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MAY 1990

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Three year warranty	Three year warranty	True-rms ac
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		4½ digit mode
		Backlit display
		Three year warranty

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Meet the meter that brings an entire test bench to your job. The versatile Fluke 80 Series do-just-about-everything "Multi" Meter.

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Radio-Electronics
Vol. 61 No. 5

May 1990

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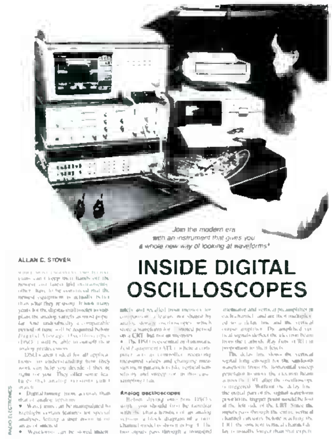
TECHNOLOGY

CIRCUITS

COMPUTERS

DEPARTMENTS

PAGE 81



PAGE 44

AND MORE

ON THE COVER

You must have noticed that video sync signals are often scrambled or altered in some way. That's the case if you try to copy a macrovision-encoded tape; but sometimes just trying to view the tape also presents problems. You'll run into similar sync problems if you try to watch a scrambled cable channel without the proper decoder or if you try to watch one scrambled show while recording another. . .and that's inconvenient. But not if your build our Universal Descrambler. See page 37.

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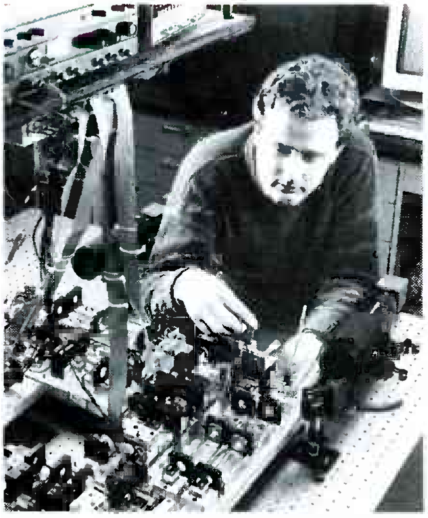
WHAT'S NEWS

World's first digital optical processor

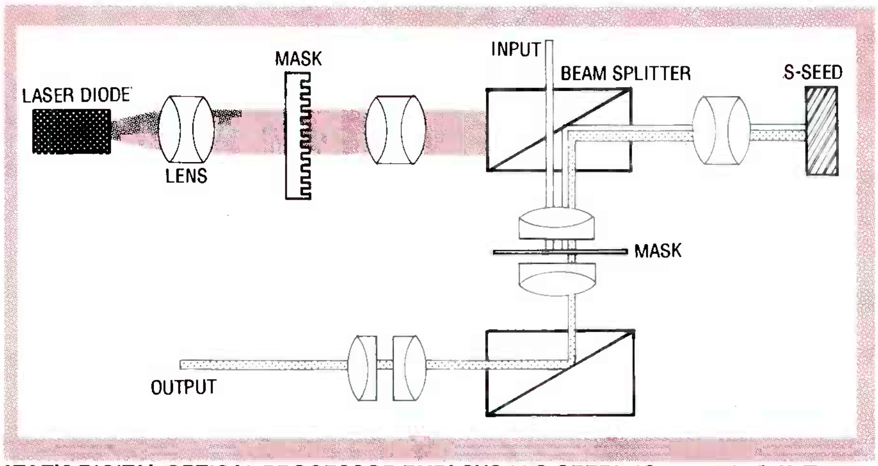
Scientists at AT&T Bell Laboratories (Holmdel, NJ) have built an experimental machine that uses light, or photons, rather than electrons to process information. The wireless processor uses lasers to transmit information internally and optical devices to process the information.

Since optics can handle many light beams at once without interference, future optical processors might be able to process more than 1,000 times as much information as their electronic counterparts. Although the digital optical processor's capabilities are "very modest," the experimental machine demonstrates that the technology is possible. AT&T's optical processor operates at 1 million cycles per second (slower than most personal computers), but its developers believe that operating speeds of several hundred million cycles per second (which is faster than most supercomputers) can be achieved in the near future.



SCIENTIST AT AT&T Bell Laboratories, Michael E. Prise, adjusts a component of the first digital optical processor.

"This processor is a major step toward such a computer," said Alan Huang, head of the Optical Computing Research Department, where the processor was built. However, he added that "significant research must be done before the new technology can be turned into commercial products." Huang predicts that the first uses of the digital optical processor will involve problems requiring parallel processing, with applications in speech and vision recognition, switching, and general computing to follow as the price becomes competitive.



AT&T'S DIGITAL OPTICAL PROCESSOR EMPLOYS 32 S-SEED's (*S*ymmetric *S*elf-*E*lectro-optic *E*ffect *D*evices) on each of four arrays. The microscopic optical switches have a potential speed of 1 billion operations per second and each can drive two inputs. Each S-SEED contains two mirrors with controllable reflectivity to infrared light, and functions as a NOR gate. Each array contains two 10-milliwatt modulated laser diodes that emit in the near infrared and are divided into many separate beams that provide communications between the arrays. The lenses and masks that separate the arrays serve the same function as connective wiring in an electronic processor. Input/output functions may be accomplished via optical fibers or laser beams transmitted in free space.

Nationwide radio-computer network

In a joint venture, IBM and Motorola have introduced a radio network that will let portable-computer users link to central computers from almost anywhere in the U.S.—without using telephone lines. The 50–50 partnership, which is based in Lincolnshire, IL under the name of Ardis, combines similar services previously offered by Motorola to clients in New York, Chicago, and Los Angeles with a nationwide in-house system designed by Motorola for IBM service technicians. A Motorola radio modem allows virtually any brand of portable computer to be linked to the Ardis network.

The new system, scheduled to begin in April, is said to have several advantages over its major data-communications competitor in the portable market: cellular phones used with modems. The Ardis network is on line all the time, so there is no need to dial up a computer. Messages that are sent to the terminal when the user isn't monitoring it can be stored and recalled later. And, since radio waves of the proposed frequency can travel where higher-frequency cellular-phone waves cannot, the service can be used to link various locations inside a building.

Potential users include police officers, field-service personnel, delivery workers, and real-estate brokers. Billing is to be based on the amount of use, with the projected cost per terminal per month estimated to range between $100 and $150. The cost per modem is not yet available. **R-E**

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New from OPTOELECTRONICS

Introducing two advanced hand held frequency counters incorporating many unique features usually found only on laboratory bench counters.

These counters are designed for virturally every measurement application from DC through Microwave including measuring RF transmission frequencies at the maximum possible distance.

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In addition, The Model UTC3000 features:

- In addition to Frequency, additional Functions Include: Period, Ratio, and Time Interval and Average.
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VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **HDTV proponents combine.** Two of the leading proponents of high-definition TV systems for the U.S. market have agreed to merge their efforts at developing a system, thereby significantly narrowing the field of candidates for compatible HDTV broadcasting here. In the systems merger, Philips Consumer Electronics (part of the Dutch Philips group) agreed to work with the combination of Thomson Consumer Electronics (RCA and GE brand TV sets), NBC, and the David Sarnoff Research Center in developing an HDTV system. Thomson is a French-owned company that bought the RCA and GE consumer-electronics operations from General Electric. The Sarnoff Center is the former RCA Laboratories, now a part of the Stanford Research Institute.

The two groups had been developing separate systems. Philips had been working on a single-step approach, permitting a move from the current broadcast system to HDTV. The NBC-Thomson-Sarnoff combine has espoused a system called *ACTV* (*A*dvanced *C*ompatible *T*elevision) that provides a compatible widescreen picture with improved (but not high) definition as an intermediate step. Philips now has agreed to accept the two-step approach. In turn, NBC-Thomson-Sarnoff has committed itself to the "simulcast" approach to HDTV. That involves the use of a second channel for HDTV, while continuing to broadcast the same program in the standard NTSC system or one compatible with it, instead of maintaining NTSC compatibility on one channel while using a second as an "augmentation" channel to add the HDTV information. The new partners-in-research urged other system proponents to join with them in developing a unified industry approach to HDTV.

Although the merger of systems was hailed in most quarters as a positive step toward an American HDTV system, there were those observers who saw some danger in the endorsement of a two-step approach to HDTV. Those expressing apprehension were concerned that the extended-definition step (called ACTV I) would satisfy the vast majority of viewers—particularly since it calls for compatible widescreen transmission—and thus would preclude the future development of a true high-definition system.

• **Return to the 1950's.** Old TV brand names continue to be revived—some 30 years or so after they disappeared. The latest comeback is the Majestic brand, a TV line that will be fielded by a new company affiliated with a former major distributor of RCA TV sets. RCA recently eliminated most distributors, and the Majestic line is being developed to fill the void and provide a brand for distributors who traditionally serve smaller neighborhood dealers. The revival of the Majestic line comes less than a year after the Crosley TV line made a comeback under more-or-less the same circumstances—a line of products to be sold to dealers through distributors (**Radio-Electronics**, August 1989). Other brand names that were dropped and resuscitated by companies unaffiliated with their originators include Emerson, Capehart, DuMont, and Symphonic.

Note: The Crosley line was designed to replace the Philco brand, which is being discontinued (on TV sets, at least) by its owner, Philips Consumer Electronics. In case you're wondering what brand will be revived next—how about Philco?

• **Pioneer's hot "secret."** Pioneer has introduced a videodisc player in England that is selling so well it's going to be taken off the market. In fact, Pioneer's *Model 1450* is the only videodisc player that is selling worth a darn in the U.K. The reason that player sales have been so poor is the lack of recorded material in the PAL format.

The secret of the *1450* is that it can play NTSC (U.S. standard) videodiscs through British PAL TV sets (as well as PAL recordings, of course). Pioneer has never conceded that the player will do that—but it's an open secret. With some 7,000 titles available on NTSC videodiscs, videophiles are snapping the machines up. However, Pioneer is becoming increasingly nervous about the whole thing, concerned that it might jeopardize its relations with the American programs' copyright owners—some movies are available on U.S. discs before they're even released to theaters in Europe. So the hottest videodisc player is likely to be replaced by another model that can't play NTSC discs—in effect, the Model 1450 is going to become a victim of its own popularity. **R-E**

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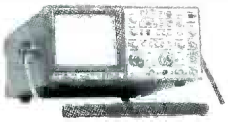
Digital Storage Scopes



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V-425	40MHz	D.T., 1mV sens, DC Offset, CRT Readout, Cursor Meas	$1,070	$849	$221
V-660	60MHz	D.T., 2mV sens, Delayed Sweep, CRT Readout	$1,295	$1,145	$150
V-1065	100MHz	D.T., 2mV sens, Delayed Sweep, CRT Readout, Cursor Meas	$1,895	$1,670	$225
V-1100A	100MHz	Q.T., 1mV sens, Delayed Sweep, CRT Readout, DVM, Counter	$2,450	$2,095	$355
V-1150	150MHz	Q.T., 1mV sens, Delayed Sweep, Cursor Meas, DVM, Counter	$3,100	$2,675	$425

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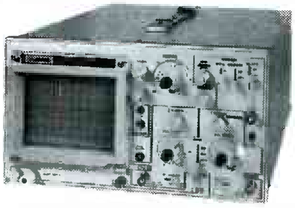

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ANY SCOPE

SCOPE PROBES

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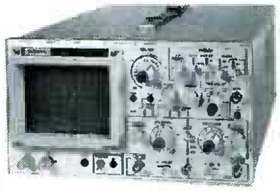
35MHz Dual Trace Oscilloscope



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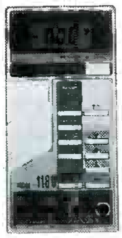

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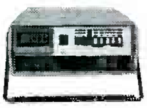

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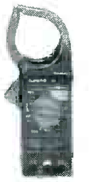

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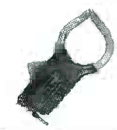

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Works with most DMM

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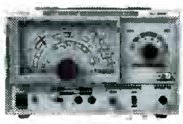

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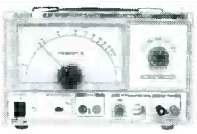

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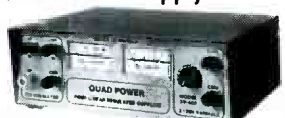

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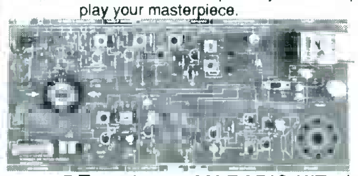

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VOLTAGE READOUT

Some time ago I bought a variable power supply for my bench. I had the option of getting a fixed supply but decided that a variable one would be more flexible. That has turned out to be true for my work but the only drawback I've come across is that I don't have any handy way of pre-setting particular voltages. Do you have any easy addition I can build that will let me know when my supply is outputting five, twelve, or fifteen volts?—R. James, Brooklyn, New York

It seems to us that all you have to do is use a voltmeter but that might be a pain in the neck—especially if you want to have the ability to switch back and forth between various output voltages.

Fortunately, there's a simple way you can add some indicators to your supply using only a handful of parts and some LED's as indicators. The circuit shown in Fig. 1 is just about the easiest voltage-detection circuit we can come up with. You'll notice that there's a fairly loose tolerance for the Zener diode. That is intentional since it's often hard to find Zeners with really specific break-

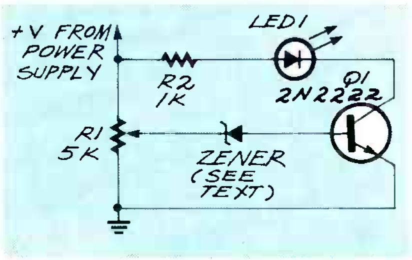

FIG. 1

down voltages. You can use the trimmer to tweak the voltage applied to the Zener and have it conduct at a particular voltage. When the Zener diode is triggered, the transistor will turn on, and the LED will then light.

The values in the schematic will work for a five-volt indicator but you don't have to be a rocket scientist to make the changes needed to have it work for just about any voltage you want. The only thing that has to be done is to change the Zener. Since you're using a trimmer to adjust the circuit's trip point, keep the Zener rating a bit below the voltage you want to detect. That means a 10- or 11-volt Zener for a 12-volt circuit, a 13- or 14-volt Zener for 15 volts, and so on.

You'll need a meter to set the trip points but once that's done, the circuit will reliably indicate the output voltage. Remember that you'll need a separate circuit for each voltage you want an indicator for. The parts are cheap and the circuit is minimal so expense and space shouldn't be a problem.

The circuit is drawing its power from the supply, but the impedance is high enough to keep it from loading down the supply. If you find that the draw is too much (although I can't imagine that), increase the value of the trimmer. The rule here is that the larger the value of the trimmer, the lower the draw but the harder you'll find it is to calibrate. Try to keep the trimmer potentiometer under 15K.

VIDEO UPGRADE

I'm about to spend some money to upgrade the video display on my IBM-compatible computer. I currently have a monochrome graphics card and an amber monitor but I want to move on to color. The problem I have is deciding between EGA and VGA, how much memory to get for the video card, and what's the difference between register compatible and BIOS compatible?—J. Robert, Chalfont, PA

One of the most paradoxical things about computers is that while they might be designed to make your life easier, trying to understand them can be anything but easy. They've given a whole new meaning to the idea of standards.

But let's take your questions one at a time.

All of the IBM color systems are designed to be downwardly compatible with each other—or at least that's what it says on page 12 of the manual. When the VGA standard was introduced with IBM's PS2 series, there was a big price differential between it and EGA, the previous system. The way things stand now, VGA cards aren't much more expensive than EGA cards (only about \$75 to \$100 in difference—the same goes for the price of the monitors themselves), so it really doesn't pay to get an EGA system. VGA is capable of much more colors and better resolution, and since you're going to be using it for a few years, it pays to get the better system. Remember that you buy the hardware to run the software and, as time goes by, more and more software is going to show up that's written exclusively for VGA.

If you do go with an EGA system, you might want to upgrade to VGA in the future, and the chances are good that you'll have a hard time unloading the EGA card and monitor.

The issue of memory is a bit simpler. The more memory you have on the card the better the resolution. EGA cards have the hardware to talk to a maximum of 256K but VGA cards can handle half a megabyte. In the original IBM cards, the EGA standard was 64K (expandable to 128K) and the VGA standard had a maximum of 256K. As more manufacturers began making cards,

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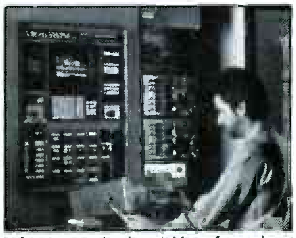
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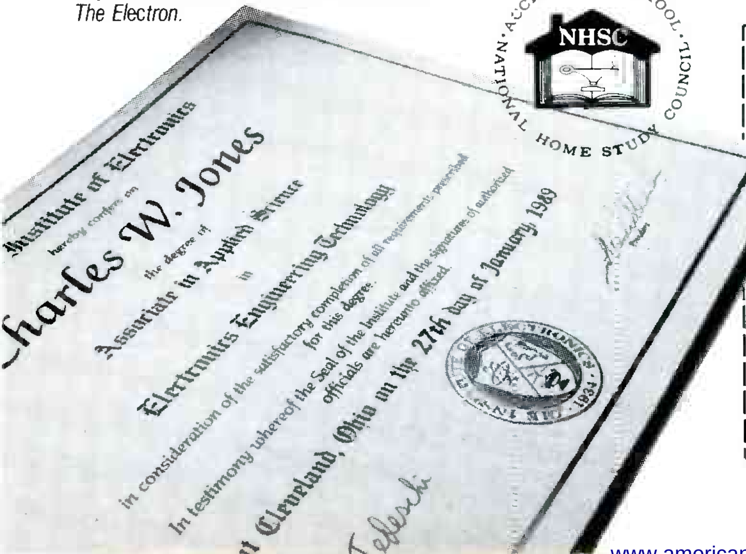

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they also began adding features to their products that went beyond the IBM specifications. That usually meant higher display resolutions.

The problem with that is that having the extra capability on the card is rather useless unless software knows how to take advantage of it. Since all the expanded display capabilities of the various cards are outside the standards set down by IBM, most software houses don't support them. You might be able to get 1024 × 768 resolution from a 512K VGA card but, since that isn't a standard resolution, the chances are that your favorite paint program has no driver to support it.

Most card manufacturers supply software to adapt a few major pieces of software (AutoCAD, Microsoft Windows, GEM, etc.), to the higher resolutions that their hardware can display. The rule here is to make sure your software can run on the hardware you buy.

The question of BIOS and register compatibility is one of hardware and the final difference is mostly speed. Both EGA and VGA cards are microprocessor-controlled devices and, as such, they need instructions to work—and that's what the BIOS is. The BIOS takes video commands from the computer and translates them into values that are then stuffed into the internal registers of the display microprocessor.

Being "BIOS compatible" means that the entry point for the video routines in the card's firmware is the same as those in the IBM. Being register compatible means that the microprocessor is organized in the same way as the IBM. The former is software compatible and the latter is hardware compatible.

People who write graphics software are always trying to make things happen as quickly as possible, and the fastest way to drive a display is to write directly to the registers. Talking to the BIOS is both slow and limiting.

The bottom line is that you should get yourself a VGA system and it makes a lot of sense to get a VGA card that specifically features both BIOS and register compatibility.

The only other thing to keep in mind is that most of the enhanced display features of a 512K VGA can be used only on a multisync

continued on page 32

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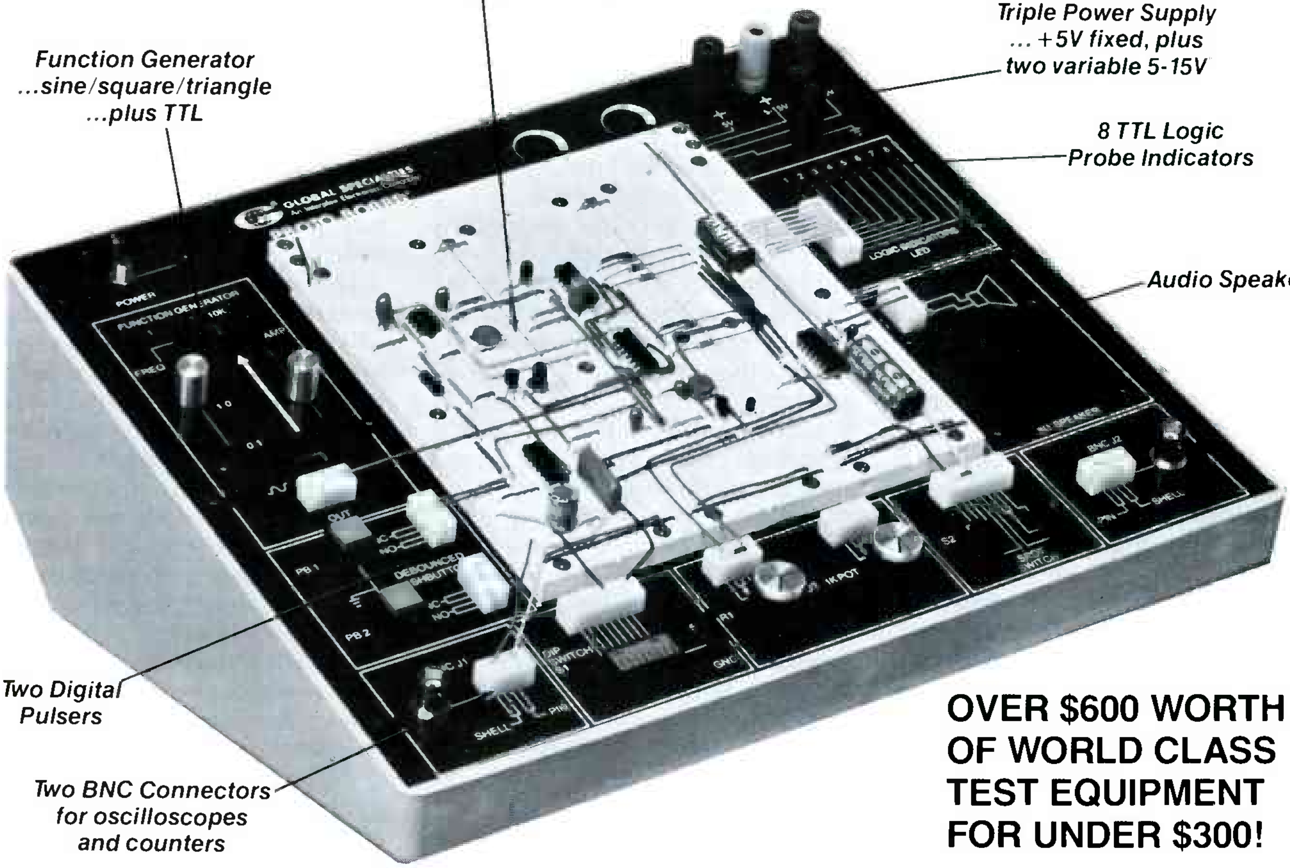

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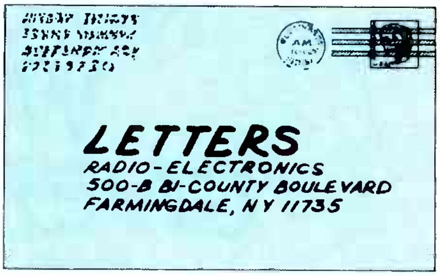

AVOIDING AM INTERFERENCE

The "Ask R-E" column in the March issue of **Radio-Electronics** explained to a reader how to rid a stereo of AM-radio interference. As Chief Engineer of a 50-kW directional AM station (our studios are located in about a 20mV/m RF field) I can think of a few easier solutions to try first. I almost never have to resort to soldering caps across an input.

Ground the amp with a decent piece of wire to a good ground. If that doesn't eliminate the interference, ground the rest of the components to the same ground. Or you might try an AC-line RF filter. Often the RF gets in through the power supply. The filters can be obtained disguised as computer surge protectors—but make sure they have the filter in them as well as the surge protector. Also, try to keep the speaker and component interconnection leads as short as possible.

Here are some tips for telephone interference. If you hear the station on all the phones on your line, call the phone company; it's often a wet or faulty connection out on a pole that causes the audio to be detected. If the interference is on only one phone, you can try a 0.01-µF, 200-volt capacitor connected across the red-green pair. If that doesn't work, AT&T phone centers sell an effective filter for just that sort of problem.

As a last resort, call the engineer at the station for more advice. We are not obligated to work on your equipment, but it is in our best interest as good neighbors to help you get rid of the problem.
STUART ENGELKE
Whitehouse Station, NJ

AND MORE....

The solution proposed in "Ask R-E" for "Overpowering AM Interference" works fine on interference from VHF and UHF stations, such as FM and TV, but you can never get enough capacitance across the input stages to bypass an AM broadcast radio station without ruining the audio response of the stereo amplifier. In many cases the medium- and high-frequency interference rides into the set via the speaker leads—the longer the lead, the worse the interference.

The cure is to choke it off or bypass it. The bypass-capacitor method is cheaper and easier. A 0.1-µF bypass capacitor connected across each of the speaker terminals on the back of the set usually eliminates all of the interference. What is particularly nice about that cure is that you don't have to enter the stereo cabinet to complete the job.

The other solution involves choking the signal before it enters the set, using RF chokes. One very-low-resistance RF choke would be used in each lead. The best way to choke it off is by winding the speaker leads around a ferrite rod or torroid core as close to the set as possible.
HAROLD ISENRING, W9BTI
Colgate, WI

BRAIN POWER

I subscribe to **Radio-Electronics** and I've always enjoyed Don Lancaster's *Hardware Hacker* column—particularly his item on the "Santa Clause Machine," which he picked up at least a week before any of the other publications that I read did.

I was extremely displeased by misinformation in the January 1990 column. One does not need to understand the workings or structure of the brain to realize that the stated capacity of "four billion memory bits or so" must be an infinitesimal fraction of its actual capacity. For an example, let's use the CD platter analogy, but this time let's imagine the CD's are storing digitized music: How many songs do you think the average person could identify at age 40? How many CD platters would it take to hold those discrete memories alone? Now, how much memory would it take to store the memories of events and people that might be associated with the hearing of those songs? And how much to store the sights, smells, temperature, and tactile sensations accumulated over the span of 60 years?

I am equally disturbed by Mr. Lancaster's "threshold effect." Computer languages, operating systems, expert systems, etc., are just algorithms. Those algorithms could be carried out by a computer or by people using filing cabinets and index cards. Increasing a computer's memory space does not automatically imply the ability to create more sophisticated algorithms. At the most, it might inspire some person to think of a more sophisticated algorithm to take advantage of the new, more powerful machine.

I am familiar with the theory of computers reaching a certain memory size and "waking up" (see Robert A. Heinlein's *The Moon is a Harsh Mistress*), and perhaps a certain number of synapses could be the only requirement for intelligence. But even if that were true, Mr. Lancaster's estimate is staggeringly inadequate.

Just look at existing systems. My desktop workstation at my job is linked to a network that has about 3.5 gigabytes of disk memory. That is by no means a large network; in fact, there are only 14 workstations on it. But that is already seven times the capacity of his original 4 gigabit "human brain" capacity. That network is hooked into the division

LAN, where it can access another 5 gigabytes or so. If we consider this very typical computer installation as one of (shall we underestimate) 500 local computer networks hooked to the internet .... So far I have seen no signs of that network waking up. Nor has it inspired anyone to create a new category of algorithm that will change the face of the world (unless you'd place a destructive virus in that category).

Hardware Hacker and other such information sources are the forces that help shape the technical minds of this and other countries. When such poorly thought out concepts are presented as facts, I worry that someone might believe them and set us all back a few paces. I would hate to go back to the times when some people were afraid of the phonograph because it could "talk."

JON ROLPH
San Diego, CA

EASIER IC REMOVAL

Regarding "Chip Removal" (*Ask R-E*, **Radio-Electronics**, March 1990), I was sad to see the answer given. The first method mentioned, using a solder pot and extractor, requires equipment not likely to be available to the average home technician. And, as you suggested, the chances of failure are very high.

A method that has been around for many years—the only one approved by government organizations—will work, and with practice it is virtually foolproof. Dip "solder-wick" desoldering braid (the fine braid jacket from coax will do nicely) into liquid flux. Hold the end on the joint to be cleaned and press a hot iron on the braid above the solder joint. The joint will almost instantly be as clean as it was before the DIP was first installed. Each joint can be treated that way, and the chip will be easy to remove.

I would recommend practicing on a defunct board to get a feel for the best iron heat and the wick and iron placement. A somewhat hotter iron than usual is best so that the heat is on the board a minimum time, to avoid damaged components and loosened foil. After each solder joint wicking, the loaded end of the braid is cut off, dipped in liquid flux again, and moved to the next joint.

JOE D. PERDUE
Nellysford, VA

IMPROPER IMPEDANCE MEASUREMENTS

Impedance measurements do indeed conjure up an image of complex test equipment and tricky calculations. However, the method suggested in Mike Rogalski's "Test Methods" (**Radio-Electronics**, March 1990) will not make things easier.

When the impedance of a signal source is complex—that is, consists of resistance and either inductive or capacitive reactance—there is no fixed relationship between the applied resistive load, the resulting drop in output voltage, and the equivalent resistance of the source impedance. The reason is that the phase angle of the impedance vector is unknown. A bridge, such as the Wheatstone type, drives the unknown impedance with a signal of its own and therefore obtains phase-angle information—the phase angle between the voltage across the unknown impedance and the current the bridge provides to produce that voltage.

Mike's method will work for signal sources that are generally purely resistive, such as the line or speaker outputs of audio equipment. However, the drop in output when R1 equals the signal source impedance is not 3 but 6 dB—half the open circuit voltage. One must be careful when measuring the output impedance of audio power amplifiers that employ large amounts of voltage feedback since their dynamic impedance is very low (on the order of fractions of an ohm). *Do not attempt this measurement without experience.* That could be the subject of a complete article in itself.

ARMAND LUCCHESI
Jersey City, NJ

ETCHING TANK TIPS

Regarding the article, "Make Your Own Etching Tank" (**Radio-Electronics**, December 1989), I'd like to add a couple of pointers.

I built the board using 5/16-inch Plexiglas that I cut with a radial arm saw using a plywood blade. It made a smooth cut, and I didn't have to file or sand any edges. Slow is the way to go when cutting the Plexiglas! As no cement was suggested in the article, I asked at my local hardware store and was advised that methyl-ethyl-ketone would work as

continued on page 35

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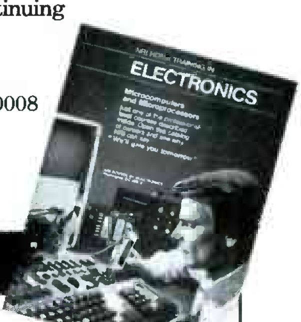

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LONG TAKEN FOR GRANTED, THE 60-Hz power lines criss-crossing our neighborhoods and running through the walls of our homes are emerging as a potential health threat. The issue is being discussed more and more frequently in the popular press, and it shows no signs of going away.

The subject has been studied by many respected organizations, including the World Health Organization, the American Institute of Biological Sciences, and the New York State Department of Health. There seems no doubt that exposures to ELF (*E*xtremely *L*low *F*requency) magnetic fields can cause biological effects. Just what effects are unknown at this time, and many studies are underway to determne safe exposure levels. However, the report issued by the New York State Department of Health recommended that a major research be undertaken by utilities, appliance makers, and the like to find ways to reduce exposures to ELF magnetic fields in homes.

We're not holding our breath waiting for the scientific community to come to firm conclusions regarding the relative safety of exposure to the 60-Hz magnetic fields generally assumed to be harmless—the studies will take years, and conflicts are sure to arise. Because we're so entrenched in our power-generation and -distribution system, it's unclear whether we'll be willing—or able—to change even if the threat is substantiated.

However, it seems prudent to us to at least be aware of the potential danger, and to be aware of the strength of fields we encounter every day. We recently found a good way to do just that: the model *IER-109* 60-Hz Magnetic Field Meter from Integrity Electronics and Research (558 Breckenridge Street, Buffalo, NY 14222; 716-886-6985).

The *IER-109* measures magnetic field intensity, or magnetic flux density, in three ranges: 2, 20, and 2000 milligauss. A narrow bandpass filter gives the unit a sharp frequency response centered around 60 Hz—its 3-dB bandwidth is specified as 11 Hz. That sharp response is important because harmonics can cause havoc with proper measurements.

The meter measures roughly 3×4×7 inches and weighs about a pound. It features a 3-1/2-digit LCD readout and runs on a single 9-volt alkaline battery.

An alarm feature allows you to pre-set an intensity level above which you want an alarm to sound. If you wish, the alarm can be turned off, and the alarm condition will be indicated by a front-panel LED.

For those more interested in total exposure than simply the intensity at a given instant, the *IER-109* features a 200-millivolt output to a recorder for dosimetry measurements.

Using the meter

Since some reports have indicated that continuous exposure to fields greater than 3 milligauss from power lines have been linked to increased incidence of childhood leukemia, we set the alarm for that level and examined various situations where we might receive chronic exposure. In front of the computer on which this report was prepared, the field was measured at 1.5 milligaus at the normal operating position. Under an electric blanket, the field was measured at 66 milligaus! It's not surprising that such blankets are often referenced in reports concerned with magnetic-field safety. The field inside the wall closest to our power-line drop was better than 4 milligauss, but fell rapidly only a few inches from the wall. Since our test site was not located near a distribution transformer, that was expected.

The *IER-109* sells for $595. Because many potential customers may be curious about their field exposure, and not need the meter on a day-to-day basis, Integrity also offers a rental service for a fee of $50 per week. It seems a small price to pay for peace of mind. **R-E**

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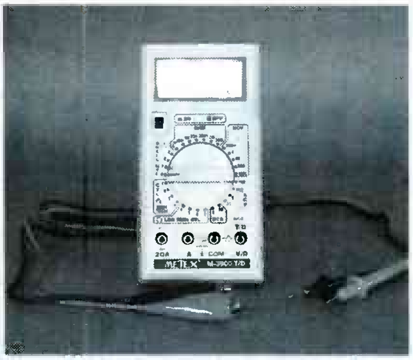


WE ALWAYS CRINGE A LITTLE BIT WHEN we have to take our digital multimeter out to our car to check on the condition of its battery, or to diagnose a wiring problem. There's really no logical reason for that, except that it just doesn't seem right to get grease on our expensive, high-accuracy instrument—even though the meter's seals will protect it. That meter just doesn't fit in with the wrenches and our other automotive tools.

We have, however, found a new digital meter that cries out to be used in automotive applications: the Metex 3900, available in the U.S. from Jameco Electronics (1355 Shoreway Road, Bellmont, CA 94002). The Metex 3900 adds tachometer and dwell-angle functions to the usual resistance, current and voltage ranges.

Basic specifications

The *M-3900* is housed in a rugged, yellow plastic case that measures about 6×3½×1¾ inches. Its front panel features a 3½-digit LCD readout, a 30-position rotary function selector, four input jacks, and a power switch. A 9-volt battery provides power to operate the meter.

The meter offers five ranges, from 200 millivolts to 1000 volts, for measuring DC volts. The specified accuracy is ±0.3%, +1 digit. Two AC voltage ranges, 200 and 750 volts, provide a worst-case measurement accuracy of 1.2%, +3 digits. Both DC and AC current can be measured in two ranges of 2 and 20 amps, with a worst-case accuracy of ±3%, +7 digits. Six resistance ranges, from 200 ohms to 20 megohms, provide a measurement accuracy within ±1%, +2 digits. An audible continuity test, along with a diode-test function (which displays the forward voltage drop of a diode) is also offered.

Those basic features are just what you'd expect from a basic digital multimeter. But the *M-3900* isn't just a bench-top meter. Dwell-angle measurements and tachometer readings are also available. Tachometer readings, in two ranges of 2000 and 10,000 RPM, can be made on 4-, 5-, 6-, and 8-cylinder engines with a rated accuracy of ±2%, +1digit. Dwell-angle measurements can also be made on 4-, 5-, 6,- and 8-cylinder engines with the same accuracy.

Automotive measurements

Although electronic ignition has taken over most new automobiles, many cars still use points to control spark generation. The dwell angle is a measurement of the time that the points remain closed during the ignition cycle. One result of setting the engine dwell incorrectly is that sufficient energy cannot be built up in the coil to provide good spark. Poor acceleration, or missing at higher engine speeds, is the usual complaint. Excessive dwell shortens the life of the points.

