however, photodiode-output optocouplers optimized for the wider bandwidth and higher speeds needed in data communications, but they are far less efficient as couplers.

Large-volume producers of commercial optocouplers include Motorola, Sharp Electronics Corp., and Siemens Components, Inc. Optek Technology concentrates on optointerrupters and optoreflectors while Hewlett-Packard's optocouplers are focused on high-speed communications and special applications.

Optocoupler characteristics

One of the most important characteristics of the optocoupler is its light-coupling efficiency specified as current transfer ratio, CTR. That ratio is maximized by matching the IRED's IR emission spectrum closely with its detector/output device's detection spectrum. CTR is the ratio of output current to input current, at a specified bias, of an optocoupler. It is given as a percent:

$$CTR = (I_{CEO})/(I_F) \times 100\%$$

A CTR of 100% provides an output current of 1 milliampere for each milliampere of current to the IRED. Minimum values of CTR for a phototransistor-output optocoupler such as that shown in Figs. 1 and 2 can be expected to vary from 20 to 100 %. CTR depends on the input and output operating currents and on the phototransistor's supply voltage.

Figure 3 is a plot of phototransistor output current (I_{CB}) vs. input current (I_F) for a typical phototransistor optocoupler at a collector-to-base voltage (V_{CB}) of 10 volts.

Other important optocoupler specifications include:

- *Isolation voltage* (V_{ISO}). The maximum permissible AC voltage that can exist between the input and output circuits without destruction of the device. Those values typically range from 500 volts to 5 kilovolts RMS for a phototransistor-output coupler.
- V_{CE}. The maximum DC voltage permitted across the phototransistor output. Typical values for a phototransistor - output coupler range from 30 to 70 volts.
- I_F. The maximum continuous DC forward current permitted to flow in the IRED. Typical values for a phototransistor-output coupler range from 40 to 100 milliamperes.
- *Rise/fall time* for a phototransistor-output coupler is typically from 2 to 5 microseconds for both rise and fall. Those determine device bandwidth.

Industry-standards

A wide variety of optocouplers is produced by many manufacturers throughout the world. Some of the suppliers of commodity optocouplers include Motorola, Sharp Electronics, Toshiba, and Siemens. In addition to the industry standard six-pin DIP shown in Figs. 1 and 2, some transistor-output optocouplers are packaged in four-pin DIP's and surface-mount packages.

Multi-channel configurations of the popular optocouplers are also available with dual and quad emitter-detector pairs per package. Those optocouplers repeat the basic schematic of

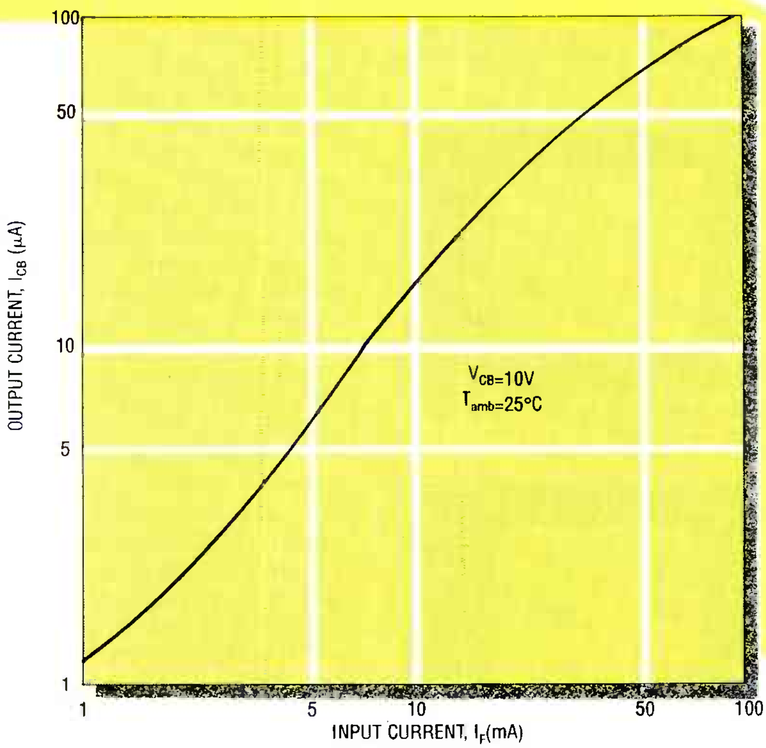


FIG. 3—TYPICAL OUTPUT CURRENT vs. input current for a phototransistor-output optocoupler with a V_{CB} of 10 volts.

Fig. 2 except that they lack external base pins. It is important to note, however, that certain electrical and thermal characteristics are derated in those packages because of the closer spacing of the semiconductor dies.

The lowest cost industry-standard phototransistor optocouplers with single channels have been designated by the JEDEC prefix "4N" and include the 4N25 to 4N28 and 4N35 to 4N37. However, many suppliers have developed their own proprietary parts with unusual features which are sold under their own designations. Popular phototransistor optocouplers are now available in small quantities for less than a dollar each.

Because optocouplers are used in AC-line powered circuits, they are subject to safety tests such as those of Underwriters Laboratories Inc. (UL) and Canadian Standards Assosiation (CSA). Most suppliers are offering UL-Recognized optocouplers and many make couplers that conform to the tighter Verband Deutsch Electrotechniker (VDE) specifications. Compliance with those specifications or the equivalent national specifications is a mandatory requirement for their use in Europe.

Figure 4 illustrates a simple optocoupler circuit. The conduction current of the phototransistor can be controlled by the forward bias current of the IRED although the two devices are separated. When S1 is open no current flows in the IRED so no infrared energy falls on the phototransistor, making it a virtual open-circuit with zero voltage developed across output resistor R2. When S1 is closed, current flows through the IRED and R1, and the resulting IR emission on the phototransistor causes it to conduct and generate an output voltage across R2.

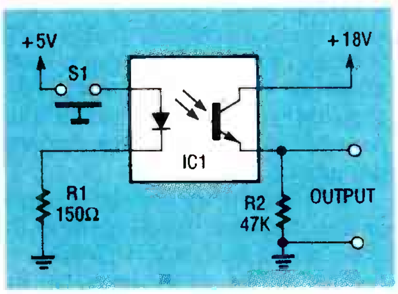


FIG. 4—CIRCUIT for phototransistor-output optocoupler.

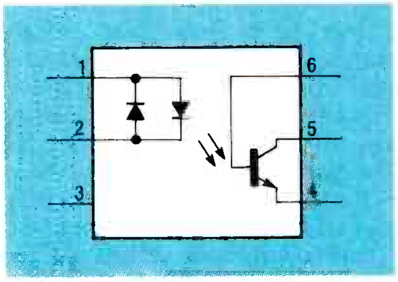


FIG. 5—AC INPUT PHOTOTRANSISTOR-output optocoupler schematic.

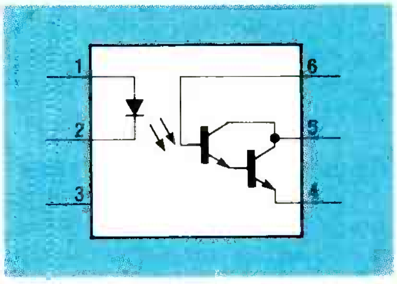


FIG. 6—PHOTODARLINGTON-OUTPUT optocoupler schematic.

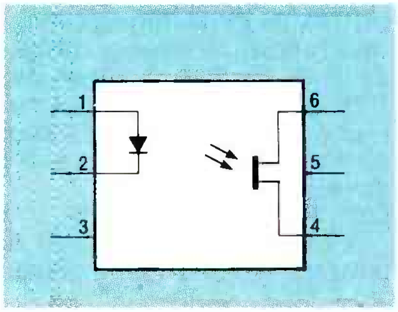


FIG. 7—BI-DIRECTIONAL LINEAR output optocoupler schematic showing MOSFET output.

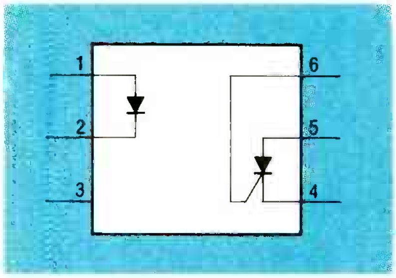


FIG. 8—PHOTOSCR-OUTPUT optocoupler schematic.

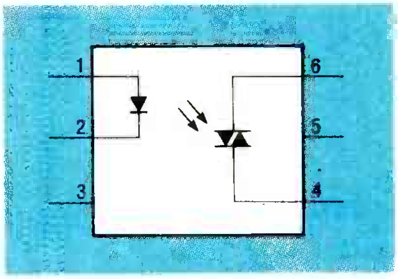


FIG. 9—PHOTOTRIAC-OUTPUT optocoupler schematic.

The simple optically-coupled circuit shown in Fig. 4 will respond only to on-off signals, but it can be modified to accept analog input signals and provide analog output signals as will be seen later. The phototransistor provides output gain.

The schematics of six other optocouplers with different combinations of IRED and output photodetector are presented as Figs. 5 thru 10. Figure 5 is a schematic for a bidirectional-input phototransistor-output optocoupler with two back-to-back gallium-arsenide IRED's for coupling AC signals or reverse polarity input protection. A typical minimum CTR for this device is 20%.

Figure 6 illustrates an optocoupler with a silicon photodarlington amplifier output. It provides a higher output current than that available from a phototransistor coupler. Because of their high current gain, Photodarlington couplers typically have minimum 500% CTR's at a collector-to-emitter voltage of 30 to 35 volts. This value is about ten times that of a phototransistor optocoupler.

However, there is a speed-output current tradeoff when using a photodarlington coupler. Effective bandwith is reduced by about a factor of ten. Industry standard versions of those devices include the 4N29 to 4N33 and 6N138 and 6N139. Dual- and quad-channel photodarlington couplers are also available.

The schematic of Fig. 7 illustrates a bi-directional linear-output optocoupler consisting of an IRED and a MOSFET. Those couplers typically have isolation voltages of 2500 volts RMS, breakdown voltages of 15 to 30 volts, and typical rise and fall times of 15 microseconds each.

Figure 8 is the schematic for one of two basic types of opto-thyristor-output optocouplers,

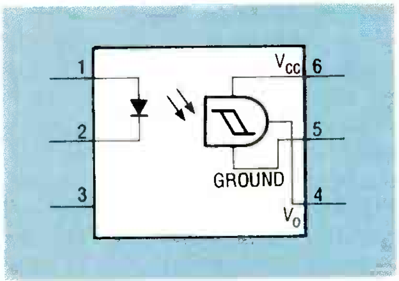


FIG. 10—SCHMITT-TRIGGER-OUTPUT optocoupler schematic.

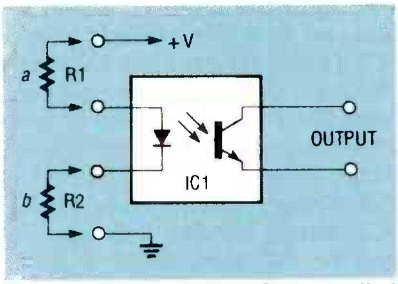


FIG. 11—SERIES RESISTOR must limit IRED current. It can be R1 at (a) or R2 at (b).

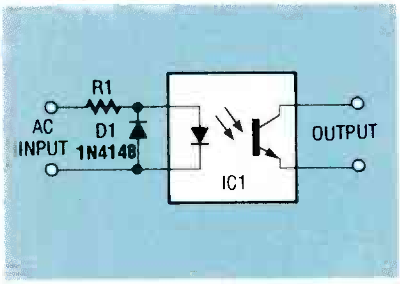


FIG. 12—IRED IS PROTECTED against reverse voltage with external diode D1.

one with an SCR output. OptoSCR couplers have typical isolation voltages of 1000 to 4000 volts RMS, minimum blocking voltages of 200 to 400 volts, and maximum turn-on currents (I_{FT}) of 10 milliamperes. The schematic in Fig. 9 illustrates a phototriac-output coupler. Thyristor-output couplers typically have forward blocking voltages (V_{DRM}) of 400 volts.

Schmitt-trigger outputs are available from optocouplers. Figure 10 is the schematic for an optocoupler that includes a Schmitt-trigger IC capable of producing a rectangular output from a sine-wave or pulsed input signal. The IC is a form of multivibrator circuit. Isolation voltages are from 2500 to 4000 volts, maximum, turn-on current is typically from 1 to 10 milliamperes, the minimum and maximum operating voltages are 3 to 26 volts, and the maximum data rate (NRZ) is 1 MHz.

Coupler applications

Optocouplers function in circuits the same way as discrete emitters and detectors. The input current to the optocoupler's IRED must be limited with a series-connected external resistor which can be connected in one of the two ways shown in Fig 10,

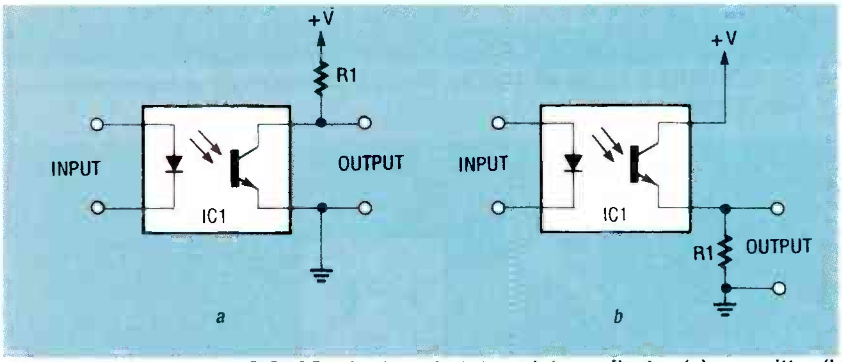


FIG. 13—EXTERNAL RESISTOR wired at phototransistor collector (a) or emitter (b).

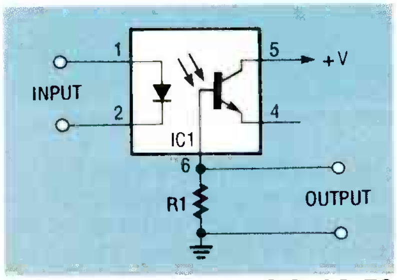


FIG. 14—PHOTOTRANSISTOR-TO-photodiode conversion with base pin connection.

either on the anode side *(a)* or cathode side *(b)* of the IRED.

Figure 5 showed an optocoupler optimized for AC operation, but a conventional phototransistor coupler can also be driven from an AC source with the addition of an external conventional diode as shown in Fig. 12. That circuit also provides protection for the IRED if there is a possibility that a reverse voltage could be applied accidentally across the IRED.

The operating current of the coupler's phototransistor can be converted to a voltage by placing an external resistor in series with the transistor's collector or emitter as shown in Fig. 13. The collector option is shown in *(a)* and the emitter option is shown in *(b)*. The sensitivity of the circuit will be directly proportional to the value of either of the series resistors.

A phototransistor-output optocoupler in a six-pin DIP can be converted to a photodiode-output optocoupler by using the base pin 6 as shown in Fig. 14 and ignoring the emitter pin 4 (or shorting it to the base). This connection results in a greatly increased input signal rise time, but it sharply reduces CTR to a value of about 0.2%.

Digital interfacing.

Optocouplers are ideally suited for interfacing digital signal circuits that are driven at different voltage levels. They can interface digital IC's within the same TTL, ECL or CMOS family, and they can interface digital IC's between those families. The devices can also interface the digital outputs of personal computers (or other mainframe computers, workstations and programmable controllers) to motors, relays, solenoids and lamps.

Figure 15 shows how to interface two TTL circuits. The optocoupler IRED and current-limiting resistor R1 are connected between the 5-volt positive supply bus and the output driving terminal of the TTL logic gate. This connection is made rather than between the TTL gate's output and ground because TTL outputs can sink fairly high current (typically 16 milliamperes). However, TTL outputs can only source a very low current (typically 400 microamperes).

The open-circuit output voltage of a TTL IC falls to less than 400 millivolts when in the logic 0 state, but it can rise to only 2.4 volts in the logic 1 state if the IC does not have a suitable inter-

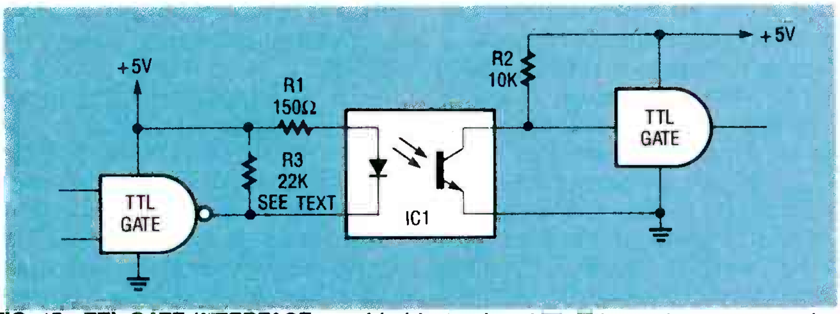


FIG. 15—TTL-GATE INTERFACE provided by a phototransistor, output optocoupler.

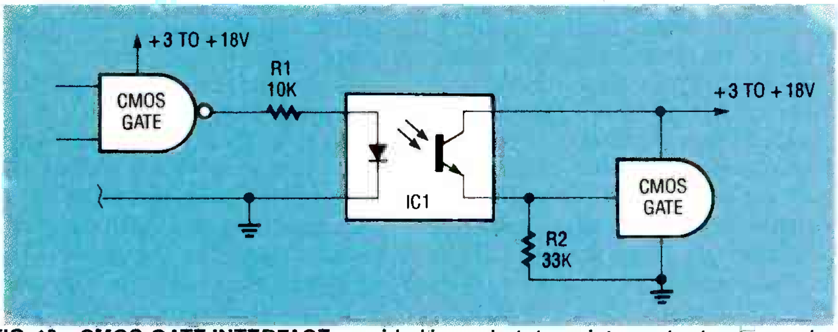


FIG. 16—CMOS-GATE INTERFACE provided by a phototransistor-output optocoupler.

nal pull-up resistor. In that case, the optocoupler's IRED current will not fall to zero when the TTL output is at logic 1. This drawback can be overcome with external pull-up resistor R3 shown in Fig. 15.

The optocoupler's phototransistor should be connected between the input and ground of the TTL IC as shown because a TTL input must be pulled down below 800 millivolts at 1.6 milliamperes to ensure correct logic 0 operation. Note that the circuit in Fig. 15 provides non-inverting optocoupling.

CMOS IC outputs can source or sink currents up to several milliamperes with equal ease. Consequently, these IC's can be interfaced with a sink configuration similar to that of Fig 15, or they can be in the source configuration shown in Fig. 16. In either case, R2 must be large enough to provide an output voltage swing that switches fully between the CMOS logic 0 and 1 states.

Figure 17 shows how a phototransistor-output optocoupler can interface a computer's digital output signal (5 volts, 5 milliamperes) to a 12-volt DC motor whose operating current is less than 1 amp. With the computer output high, the optocoupler IRED and phototransistor are both off, so the motor is turned on by Q1 and Q2. When the computer output goes low, the IRED and phototransistor are driven on, so Q1, Q2 and the motor are turned off. Note the 1-ampere current limitation.

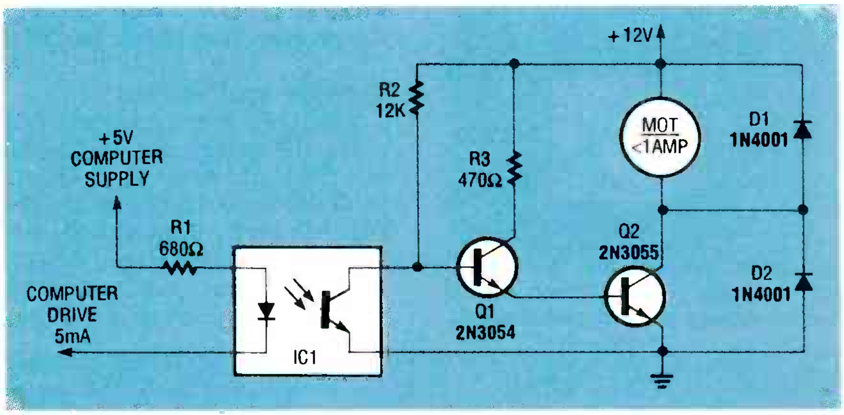


FIG. 17—COMPUTER TO DC-MOTOR INTERFACE provided by a phototransistor-output optocoupler.

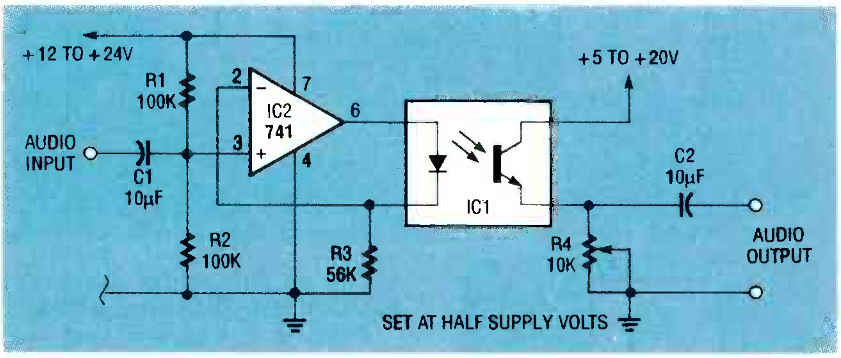


FIG. 18—AUDIO INTERFACE provided by a phototransistor-output optocoupler.

Analog interfacing

An optocoupler can interface analog signals from one circuit to another by setting up a "standing" current through its IRED and then modulating that current with the analog signal. Fig 18 shows this method applied to audio coupling. The operational amplifier IC2 is connected in a unity-gain voltage-follower mode. The optocoupler's IRED is wired into the op-amp's negative feedback loop so that the voltage across R3 (and thus the current through the IRED) precisely follows the voltage applied to non-inverting input pin 3 of the op-amp. This pin is DC biased at half-supply voltage with the R1-R2 voltage divider. The op-amp can be AC modulated with an audio signal applied at C1. The quiescent IRED current is set at 1 to 2 milliamperes with R3.

On the output side of the coupler a quiescent current is set up by its transistor. That current creates a voltage across potentiometer R4 which should have its value adjusted to give a

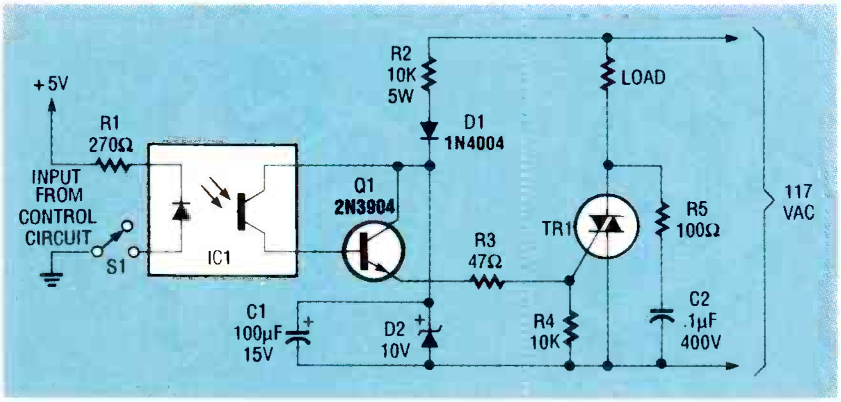


FIG. 19—**NON-SYNCHRONOUS TRIAC** power switch with optocoupled input.

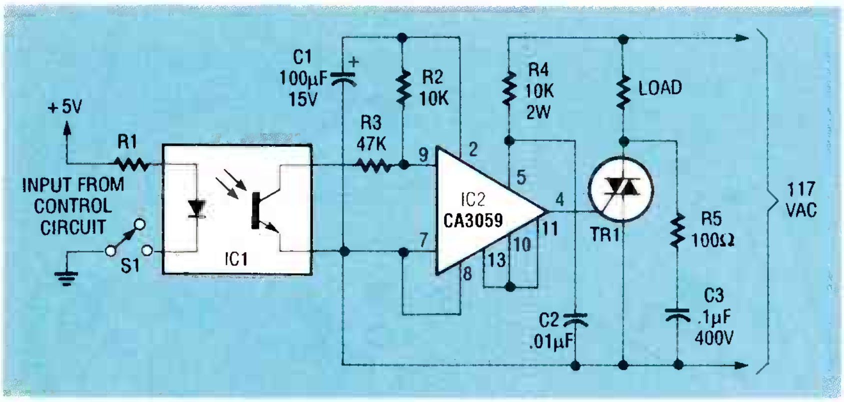


FIG. 20—**SYNCHRONOUS TRIAC** power switch with optocoupled input.

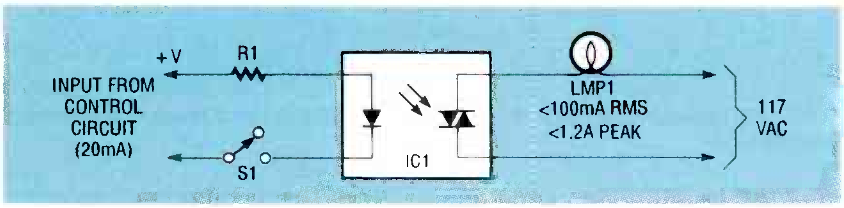


FIG. 21—**INCANDESCENT LAMP CONTROL** with a Triac-driver output optocoupler.

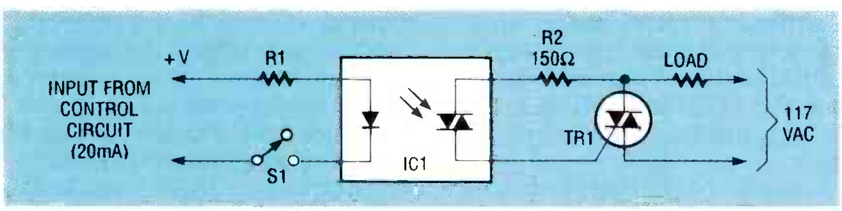


FIG. 22—**HIGH-POWER LOAD CONTROL** with Triac-driver output optocoupler.

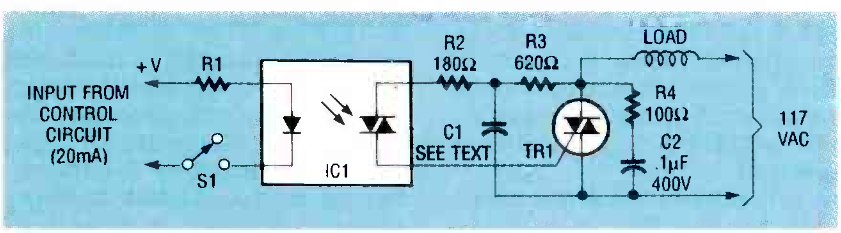


FIG. 23—**INDUCTIVE LOAD CONTROL** with Triac-driver output optocoupler and Triac slave.

quiescent output equal to half the supply voltage. The audio-output signal appears across potentiometer R4, and it is decoupled by C2.

Triac interfacing.

Interfacing the output of a low-voltage control circuit to the input of a Triac power-control circuit driven from the AC line is an ideal application for the optocoupler. (It is advisable that one side of its power supply be grounded.) That arrangement shown in Fig. 19 can control the power to lamps, heaters, motors and other loads.

Figures 20 and 21 show practical control circuits. The Triacs should be selected to match load requirements. The circuit in Fig. 19 provides non-synchronous switching in which the Triac's initial switch-on point is not synchronized to the 60-Hz voltage waveform. Here, R2, D1 Zener diode D2 and C1 develop a 10-volt DC supply from the AC line. This voltage can be fed to the Triac gate with Q1, which turns the Triac on or off. Thus, when S1 is open, the optocoupler is off, so zero base drive is applied to Q1 (keeping Triac and load off). When S1 is closed, the optocoupler drives Q1 on and connects the 10-volt DC supply to the Triac gate with R3, thus applying full line voltage to the load.

The circuit in Fig. 20 includes a silicon monolithic zero-voltage switch, the CA3059/CA3079, sourced by Motorola and Harris Semiconductor. That IC with a phototransistor-output optocoupler provides synchronous power switching. The gate current is applied to the Triac only when the instantaneous AC line voltage is within a few volts of the zero cross-over value. This synchronous switching method permits power loads to be switched on without generating sudden power surges (and consequent radio frequency interference (RFI) in the power lines). This scheme is used in many factory-made solid-state relay modules.

PhotoSCR's and PhotoTriacs

Both photoSCR and photo-Triac-output optocouplers have rather limited output-current ratings. However, in common with other semiconductor devices, their surge-current ratings are far greater than their RMS values. In the case of the SCR, the surge current rating is 5 amps, but this applies to a 100 microsecond pulse width and a duty cycle of less than 1%. In the case of the Triac, the surge rating is 1.2 amps, and this applies to a 10 microsecond pulse width and a maximum duty cycle of 10%.

The input IRED of optocoupled SCR's and Triac's is driven the same way as in a phototransistor-output optocoupler, and the photoSCR and photoTriac perform the same way as their conventional counterparts with limited current-handling capacity. Figures 21, 22, and 23 illustrate practical applications for the photoTriac-output optocoupler. In all circuits R1 should be selected to permit an IRED forward current of at least 20 milliamperes.

In Fig. 21, the photoTriac directly activates an AC-line-powered incandescent lamp, which should have an RMS rating of less than 100 milliamperes and a peak inrush current rating of less than 1.2 amps to work in this circuit.

Figure 22 shows how the photoTriac optocoupler can trigger a slave Triac, thereby activating a load of any desired power rating. This circuit is only suitable for use with non-inductive (i.e.resistive loads) such as incandescent lamps and heating elements.

Finally, Fig. 23 shows how the circuit in Fig. 22 can be modified for inductive loads such as motors. The network made up of R2, C1, and R3 shifts the phase to the Triac gate-drive network to ensure correct Triac triggering action. Resistor R4 and C2 form a snubber network to suppress surge effects.

Figures 24 and 25 show two other variations on the optocoupler theme. A slotted coupler-interrupter module is shown in Fig. 23-a. The slot is an air gap between the IRED and the phototransistor. Infrared energy passes across the unobstructed slot without significant attenuation when the interrupter is "on". Optocoupling can, however, be completely blocked by opaque objects such spokes of a wheel or unpunched tape moving across the slot.

A typical slot width is about 3 mm (0.12 inch) wide, and the module has a phototransistor output that gives an "open" minimum CTR of about 10%. The schematic for this device is similar to that of Figure 2 except that the IRED and photodetector are enclosed in separate boxes.

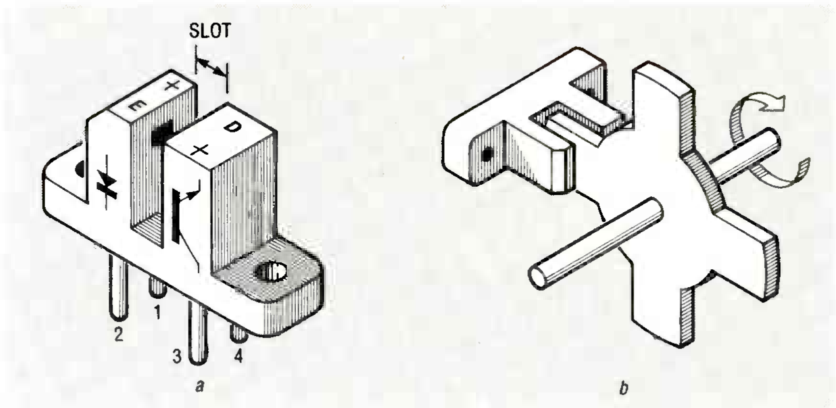


FIG. 24—OPTICALLY-COUPLED INTERRUPTER MODULE (a) and speed-counting application (b).

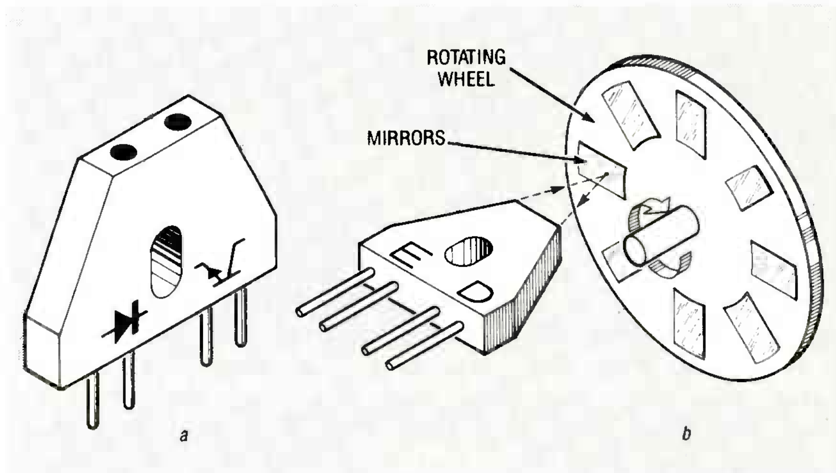


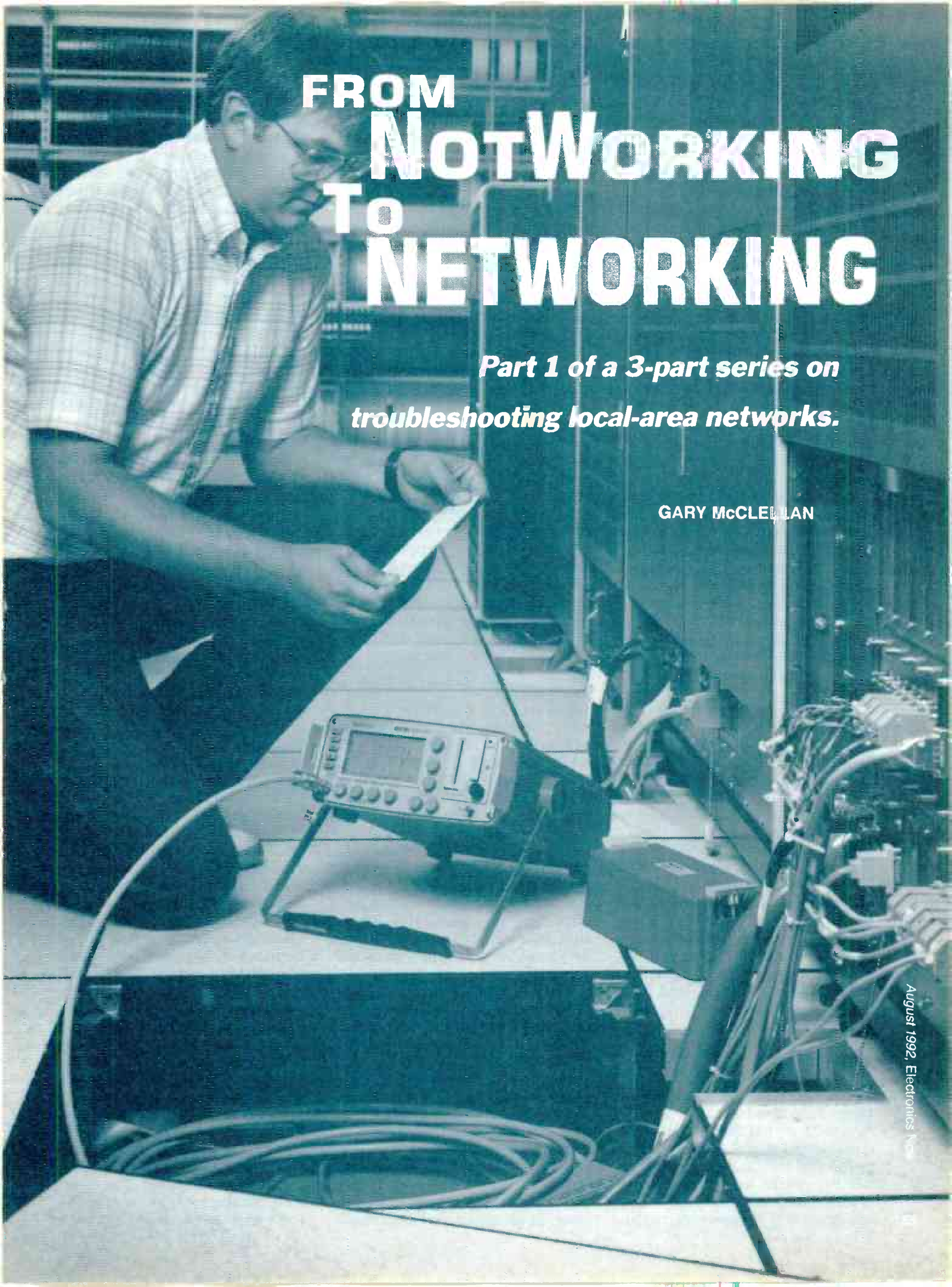
FIG. 25—OPTICALLY-COUPLED REFLECTOR MODULE (a) and revolution counting application (b).

Figure 24-b illustrates a method for counting revolutions with the interrupter. Each time a tab on the wheel blocks the optical path, a count is made. Other interrupter uses include end-of-tape detection, limit switching, and liquid-level detection.

A reflective optocoupler module is shown in Fig. 25-a. Direct infrared emission from the IRED is blocked from the phototransistor by a wall within the module, but both IRED and phototransistor face a common focal point 5 mm (0.2-inch) away. Interrupters are used to detect the presence of moving objects that cannot be easily passed through a thin slot. In a typical application, a reflector module can count the passage of large objects on a conveyor belt or sliding down a feed tube.

Figure 25-b illustrates a revolution counter based on reflecting IR from the IRED back to the phototransistor with reflectors mounted on the face of a spinning disk. The module-disk separation is equal to the 5-mm focal length of the emitter-detector pair. The reflective surfaces can be metallic paint or tape. Other applications for the reflective module include tape-position detection, engine-shaft revolution counting, and engine-shaft speed detection.

Photointerrupters and photoreflectors are also available with photodarlington, photoSCR, and photoTriac ouput stages. R-E



FROM NOTWORKING TO NETWORKING

Part 1 of a 3-part series on troubleshooting local-area networks.

GARY McCLELLAN

NETWORKING IS PERVASIVE. FROM two-PC home offices to corporations with literally thousands of computers, people want to connect. People want to share data and peripherals (laser printers and large hard disks). People want efficient ways to set up, configure, and maintain software. People want to send messages to individuals and groups. People want to tap into corporate databases and outside sources.

If your daily work involves computers, chances are good that you are using and maintaining a Local Area Network (LAN). Even if you're not now, chances are you will be soon, as more and more companies discover the benefits a LAN has to offer.

In this first of a three-part series we provide background on LAN basics and important terminology. In Part II, we will discuss tools and test equipment, along with useful troubleshooting techniques. Last, in Part III, we'll discuss several case histories, including discussions of actual LAN faults, how they were located, and how they were repaired.

There are many career opportunities in LAN's; this series will give you a good taste for the service side of the business. You should know that industry experts predict that new LAN installations will peak in 1994, with lots of service opportunities following. LAN use is spreading from Fortune 100 companies into legal and medical clinics, and many other kinds of small businesses. This means that there will be plenty of work for people who can install and maintain computers, software, peripherals, and LAN cabling. So keep reading, and get in on the action!

LAN origins

In the early 1970's, some smart people at Xerox Corporation's Palo Alto Research Center (PARC) realized that the *centralized* model of computing in force at the time was unsuitable for some tasks and some users. The centralized model includes a big, expensive mainframe servicing several "dumb" terminals, which were little more than TV's with built-in alphanumeric character generators. Instead, the revolutionaries at PARC developed a *distributed* model in which each local machine contained a fair amount of intelligence of its own. The problem was that each local machine was isolated from the others. Thus, in going from a centralized to a distributed model, something was lost: the ability to share data. Hence the PARC folks (primarily Bob Metcalfe, founder of networking pioneer 3Com, now an editor at InfoWorld magazine), had to invent a new form of communication, and that's how the Xerox Network System (XNS) came into existence. XNS was a precursor to Ethernet.

In the ensuing twenty or so years, Ethernet has evolved and several new network technologies have become popular. The remainder of this article outlines these technologies. For more detailed information, see the books, magazines, and catalogs listed in the sidebar.

Basic terms

Networking involves four basic concepts: cable type, topology, access method, and signal type. It's important to understand that each of those is independent of the others. Most protocols can run on different kinds of cables in several topologies. For example, Ethernet can run on coaxial cable, telephone wire, or fiberoptic cables, in both bus and star topologies. However, this does not mean that one can run any protocol on any cable across any network topology.

Topology LAN's come in three basic topologies: bus, star, and ring, as shown in Fig. 1. In a bus topology (*a*), all machines (or nodes) are connected in parallel through a common cable. In a star topology (*b*), a separate cable connects each machine to a common device called a hub or concentrator. In a ring topology (*c*), Media Access Units (MAU's) connect and disconnect particular devices from the main ring, at all times maintaining a continuous electrical loop.

Bus and ring systems use less cable, so they can be cheaper to install. A star configuration uses more cable, but offers higher reliability, because a broken connection to a given node cannot bring down the entire network. Cable for modern ring-based topologies is often laid in a star configuration using shut-out relays or special connectors that help ensure integrity of the network if a station on it develops trouble.

Cable: LAN cabling systems today include thin and thick coax, shielded and unshielded twisted pair, and fiberoptic. Thick coax offers high reliability and bandwidth, but is expensive and awkward to install. Thin coax is easier to install and less expensive, but has limited distance and number of workstations.

The ability to run network protocols on unshielded twisted-pair (UTP) wiring was developed to take advantage of existing telephone wiring. However, due to lack of shielding, existing telephone wire is often unreliable, so shielded twisted-pair (STP) wiring is often installed in new buildings, and it is increasingly used in retrofitting existing sites.

Most existing LAN installations use some form of copper cable, but fiberoptic cable prices have dropped in recent years, making fiber an increasingly attractive option. Compared with copper, fiber offers much higher bandwidth, total immunity to EMI, and total immunity to "snooping" or "eavesdropping." Fiber is most often used to interconnect networks in separate buildings, cities, and even countries.

Signal Type: There are two basic signal types: broadband and baseband. A baseband scheme allows only a single communications signal on a cable at one time. A broadband scheme allows several. For example, a broadband cable might simultaneously carry network, video, and voice signals.

Access Method: There are two basic access methods: token passing and Carrier

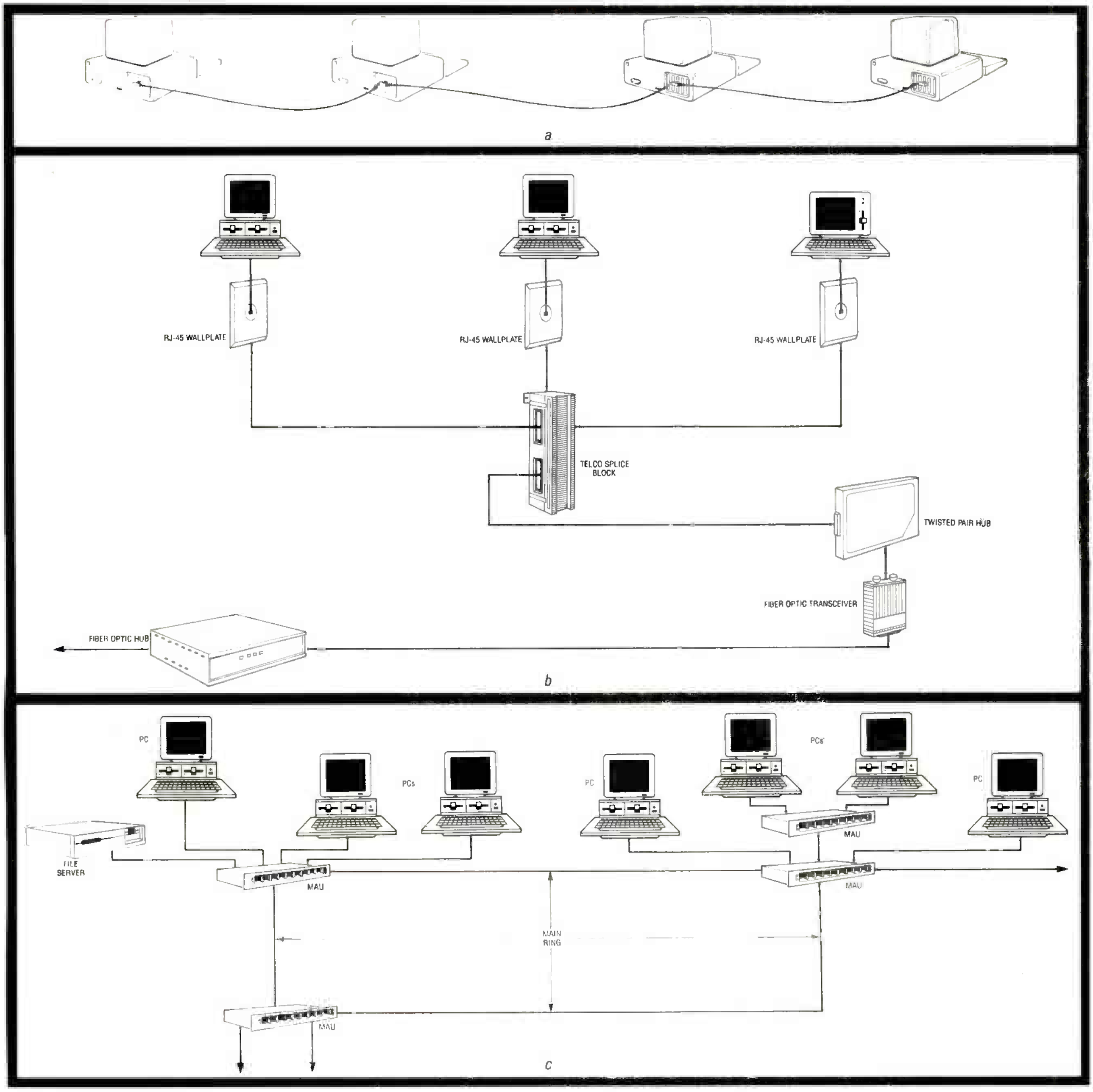


FIG. 1—BASIC NETWORK TOPOLOGIES: bus (*a*), star (*b*), and ring (*c*). Bus nets typically offer lower cost and simpler installation; star and ring offer increased reliability and flexibility at higher cost.

Sense Multiple Access/Collision Detection (CSMA/CD), both of which deal with how various devices on the wire communicate. One way to understand token passing is to think of a railroad train with an engine, several boxcars, and a caboose (the token). As the train moves from station to station through the network, "cars" are added to and removed from it. Adding and removing cars can not happen at random, but only when the train is at a station. One story has it that the idea of token passing dates from the late 1800's. It seems there were two trains that hauled cargo over a bridge and back again. Unfortunately, there was only one set of tracks, so the trains would collide if they tried to use the bridge at the same time. Someone developed the idea of placing large hooks at each end of the bridge. When one train wanted to cross, a large, round metal disk (the token) was removed from the hook and it crossed the bridge. Upon reaching the other side, the train placed the token on the second hook and continued on its way. When the other train came along, it picked up the token, crossed the bridge, replaced the token on the first hook, and departed. The point is that trains were forbidden to cross the bridge without the token.