Although the increasing use of electronics under the hood makes it difficult for Saturday mechanics to perform many maintenance functions, a tachometer is still useful to determine whether the engine is operating efficiently, the choke is working according to specifications, the idle speed is correctly set, and the like.

To make the automotive measurements easier, the *M-3900* comes equipped with an extra set of test leads with clips, and a manual that details automotive measurements. The total cost of the Metex *M-3900* is $69.95. **R-E**

NEW PRODUCTS

CIRCLE 10 ON FREE INFORMATION CARD

DIGITAL LCR METER. Billed by *Hewlett-Packard* as the first digital inductance-capacitance-resistance meter capable of automatic measurements and direct-Q measurements from 75 kHz to 30 MHz, the *HP 4285A* also provides high throughput and 6 digits of resolution. For improved testing efficiency, 10 error-free instrument set-ups can be quickly loaded from an external memory card.

With a basic accuracy of 0.1%, the instrument has 100-Hz resolution and six full digits of resolution for all measurement parameters. The *HP 4285A* can test components and materials to commercial and military RF standards. For demanding military tests, it has a constant test-signal-level feature that controls the applied test signal at the device. Direct quality-factor measurements can be performed in fractions of a second with the *HP 4285A* and the optional *HP 42851A* precision-Q adapter, yielding 5% accuracy at 30 MHz.

To test inductors under operating conditions, the meter uses the optional *HP 42841A* bias-current source to test a device up to 30 MHz at 10 amps DC of bias. For even more measurement flexibility—and to simplify integration with handlers, scanners, and environmental chambers without sacrificing accuracy—specifications apply at the front panel and at one- and two-meter cable lengths when Hewlett-Packard cable sets are used.

Several other options can be added to customize the meter. For high-volume testing, a handler interface and built-in comparator can be combined with component-handling equipment. A scanner interface and switch/text unit provide optimal environmental-chamber testing. Test fixtures for axial, radial, and chip components are also available.

The *HP 4285A* has a built-in HP-IB interface and uses a standard language that is compatible with IEEE 488.2 (1987). That allows the use of generic commands.

The *HP 4285A* digital LCR meter costs $12,900. The *HP 42851A* precision-Q adapter, *HP 42841A bias-current source, and HP 42842C* bias-current test fixture cost $4,850, $6,800, and $2,500, respectively. The *001* DC bias, *002* accessory-control interface, *202* handler interface, and *301* scanner interface cost $920, $280, $310, and $600, respectively.—**Hewlett-Packard Company**, Customer Inquiries, 19310 Pruneridge Avenue, Cupertino, CA 95014.

BURGLAR-ALARM SYSTEM. Offering advanced features such as a built-in telephone dialer, an emergency-message system, and a speaking computerized central console, the *Dicon 3000* home burglar-alarm system can be installed in any house or apartment in minutes without tools. In addition to detecting intruders, the system monitors itself for proper operation and vocally reports its status to the homeowner.

The heart of the system is the console, which vocally guides the user through a brief set-up procedure and provides prompts and messages during regular use. The console has a built-in microphone and can store a 15-second emergency message in its digital memory. If a break-in occurs, the console automatically places calls to as many as four numbers, which are selected by the homeowner during initial setup. A built-in back-up battery pack is continually monitored by the system, which notifies the homeowner when replacement batteries are needed.

CIRCLE 12 ON FREE INFORMATION CARD

Other components include a passive infrared motion detector, a siren, and accessories. The motion detector, which must be placed within 500 feet of the central console, transmits FM radio signals using 16-bit digital encoding to the console. Accessories in the basic *Dicon 3000* package include an ex-

SOLDERING-IRON STAND. A heavy-duty soldering-iron stand, *M.M. Newman's Antex ST-5*, features a metal base for added stability. Its coil-spring holder dissipates heat and comes with two different types of bezels to accommodate all popular irons. The tray holds a ½-inch-thick sponge that is used for wiping soldering-iron tips, and has a center hole for collecting dross. Conforming to Department of Defense requirements for soldering-iron holders, the *Antex ST-5* soldering-iron stand leaves the soldering tip unsupported, eliminating contact between the soldering tip and the coil-spring holder, to prevent heat sinking and to protect the user from burns.

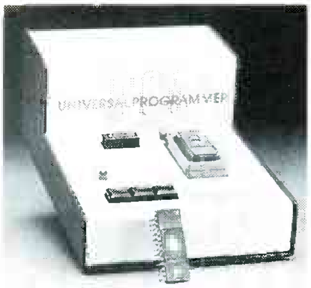
The *Antex ST-5* soldering-iron stand costs $11.95.—**M.M. Newman Corporation**, 24 Tioga Way, P.O. Box 615, Marblehead, MA 01945.

CIRCLE 11 ON FREE INFORMATION CARD

tended-range antenna, window decals, and an owner's manual. Additional sensors and a remote-control keypad are available as options.

The *Dicon 3000* home burglar-alarm system has a suggested retail price of $399.00.—**Dicon Systems Inc.**, 651 Executive Drive, Willowbrook, IL 60521; Tel. 708-850-7370.

UNIVERSAL EPROM PROGRAMMER. Providing extra flexibility, the *Wintek UEP02* universal EPROM programmer can be used either with a personal computer or as a stand-alone unit, making it particularly well suited for PC-based microcomputer development software. It can also be moved easily between machines, since it does not require the installation of a circuit board in the computer, but connects via the PC's serial port instead. The *UEP02* includes 2716, 2732, 2764, 27128, and 27256 EPROM's, and accepts most industry-standard byte-wide EPROM's. The programmer



CIRCLE 13 ON FREE INFORMATION CARD

also comes with comprehensive documentation, software, configuration plugs, and cables for both 9- and 25-pin serial ports.

The *UEP02* universal EPROM programmer costs $495.00.—**Wintek Corporation**, 1801 South Street, Lafayette, IN 47904-2993; Tel. 800-742-6809.

PULSE GENERATOR. An easy-to-use, 125-MHz, fully programmable pulse generator, the *PM 5781* from *John Fluke Mfg.*, has many applications in automated testing systems (including digital or analog circuitry and components) and in radar, sonar, and communications. The instrument produces high-speed, high-performance pulses, has a normal frequency range of 0.1–125 MHz (which can be extended to 0.025 MHz), and provides individually programmable rise and fall times from 2 ns to 100 ms.

The *PM 5781* provides two outputs for both positive- and negative-going pulses. It has independent DC-offset control on the second channel output, plus a third switchable TTL/ECL level output. Thanks to the inclusion of internal 50-ohm back-matching terminations, the generator provides clean pulses even with mismatched loads.

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Operating modes include the generation of continuous, externally triggered (single), and externally gated pulses. In addition, a burst mode allows the number of pulses in a burst to be specified, eliminating the need for a separate generator. Single- and double-pulse, square-wave, programmable-duty-cycle, externally controlled pulse-duration, and manual operation modes are also featured. All ten pulse parameters are displayed simultaneously on the unit's front-panel LCD.

Several features ensure reliable operation. A track mode maintains a programmable fixed relationship between specified pulse parameters, which can be locked to prevent accidental modification. Output-amplitude limits can be set to prevent damage to connected loads. All pulse parameters are automatically checked for inconsistencies, and the output can be inhibited until all parameters have been defined and validated.

The *PM 5781* pulse generator has a list price of $9585.00.—**John Fluke Mfg.**

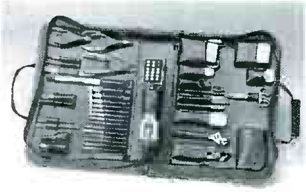
CIRCLE 117 ON FREE INFORMATION CARD

CIRCLE 178 ON FREE INFORMATION CARD

JN163-01-0590

Co., Inc., P.O. Box 9090, Everett, WA 98206; Tel. 800-443-5853, ext. 77.

COMMUNICATIONS-MAINTENANCE KIT. Designed to handle service requirements in facilities with multi-system communications, *Jensen Tools' JTK-46C* communications-maintenance kit contains every tool needed to access, test, and repair phones, modems, fax machines, teletypes, switches, and distribution systems. The kit contains cabinet/chassis access tools, including hollow-shafted nutdrivers, Phillips and slotted screwdrivers, an adjustable wrench, and hex keys. A selection of strippers for work with stranded or solid wire, a wire-wrapping tool, pin- and IC-insertion/extraction tools, a modular line tester, pliers, and other tools for wire termination and telecom/datacom applications are also included.



CIRCLE 15 ON FREE INFORMATION CARD

A gray Cordura zipper case holds the more than 50 tools. The case features a roomy internal pouch, three exterior pockets, and durable webstrap handles. An internal restraining strap can hold an optional rotary/tone handset. Other options include the Triplett Fox/Hound tracer/tester, and a punchdown tool.

The *JTK-46C* communications-maintenance tool kit costs $319.00.—**Jensen Tools, Inc.**, 7815 South 46th Street, Phoenix, AZ 85044; Tel. 602-968-6241.

SWITCH AND INDICATOR LINE. Sleek European-styling highlights *Eaton's* new line of rocker switches, pushbutton switches, and indicators. Designed for convenient snap-in front-panel mounting, they feature contoured corners and matte finishes. The

CIRCLE 16 ON FREE INFORMATION CARD

switches and indicators can be unlighted, or illuminated with incandescent, neon, and fluorescent lamps.

The units meet both domestic and international electrical/electronics standards. Suitable for AC and low-voltage DC applications, the switches have a power-switching capability of up to 20 amps and a switching capability of one to four poles in both maintained and momentary circuits. They also have a wide range of termination types. The double-insulated units are available with display indicators and come in a variety of operator and housing colors. The most popular types are available in sealed versions. They can withstand temperatures to 120°C.

The switches and indicators are available in quantities of 1,000 pieces or more, and range in price from $0.60 to $3.00.—**Eaton Corporation**, 4201 North 27th Street, Milwaukee, WI 53216.

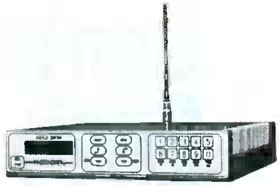
ESD FIELD-SERVICE KIT. A fully portable field-service kit, the *Statfree CP636* comes in a canvas pouch and easily fits inside a standard briefcase to create a static-safe work area outside the plant

CIRCLE 17 ON FREE INFORMATION CARD

environment. The kit, from *Charleswater Products* includes everything needed to create a static-safe electronic repair station while making service calls. Included are a static-dissipative vinyl work surface, an elastic wrist band, two grounding cords, and a canvas storage pouch. The kit can drain electrostatic charges from personnel, spare parts, and equipment, helping to prevent costly electrostatic-discharge-related repair failures. The 18 × 22-inch work surface provides a surface resistivity of 10^9 ohms/sq. The wristband includes a 6-foot coiled cord, and a 10-foot grounding cord with an alligator clip.

The *Statfree CP636* ESD field-service kit has a list price of $40.00.—**Charleswater Products, Inc.**, 93 Border Street, West Newton, MA 02164.

STAND-ALONE RADIO MODEM. *Megadata's SA9600* stand-alone radio modem allows mini- and mainframe



CIRCLE 18 ON FREE INFORMATION CARD

computers to communicate at data rates up to 9600 bits per second via a narrow-band UHF radio line. Connecting to a synchronous serial port of the host computer, the radio modem converts the serial data stream to radio packets transparently. Because the host computer perceives the *SA9600* as a conventional synchronous telephone modem, no software modification is required to establish a wireless link.

The radio modem allows data communication where conventional wiring is impractical, expensive, or impossible. Potential applications include land mobile, ship-to-ship, building-to-

CIRCLE 50 ON FREE INFORMATION CARD

BASIC TELEVISION AND VIDEO SYSTEMS, Fifth Ed. *By* B. Grob. *592 pp., illus.* Provides the clearest picture of how television and video systems work, and what to do when they don't. Covers television receivers, VCR's, video cameras, and cable systems — all in readable, practical detail.
249/334 Pub. Pr., $39.95 Club Pr., $24.95

BUILD YOUR OWN UNIVERSAL COMPUTER INTERFACE. *By* B. Chubb. *309 pp., illus., softcover.* Guiding you from theory to step-by-step assembly instructions, this lively manual shows you how to construct a computer interface and hook it up to virtually any IBM or IBM compatible personal computer, including the XT, XT-286, AT, and System/2 Model 30.
585080-X Pub. Pr., $19.95 Club Pr., $15.95

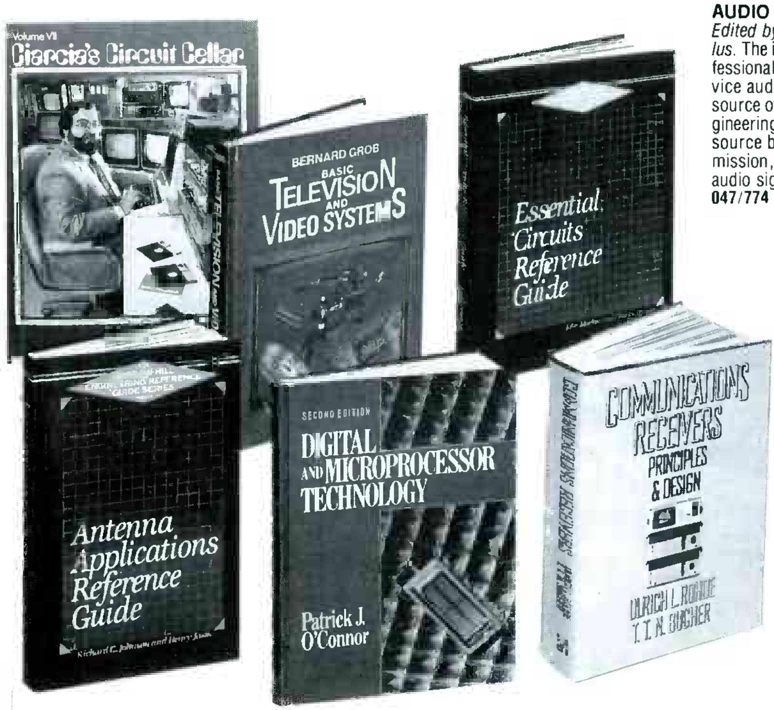
HANDBOOK OF ELECTRICAL NOISE MEASUREMENT AND TECHNOLOGY, Second Ed. *By* C.A. Vergers. *440 pp. 213 illus.* Provides answers to all your questions about noise origins, causes, effects. Also shows you how to predict and measure noise, and how to design low-noise circuits.
583947-4 Pub. Pr., $39.95 Club Pr., $29.95

SWITCHGEAR AND CONTROL HANDBOOK, Second Ed. *Edited by* R. W. Smeaton. *1,056 pp., 789 illus.* The only handbook that treats all aspects of switchgear control, including design, applications, safety, and maintenance. Updated to reflect the changes brought about by the use of computers, solid-state devices, and programmable controls.
584/494 Pub. Pr., $83.00 Club Pr., $56.95

ANTENNA APPLICATIONS REFERENCE GUIDE. *Edited by* R. C. Johnson and H. Jasik. *496 pp., 368 illus.* and tables. Covers the major applications of antenna technology in all areas of communications and their design methods. Emphasizes important new applications such as earth station, satellite, seeker, aircraft, and microwave-relay antennas.
322/848 Pub. Pr., $59.95 Club Pr., $42.50

RADIO HANDBOOK, Twenty-Third Ed. *Edited by* W. I. Orr. *667 pp., 1,073 illus. and tables.* The latest edition of the most complete, current resource on radio technology and its applications. Expert contributors show you how to select, design, build, test and operate all kinds of equipment.
584638-1 Pub. Pr., $29.95 Club Pr., $23.95

AUDIO ENGINEERING HANDBOOK. *Edited by* K. B. Benson. *1056 pp., 722 illus.* The ideal on-the-job reference for professionals who design, operate, and service audio equipment. It's a one-volume source of fundamental audio acoustics engineering information and practical how-to source book covering generation, transmission, storage, and reproduction of the audio signal.
047/774 Pub. Pr., $83.50 Club Pr., $59.95



Be sure to consider these important titles as well!

BUCHSBAUM'S COMPLETE HANDBOOK OF PRACTICAL ELECTRONIC REFERENCE DATA, Third Ed. By W.H. Buchsbaum.
583880-X Pub. Pr., $34.95 Club Pr., $26.50

ON-LINE ELECTRICAL TROUBLESHOOTING. *By* L. Lundquist.
391/106 Pub. Pr., $34.50 Club Pr., $26.50

ESSENTIAL CIRCUITS REFERENCE GUIDE. By J. Markus & C. Weston.
404/623 Pub. Pr., $59.95 Club Pr., $47.50

INTRODUCING PC-DOS AND MS-DOS, Second Ed. *By* T. Sheldon.
565/651 Pub. Pr., $28.95 Club Pr., $19.95

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335/281 Pub. Pr., $49.95 Club Pr., $37.50

INTRODUCTION TO DIGITAL SIGNAL PROCESSING. *By* J. G. Proakis *and* D. G. Manolakis.
584954-2 Pub. Pr., $50.00 Club Pr., $37.50

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712/31X Pub. Pr., $52.95 Club Pr., $36.95

BOB MIDDLETON'S HANDBOOK OF ELECTRONIC TIME-SAVERS AND SHORTCUTS. By R.G. Middleton.
583865-6 Pub Pr., $29.95 Club Pr., $22.50

DIGITAL AND MICROPROCESSOR TECHNOLOGY, Second Ed. *By* P. J. O'Connor.
585184-9 Pub. Pr., $42.00 Club Pr., $33.50

OP-AMP HANDBOOK, Second Ed. *By* F.W. Hughes.
583651-3 Pub. Pr., $39.00 Club Pr., $27.50

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ECGA-034

building, communication to remote sites where telephone service is unreliable or non-existent, and communications within a building where computers are frequently relocated. The *SA9600* offers some advantages over other wireless data-communication methods like cellular radio, including lower cost, independence from the telephone network, and a data rate four times faster than that available over a cellular link.

The unit's specialized FM radio transceiver and advanced data-modulation techniques provide a 9600-bits-per-second data rate while requiring less than 3-kHz of bandwidth. The narrow bandwidth allows repeaters normally used for voice data communications to be used for data communications. With a 2-watt transmit output power, the *SA9600* can achieve an outdoor line-of-sight range of up to 15 miles. The range can be extended to hundreds of miles using repeaters, power amplifiers, and antennas. The radio modem operates at 450–470 MHz, the UHF frequency band allocated for business use by the FCC. Other versions of the *SA9600* operate in the 406–420-MHz federal government band, or in the 420–450-MHz amateur-radio band.

The SA9600 radio modem has a list price of $3,000.—**Megadata Corporation**, 35 Orville Drive, Bohemia, NY 11716-2598.

ASK R-E

continued from page 12

monitor since the horizontal frequency needed to do 1024 × 768 resolution is beyond the 31-kHz VGA standard. Multisync monitors aren't that much more expensive than regular VGA's, and they are a lot more versatile.

TWO INTO ONE

I have a stereo amplifier and I want to connect both outputs to one speaker. My reasons for doing that are complicated but it will solve a need I have. The problem is that I don't know exactly how to go about wiring the speaker to the left and right outputs. I'm not that experienced in electronics but it does not seem that all I have to do is connect the two speaker outputs together.—G. Offrey Madison, AL

What you're missing in experience you obviously make up for in intuition. Connecting the two outputs together is more than not a good idea—it's definitely a bad idea. If you did that, you would be running the risk of having one output drive the other. You didn't tell me how powerful your amplifier is but, no matter how many watts you have pouring out of each channel, driving one directly into the other is a sure recipe for an enormous electronic disaster.

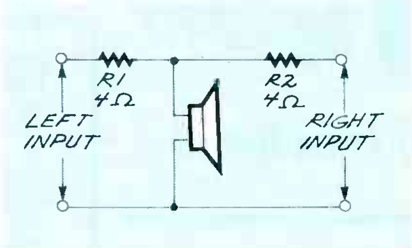
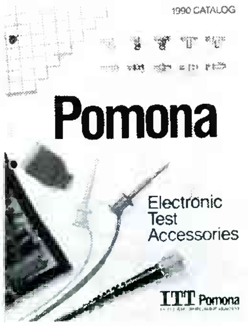


FIG. 2

The way around the problem is to connect things so that each of the outputs always sees a reasonable load. That's pretty easy to do, and the most straightforward solution is shown in Fig. 2. Make sure the resistors are chunky enough to handle the power output of the amplifier. You didn't give me any numbers but start out with some 2-watt resistors and see how warm they get. If they seem to get much too hot, replace them with a pair of higher wattage resistors. **R-E**

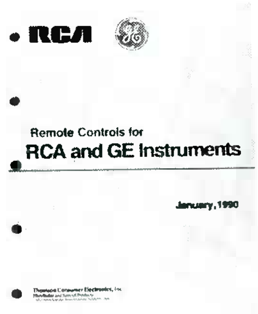
NEW LIT

ELECTRONIC TEST ACCESSORIES. Five new product groups are featured in *Pomona Electronics'* 138-page *Electronic Test Accessories* catalog. Those include IC test clips, low-cost cable assemblies, and a family of digital multimeter test-lead kits. An index makes it easy to find items in each of ten major product categories, and helpful selection guides are provided for the reader. The brochure contains complete descriptions of Pomona's popular selection of jumpers and cables, boxes, connectors, plugs and jacks, adapters, single-point test clips, and static-control devices. The catalog is free upon request.—**ITT Pomona Electronics**, 1500 East Ninth Street, P.O. Box 2767, Pomona, CA 91769; Tel. 714-629-3317.



CIRCLE 21 ON FREE INFORMATION CARD

REMOTE-CONTROL REPLACEMENTS. Designed for servicers, the 1990 edition of *Thomson's* publication, *Remote Controls for RCA and GE Instruments (#1F5790)*, contains all avail-



CIRCLE 22 ON FREE INFORMATION CARD

able direct-replacement remote-control hand units for RCA and GE televisions, video recorders, videodisc players, camcorders, and audio components. The catalog is divided into three sections. The first two parts contain cross-reference material both in model-number and remote-type-number sequences. The last section contains photographs of over 220 different remotes, to help the reader identify the correct model.—**Thomson Consumer Electronics**, Distributor and Special Products, 2000 Clements Bridge Road, Deptford, NJ 08096-2088, ATTN: Service Dealer Merchandising.

TEST & MEASUREMENT INSTRUMENTS. The *1990 Fluke and Philips Test & Measurement Catalog* highlights 20 new products in a full-color introduction section. Several features designed to help customers choose the equipment that best fits their test and measurement re-

New solid-state and digital TV sets, stereos, and videorecorders are tougher to repair than old-fashioned tube type sets and require special training for the service technician who works on them.

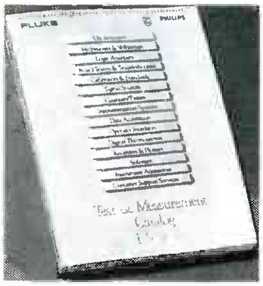
Only a few states have laws requiring competency tests for licensing technicians who repair consumer electronics, but fifteen years ago the International Society of Certified Electronic Technicians (CET) began its own certification program to qualify these technicians and those in industry. To carry the CET designation, technicians must have four years experience and pass a rigid examination on general electronics and a specific area of expertise such as audio or radio-TV.

Many consumers look for a Certified Electronic Technician in the shop when they need any electronic item repaired.

Free Consumer Checklist

A consumer checklist for selecting a service shop is available free by sending a stamped, self-addressed envelope to: Checklist, ISCET, 2708 West Berry, Fort Worth, TX 76109. The list reminds consumers to check such items as "Does the business have the parts for your particular brand?", "Did you get an estimated price?", and "Did you check this company with the Better Business Bureau?"

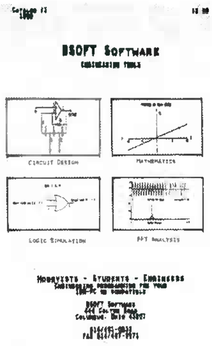
Modern electronic equipment such as digital TVs or stereos should be repaired by specially trained people.



CIRCLE 23 ON FREE INFORMATION CARD

quirements have also been added. Those include a rack-mount selection guide, a glossary of terms, and an abbreviations and symbols section. All products and services are also indexed both alphabetically and numerically. The 536-page publication provides descriptions, photographs, product-selection guides, and ordering information for more than 650 products, accessories, and software programs. Product lines in 18 major categories are included, as well as listings of available technical literature and worldwide sales offices, technical centers, and authorized distributors. There is no charge for the catalog.—**John Fluke Mfg. Co., Inc.**, P.O. Box 9090, Everett, WA 98206; Tel. 1-800-443-5853.

ENGINEERING SOFTWARE. *BSOFT Software Engineering Tools #3* contains descriptions and ordering information for several new products and new versions of existing software. Designed for students, hobbyists, and professional engineers, it includes low-cost stand-along engineering programs for IBM-PC's and compatibles. Programs are offered for drawing schematics, simulating logic-control circuits, and circuit analysis. CAD programs for designing circuits and PC boards are offered, along with computer-aided mathematics and waveform-viewer software. The catalog is free upon request.—**BSOFT Software**, 444 Colton Road, Columbus, OH 43207; Tel. 614-491-0832.



CIRCLE 24 ON FREE INFORMATION CARD

SMALL-MECHANISM DESIGN. A 784-page technical data book from *Stock Drive Products*, titled *Design and Application of Small Standardized Component (Data Book 757)*, helps the reader learn how to design mechanisms that use small mechanical-drive components. The book is comprehensive enough to be used as a textbook in machine design and related courses at the vocation-technical level.

CIRCLE 25 ON FREE INFORMATION CARD

A special 51-page section on robotic component design includes a detailed specification guide comparing 42 performance features of 147 industrial- and teaching-class robots. Other major sections in the book cover design procedure, selection, and application data for designing with small gears, belt and chain drives, speed reducers, AC motors, miniature DC motors, gear trains, stepper motors, constant force springs, universal joints, and vibration mounts. A "Designer's Data Section" includes more than 50 tables such as mathematical formulas, conversion and units, and material properties.

Data Book 757 costs $7.95 postpaid in paperback, or $12.95 for hardcover.—**Educational Products**, P.O. Box 606, Mineola, NY 11501. **R-E**

LETTERS

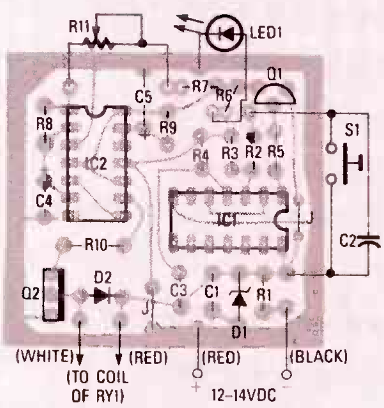
continued from page 16

a cement. Avoid breathing the fumes.

I bought the 100-watt heater at an electronics parts store, and later found the same unit, but marked for aquarium use, for less money at a pet supply store. The air pump I bought is designed for medium-size aquariums.

Your magazine and its predecessors have been on my workbench for about 50 years, and I've built so many of your projects that I've lost count. I like the editorial mix the way it is now—some new stuff, some like the etching tank, and some on computers. Don't forget us old "tube-type" guys who know how tubes work, but aren't really sure about solid-state circuits. I use a TI-99/4A computer, and I'd like to see some programs written in pure BASIC so I could convert them to TI BASIC (although I'm one of the few who use the orphan).

Thanks for a great magazine, and keep it coming.
DAVID C. SWARTZ
Aurora, CO



CORRECTION

Due to a printing error, the parts-placement diagram in our "Solid State Wiper Control" story (**Radio Electronics,** April 1990) was shown improperly registered. We have correctly reprinted that figure here.

CONSUMER ASSISTANCE

Radio-Electronics readers might be interested in the Consumer Complaint Assistance/Inquiries Program of the Electronic Industries Association's Consumer Electronic Group (EIA/CEG). The EIA/CEG represents major manufacturers of televisions, VCR's, audio and video systems, telephones, personal computers, and home-office products. The program was set up to help individual consumers who are having difficulties resolving complaints with manufacturers. Our office acts as a catalyst, mediator, or arbitrator in disputes between the consumer and the (member or non-member) manufacturer.

There is a standard procedure: First, the consumer should try to resolve the complaint at the retail level. If that fails, the manufacturer whose address is on the warranty card should be contacted. If the consumer feels that the manufacturer has not resolved the problem satisfactorily, the consumer should contact this office, by mail or by phone (collect calls are accepted only on safety-related problems). The consumer must be prepared to supply his name, address and phone number; the product's brand name, model number, and serial number; date of purchase; dealer's name and address; service history, including itemized invoices and work orders. The consumer will be asked for a brief, concise statement of the problem and of the resolution being sought.

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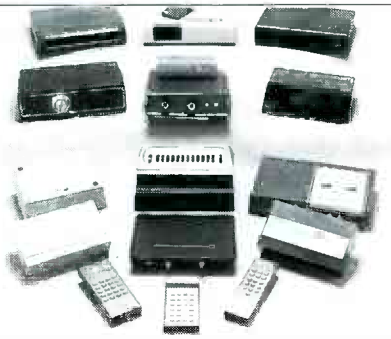

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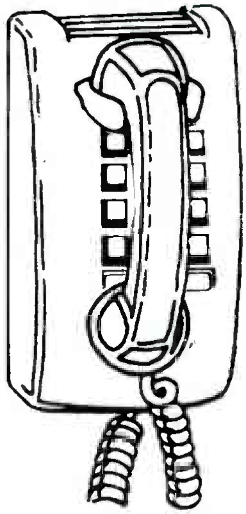

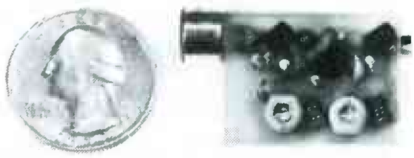

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WARNING

Please note that unauthorized (i) reception of cable service, (ii) satellite decoding, or (iii) video decoding or copying is illegal under Federal and State law. Federal law renders illegal both the interception and reception of any communication service offered over a cable or satellite system, or the decoding or copying of videos unless specifically authorized by law. Federal law imposes both civil and criminal penalties for violations of the applicable statutes. In addition, most if not all of the states have enacted "theft of cable services" statutes imposing penalties for violation thereof. Thus, the use of the unit described in this article should be restricted to educational, scientific, and/or informational purposes and prior to the use thereof authorization should be obtained from your cable service company, satellite transmission service or video producer. This is not intended to constitute legal advice as to the propriety of their use thereof based upon their individual circumstances and jurisdictions.

UNIVERSAL DESCRAMBLER

Restore missing video sync signals with our universal decoder.

RUDOLF F. GRAF and WILLIAM SHEETS

WE'VE ALL ENCOUNTERED VIDEO SIGNALS with missing, weak, or noisy sync pulses that can make it difficult or impossible to use the signal. Those disturbances may cause rolling, tearing, or other instability in the displayed video image. The example we're most familiar with is a scrambled TV signal, or a Macrovision-encoded video tape. The unit will restore usable sync to virtually any video signal. You can use it to watch one scrambled show while taping another, to clean up Macrovision when watching a video tape, or to simply restore clean sync to a noisy video signal.

Another difficulty is that the video itself may be incorrectly phased (negative, for example). While that is more of an interface problem than a transmission problem, it usually results in a picture that has its tones reversed or colors shifted in hue due to phasing differences between the correct burst (reference) signal and the burst signal actually received.

Very often, the distortions are deliberately introduced into the video signal to prevent unauthorized reception, or to introduce other obstacles to their misuse. One example is "copy guard," a technique used to discourage unauthorized copying of video tapes, and another case is scrambling, used on cable systems to prevent unauthorized viewing.

In order to deal with those problems, a dedicated "decoder" box or other such device is used. The device is generally useful for only one type of coding or scrambling scheme.

The technique of sync suppression and/or video inversion is used on both cable and satellite video transmissions. How that works is simple; the sync pulses are altered in either level or total amplitude, or omitted entirely from the video (see Fig. 1). The video may also be inverted, although that is not always done. Sometimes the sync pulses may be suppressed to random levels, at different times. That is done to "confuse" unsophisticated decoders, and make video piracy more difficult.

With all of those schemes, a "key" or pilot signal must be sent along with the scrambled signal in order to properly reconstruct the missing or distorted sync signal. The key or pilot signal may take several forms. An audio subcarrier, usually 15.7, 31.5 or

94 kHz (or some other frequency that has a fixed ratio to the horizontal-sync frequency of 15.734 kHz) is added to the video signal, and is used by the decoder as a reference to reconstruct the sync signal. Sometimes a digital "addressing" signal is used to activate and deactivate the decoder. For our purposes, though, the addressing signals can be ignored since they are not involved in the scrambling and descrambling process.

Another method makes use of a series of horizontal pulses immediately following the vertical-sync pulses to phase lock a horizontal frequency oscillator in the decoder. That, in turn, is used to regenerate the missing or suppressed horizontal sync. That system is known as a "pilotless" method, and that's because no pilot subcarrier is sent along with the audio.

All of those methods have one thing in common: They all alter the sync information. But in order to decode the signal, there must be a key of some kind present in the signal that can be used to reconstruct the sync.

Sometimes, as a scrambling technique, the video is inverted. If that's the case, you would see a picture, but the tones and colors would be reversed. Dark areas will be light, greens will appear as red, etc. One would assume that simply inverting the video would correct that problem. However, only the video must be inverted, not the sync. Sync must be left in original form. That requires separate sync and video channels and a means of splitting the video from the sync.

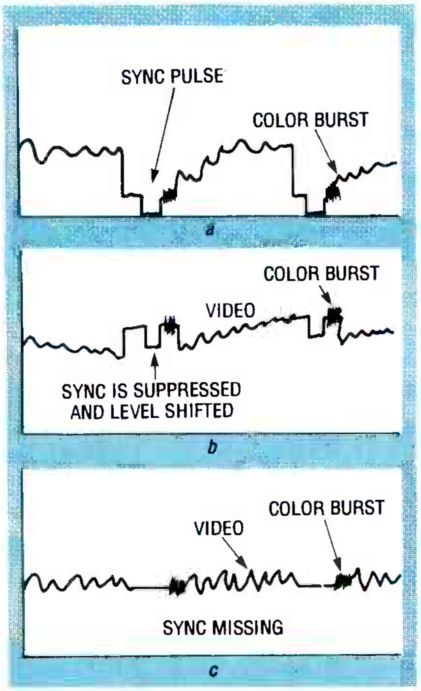


FIG. 1—THE SYNC PULSES are altered in either level or total amplitude, or omitted entirely from the video. The video may also be inverted. Sometimes the sync pulses may be suppressed to random levels, at different times.

This article will discuss a single-circuit device that can be used to regenerate any of those distorted video signals. The device will:

1. Regenerate missing or distorted sync.
2. Remove interfering signals from the sync pulses due to scrambling, noise, etc.
3. Invert (or revert) video polarity.
4. Change the DC level of video (brightness).
5. Adjust the contrast levels (luminance).
6. Correct tint distortion (color shifts).
7. Generate scrambled video signals for testing decoders and scrambling/descrambling experiments.

Please note that the unit will work only on baseband video from DC to 4 MHz. It does not operate on audio signals.

WARNING: this device is intended for experimental use, and is definitely not intended for theft of scrambled material. See the box in the beginning of this article.

How it works

Present in all (NTSC) video signals is a color-burst component at 3.58 MHz. That signal is the "key" from which all other sync and timing information is derived. The horizontal frequency is related to the burst by a factor of 227½, and the vertical frequency is related to the horizontal frequency by a factor of 525 (NTSC video only). If there is some burst signal present, even if noisy, the decoder system will be able to use it to generate the necessary signals. It will not remove video noise during the scan intervals (noisy picture), only the sync so that lockup is possible. Figure 2 is a block diagram of the sync regenerator.

Video input at J1 is split two ways: One portion goes through level-control R2 into a video amplifier. It is amplified by a factor of ten and fed to a polarity-selector circuit. The switch selects the desired polarity (usually negative) and feeds it to a clamp circuit. There the blanking pedestal (blackest black) is clamped at zero volts DC, and the DC video level is established by referencing the scan portion (line scan) to a variable DC level set by the clamp or DC-level control. That feature allows independent control of scene brightness. Next, the video-plus-blanking signal is fed to a sync combiner where a pulse of approximately −0.4 volts is added to the video. The output of the sync combiner is fed to a burst keyer where a new burst signal is added to the signal. Now we have a complete NTSC signal at the output of the burst keyer, having a zero-volt DC blanking level, −0.4-volt negative sync, and a 0- to 1-volt video level. A video output driver is used to interface a 75-ohm load to the output of the burst keyer.

The requisite components of the sync portion are derived from a CD2240 CMOS LSI video sync generator that operates from a 1.08-MHz clock circuit. The clock signal is generated by a clock oscillator that is phase locked to a reference derived from the original "defective" video signal as follows: The 3.58-MHz components are extracted by a 3.58-MHz filter and fed to a 3.58-MHz oscillator circuit. The circuit is similar to the 3.58-MHz oscillator circuit used in color TV reception. The oscillator is keyed on during the burst interval so it "looks" only at the burst signal on the original video signal. The signal then feeds both the burst keyer and a divide-by-455 circuit that has an output at 7.9 kHz (nominally). Next, the 7.9-kHz signal is used as a reference to phase-lock the 1.08-MHz clock oscillator. The 1.08-MHz oscillator is therefore phase coherent with the original video signal's color burst.

Note that the sync portion of the original video signal (if present) is simply discarded. Therefore it does not matter if the sync was noisy, missing, or at the wrong level. A new sync is generated and inserted.

Circuitry

Figure 3 is a detailed circuit schematic. Input video at J1 appears across termination resistor R1. If desired, R1 may be omitted for a 1K input impedance rather than 75 ohms. Resistor R2 controls the level of video signal fed to IC1, an LM733 differen-

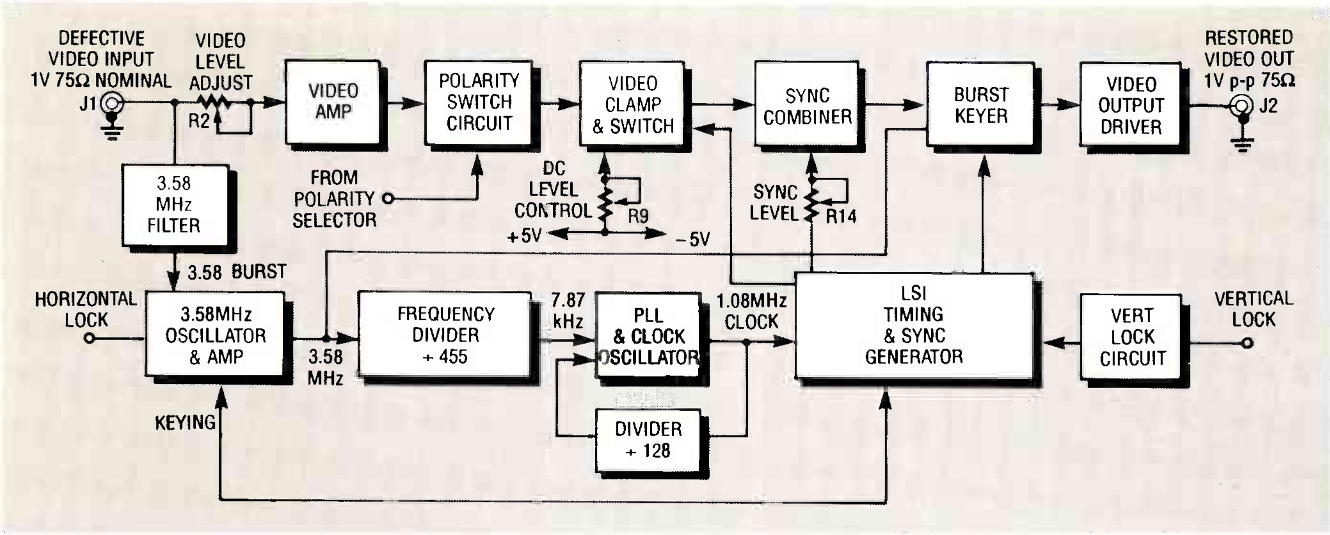


FIG. 2—HERE IS A BLOCK DIAGRAM of the sync regenerator. The circuit removes the "defective" sync and replaces it with a good one.

tial video amplifier, through coupling capacitor C1. R3 and R4 are bias resistors for IC1, which obtains DC power through decoupling networks R5, C2, and C3, and R6, C4, and C5; IC1 produces both an in-phase and a 180° out-of-phase signal at pins 8 and 9.

The two signals from IC1 are fed to a portion of IC2, a CD4053BE triple 2-channel analog multiplexer, which is used like an analog switch. The video polarity is controlled by the logic level at pin 10; S3 grounds pin 10 if reverse polarity is desired. R7 is a pull-up resistor for pin 10. The signal from the common pole of the switch is coupled through C6 to clamp-switch IC2-b and to switch IC2-c. During horizontal back-porch (black) periods, pin 3 of IC2-b and the negative side of C6 is clamped to a DC voltage determined by R9. Capacitors C11 and C12 form a bipolar bypass electrolytic. That sets the DC clamping level of the video signal.

During blanking intervals, the output at IC2-c pin 4 is switched from video to ground. Therefore, pin 4 has a ground level during blanking intervals and video during scan intervals. The original "defective" sync is not passed along. Instead, a new, ground-level blanking pedestal is inserted. Power-supply decoupling networks for IC2 are formed by C9, C10, and R12, together with R8, C7, and C8.

Video that has been stripped of its original sync at pin 4 of IC2-c is fed to pin 1 of IC3-a and on to the output of IC3-a at pin 15. During sync intervals, a −0.4-volt level (set by R14) is fed to pin 15. Therefore, the output from IC3-a at pin 15 is a video signal with zero volts blanking level and −0.4-volt sync tips added. Resistor R13 and C13 are decoupling and bypass components.

All that's missing now is the 3.58-MHz color-burst signal. That is added through switch IC3-b. The burst signal comes from the oscillator and amplifier circuit to be discussed later via R45. The signal rise time to the control input of IC3-b is limited by R44, and R15 is a bias resistor. Components Q5, Q6, R16, C16, R17, and R18 form a unity-gain video driver. The output (corrected video) across R18 is fed to output jack J2.

In order to correctly perform all of the switching, timing signals are necessary. The 3.58-MHz components of the input video are picked off by filter C17 and L1 and fed to IC5 via R20, R21, and C18. When the horizontal-lock switch S1 is closed, Q1 is turned on, shorting the 3.58-MHz signal to ground. That function is used for both setup and establishing proper sync relations upon initial lockup. Since the oscillator initially cannot "know" which portion of the 3.58-MHz signal is the burst, pushbutton S1 is momentarily depressed. That causes the restored video image to roll horizontally on the video display. Switch S1 is held depressed until the image is correctly formed (centered). At that point, the sync relations are correct and the oscillator will lock up to correct phase. Actually, that will happen eventually anyway, since the only constant 3.58-MHz signal is the burst and, sooner or later, it will slip in and lock up. Once locked up, the circuit is stable. A momentary loss of video may cause loss of lock in some instances. To correct that, depress S1 and reestablish lock.

Oscillator IC5 generates a 3.58-MHz signal that's phase-locked to the input signal. Components C19, R24, C21, and C22 form a loop filter, and C16, C27, and L3 are for power-supply decoupling. Crystal XTAL1, R25, C23, C24, and C25 form the oscillator circuit for IC5, and Q2, R26, R27, and R28 form a pulse-inverter circuit. The PLL circuit in IC5 is keyed on only during burst intervals; a burst-key pulse at pin 9 (produced by Q2) is used for that. Without that pulse, IC5 will not maintain a stable lock to the burst component from C18. Trimmer C24 adjusts the oscillator free-run frequency.

The 3.58 MHz CW signal, referenced to the burst from the input signal, is fed to amplifier Q3, and associated components (R30, R31, bypass-capacitor C29, R31, and L2—R32 is a bias resistor). Trimmer capacitor C32 and C30 tune L2 to 3.58 MHz; C32 is used to adjust the phase of the 3.58-MHz burst reference to compensate for tint (hue) variations, and C31 is a DC blocking capacitor. The 3.58-MHz signal (about 8–10 volts p-p) is fed to R34 and IC6. Components R34, R35, C41, and L4 form a network for coupling the 3.58-MHz signal through R45 to IC3-b, the burst keyer. Potentiometer R34 sets the burst level that appears on the corrected-video output at J2.

CMOS frequency divider IC6, along with diodes D1–D6, Q4, R36, R37, and C34, is used as a divide-

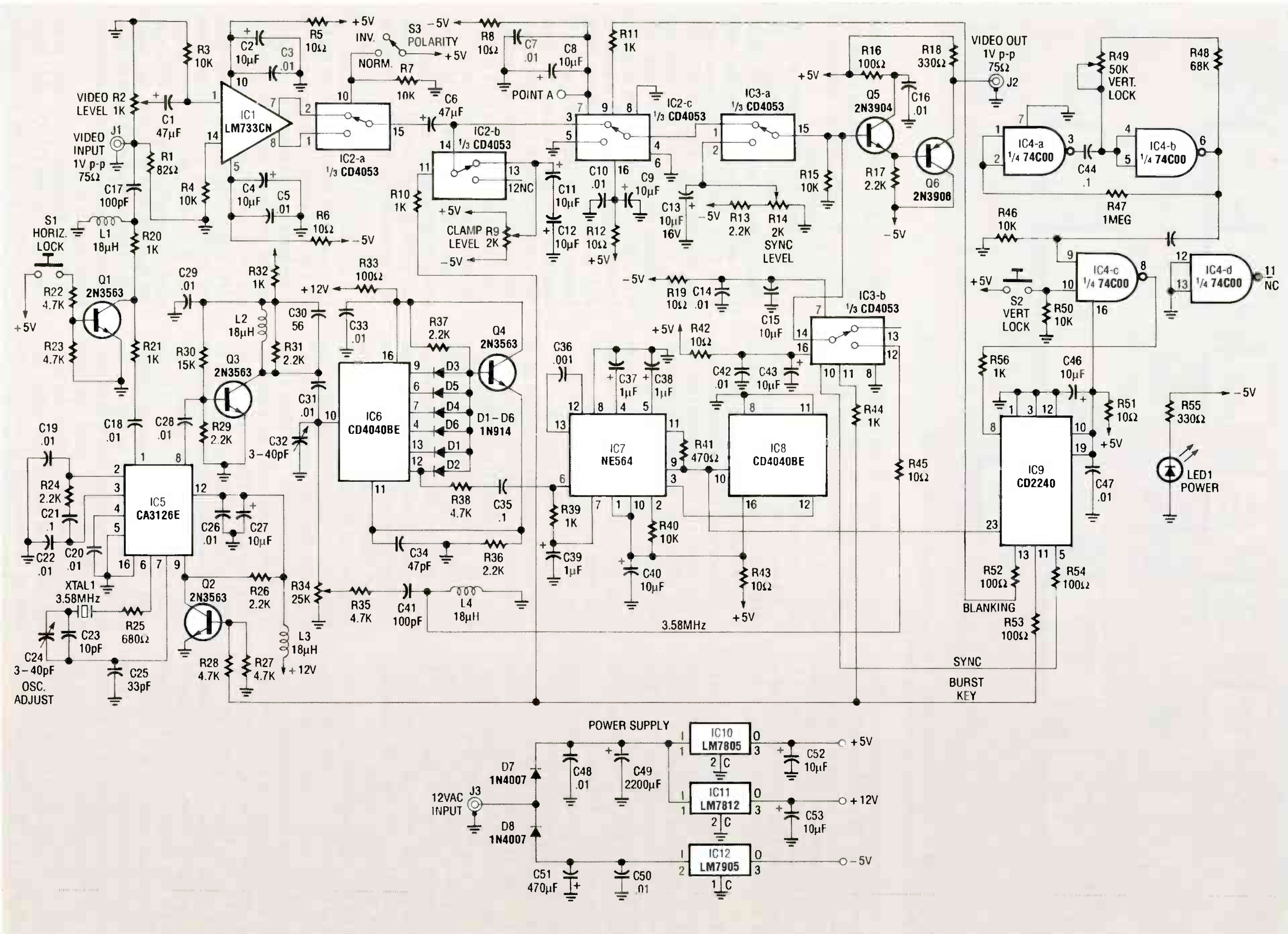


FIG. 3—SYNC REGENERATOR SCHEMATIC. "Defective" video is input at J1. It is then stripped of its sync, given new sync, and then output at J2.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—82 ohms
R2—1000 ohms, potentiometer with shaft
R3, R4, R7, R15, R40, R46, R50—10,000 ohms
R5, R6, R8, R12, R19, R42, R43, R45, R51—10 ohms
R9—2000 ohms, potentiometer with shaft
R10, R11, R20, R21, R32, R39, R44, R56—1000 ohms
R13, R17, R24, R26, R29, R31, R36, R37—2200 ohms
R14—2000 ohms, potentiometer
R16, R33, R52–R54—100 ohms
R18, R55—330 ohms
R22, R23, R27, R28, R35, R38—4700 ohms
R25—680 ohms
R30—15,000 ohms
R34—25,000 ohms, potentiometer
R41—470 ohms
R47—1 megohm
R48—68,000 ohms
R49—50,000 ohms, potentiometer

Capacitors
C1, C6—47 µF, 16 volts, electrolytic
C2, C4, C8, C9, C11–C13, C15, C27, C40, C43, C46, C52, C53—10 µF, 16 volts, electrolytic
C3, C5, C7, C10, C14, C16, C18–C20, C22, C26, C28, C29, C31, C33, C42, C45, C47, C48, C50—0.01 µF, ceramic disc
C17, C41—100 pF, NPO
C21, C35, C44—0.1 µF, Mylar
C23—10 pF, NPO
C24 C32—3–40 pF, trimmer
C25—33 pF, NPO
C30—56 pF, NPO
C39—47 pF, NPO
C36—0.001 µF, Mylar
C37–C39—1 µF, 50 volts, electrolytic
C49—2200 µF, 16 or 25 volts, electrolytic
C51—470 µF, 16 or 25 volts, electrolytic

Semiconductors
IC1—LM733CN differential video amplifier
IC2, IC3—CD4053BE triple 2-channel analog multiplexer
IC4—74C00N quad 2-input NAND gate
IC5—CA3126E TV chroma processor
IC6, IC8—CD4040BE ripple carry binary counter/divider
IC7—NE564N—phase-locked loop
IC9—CD2240 CMOS LSI video sync generator
IC10—LM7805 +5-volt regulator
IC11—LM7812 +12-volt regulator
IC12—LM7905 −5-volt regulator
D1–D6—1N914B small signal diode
D7, D8—1N4007 rectifier diode
LED1—light-emitting diode, any color

Other components
L1–L4—18 µH choke
XTAL1—3.58 MHz crystal, 0.005%, 32 pF, fundamental mode, parallel resonant
J1, J2—RCA-type phono jack
J3—2.5 mm power jack
S1, S2—N.O. pushbutton switch
S3—SPST toggle switch
Miscellaneous: cabinet (Radio Shack # 270-272A is perfectly suited), hardware as required, IC sockets (if desired), 12-volt AC, 350 mA wall transformer or other power transformer (see text)

Note: A complete parts kit, including the PC board, switches, potentiometers, jacks and plugs, and all parts that mount on the PC board is available from North Country Radio, P.O. Box 53, Wykagyl Station, NY 10804. Price for the kit is $92.50 + $2.50 shipping and handling. A wall transformer is available for $8.75 extra when ordered with the kit. A partial kit consisting of only the PC board and IC1 through IC12 is available for $72.50 + $2.50 shipping and handling. Case is not included in either kit.

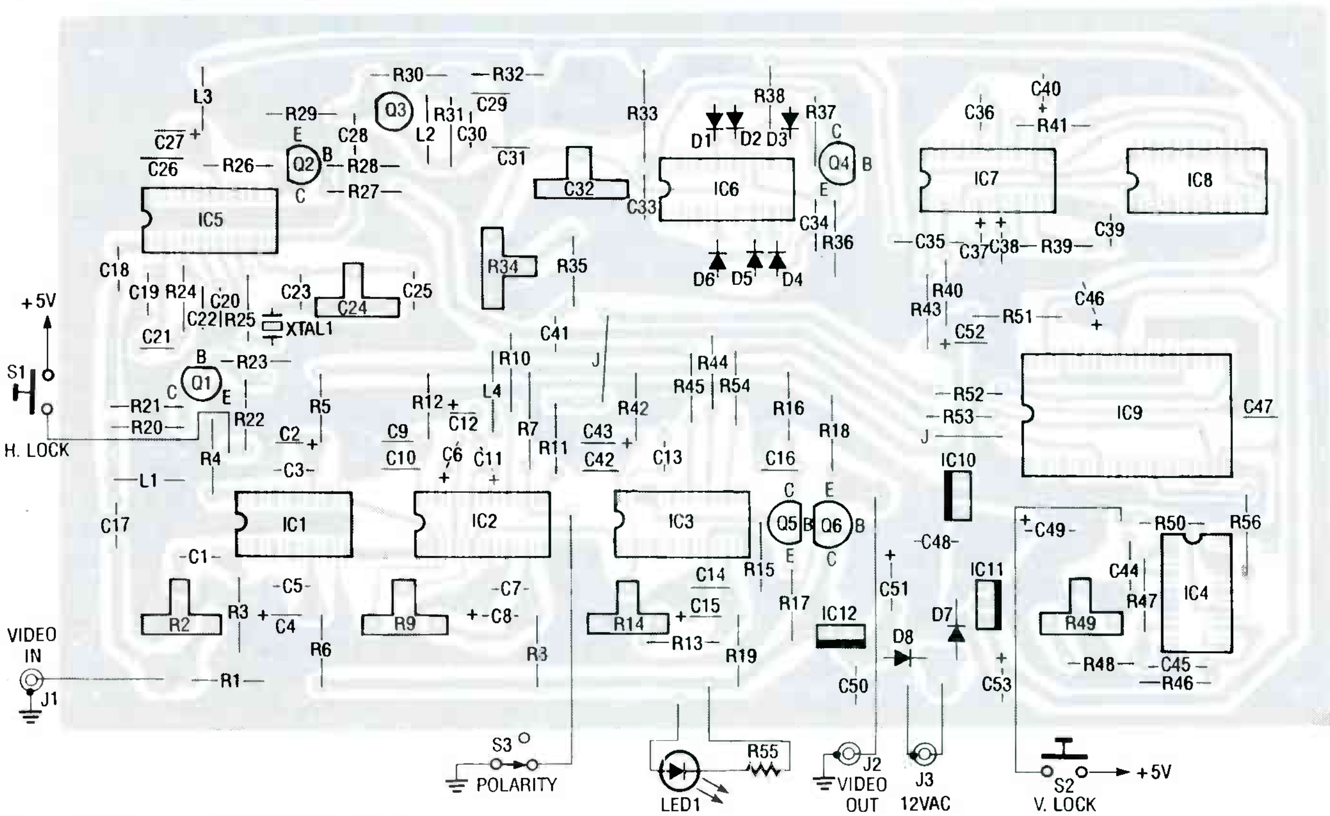


FIG. 4—PARTS-PLACEMENT DIAGRAM for the sync regenerator.

by-455 circuit. That results in a 7.87-kHz signal at pin 12 of IC6; the signal is coupled via R38 and C35 to IC7, an NE564 phase-locked loop frequency multiplier that operates at about 1.08 MHz. Capacitor C36 determines the initial frequency, and C37 and C38 determine loop characteristics. The 1-MHz VCO output from IC2 is fed to IC8, a CD4040 CMOS binary counter, that divides by 128 and feeds the nominal 7.87-kHz result back to the phase detector of IC7. That produces a lock condition and the 1.08-MHz signal from IC7 is phase-locked to the 7.87 kHz input signal. Resistor R40 sets the gain of PLL IC7, C40 and C37 are bypass capacitors, and R43 is a supply decoupling resistor.

The 1.08-MHz clock signal is fed to video sync generator IC9 that produces requisite timing signals from that clock signal. IC9 supplies burst-keying, blanking, and sync signals to analog switches IC2 and IC3, and also to Q2. Resistors R52, R53, and R54 provide short-circuit protection as well as test points for those signals. R51, C46, and C47 are power-supply decoupling components.

Even if horizontal locking is correct in phase, vertical locking may not be, so IC9 must be locked up by pulses from lock-oscillator circuit IC4. Pressing S2 enables pulses from IC4-a and -b to synchronize vertical pulses generated by IC9. That is evidenced by a vertical rolling of the video image seen on a monitor connected to J2. Switch S2 must be held depressed until vertical lockup (framing) is correct.

DC power (−5V, +5V, and +12V) is supplied to all IC's, as required. Regulators IC10, IC11, and IC12, C48–C53, and diodes D7 and D8 make up the power supply. About 12-volts AC at 350 mA is required at power-jack J3. A power-on indicator is formed by R55 and LED1, and may be omitted, if desired.

Construction

A PC board is the preferred construction technique for this project to keep stray-signal pickup, ground loops, or other glitches to a minimum. Therefore we strongly suggest that you either make a printed-circuit board from the foil pattern provided in PC Service, or use a PC board from the source mentioned in the parts list. A parts-placement diagram is shown in Fig. 4.

Begin assembly by first installing all fixed resistors. Next, install the diodes, the four chokes, then the capacitors. Then install the five potentiometers. The two potentiometers R2 and R9 should be fitted with shafts, as they are front-panel controls. The use of sockets for all IC's is recommended, though not essential: that makes testing easier. Do not install any IC's until the last components are installed on the board.

Switches S1–S3, J1–J3, and LED1 can be wired to the PC board after all components except the IC's are installed. That allows the entire unit to be installed in one step in the case of your choice. The project was designed to fit a case that's 8 inches wide by 6 inches deep by 2 inches high, or thereabouts. It's best to use a metal case; other cases can be used—wood or plastic is OK—but stray-signal pickup can occur due to the lack of shielding. The prototype was built in Radio Shack's # 270-272A. The board should be mounted on four ½-inch standoffs (see Fig. 5).

A power source can be any 12-volt AC, 60-Hz wall transformer of at least 350 mA capacity. A power jack (J3) is mounted on the rear of the case, but you can hardwire the power pack directly to the board—J3 is therefore optional. A 12-volt AC general-purpose transformer can be mounted in the case along with the PC board if preferred. If you exceed 14-volts AC, the voltage regulators (IC10–IC12) may run too warm as they are not heat sinked. C49 and C51 should be increased to 25-volt ratings and IC10–IC12 should be heat sinked if more than 14-volts AC is used.

A DC power source cannot be used, since we use both positive and negative half cycles of an AC waveform to derive the +12-, +5-, and −5-volt DC supplies. A power switch was not used on the prototype; the plug can simply be pulled out from J3 to turn the unit off.

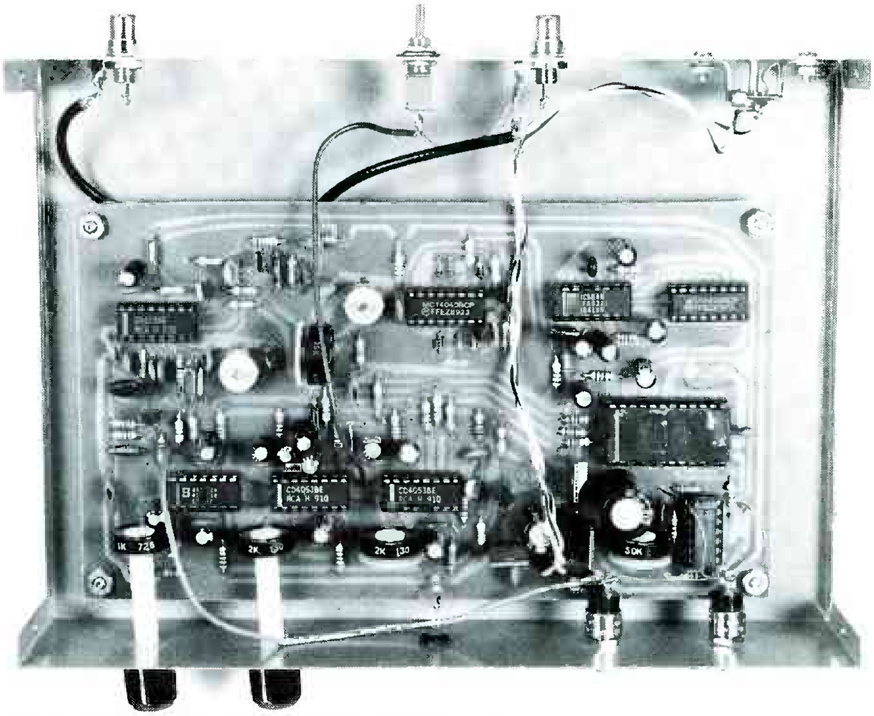


FIG. 5—HERE IS THE COMPLETED prototype unit.

Checkout

Carefully inspect all connections for correct soldering. Next, check for any inadvertent solder bridges especially around the IC pins. Make sure correct components have been used and that all components are correctly oriented. At this point, without the IC's inserted, apply power and immediately measure the voltages on the +5-, −5-, and +12-volt buses. They should be within ±0.25 volts of those values. If any of the voltages are incorrect, immediately remove power and find the problem. If everything seems OK, keep the PC powered for several minutes; nothing should get hot or smoke. If it does, locate and correct the problem.

When the power-supply section is working, check for the following voltages (±10% unless otherwise noted) before inserting the IC's.

- IC1 pin 5: +5V
- IC1 pin 10: −5V
- IC2 and IC3 pin 7: −5V
- IC2 and IC3 pin 16: +5V
- IC5 pin 12: +12V
- IC6 pin 16: +12V
- Collector of Q2: +12V
- Collector of Q3: +4 to +8V
- Emitter of Q5: −0.6V
- Emitter of Q6: OV ±0.3V
- IC7 pins 1 and 10: +5V
- IC8 pin 16: +5V
- IC9 pins 10 and 19: +5V
- IC4 pin 16: +5V
- IC2 pin 13: +5 to −5V (should vary with setting of R9)
- IC2 pin 2: 0 to −2.2V (should vary with setting of R14, adjust R14 for −0.45V)

Remove power from J3 and insert all IC's in the board. Next, set all trimmer potentiometers and capacitors at midpoint except R14, which was initially set during checkout. Now apply power to the board and quickly check for the following voltages. Note that the voltages can vary by as much as 20%.

- IC1 pins 7 and 8: +1.5 to +3.0V
- IC5 pin 9: −0.2V
- IC9 pin 13: +3.6V
- IC9 pin 11: +4.1V
- IC9 pin 5: +4.6V
- IC2 pin 9: +3.6V
- IC2 pin 10: +4.9V
- IC2 pin 11: +4.1V
- IC3 pin 10: +4.6V
- IC3 pin 11: +4.1V
- IC4 pin 6: +2.5V

Testing and using

Hook up the unit as shown in Fig. 6. Connect a video monitor to J2. If no such device is available, you can use an ordinary TV tuned to CH3 or CH4 with an RF modulator connected as shown in Fig. 6. Rotate R9; there should be a blank raster on the screen, white, gray, or black, adjustable with R9. Figure 7 shows what the waveform at J2 should look like on an oscilloscope at this point.

Now apply a video signal to J1. Adjust R2 and then R9 for a visible image as shown in Fig. 8. It may roll, but that's normal. Set R9 for barely visible white clipping, and then back off a bit. Adjust R2 for proper contrast. Next, depress vertical-lock switch S2. A bar should roll visibly

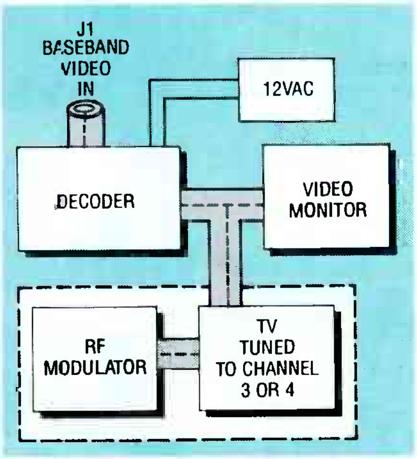


FIG. 6—HOOK UP THE UNIT as shown here. The unit requires a baseband-video input, and it outputs baseband video. If you don't have a baseband video source, then you need something like a VCR with an RF input and a baseband-video output jack. If you don't have a monitor that accepts baseband video, then you need an RF modulator or a VCR with a baseband-video input jack and an RF output.

up and down. Adjust R49 for a slow roll. By "tapping" S2 you should be able to lock the picture vertically. Set S3 to positive polarity (open). Now depress S1, the horizontal-lock switch. The picture should roll horizontally and possibly vertically, as well. Adjust trimmer-capacitor C24 until the roll is slow. By "tapping" S1 you should be able to lock in the image horizontally.

Adjust R2 and R9 for a good image. Misadjustment of R9 will either wash out the picture or cause horizontal tearing and loss of lock. Actually,

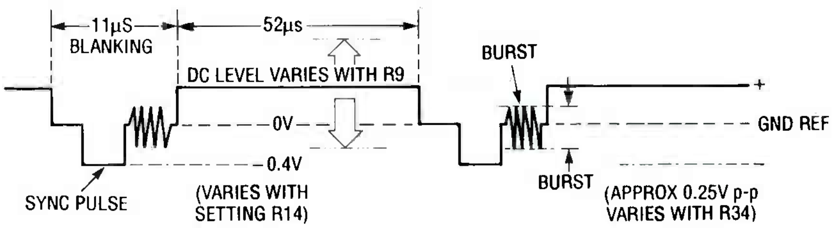


FIG. 7—THE WAVEFORM AT J2 should look like this when the circuit is powered up with no video input to J1.

you can deliberately scramble a picture by adjusting R9 so that the new sync pulses are suppressed with respect to the video. Toggle-switch S3 should invert the video yielding a negative picture.

If the resultant image has weak color, adjust the burst-level control R34. Tint shifts can be adjusted with C32, if necessary. Instability in the color of the received picture normally

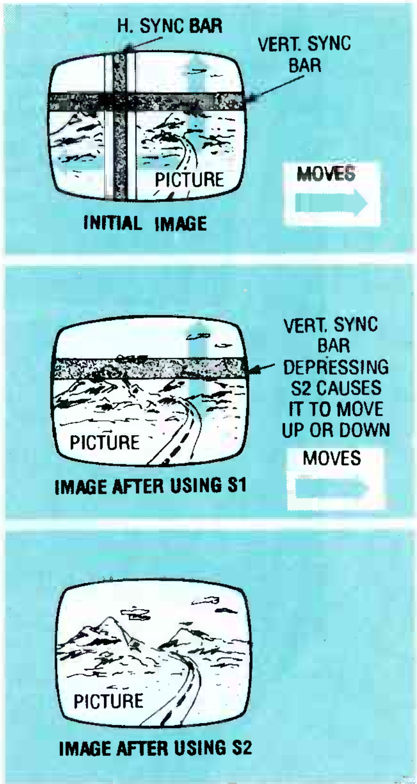
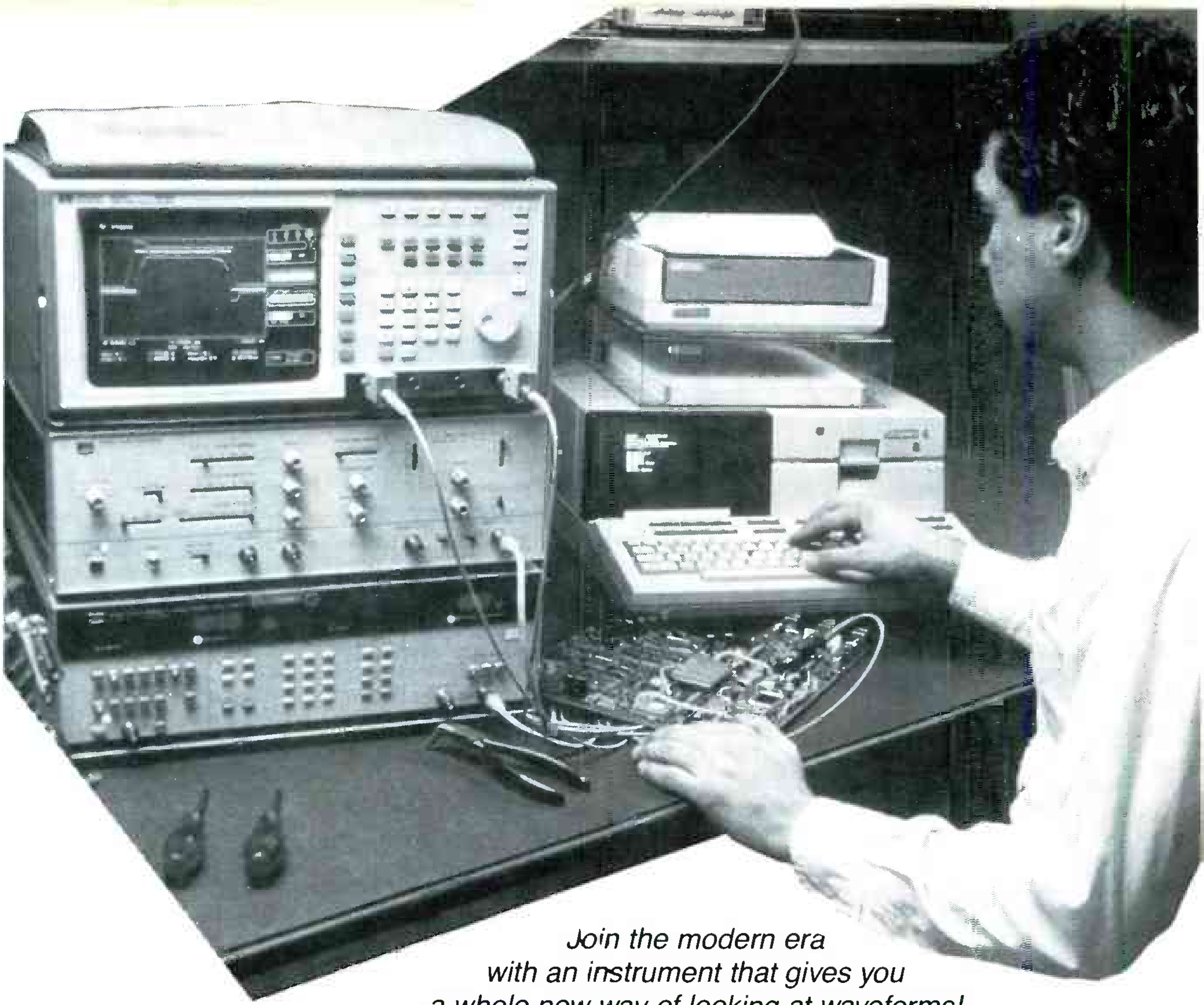


FIG. 8—AFTER APPLYING A SIGNAL TO J1, adjust R2 and R9 for a visible image as shown here; it may roll, but that's normal.

indicates incorrect lockup. Tap S1 (horizontal lock) to correct the problem. S3 can be used to change video polarity, but that will normally require a slight readjustment of R9 to correctly set the DC levels.

In case you have any difficulty in getting the decoder working, first check for a 1-volt p-p video signal at J1. It is assumed that +5, −5, and +12 volts are present. Next check to see that IC5 is producing a 3.58-MHz signal. Also check for about 8–12 volts p-p at 3.58 MHz at pin 10 of IC6. Check for a 7.8-kHz pulse train at pin 12 of IC6. Check for a 1.08-MHz clock signal at pin 23 of IC9. Those are just a few troubleshooting tips in case you have any problems. However, you shouldn't experience any problems if your workmanship is good. **R-E**



Join the modern era with an instrument that gives you a whole new way of looking at waveforms!

ALLAN C. STOVER

INSIDE DIGITAL OSCILLOSCOPES

WHILE MOST ENGINEERS AND TECHNICIANS can't keep their hands off the newest and latest test instruments, others have to be convinced that the newest equipment is actually better than what they're using. It took many years for the digital multimeter to supplant the analog variety as most popular. And, undoubtedly, a comparable period of time will be required before *D*igital *S*torage *O*scilloscopes (DSO's) will be able to outsell their analog predecessors.

DSO's aren't ideal for all applications, so understanding how they work can help you decide if they're right for you. They offer some features that analog versions can't match:

- Digital timing, more accurate than that of analog versions.
- Waveforms can be manipulated to highlight certain features for special analysis, letting a user zoom in on areas of interest.
- Waveforms can be stored indefinitely and recalled from memory for comparison, a feature not shared by analog storage oscilloscopes, which store a waveform for a limited period on a CRT, but not in memory.
- The DSO is essential in *A*utomatic *T*est *E*quipment (ATE), where a computer acts as controller, receiving measured values and changing measurement parameters like vertical sensitivity and sweep (or, in this case, sampling) rate.