In a CSMA/CD system, any machine can begin transmission at any time (assuming no other machine is already "talking"). However, there is a probability that several machines can begin speaking at the same time, in which case there is a collision. In that event, each machine waits a random amount of time and attempts to begin transmission again.

The relative merits of *deterministic* (token-passing) vs. *probabilistic* (CSMA/CD) schemes have fueled many spirited debates in the network community. However, few would dispute that small installations without constant high-volume traffic perform similarly using either token passing or CSMA, or that very busy networks function better with token-passing than CSMA/CD.

Access methods are typically implemented on a network interface card that plugs into a personal computer or workstation. The card gathers signals from the wire, converts them to digital format, then decodes them. Higher-level software then takes over to perform error detection and gradually add more useful information to the message. The end result is that an analog signal on a wire is converted to a format that can be understood by a computer's operating system and the applications that run on it.

The OSI stack

Due to the proliferation of incompatible network communications protocols in the 1970's and 1980's, the International Standards Organization (ISO) defined the well-known Open Systems Interconnect (OSI) reference model. The OSI model defines a seven-layer "stack" of software modules that provides a clean way of interconnecting different kinds of computers. Details of the model are beyond the scope of this article, but Fig. 2 shows its essential features.

The seven layers consist of two main groups of services: transportation services concerned with the reliable transfer of information, and interworking services concerned with the structure and meaning of that information.

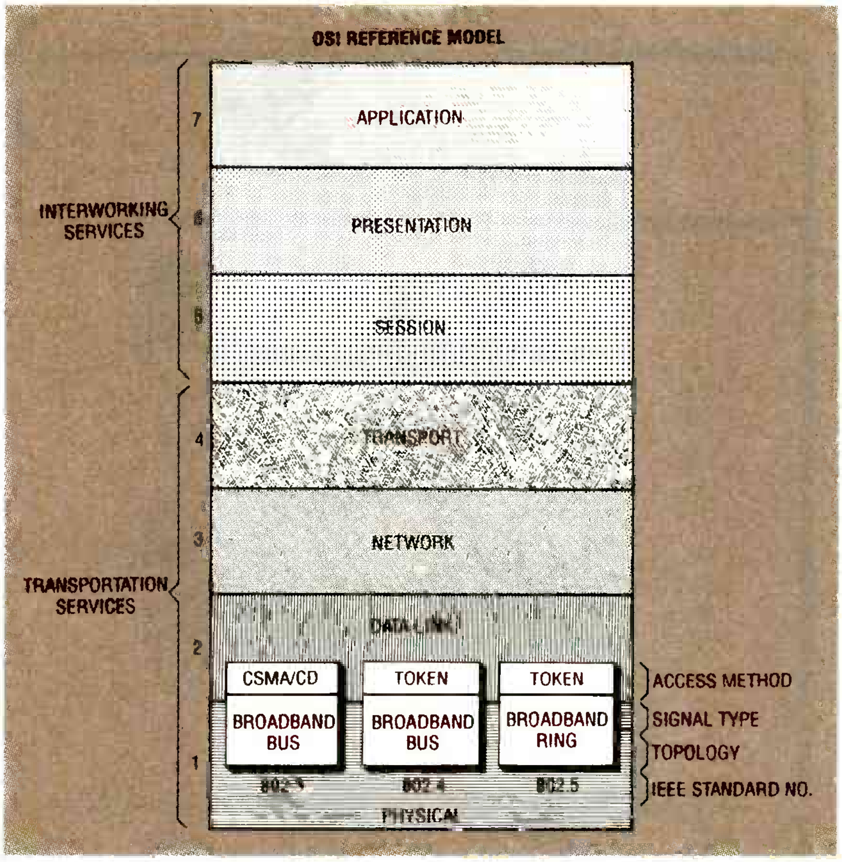


FIG. 2—THE OSI STACK is an internationally accepted seven-layer reference model that defines a set of options for implementing network communications. Layers 1 and 2 were hotly contended at first, but focus is now shifting to higher level issues.

The reason for using layers is to isolate and allow independent implementation of each layer. Any two layers separated by at least one intervening layer need know nothing about how physical communications are performed. When two OSI-compliant machines are communicating, corresponding layers on the two machines perform the communications (e.g., layer four talks to layer four).

Application software (e.g., E-mail) resides in layer seven. Protocols like NetBIOS and Novell's IPX occupy layers two through six. One widely held misconception is that layer one, the physical layer, refers to cables, connectors, and interface cards. In spite of its name, layer one refers to a stream of bits and how they move on a cable, not to the paraphernalia itself.

In this series of articles, we are most interested in the bottom two layers, which provide internationally recognized standards for the access methods we've been discussing. Note that 802.3 is the official standard corresponding to Ethernet, and 802.5 is the official standard corresponding to Token Ring. The remaining protocol, 802.4, puts a token-based protocol on a broadband bus. General Motors at one time tried to make 802.4 a broadly accepted standard for manufacturing, but 802.4 provided little performance advantage at substantially greater cost than the other protocols, which generally turned out to be good enough.

What does all that mean in terms of real-world products? The layered approach allows various high-level software packages to run regardless of the low-level protocol. So, for example, you can run most major network operating systems (e.g., Novell's NetWare or Microsoft's LAN Manager) on Token Ring or Ethernet.

Ethernet is a particular implementation of a CSMA/CD access method. Ethernet can (and does) run on thick coax, thin coax, twisted pair, and fiber, all of which can be implemented in bus and star topologies. You might also have heard of IBM's Token Ring. It too can run on various types of cables (twisted pair and fiber) and topologies (bus and ring).

Connecting networks

A group of connected computers—a network—must all use the same low-level protocol. But it is also possible to connect several groups of computers together by means of special devices (presented in increasing order of internal intelligence, circuit complexity, and cost): repeaters, bridges, routers, brouters (combination bridge and router), and gateways. Figure 3 shows the OSI level at which each functions.

Repeaters and bridges are fairly dumb, inexpensive devices. A repeater is little more than an amplifier that allows cable-length and number-of-station limitations to be overcome. Repeaters work at OSI level two.

A bridge works at OSI level three to connect networks that use different access protocols, or different high-level protocols. For example, you would use a bridge to connect a NetWare segment running Ethernet to another NetWare segment running Token Ring. Bridges typically contain intelligent filters that only pass network traffic from one segment to the other if it really needs to pass. Modern bridges can even convert high-level protocols such as NetWare, TCP/IP, and OSI.

A router contains even more intelligence, and it works at OSI level four to help route network data in the most efficient way possible. A brouter functions as a combined bridge and router.

A gateway allows connection between totally dissimilar systems (e.g., a PC running NetWare to a mainframe). A gateway functions at OSI layer seven.

Net types

Now let's look at some of the practicalities of common networks. We'll discuss the basic issues (cable, topology, access, signal) for Ethernet, Token Ring, and ARCnet.

Ethernet: Ethernet (and IEEE 802.3) uses a CSMA/CD access method that runs at 10 megabits per second (Mbps). Ethernet can run on two types of coax. With thick Ethernet (10Base5), a thick backbone cable runs through a plant or office. The backbone is typically a yellow-jacketed coaxial cable about one-half inch in diameter. Attached to each end of the backbone is a 50-ohm terminating resistor. Typically you will find backbone cable installed on the wall of the building located between the ceiling panels and the roof.

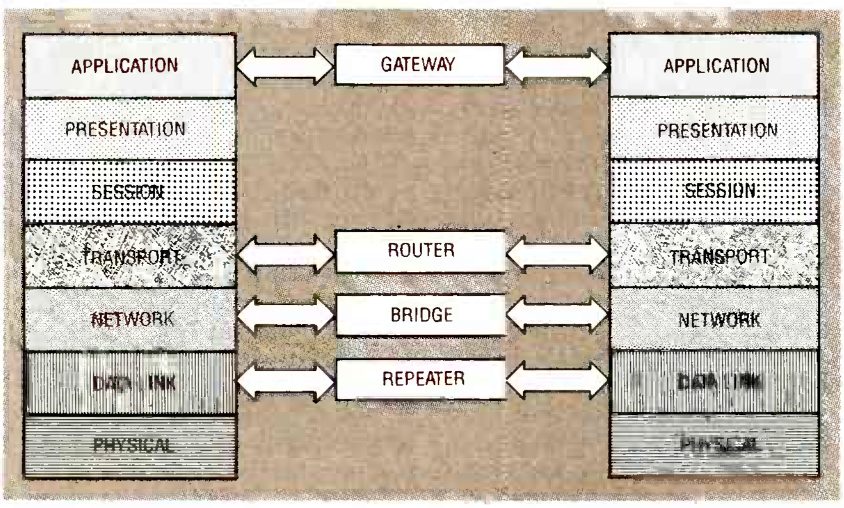


FIG. 3—REPEATERS, bridges, routers, and gateways work at progressively higher levels of the OSI stack.

Every 8.2 feet a transceiver can tap into the backbone, and from the transceiver a cable drops down to an attached workstation, file server, PC, or other device. Most thick Ethernet LAN's use RG-58 coax with BNC connectors as drop cables. However, there is a growing tendency to use twisted-pair cable with RJ-45 modular connectors in more recent Ethernet installations.

The maximum length of a thick Ethernet segment is 1640 feet; the maximum number of transceivers per segment is 100. To extend that maximum distance or add units, a repeater must be used.

Thin Ethernet (sometimes called Cheapernet) uses RG-58 coax (10Base2) that snakes directly from machine to machine using T connectors. In this setup, the transceiver mounts directly on the network interface card in the PC or other device. The maximum length of a thin Ethernet segment is 607 feet, with a maximum of 30 devices per segment.

Ethernet also runs on unshielded twisted pair (10BaseT) in a star topology. The maximum length of any segment from hub to workstation is 328 feet. 10BaseT is growing in popularity due for the most part to its low cost and easy configuration with modular telephone-style connectors.

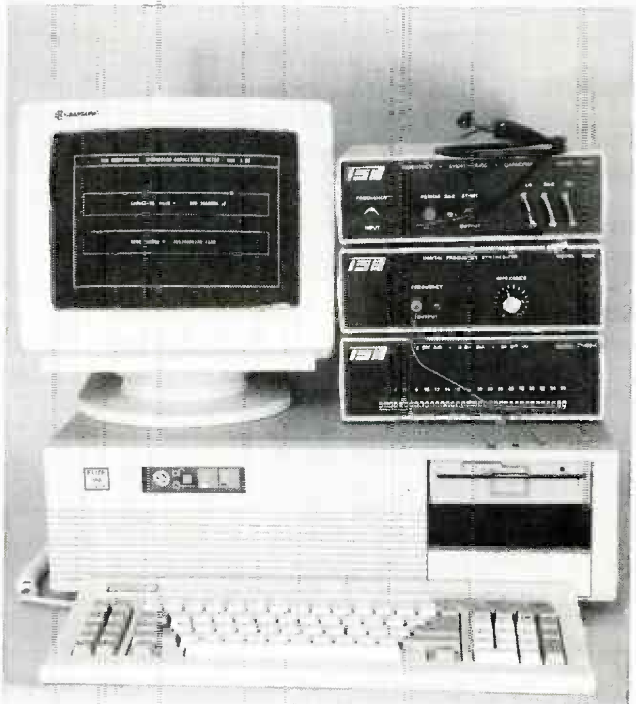
Last, Ethernet runs on fiber cables, including 50-, 62.5-, and 100-micron duplex and plenum duplex cables. Currently (unless cost is no object), fiber is used mostly to link individual networks separated by some distance.

Token Ring: Token Ring (IEEE 802.5) uses a token-passing protocol, and runs at 4 or 16 Mbps. A given network (or subnet) runs at either 4 or 16 Mbps, but it is possible to bridge Token Ring nets running at different speeds.

Token-ring topology is somewhat more complicated than the name might suggest, as shown back in Fig. 1. Note that the ring really consists of a ring of Media Access Units (MAU's),

Continued on page 66

PC-BASED TEST BENCH



The T1003 has 24-bit digital I/O, 8 channels of 8- or 12-bit A/D conversion, and a single 8-bit D/A conversion.

STEVE WOLFE

IN THE EARLY EIGHTIES there was no easy way for personal computers and control circuitry to interact with each other. The interfaces that were available were cumbersome and expensive. Today, however, real-world interfaces like our T1003 let your PC receive and send both analog and digital signals. The T1003 is capable of 24-bit digital I/O, eight channels of 8- or 12-bit analog-to-digital conversion, and a single 8-bit digital-to-analog conversion.

The T1003 comes with easy-to-use software that allows you to quickly configure every aspect of the unit. As an example of what the T1003 can be used for, the software includes a storage-oscilloscope program that lets you monitor eight low-frequency voltages graphically and save the results to disk.

24-bit I/O port

Look at the block diagram in Fig. 1. The I/O section is composed of one IC (an 8255 programmable peripheral interface, or PPI). The IC is configurable as three 8-bit ports or two 8-bit ports and two 4-bit ports. Additionally, each port can be configured for either input or output using the software included with the T1003.

The output DAC (D to A Converter) section consists of a data latch, a DAC IC (a DAC0800 or DAC08), and an operational amplifier. Any byte sent to the DAC section will be output as a voltage between 0 and 5 volts at pin 33 of the terminal block (TB1-33).

The A/D section uses three analog signals: $V_{REF/2}$, V_{IN-}, and V_{IN+}. $V_{REF/2}$ is used as a reference voltage by the A/D converter. From that voltage the A/D establishes full scale. If $V_{REF/2}$ is 2.500 volts, full scale is 5.000 volts. If the byte read back from the A/D converter is 128 (10000000), the voltage being measured at V_{IN+} is 2.500. This assumes that V_{IN-} is set to 0 volts. V_{IN-} is similar to the ground lead of a voltmeter. It is grounded during operation. The A/D converter measures the difference between V_{IN+} and V_{IN-}. The analog multiplexer section is software addressable. Address values of 0 through 7 cause channels 1 through 8, respectively, to be connected to the A/D converters V_{IN+} pin.

The A/D converter used in the T1003 (an ADC0803) is an 8-bit device. A 5-volt 8-bit device is typically capable of approximately 20-millivolt resolution steps. To achieve 1-millivolt resolution (greater than 12 bits), the reference multiplexer is set to pass 2.5 volts to the $V_{REF/2}$ pin. The reference DAC which is connected to V_{IN-} is set to 0 volts. The analog multiplexer is set to connect one of its 8 channels to V_{IN+}. The A/D converter is sent a start conversion pulse and, after 100 microseconds (conversion time), it is ready to return the value measured. The value measured is then read back into the software.

The reference multiplexer is now re-addressed to pass 128 millivolts to the A/D converter's $V_{REF/2}$ pin, so full-scale is set to 256 millivolts. Since our A/D converter has a total of 256 counts (0–255), the T1003 is now set to a resolution of 1 millivolt per count. However, we are not yet home free. If we are measuring 3 volts, then we are, in essence, measuring 3000 millivolts. If V_{IN-} is still set to 0 volts, then we will overrun our A/D's capability by 2745 millivolts. That would yield a reading of 255 which, in this case, would mean overrange. Instead, we will set the reference DAC section two counts (40 millivolts) below what we measured using the 20 millivolt mode.

The V_{IN-} is now 20 to 60 millivolts below the actual voltage being measured. While in the 1-millivolt mode we are able to resolve 255 millivolts in 1-millivolt steps. The A/D converter is again told to start conversion. The resultant reading is the number of millivolts to be added to the voltage we are producing at the reference DAC (V_{IN-}). First, we did a 20-millivolt conversion to determine a rough value of the voltage being measured. Next, we adjusted V_{IN-} to a value just below the measured voltage and did a 1-millivolt conversion. V_{IN-} plus the 1-millivolt result equals the 1-millivolt resolution final value.

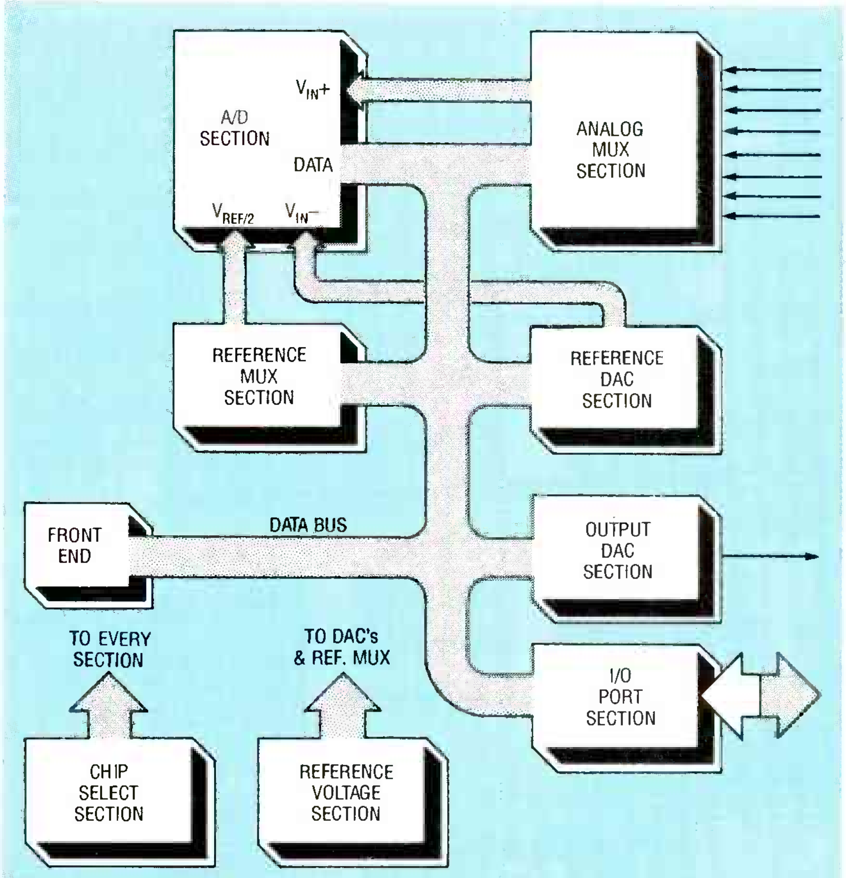


FIG. 1—T1003 BLOCK DIAGRAM. The I/O section contains an 8255 programmable peripheral interface (PPI), which is configurable as three 8-bit ports or two 8-bit ports and two 4-bit ports. Each port can be configured for either input or output.

is the LSB of the address lines. The chip-select section is made up of IC1–IC5 and IC19. (IC1–IC4 are 74HCT138's; whenever G2A and G2B are low and G1 is high, one of eight outputs will go low, depending on the address present at the A, B, and C inputs.) Chip IC1 is active when BEN is high and $\overline{\text{SEND}}$ is low. If IC1 is inactive then IC2–IC4 are also inactive.

If IC1 is active and the address value is less than 8, then IC1 pin 15 activates IC2. If the address in use is between 0 and 3 then IC19 activates IC6 (the 8255). Therefore, IC6 is active during writes and reads in the address range of BAS+0 to BAS+3. If the address is BAS + 4, then the CHIP SELECT line of the A/D converter is activated, allowing it to respond to read or write pulses. If IC1 is active and the address is between 8 and 15, then IC1 pin 14 becomes active. If the function is read, and the address is 8, IC3 pin 15 becomes active causing IC10 to move its latched data to the data bus.

Chip IC10 holds seven hardwired bits that are used to determine whether the T1003 is at-

Detailed operation

As was the case with the previous I1000 peripherals, we'll continue using BASIC language. 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 + 31,3

768 (hex 300) is the factory-preset base address of the I1000. As noted earlier, the address is DIP-switch selectable. Next, we have an OUT to BAS + 31. As you might recall that address is reserved for peripheral selection. The T1003 has a unit or peripheral address of "3." Consequently, if I send an OUT to BAS + 31 with a data byte of "3," the T1003 will be readied for full I/O operation.

Look at the schematic in Fig. 2. Address lines A5 through A9 are used by the I1000 only, and A0 through A4 (32 bytes) are used by the peripherals to address their IC's. Address line A0

T1003 PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted
R1—2200 ohms
R2, R4—10,000 ohms
R3—33 ohms
R5—not used
R6, R10—2320 ohms, 1%
R7, R11, R16—1000 ohms
R8, R12—5110 ohms, 1%
R9, R13—2050 ohms
R14—1100 ohms
R15—240 ohms
R17—10,000 ohms, multiturn potentiometer
R18—1000 ohms, multiturn potentiometer
R19, R20—500 ohms, multiturn potentiometer
R21—5000 ohms, potentiometer
Capacitors
C1, C2, C5, C17, C24, C25, C31, C32, C35, C36, C45–C49—not used
C3, C4, C10, C12–C15, C19—0.15 µF, ceramic
C6, C11, C38, C41, C43—100 µF, 25 volts, electrolytic
C7–C9, C16, C18, C20–C22, C28, C29, C39, C40, C42, C44, C50, C51—10 µF, 35 volts, electrolytic
C23, C26, C33, C37, C52, C53—2.2 µF, 50 volts, electrolytic
C27—150 pF, mica
C30, C34—36 pF, mica
Semiconductors
IC1–IC4—74HCT138 3-to-8 line demultiplexer
IC5—74HCT540 octal inverting buffer
IC6—8255A programmable peripheral interface
IC7–IC9—TL082 dual JFET-input op-amp
IC10, IC12, IC15, IC17—74HCT573 octal D-type latch
IC11—ADC0803 8-bit A/D converter
IC13, IC14—74HCT4051 8-channel multiplexer
IC16, IC18—DAC0800 D/A converter
IC19—74HCT20 dual 4-input NAND gate
IC20—LM336-2.5 reference diode
IC21—LM317T adjustable voltage regulator
IC22—LM340K-5.0 voltage regulator
IC23—LM7905T negative 5-volt regulator
D1—1N4002 diode
Other components
TB1—two 18-position terminal blocks
TP1–TP4, TP6—PC-mount test point
TP5—not used
Miscellaneous: IC sockets, TO3-type heatsink, instrument case, wire, solder, etc.