Analog oscilloscopes

Before diving into how DSO's work, you should first be familiar with the characteristics of an analog version; a block diagram of a two-channel model is shown in Fig. 1. The two inputs pass through a front-end attenuator and vertical preamplifier in each channel, and are then multiplexed to a delay line and the vertical output amplifier. The amplified vertical signals deflect the electron beam from the *C*athode-*R*ay *T*ube (CRT) in proportion to their levels.

The delay line slows the vertical signal long enough for the sawtooth waveform from the horizontal sweep generator to move the electron beam across the CRT, after the oscilloscope is triggered. Without the delay line, the initial part of the signal waveform prior to the trigger point would be lost at the left side of the CRT. Since the inputs pass through the entire vertical channel circuitry before reaching the CRT, the inherent vertical channel delay is usually longer than that experi-

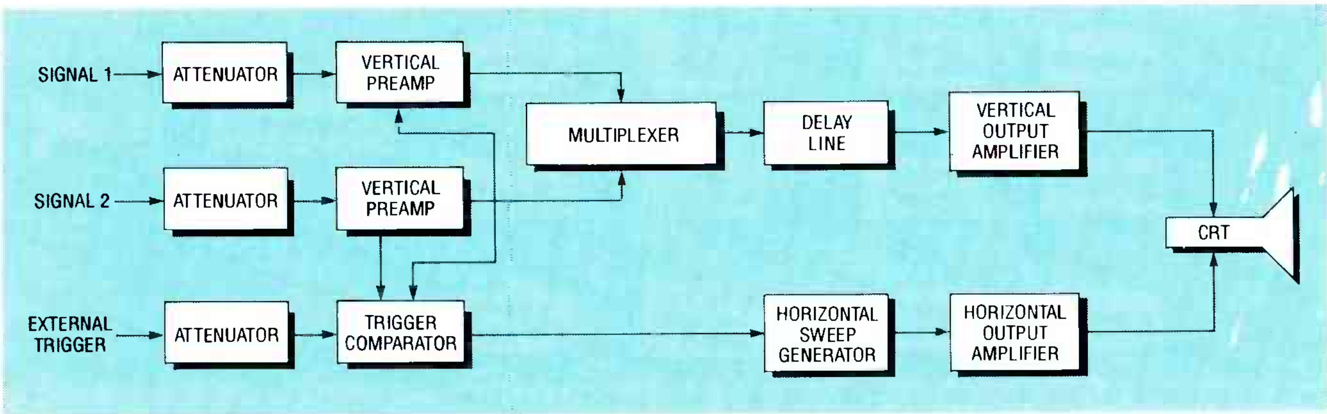


FIG. 1—SIMPLIFIED BLOCK DIAGRAM of an analog oscilloscope, with two vertical channels and an external signal input. The two vertical channels are multiplexed before application to the vertical and horizontal circuitry. The external and internal triggers can trigger the horizontal sweep, whose output is applied to the horizontal input of the CRT.

enced by the trigger signal as it passes through the trigger circuits and horizontal sweep generator.

A vertical amplifier needs enough bandwidth to pass an applied input without distortion, which translates into increased cost. Both vertical preamplifiers use part of their individual inputs for triggering purposes. Triggering can also be external, with the user selecting the desired option by manual switching. The trigger-comparator starts the horizontal sweep generator, determining the vertical level in a given waveform where the oscilloscope is triggered.

Triggering basics

Since triggering is important in DSO operation, let's cover some basics. Suppose an external trigger arrives before a signal. The beam starts sweeping, and the signal appears somewhere later (toward the right side) on the CRT. In fact, if the triggering occurs long enough before the signal, the sweep would finish before the signal arrives, and no waveform would appear on the CRT. If the trigger occurs after the signal begins, the CRT will display a later portion of the signal at the left-hand side of the CRT.

Fig. 2-*a* shows an example of early, or pre-triggering, Fig. 2-*b* shows normal, on-time triggering, and Fig. 2-*c* late, or post-triggering. This idea will be important later, when discussing DSO triggering.

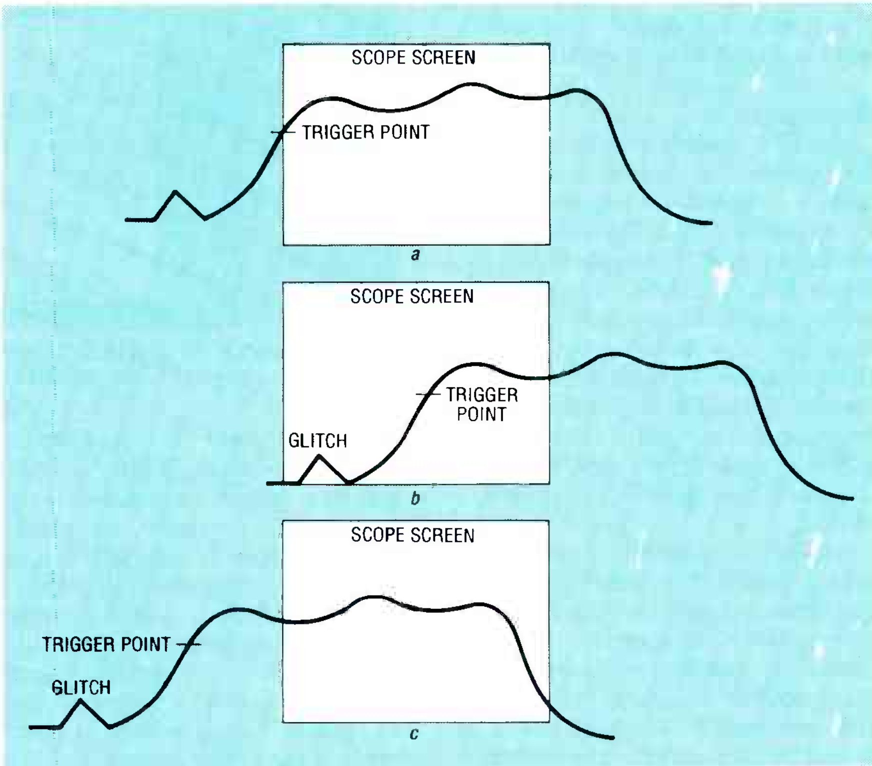


FIG. 2—THREE EXAMPLES OF TRIGGERED WAVEFORMS. An example of the CRT with normal triggering on the positive-going slope is shown in (*a*). An example of early, or pre-triggering is shown in (*b*), where the normal trigger point is visible in the early part of the display, letting the glitch before the main waveform to be detected and observed. Finally, (*c*) shows an example of late, or post-triggering, where the trigger occurs early in time, letting the latter portion of the waveform be observed.

Inside DSO's

The DSO is similar to an analog oscilloscope in certain regards, but different in others. Figure 3 shows a block diagram of a two-channel DSO; the front end consists of attenuator, vertical preamplifier, and trigger, each with the same function as in the analog version of Fig. 1. However, the two vertical channels of the DSO aren't multiplexed as they are in the analog version; each has a separate path to the microprocessor, permitting data to be captured on both channels simultaneously.

An input goes through an *A*nalog-to-*D*igital (A/D) converter, with the digitized version stored in memory until the microprocessor can display it on the CRT. The available waveform storage memory is determined by the DSO's *record length*. The longer the record length, the longer the waveform you can store, although you may be able to display only a piece at a time. The bandwidth of all circuitry after the A/D converters, including the CRT, can be much lower (sometimes called *slower*) than the DSO's

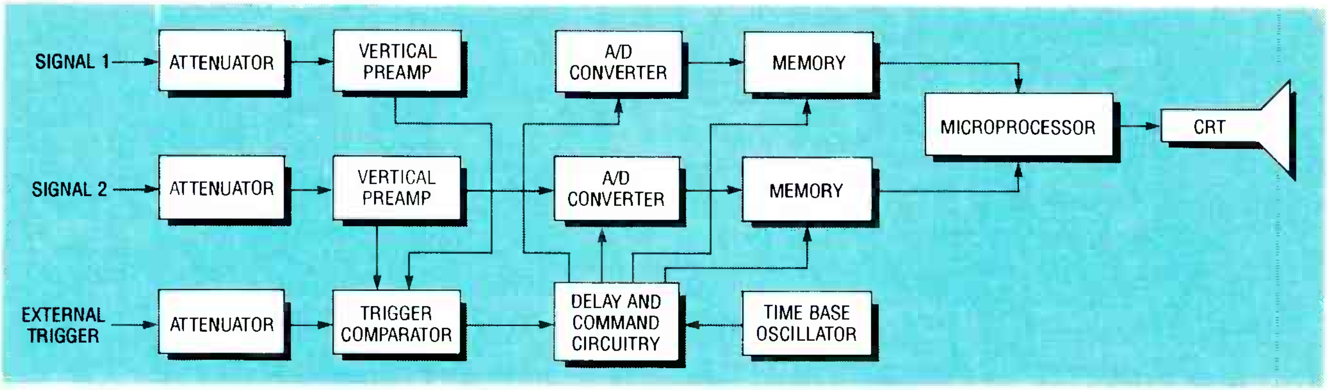


FIG. 3—SIMPLIFIED BLOCK DIAGRAM OF A DSO. The front end is similar to that of its analog predecessor. After the vertical preamplifier, however, the inputs are digitized by an A/D converter, and stored in memory until the microprocessor can process them and display the waveform on the CRT.

rated bandwidth. Once an input is digitized, the circuitry thereafter need only run at the digital word rate to keep it displayed on the CRT.

Sampling

A DSO doesn't process an input continuously as does an analog version; it samples at a rate determined by its digital clock. Figure 4 shows a sampled signal displayed on a CRT. When buying a DSO, not only the analog bandwidth needs to be considered, but also the sampling rate, to determine how high a frequency it can handle. If it had to display a sinusoid, for example, but took a random sample every cycle or two, the CRT image wouldn't look anything like what it should.

In order to reconstruct a continuous signal with finite bandwidth from equispaced digital samples of it, the rate at which the samples are taken, called the sampling rate, must be *at least* double the signal bandwidth; this minimum sampling speed is called the Nyquist rate, after the engineer who discovered this principle. Sampling slower than the Nyquist rate causes *aliasing*, a form of signal distortion which can render a reconstructed signal useless.

Some DSO manufacturers use the Nyquist rate to calculate their digital bandwidth, which gives a higher specification than others that use four or more points per period. You need to know how individual manufacturers calculate bandwidth to compare DSO's. The higher the actual sampling rate, the better the resulting reconstructed CRT signal will appear. If aliasing occurs during measurement, you may need to change the sweep speed, or switch to an unaliased

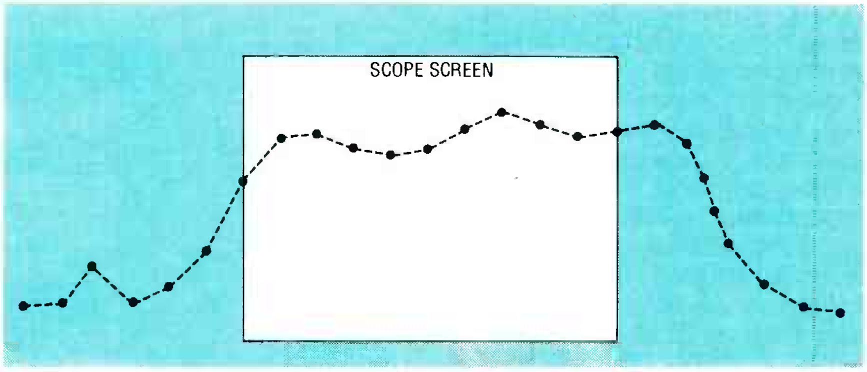


FIG. 4—SAMPLING OF A WAVEFORM ON A DSO. The DSO either needs more sample points, or to *connect the dots*, to make the waveform appear continuous.

mode, if the DSO has that capability.

DSO's use several sampling methods, the two most common being *real-time* and *repetitive*. Sampling is performed under direct microprocessor control, as shown in Fig. 3. Real-time sampling is used to capture single-shot waveforms, since a high sampling rate is needed for enough points in one sweep for an accurate reconstruction. The analog bandwidth of the DSO front end has to be high enough in order to prevent analog distortion.

Repetitive sampling is used for periodic waveforms that can be sampled over an adequate period of time, not single-shot events. The two types of repetitive sampling are random and sequential equivalent-time sampling. The former is done constantly without waiting for triggering. The DSO stores the time each sample is taken, and when enough points are gathered, reconstructs them on the CRT in the order they occurred after triggering. The latter is done with the DSO waiting a certain interval after triggering, and then taking a sample. On each pass, the time between triggering and sampling is increased, giving a string of samples in time appearing on the CRT.

The visual results of both random and sequential sampling are identical. Each gives the same number of samples on the CRT, so the user sees the same signal with either method. The main difference is that random repetitive sampling samples the signal without regard to triggering, so many samples are taken before the trigger occurs, letting the signal before the trigger be reconstructed; this is useful in troubleshooting glitches. Since random sampling collects signal information both before and after triggering, then puts it together in relation to the trigger time, both before and after, the DSO provides pre-trigger capability.

The timebase oscillator block in Fig. 3 performs the same function as the horizontal sweep block in Fig. 1, except that the timing is digital and considerably more accurate than in the analog case. The delay and command block in Fig. 3 is timed by the timebase oscillator, and in turn coordinates the operation of the A/D converters and the waveform storage memories for both channels.

Automatic testing

Figure 5 shows a DSO in a simple ATE system. The ATE computer controls the test equipment and reads measurement results transmitted via *G*eneral *P*urpose *I*nterface *B*us (GPIB). (See **Radio-Electronics**, July 1988, Page 57, *The General Purpose Interface Bus*, by Vaughn D. Martin.) The ATE computer can analyze sampled signals to determine amplitude, frequency, pulse width, and other characteristics.

Since the DSO has a microprocessor, it can analyze waveforms by itself, and send the results to the ATE computer via GPIB. Product testing that once required technicians to make complex judgments of oscilloscope signals can now be done via ATE using a DSO to analyze signals at high speeds and without human error.

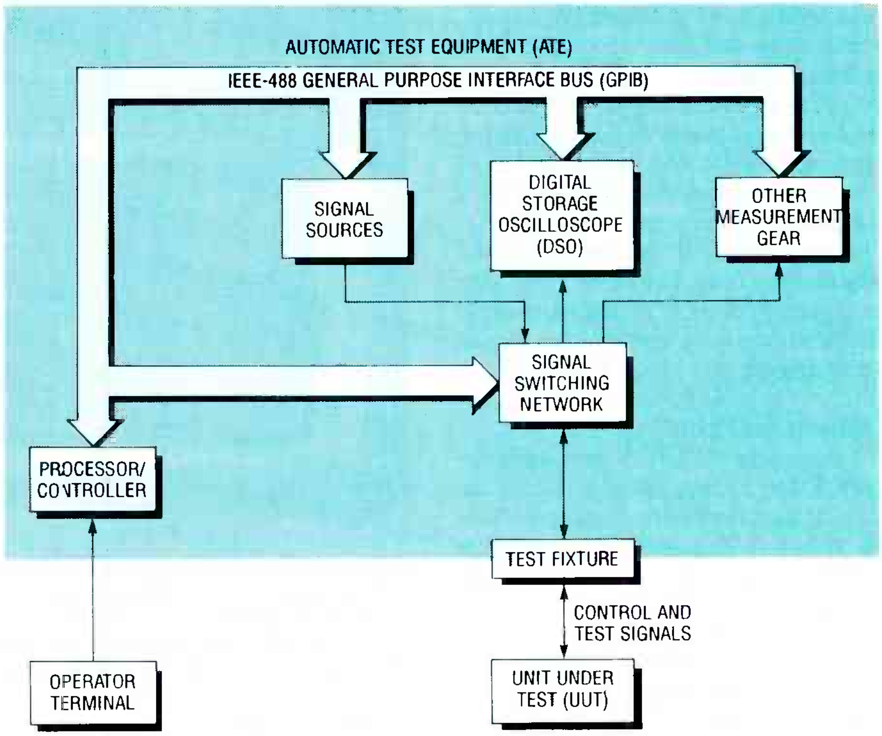


FIG. 5—BLOCK DIAGRAM OF A TEST SETUP where a DSO is used in conjunction with ATE. The computer controls the DSO via GPIB, as are all the other test equipment in the system. Waveform parameters can be sent to the computer via GPIB for processing.

DSO features

A DSO can store waveforms indefinitely, provided power is continuously available, and the signal isn't overwritten. In the DSO block diagram in Fig. 3, there's volatile digital memory between the A/D converter and the microprocessor. DSO's have several features that allow signals to be manipulated, have certain characteristics highlighted, or compared to one another. Some of these are:

- *Automatic measurements*: A DSO can measure a number of digital waveform characteristics and display them on its CRT, including rise time, fall time, delay after trigger, peak-to-peak voltage, offset, frequency, overshoot, pulse width, and duty cycle, among others. A user can also control the position of cursors on the CRT to display the difference in time and amplitude between two points on a waveform. These features speed up measurements, improve accuracy, and eliminate human error.
- *Infinite persistence*: This feature, also called point-accumulate mode, lets a technician see the total jitter in a signal. The signal on the CRT is never erased; it just accumulates on the CRT. The stable parts of the signal show up as solid lines, but any jitter become "fuzzy," and the width of the fuzzy region indicates the amount.
- *Envelope mode*: Similar to the infinite persistence feature, in that it displays minimum and maximum excursions of a waveform over time, thereby showing the maximum and minimum points of jitter.
- *Hardcopy output*: Some DSO's can be connected to a graphic printer or plotter for a hard copy of a CRT image without needing an oscilloscope camera.
- *Averaging*: This lets you display

TABLE 1—DIGITAL STORAGE OSCILLOSCOPE (DSO) MANUFACTURERS

Analogic Corp.
8 Centennial Dr.
Peabody, MA 01961
(508) 977-3000
(800) 343-8333

B&K-Precision Maxtec Intl. Corp.
6470 W. Cortland St.
Chicago, IL 60635
(312) 889-1448

Hameg, Inc.
88-90 Harbor Rd.
Port Washington, NY 11050
(516) 883-3837
(800) 247-1241

Heath Co.
Hilltop Rd.
St. Joseph, MI 49085
(616) 982-3200

Hewlett-Packard Co.
1820 Embarcadero
Palo Alto, CA 94303
(415) 857-8500

Hitachi Denshi America, Ltd.
175 Crossways Park W.
Woodbury, NY 11797
(516) 921-7200

John Fluke Mfg. Co., Inc.
6920 Seaway Blvd.
Everett, WA 98203
(206) 347-6100
(800) 443-5853

Kikusui Intl. Corp.
19601 Mariner Ave.
Torrance, CA 90503
(213) 371-4662
(800) 545-8784

Leader Instruments Corp.
380 Oser Ave.
Hauppauge, NY 11788
(516) 231-6900
(800) 645-5104

Nicolet Oscilloscope Div.
5225 Verona Road
Madison, WI 53711
(608) 273-5008
(800) 356-3090

Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97077
(503) 627-9000
(800) TEK-WIDE

the average of a repetitive signal, smoothing out jitter and noise for a clearer display.

- *Pre- and post-triggering*: A DSO samples and stores signal data in numerous ways. It can sample and store data in a constant stream, then display whatever is in memory whenever triggering occurs. It can sample signal data either long before or long after triggering. A technician can observe what occurs on a signal either pre- or post-trigger, as shown in Fig. 2.

What's available

A variety of DSO's are available; see Table 1 for a list of some of the major manufacturers. Figure 6 shows a Hewlett-Packard (HP) 54501A DSO, a low-cost version of its top model. The 54501A has four channels, a repetitive waveform bandwidth of 100 MHz, a single-shot bandwidth of 1 MHz, and a 10-megasample/s digitizing rate. It also features time-base and channel controls similar to those of analog oscilloscopes, but controlled via an on-screen menu and universal controls.

Operating an HP 54501A is different from and much easier than operating an analog oscilloscope. When a user presses a menu key, a list of available functions appears on the right side of the CRT, each one in-line with a function key just to the right. A user selects the desired function, and enters the desired value via either the keypad or the universal knob on the front panel. The following features are also controlled via on-screen menus:

- *Display Menu* provides variable persistence for display of worst-case jitter, noise averaging, and envelope display modes, as well as the ability to "connect the dots" whenever individual data points are visible on the CRT.
- *Delta V/Delta T* controls the positioning of cursors to read the differences in voltage and time between two points on a waveform.
- *Waveform Math* lets a user mathematically manipulate two signals. The math includes A + B, A–B, A × B, and A versus B.
- *Waveform Save* lets a user store waveforms for later use in four nonvolatile waveform memories, and two volatile pixel memories.
- *Measurement Definition* lets a user set measurement limits, and lets the DSO itself determine if a waveform passes the test. A user can even leave the DSO unattended. If the waveform exceeds a limit, the results can be stored, printed, or sent to a computer. This mode allows automatic measurement of 16 different pulse parameters, and lets a user define measurement thresholds, like the standard rise-time measurement from 10% to 90%.

FIG. 6—THE HEWLETT-PACKARD 54501A DSO is a low-budget version of the manufacturer's top-of-the-line models. It has four channels, a repetitive waveform bandwidth of 100 MHz bandwidth, and a single-shot bandwidth of 1 MHz. It features a 10-megasample/s digitizing rate, and time-base and channel controls similar to those of analog oscilloscopes, but controlled through an on-screen menu and universal controls.

The Hewlett-Packard 54501A has a number of other useful features. *Timebase Windowing* lets a user zoom in on a specific waveform area. The HARDCOPY key prints a hardcopy output of the DSO CRT. The SAVE and RECALL keys let a user store and recall four instrument setups in nonvolatile memory. The AUTOSCALE key automatically scales time, voltage, and trigger level for a stable display.

continued on page 69

FIG. 7—THE TEKTRONIX 2432A DSO has a 300-MHz bandwidth and a 250-megasample/s digitizing rate. The 2432A includes signal averaging that reduces noise on repetitive signals. A smoothing feature uses a digital low-pass filter to improve the SNR for single-shot waveforms. There's also an AutoStep feature that lets a user build and run test procedures automatically, or by computer via GPIB.

MORSE/RTTY DETECTOR

Let your computer decypher Morse Code and radioteletype signals even if you don't know a dit from a dah

LARRY ASHWORTH, KA7AFR

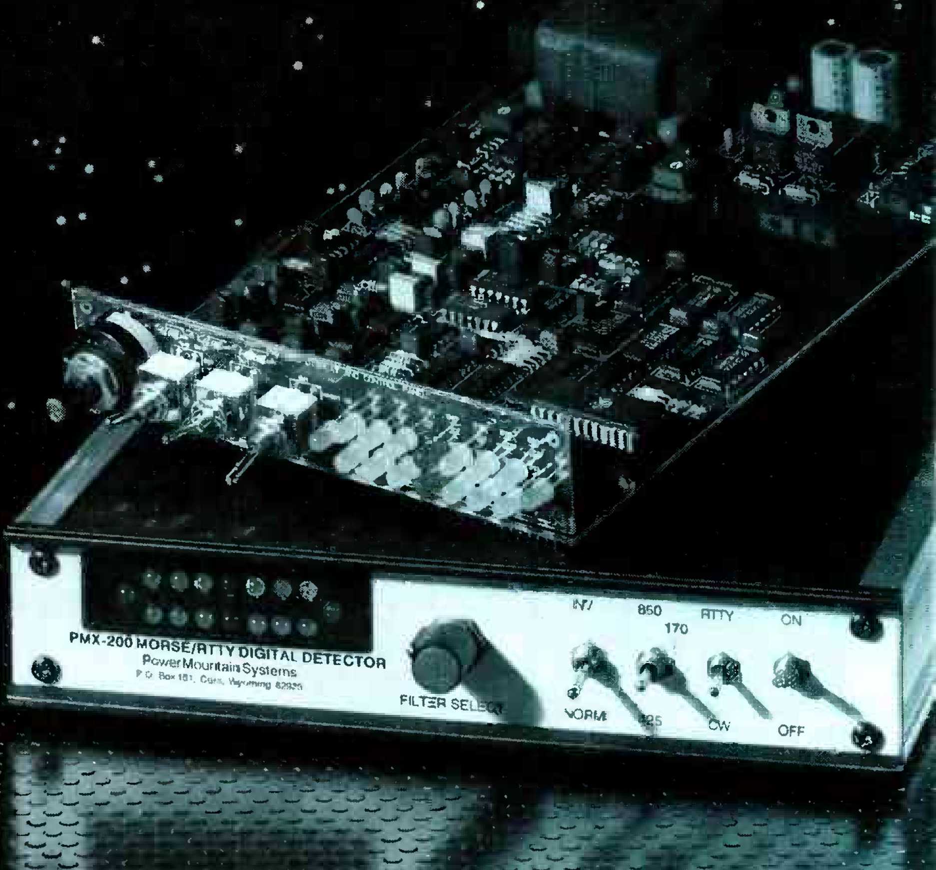
LAST MONTH WE WENT OVER MOST OF THE internal circuitry of the PMX-200, including the front end, input-filter, AGC, detectors, and the tuning indicator. Now we will finish up our discussion on the rest of the circuitry, which includes the AFSK section and the power supply. We will then show you how to build and test the unit. Finally, we'll discuss the necessary software, and show you how to get the detector up and running with your computer.

The AFSK (*A*udio-*F*requency *S*hift *K*eying) and interface section, shown in Fig. 4, contains a DB25 connector that can be plugged into your IBM PC/compatible serial port for decoding CW with your computer. (While any computer with a serial port can theoretically be used, the software provided on the R-E BBS will run only on IBM PC's and compatibles.) There is also an input from the computer that can drive a relay to provide an output for transmitting CW.

To enable a radio amateur to use the system to communicate in RTTY mode, an FSK generator (IC35–IC40) is on board, that uses a digital sine-wave generator to produce stable, high-quality audio output at J4. A CMOS counter (IC41) is used in a walking-ring configuration to produce a digitized sine-wave approximation. The output is very clean, since the first harmonic is many times the output frequency and very low in amplitude. After filtering, we have a signal that is virtually switching-transient free.

The low-level audio signal is designed to be sent to the microphone input of an SSB transmitter. A relay output is provided to key the mike from the computer. A separate relay output is included to key the CW key input on an amateur transmitter for CW operation. Both relay outputs are fully isolated from internal circuitry.

The schematic for the power supply



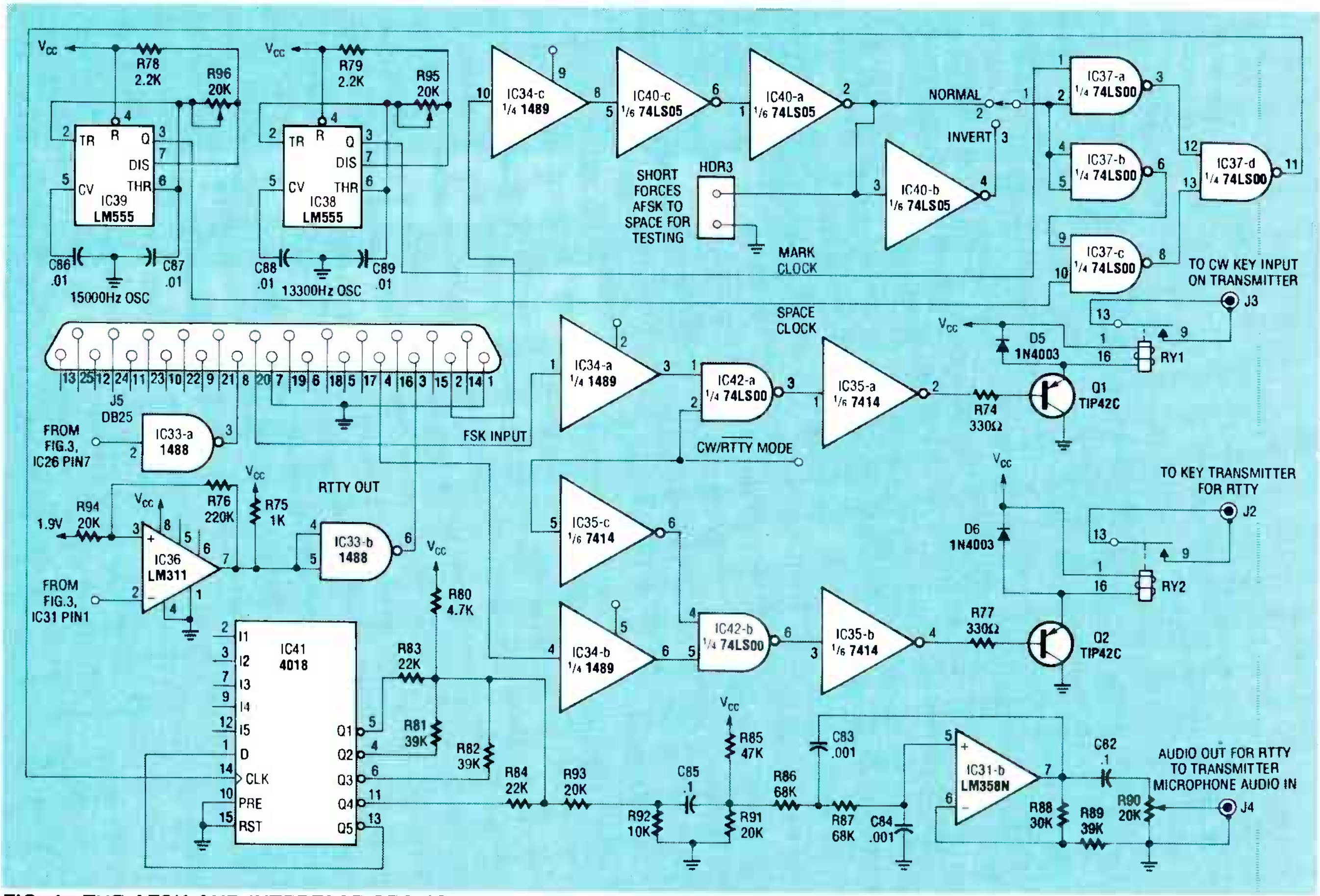


FIG. 4—THE AFSK AND INTERFACE SECTION contains a DB25 connector that can be plugged into your IBM PC/compatible series port for decoding CW with your computer.

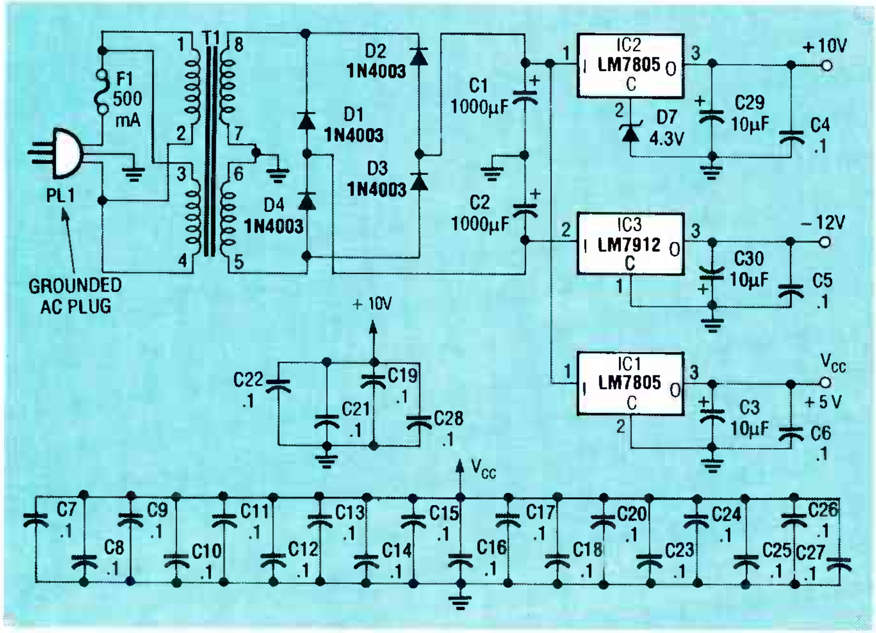


FIG. 5—SCHEMATIC FOR THE POWER SUPPLY. Power consumption is about 5 watts.

is shown in Fig. 5. Power consumption is about 5 watts, and all of it goes through the voltage regulators (IC1–IC3). Therefore, one of the 5-volt regulators (IC1) must be heat-sinked or else it will overheat during operation.

The other 7805 (IC2) is set up to output about 10 volts by attaching the ground terminal to a 4.3-volt Zener diode, D7. A 7912 (IC3) provides −12 volts. Since current demands are low, those two regulators do not require heatsinking.

Construction

Various parts and kits of parts are available from the source mentioned in the parts list. Foil patterns for the two PC boards (the main board and the display board) are provided in PC Service. However, because of their complexity, they are not recommended for beginners. Parts-placement diagrams for the two boards are shown in Fig. 6; the two boards are connected together by two 18-pin right-angle headers (HDR1 and HDR2—HDR2 is not shown schematically, as it is used in various places throughout the circuitry).

You should mount the 5-volt regulator to the case (a metal case can dissipate a lot of heat), and mount the circuit board in the case in such a way as to keep lead lengths under four inches. The other two regulators (IC2 and IC3) don't dissipate enough heat to require off-board mounting.

After you've assembled the boards and checked them carefully for poor soldering, etc., you must install them in an appropriate case. The one used for the prototype measures 9.8- × 1.75- × 10.25-inches, and an identi-

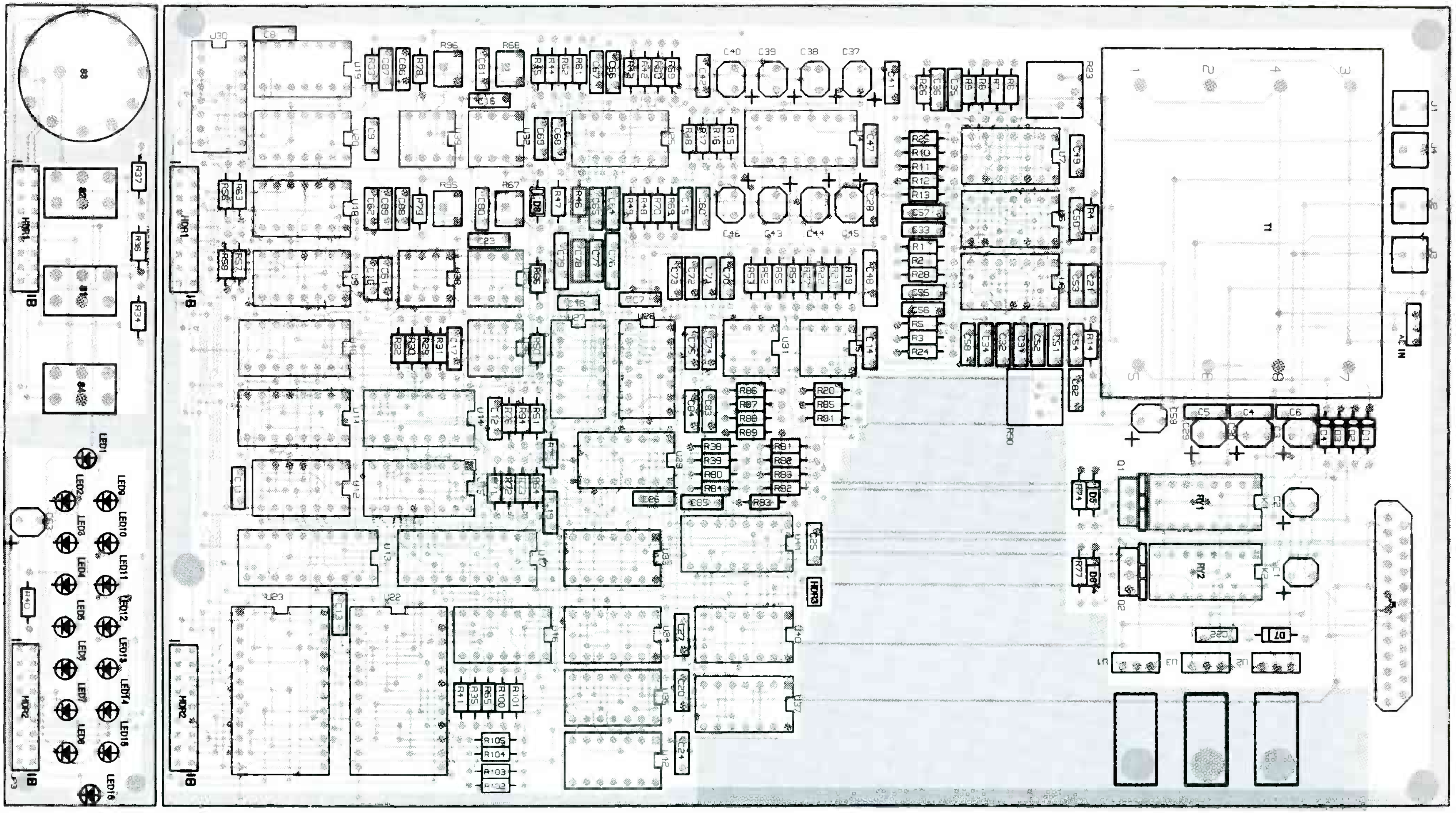


FIG. 6—PARTS-PLACEMENT DIAGRAMS for the main board and the display board. The main board is very complex, so you probably won't want to make it yourself.

PARTS LIST

All resistors are ¼-watt film except where otherwise indicated.

R1, R3, R6, R12, R43, R45, R49, R55, R81, R82, R89—39,000 ohms
R2, R9, R52, R53—27,000 ohms
R4, R7, R8, R19, R22, R24, R59–R62, R85—47,000 ohms
R5, R13, R86, R87—68,000 ohms
R10, R11, R14, R28—15,000 ohms
R15–R18, R69, R70—33,000 ohms
R21, R51, R76—220,000 ohms
R23, R90—20,000 ohms, ⅜-inch single-turn potentiometer
R25, R26, R34, R74, R77—330 ohms
R27, R30, R31, R78, R79—2200 ohms
R20—270 ohms
R29, R32, R33, R35–R39, R41, R50, R56–R58, R63–R65, R71–R73, R75—1000 ohms
R40—470 ohms
R42, R44, R48—48,000 ohms
R46, R47, R92—10,000 ohms
R54, R88—30,000 ohms
R66, R91, R93, R94—20,000 ohms
R67, R68, R95, R96—20,000 ohms, 10-turn potentiometer
R80—4700 ohms
R83, R84—22,000 ohms
R100–R105—2000 ohms

Capacitors

C1, C2—1000 µF, electrolytic
C3, C29, C30, C40, C46, C63—10 µF, electrolytic
C4–C28, C41, C47, C77, C78, C80–C82, C85—0.1 µF, mylar
C31, C34–C36, C49, C51—0.0047 µF, mylar
C32, C33—0.0027 µF, mylar
C37, C38, C43, C44, C59—1 µF, tantalum
C39, C45—2 µF, tantalum
C42, C60—30 pF, ceramic
C48, C76, C79—0.22 µF, mylar
C50, C52—0.002 µF, mylar
C53, C55—0.003 µF, mylar
C54, C56—0.0005 µF, mylar
C57, C58—0.0068 µF, mylar
C61, C62, C64, C65—0.047 µF, mylar
C66–C69, C86–C89—0.01 µF, mylar
C70, C71—0.15 µF, mylar
C72, C73—0.068 µF, mylar
C74, C75—0.03 µF, mylar
C83, C84—0.001 µF, mylar

Semiconductors

IC1, IC2—LM7805 5-volt regulator
IC3—LM7912 −12-volt regulator
IC4—NE570 compander
IC5, IC26, IC36—LM311 voltage comparator
IC6, IC25—LM324 low-power quad op-amp
IC7, IC8, IC27, IC28—4066 quad bilateral switch
IC9—74LS14 hex low-power Schottky Schmitt-trigger inverter
IC10, IC11, IC14, IC15—74LS161 synchronous binary counter
IC12, IC16—74LS30 8-input NAND gate
IC13, IC17—74LS244 octal tri-state buffer
IC18—74LS10 triple 3-input NAND gate
IC19—2.4576-MHz crystal oscillator
IC20—74LS90 decade counter
IC21, IC24—not used
IC22—2732 EPROM
IC23—74154 4-to-16 line decoder
IC29—7416 hex inverter buffer with high-voltage open-collector outputs
IC30—74LS147 10-line decimal to 4-line BCD encoder
IC31, IC32—LM358N low-power dual op-amp
IC33—1488 quad MDTL line driver
IC34—1489 quad MDTL line receiver
IC35—7414 hex Schmitt-trigger inverter
IC37, IC42—74LS00 quad 2-input NAND gate
IC38, IC39—LM555 timer
IC40—74LS05 open collector hex inverter
IC41—4018 presettable divide-by-N counter
D1–D6—1N4003 rectifier diode
D7—4.3-volt Zener diode
D8—4.7-volt Zener diode
Q1, Q2—TIP42C PNP transistor
LED1, LED16—green light emitting diode
LED5, LED12—red light emitting diode
LED2–LED4, LED6–LED11, LED13–LED16

Other components

T1—FP24-500................
HDR1, HDR2—18-pin right angle header
HDR3—2-pin jumper header
S1, S4—DPDT PC-mount switch
S2—DPDT PC-mount switch with center off
S3—12-position rotary PC-mount switch
J1–J4—RCA-type jack, chassis mount
J5—DB25 connector
RY1, RY2—16-pin PC-mount relay
PL1—grounded AC line cord
Miscellaneous: case, hardware, wire, solder, etc.

Note: The following items for the PMX-200 Morse Detector are available from Power Mountain Systems, P.O. Box 161, Cora, Wyoming 82925. Double-sided silk-screened PC boards, $79.95; discrete parts kit (no boards or case), $159.95; pre-programmed EPROM, $15.95; detector software package for IBM/compatible, $19.95; black brushed-aluminum case ready for you to drill, $79.95; complete kit (contains everything), $269.95; an assembled, aligned, and tested unit, $389.95. All prices include UPS Ground, or mailing charges in the USA.

cal one is available from the source mentioned in the Parts List. A photograph of the installed boards is shown in Fig. 7.

Tune up

The master oscillator is crystal-controlled and preset. Since we're dealing with a digital system, set up isn't very difficult. However, a few tips will make tune up easier.

If you want the best possible performance you should use an audio-signal generator and a frequency counter to verify that the filter circuits are performing as designed. Remember that when you change S2 (170-, 425-, and 850-Hz) you are changing the input bandpass filter width. You must make your measurements at IC6 pin 1, which is prior to the NE570 AGC circuit; otherwise the AGC will prevent you from seeing the filter's actual response.

Potentiometer R23 sets the input level, but the setting is not very critical. If you don't have a scope to check for audio-clipping at the output of the front filter section, just set it to a level where the detector seems to work well.

The 20K, ten-turn trim potentiometer, R68, on IC32 sets the DC threshold voltage for squaring up the AC input waveform (VADJ, IC32 pin 1). To set it you must use a frequency counter and a clean sine-wave generator. Set your generator to 1500 Hz and feed about a 1-volt signal into the PMX-200, using the counter as a frequency reference. Set the potentiometer so that the center LED on the upper row is lit. Normally you will see two LED's lit and, as you approach the correct setting, the two LED's will merge until only one is lit. So, as long as your generator is clean, the adjust-

continued on page 88

Why Are There so Many Transistors?

Selecting the right transistor for a particular application does not have to be frustrating.

JOSEF BERNARD

IT'S EASY TO BECOME overwhelmed by the number of transistor devices available. Understanding where they all come from can make it easier to select the one best suited to your needs. Suppose the instructions in a given project article call for "any general-purpose transistor." So you leaf through the back of **Radio-Electronics**, or pull out the pile of catalogs you've accumulated as the result of filling out reader-service cards month after month, and look to see who's got a good deal on general-purpose devices.

Let's see, where are they? "RF transistors?" "Power transistors?" "Small-signal transistors?" "Switching transistors?" Since you're building a little audio amplifier, you probably want "small-signal" transistors; after all it'll be handling only a small signal. Fine. OK, let's see what there is in that category: Hmmm . . . 2N2222, 2N3904, 2N3906, and about 15 other types. Maybe your procured-with-difficulty data book will give you a better idea.

Well, that's no help either. With something on the order of 30,000 different types of bipolar transistors alone, there are at least 15 pages of small-signal devices, and only one or two also appear in your Jameco or Digi-Key catalog. How do you decide which is the right one? Why are there so many?

Transistor classes

Even the most confused parts hunter will have to agree that dividing transistors into classes according to the purpose makes sense. To use a bulky heavy-duty power transistor that costs several dollars to do a job that could that could just as easily be handled by a smaller, less-expensive version is foolish. The question is, which specifications make it "just right?"

Each class of transistor is designed specifically for a particular type of operation, and those characteristics are what makes it suitable for a particular job. In some cases, the main criterion is the maximum frequency that a device can function at for rated performance, called unity-gain bandwidth, or f_T; it is the frequency at which the voltage gain drops to one. RF transistors, for instance, can have f_T's of hundreds—or even thousands—of megahertz, while good old "general purpose" types get by with a much lower value.

Gain is another factor used to divide devices into classes. Whether or not a specific transistor has a specific gain can be a matter of either design or practical limitations. Power transistors, for example, are built primarily for high-power loads. While their gain may not be as impressive as that of other varieties, they can handle high currents or voltages without overheating, melting, or exploding.

Another important characteristic is breakdown voltage, or the maximum voltage that a particular device can handle. Depending on whether it's in the millivolt, volt, or kilovolt range, the required size, packaging, operating characteristics, and price of a transistor can be affected. There are small-signal transistors designed for only a few volts and milliamperes of current, and power transistors designed for massive amperages.

Another class of transistor altogether is the switching transistor, or saturated switching device. While switching transistors can be, and often are, used for small-signal amplification (and vice-versa), they're really designed just to turn a low-level current on or off. They do that by being driven to saturation with a base-emitter voltage beyond the level for useful amplifications. Depending on component type, application, and packaging, transistors can be divided into over three dozen classifications.

Where transistors come from

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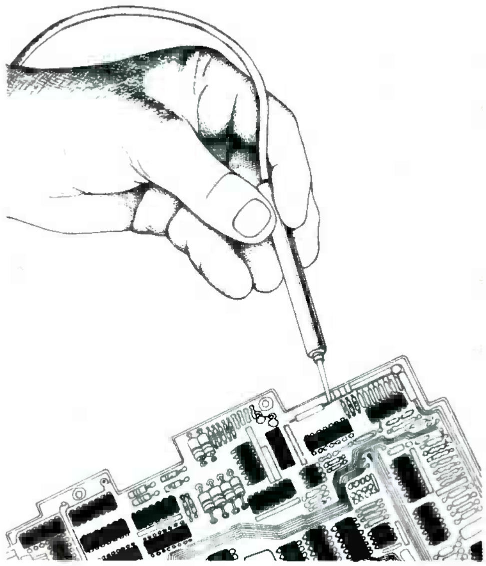

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Valid for new members only. Foreign applicants will receive special ordering instructions. Canada *must* remit in U.S. currency. This order subject to acceptance by the Electronics Book Club. RE590 accident; they're all there for a reason. Many new designs come about as the result of technological advance, or improved manufacturing. For example, when power MOSFET's became practical to produce in large commercial quantities, a whole new product line was launched. That obviously didn't mean that all previous power transistors already in use were now obsolete. Rather, those older products continued to be manufactured because there were many circuits where they performed well in, possibly at lower cost.

Take the 2N2222 general-purpose NPN bipolar transistor; it drives relays, small audio amplifiers, digital inverters, etc. However, not all 2N2222's are alike, and the four dies in Fig. 1 prove it; a die is an actual chip, minus packaging and leads. When you buy a Digi-Key 2N2222, even though it's electrically identical to all others, its geometry might be any of those shown. Unless you find out which die is used, you'll probably never know the difference. For example, Fig. 1-*c* is the type of die typically associated with 2N2222A-class transistors.

Different die geometries have slightly different operating parameters. The unity-gain bandwidths for the dies in Figs. 1-*a*–1-*d* are: f_T = 340, 420, 300, and 400 MHz, while their typical maximum collector-base breakdown voltages are: V_{CBO} = 140, 130, 110, and 95 volts, respectively. Obviously, parameters like rise time and gain (β) also vary between models.

Quite a few new products arise from the requirements of design engineers. The calculations for a specific circuit may call for product specifications that can't be met, at least within required tolerances, by any existing device. If a large enough quantity of a new device is required, or if the manufacturer sees a general-market potential, he'll set his engineers to work, and the product will eventually be manufactured and wind up in the next data book.

A small manufacturing company in search of a transistor may take the time to investigate preexisting devices in the hope of finding one for a specific job. Sometimes redesigning a circuit around an existing device to take advantage of its characteristics may avoid the expense of having a special part manufactured.

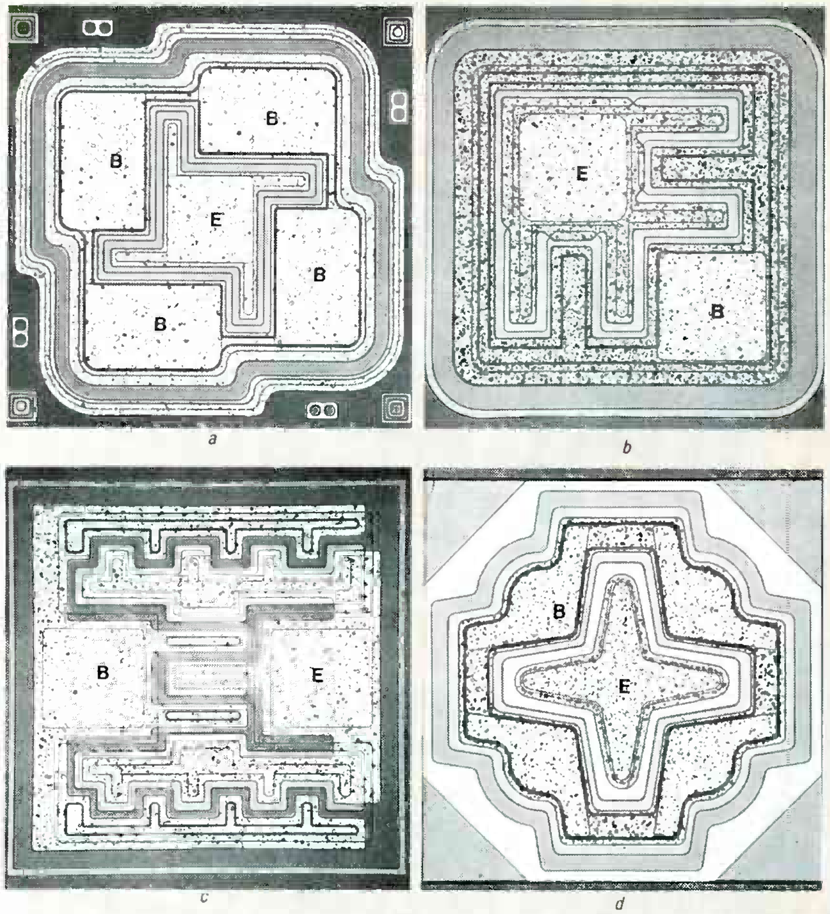


FIG. 1—THIS IS WHAT TRANSISTOR DIES look like under a microscope. The names of the different geometries are: (*a*) BBC, (*b*) JGA, (*c*) DCA, and (*d*) TNL.

However, for a company that anticipates the purchase of millions of a specific device to request that a part be produced to exact specifications may well be more economical. Taking that route is often cheaper than using a device that may already exist, but of questionable availability. It may be identical in all but one minor characteristic to another that already exists, but no semiconductor manufacturer will turn down an order worth millions. He'll produce it, and another part number will find its way into a data book.

Adding to the proliferation of device types is the fact that solid-state manufacturing isn't an exact process. It's certainly much less of an arcane art and more of a science than it was many years ago. There are still numerous variables, however, that can't be precisely controlled. During a manufacturing run, there are always some devices that either fall short of or exceed specified tolerances; examples are gain, breakdown voltage, and power dissipation.

Those devices exceeding specifications can be marketed as a premium product for those who need superior characteristics. For example, the mean desired cutoff frequency might be 200 MHz, but a number of devices might be made with much higher values, say 300 MHz. While those could be used by the original buyer, they're really wasted. There are probably other uses for such a high-performance part, so it's culled out and sold separately—at a premium price.

Some devices meeting very high tolerances may be classed as "mil-spec" or "high-rel(iability)" parts. They have to meet stringent test criteria and, if they pass, they get their own part numbers. Similarly, there may be a significant number of parts with a cutoff frequency of only 125 MHz. The buyer certainly can't use them, but they're not worthless, and they aren't discarded. Someone is out there with less critical design needs, who can use such out-of-spec parts. Actually, many "general purpose" parts originate that way.

CATALOGS ON FLOPPIES

To make the job of selecting transistors easier, several companies now let you enlist the aid of a computer. Here are two examples.

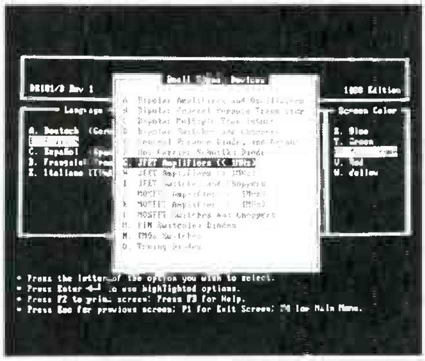


FIG. 1—FROM THE *SPECS IN SECS* menu "Small Signal Devices," option G is "JFET Amplifiers (< 1 MHz)."

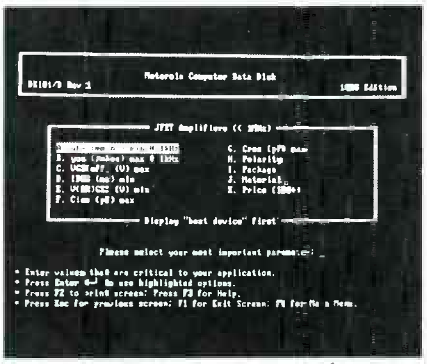


FIG. 2—IN THE "PARAMETRIC SEARCH mode," the user can select one or more parameters of the desired transistor.

The floppy catalog *SPECS IN SECS* handles all discrete Motorola products, over 7,500 parts; you can then use a databook for specifications. Also, *PRECISION DECISIONS* from Precision Monolithic, Inc. (PMI), accesses a complete line of analog signal-conditioning and data-conversion IC's; both use parametric search methods.

To illustrate how such software operates, simple parametric search will be shown using both packages. In *SPECS IN SECS*, the user can select different languages, product categories, and screen colors. On selecting a specific entry in each column, and performing a search, the entries are stored to save time on the next run. Here, "English" (option B), "Small Signal Devices" (option P), and "Monochrome" (option U) were used. On hitting Enter, a menu appears (see Fig. 1); "JFET Amplifiers (< 1 MHz)" was selected.

Another menu (not shown) displays the types of JFET amplifiers. Selecting the "Parametric Search" mode from that menu gives the one shown in Fig. 2. *SPECS IN SECS* tells whether the values in the menus and prompts are minimum or maximum, and the limits on the values that can be entered. Figure 3 shows a list of appropriate Motorola devices, with specifications on each.

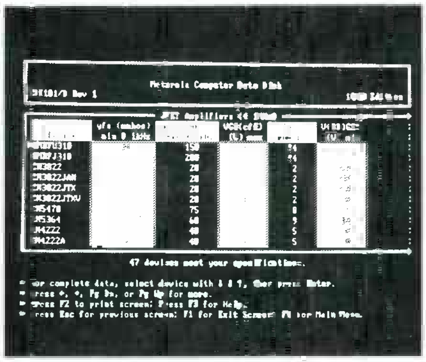


FIG. 3—A LIST OF MOTOROLA devices satisfying the selected parameters, with some specifications on each.

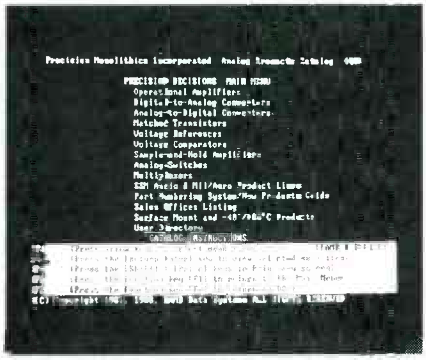


FIG. 4—*PRECISION DECISIONS* MAIN menu; the user can select from the different part types shown.

A similar set of examples for *PRECISION DECISIONS* is shown in Figs. 4–6. Figure 4 shows the main menu; the user can select from the different part types shown. Figure 5 shows the data-entry screen for a parametric search of matched transistors; the parameter values shown are the minimum and maximum permissible. You can also get data on a specific part, if you know the one you're interested in. Finally, Fig. 6 shows the results of the parametric search from Fig. 5 for matched transistors from the PMI database meeting the specified parameters.

The *SPECS IN SECS* Motorola Data Disk floppy-disk component selection guide from **CyberSoft, Inc.**, 440 E. Harmony Ave., Mesa, AZ 85204, (602) 962-0075, has significantly modernized device selection.

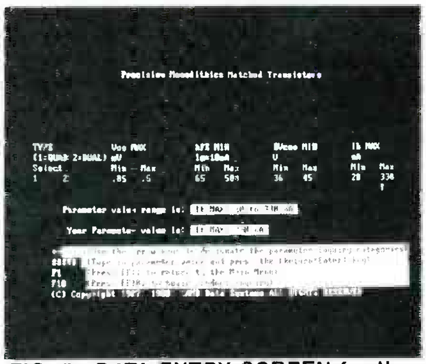


FIG. 5—DATA-ENTRY SCREEN for the Precision Decisions parametric search for matched transistors.

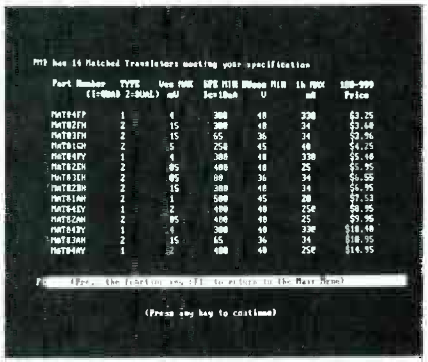


FIG. 6—PARAMETRIC SEARCH results for matched transistors from the PMI database.

It has 7,000 devices and 20,000 cross-references in 58 categories, for Motorola's entire discrete product line, including optoelectronics, RF, power, small-signal, and specialty items, and has both part number and parametric search modes. Once satisfactory devices are displayed, you can use a catalog for more data. Copies are $2.00 from the Motorola Semiconductor Literature Distribution Center, PO Box 20912, Phoenix, AZ 85036, (602) 994-6561 or (800) 521-6274 (part number DK101/D REV-1).

Precision Monolithics, Inc. (PMI), also has a floppy-disk catalog called *PRECISION DECISIONS*, with their complete line of analog signal-conditioning and data-conversion IC's, using both part number and parametric search modes. Packaging, pricing, and competitive cross-referencing are included. Available categories are op-amps, D/A and A/D converters, matched transistors, voltage references and comparators, sample-and-holds, analog switches, multiplexers, military/aerospace products, the part numbering scheme, new products, sales offices, surface-mount and extreme temperature range devices, and a user directory. For a free copy, call the PMI Communications Dept., Santa Clara, CA 95052, (408) 562-7470. **R-E**

The number of devices that won't meet specifications in a given run can be predicted statistically, and there are frequently enough to be included in a catalog as a new product with a separate part number. That's not to say that quality control or manufacturing are at fault—it's just that some parts meet specifications and some don't. What's a company supposed to do, just throw them away? The name of the game is profit, and if somebody can use them, why not wring out the maximum profit possible?

The case for cases

A given part isn't set apart from all others only by ratings and electrical characteristics. The same part can be packaged several different ways, each with its own part number, or with suffixes to differentiate them. Certain applications may need "ruggedized" parts to withstand extreme temperature, humidity, or shock, or special ceramic or metal packaging instead of plastic. A part originally specified for such extremes may be worth producing in a less rugged version for more ordinary use. Bingo, another part number.

Power dissipation is another factor that can add part numbers to data books, and can vary according to packaging. A transistor in a plastic TO-92 case may safely dissipate only a few hundred milliwatts. A TO-220 tab-type case may raise that to a few watts, while a heavy duty metal TO-3 case can push it even higher. The contents are identical; the point is that cases affect device characteristics. Sometimes the part numbers may be identical, with only the suffix changed to denote the different case, although new cases sometimes get entirely new numbers. Some common cases appear in Fig. 2.

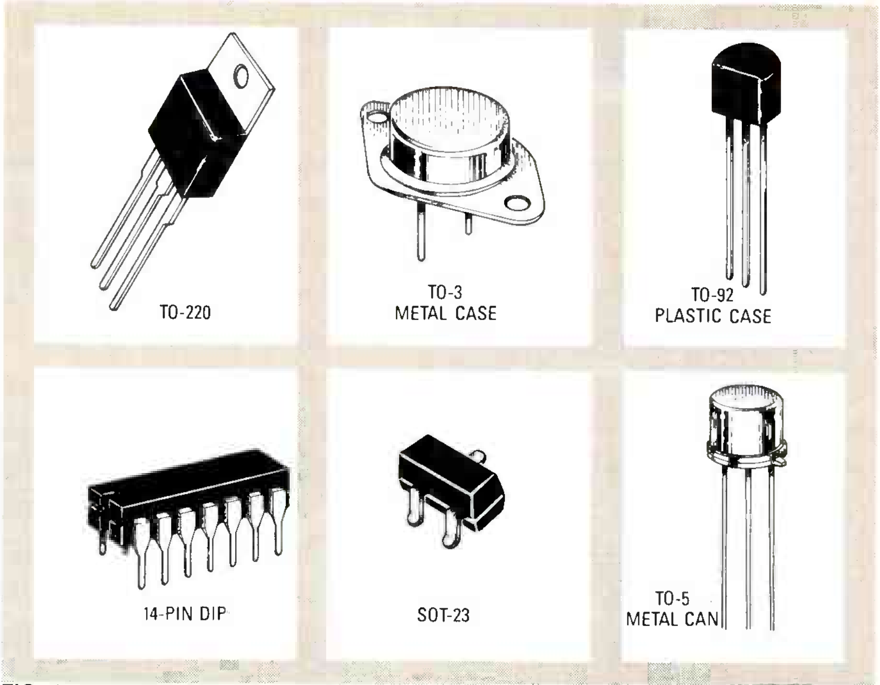


FIG. 2—TRANSISTORS CASES come in a wide variety. These are a few of the more common versions.

Size and shape are also important. Someone designing a high-density PC board may need a part in a case of specific shape or size, so he can fit as many devices as possible in a given space. Such custom packaging isn't cheap and manufacturers may deem it worthwhile to make a part available in a cheaper, more conventional case to increase availability.

Where do they get them?

As you browse through your Jameco, Digi-Key, or other catalog searching for parts, the selection of transistors offered by your favorite supplier is obviously much smaller than the range of offerings from even the smallest manufacturer. How do those people narrow down the choices? The line stocked by a company like those advertising in **Radio-Electronics** depends on two main factors: availability and customer need, which works out to the familiar law of supply and demand.

Manufacturers—both of transistors and equipment that uses them—frequently find themselves with more of a particular part than they need. There's no problem with quality, just inventory, solved by selling the excess. There are firms specializing in disposing of excess inventory, taking it off an overstocked company's hands for a price probably less than that originally paid or asked. Sometimes an over-inventoried manufacturer can sell directly to a vendor through an ad indicating his excess stock placed in the classified ads of a trade publication. The low price you may pay isn't a reflection of item quality, but rather the sacrifice that the overstocked manufacturer had to make to dispose of the excess.

Many devices in a vendor's catalog are there simply because they're consistent best-sellers. As long as people keep buying 2N2222's, they'll keep appearing in vendor price lists. Depending on supply, their price may vary, but they'll still be there. Sometimes, a device is a frequent "special-request." Vendors receive many phone calls and letters from people trying to locate such-and-such a part. On occasion, such requests arise from specific projects that appear in such magazines as **Radio-Electronics**.

The individual responsible for the project may have used an "orphan" transistor he found at the bottom of a junk box. Some people (and you know who you are!) are unwilling (or unable) to look for a more readily available substitute, and so they request the oddball one. If there are enough such requests, a vendor will see a profit and add the item to his list. Sometimes, albeit rarely, there's no readily available substitute; that, too, is a reason to stock it. Whatever the reason, if there are enough requests for an item, a source will be located, and it'll find its way into a catalog.

How do you choose?

Selecting the right part may at first seem difficult from the plethora of transistors available; all you need is common sense. First, determine the category. If you're building a huge audio amplifier, you need a power device. If your project will operate at moderate power, perhaps an audio device of some sort such as a small-signal transistor will work. If it'll be oscillating or switching at high frequencies, a switching transistor may be needed, although at audio frequen-

Continued on page 68

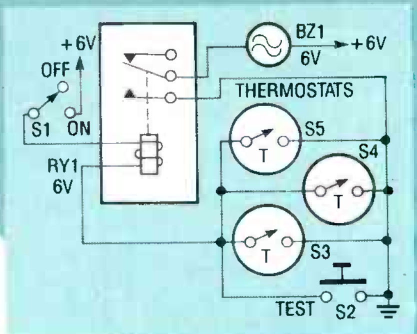


FIG. 1—SIMPLE RELAY-AIDED non-latching fire alarm using thermostat temperature sensors.

HOME-SECURITY COOKBOOK

An introduction to modern home-security systems.

RAY MARSTON

ALTHOUGH IT'S UNFORTUNATE, THE chance of being attacked, robbed, or incinerated in your own home is steadily increasing. Fortunately, the odds against those kinds of disasters can be greatly improved by taking a few common-sense precautions, like using good locks on all doors and locking all windows at night. The odds can be improved even further with a good electronic home-security system.

Home security is a fairly large and involved subject. To understand it, you first need to understand the basic principles of security- system installation, some criminal psychology, and to examine some actual burglar alarm systems. We'll deal with all of those topics here, and continue the subject in future articles. Let's start with some of the basic principles that are involved in a modern home-security system.

Basic precautions

The disasters most likely to strike you at home are fire and intruders. Most home fires are caused by things like lit cigarettes, pieces of smoldering coal or wood falling onto rugs, overheated electric appliances, or cloth igniting from the heat of gas or electric stoves.

The first line of defense against fire is common sense, and the second is a fire-alarm system. The latter can be sophisticated, including smoke and gas detectors, or simple, like a number of *N*ormally-*O*pen (N.O.) thermostats, mounted at ceiling height, connected in parallel and arranged so that they trigger an alarm if any of them close. Any fire alarm is better than none at all, provided it's reliable, and a simple thermostat system like the version shown in Fig. 1 can easily be used with most burglar alarms.

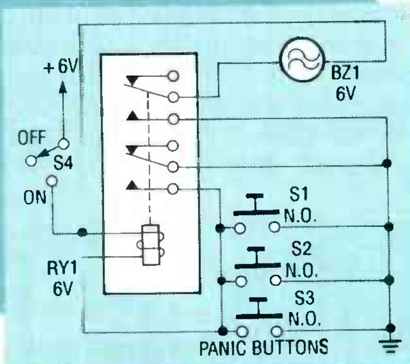


FIG. 2—THIS SIMPLE SELF-LATCHING panic burglar alarm with N.O. panic buttons or pressure pads is adequate for many domestic applications.

Intruder prevention

Intruders are a very real menace, and are generally divided into either thugs or burglars. Thugs generally operate by having one or more males attack you either as you open your front door. Sometimes, an attack can occur late at night after or during a break-in.

The first defense against thugs, as with fire, is common sense: have a peep hole and chain on the front door. An excellent second defense is permanently armed panic buttons near likely attack points, like the front and rear doors, living room, and bedroom, arranged to operate a self-latching alarm when they're momentarily activated, as shown in Fig 2. Panic buttons are ordinary N.O. push-button switches. A simple panic system like Fig. 2, can easily be used with most burglar alarms. Of course, ON/OFF key switch S4 is an absolute necessity to make the circuit practical, to let it be shut off once it's activated.

Burglary prevention

Any burglar alarm system can be broken down into the three blocks shown in Fig. 3. The first is the "sensor network," which detects an actual or possible intrusion at one or more protected points, and sends a signal to

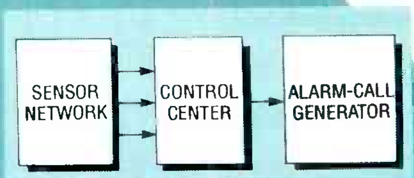


FIG. 3—BLOCK DIAGRAM of a burglar alarm system.

the "control center." That block checks the sensor signals for validity, and trips the "alarm-call generator" (a bell, buzzer, or siren), when conditions are appropriate.

Four basic types are available: the radar, ultrasonic, infra-red, and microswitch varieties. The most important performance characteristic of any burglar alarm system is its reliability, or immunity to false alarms. Many sophisticated systems that give frequent false alarms (99% of all alarms are false) will be ignored by both the police and the owner, and are thus useless. Many can be false-triggered by electrical interference from sources like lightning or electric motors.

Radar systems generate a microwave field over the whole house, and sound an alarm when the field is disturbed. Unfortunately, they can sometimes be falsely triggered by large vehicles passing by, and may have poor reliability. Ultrasonic alarms usually protect an individual room. They generate an ultrasonic field in the room, and sound an alarm if physical movement within the room causes a significant Doppler shift. Such systems can be falsely triggered by a draft moving curtains or drapes, or by insects close to the ultrasonic sensors.

Infra-red systems normally monitor along an invisible line-of-sight beam, and sound an alarm if the beam is broken by a physical object. Most alarms of that type use single beams, and can easily be falsely triggered by insects, as shown in Fig. 4. A few such systems use dual beams, as shown in Fig. 5, activating only when both are broken simultaneously. Those beams are separated by 10–25 cm, to prevent being falsely triggered by insects.

but consumes 1 mA of quiescent current via R1-Q1 (in practice, that can be reduced to a negligible level with a more elegant relay driver). It can also be easily modified for N.O. switches, as shown in Fig. 7.

In a practical contact-operated alarm system, the sensor switches actually connect to the inputs of a control center, which houses the electronics and battery, plus a number of switches that allow different system sections to be turned on or off, or to be tested. Ideally, the control center should be housed in a burglar-proof box with a key-operated ON/OFF switch. Figure 8 shows a typical control-center panel with six switches.

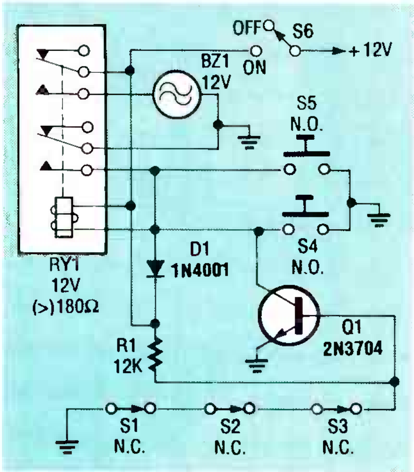


FIG. 7—BURGLAR ALARM CIRCUIT using N.C. and N.O. sensor switches.

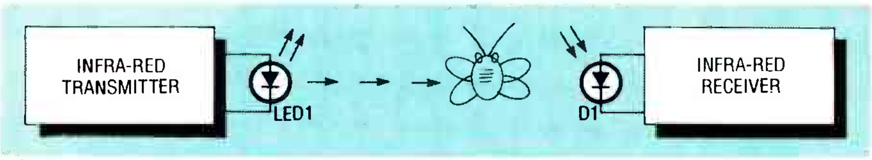


FIG. 4—A SINGLE-BEAM IR ALARM SYSTEM CAN easily be false-triggered by an insect breaking the beam.

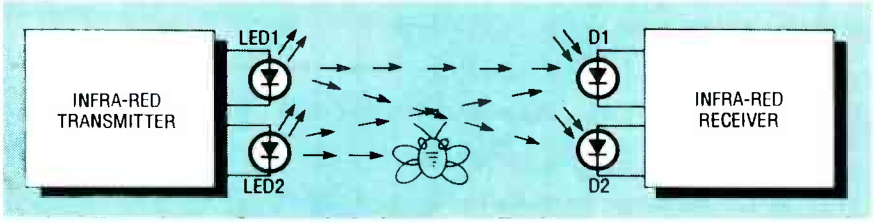


FIG. 5—A DUAL-BEAM IR ALARM ACTIVATES ONLY when both beams are broken simultaneously, and can not be false-triggered by small insects.