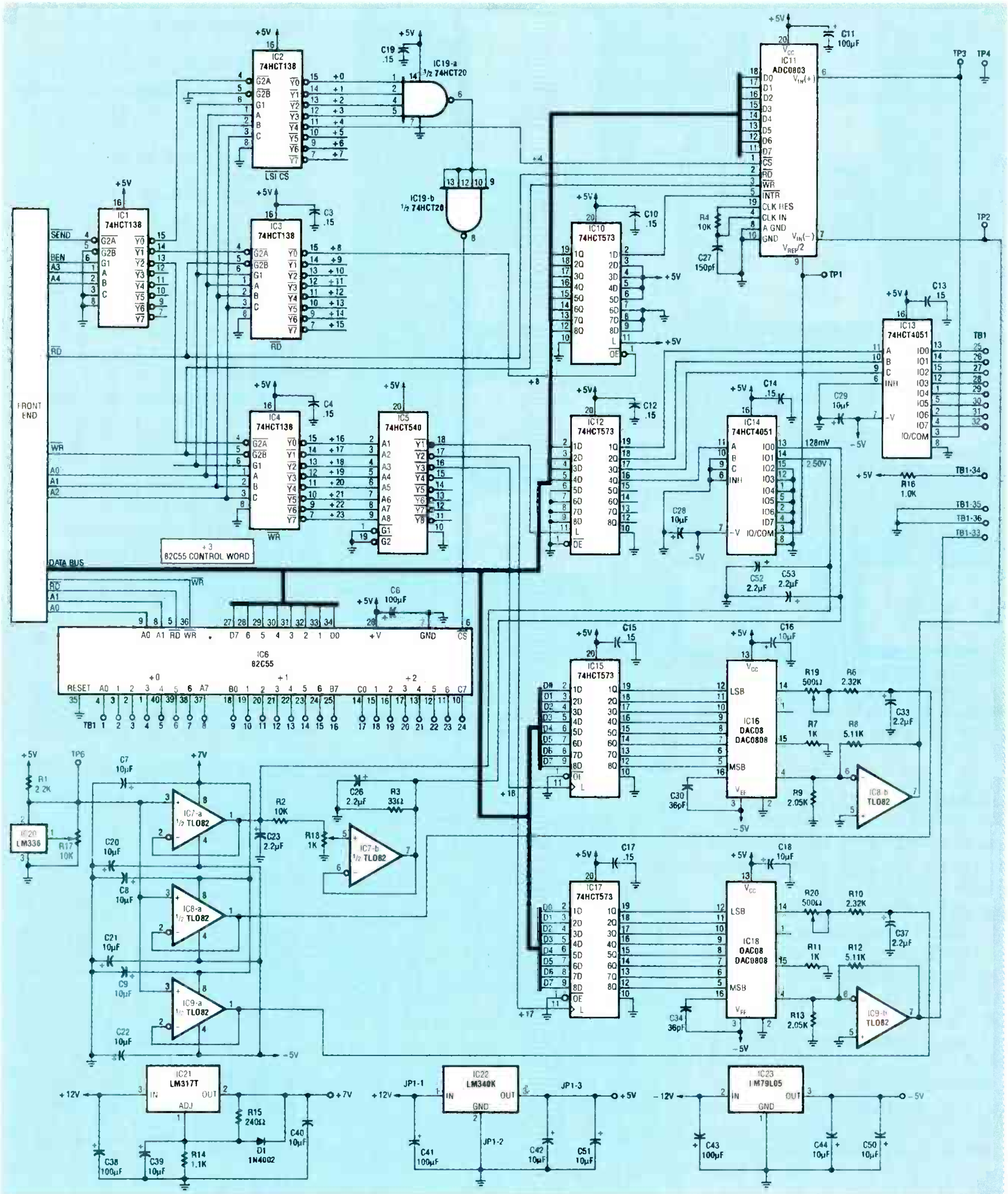


FIG. 2—T1003 SCHEMATIC. The chip-select section is made up of IC1–IC5 and IC19. If IC1 is inactive then IC2–IC4 are also inactive.

tached to the I1000. It is also used to check the A/D INTERRUPT line. The line indicates whether the A/D has finished its conversion process. If IC1 is active and the address is in the range of 16 through 23, then IC1 pin 13 becomes active. If the function is a write, and the address is in the range of 16 through 18, then IC4 pins 15 through 13 become active. The signals pass through IC5 where they are inverted. The three inverted signals are used to load three latches; IC12, IC15, and IC17 respectively.

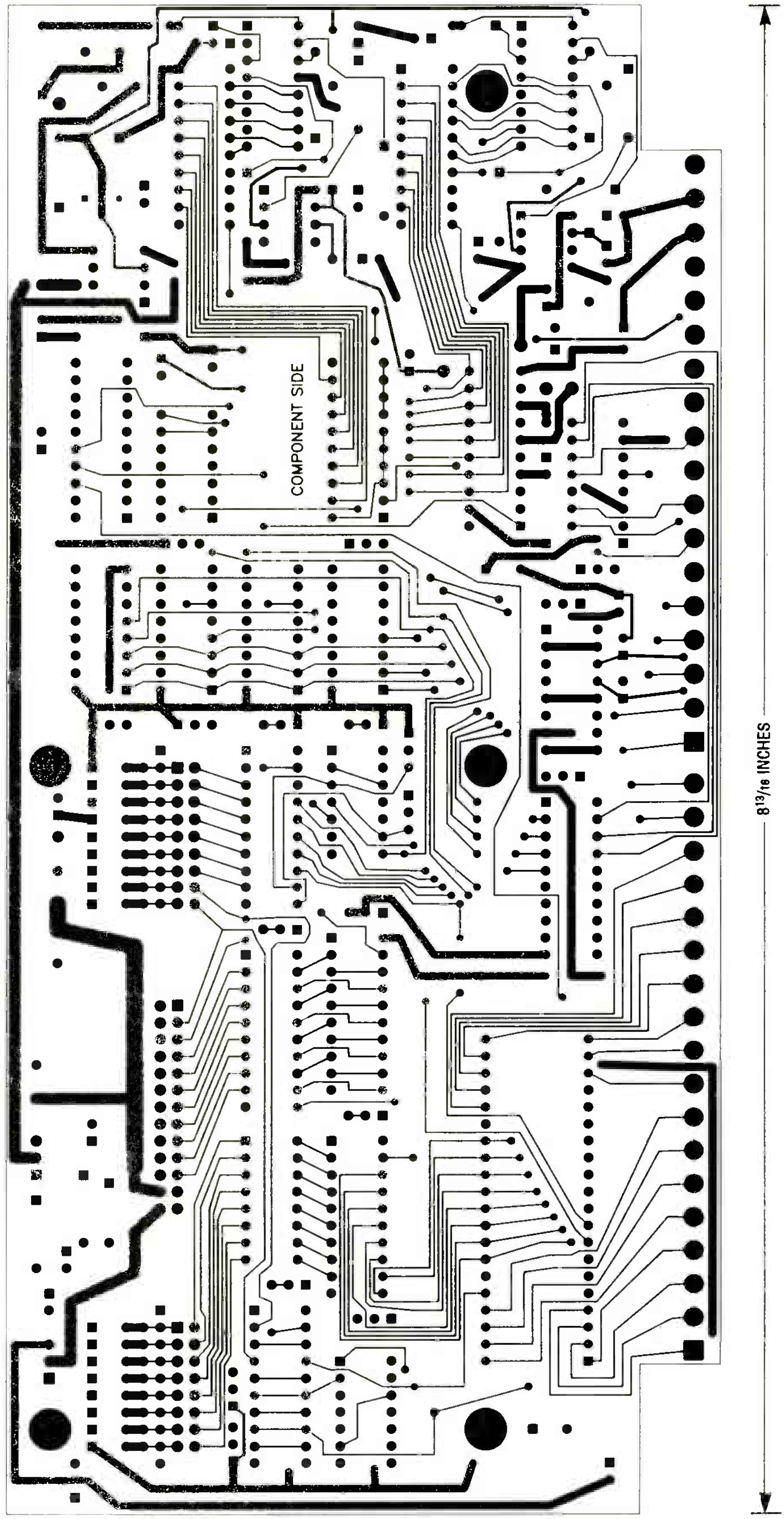
OUT's and IN's in the range of BAS+0 to BAS+3 activate IC6 (the 8255). "OUT BAS+3,BYTE" is used to configure the 8255 where "BYTE" is the input/output configuration. BAS+0 through BAS+2 represent ports 1 through 3 respectively. If the 8255 is configured with port 1 an input, port 2 an output, and port 3 an output, then an "OUT BAS + 2,85" would place alternating ones and zeros on TB1 pins 17–24. The line "A = INP(BAS + 0): A = INP(BAS + 0)" would read into the computer the byte present on TB1 pins 1–8. As you might recall from the previous articles, two input statements are used to read data. The first statement moves the data from the peripheral to the I1000. The second statement moves the data from the I1000 to the computer's memory (variable a).

The voltage-reference section generates the reference voltages used by the DAC and A/D converter sections. Five volts is applied to R1 and subsequently IC20, an LM336 voltage regulator. Potentiometer R17 is adjusted for 2.5 volts at TP6; the 2.5-volt reference is buffered by IC7-a, IC8-a, and IC9-a, and then sent to IC14, IC16, and IC18. The reference voltage is also sent through R2, R18, IC7-b, and across C26 and R3 (R18 is adjusted for 128 millivolts at IC14 pin 13).

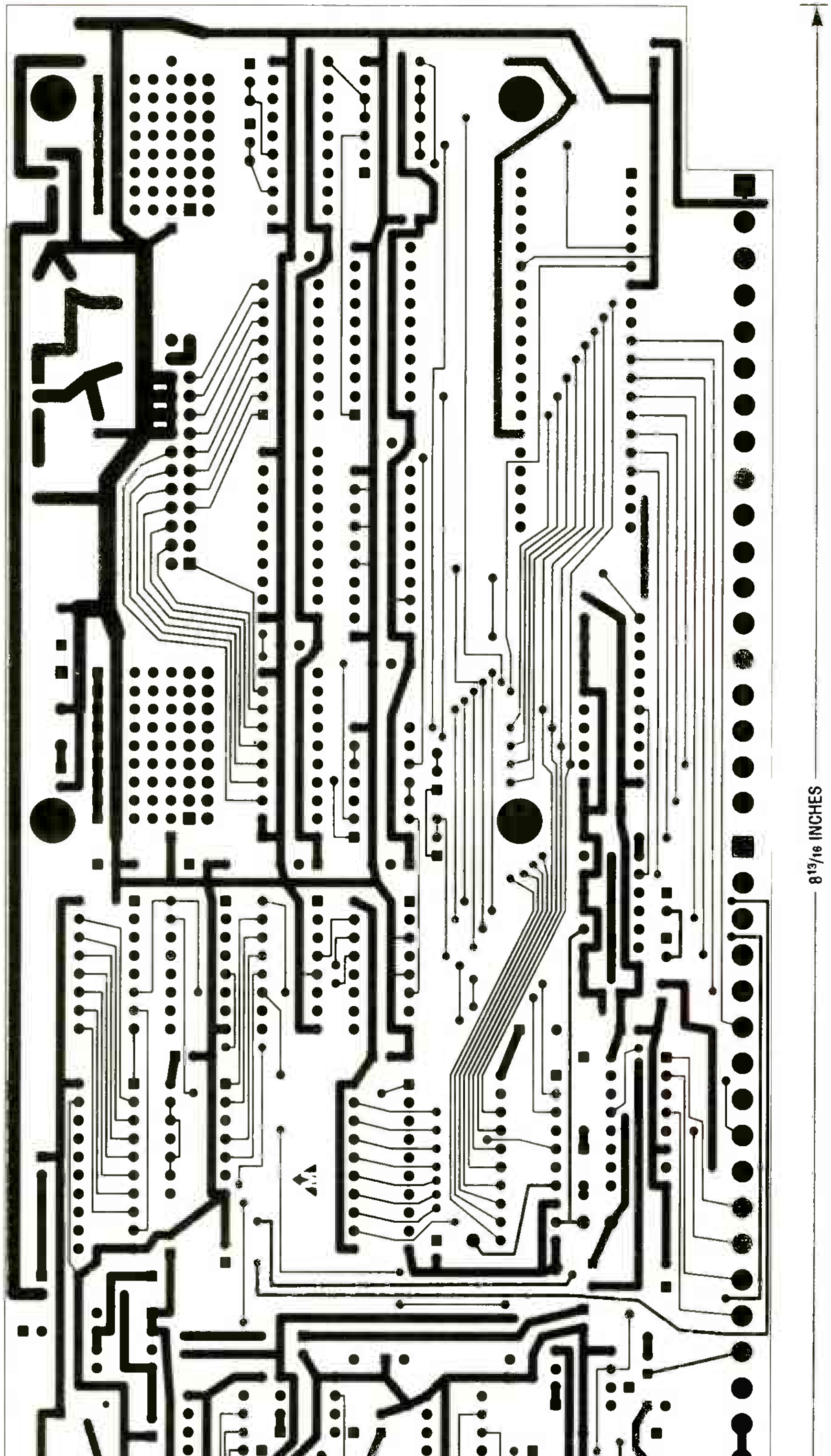
The output DAC section is composed of IC17, IC18, and IC9-b. An "OUT BAS + 17,BYTE" will cause a data byte to be loaded into IC17. The data byte is converted to a current in IC18. The current is fed to IC9-b where it is converted to voltage. The voltage is available to the user on TB1 pin 33. Potentiometer R20 is used to adjust the full-scale voltage output to 5 volts.

As for the A/D section, we'll jump right to the explanation of the 12-bit mode because it includes the 8-bit explanation. Let's assume that we want to measure the voltage on TB1 pin 25 using the 12-bit mode.

First, we will do an "OUT to BAS + 16" with a data byte of 8 (OUT BAS + 16,8). That causes 2.5 volts to pass through IC14 and be applied to A/D converter IC11 pin 9 ($V_{REF/2}$). It also applies an address of 0 to IC13 which connects TB1 pin 25 to IC11 pin 6 (V_{IN+}). Next, we will "OUT" the value "0" to BAS + 18. That causes the reference DAC



COMPONENT SIDE of the T1003 board.



SOLDER SIDE of the T1003 board.

to apply 0 volts to IC11 pin 7 (V_{IN-}). Now we are ready to start the A/D converter. That is accomplished by doing an "OUT" to BAS + 4. The data byte is irrelevant when sending a start pulse so you can use any value you like (as long as it is in the range from 0 to 255).

Next, we will read IC10 to see if the A/D interrupt line has gone low (end of conversion). If it is still high, then the A/D has not finished, and we will read IC10 again. When IC10's LSB goes low the A/D converter is ready to be read. A pair of inputs to BAS + 4 brings the measured byte back into the computer. We now have an 8-bit measurement of the voltage under test. We will call our result byte 1.

To get a 12-bit reading, we must continue from where we left off. An "OUT" to BAS + 16 carrying a byte of 0 is done, which changes $V_{REF/2}$ to 128 millivolts. We are still connected to TB1 pin 25 as before. Next, an "OUT" to BAS + 18 is done using the byte received during the 8-bit measurement (BYTE1) minus two counts. In other words, if the byte was a 100, we now OUT a 98. That causes the V_{IN-} to be 20 to 60 millivolts below the voltage received from the terminal block. We are again ready to start the A/D converter using an OUT to BAS + 4. We read BAS + 8 until the A/D converter finishes its conversion and then read back the new value (BYTE2). Since $V_{REF/2}$ is presently equal to 128 millivolts, BYTE2 is equal to the number of millivolts above V_{IN-}. V_{IN-} is equal to (BYTE1 − 2) × (5/255). Therefore, the value of the voltage at pin 25 is equal to (BYTE1 − 2) × ((5/255) + BYTE2)).

Power supplies

Regulator IC21 makes use of the computer's + 12-volt supply to produce the + 7 volts required by IC7–IC9. Regulator IC22 makes use of the computer's + 12-volt supply to produce the + 5 volts required by all of the other IC's. Regulator IC23 makes use of the computer's − 12-volt supply to produce the − 5 volts required by IC7, IC8, IC9, IC13, IC14, IC16, and IC18.

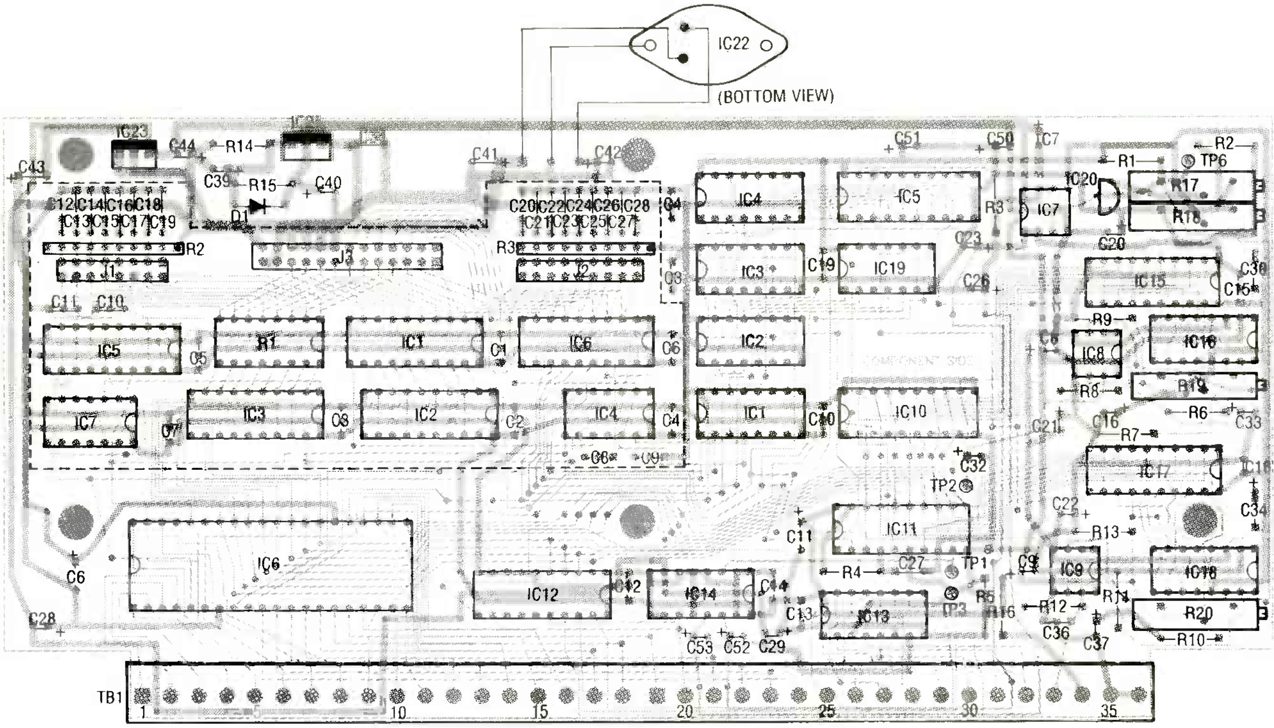


FIG. 3—T1003 PARTS-PLACEMENT DIAGRAM. You can either buy a PC board or make your own from the foil patterns we've provided. The Front End parts are shown with a dark line around them.

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—26-pin dual-row header with matching IDC connector, ribbon cable, and male IDC DB25 connector

Miscellaneous: 17 shorting blocks (for J1 and J2)

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—$179.00**
- **T1001 software (included free with T1001 order)—$10.00**
- **Capacitor kit (unmeasured)—$21.00**
- **Capacitor kit (measured to within 1%)—$26.00**
- **T1003 kit (includes PC board, all listed parts, project case, and preassembled front and rear panels—$159.00**
- **T1003 PC board only—$59.00**
- **T1003, assembled and tested—$189.00**
- **T1003 software (included free with T1003 order)—$10.00**

Add $5.00 S&H to any order. Check or money order only. Florida residents must add 6% sales tax.

Construction

To build the T1003 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 T1003 board shown with a dark line around them in the Parts-Placement diagram of Fig. 3. There is also a separate Parts List for the Front End. (The Front End circuitry was discussed in detail in the June issue.) Do not confuse the two lists of parts, or where the parts go on the board. Also, notice that there are three holes on the board for many of the capacitors, with two of them electrically the same. The holes can accommodate capacitors of different sizes. Use the pair of holes that best fits the capacitors that are available to you.

Four voltage regulators are in the T1003: IC20–IC23. Three of

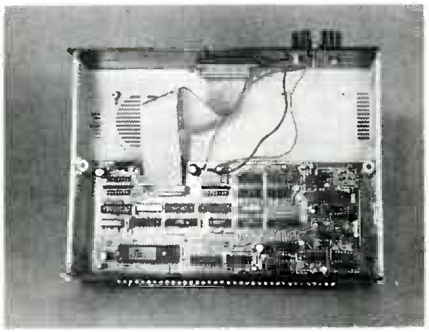


FIG. 4—THE DB-25 CONNECTOR attaches to the board with a length of ribbon cable and a 26-pin header and matching connector. The LM340K regulator mounts on the back panel of the T1003 case along with a heatsink.

PC-BASED TEST BENCH

continued from preceding page

them mount directly on the PC board, but one of them (IC22) is an LM340K in a TO-3 case that must be mounted on the back panel of the T1003 case. Mount the regulator, along with an appropriate heatsink, on the back panel and hardwire it to the board. Figure 4 shows the completed T1003 board.

Software

Each peripheral, including the I1000, has its own software program to control its own operation. All of the programs end up in one directory as more peripherals are added. Software for the I1000 and the entire series of peripherals, including the T1003, can be downloaded all at once from the RE-BBS (516-293-2283, 1200/2400, 8N1) as a self-unarchiving zip file called I1000.EXE. Both compiled and uncompiled software is included. Software is included free with the purchase of any peripheral from the source in the Parts List. (Software can also be purchased from that source without purchasing any hardware items ifyou have no way of downloading it from the RE-BBS.)

The T1003 peripheral must be calibrated precisely if you expect it to work properly. You'll need a DC voltmeter for electrical testing. The hand tools you'll need include a non-conductive alignment tool to set the potentiometers, a small flatblade jeweler's screwdriver, a 5K calibration potentiometer (included with the T1003), and a "U" shaped wire (also supplied with the T1003). The main, or "TSW" menu allows you to select "A/D, D/A, I/O." That starts the T1003. Select "C" from the next menu to calibrate the T1003, and carefully follow all of the instructions that you are given.

The T1003 will provide you with a relatively simple method for obtaining real-world data and getting it into your PC. With practice you will be able to generate your own custom applications for this project. R-E

TROUBLE SHOOTING

continued from page 59

each of which has one or more connectors for cables that drop to individual workstations. If a station drops off the network, the MAU takes on the responsibility of ensuring that the ring maintains electrical continuity throughout.

Calculating maximum cable lengths is straightforward, but it is a little bit more complicated than the simple maximums for 802.3.

Token ring runs on several types of cable; common types include Type 1 (22 AWG STP), Type 2 (22 AWG STP plus four unshielded pairs for phone, e.g. RS-232), Type 3 (24 AWG UTP), Type 5 (fiber), Type 6 (26 AWG STP), and Type 9 (26 AWG STP). Unshielded Type 3 is not recommended for 16-Mbps operation. Types 6 and 9 are more flexible, hence convenient, than Types 1 and 3. Types 1 and 3 are often used for the main ring, and Types 6 or 9 for runs from a wall plate to a PC or device. Type 1 was the first type offered, and is still most popular.

ARCnet: ARCnet uses a token-passing protocol, and it runs at 2.5 Mbps over RG-62 coax or UTP. ARCnet has a flexible topology configuration, including daisy chained coax (like thin Ethernet), coax star, and twisted pair star. With proper network interface cards, ARCnet also supports hybrid bus/star topologies, as shown in Fig. 4.