The most popular system type is the electro-mechanical switch variety. These switches can be either micro-switches or reed relays connected to doors or windows, or pressure pads under rugs. They can all be of the *N*ormally-*O*pen (N.O.) variety (activate by closing), or the *N*ormally-*C*losed (N.C.) type (activate by opening), or a combination thereof. If N.O. switches are used exclusively, a self-latching burglar alarm can be made by wiring all switches in parallel and connecting them to buzzer BZ1 via relay RY1, as shown in Fig. 2. That may involve a lot of wiring, but the circuit consumes zero standby current.

If N.C. switches are used exclusively, a self-latching burglar alarm can be made by wiring all switches in series and connecting them to BZ1 via a transistor-aided relay, as shown in the version in Fig. 6. That circuit uses minimum wiring,

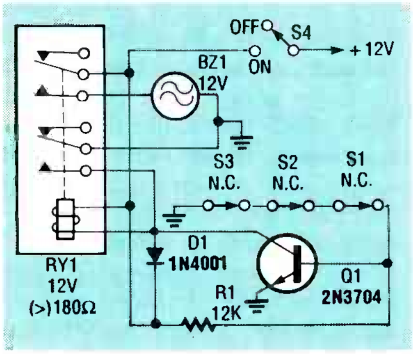


FIG. 6—SIMPLE BURGLAR ALARM WITH N.C. switches, drawing 1 mA of quiescent current.

The main ON/OFF switch is (S1) of the key type, and S2 is a pushbutton that enables the alarm and battery for a functional check. The remaining four switches are toggle types, allowing sensors to be enabled or disabled.

Figures 9 and 10 show the connections for turning individual sections of the sensor network on and off. Series-connected N.C. sensor networks can be enabled or disabled by wiring such a series string of N.C. sensors in parallel with S1, as shown in Fig. 9. Here, the sensors are enabled with S1 open, and disabled with S1 closed. Parallel-connected N.O. sensor networks can be controlled by wiring such a series of parallel N.O. sensors in series with S1, as shown in Fig. 10. In that case, the sensors are enabled when S1 is closed, and disabled when S1 is open.

Planning a system

The most popular burglar alarm type uses switch sensors. Let's look at the actual techniques of planning such an installation in a house. A building can, for the present, be regarded as a box with an enclosing "perimeter" around a number of interconnected compartments. That perimeter is the shell, containing walls, floors, ceilings, doors and windows. To commit a crime, an intruder must penetrate the perimeter, the owner's first line of defense.

Once an intruder enters a building, he can move from one room to the next only along paths determined by internal doors and passages. In doing so, he must pass over or through certain "spots," or checkpoints, as shown in Fig. 11, the ground-floor plan of a medium-sized mid-terrace house. To move between the kitchen (a likely break-in area in the average home) and the living room requires passing through the kitchen door, adjacent point "X," and the living room door. Those "spot" locations represent the owner's second line of defense.

The house owner can use perimeter

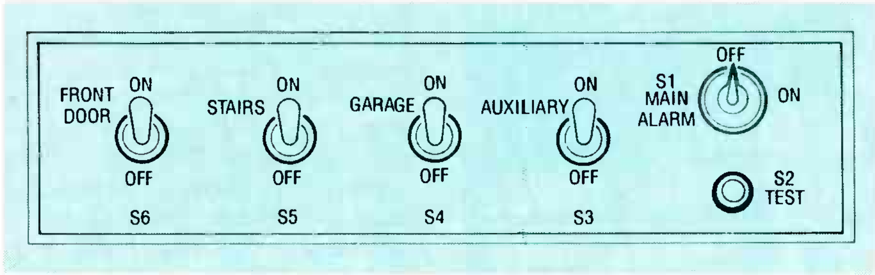


FIG. 8—TYPICAL CONTROL-CENTER INSTRUMENT PANEL.

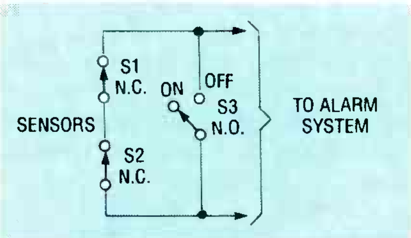


FIG. 9—METHOD OF ENABLING/DISABLING series N.C. sensor switches by operating S3.

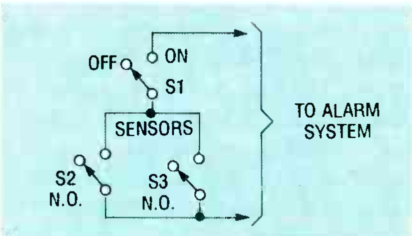


FIG. 10—METHOD OF ENABLING/DISABLING parallel N.O. sensor switches via S1.

defense, spot defense, or a combination thereof. Perimeter sensors include microswitches or reed-relay/magnet combinations fitted to external doors and windows, and window foil fitted to the windows on external doors, windows, and skylights. Spot sensors include pressure-pad switches fitted under rugs or carpets, microswitch or reed-relay/magnet door switches, and baited traps using an attractive or valuable item (like a clock) placed on top of a concealed microswitch.

When planning an installation, you should try to think like a burglar. Normally, a burglar enters from an easy access point obscured from the view of neighbors, like a back door or window. Often, they'll even break in using tools from your own garage, so include the garage in any system layout. Almost invariably, a burglar's first action after gaining entry to your home is to provide for rapid escape by opening a back door, and then to start stealing.

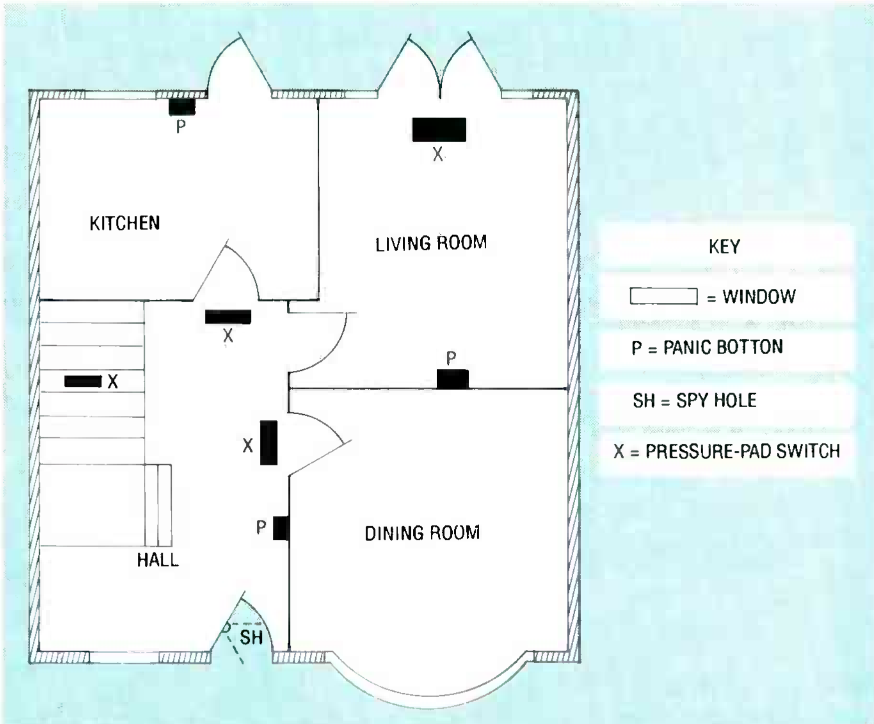


FIG. 11—GROUND-FLOOR PLAN OF A MEDIUM-SIZED mid-terrace house with minimal spot and panic defenses.

Two examples

Figures 11 and 12 show alternate ways of installing security systems in the ground floor of a medium-sized mid-terrace house. In both cases, a peep hole is installed in the front door, with panic buttons at three likely attack points. The two houses differ considerably, however, in the methods of burglary protection that are used.

Figure 11 presupposes that a burglar will most likely enter via the French windows of the living room, or the kitchen door or window. If he uses the French windows, he'll be detected by a pressure pad under a mat or carpet, but if he enters via the kitchen, he'll find nothing worth stealing. So, he'll open the kitchen door into the hall, where he'll be detected by another pressure pad.

In the unlikely event that a burglar enters the house from the front, he'll eventually be detected by yet another pressure pad in the hall near the dining room door, or one on the stairs. That arrangement makes no attempt to keep a burglar out, but uses "spot" defense to detect him once he's inside. The approach is highly cost-effective, and gives reasonably good protection.

By contrast, Fig. 12 assumes extensive perimeter and spot defense. Its owner has decided to try to scare off potential burglars by using clearly visible window foil on selected windows, both in front and in back. Some foil is really connected into the alarm system, and some is dummy foil. All external and internal doors are protected by door switches, and two pressure pads are on the stairway. Also, baited traps are placed in both the living and dining rooms. That house has excellent protection.

Installation notes

Pressure pads are available as small mats; they're excellent spot defense devices, easily hidden under rugs and carpets. Both standard and stair types are available. However, they're fairly sensitive and can be set off easily by large cats and dogs; if you own a pet, make sure it's confined when the pressure pads are on.

Window foil is adhesive-backed aluminum stripping that bonds to

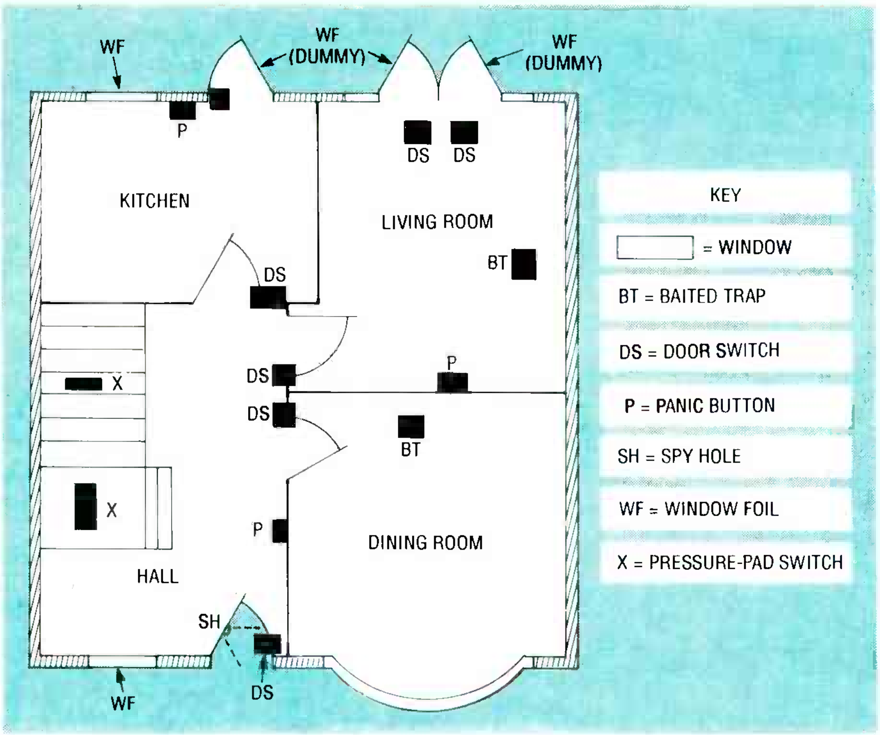


FIG. 12—GROUND-FLOOR PLAN OF A MEDIUM-SIZED mid-terrace house with a high level of perimeter and spot defenses, plus minimal panic defenses.

glass, and couples into an alarm system using special connector blocks. The strip breaks when a window is shattered. Door and window switches are usually a reed-relay/magnet combination. The magnet goes in the edge of the door or window, opposite the reed-relay installed in the frame, as shown in the version in Fig. 13. When a door or window is closed, the magnet holds the reed-relay in one position. When it's open, the magnet moves away, making the reed-relay switch states. Most commercial versions have two sets of output wires in the reed-relay, one giving N.O. operation, and the other N.C. operation.

When you plan your installation, don't forget to provide for some means of bypassing the front door, so you can enter and leave without sounding an alarm. Keep all wiring neat and concealed, and test each section as it's installed. If possible, fit your system with both internal and external alarms. The external unit should be prominently displayed in front of the house, where it'll act as a deterrent; weather-proof housings are available.

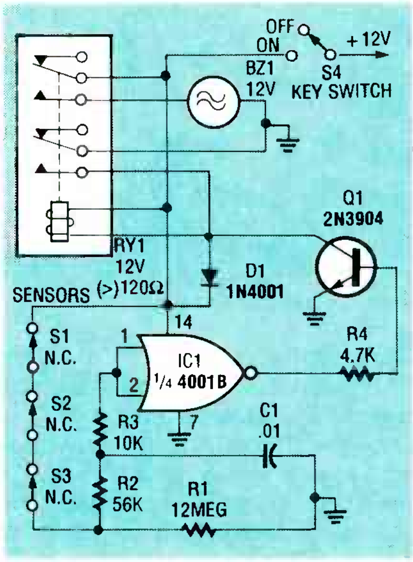


FIG. 14—THIS CMOS-AIDED ALARM draws only 1 μA of standby current.

Home-security circuits

We've already looked at the very simple burglar alarms shown in Figs. 2, 6, and 7. In reality, they need modification to be practical. A major defect of the circuits shown in the Figs. 6 and 7 is that they consume 1 mA of quiescent current via R1-Q1. That can be overcome by increasing R1 to 12 megohms, and using a CMOS inverter as a buffer between R1 and Q1, as shown in Fig. 14. That circuit consumes 1 μA of quiescent current.

In practical installations, long wires used to interconnect series sensor switches tend to pick up spurious pulses and signals, especially during thunderstorms. The purpose of R2-C1 is to act as a low-pass filter to reject such signals, and minimize susceptibility to false alarms. Note that Figs. 2 and 14 each show the left-hand relay contacts being used to provide self-latching action. An alternative is shown in Fig. 15. Here, self-latching is performed by a bistable made from IC1-a and IC1-b, and low-pass filter R5-C2 causes the bistable output to latch low when S6 is first closed.

If any sensor switches are then activated, a logic high is fed to pin 2 of the bistable via the low-pass filter R3-C1, which latches high and turns on Q1 and RY1, activating buzzer BZ1. In Fig. 15, R2 is in series with the sensor switches, letting the circuit be activated by either the series switches or parallel pressure pads across R1. That

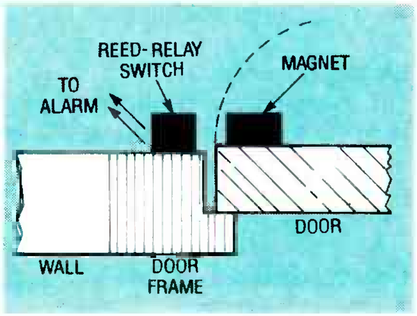


FIG. 13—PLANS SHOWING METHOD OF CONNECTING a reed-relay/magnet combination to form a door/window-activated switch.

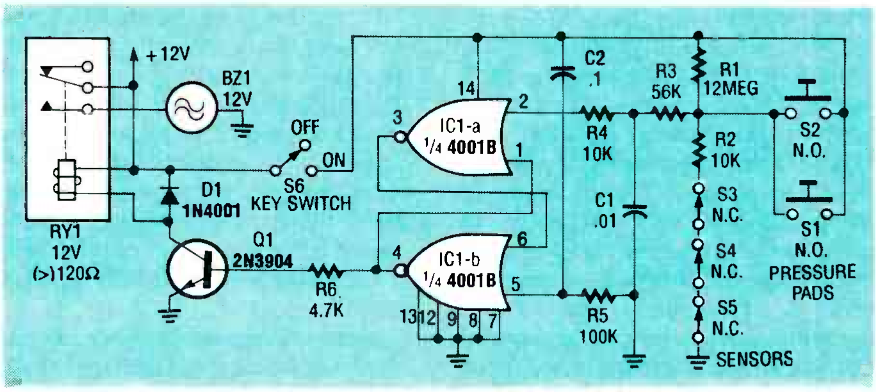


FIG. 15—A SIMPLE SELF-LATCHING BURGLAR ALARM.

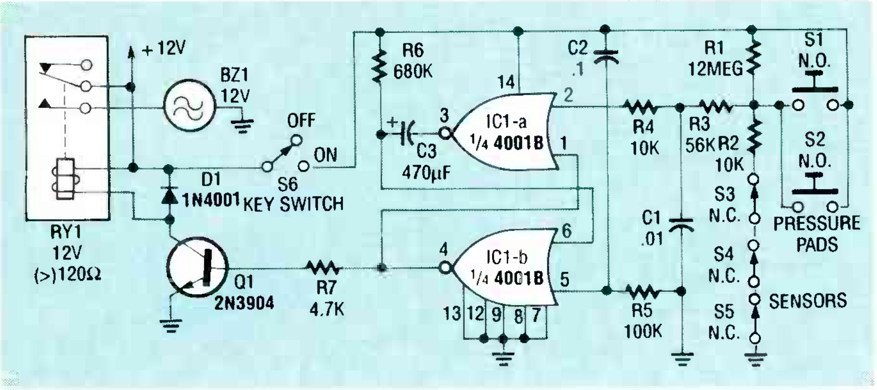


FIG. 16—AN AUTO-TURN-OFF BURGLAR ALARM with 4-minute turn-off delay.

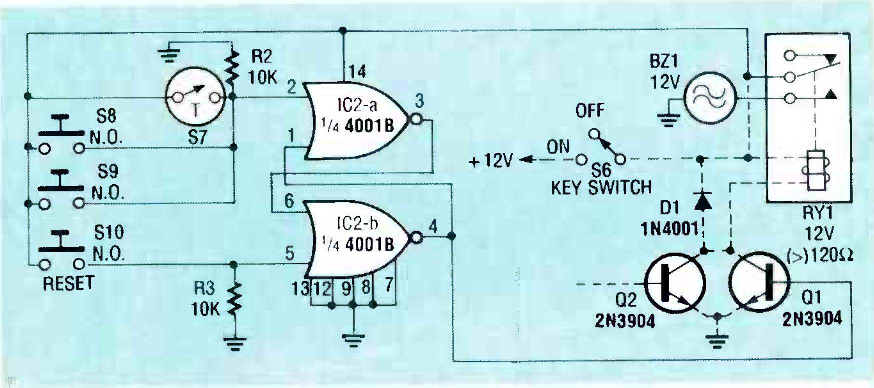


FIG. 17—PANIC AND FIRE ALARM CIRCUIT that can be added to the circuits of Figs. 16 and 17.

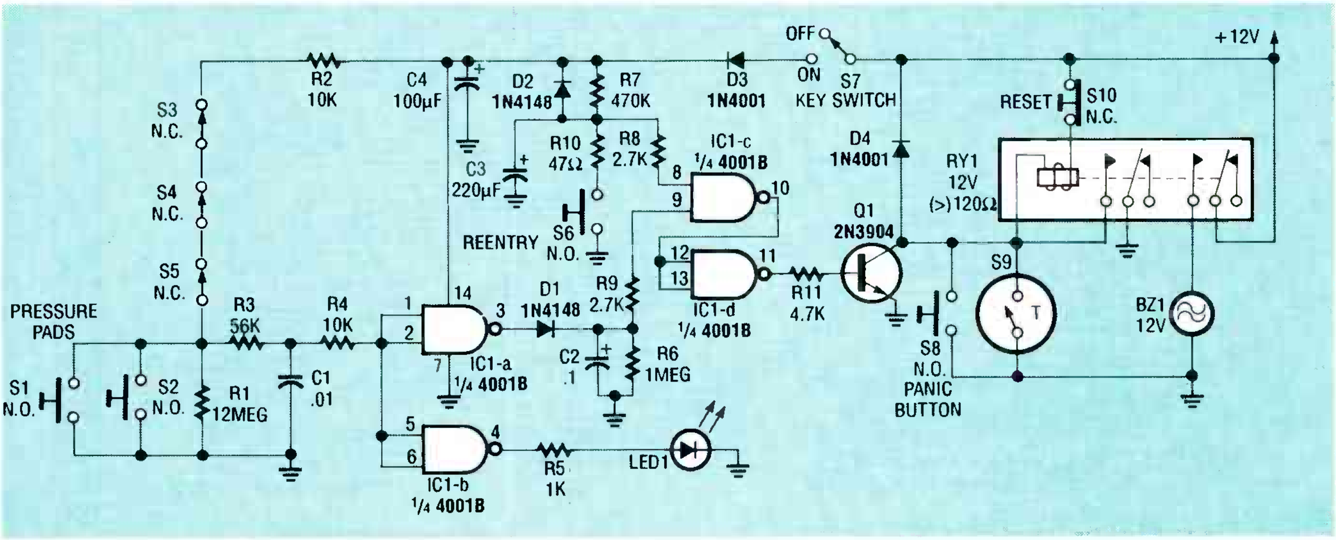


FIG. 18—COMPREHENSIVE HIGH-PERFORMANCE home security system.

makes a very versatile burglar alarm; ideally, the alarm generator (BZ1) should be powered by a completely separate supply.

Figure 16 shows how Fig. 15 can be modified for auto-turn-off action, so the alarm sounds as soon as an intrusion is detected, but turns off automatically after four minutes. That action is obtained via IC1-a and IC1-b, which act as a monostable that drives RY1 via Q1, and is triggered via the sensors. In Figs. 15 and 16, Q1 and RY1 are permanently connected to the power supply, even when S6 is open and the sensors disabled. That makes adding accessories like fire detectors and panic switches, which must be permanently enabled, easy.

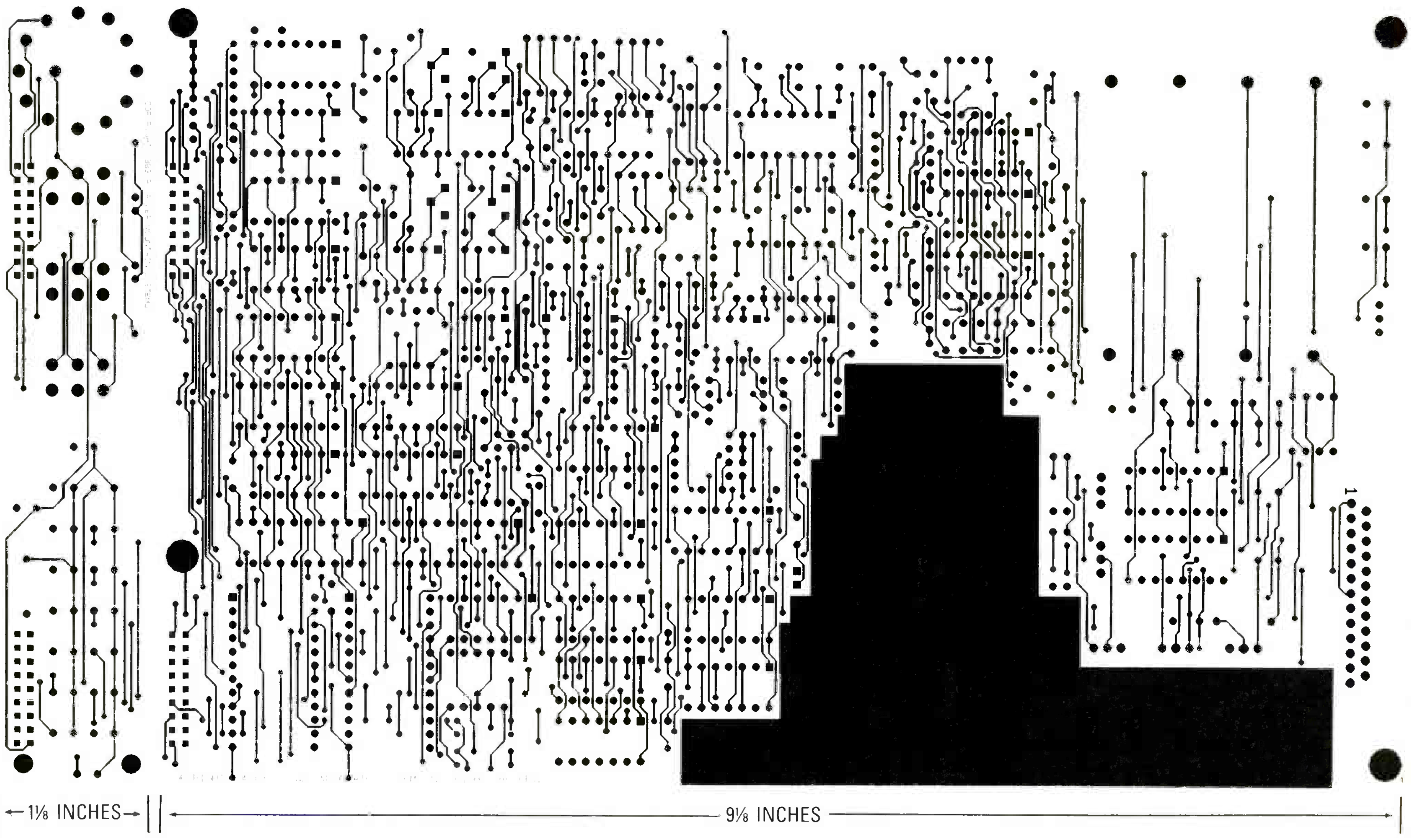
Figure 17 shows a practical add-on panic and fire alarm circuit for use with the circuits shown in Figs. 15 and 16. Here, IC2-a and IC2-b make up a flip-flop that turns RY1 on through Q2 via any of a number of parallel panic switches or thermostats. If you combine the circuits shown in Figs. 16 and 17, you'll still need an independent IC1 and IC2, since they need separate supplies.

A comprehensive system

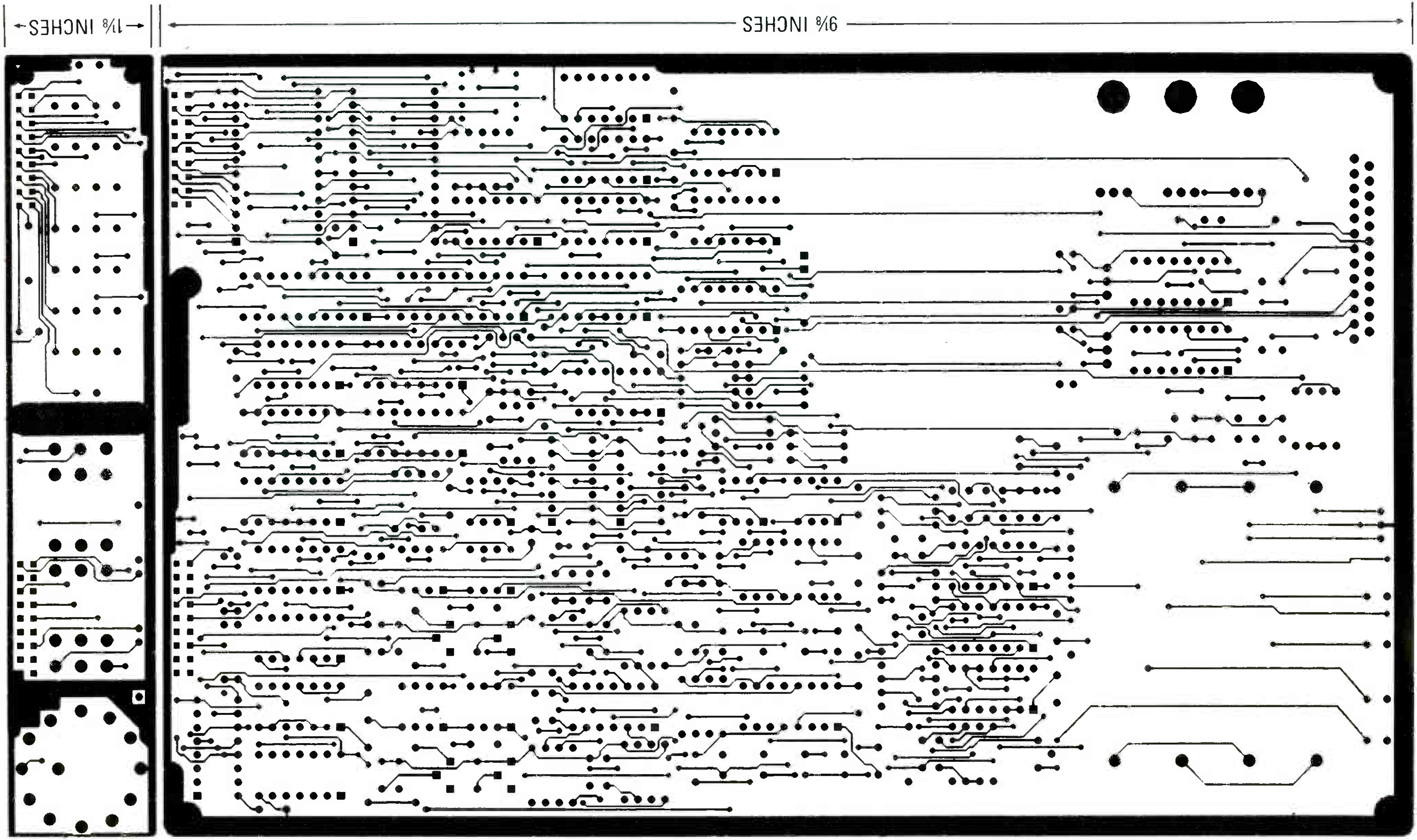
Most of the burglar alarms examined thus far give useful but limited performance. The final version, shown in Fig. 18, gives outstanding performance and has several sophisticated features. It uses a +12-volt supply and draws a few µA of quiescent current. The +12-volt power to the CMOS circuitry is smoothed via D3 and C4, enabling the circuit and alarm generator (BZ1) to use the same supply. Normally, with S7 closed and all sensors inactive, LED1, RY1, and BZ1 are all off. Low-pass filters R3-C1 and R6-C2 suppress any transients.

If any sensor switches activate, the inputs of IC1-a and IC1-b go high, turning on LED1 and RY1, the latter through Q1, IC1-c, and IC1-d. As RY1 turns on it self-latches via the left-hand contacts, and activates BZ1 via the right-hand contacts. Note that the self-latching relay is permanently wired to the +12-volt supply, and can be activated at any time by either the panic buttons or thermostats.

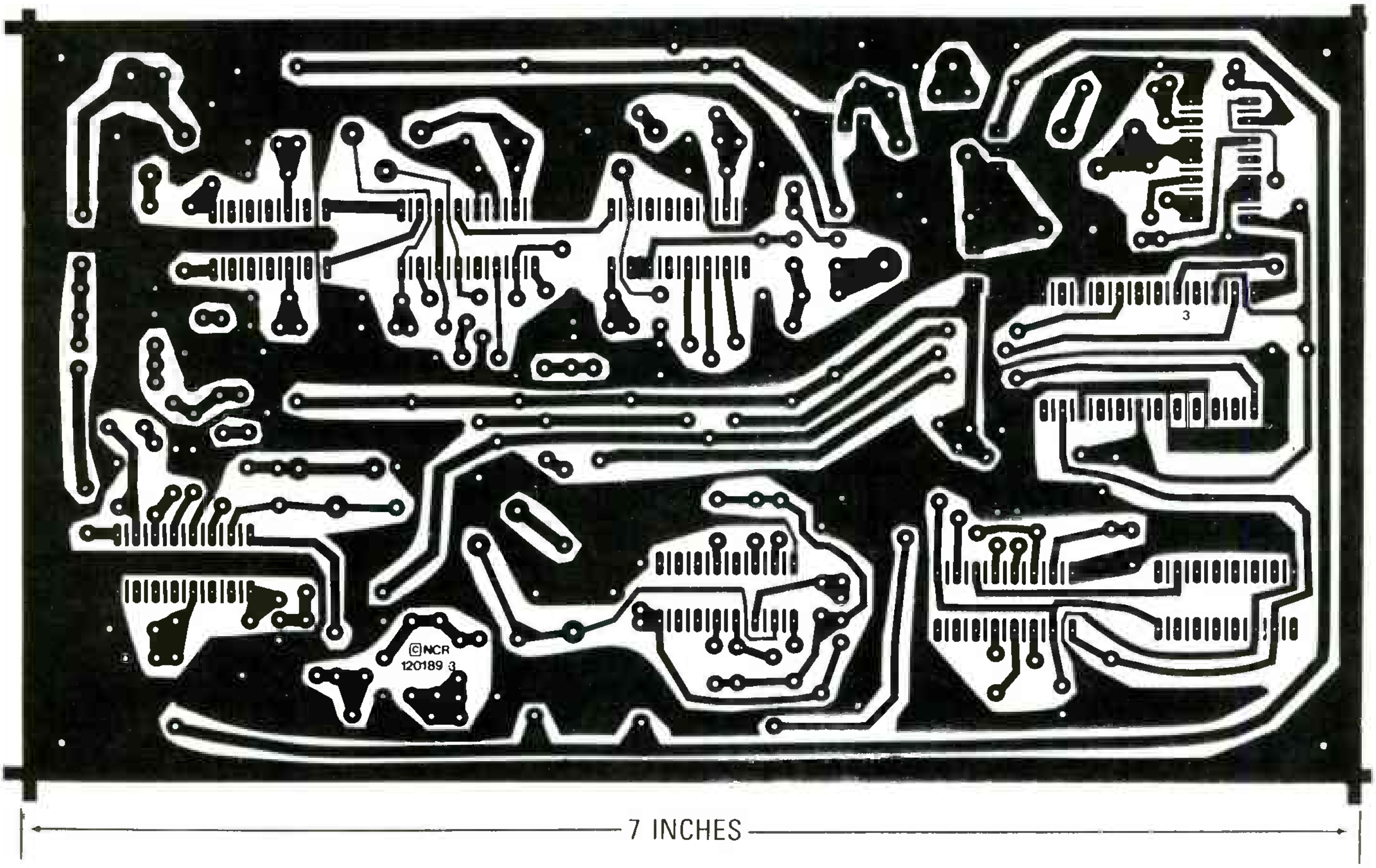
If key-switch S7 is initially closed, or if pushbutton S6 is pressed and released, the R7-C3-IC1-c network disables Q1 for about 100 seconds. At the end of that period, the circuit returns to normal operation. That's of great practical value, since when the system is first turned on via S7, LED1 should stay off. **R-E**



COMPONENT SIDE of the RTTY decoder.



SOLDER SIDE of the RTTY decoder.



UNIVERSAL DESCRAMBLER FOIL PATTERN. It's a single-sided board.

TRANSISTORS

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cies that same small-signal device (most likely a "general-purpose" device) will also do.

In most cases you don't even have to look at specifications—unless you're "pushing the edge of the envelope," working somewhere out at the outer fringes of a category, almost any transistor in a class will do suffice. If you want to be more particular, start scrutinizing the specifications, but bear in mind that your application and the specifications don't have to match perfectly.

If your amplifier has to handle up to 100 kHz, there's no reason why the cutoff frequencies have to be exact. You can establish cutoffs slightly higher than required, if you follow good engineering practice and over-design. A device usable up to 1 MHz will work just as well at 100 kHz as it will at the high end of its range. If your application falls within those extremes, you can use the device. And if you get the "higher-quality" part at a bargain price, so much the better.

There are several computer programs to simplify electronic design. One has a library of about 12,000 transistors, while another only 200 or so. The rationale behind the seemingly small selection in the latter is that there really aren't that many different transistors—it just seems that way. Many are the same device in a different package, or behaving slightly differently from its peers when pushed to its limits. If you stick to the middle ground, it's hard to go wrong. Once you're in the ballpark, there's no absolute right or wrong. **R-E**

"Great color bars!"

OSCILLOSCOPES

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The triggering capability of the HP 54501A shows the versatility of DSO's. Users can select a "time-qualified pattern trigger," for example, where the DSO will trigger only on a glitch. Logic triggering allows triggering only for certain user-defined conditions. A user can select a particular pattern of either positive- or negative-going edges to trigger on for each of the four channels. Triggering occurs only when the selected pattern occurs. A user can also specify a pattern using any three channels, with the fourth as a clock. A TV/Video Sync Pod option can capture unclamped video waveforms; the HP 54501A also has an internal TV trigger.

Figure 7 shows the Tektronix 2432A, with a 300-MHz bandwidth and a 250-megasample/s digitizing rate. The single-shot bandwidth is 100 MHz for band-limited signals. The repetitive mode uses an equivalent-time sampling technique (random and multiple point). The Tektronix 2432A has a number of other useful features, including envelope mode, averaging, and smoothing. Averaging reduces noise on repetitive signals, while smoothing greatly improves *S*ignal-to-*N*oise *R*atio (SNR) of single-shot waveforms.

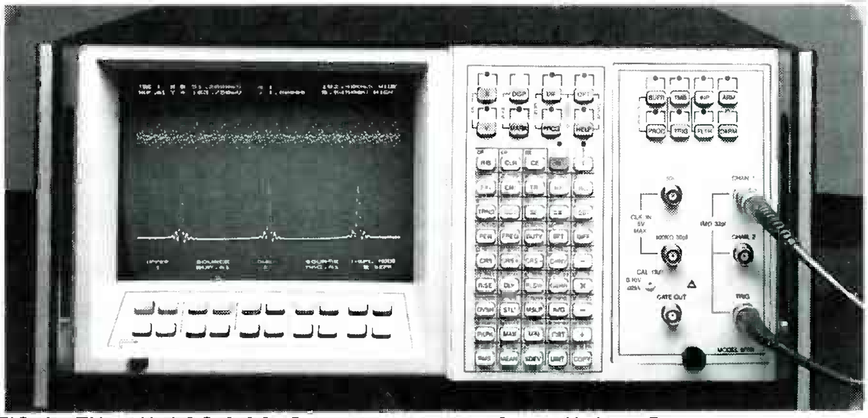

FIG. 8—THE ANALOGIC CORP. DATA 6100 WAVEFORM ANALYZER is *much* more powerful than most DSO's, with many accessories, including plug-in front ends from 100 kHz–125 MHz in bandwidth, RS-232C serial and GPIB interfaces, preprogrammed handshaking, a programming language, and soft display keys. It's also a two- or four-channel spectrum analyzer, with numerous math functions on the calculator-style keyboard (see text), and can both work in real-time and store up to 32K points per waveform. There's a double floppy-disk drive add-on to store waveforms and programs, and extensive technical support.

One of the most impressive DSO manufacturers is Analogic Corp. of Peabody, MA. Their DSO, the Data 6100 Waveform Analyzer shown in Fig. 8, is *much* more powerful than most, with numerous accessories, including plug-in front ends from 100 kHz–125 MHz in bandwidth, RS-232C serial and GPIB interfaces, preprogrammed handshaking, a programming language, and an incredible array of math functions. There's also a calculator-style keyboard, and soft keys on the display.

It's not just a DSO, but a spectrum analyzer. There are two or four independent channels, letting you display magnitude, phase, real, and imaginary parts of frequency spectra simultaneously. You can add, subtract, multiply, divide, differentiate, and integrate signals, and display power spectra or histograms, do convolution, auto- and cross-correlation, find fundamental frequency, RMS, peak-to-peak, mean, standard deviation, and rise time, and signal averaging, all in real-time, and store up to 32K points per waveform. There's also a double floppy-disk drive add-on for storing waveforms and programs, and extensive technical support.

Since DSO's are here to stay, you should get familiar with them. Most manufacturers provide a tutorial handbook that you should read if you have access to one. **R-E**

HARDWARE HACKER

Hall Effect Resources
Shape Memory Alloys
Cycolor Printing Secrets
Low Noise Amplification
Unusual Mechanical Stuff

DON LANCASTER

Cycolor printing secrets

IF YOU EVER FIND OUT WHATEVER IT IS WE are doing here, please be sure and let me know. At any rate, this month's goodies include a brand-new color imaging process, low-noise amplifiers, *Hall-Effect* devices, and some unusual new non-electronic items that cry out for hacker use. As usual, all of our referenced sources appear in either the upcoming *Hall Effect* resource sidebar or in the *Names and Numbers* box. Please check out those sidebars before using the free help line. And please make your product and your literature requests to anyone listed in either sidebar specific, rather than general. Onward and upward...

The Cycolor process

Color copiers are getting better and better. While they cannot today challenge production color printing or photographic processes for cost or clarity, the handwriting is on the wall. As you might expect, there are now dozens of new color technologies in one stage of development or another. Several of the obvious needs that any color system must meet are accurate color registration, low materials cost, dense resolution, and the ability to faithfully reproduce an original.

One of the candidate systems is called the *Cycolor* process. That one is in volume production, solves most registration problems in one swell foop, and appears to be eminently hackable.

The key Cycolor secret lies in the materials used. Figure 1 shows details. Picture three different egg-like packages called *cyliths*. Each cylith is around one-third of a mil (0.0003 ") in diameter. Zillions of them are uniformly spread out one cylith deep over a polyester carrier, similar to a piece of photo film.

Each cylith starts out with a soft outer shell. The first cylith type is full of a liquid cyan (process blue) *leuco* dye. The second cylith type is full of magenta (reddish-purple) dye. The third cylith type is full of yellow dye.

The cylith shells are sensitive to different color light. On exposure, the cyliths will *harden*. For instance, red light will harden the cyan cyliths but leave the magenta and yellow ones soft. White light will harden all of the cyliths, while black (no light at all) will leave all the cyliths soft.

To create a color print or slide, an image is projected onto the developer sheet containing all the cyliths. After exposure, your developer sheet will consist of a mixture of hard and soft cyliths. You now have a *latent image* on your sheet that is somewhat similar to a color negative.

The developer sheet is then placed in pressure contact with a suitable paper, slide, or transparency material. The pressure breaks all of the soft cyliths, releasing their internal dyes. The hard cyliths remain intact and do not release their dye.

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Synergetics
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Thatcher, AZ 85552
(602) 428-4073

For instance, if you've got hard cyan cyliths and soft magenta and yellow cyliths, then the magenta and yellow dyes will get released and will mix to form a red image. For a blue image, those yellow cyliths harden, leaving the magenta and cyan cyliths soft. Squashing the soft cyliths mixes a magenta and cyan to produce a deep blue. And so on.

One more time. Bunches of cylith capsules are on the polyester carrier. Some of the capsules get selectively hardened when exposed to light. A pressure roller then squashes the soft capsules, releasing their dye onto a suitable final paper, plastic, or slide material. Like stomping on balloons. A brief heating completes the imaging process. Neat stuff.

A free and interesting brochure on Cycolor is available through *Mead Imaging*, while leading companies offering Cycolor machines include *Brother*, *Noritsu*, *Pic-Mount*, and the folks at *Seiko-Mead*.

Probably the best way to start off hacking that stuff is to get free demos of the various machines and then rip off small quantities of the supplies for your own testing and use.

I can think of dozens of specialized hacker uses for this new technology. What can you come up with?

Low-noise amplifiers

The best of new integrated circuit amplifiers now offer noise levels that are much lower than a circuit built from discrete components, and significantly lower than what vacuum tubes used to be able to

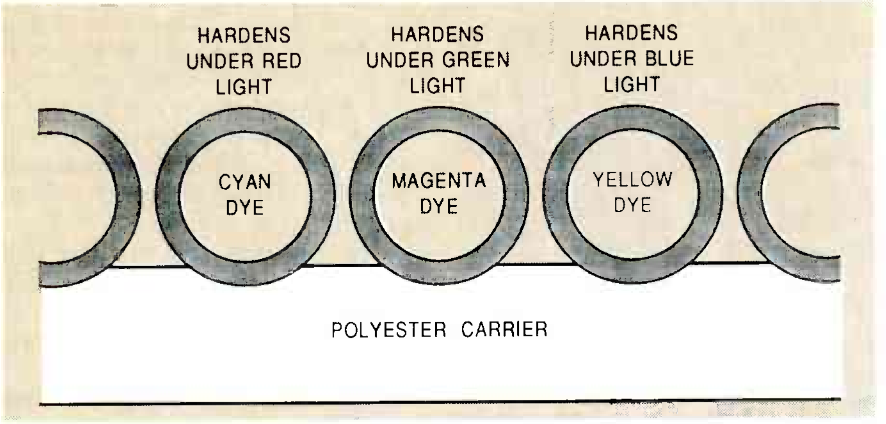


FIG. 1—THE CYCOLOR PROCESS uses tiny cylith microspheres. Each of the cyliths is initially soft, but hardens under exposure to certain light wavelengths. Crushing the soft cyliths releases a dye that creates the final image.

accomplish eons ago.

Four of the leaders in the field of ultra-low-noise chips include *Linear Technology*, *Precision Monolithics*, *Burr-Brown*, and *Analog Devices*.

While all of those sources have lots of free and excellent technical info available, I am most impressed with the *Linear Technology* offerings at the present time.

But, before we really get into this, let us shatter a few hacker myths involving low-noise amplification. First off, in no way will a low-noise amplifier by itself *reduce* the noise from an already noisy source. All a low-noise amplifier can do is limit the amount of extra noise *added* by its own amplification process.

Second, in the overwhelming majority of hacker circuits, most noise problems are caused by improper circuit layout, sloppy decoupling, instabilities, poor shielding, and undesired ground currents. Switching from an ordinary amplifier to a low-noise one in such instances will not in any significant way reduce your apparent output noise. It could even make things much worse.

Third, the wider the bandwidth, the more noise you are going to have. The wideband circuits are inherently noisier than narrowband ones. All other things being equal, noise will increase as the *square root* of your bandwidth. Most often, if you quadruple your bandwidth, you double the noise involved.

Fourth, integrated-circuit noise tends to increase dramatically at extremely low frequencies. If a precision DC response is not needed, you will be better off capacitively coupling an AC or audio amplifier.

Fifth and finally, circuit noise is a very strong function of frequency and source impedance. There is no such thing as a universal "low noise" amplifier. In fact, a "low noise" amp run in the wrong frequency range or at the wrong input impedance will actually generate *more* noise than might a plain old op-amp.

Thus, if you want low noise, it is super important that you have all the data sheets and applications literature on hand for the device you want to use, along with a thorough understanding of the options available in other chips.

There are two types of noise that the first stage of an integrated amplifier can generate. They are *voltage noise* and *current noise*. It turns out that current noise is *directly* proportional to the square root of the first stage collector current, while voltage noise is *inversely* proportional to the square root of the collector current.

Iffen the right one don't git ya, the left one will.

Voltage noise tends to be constant with frequency and more important at *low* impedance levels, while current noise tends to increase sharply below a *noise corner* (or "1/f") frequency in the low audio range. Current noise is more important at *higher* input impedance levels than low ones.

Voltage noise is usually measured in *nanovolts per square root of bandwidth* ($nV\sqrt{Hz}$), with any value under 1.0 being fairly decent. Current noise gets measured in *picoamperes per square root of bandwidth* ($pA\sqrt{Hz}$), again with anything under 1.0 being desirable.

Figure 2 shows some possible choices for *Linear Technology* amplifiers that will give you the "best" noise performance for a given impedance level or frequency range. Of the previous generation devices, the *Precision Monolithics* OP-37 is considered the "parent" of the newer low-noise devices in the same way that the original 741 started the whole op-amp universe.

Let's look at a typical device. The *Linear Technology* LT1115 is an ultra-low-noise and low-distortion audio op amp. It works best when AC coupled at higher gains and over an optimum input source impedance of 30 to 300 ohms. Figure 3 shows you a simple microphone preamplifier that receives balanced inputs (for hum cancellation) and provides a single-ended output with a gain of 300. The total of combined noise and harmonic distortion is under 0.028 percent over a 20-Hz to 20-kHz bandwidth.

Should you truly and genuinely need the lowest voltage noise you can possibly get, and already have total and absolute control over all the usual ground, hum, stability, and stray noise sources that usually swamp hacker-circuit first-stage noise figures, there is one sneaky trick you can pull. At least it's theoretically possible.

Simply arrange several low-noise amplifiers in parallel and sum all of their outputs into a second-stage low-noise amplifier. The gain goes up with the number of amplifiers, while the noise only goes up as the square root of the number of amplifiers in use.

Five parallel amplifiers seems a practical limit, which, in theory, can reduce your first stage noise by a factor of slightly over two. In the real world, that works only for input impedances less than ten ohms. Worse yet, circuit strays are likely to eat you alive if you attempt it. More details on the LT1028 data sheet.

Unusual mechanical goodies

There has been plenty of unusual non-electronic stuff piling up here lately, much of it with great hacker potential. Time for a rundown.

First and foremost, if you really want to get a handle on things, pick up your free sample kit from *GripWorks*.

A new material known as *Trovicel*

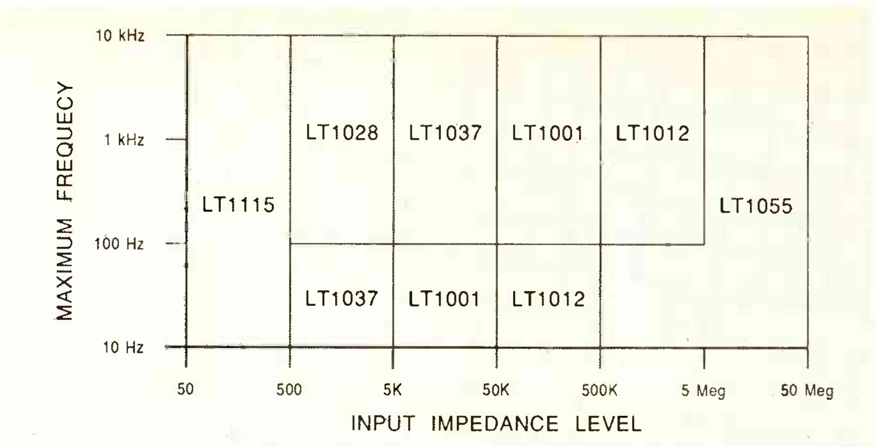


FIG. 2—ANY LOW-NOISE AMPLIFIER has to be specified over a certain input-impedance level and a certain frequency range. Here are Linear Technology's selections for the "best" low-noise op-amps. Note that a misapplied "low-noise" amplifier can actually be noisier than a regular one.

looks like a really good board product for use on everything hacker from cases through prototype models and displays. Trovicel is a rigid foam center plastic sheet that comes in lots of attractive colors and in several thicknesses. It is lightweight, tough, paintable, outdoor rated, printable, pretty, and self-extinguishing. You work it with pretty near any hand or power tool, although hacksawing and power shearing are not recommended. You can bond it with ordinary PVC cement, and even grind or weld it. Free samples are available.

Should you need any curved plywood in tubes, quarter-round, half-round, or with a radiused end, try some of the *Deco Shapes* product from *Laminates Incorporated.*

There seems to be a lot of interest lately in *machinable waxes.* Besides being obviously ideal for CAD/CAM training and program debugging, the material is well suited for one-of-a-kind mockups, proof-of-concept models, and for "does-it-fit?" product verification.

With a machinable wax, your tools stay sharp, the chips are safe, and you can easily recycle your final material simply by remelting it.

The product is available from two to eight inches thick, in cylinders up to nine inches in diameter, and in bulk. You could easily recast their wax into any shape you want to. It melts at 310 degrees Fahrenheit. One good source for machinable waxes is *Freeman Supply.* Prices start at $4 per pound.

The *American Safety Razor* folks are obviously one sharp outfit. Their catalog lists zillions of different low-cost blades, including ripple ones for cutting potato chips and big mutha ones nearly *eighteen inches* long! The variety here is amazing.

One obvious project around here is a $5 cutter for laser-printed business cards. I'm wondering if you couldn't use their blades for a clamping paper cutter as well. A proper support, of course, would be essential for it to work.

In what just might be the most obscure free trade journal in the entire world, *Power and Bulk Solids* covers such things as bin-level detectors and similar goodies. Amazingly, several hacker helpline callers per week are asking for that sort of stuff, especially for agricultural electronics.

A new product called *Scotch 9703 Conductive Adhesive Transfer Tape* from *3-M* has a very unusual property. It conducts electricity *through its thickness* but not along its length. From face to face, the resistance is under 0.1 ohms. Yet, along its length, it insulates to the point of allowing 500 volts across a ten mil gap!

Embedded silver-plated particles apparently do the trick. Adhesion values are in the 50-ounces-per-inch range for most substrates. Free test samples are available.

Finally, short shape metal alloy wire samples are available free from *Beta Phase.* These magic wires can be bent into any shape at all and will stay that way until heated to hot coffee temperatures. Then they'll rapidly spring back to their original size and shape. You can repeat the shape-and-restore process zillions of times. Applications include everything from high-density zero-insertion-force connectors to dentistry.

Tellyawhat. For this month's contest, just dream up an off-the-wall use for any of those unique new

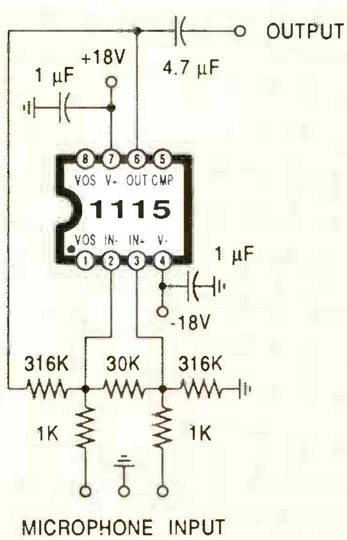


FIG. 3—AN ULTRA-LOW-NOISE balanced preamp circuit that uses the Linear Technology LT1115. Combined noise and distortion is under 0.028 percent.

NAMES AND NUMBERS

American Safety Razor
Razor Blade Lane
Verona, VA 24482
(703) 248-8000
CIRCLE 226 ON FREE INFORMATION CARD

Analog Devices
One Technology Way
Norwood, MA 02062
(617) 329-4700
CIRCLE 227 ON FREE INFORMATION CARD

Beta Phase
1200 Chrysler Drive
Menlo Park, CA 94025
(415) 494-8410
CIRCLE 228 ON FREE INFORMATION CARD

Burr-Brown
6730 South Tucson Blvd
Tucson, Az 85706
(602) 746-1111
CIRCLE 229 ON FREE INFORMATION CARD

Freeman Supply
1246 West 70th Street
Clevelend, OH 44102
(800) 321-8511
CIRCLE 230 ON FREE INFORMATION CARD

Grip Works
6916 South Broadway
St. Louis, MO 63111
(800) 827-GRIP
CIRCLE 231 ON FREE INFORMATION CARD

Laminates Inc.
35 Engineers Road
Hauppauge, NY 11788
(800) 221-5454
CIRCLE 232 ON FREE INFORMATION CARD

Linear Technology
1630 McCarthy Blvd
Miliptas, CA 95035
(408) 432-1900
CIRCLE 233 ON FREE INFORMATION CARD

Maxim
120 San Gabriel Drive
Sunnyvale, CA 94086
(408) 737-7600
CIRCLE 234 ON FREE INFORMATION CARD

Mead Imaging
3495 NewMark Drive
Miamisburg, OH 45342
(513) 495-9100
CIRCLE 235 ON FREE INFORMATION CARD

Motorola
5005 East McDowell Road
Phoenix, AZ 85008
(602) 244-6900
CIRCLE 236 ON FREE INFORMATION CARD

MWK Industries
1440 S State College Blvd, 3B
Anaheim, CA 92806
(800) 356-7714
CIRCLE 237 ON FREE INFORMATION CARD

Omega Engineering
Box 4047
Stamford, CT 06907
(203) 359-1660
CIRCLE 238 ON FREE INFORMATION CARD

Power/Bulk Solids
PO Box 650
Morris Plains, NJ 07950
(201) 292-5100
CIRCLE 239 ON FREE INFORMATION CARD

Precision Monolithics
1500 Space Park Drive
Santa Clara, CA 95052
(408) 727-9222
CIRCLE 240 ON FREE INFORMATION CARD

Raytheon
350 Ellis Street
Mountain View, CA 94039
(415) 968-9211
CIRCLE 241 ON FREE INFORMATION CARD

Sharp
Sharp Plaza
Mahwah, NJ 07430
(201) 529-8757
CIRCLE 242 ON FREE INFORMATION CARD

Silicon Valley Surplus
4222 East 12th
Oakland, CA 94601
(415) 261-4506
CIRCLE 243 ON FREE INFORMATION CARD

Teledyne
1300 Terra Bella Avenue
Mountain View, CA 94039
(415) 968-9241
CIRCLE 244 ON FREE INFORMATION CARD

Texas Instruments
PO Box 1443
Houston, TX 77001
(800) 232-3200
CIRCLE 245 ON FREE INFORMATION CARD

3-M/Scotch
3M Center Bldg. 220-7E-01
St Paul, MN 55144
CIRCLE 246 ON FREE INFORMATION CARD

Trovicel Huls
Turner Place Box 365
Piscataway, NJ 08855
(201) 981-5000
CIRCLE 247 ON FREE INFORMATION CARD

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

As usual, send all your written entries directly to me at *Synergetics*, rather than to **Radio-Electronics**.

Hall-effect devices

There are lots of different ways of sensing magnetic fields, ranging from a compass on up. In past issues and in the *Hardware Hacker* reprints, we've looked at the *flux gate magnetometer*, that appears to be far and away the best method for sensing and measuring the Earth's magnetic field.

Another magnetic-field sensor is called a *Hall-Effect device*. While not nearly sensitive enough for accurate electronic compass uses, a wide range of Hall devices are available for use in position- and speed-sensing devices that can interact with nearby magnetic materials. Our resource sidebar for this month shows you a few of the leading sources of useful Hall-Effect products and information.

Figure 4 shows you how the Hall Effect works. A thin film of selected semiconducting material has a current applied to it from a top-edge terminal to a bottom-edge terminal. Two additional contacts are placed midway along the sides of the film. The Hall voltage will develop across those terminals. In the absence of any magnetic field, your current will be uniform across the film, and there will be no Hall output voltage.

Now, should a magnetic field be applied into the film, the current will shift towards one edge or the other, and a Hall voltage will be generated whose strength is proportional to the magnetic field and whose polarity depends on the polarity of the applied magnetic field.

The Hall action is related to the magnetic deflection phenomenon used in a television picture tube and follows the "right-hand rule" where the resultant force of a magnetic field causes an electron beam current to move sideways.

The Hall voltage is usually rather low, and is typically in the tens of millivolts. In most Hall applications, fairly strong magnets are required to be placed quite close for reliable operation.

In general, there are two types of Hall-Effect sensors, *linear* and *digital*. Linear sensors are used whenever you wish to measure the actual strength of a magnetic field. A *Gaussmeter* is one instrument that can use Hall-Effect devices to measure medium-strength magnetic fields. *F.W. Bell* is a major source for the precision linear Hall devices and instruments.

Digital sensors are used whenever the presence or absence of a magnetic field is intended to produce a "yes-no" output. Figure 5 shows you one typical digital Hall-Effect sensor, the Sprague UGN-3013, which is a three-terminal device about the size and shape of a small signal transistor. The price is under a dollar.

A supply voltage is applied. While that can range from 4.5 to 25 volts, the usual +5 is typical. There is an open-collector output that is *off* in the absence of a magnetic field. Note that you must provide an external pull-up resistor to get an output. Typical supply current is three milliamperes, plus the "on" current through the load resistor.

The chip is guaranteed to turn on with a magnetic field of 500 Gauss, or roughly 500 times the strength of Earth's magnetic field. It's also guaranteed to turn off with a magnetic field of less than 30 Gauss. To prevent any chattering, a snap-action hysteresis of 75 Gauss or so is usually provided via an input Schmitt trigger.

A cheap *Alnico* magnet a third of an inch in diameter and a quarter inch thick will activate your chip from a distance of 0.15 inches. Sensitivity drops off dramatically with distance. On the other hand, *flux concentrating* pole pieces can be added for extended range, as can stronger magnets.

Other devices are available with different sensitivity. Some are *bipolar* in which you purposely *reverse* the applied field, rather than dropping it to zero. That can give you a more reliable sensing as alternate poles of a magnet go flipping on by.

Two excellent and sometimes free books on the Hall Effect include the *Hall Effect Sensors* data book SN-500 from *Sprague*, and the *Hall Effect Transducers* applications book from *Micro Switch*. The latter shows a $10 optional list price.

There are bunches of hacker uses for Hall-Effect devices, since they can sense though a modest noncontacting distance in a dirty environment. Obvious digital uses now include high-reliability keyboards, automotive ignition contacts, shaft-angle encoders, position detectors, model-railroad controls, speed sensing, brushless DC motor commutation, and tilt switches.

Linear applications include current sensing, circuit breakers, and direct magnetic-field measure-

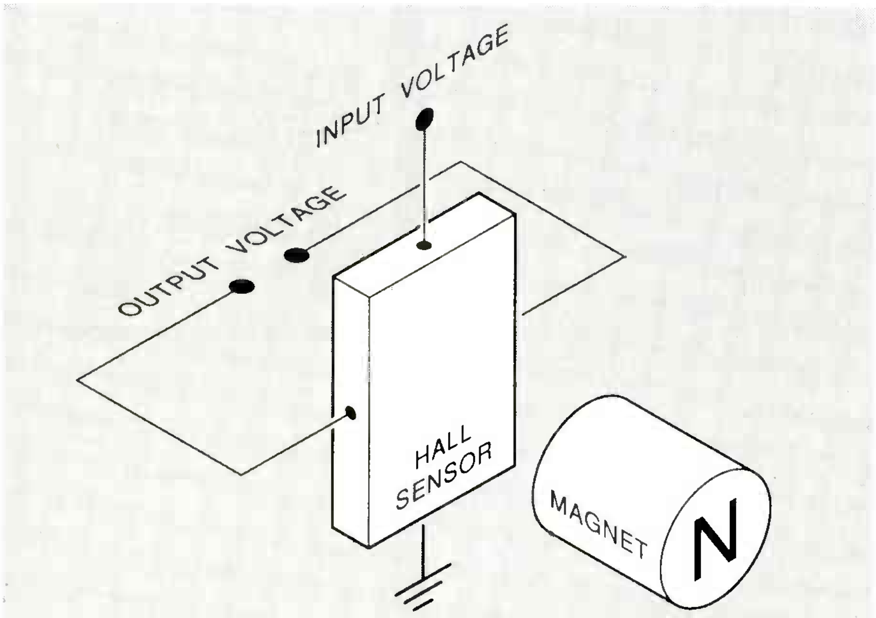


FIG. 4—THE HALL EFFECT in a semiconductor will produce a transverse output voltage that is proportional to the strength and direction of a magnetic field.

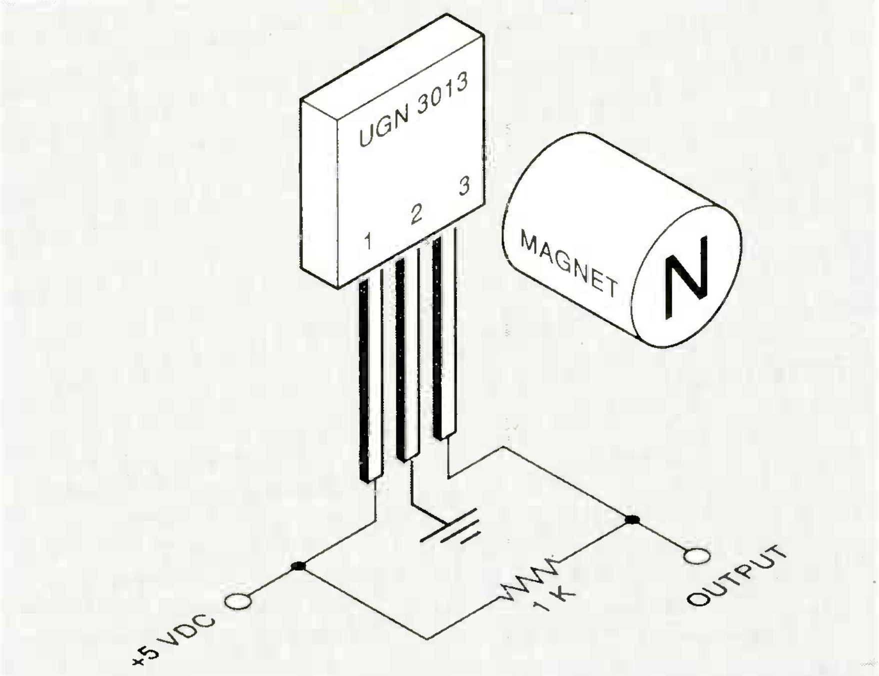


FIG. 5—THE SPRAGUE UGN3013 is a low-cost Hall-Effect sensor having a snap-action digital output. The open-collector output remains high in the absence of a magnetic field and goes low when a field is present.

ments. Hall devices also show up in all the usual surplus catalogs, and in many of the ads that you'll find right here in **Radio-Electronics**.

New tech literature

Certainly the fanciest data books in the industry are in the free series available from *Omega Engineering*. These thick hardback volumes now include their *Temperature; Flow and Level; Data Acquisition; Conductivity and PH; Pressure, Strain, and Force*; and *Electrical Heaters* handbooks. They all include useful engineering info. And, all of them are available free upon a professional-sounding request. Unfortunately, the Omega prices are extremely high. Then again, they would have to be to pay for the aggressive distribution of all their exotic catalogs.

HALL EFFECT DEVICES AND RESOURCES

F.W. Bell
6120 Hanging Moss Road
Orlando, FL 32807
(407) 678-6900
CIRCLE 248 ON FREE INFORMATION CARD

M & C Magazine
2994 West Liberty Avenue
Pittsburgh, PA 15216
(412) 343-9666
CIRCLE 249 ON FREE INFORMATION CARD

Micro Switch
11 West Spring Street
Freeport, IL 61032
(815) 235-6600
CIRCLE 250 ON FREE INFORMATION CARD

Sensors Magazine
1244 Reamwood Avenue
Sunnyvale, CA 94089
(408) 744-1500
CIRCLE 251 ON FREE INFORMATION CARD

Siemens
19000 Homestead Road
Cupertino, CA 95014
(408) 257-7910
CIRCLE 252 ON FREE INFORMATION CARD

Sprague
70 Pembroke Road
Concord, NH 03301
(603) 224-1961
CIRCLE 253 ON FREE INFORMATION CARD

Texas Instruments
PO Box 809066
Dallas, TX 75380
(800) 232-3200
CIRCLE 254 ON FREE INFORMATION CARD

Wabash Magnetics
1375 Swan Street
Huntington, IN 46750
(219) 356-8300
CIRCLE 255 ON FREE INFORMATION CARD

Other data books this month include the new *Precision Analog and Power Control IC Handbook* from *Teledyne*, and a new *Linear Integrated Circuits* databook from *Raytheon*. Looking at short forms, *Sharp* has a pair of them out, one titled *RF Components for CATV Systems*, and the other *RF Components for Satellite Receivers*.

And two free new surplus flyers: *MWK Industries* for lasers and optics, plus *Silicon Valley Surplus* for great robotics prices.

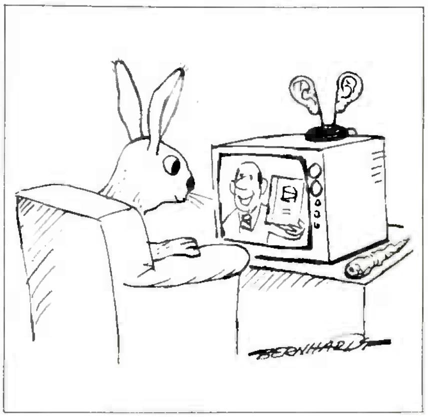
What appears to be a stupendous breakthrough is described in *A light source smaller than the optical wavelength*, beginning on page 59 of the January 5, 1990 issue of *Science*. That one is downright scary in its potential.

Free samples this month include a MC14507 single supply RS-232 driver from *Motorola*, a Johnny-come-lately imitation of the *Maxim* chips that pioneered this field. Also, there are a bunch of freebie chips from *Texas Instruments*. Those include their TL499A battery-backup DC-DC converter, a TL1451A pulse-width modulator chip, and their SN75C188 line-driver circuit.

Turning to my own products, for the fundamentals of digital integrated circuits, check into both my classic million-selling *TTL* and *CMOS Cookbooks*. I do have some autographed copies on hand here for you.

I also have a new and free mailer for you which includes dozens of insider hardware hacking secret sources. Write or call for a copy.

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



AUDIO UPDATE

The search for the perfect tweeter

Larry Klein,
Audio Editor

IN EVERY YOUNG MAN'S LIFE THERE ARE certain milestones on the road to maturation. For example, I recall the circumstances surrounding my first tweeter and crossover as though it were yesterday. The time was 1951, and I had recently assembled my very first audio system—a Garrard changer with a GE phono cartridge feeding a Bell 8-watt integrated amplifier driving a GE 1201 single-cone, 12-inch "full-range" speaker. The speaker was housed in a home-built and—as I learned later—badly mistuned bass-reflex cabinet.

I was satisfied with the sound of my modest setup until a chance acquaintance invited me to audition his system. Little did I know as I took the Lexington Avenue subway uptown that I was about to experience an audio epiphany. My friend's system turned out to be overwhelming in its sophistication; it actually had a separate little horn-loaded speaker called a tweeter designed specifically to reproduce the high frequencies! And, furthermore, he owned two special demonstration discs with highs on them for the tweeter to reproduce. As I sat there in his living room regaled by the recorded sounds of shattering glass and whistling tea kettles, I realized that I was hearing the future, and that I needed to upgrade to it.

It wasn't that I hadn't seen tweeters in the catalogs, it was just that I misjudged them to be simply another example of pricey audio excess (such as separate tone arms and turntables) that contributed more to snob appeal than to sound quality. But my ears were now opened, and I vowed that my next audio purchase would be a tweeter. (I say "a" tweeter because in 1951 stereo LP's were still six to seven years away.)

As I recall, my friend's tweeter was a small University horn fed by a matching crossover, each selling for about $12. That was not an inconsiderable sum in 1951, since at the time I was making $70 a week as an electronic technician. Unfortunately, after several listening sessions my friend's tweeter no longer sounded quite as miraculous as it had at first hearing. Its sound had a nasal, raspy quality that considerably dampened my pleasure with the newly heard highs. (Damping, as a matter of fact, was exactly what was missing from the University horn; as I learned later, it suffered from severe diaphragm and horn resonances.) That was the start of my Great Hi-Fi Tweeter/Crossover Hunt that lasted for at least a decade.

Tweeters I have known

Virtually all tweeters in the early Fifties were horn-loaded, and their designers apparently had lots to learn about resonance control. In general, the tweeters were directional, harsh, and hollow sounding. After making a pest of myself at numerous hi-fi salons (as they were called in those days), I finally settled on the only cone tweeter I could find: a 5-inch model and associated 3,000 cps (Hz) beeswax-filled crossover, both made by Wharfedale, a British manufacturer. My new tweeter didn't provide instant audio ecstasy, but at least I finally had highs without harshness.

In the next two decades, there was a proliferation of tweeter designs driven, I think, by the newly acknowledged inadequacies of existing models. Some of the designs have disappeared; others have reappeared using new materials that contributed to improved performance and reliability. Here's a brief—and incomplete—rundown:

The Electrostatic Tweeter. Usually thought of as a modern high-technology device, the electrostatic driver—or at least the concept of such a device—has been around since about 1925. As a tweeter, it consists of a very thin conductive diaphragm supported in close proximity to a perforated metal plate—or sandwiched between a pair of plates as in Fig. 1. A fixed high-voltage charge is applied between the metal plates (P) and the diaphragm (D). The audio signal voltage is stepped up by a transformer to an appropriately high value to override the fixed elec-

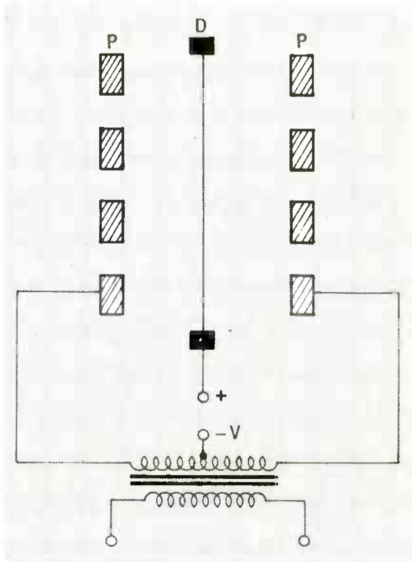


Fig. 1: FLEXIBLE DIAPHRAGM D is suspended between plates P in a typical push-pull electrostatic tweeter. The polarizing high-voltage DC supply is applied at the secondary of the matching audio-input transformer.

trostatic charge and thereby produce diaphragm motion. Transient response can be quite good as a direct result of the very low-mass diaphragm. At the present time, it appears that dynamic cone/dome tweeters have progressed sufficiently that to many listeners they audibly compete with the electrostatic designs—and don't require a high-voltage power supply.