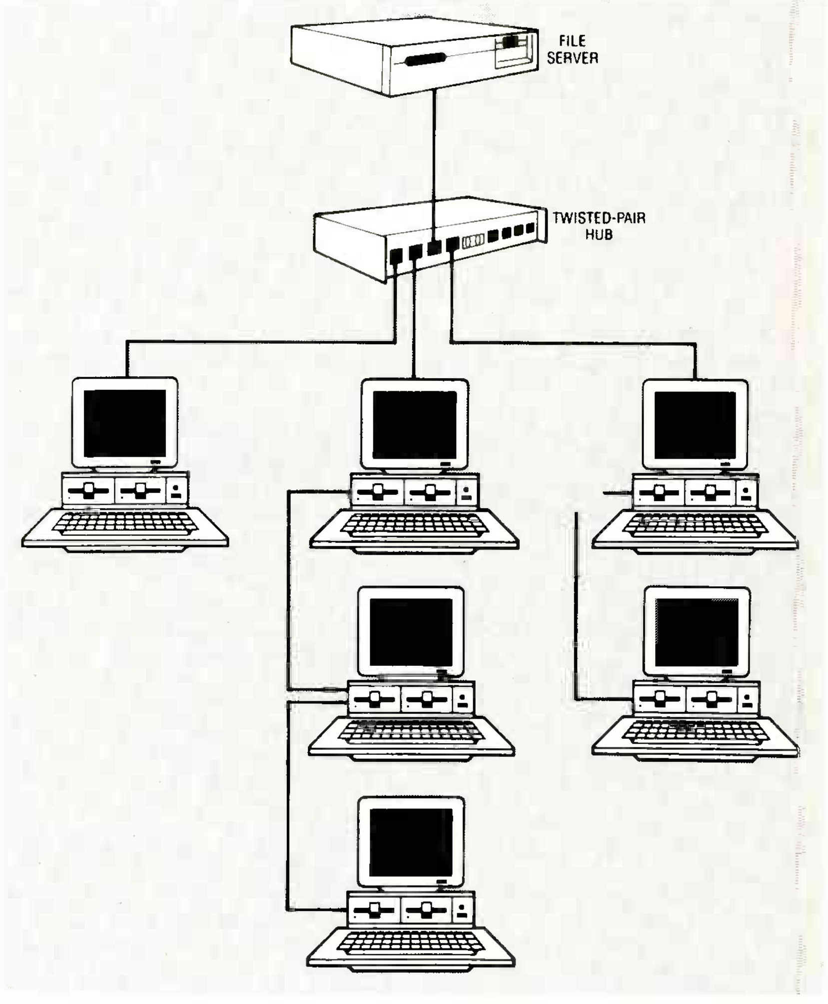
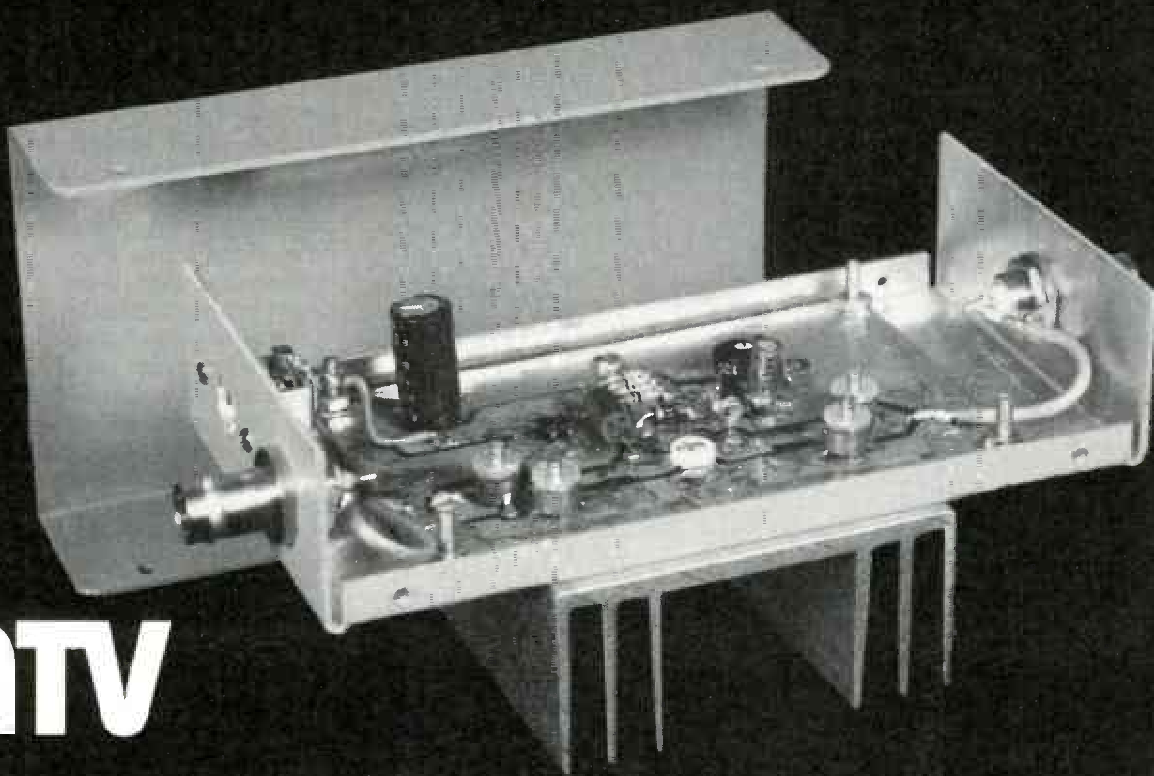


FIG. 4—ARCNET offers a hybrid star/bus topology that runs on twisted-pair cabling. Note that the middle cluster of PC's is wired as a bus, which is itself connected to a hub that services another PC and cluster in a star configuration.

Continued on page 71

Build this linear amplifier to boost the output of an amateur television transmitter from 2 to 10 watts



ATV Linear Amp

RUDOLF F. GRAF and WILLIAM SHEETS

THIS ARTICLE DESCRIBES THE DESIGN and construction of an amplifier that can increase the power output of the amateur television transmitter described in the June and July 1989 issues of **Radio-Electronics**. That transmitter had a nominal 2-watt peak output. However, with this linear amplifier, the transmitter's output can be increased to 10 to 15 watts over the frequency range from 420 to 480 MHz. (The power output will be slightly less up to 500 MHz, and slightly more below 420 MHz.) The amplifier should also be useful for amateur FM at 450 MHz as a power booster for 1- or 2-watt handheld portable transceivers, provided that a suitable switching relay is added.

Referring to the schematic in Fig. 1, the amplifier has a single Motorola MRF654 RF power transistor (Q1) as the active element. RF input power is fed to C1, where C1, C2 and L1 form an adjustable matching network to transform the low input impedance of Q1 (typically 3 ohms) to about 50 ohms. (L1 and L3 are part of the PC board etching, so you should not make changes in the design of the foil pattern.) Base bias for Q1 is fed through R2 and L2. Ferrite choke L4 supplies 13.2-volts DC to the collector of Q1. For optimum performance, Q1 should have a low-impedance load, so L3, C3, and C4 transform the nominal 50-ohm load (the coaxial line to the antenna) to 2.6 ohms.

Although Q1 is designed for FM service, it can function as a linear amplifier if it is forward-biased with about 0.6-volt to an idling current (when no signal is present) of 50 to 100 milliamperes. Good linearity is important, because it is handling an AM signal with video modulation. Also, the matching networks should have adequate bandwidth (about 10 MHz) to avoid cutting the higher video frequencies. Poor linearity will show up as sync compression, sync buzz in audio, or video level clipping.

Bias for Q1 is provided by diode D1. It's important that D1 be thermally connected to Q1 so that Q1 and D1 are at nearly the same temperature to avoid thermal runaway. That is done by soldering one lead of D1 directly to the emitter lead of Q1, and keeping D1 in contact with the

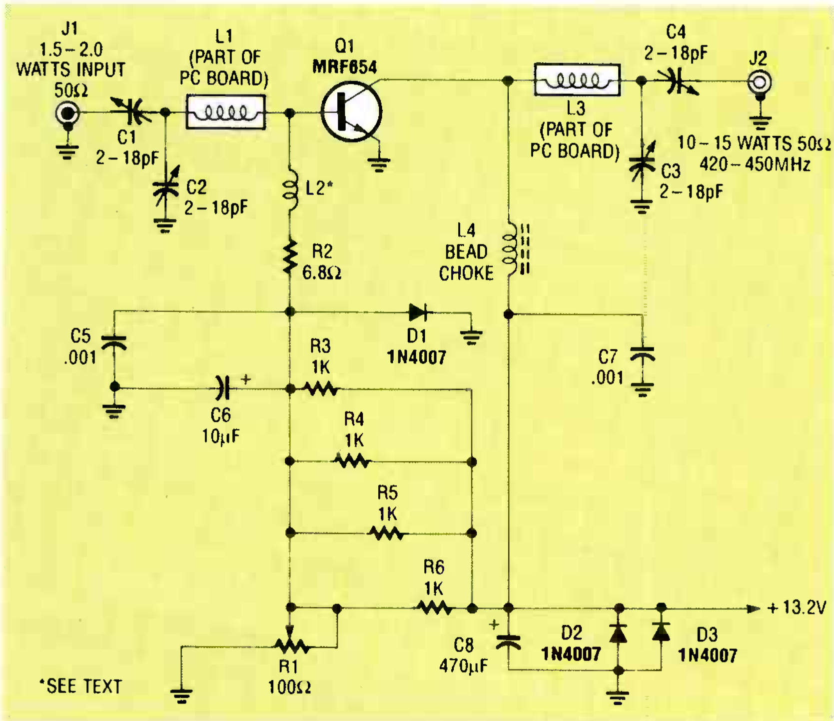


FIG. 1—LINEAR AMPLIFIER SCHEMATIC. The amplifier has a single Motorola MRF654 RF power transistor (Q1) as its active element.

PC board foil around Q1. Capacitors C5 and C6 provide broadband bypassing of D1, and L2 and R2 feed DC bias into the base of Q1. Coil L2 is a low-Q broadband choke that prevents parasitic oscillation.

Potentiometer R1 is adjusted so that, in the absence of an input signal to J1, the amplifier draws about 125 milliamperes from a 13.2-volt DC supply. Capacitors C7 and C8 perform broadband bypassing in the collector circuit, and D2 and D3 provide reverse-polarity protection in the event of power-supply spikes or accidental misconnection. A 3-amp fuse, not included on the PC board, is desirable in the positive lead of the power supply.

Construction

The linear amplifier is constructed on a G-10 0.062-inch epoxy fiberglass double-sided PC board. Note that one side of the PC board is a ground plane with no components or traces on it. That is absolutely essential to the operation of this circuit. The PC board traces have capacitance and inductance that are incorporated into the design of the amplifier. Inductors L1 and L3 are two examples, as are the mounting pads for C1, C2, C3, and C4, which offer significant capacitance to ground. Therefore, it is important that you do not modify the foil pattern provided. You can buy the PC board from the source given in the Parts List.

Figure 2 is the parts-placement diagram. All components are mounted on the component side of the board and soldered to their respective pads with zero lead length, except as in the specialized instructions that follow. Refer to Fig. 3 for details concerning those specialized instructions.

A number of grounding wires must be passed through holes in the board and soldered on both sides to connect the top and bottom ground planes together. All of those points are designated on the board with a "G." A short length of excess component lead can be used. Wrap a length of 3/16-inch copper-foil tape around all four outside edges of the PC board, fold it over, and then completely solder it on both sides.

Variable capacitors C1 and C4 must have their leads bent at 90° angles and soldered flat against the board. However, insert the leads of variable capacitors C2 and C3 through holes in the board and solder them on each side. The leads of potentiometer R1 must also be bent at 90° angles and soldered flat against the board. Bend the leads of electrolytics C6 and C8 at right angles so they are flush with their cases, and solder them to the PC board. Trim the leads as short as possible.

Coil L2 is actually just one lead of R2 (a 6.8-ohm resistor) formed into a 2½-turn inductor. Wrap the lead 2½ times around an ⅛-inch thick nail or similar form. When soldering it to the board, make sure that you raise the coil part of the lead slightly above the board so that it doesn't touch the copper trace below it.

Two chip capacitors are used

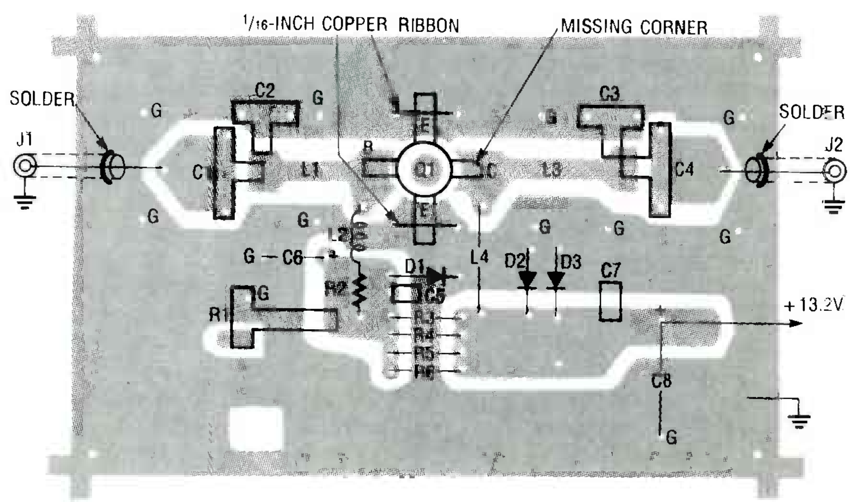


FIG. 2—PARTS-PLACEMENT DIAGRAM. All components are mounted on the top surface of the board.

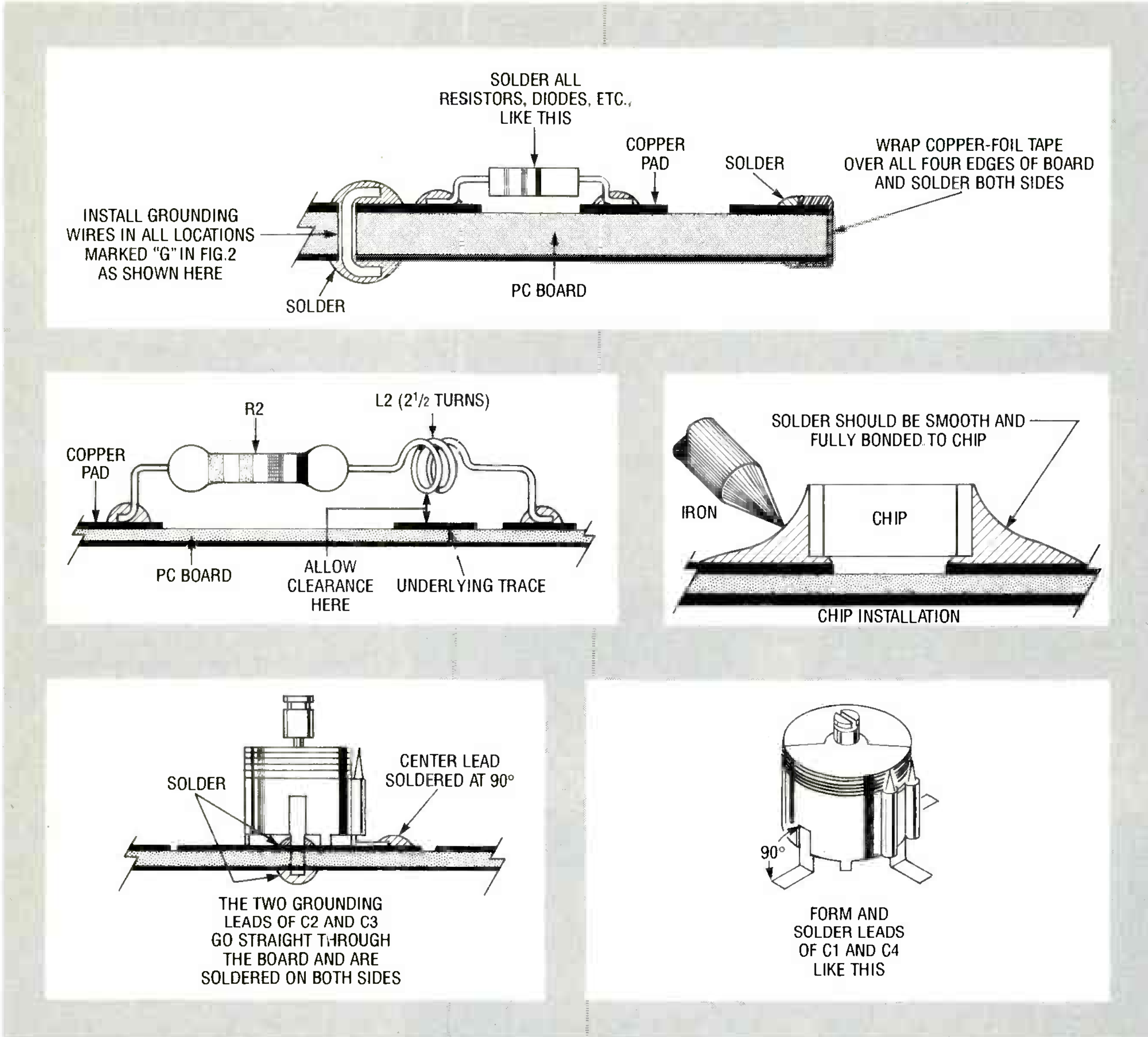


FIG. 3—CONSTRUCTION DETAILS. Because of the high frequencies involved, certain aspects of the design are very critical.

in this project (C5 and C7). To install them properly, first tin the area where the chip is to be installed, and then place the chip on the board. Hold the chip down with the tip of a small screwdriver and tack solder one side to the tinned surface. After one side is tacked in place, tack solder the other side. After both sides are tacked in place, permanently solder both sides as shown in Fig. 3.

Now install Q1. Note that a hole is drilled in the board for Q1, large enough so that no part of Q1's case touches the board. Look for the lead that's missing a corner, and position that lead as indicated in Fig. 2. There are two larger holes near each emitter lead of Q1. Thread a short length of copper foil, 1/16-inch wide (cut from foil tape) through those holes and solder it to both sides of the board after Q1 is installed. The copper solidly grounds both emitter leads to the top and bottom ground planes (see Fig. 4).

After Q1 is soldered in place, mount the PC board inside the case, as shown in Fig. 4, so that the bottom of Q1 is level with the outside surface of the case. Use a metal case for proper shielding. Mount the board with the four corner mounting holes and 4-40 or 6-32 screws. Use washers or available spacers that will allow the proper fit for Q1. Drill a hole in the heatsink for Q1's 8-32 threaded stud, and deburr the hole so that the bottom of Q1 mounts flush. Secure the heatsink with an appropriate nut and lockwasher.

Make sure that Q1 fits in its mounting hole and that no part of it, except for the four ribbon leads, touches the PC board. There must be no mechanical stress on Q1's leads. If Q1 is off-center or cocked at an angle to the PC board, the stud might break off when the mounting nut is tightened.

The heatsink for Q1 should be at least a 1/16- or 1/8-inch aluminum plate measuring about 3½

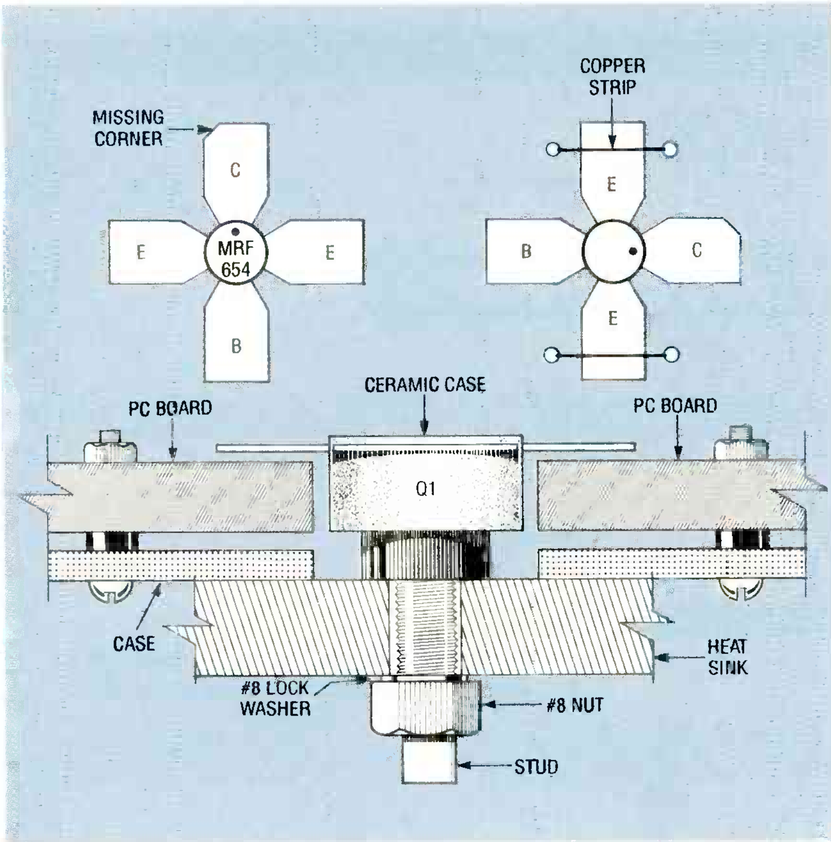


FIG. 4—Q1 IS INSTALLED so that no part of its case touches the board. Heatsinking is very important.

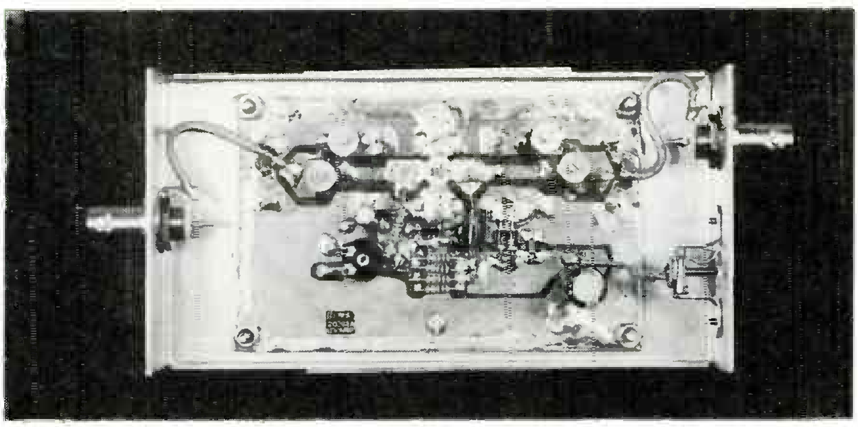


FIG. 5—THE AUTHOR'S PROTOTYPE. A metal case provides superior shielding.

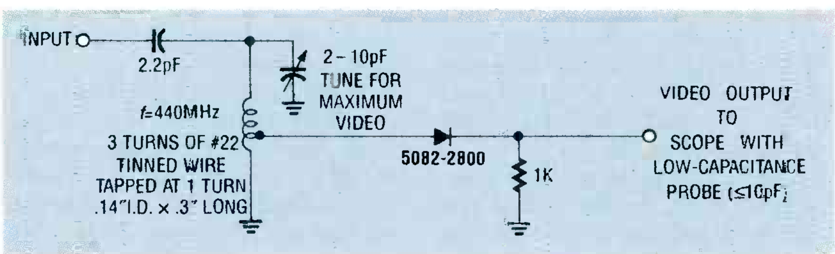


FIG. 6—THE AMPLIFIER can be monitored for linearity with this video-detector circuit and an oscilloscope.

× 5 inches. The heatsink temperature should not exceed 140°F (60°C) during amplifier operation. If the amplifier runs too warm, replace the heatsink with a larger one. A suitable heatsink is included with the kit available from the source given in the Parts List.

Connectors J1 and J2 can be BNC- or N-type. Do not use type F connectors because the impedance is not satisfactory at 400 to 500 MHz. Use a short length of miniature coaxial cable to connect J1 and J2 to the PC board. Figure 5 shows the inside of the author's prototype.

Alignment

After carefully inspecting the board, set R1 fully counterclock-

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—100 ohms, potentiometer
R2—6.8 ohms
R3–R6—1000 ohms

Capacitors
C1–C4—2–18 pF trimmer
C5, C7—0.001 µF, 50 volts, chip
C6—10 µF, 16 volts, electrolytic
C8—470 µF, 16 volts, electrolytic

Semiconductors
D1–D3—1N4007 diode
Q1—MRF654 transistor

other components
L1, L3—part of PCB etching
L2—one lead of R2 wrapped 2½ times around a ⅛th-inch thick nail (see text)
L4—VK200-19-4B bead choke (Ferroxcube)
J1, J2—BNC connector
Miscellaneous: PC board, metal case, heatsink, hardware, 15 inches of copper-foil tape, coaxial cable, wire, solder, etc.

Note: The following items are available from North Country Radio, P.O. Box 53 Wykagyl Station, New Rochelle, NY 10804:
- **Linear amplifier kit (includes PC board, all parts, case, heatsink, hardware, copper-foil tape, coaxial cable, and connectors)—$79.50**
- **Linear amplifier PC board only—$11.50**
- **ATV transmitter kit (includes all parts, case, 439.25-MHz crystal, and all connectors)—$125.00**
- **ATV transmitter PC board only—$12.50**
- **Additional crystals for the ATV transmitter (channels 14, 15, 16, 17, or 18)—$7.50 each**

Add $3.50 shipping and handling to any order. New York residents must add appropriate sales tax.

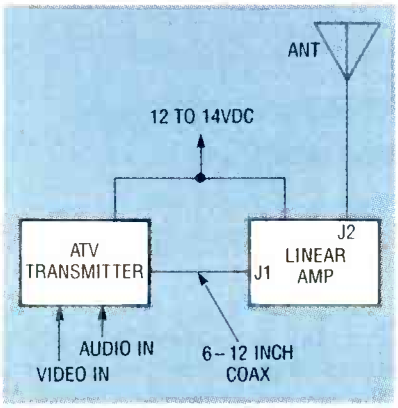
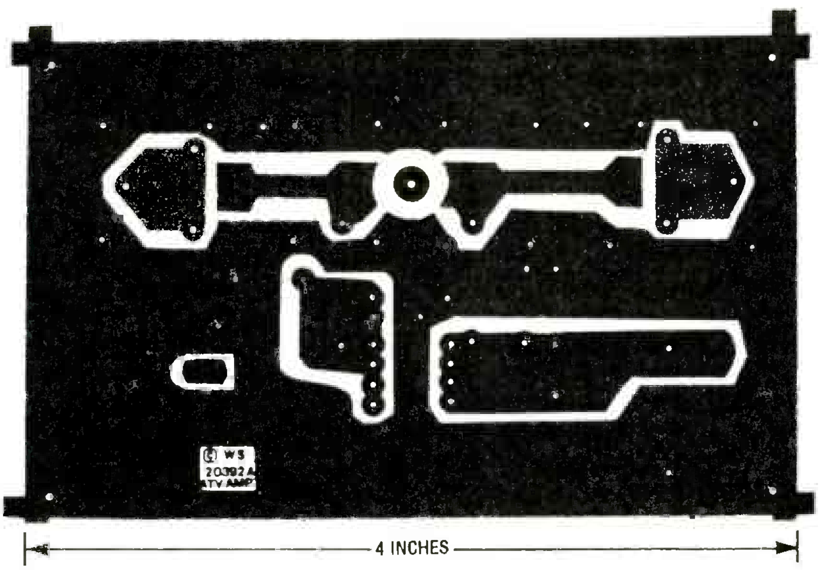


FIG. 7—THE TRANSMITTER connects to the linear amplifier with a short coaxial cable, and the antenna is connected to the amplifier.



COMPONENT SIDE for the linear amp.

wise and connect a regulated 3-amp, 13.2-volt DC supply, observing proper polarity. An ammeter must be installed in series with the positive lead unless the power supply has a built-in meter. Connect a suitable wattmeter (0–25 watts) and a 50-ohm dummy load to J2. (Do not use an antenna, because the circuit might radiate interference during tests.) Make sure your wattmeter and load are both functional at 400–500 MHz (many CB and ham-radio meters are unsatisfactory at those frequencies). Do not yet connect anything to J1. Adjust R1 so that the amplifier draws 100 to 125 milliamperes (do this very quickly).

Next, apply RF drive of 1.5 to 2 watts to J1 and slowly tune C1 and C2 until the amplifier draws about 1 ampere. Quickly adjust C3 and C4 for maximum RF output. Now go back and adjust C1 and C2 for maximum RF output. Now readjust C3 and C4. Repeat that procedure until a maximum RF output is obtained. You should obtain 10 to 15 watts or more from J2, and the amplifier will draw about 1.5 to 2.2 amperes. Check to see if any part is overheating. Now vary the drive to J1; the RF output should smoothly follow the input, if it is correctly tuned.

For amateur TV use, the amplifier can be monitored for linearity with a video detector on the output and an oscilloscope. Fig. 6 shows a suitable detector for that purpose.

Figure 7 shows how to connect the transmitter (from the June and July 1989 issues of **Radio-Electronics**) to the linear amplifier. The best performance is obtained by adjusting R33 in the transmitter so that initially there is an output of 3 to 5 watts from J2 with no video input. Check to see that the output varies smoothly with R3. Then adjust R32 and R33 for the best video performance without sync clipping or white clipping. Slight adjustments of R1 in the linear amplifier might be needed for optimum linearity. Do not overdrive the amplifier, or sync clipping and degraded video will occur. **R-E**

TROUBLESHOOTING LAN'S

continued from page 66

The chief attractions of ARCnet have always been low cost and ease of network expansion (to a limit of about 100 users). For example, ARCnet network interface cards from brand-name dealers cost about $150, half that of comparable thin Ethernet cards. In comparison, 4-Mbps Token Ring cards from the same vendor cost about $400. Offshore-made ARCnet cards sell for under $100.

Conclusions

This whirlwind tour of network cabling, topologies, signal schemes, and access protocols will not make you a full-fledged network wizard. But if you master the concepts presented here, everything else will fall into place easily. Next time we'll delve into what to do when these wonderful beasts don't do what they're supposed to do. See you then. **R-E**

RESOURCES

Following are reference materials, equipment suppliers, and network-related standards organizations. We especially recommend *The Black Box LAN Catalog*.

References:

- *The Practical Guide to Local Area Networks,* Rowland Archer, Osborne-McGraw Hill. Good introduction to cable types, topologies, and access methods.
- *Networking IBM PC's,* Michael Durr, Que Corporation. Chapter 14 contains good overview of bridges, routers, and gateways.
- *LAN Magazine,* 600 Harrison Street, San Francisco, CA 94107 (415) 905-2200.

Suppliers:

- Black Box Corporation, P.O. Box 12800, Pittsburgh, PA 15241, (412) 746-5530.
- JDR Microdevices, 2233 Samaritan Drive, San Jose, CA 95124, (800) 538-5000.
- Cable Express Corporation, 500 East Brighton Avenue, Syracuse, NY 13210, (315) 476-3100.

Standards Organizations:

- American National Standards Institute, 1430 Broadway, New York, NY 10018, (212), 642-4900.
- IEEE Headquarters, 345 E. 47th Street, New York, NY 10017-2394, (212) 705-7900.

HARDWARE HACKER

Santa Claus machine BBS, FM antenna range contest, direct toner breakthrough, synchronous rectifier ideas, and the fundamentals of correlation.

DON LANCASTER

A quickie update before we begin: We've found out that most of those popular FM wireless broadcaster circuits will no longer work because nearly all of the newer synthesized receivers positively *demand* exactly on-channel frequencies. In recent columns, we've seen how that *Pioneer* CD-FM-1 can easily be modified into a fine crystal-controlled and high-quality FM stereo broadcaster.

At the time, I didn't really believe that a plain old third-overtone crystal could really get pulled that far and still provide a CD-quality result. So, I asked an outstanding VCXO designer by the name of Jim FitzSimons to do a circuit analysis for me. The bottom line: Yes, you can pull an ordinary third-overtone crystal far enough and linearly enough to do the job.

But just barely.

Some other fallout from the VCXO analysis: The temperature-compensated 1.4-volt supply is quite critical for linearity, and you should *not* try and raise the voltage. And the varactor modulator does its work by shifting the *series* resonant point of the crystal.

Do let me know if you need any further information on this. Now let us go on to some new stuff that involves...

Electronic correlation

This is one topic that can get real hairy fast, but let us try it anyhow. Many fancy electronic applications need *correlation* techniques of one sort or another. A few of the zillions of possible examples include spread-spectrum communications, machine vision, radar, GPS navigation, speech recognition, video compression, radio astronomy, planetary probes, fuzzy logic concepts, pattern recognition, neuron computing, etc...

Well, correlation is simply *looking for a match*. A match against some original signal. Or any replica of that signal. Or against some expected pattern. And the longer you look for your match, the deeper the noise you can extract it from. With luck and a decent correlator, all your noise and interfering signals will cancel out or, at the least, pile up far more slowly. As a general rule, if any electronic system has to push the limits of what can be done, correlation often will end up playing a big role.

A trivially simple ferinstance of correlation is the Morse Code. You (or some machine) receive a pattern of short-long-short-short. You can then compare that pattern against a stored list of all of the acceptable characters and numbers. A beginner might note that it sounds like "li-no-le-um" and linoleum starts with an "L." With practice, you can do a near-immediate correlation, rather than having to go and compare each and every possible pattern. You simply "hear" the code as letters, in the same way a musician "sees" notes. But, inside your brain, a very elegant wetware correlation is coming down.

Let's see how correlation can help push the detection limits of a simple problem. Say you have a very long driveway and want to know whenever anyone shows up. You put a bright LED on one post and a photocell on the other and build an "electric eye." And it works just fine at night.

NEED HELP?

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

But when the sun comes up, the photocell saturates and nothing seems to work. You next try some obvious non-correlation cures to see if they help. You raise the LED power, add a deep red filter and some focusing optics to improve your signal and reduce the noise. You amplify only those received signal changes that are in the expected frequency range of a passing car. And you even use some sort of AGC loop to keep the sensed light in the linear detector range.

Any of those stunts should work in a plain old driveway sensor, but let's pretend that, after trying everything you could think of to improve your linearity, noise rejection, and signal-to-noise ratio, that things still aren't quite reliable enough.

Now what?

Figure 1 shows you one of the oldest and simplest of the electronic correlation techniques. It is called a *synchronous demodulator*, and may still even go by its ancient name of a *lock-in amplifier*. You chop your LED at an audio rate, turning it on and off at, maybe, 1000 times a second. You design a receiver that amplifies only signals near 1000 Hertz.

Now for the tricky part. Instead of just detecting your 1000 Hertz, you *take a copy of your original signal* and route that to a specially crafted demodulator which follows the rule "amplify when I am positive, but amplify *and invert* when I am negative."

Well, neglecting any phase shifts or delays (they can be easily gotten around), your real received signal will *always* match your signal copy, and it should nicely pile up. But any interfering signals will sometimes add and sometimes subtract. So, the interference cancels. At least some of it some of the time.

By correlating, or *looking for an exact match for an expected input signal*, you have quite dramatically improved your ability to reject nearly all types of potential interference or conflicting signals.

You can also view a synchronous demodulator as an extremely narrow bandpass filter that automatically and exactly tracks your input signal. Even if your input signal is varying. But synchronous demodulation goes one step further than a simple filter. Note that signals of the wrong phase get more or less rejected. For instance, any interfering signal that happens to be at a phase angle of plus or minus 90 degrees gets *completely* rejected. Other phase angles might only get partially rejected, but they will still be reduced.

Go through the math, and you'll find that a synchronous demodulator offers a "free" additional *three decibels* of signal-to-noise ratio improvement over the best detector you can come up with that does not use correlation. And three decibels at or near a digital detection threshold can mean a big world of difference in reliability. From errors per second to errors per hour.

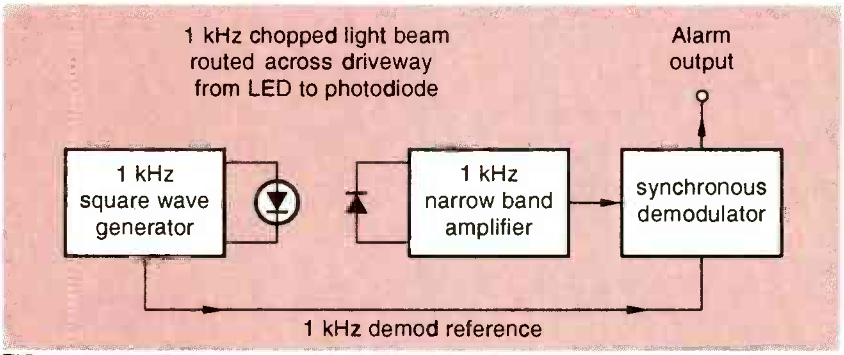


FIG. 1—A "LOCK-IN AMPLIFIER," or synchronous demodulator is an older and simpler example of electronic correlation. In this driveway detector, the desired "no cars" signal can easily be extracted from sunlight or other interference.

Building a correlator

In general, you do a correlation by *multiplying* and then by *adding*. You first find out how well a smaller piece of your received signal can match. You might assign a +1 for "agree" and a −1 for "disagree." Then you add up (or *integrate*) each individual agreement or disagreement to get some overall total. The summed total is called your *correlation coefficient*. If your final correlation coefficient ends up high enough, you vote "yes." Or else you simply pass the correlation value on to more circuitry that wants to know relatively how well you happened to do this time around.

Correlation can be done by using analog, digital, or mixed signals. In the digital world, you can correlate in either a serial or parallel mode. Serial is slow and low in cost, while parallel is fast and complex. But serial might not be nearly fast enough for many real-world uses. A special class of microprocessors we know as *digital signal processors* are arranged to do many correlation techniques faster and easier than can the traditional personal computer CPU chips.

Several simple correlator circuits are shown in Fig. 2. For linear circuits, a diode bridge or any four-quadrant multiplier should work just fine. For high-frequency RF work, the *Signetics* NE605 is a great choice.

But my favorite lower frequency linear synchronous demodulator is the gated gain amplifier of 2-*a*. If the *mask* signal is low, the gain is *plus one*. If it is high then the gain is *minus one*. This is a synchronous full-wave rectifier that does all of the multiplying for us. A following *integration* stage will do the addition for us. Often the addition can be done with nothing but a series resistor and storage capacitor.

The fundamental digital correlation circuit is the *compare* gate, otherwise known as an exclusive NOR, shown in Fig. 2-*b*. A compare gate gives you a one out if the inputs are *identical* and a zero out if they are *different*. For serial use, one compare gate can be followed by an up-down counter. For parallel use, bunches of compare gates are followed by a special pile of adders configured as a "how many ones are in this word?" circuit. Figure 2-*c* shows the details.

Yes, you can go out and buy digital correlator chips, but they do tend to be specialized and expensive. *TRW* and *Stanford Telecomm* are two big sources for these chips. A second more popular route is to use firmware and a digital signal processing chip.

On your own, you can easily and cheaply hack up an eight-bit digital correlator out of any plain-Jane 2764 EPROM, following the details from Fig. 2-*d*. Your truth table simply answers the question "How many bits match?" The answer will be a four-bit word ranging from −8 to +8.

For any sixteen-bit parallel digital correlator, simply precede a different 2716 EPROM with four quad XOR gates. Or use a device such as a PLA or PLD.

Correlation could also be done in software. For instance, in PostScript, just do an *exclusive-or-not* sequence, followed by a table lookup which converts a binary number to the number of ones in the word. Fast and fun.

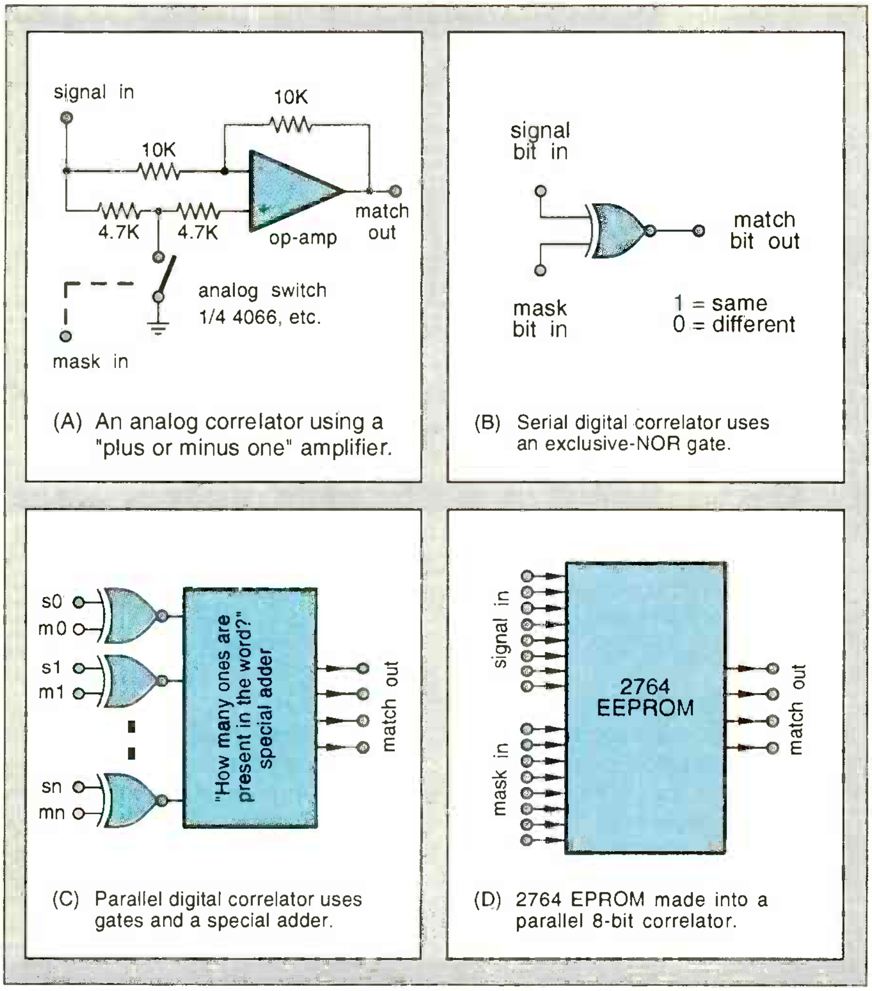


FIG. 2—HERE ARE FOUR POPULAR METHODS for doing electronic correlations.

Correlation functions

An exact match against your initial signal is called an *autocorrelation*. Attempting a match against anything else is a *crosscorrelation*. Should you try a match against some shifted or delayed version of your initial signal, you are now performing a *shifted autocorrelation*.

Ideally, your autocorrelations will always strongly agree, and most of your crosscorrelations will more or less cancel to zero. But those shifted autocorrelations get interesting in a very big hurry.

For instance, say you now have a planetary probe flying past Neptune. The extension cord needed to deliver an exact copy of your autocorrelation signal tends to end up a tad on the long side. Not to mention asteroid breakage. The trick, instead, is to take a local shifted autocorrelation signal and move it around until you get a strong match to your incoming data. This is called *acquiring a lock*. Until you have your local clone reference precisely locked to the incoming data, you can't receive any useful information.

By far the most unique autocorrelation function occurs with the sequence 1000. Like so...

$$\begin{array}{cccccc} 1 & 0 & 0 & 0 & & \\ 1 & 0 & 0 & 0 & & \\ \hline +1 & +1 & +1 & +1 & \rightarrow & 4 \end{array}$$

$$\begin{array}{cccccc} 1 & 0 & 0 & 0 & & \\ 0 & 1 & 0 & 0 & & \\ \hline -1 & -1 & +1 & +1 & \rightarrow & 0 \end{array}$$

$$\begin{array}{cccccc} 1 & 0 & 0 & 0 & & \\ 0 & 1 & 1 & 0 & & \\ \hline -1 & +1 & -1 & +1 & \rightarrow & 0 \end{array}$$

$$\begin{array}{cccccc} 1 & 0 & 0 & 0 & & \\ 0 & 0 & 0 & 1 & & \\ \hline -1 & +1 & +1 & -1 & \rightarrow & 0 \end{array}$$

Here we are *not* adding. We are comparing two *vertical* bits at a time, and putting down a "+1" if they are identical and a "−1" if they

NAMES AND NUMBERS

Burr-Brown
6730 South Tucson Blvd
Tucson, AZ 85706
(602) 746-1111
CIRCLE 301 ON FREE INFORMATION CARD

Consolidated Electronics
705 Watervliet Avenue
Dayton, OH 45420
(513) 252-5662
CIRCLE 302 ON FREE INFORMATION CARD

Dr. Dobb's Journal
411 Borel Avenue Suite 100
San Mateo, CA 94402
(415) 358-9500
CIRCLE 303 ON FREE INFORMATION CARD

Environmental Protection
225 North New Road
Waco, TX 76710
(817) 776-9000
CIRCLE 304 ON FREE INFORMATION CARD

GEnie
401 North Washington Street
Rockville, MD 20850
(800) 638-9636
CIRCLE 305 ON FREE INFORMATION CARD

Iterated Systems
5550A Peachtree Pkwy #650
Norcross, GA 30092
(404) 840-0310
CIRCLE 306 ON FREE INFORMATION CARD

MCM Electronics
650 Congress Park Drive
Centerville, OH 45459
(513) 434-0031
CIRCLE 307 ON FREE INFORMATION CARD

Pollution Equipment News
8650 Babcock Blvd
Pittsburgh, PA 15237
(412) 364-5366
CIRCLE 308 ON FREE INFORMATION CARD

Signetics/Philips
811 East Arques Avenue
Sunnyvale, CA 94088
(800) 227-1817
CIRCLE 309 ON FREE INFORMATION CARD

Stanford Telecom
2421 Mission College Blvd
Santa Clara, CA 95054
(408) 980-5684
CIRCLE 310 ON FREE INFORMATION CARD

Don Thompson
23072 Lake Center Dr #100
El Toro, CA 92630
(800) 457-5776
CIRCLE 311 ON FREE INFORMATION CARD

TRW Microelectronics
Box 2472
La Jolla, CA 92038
(619) 475-1000
CIRCLE 312 ON FREE INFORMATION CARD

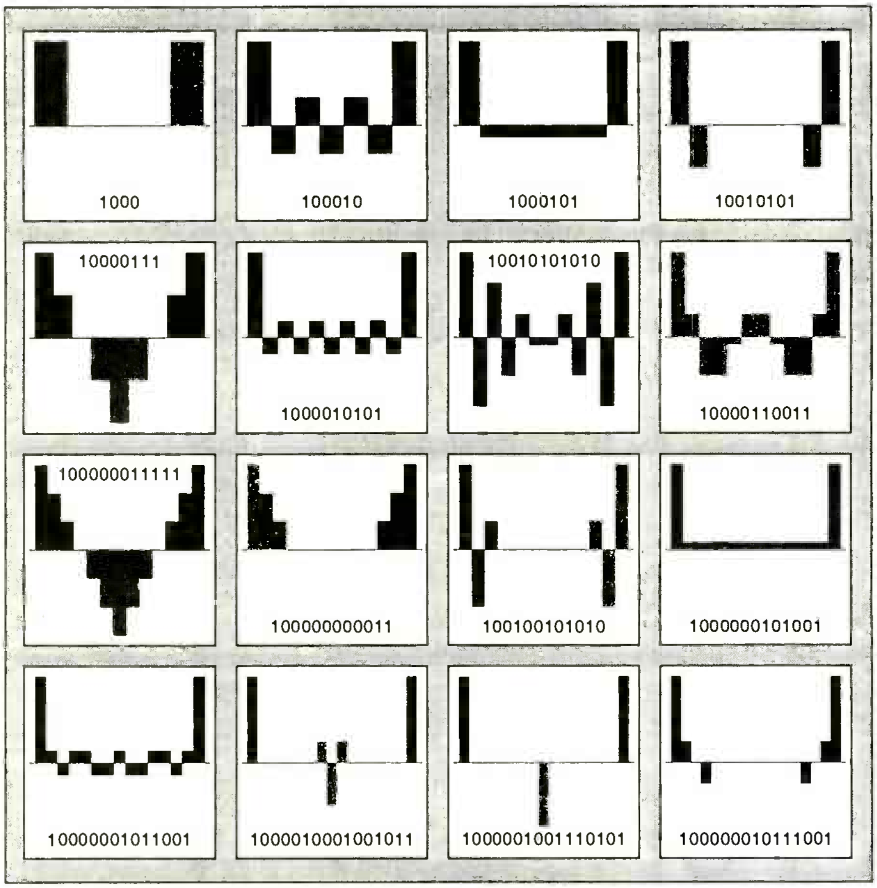


FIG. 3—SHIFTED AUTOCORRELATION FUNCTIONS appear when you correlate a digital word against a time-shifted or bit-shifted replica of itself. Those functions get important in a hurry whenever you are trying to lock onto an incoming digital data stream. These examples are from GEnie PSRT download #427.

are different. Only then do you add up the total results. Note that the second, third, and fourth examples represent shifts of one, two, and three bits in your target word. Amazingly, all of the shifted autocorrelation results are precisely zero!

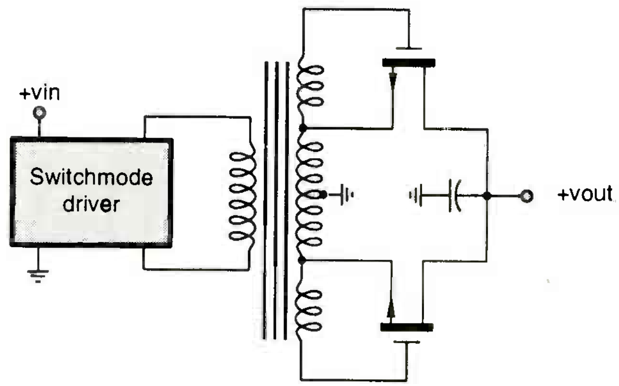
Very sadly, this is the *only* known digital sequence that gives a "perfect" shifted autocorrelation. The longer codes will do all sorts of weird things with the shifted summations. Most of which can end up as less than useless. Some of the more interesting (and more useful) shorter autocorrelation codes are shown in Fig. 3.

There are far fewer autocorrelation functions than there are possible bit combinations in any word. Why? Because shifted bit patterns, mirror patterns, and complementary patterns will all end up generating identical functions.

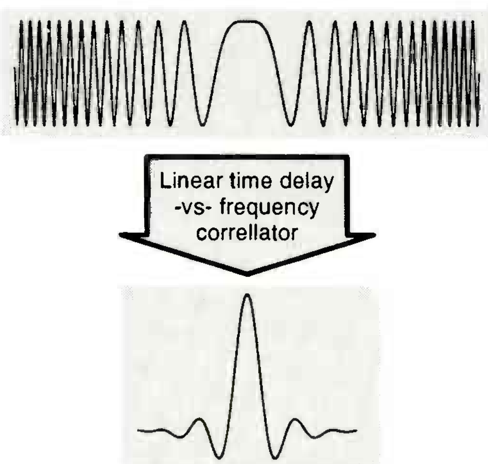
The best possible autocorrelation codes are called *Barker Codes*. Sadly, these are all short, and are few and far between. Instead, when you are using a long correlation code, you'll often have to settle for one that is simply "well behaved," rather than the best possible.

On any longer digital codes, most crosscorrelation values will be very low. For any code length, you could easily predict how badly a random interfering noise code might crosscorrelate. Just use a messy piece of mathematics known as the *bionomial coefficients*. For instance, on a fairly short code of 20 bits, only *one* crosscorrelation will total to +20 and one other to −20. A mere twenty will sum to a value of +18.

Why twenty? Because there are only twenty possible places in a 20-bit word for the one-bit errors. How many possible errors of two bits? Go through the binomial math and the answer is a scant 190 cases that sum to +16. Of the 1048576 possible 20-bit crosscorrelations, a huge 772616 will sum to +4, +2, 0, −2, or −4. Put another way, a tad over three quarters of all of those possi-



In a SYNCHRONOUS RECTIFIER, power switches are turned on only when conduction is desired. Because of the lower forward drop of a switched transistor, the efficiencies can be much higher than using ordinary silicon diodes in low voltage, high current supplies.



In a CHIRP radar system, a frequency swept pulse is transmitted that permits both high power (for long range) and narrow time resolution (for closer target separation.) A linear delay-versus-frequency correlator converts the received target swept phase histories back into actual viewable or recordable target maps.

FIG. 4—AS THESE TWO WILDLY DIFFERENT EXAMPLES show us, there is now an incredible number of applications for electronic correlation techniques.

ble 20-bit interfering signals will be strongly attenuated by your correlator. As you go to longer codes, the odds of noise interference become astronomically low.

I've now posted a quick-and-dirty autocorrelation generator to *GEnie* PSRT as my file #435 AUTOCORR.PS. As is, it will generate *all* of those unique autocorrelation codes up to 20 or so bits in length. Yes, duplicate codes are discarded and not reported. And you can easily extend the technique to quickly and accurately find autocorrelation functions as long as 65536 bits! It's written in PostScript, of course.

The trick is to put all your ones and zeros into a string. Then play around with the string. That bypasses the precision limits of any conventional digital arithmetic. Sneaky, huh?

We will be seeing much more on correlation in some future columns. Especially if we do get into more on spread-spectrum communications and GPS navigation. I just wanted to give a bare bones intro to a tricky topic here. Those shifted autocorrelation functions are lots of fun to play with (and a winning school paper topic) just because they are there.

Let's wrap this up by looking at two wildly different examples of an electronic correlation in Fig. 4—one simple, one elaborate.

Say you want to build up a low-voltage, high-current power supply, maybe 5 volts and 100 amps. If you try using plain old silicon diodes for your outputs, you'll get a volt or two of forward drop across your diodes. And lots of waste heat and terrible efficiency. While the newer *Schottky* diodes help some, even those are very inefficient at higher currents.

But a properly chosen and driven power transistor could have a much lower forward drop than a diode. So, instead of using diodes, use field-effect transistors as switches set up as *synchronous rectifiers*. You turn your transistor on only when you desire conduction and turn it off otherwise. The forward drop can be much lower and the efficiencies much higher.

The synchronous rectifier is most likely to be your least elegant correlator example. Solar energy converters are another area in which high rectification efficiencies are super important.

Shortly after World War II, pulse radar systems hit their limits. The *resolution* of a traditional pulse radar is inversely proportional to its pulse *width*; the *range* is proportional to the energy inside the *pulse area*. Ideally, you want a super powerful yet ultra-narrow pulse waveform.

The trick is to conjure up some method of sending a *long* pulse that still gives you acceptable resolution. And the solution was called *chirp*. By sending a long linearly swept FM pulse out and then by routing the received swept waveforms through a *linear delay vs. frequency network* (a fancier example of a correlator), the individual bits and pieces of that swept waveform would *pile up* and generate a narrow target pulse.

The exotic *coherent* radar systems even went one step further, especially those that were side-looking. The swept transmitted chirp pulses were suitably recorded, generating what were known as *target phase histories*. Those phase histories were converted into viewable data by using linear delay-vs-frequency networks, optics that made a *Fourier Transformation*, holography techniques, or electronic digital correlators. All of those techniques perform a correlation in one way or another.

Chirp may sound really complex and hairy. But bats have done it for eons. Compactly and elegantly in wetware. And the bat's "figure of merit" for their radar beats out our best and newest military radars by some ten orders of magnitude. That's 10,000,000,000:1. And not half bad for amateurs!

But, in all fairness, they did have a head start.

Printed-circuit update

From time to time in the past, we have looked at the new *direct-toner* method for making printed circuit boards. The new direct-toner method promises to revolutionize hacker PC boards, doing the job in minutes for pennies with zero darkroom work or other special techniques.

The two key secrets to the direct-toner method are that laser-printer toner does make an outstanding etch resist, and that the great PostScript computer language makes printed circuit layout exceptionally fast, fun, and easy to do. From *any* computer, using nothing but your favorite word processor.

One early transfer film sheet was the TEC-200 film from *MeadowLake*. Sadly, many hackers swore at this new product, rather than by it. Even though many of the partial-transfer problems were caused by improperly cleaned boards, not doing a pre-etch or pre-heat, by using any old copier (instead of an SX laser printer), and trying to use an iron (instead of a Kroy Kolor machine or suitable heat press of some sort). As we saw last month, a very much improved transfer film is now offered by *Technics Inc* as its PCBF-1000.

Both of those products suffer a common flaw: They both expect a *differential transfer* to take place reliably in the real world. You first ask all of your toner to stick loosely to the transfer film. Later, you expect all of your toner to adhere strongly to the board, leaving zero residue on the film.

The differential transfer problem has been solved in spades by a brand new *Toner Transfer System* offered by *DynaArt Designs* and available from *All Electronics* and *DC Electronics*. The system is basically a polyester film coated with some high-tech sugar water. There are two different ways to use the film, called the *cold method* and the *hot method*. Both methods open all sorts of new hacker opportunities.

The hot method is best for hacker circuit boards. With the hot method, you will laser print a backwards but positive image by using an SX printer with a good grade of graphics refill toner. As with the previous films, you then iron the toner onto a super-clean bare printed circuit board. You now have toner that is very tightly stuck to *both* the PC board and the film.

Soak your board in warm water for a few minutes, and all the high-tech sugar water dissolves, *floating away the backing sheet*. And leaving pretty near all of the toner on your circuit board nearly all of the time. Gently wash the board in warm water to remove any residue. Then etch as usual.

The cold method is best for circuit-board component-callout overlays, dial plates, and ordinary decals. Print the normal and positive image to the film. Then spray the image using several light coats of a clear lacquer, urethane, or epoxy. Cut out all your images slightly oversized and soak them in warm water. Then transfer the images just as you would any model-railroad decal. You can either remove the lacquer with alcohol to get at the bare toner, or add additional and more protecting clear sprays for extra durability.

Those cold method results look especially impressive when you use a *Canon* color copier. Note that you can now transfer toner onto *anything*. The cost of the introductory kit with five sheets is $9.95.

For the first of our two contests this month, just show me something new, different, or off-the-wall that you can do using either the hot or cold method of the DynaArt transfer system.

As this month's resource sidebar, I have gathered together a few of the better known direct-toner resources. Besides the three films we just looked at, *Kepro* is your leading source of hacker printed circuit supplies. More on the direct-toner method is likely to appear in *The Flash* or in *Midnight Engineering* magazines. My two very favorite toner sources remain *Lazer Products* and *Black Lightning*, while others advertise in the *Recharger* and *Supplies Unlimited* magazines.

I've recently posted my shareware PostScript printed circuitry layout package over to *GEnie* PSRT as our file #401 PRNCRCT.GPS. Plus a new summary tutorial on the new hacker printed circuit techniques as file #419 NUTS3.PS. There will be bunches of exciting new stuff on toner in general as #435 TONERTRX.PS.

TONER RESOURCES

All Electronics
P.O. Box 567
Van Nuys, CA 91408
(818) 904-0524
CIRCLE 323 ON FREE INFORMATION CARD

Black Lightning
Riddle Pond Road
West Topsham, VT 05086
(800) BLACK99
CIRCLE 313 ON FREE INFORMATION CARD

DC Electronics
P.O. Box 3203
Scottsdale, AZ 85271
(602) 945-7736
CIRCLE 324 ON FREE INFORMATION CARD

DynaArt Designs
3535 Stillmeadow Lane
Lancaster, CA 93536
(805) 943-4746
CIRCLE 314 ON FREE INFORMATION CARD

The Flash
Riddle Pond Road
West Topsham, VT 05086
(800) BLACK99
CIRCLE 315 ON FREE INFORMATION CARD

Kepro
630 Axminister Drive
Fenton, MO 63026
(800) 325-3878
CIRCLE 316 ON FREE INFORMATION CARD

Lazer Products
12741 E Caley Ave #130
Englewood, CO 80155
(800) 843-5277
CIRCLE 317 ON FREE INFORMATION CARD

Meadowlake
Box 497
Northport, NY 11768
(516) 757-3385
CIRCLE 318 ON FREE INFORMATION CARD

Midnight Engineering
111 E Drake Road Ste 7041
Ft Collins, CO 80525
(303) 491-9092
CIRCLE 319 ON FREE INFORMATION CARD

Recharger
101 Granite Street Ste F
Corona, CA 91719
(714) 371-8288
CIRCLE 320 ON FREE INFORMATION CARD

Supplies Unlimited
101 Granite Street Ste F
Corona, CA 91719
(714) 371-8288
CIRCLE 321 ON FREE INFORMATION CARD

Techniks, Inc
45 J. Ringo Road
Ringoes, NJ 08551
CIRCLE 322 ON FREE INFORMATION CARD

A second contest

Our big-time name-brand cable company here in the Gila Valley has stupidly discontinued all of its FM broadcast services. And it's in an area where any decent and useful FM stations are extremely hard to pull in otherwise.

What really saddens me is that the reception on top of the mountain in my front yard is exceptional. Take any old $4 receiver up the mountain, and a Tucson FM station comes in loud and clear. Tilt the antenna slightly, and the El Paso station *on the same channel frequency* booms in, again loud and clear. The same goes for Phoenix and Albuquerque at 93.3.

So, I guess this month's contest is in that "Don't get mad... get even" category. Just tell me all about any favorite tricks, circuits, antennas, or other products you know of which really work for reliable long-range FM reception.

With both contests, there will be the usual dozen or so newly revised *Incredible Secret Money Machine II* book prizes, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best.

As usual, send your written entries directly to me per that *Need Help?* box, rather than to **Radio-Electronics** editorial.

New tech lit

Two reliable sources for foreign semiconductor replacements are *MCM Electronics* and *Consolidated Electronics*. Both send free catalogs.

A free video on laser-printer repair training is now available from *Don Thompson*. Don is regarded as having *the* finest training services in this field, and stocks hard-to-find replacement parts.

Two environmental trade journals are *Environmental Protection* and *Pollution Equipment News*. The latter has plenty of ads for interesting and unusual sensors.

For lots more information on Santa Claus Machines, check out the brand new stereolithography user's group on *GEnie* UNIX. And a good tutorial on wavelets has appeared on page 16 of *Dr. Dobbs Journal* for April 1992.

Two free software sources for this month: *Iterated Systems* has a free demo diskette on its new *real time* fractal decompression software. And *Burr-Brown* now has a new freebie *Active Filter Design* disk available.

If you are interested in active filters, be sure to check out my classic *Active Filter Cookbook*. It's available by itself or as part of my *Lancaster Classics Library*, as per my nearby *Synergetics* ad. **R-E**

SURFMAN

continued from page 36

leads with your fingers or all you'll hear is hum. Listen to the noise produced; it should be loud and smooth. If it's not, try another transistor. If you find a transistor that produces good quality noise, but the volume is not loud enough, the gain of the preamp stage IC2-a can be increased by decreasing the value of R12. But don't go below 10K.

Drill holes for the volume control and earphone jack in the front panel of the case (notice that the circuit board is notched to allow space for these parts) and mount them. Install the circuit board as shown in Fig. 3. No hardware mounts the circuit board directly; instead, the two large mounting holes in the corners of the board fit over the mounting posts in the case so that when the top is installed it holds the circuit board in place.

Using SurfMan

Trimmer R17 controls rain/surf/pink noise selection. By setting R17 fully clockwise, you turn the filters off and obtain white noise (rain). When R17 is fully counterclockwise, the filters are fully on for pink noise. At intermediate settings, the filters will be modulated by the chaotic voltage generators for various surf sounds.

If you want to connect SurfMan to your hi-fi setup, the simple capacitively coupled voltage divider shown in Fig. 4 will isolate and attenuate the signal so that it can be plugged into an auxiliary input of your amplifier. A "Y" connector can be used as shown to drive both stereo inputs. If you're really adventuresome, build two SurfMans for stereo.

A word of caution: SurfMan really blocks outside noise and puts you in a kind of sound closet. Nothing short of a Scud attack will attract your attention. Don't use it while you're supposed to be baby-sitting the kids. Don't use it while jogging down the boulevard, and please don't use it while driving. **R-E**

A User Manifesto

JEFF HOLTZMAN

I get excited when a new tool comes along that provides me with a better way of doing my work. I am disappointed when the tool lets me down. In the software industry these days, there is a lot of excitement; there is also a lot of disappointment.

In analyzing the causes of this disappointment, I came up with the Software User Manifesto (SUM) shown in the sidebar. It includes everything I could think of, but it undoubtedly misses some things. If you think of additions, send them to me c/o the magazine; we'll publish an update later. For this project, I'm looking for general rules, not complaints about specific products.

The purpose of the SUM is as follows: If you have ever been or are now disappointed by a software product, make two photocopies of the SUM. Send one to the CEO and the other to the marketing department of the vendor of the offending product, along with a cover note expressing your displeasure. Add a specific explanation of the circumstances that raised your blood pressure. Then put your money where your mouth is.

Windows product watch

In all the hoopla surrounding the release of Windows 3.1, it's easy to lose sight of the fact that Microsoft has also released significant updates to numerous products, including Excel, Project, Visual BASIC, and the C compiler. The Excel upgrade is particularly significant, because new features typically appear there first and subsequently migrate to other products.

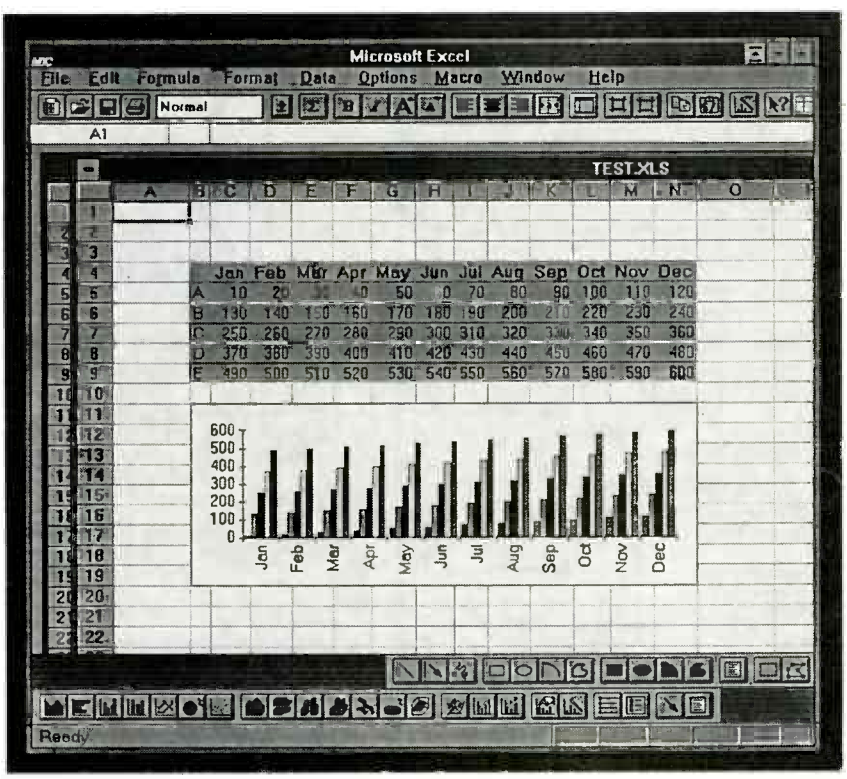


FIG. 1—EXCEL 4.0 gives new meaning to the phrase user-friendly. Multiple customizable toolbars let you set up for the way you work; automatic table generating, formatting, and charting features make fast work of common operations; powerful macro tools simplify development of custom functions and operations.

There are far too many new and improved features to cover here. Among the most interesting are the user-interface improvements, including fully customizable toolbars, right-button mouse usage, drag-and-drop table building, auto-fill, and automatic table formatting.

Toolbars have become required on most serious Windows products; Excel pushes the concept in new ways. Typically a tool bar adds a row of "buttons" somewhere near the top of the screen. You click a button to execute a built-in command or custom macro. Most products allow you to add and delete buttons, change the icon associated with a button, or change the associated command or macro. Excel 4.0 does all that and quite a bit more. It comes with seven toolbars covering common functions such as formatting, charting, creating, and debugging macros; you can create your own at will. A toolbar can float over the current document, or dock along a screen edge.

Now the right button works consistently throughout the program. Select an object (cell, range, chart, graphic), press the right button, and up pops a menu of actions appropriate to that object. Typically you'll see cut, copy, and paste, format changes such as font, color, and border.

Drag-and-drop allows you to select a rectangular range, then drag it with the mouse to a new location. Often this is much more convenient than the old method of cutting to the clipboard, going to a new location,

Software User Manifesto

Dear ______________________:

I am a user of personal computer software, and I am dissatisfied. The following statements express my needs. If you do not pay attention to my needs, I will not pay attention to your product.

Product Functionality

The tool should extend the range of tasks that I currently perform, while providing a smooth transition into new user features. The tool must not be underpowered; I want assurance that I can use all the latest and greatest features—when I'm ready. But I don't want them to get in the way until I am ready.

Integration With Other Tools

I want your tool to integrate smoothly *with* the others in my toolbox, and I want your tool to work *like* my other tools.

I want plug-and-play functionality. If I break a ½" socket wrench, I can go to any hardware store and get a replacement. I want the equivalent with software. Include a mini graphics editor with your word processor, but let me substitute my full-fledged editor seamlessly.

I want your tool to share data easily, and to read the various files in the various formats I've collected over the years reliably.

I want to be able to automate your tool and make it work with my other tools.

I want your tool to overlap the functionality of my other tools so I can get by with just it in an emergency. But I don't want to be penalized for using more capable tools when it is necessary.

Inner Workings

I don't care what's under the hood. I don't care whether it's object-oriented or structured; I don't care whether it's written in COBOL or C++. Go ahead and use whatever you think is best. If you make a mistake, you lose. But don't try to confuse me with technology. All I want is a solution.

Customization And Automation

I want to be able to customize your tool, even in trivial ways like changing colors or icons, just to prove who's master—me, not it.

I want you to leave room in your menus and toolbars for two, three or four of my most important items so I can automate my most important tasks without drowning in macro languages or complex customization procedures.

User Interface

I want your tool to faithfully mimic the real world, and where that's not possible, to extend current metaphors in non-arbitrary ways consistent with mainstream directions. Don't create whole new interfaces built around small incremental improvements in limited areas. Let engineers design the engines; let writers, graphic designers, and users create the interfaces.

Product Support

Give me a built-in, on-line tutorial, with beginning and advanced lessons, for every facet of your tool. Provide context-sensitive help for every dialog box and screen item. Give me all reference information on-line and on paper. I need detailed, integrated, hyper-linked on-line reference information when I'm under deadline pressure. I want decent paper documentation when I've time to browse (e.g., for toilet-side or air-travel reading).

For paper documents, provide concise, comprehensive, well-organized manuals, not six or eight separately, bound booklets with no obvious relations between them. Put as much effort into designing the document as the product—it *is* part of the product. Use spiral or loose-leaf binding. Provide quick-reference charts and keyboard templates, including blanks for creating my own manuals.

Product Updates And Upgrades

Provide regular upgrades and easy access to updates. I'd rather wait for bug-free code than waste time on buggy early releases. Post bug fixes and driver updates on CompuServe or some other accessible public forum.

Product Performance

Both maximize speed and minimize storage. If you must choose, go for speed. Storage continues to get cheaper, but God has shown little willingness to give us more time.

Product Installation

Provide simple installation and *complete* un-installation routines. For the latter, remove *every* file and every setting in every system file.

Provide separate initialization files. Don't muck around with system files. Don't require your tool to be on the path; keep all its setup files in its startup directory. Don't put any files in the root directory. Use the main product directory as the root for all support files.

Document every file included with your product, and minimize the number of them. Provide a list of files required for a minimal installation, and a setup procedure to quickly clone a minimal installation from an existing one (for last-minute traveling).

Run your installation routine in the background, letting me accomplish something in the meantime.

Network Support

Don't store customization files in a common network directory. Better yet, store organizational level customization files on the network, and user-specific overrides locally.

In General

Make designers listen to me, not to the engineers building my tool. If your management doesn't support that philosophy, kiss your company goodbye.

Provide smooth transitions. I will probably never accept drastic changes to totally new ways of doing things. Evolve me gradually. Apply this to both hardware and software.

Signed

____

A (satisfied) (disgruntled) (former) user.

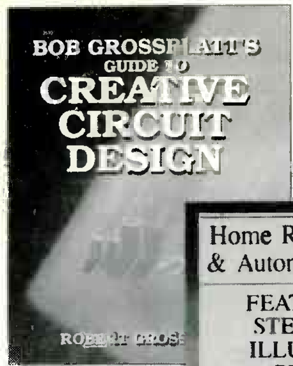
and pasting.

Auto-fill is special. Type "January" into a cell, drag the lower right corner of the cell across eleven adjacent columns, and Excel fills in the remaining months for you. It can do the same with other labels and arithmetic series.

Automatic table formatting allows you to select a range, choose a menu item, and automatically format the range in one of several attractive pre-defined styles. Although the style-selection dialog box allows you to preview styles, you cannot modify them or add your own.

There's also lots more horsepower under the hood, including workbooks that allow you to save several spreadsheets in one file, spelling checker, better printing capabilities, voice annotation (if you have a sound card), rotated text, and text centered over multiple columns. Many new analysis features

Continued on page 86



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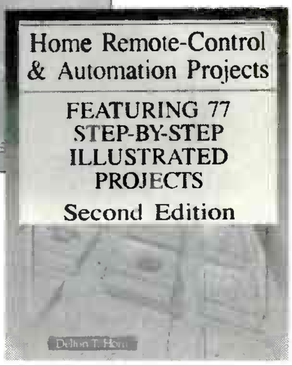

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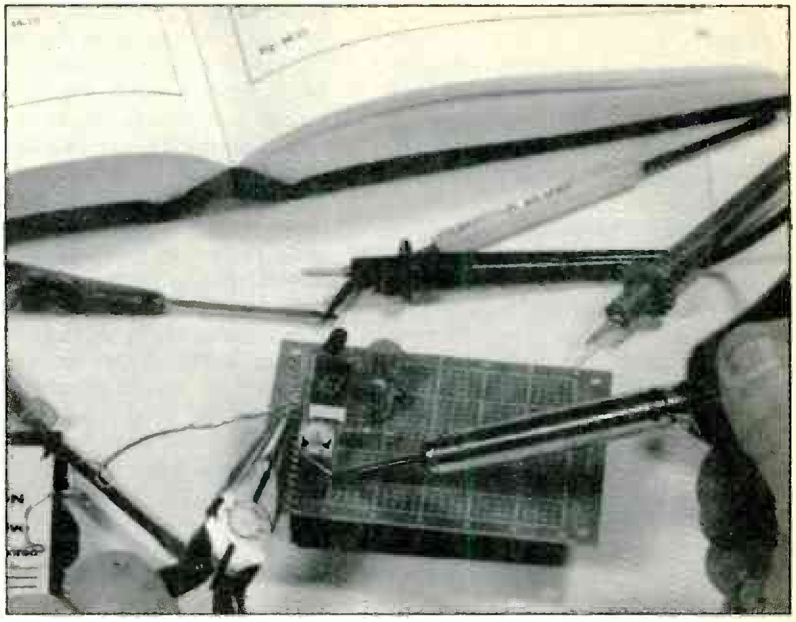

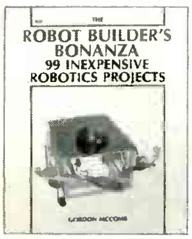

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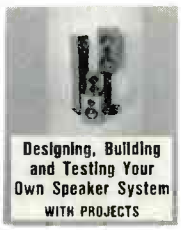

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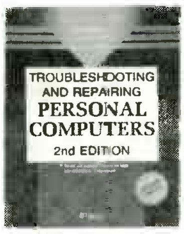

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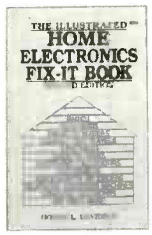

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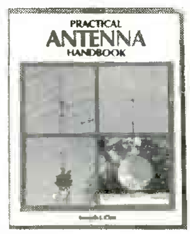

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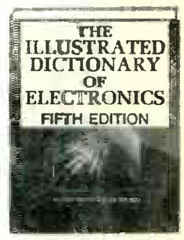

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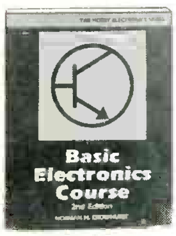

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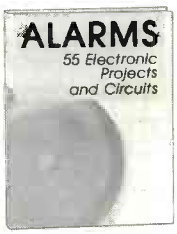

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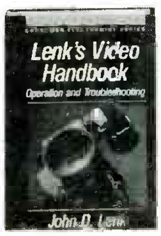

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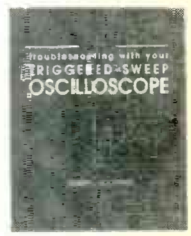

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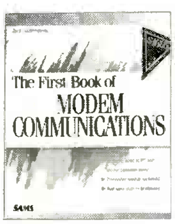

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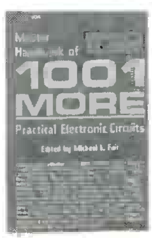

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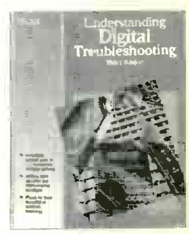

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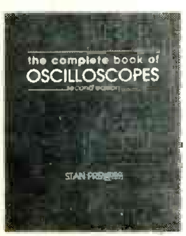

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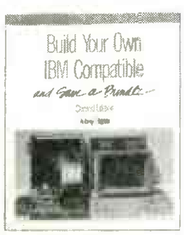

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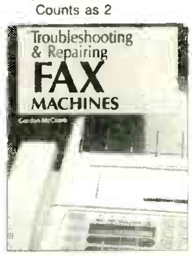

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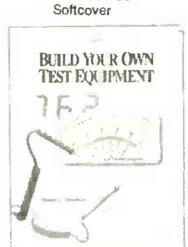

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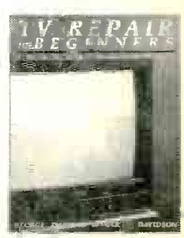

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COMPUTER CONNECTIONS

continued from page 81

for science and engineering, improved graphing, and quite a bit more are included as well.

Industry leadership

Microsoft shows true leadership with Excel 4.0; I look forward to seeing these improvements in other products, particularly Word for Windows. The gripers who complain about Microsoft's domination of the industry should understand that the company is doing so not by legal wrangling but by paying increased attention to user needs and delivering quality products to meet those needs.

In fact, Microsoft's domination appears likely to increase even more. We are headed toward the day when the word *computer* doesn't refer just to hardware, but to a complete solution that includes both hardware and software. And Microsoft is gearing up to provide a complete software solution, everything from operating system (DOS, Windows, NT) to word processing, spreadsheet, database (to be released this year), E-mail (likewise), and more.

When you buy a car you don't just buy an engine, you buy a solution for the problem of traveling. Sure, the engine is important, but for most people, even more important are the seats, the console, and the body style. Microsoft already dominates engines and is in the process of mastering the rest.

When you buy a car, you don't buy the engine here, the transmission there, the body elsewhere: You buy a complete solution. Computer buyers have never had that luxury. Soon, though, you'll be able to buy a single CD-ROM with a complete suite of applications under your fingers. You won't think of them as separate applications, they'll work together as if they were made to.

Microsoft will be the General Motors of the Information Age; Borland will be Ford; some combination of Novell, Lotus, and Symantec will be Chrysler; pieces of the remainder will end up as suppliers to the big three. Enthusiastic users may buy racing stripes and fancy carburetors from specialty houses, but most will stick with stock factory offerings.

OS/2 update

Shrink-wrapped copies of OS/2 2.0 finally hit the shelves. IBM has done a nice job with all the basic pieces. As reported here in the April issue, 2.0 does a better DOS than DOS. However, it still does not do a better Windows than Windows. Although you can now run Windows apps on-screen simultaneously with OS/2 apps, doing so is slow; in fact, slower on the same hardware than simply running Windows. In addition, the product currently supports Windows apps only in standard VGA mode. Windows 3.1 support is absent, and hard-disk requirements are two to four times that of Windows. However, IBM promises a 3.1 compatibility update in early summer, and Stac Electronics has confirmed development of an OS/2 version of Stacker.

OS/2 is still missing significant driver support, and system compatibility issues keep cropping up. However, IBM promises better driver support soon, and I have seen concrete evidence that IBM is trying to resolve OS/2's compatibility issues expeditiously.

Windows 3.1 promised to eliminate UAE's, and has not made good on that promise. OS/2 stands a good chance of providing a more stable environment than Win31, but still asks too many compromises in the way of speed, resolution, disk space, and device support. For now, I still prefer Windows to OS/2, and I think the vast majority of Windows users will too. IBM's best bet might be to position OS/2 against Windows NT, which makes more sense anyway. Then they should try to resolve current difficulties before NT rolls out. At least we'll have an apples-to-apples comparison. As they say in Michigan, go Blue! **R-E**

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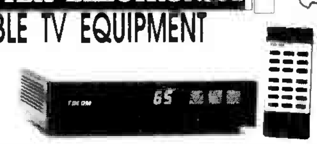

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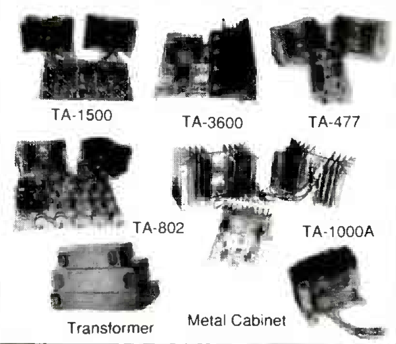

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TA-120MK2	35W Class'A' Main Power Mono Amp. ▲▲	31 50	42 80
TA-300	30W Multi-Purpose Single Channel Amp ▲	20.00	29.00
SM-302	60W +60W Stereo Power Amplifier (with Mic. input case & transfomer included)▲▲★	73 00	85.00
TA-323A	30W + 30W Stereo Pre-main Amp ▲	31 50	42.80
TA-377A	State of the Art Fully Complementary Systemmetrical Fet Pre-Amp ▲▲▲	59.95	75 00
TA-400	40W Solid State Mono Amp. ▲	28.00	34 93
TA-477	120W Mosfet Power Mono Amp ▲▲	68 00	85.00
SM-720	120W +120W AC/DC Stereo HI-FI & Pre-Main Amp (case & transfomer included)▲▲★	75 00	89.00
TA 800MK2	120W + 120W Low Tim Pre-Main Stereo Power Amp ▲▲	63 92	73 95
TA-802	80W + 80W Pure DC Stereo Main Power Amp ▲▲	45 94	59 72
TA-1000A	100W Dynamic Class "A" Main Power Mono Amp ▲▲	50 00	65.00
TA-1500	100W +100W New Class "A" DC Stereo Pre-Main Amp ▲▲▲	73 70	95 81
TA-2200	DC Fet Super Class "A" Pre-Amp ▲▲▲	47 70	58 24
TA-2500	HQ Pre-Amp w/10 band graphic equalizer ★		78 00
TA-2800	BI-FET IC Pre-Amp. w/3 way tone control ▲▲	48 90	63 57
TA-3000	Stereo Simulator (For Mono TV or Any Mono Source) ▲▲	27.00	38 50
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SM-222	7 Band Stereo Hi-Fi Graphic Equalizer ▲▲▲	26.80	38 80
SM-328	4 Channel Professional Color Light Controller ★		165 00
SM-333	Audio/Video Surround Sound Processor (case & transformer included)▲▲▲★	73 00	85 00
SM-666	Dynamic Noise Reduction ▲	26 00	34 00
SM-888	Universal Audio/Video KARAOKE Mixer Pre-Amp ★		155 00

	MISCELLANEOUS	KIT	ASSEMB.
TY-1AMK5	Battery Flourescent Light Driver ▲	8 50	10 50
TY-7	Electronic Touch Switch ▲	8 20	10 20
TY-8	Electronic Lotto ▲	15 00	21 00
TY-11A	Multi-Functional Control Switch ▲	6 19	8.79
TY-12A	Digital Clock w/Timer ▲	17 95	26 00
TY-13	Color Led Audio Level Meter ▲	20 15	26 20
TY-14	Electronic Shock ▲	8.25	
TY-18	High precision Sound Control Switch ▲	10 22	14 50
TY-20	V Shape color Led Level Meter ▲▲	21 45	25 00
TY-23B	3 Channel Color Light Controller ★		73 00
TY-25	Stereo Loudspeaker Protector ▲	14 85	20.85
TY-35	FM Wireless Microphone ▲	11 25	
TY-36	AC/DC Quartz digital Clock ▲	19.00	26 20
TY-38	Sound/Touch Control Switch ▲	12 00	15 50
TY-41MK5	Infrared Remote Control Unit(case,transmitter & receiver included) ▲▲▲	25 00	38.00
TY-42	Bar/Dot Level Meter ▲▲	24 15	33 81
TY-43	3½ Digital Panel Meter ▲	29 00	38 00
TY-45	20 Steps Bar/Dot Audio Level Display ▲▲	38 45	46 14
TY-47	Superior Electronic Roulette ▲▲	19.46	27 24
#016	10,000u/f 80V Capacitor (Suggeted for TA-3600 TA-477,TA-1000A& TA-802)		23.00
#017	8,200u/f 50V Capacitor (Suggeted for TA-802, TA-120MK2)		13.00
#021	NOBEL (Single)Variable Resistor (Suggested for TA-3600, TA-477,TA-1000A & TA-120MK2)		12 00
#022	ALPS (Dual)Variable Resistor (Suggested for TA-377A TA-2200 & TA 802)		22 00

	REGULATORS	KIT	ASSEMB
TR-355A	0-15V 5A Regulated DC Power Supply (case transformer not included) ▲	15 65	21.76
TR-355B	0-30V 3A Regulated OC Power Supply (case, transformer not included) ▲	15.65	21.76
TR-503	0-50V 3A Regulated DC Power Supply w/Short Circuit & Overload Protection (case, transformer not included) ▲▲	16.75	23.65

	DIGITAL METERS AND COUNTERS	KIT	ASSEMB.
SM-43	3½ Mult Functional Led D P M (w ABS plastic case) ▲▲	34 50	43 00
SM-48	4½ Hi-Precision D P M ▲▲▲	38 00	48 00
SM 48A	4½ Hi Precision D P M (w/ABS plastic case) ▲▲▲	41 20	52 00
SM-49	3½ Multi-Functional LCD O M P (w/Hold Function) ▲▲	36 00	44.50
SM-100	150 MC Digital Frequency Counter ▲▲▲	79 00	90 00

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MODEL	H"	X W"	XD"	MATCHING	PRICE
LG-1273	3"	12"	7"	TA-2800 TA 377A, TA-2200	23 85
LG-1684	4"	16"	8"	TA-323A TA-377A TA-2200	28 50
LG-1924	4"	19"	11½	TA-802, TA-1500, TA120MK 2, TA-800 MK2, TA-1000A	34.50
LG-1925	5"	19"	11½	TA-477 TA-800MK2, TA-1500, TA-1000A TA-3600	38 00
LG-1983	2¾"	19"	8"	TA-377A TA-2800 TA-2200 TA-120MK2	30 50

POWER TRANSFORMERS

MODEL	DESCRIPTION	MATCHING	PRICE
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#002	36V x 2 3A	TR-503, TA-323A, TA-400, TA-300 TA-377A	23 00
#003	40V x 2 6A	TA-477	30 00
#004	24V x 2 6A	TA-120MK2	23 00
#005	26V x 2 3A	TR-355B	17 00
#006	18V x 2 5A	TR-355A	17 00
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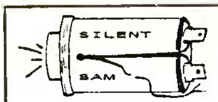

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8" paper cone subwoofer with polymer resin coating. Dual voice coils with 8 ohm impedance per coil. Ported plate speaker with integral crossover. Frequency response: 30-500 Hz. 50 watts RMS, 100 watts maximum power handling capability. Sensitivity: 90 dB 1W/1M. Dimensions: 10-5/8" (W) 14-5/8" (L) x 3" (D). Hole dimensions: 9" (W) x 13" (L). Net weight: 8 lbs.

#RH-300-430 Sug List $192.95 $85.50 (1-3) $79.90 (4-up)

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#RH-294-130 $139.90 (1-3) $128.60 (4-up)

8 Ga. In-Line Fuse Holder

Screw together Bakelite fuse holder with 8 ga. wire. For use with AGU type fuses or regular AGC fuses when spring spacer is used. 50 amp max at 12 volts.

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#RH-020-950 $49.95 Kit

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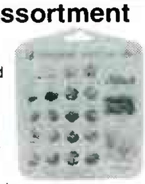

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ASK R-E

continued from page 15

I'll assume that you've already tried getting in touch with the original equipment manufacturers and found them to be either no help or out of business. There are several companies that make new tape heads and also have tape-head reconditioning services.

Here are two companies in the tape-head business and if they can't help you, the chances are they'll be able to direct you to someone who can.

International Electro Magnetics, Inc.
Eric Drive and Cornell Avenue
Palatine, Illinois 60067
(312) 358-4662

Nortronics Company, Inc.
8101 Tenth Avenue
Minneapolis, MN 55427
(612) 545-0401

There's no guarantee that either of those companies will have exactly what you need, but I'd be surprised if they can't supply something similar that will work just as well. **R-E**

EQUIPMENT REPORT

continued from page 23

CompuScope Lite card and software. At $595, the product is a price/performance leader. However, many sophisticated users will find it inadequate for their needs. The $995 64K version adds considerable measurement power, as do five *GageCalc* software modules, each priced at $100. One module, for example, lets you add, subtract, multiply, and divide signals, and creates a dual-channel digital voltmeter. Another lets you differentiate and integrate any signals displayed by CompuScope, while yet another lets you use the card as a frequency counter. Even without the add-on modules, you are free to write your own custom programs to manipulate and measure signals. And that's the real beauty behind PC-based test equipment. **R-E**

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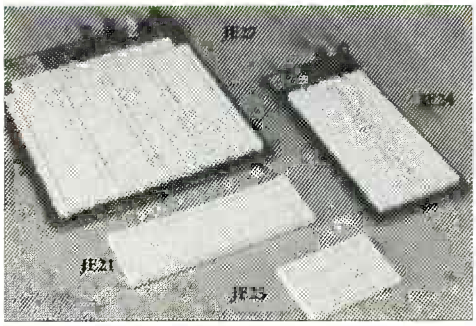

Jameco's long-lasting breadboards feature screen-printed color coordinates and are suitable for many kinds of prototyping and circuit design. Larger models feature a heavy-duty aluminum backing with voltage and grounding posts.

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
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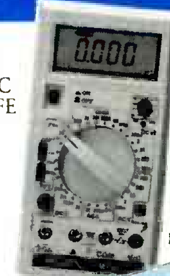

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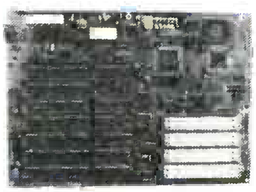

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2N2222A	.25	1N4148	.07
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2N3904	.12	1N270	.25

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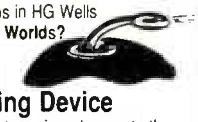

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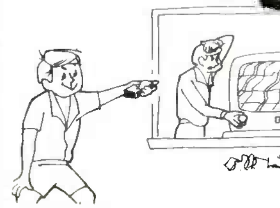

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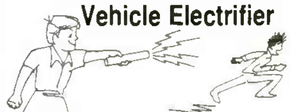

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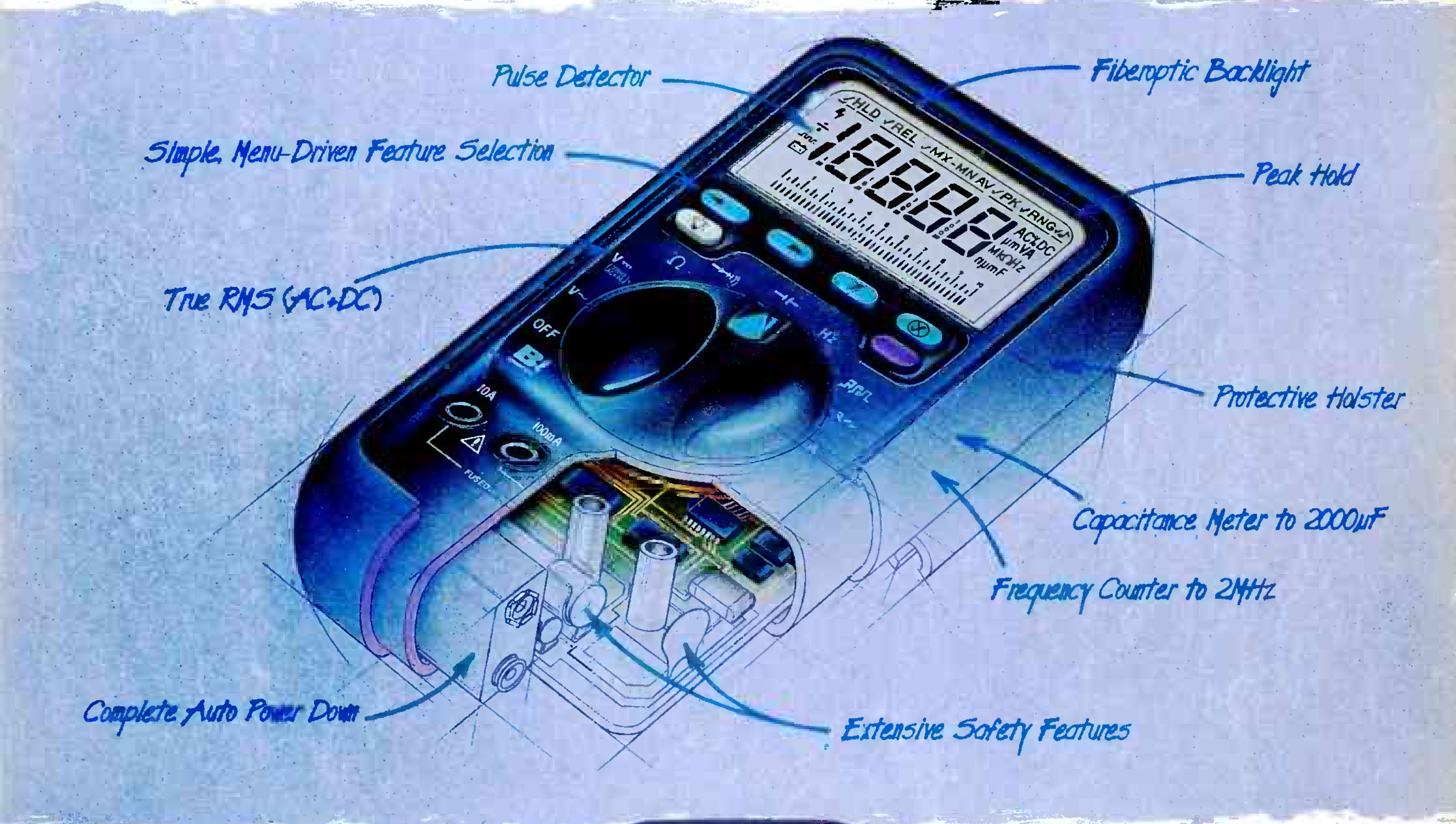

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