The Ionvac Tweeter. Invented by a French engineer named Sigmund Klein (no relation), it used a high-voltage RF signal to ionize the air in a small open-ended quartz element. To produce sound, the RF voltage was audio modulated, causing the ionized air to expand and contract at audio frequencies. This truly massless "diaphragm" was free of resonances and had exceptional high-frequency bandwidth and transient response. The tweeter appeared briefly in the U.S. under the Du-Kane brand name, and in England as the Ionofane. The need for a high-power RF oscillator—along with the machined quartz cell—ultimately limited its popularity.

The Ribbon Tweeter. This is another old-timer (c. 1923), but there are several current speaker systems using ribbons as tweeters. Simpler in both concept and execution than the ionic and electrostatic tweeters, the ribbon is merely a thin strip of corrugated conducting foil suspended in a powerful magnetic field. In the latest designs, the field is created by groupings of many small magnets epoxied into position, instead of two (or four) large magnets as shown in Fig. 2. Basically, the ribbon can be considered a single long voice-coil/diaphragm that is both low mass and driven over its entire length.

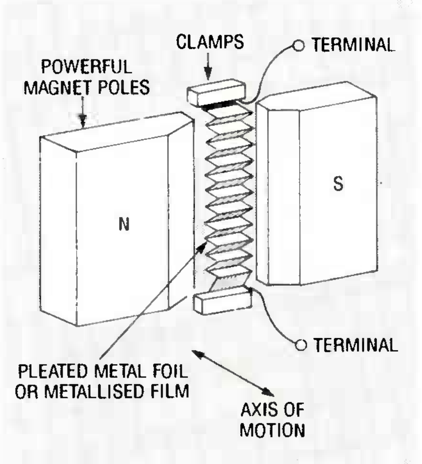


Fig. 2: RIBBON TWEETER in simplified form.

The Dome Tweeter. Developed by Edgar Villchur in 1957, dome tweeter designs are currently found in more speaker systems than any other type of high-frequency reproducer. Mr. Villchur, incidentally, was also the founder of Acoustic Research and the developer of the acoustic-suspension speaker system, which also has achieved world-wide acceptance. The dome was the first truly successful attempt to produce a small radiating surface (which ensures good dispersion) that also had substantial power response. (Fig. 3) Unlike a conventional cone diaphragm (which is driven at its apex with resulting flexing and resonances), the dome sits directly on its driving voice coil and has essentially the same diameter. Various hard and soft materials are now used in domes: phenolic, butyl, copper, aluminum, titanium, and mixtures of boron, carbon fibers, diamond dust, and heaven knows what else. The intention is to decrease the mass and stabilize the dome shape without introducing resonances. Incidentally, in a recent conversion, Ed Villchur said that because of its superior dispersion characteristics, he regards the convex diaphragm tweeter (which is sort of a dome with skirts, developed by Allison Acoustics) as a basic improvement on the dome configuration.

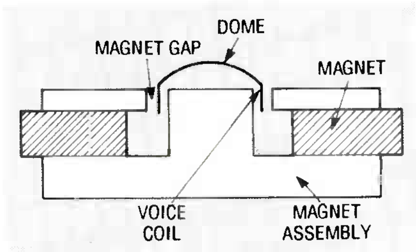


Fig. 3: SIMPLIFIED DOME TWEETER. The dome/voice-coil assembly in the original design was supported by four drops of butyl-rubber compound.

Tweeter progress over the years has been truly astonishing, and today it's possible to realize exceptional high-frequency performance from designs that are simpler and cost far less than those of yesteryear. That's just as well, considering the quantity and *quality* of the recorded high frequencies found on the best of today's digital recordings. **R-E**

DRAWING BOARD

Video-sync generator

ROBERT GROSSBLATT,
CIRCUITS EDITOR

THE VIDEO CIRCUIT WE'VE BEEN BUILDing isn't quite at the point where you can use it to tune in the news, but it's getting there.

Way back when we first started our adventures in videoland (**Radio-Electronics**, January and February 1990), we looked at a simple block diagram of the circuit we needed. If you refer to it now, you'll see that most of the work is finished. We've got the master clock generator and have just finished the arithmetic circuits that generate the frequencies we need to produce NTSC video.

The last part of the timing circuit we have to come up with is the one that produces the actual pulses to control the electron beam in the television. What we've done so far is create the triggers that will enable horizontal and vertical sync, but we still have to design the pulse circuits themselves.

Horizontal sync pulse

There's certainly no shortage of monostable multivibrators, also known as pulse generators. You can build them from something as simple as a resistor and capacitor or as standard as a plain old 555. There are some special considerations in our application (pulse width and shape), meaning that we have to go a bit beyond those methods.

The diagram in Fig. 1 shows all the timing information for the parts of the horizontal interval and, if you take a good look at the numbers, you'll understand the problem. We have to have a horizontal sync pulse with short rise and fall times, and the pulse width has to be, according to the NTSC standard, 4.71 ± 0.05 microseconds. When you need that short a pulse and you want to keep the shoulders nice and sharp, you need something other than a 555.

The most common way to make accurate monostables is to use a D-type flip flop in combination with an RC network. That is such a routine combination, that special MSI chips were developed for it. Those IC's have been around for a while, and one of them, the 4528 dual monostable multivibrator, is a good choice for us to use. You can see the pinouts in Fig. 2.

Since that is a dual chip, and each half can be used independently, we can use one section to generate the horizontal sync pulse. As you can see from Fig. 3, it takes only two parts to make it work. The width of the output pulse is determined by the RC product. We're talking about straight multiplication. Due to the fact that we're using a capacitor in the timing chain, there's a delay between the time you trigger the chip and the time the output pulse is generated—but that is more of a drawback when you want to produce long pulses. The problem can be minimized by using small-value capacitors and, since we want a 5-μs pulse, the inherent charge-discharge delay in the capacitor won't be much of a problem.

The timing circuit we developed produces positive-going signals, so we'll be feeding them to pin 4, the positive trigger input of the 4528. The resistor and capacitor values will generate a pulse width of about 4.7 μs. The actual value you'll get depends entirely on the components you use. A metal-film resistor and mica capacitor are the best choices for overall stability but, if you can't get your hands on those,

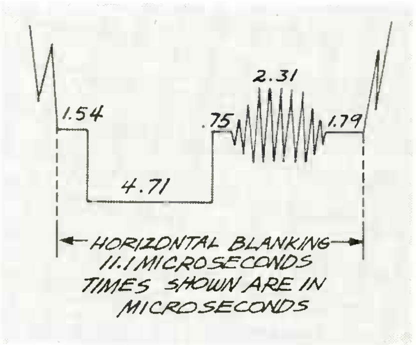


FIG. 1

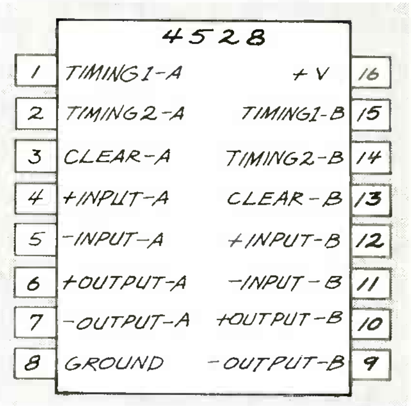


FIG. 2

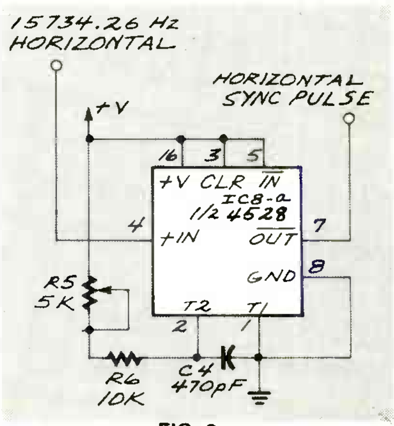


FIG. 3

standard carbon resistors are fine. Try to avoid using a ceramic-disc capacitor since the value stamped on them is usually nothing more than wishful thinking. Should you have any problems, you can add the trimmer shown in the schematic to tweak the pulse width.

The vertical interval

Just as the horizontal sync pulse is only one of the signals found in the horizontal interval, a vertical sync pulse is only one of several signals you'll find in the vertical interval. Just what sort of stuff will show up there depends on the broadcaster, the area you live in, and the open mindedness of the FCC. The only thing that really has to be there, however, is vertical sync...and a bit more.

Several things have to happen during the vertical interval. Things get a bit complicated because the NTSC standard calls for interlaced video. Remember that field one scans all the odd-numbered horizontal lines (1, 3, 5, etc.), and field two scans the even-numbered lines. Each field covers the entire picture area on the screen. Both fields contain a complete vertical-blanking interval and they both have the same information during the interval. But each field carries different picture information so there has to be a way of telling them apart.

In the NTSC standard, there are 262½ lines per field (525 lines per frame), and it's that half line that forms the basis for distinguishing between field one and field two. That is evident in Fig. 4 where the two fields are drawn as you would see them on the screen. You can see how the two fields are combined to make up one frame. And, as you might guess, the control signals are exactly the same for both.

You must keep in mind that the two fields differ from each other in timing, not signals. The movement of the electron beam in the tube is controlled by the hardware in the TV. The beam's deflection angle as it goes from left to right and back again is not controlled by the signals sent to the TV. It's determined by the hardware in the TV's deflection circuitry. The only control that the video signal has over the movement of the beam is to make it go to the beginning of the next line on the left side of the screen (horizontal sync), or to the top of the screen (vertical sync).

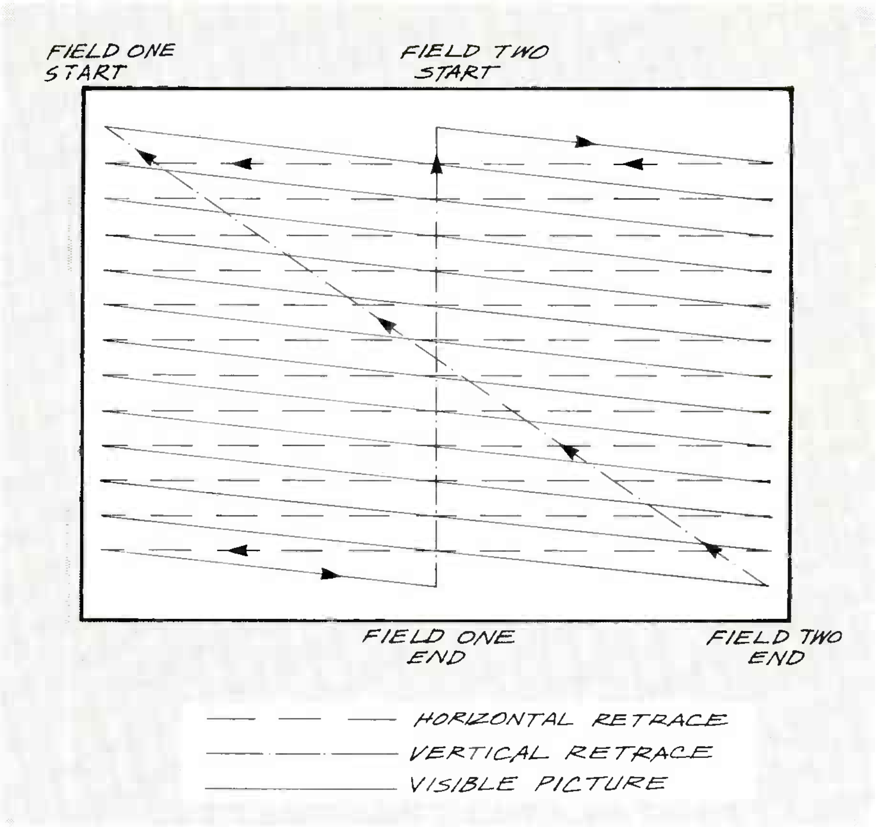


FIG. 4

If you think of field one as beginning with the end of a vertical interval, then the first field starts with a full line of video and the second field starts with a half line of video. That means that field one starts at the upper left of the screen and ends at the center of the bottom. It follows that field two starts at the top center and ends at the bottom right.

Those differences between the two fields may be evident to the eye but they're not the sort of distinctions that are needed to provide a means of electronically knowing which field is being painted on the screen. In order to understand that we have to take a close look at the anatomy of the vertical interval.

The first nine lines in each field's vertical interval are shown in Fig. 5 I've put one right on top of another to help you see the difference between them. The two contain the same number of pulses but they differ in their timing relationship (phase) with the rest of the video signal.

The beginning of the vertical interval is marked by a series of six pre-equalizing pulses (two per line for three lines of video). If you look carefully at Fig. 5 you'll see that the first pre-equalizing pulse for field one occurs a full line after a horizontal sync pulse while the first pre-equalizing pulse in field two occurs a half line after horizontal sync. That difference in timing is the mechanism used to identify which field is being painted on the screen.

It's important to notice that there are no real horizontal sync pulses during the first nine lines of the vertical interval. In order to maintain the horizontal sync in the receiver during that period, there are two pre-equalizing pulses per line. Each pulse is half the width of a horizontal sync pulse and, since they occur twice as often, they provide the same DC level as one horizontal sync pulse. That is done because the circuitry in your TV integrates the DC level on each line of video to determine what to do with the electron beam. One level will be interpreted as horizontal sync and, as we'll see in a minute, a greater level will be interpreted as vertical sync.

The vertical sync signal is really just an inverted version of the pre-equalizing pulses and that means that each pulse is very wide (92%

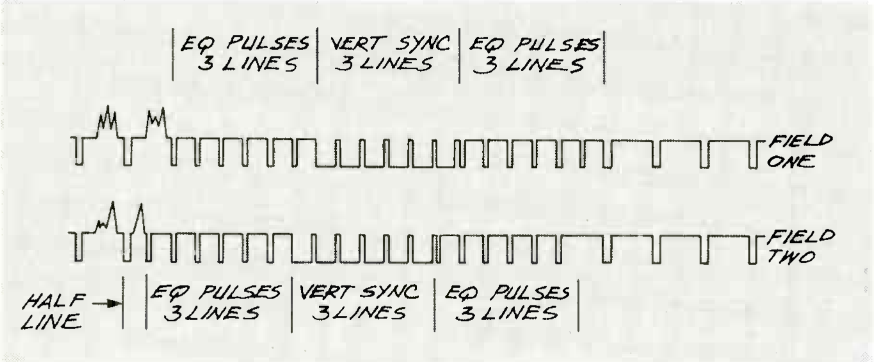


FIG. 5

duty cycle). The result is that the three lines (4, 5, and 6) in which vertical sync appears have a very large negative value—as a matter of fact it's the most negative value in the video signal—and that's exactly what triggers the vertical-deflection circuitry in your TV. By integrating the DC level on each line, the TV can detect the presence of the vertical sync signal and move the electron beam to the top of the tube.

Remember that when the vertical deflection circuitry in the TV is activated by detecting the vertical sync in the video signal, it only moves the beam to the top of the screen—not the top left corner of the screen. Moving the beam to the left is the job of horizontal sync. Since field one starts at the top left of the screen and field two starts at the top center, you can understand why the TV has to be told which field it's about to paint. In order to build a correctly aligned frame from two fields, the two fields have to be lined up. If vertical sync doesn't appear at the right time, a properly interlaced image is impossible.

Figure 5 shows that there are six more equalizing pulses in the three lines (7, 8, and 9) following the vertical sync signal. Although they are identical to the pre-equalizing pulses, they're officially the—you guessed it—post-equalizing pulses. In the early days of TV, they were needed to maintain interlace but, as with so many other things, modern technology has made them obsolete. You'll still find them in the signal but they're not really used for anything at all. Even the distinction between pre-equalizing pulses and post-equalizing pulses has disappeared. Most people today just consider the vertical interval as having two signals: equalizing pulses (sans prefix), and vertical sync.

Interlace or non-interlace

Even though the NTSC standard calls for interlaced video, it's not an absolute requirement for getting images on the TV screen. Broadcast TV is interlaced but a lot of computer video is non-interlace. If you want to do non-interlaced video and you also want to paint more than 400 or so lines of video on the screen, it's clear that you have to do something to avoid the flicker that would be caused by having the top part of the image start to fade before the electron beam worked its way down to the last line on the screen. That means either using a tube with a high-persistence phosphor (like IBM monochrome monitors), or increasing the horizontal scan rate (IBM EGA and VGA monitors).

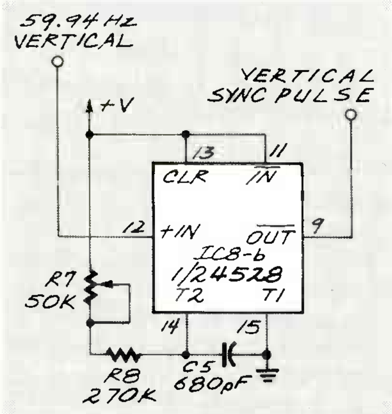


FIG. 6

Generating vertical sync

A properly constructed video signal will have all the equalizing and sync pulses we've been talking about but, as you can imagine, the circuitry needed to properly construct the vertical interval can get to be really complex. You'd need a separate pulse generator for the equalizing pulses (and an inverter to make the vertical sync pulses), and the circuitry needed to make sure they showed up at the correct time would have to be designed as well. That is why most of the early sync generators were really expensive.

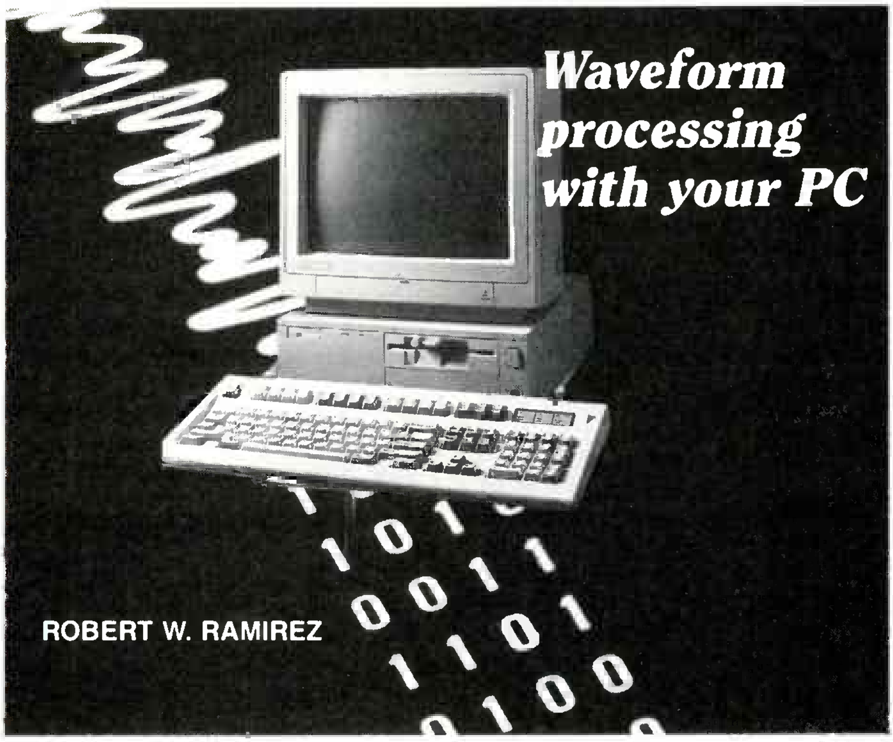
That kind of stuff isn't designed from discrete parts these days because there are sync-generator chips that do the whole job for you. For our purposes, we can generate non-interlaced video and produce a single vertical sync pulse that's wide enough to be detected by the TV's vertical-deflection circuitry. The only signal we'll need in the vertical interval will be a long vertical sync pulse; the equalizing pulses are unnecessary since we're not going to interlace the image.

The field of video we're going to produce will be 262 lines long but some of that has to be reserved for vertical blanking. That is for two reasons: The first is that most TV sets overscan the image so that some of the lines fall outside the screen area, and the second is that a certain amount of time is needed for vertical sync.

We can solve the first problem by not putting any picture information at the very beginning and end of the image; we'll leave the beam turned off. The second problem can be handled by following the NTSC standard and making our long vertical sync pulse at least three horizontal lines wide.

Actually generating the vertical sync pulse is simple since we have half of the 4528 available. By using the values shown in Fig. 6, the chip will output a negative-going vertical sync pulse with a width that's exactly three lines long. As I mentioned earlier, you should use metal-film and mica parts to make the pulse as accurate and stable as possible but, once again, add the trimmer shown in the schematic if you're in doubt as to the measured values of the parts you're using.

Once you assemble the circuits we've discussed and add them to the circuitry we've developed so far, you'll have a working video-sync generator. I know I promised we would get some images up on the tube this month, but it took a bit longer than I had planned on to get this far. Next month we'll produce a real 75-ohm video signal, and we'll put more than dots on the screen—I swear. **R-E**



Waveform processing with your PC

ROBERT W. RAMIREZ

Just about any observable activity can be represented as a series of numbers, and, using the techniques described in this article, you can write simple BASIC programs to analyze those numbers in any manner desired.

For example, standard electronic waveforms (sine waves, square waves, sawtooth waves, etc.) can be expressed as a series of numbers computed from standard equations. In addition, you can capture that type of series from real-life waveforms generated by an ADC (Analog-to-Digital Converter) or a digital-storage oscilloscope.

Not only that, but non-electronic phenomena are also amenable to the same types of analyses. For example, you could analyze the Dow Jones industrial average over a period of time, or you could track the performance of any individual stock. Even lottery results are candidates for that type of analysis.

The point is that each of those phenomena can be thought of and analyzed just like a waveform, be it an electronic waveform, a stock "waveform," or a lotto "waveform." More generally, those things can be thought of simply as a series of events occurring over a period of time. Any such series of events can be subjected to what mathematicians and scientists refer to as *numerical analysis* or *time-series analysis*.

Don't be intimidated by the terminology. Time-series analysis is nothing more than basic mathematics applied to a series of numbers. To see how easy it really is, let's look at some examples.

Tables

To analyze a series of numbers, the numbers need to be organized into some form for easy reference. The most familiar and easiest form of organization is a simple table of values like the one shown in Table 1. You might rec-

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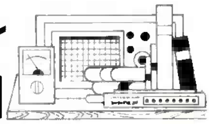
EDITOR'S WORKBENCH



The Talking PC

Speech synthesis on a PC is hard to come by, if not expensive—usually. Street Electronics has come to the rescue with the Echo PC+, an under $200 (depending on host PC) setup that includes a PC board, an external speaker with volume control, and software. The software (which is supplied on both 5-¼- and 3-½-inch diskettes) includes several speech generators, demonstration programs, and assorted miscellany. A 50-page booklet explains how to install and use the Echo PC+. Special versions of the card are available for PS/2's with the MicroChannel bus, for Tandy 1000's, and the Apple II. I looked at the PC version.

The half-length board plugs into any 8- or 16-bit PC expansion slot and has two connectors. One connector (a ⅛-inch mini plug) is for the external speaker; the other (a standard 17-pin D connector) is an IBM-compatible game port. The board includes half-a-dozen logic devices (bus buffers, a PAL presumably used for decoding, etc.), an NE558 quad op-amp, an LM380 for audio output, and a proprietary speech chip. The board is laid out well, and construction is excellent.

The software consists of two programs: Talk and Words. Both load as memory-resident programs that capture ASCII text sent to a phantom output device (LPT3, for example).

Talk and Words

Talk is a generic text-to-speech converter that can pronounce any word based on a set of rules stored in the program. Talk's "voice" is synthesized and mechanical sounding. It is based on the LPC (*L*inear *P*redictive *C*oding) technology used in TI's Speak 'n' Spell games.

Words, on the other hand, speaks in a more natural sounding way. Words has a limited 700-word vocabulary consisting of the actual digitized sounds of a female voice. Words' vocabulary includes all the letters of the alphabet, numbers from 0–9, the months of the year, and many common words (electronics, hello, good-bye, you, me, question, multiply, etc.). There are some strange omissions, however. *Boy* and *man* are both included, but neither *girl* nor *woman* is.

You can increase Words' vocabulary in a limited way by adding one of seven prefixes and suffixes (dis-, ex-, re-, un-; -d, -t, -s) to a word by enclosing the addition in parentheses. For example:

I like her.
I (dis)like her.
I like(t) her.
I (dis)like(t) her.

The version of the product that I saw doesn't allow you to add to the digitized vocabulary, but around the time you read this, the company should be introducing a DSP (*D*igital *S*ignal *P*rocessing) board for about $500 that will allow you to digitize any audio signal and convert it to a form suitable for playback through the Echo PC+.

Fine tuning

Several parameters affect how both Talk and Words speak. For example, you can vary the speech rate of either program by sending this command:

*RATE = *n*

where *n* has a value from 0 (slow) to 15 (fast). The default value is 2. You may find, as you gain experience with Echo PC+, that you can increase the rate somewhat.

Other parameters common to both programs include pitch, volume, and delay. Pitch can vary from −63–+63, with 0 being the default. Although the external speaker has its own volume control, you can also set volume under program control using the Volume parameter, which may range from 0–15 (14 is default). The Delay command allows you to specify a delay between each spoken word; values are specified in tenths of a second, and may range from 0–20. Delay is independent of Rate; 0 is the default.

In addition, each program has several unique performance parameters. Since it has its own limited "intelligence" for deciding how to pronounce any given combination of letters, Talk allows you a fair amount of control over how it forms its interpretation. For example, the program can operate in either of two basic modes: Word or Letter. In Letter mode, every letter of every word is pronounced separately. In Word mode, however, the product's intelligence is put to the test.

FIG. 1

Within Word mode, there are several punctuation modes: Some, Most, and All. In All mode, every punctuation mark is pronounced. In Some mode, Talk tries to pronounce sentences with end-stops (question mark, period, semicolon) correctly. Questions, for example, end in English with a slight rise in pitch.

One other mode ("Caps") available in Talk forces words spelled in all caps to be pronounced letter by letter. That mode could be useful in creating an interactive spelling tutorial.

Words' special features include the prefixes and suffixes discussed above, and the ability to speak several complete pre-programmed phrases, including *disk drive, I am, I win, it is, select one of fol, that is correct, that is right, United States, when was that, you are*, and *you win*.

One way of overcoming Words' limited vocabulary is to load both Talk and Words into memory. Then when you send a string to Words, any text that it can't process it will send on to Talk. However, the two voices are so different that maintaining continuity is impossible.

One problem with Talk is its inability to deal with compound words and words that break the "rules" of English pronunciation. For example, Talk pronounces *typewriter* as tip-eh-writer. However, by breaking compounds up into the component parts, it will often pronounce them correctly. To get Talk to pronounce rule-breakers correctly, you must misspell the word. For example, for the first syllable to be pronounced *ee* rather than *eh*, *electrolyte* must be spelled *eelectrolyte*.

I also had trouble getting the Echo PC+ to pronounce other words correctly. *Rigid*, for example, sounded more like a croaking frog than a word. And though it did all right with words like Brian, Jeff, Marc, Carl, Bob, John, Julian, Larry, Kathy, Terry, I had to spell Byron as two words (*bie ron*), and I was unsuccessful in getting it to say the first syllable of Andre (*an dray*) to rhyme with the first syllable of father; it insisted on rhyming it with hand. (Sorry, Andre!)

How it works

Both Talk and Words work by hooking into the appropriate BIOS interrupt and capturing output sent to a COM or LPT port. Then you force the board to speak simply by "printing" the desired text to the appropriate port. For example, if you start Words like this

Words lpt3:

any ASCII data you send to LPT3 will be interpreted and pronounced by the program, if possible. You can set the software up to respond as any legal COM or LPT port.

The demo programs allow you to type a line at a time at the keyboard and send it to the Echo PC+. To get it to talk from your own programs, you just PRINT or

WRITE the desired string to the appropriate port. For example, the manual supplies the following BASIC program:

```
10 OPEN "LPT3:" FOR OUTPUT
AS #1
20 PRINT
30 INPUT "Enter text: ";A$
40 PRINT #1,A$
50 GOTO 20
60 END
```

Some versions of BASIC won't let you PRINT in that fashion; the manual includes another example with some in-line assembler code that does the same thing. Examples are also provided in several varieties of Pascal and C.

All in all, considering the price of the product, my complaints are really just nit-picking. If you'd like to add speech to a science-fair project, an interactive demo, or a self-paced, PC-based tutorial, the Echo PC+ is an excellent buy. CD

War of the Words

Word processors have been evolving rapidly over the past few years. Due to my work with different clients, I have checked out all the major contenders during the past year or so, including Word Perfect 5.0, Word 5.0, WordStar 5.5, XyWrite III Plus, and several lesser packages. I can state unequivocally that Word Perfect was my least favorite, due mainly to the lack of any logic in the way its commands are assigned. Many people would claim the same of WordStar, but that's false; WordStar commands are for the most part well organized, it just takes a while for the system to sink in. And there's no question that WordStar has the best page preview of any non-graphical word processor. XyWrite offers a lot of power, but its on-screen display is mighty ugly for this day and age, and its spelling checker is almost more trouble to use than it's worth. (However, a new version of the program is due out in early spring; we'll see....)

That leaves Word. Even though I've only used it a few weeks so far, it has grown on me quickly. It is highly customizable, offers a wealth of display modes (including, on a VGA, very nice 30- and 34-line graphics modes that do a decent job of displaying italics and boldface text). Like Word Perfect, its macro facility amounts to a miniature programming language. One of Word's most famous (and justly so) capabilities is the style sheet, or set of formatting attributes you can apply to text. Even though you can't see fonts, etc., on-screen, you can enable a so-called style bar along the left side of the screen that provides a one- or two-letter indication of the style of each paragraph. The style bar thus gives you the ability to produce nicely formatted documents without requiring the expensive hardware resources required by graphical word processors (Word for Windows, Ami) and desktop publishing packages.

Word has many other features, including on-line help, a good spelling checker and thesaurus, multiple windows, support for many printers (including LaserJets and PostScript devices), and a document-management function that allows you to create a summary sheet that remains with the document and that specifies the original author, date of creation, and a one-line summary of contents. You can then search for a specific document based on the summary using a special load function.

Word also has a built-in outlining function that, although no match for Symantec's GrandView, is better than nothing, and has the benefit of being built-in, so you can do things like apply styles to different outline levels.

Word naturally stores documents in its own format, but it can also load and store ASCII text directly, in both line- and paragraph-delimited forms. That capability is indispensable if you do much work with on-line systems, E-MAIL, etc.

There's a lot more to Word, but no space to give it justice. For me, it seems to have the right balance between formatting tools and text creation tools, unlike much of the competition, which tend to push too far one way or the other, or are simply disorganized conglomerations of features. Word 5.0 lists for $450, but you can pick it up mail order for little more than $200. CD

ITEMS DISCUSSED

- Echo PC+ ($179.95 (PC), $134.95 (Apple II), $199.95 (MicroChannel), $249.95 (RS-232), Street Electronics Corporation, 6420 Via Real, Carpinteria, CA 93013. (805) 684-4593.
CIRCLE 256 ON FREE INFORMATION CARD

- Word ($450), Microsoft Corp., 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717. (206) 882-8080.
CIRCLE 257 ON FREE INFORMATION CARD

WAVEFORM

continued from page 81

ognize it as the solution to a typical beginning algebra problem: *For five values of X ranging from zero to two compute a table of values for* $Y=X^2$.

TABLE 1—$Y=X^2$

Entry	X	Y
1	0	0
2	0.5	0.25
3	1.0	1.0
4	1.5	2.25
5	2.0	4.0

Essentially the same approach can be taken on a PC using any standard spreadsheet program, as illustrated in Fig. 1. In this case, the five values of X have been entered manually in the five cells or elements of column A. The values in column B are obtained by entering the necessary formula in each of the B cells. For example, the formula in B1 would

	a	b	c
1	0	0	
2	0.5	0.25	
3	1.0	1.00	
4	1.5	2.25	
5	2.0	4.00	
6			
7			

Fig. 1. *STORE DATA FOR $Y=X^2$ in a spreadsheet program. The X values are stored in column A, and the Y values in column B.*

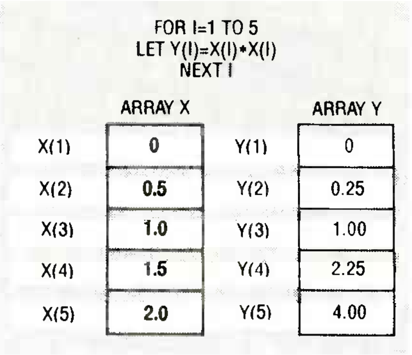


Fig. 2. *STORE DATA FOR $Y=X^2$ in a two-dimensional array in a high-level programming language (BASIC, Pascal, etc.).*

be A1×A1, the formula in B2 would be A2×A2, and so on.

The same principles apply when using numeric arrays in any high-level programming language (BASIC, Pascal, C, Fortran, etc.). We'll show basic techniques in BASIC here; it certainly wouldn't be difficult to adapt our techniques to other languages.

Arrays

An array is a set of subscripted variables or elements; you can think of it as shown in Fig. 2. In that figure, array X has five elements (with subscripts 1–5). The first element is X(1), the second is X(2), and so on. Array Y also has five elements, subscripted the same way.

The nice thing about creating and manipulating an array in a programming language is that the elements of the array can be referred to and operated on with FOR loops. That allows a single general formula to be applied to every element in the array. Entering five items of data in a spreadsheet is not so bad, but think about entering (and performing calculations on) 500 items by hand!

To gain a better understanding of how the problem might be generalized and attacked using BASIC, consider the program in Listing 1.

The first few lines of the program prepare an array of the desired size. The statement in line 10 specifies that arrays are numbered from one (1), not zero (0), because computations are usually easier. Line 20 asks you to enter the number of values you want to calculate, and line 30 uses an INPUT statement to assign the desired number to variable *n*. Now that the program knows how many numbers you want to process, the arrays for storing those numbers are created with one or more DIMension statements.

Getting the data in

Typing data into the program gets old fast; it would be nice if we were able to bring data into the program directly.

For example, a digitizing oscilloscope could be a source of data. The data would be a series of numbers representing the amplitude of a waveform captured at discrete points in time; each value is stored in the scope's memory. Then, if the scope has an RS-232 interface, the data could be transferred to a disk file on your PC and subsequently read into a numeric array of the type discussed earlier. The waveform data could then be processed just like data typed in by hand. Of course, the method of transferring data to the PC depends on the scope, data-capture software running on the PC, etc. However, most digitizing scopes provide transfer utilities for dealing with their scope's data format.

LISTING 1

```
10 OPTION BASE 1
20 PRINT "ENTER THE NUMBER OF X VALUES TO PROCESS."
30 INPUT N
40 DIM X(N), Y(N)
50 FOR I=1 TO N
60 PRINT "ENTER THE ";I;"th VALUE OF X."
70 INPUT X(I)
80 NEXT I
90 FOR I=1 TO N
100 LET Y(I)=X(I)*X(I)
110 NEXT I
120 FOR I=1 TO N:PRINT X(I),Y(I):NEXT I
130 END
```

The next step is to get some numbers into those arrays for processing. Lines 50–80 handle that chore by requesting values from you *n* times, one at a time. The process of squaring each array value occurs in lines 90–110. Last, line 120 prints all *X* and *Y* values.

Even though that program is quite simple, it contains all of the essential steps necessary for array processing:

1. Dimension the necessary array variables.
2. Input the values for use in computations.
3. Do the element-by-element array computations.
4. Output the results of the computations.

For some applications (purely theoretical analyses, for example), input data can be generated by a program. For example, the program in Listing 2 can be used to generate a sine wave (SWAVE) composed of any number of points (*n*) and cycles (*cy*) that you choose.

A plot of the data generated by that program is shown in Fig. 3. The plot was created using a program called Graph-in-the-Box, which captures data printed to the PC screen. Of course you could write your own custom graphics routine, but Graph-in-the-Box works well with many types of programs.

As a point of interest, the sine wave in Fig. 3 was generated with

LISTING 2

```
10 OPTION BASE 1
20 PRINT "ENTER NUMBER OF POINTS TO USE."
30 INPUT N
40 DIM SWAVE(N)
50 PI=3.141593
60 PRINT "ENTER NUMBER OF CYCLES DESIRED."
70 INPUT CY
80 FOR I=1 TO N
90 SWAVE(I)=I-1/N
100 SWAVE(I)=CY*SWAVE(I)
110 SWAVE(I)=SIN(2*PI*SWAVE(I))
120 NEXT I
130 OPEN "O",#1,"B:SWAVE.DAT"
140 FOR I=1 TO N
150 WRITE #1,SWAVE(I)
160 NEXT I
170 CLOSE
```

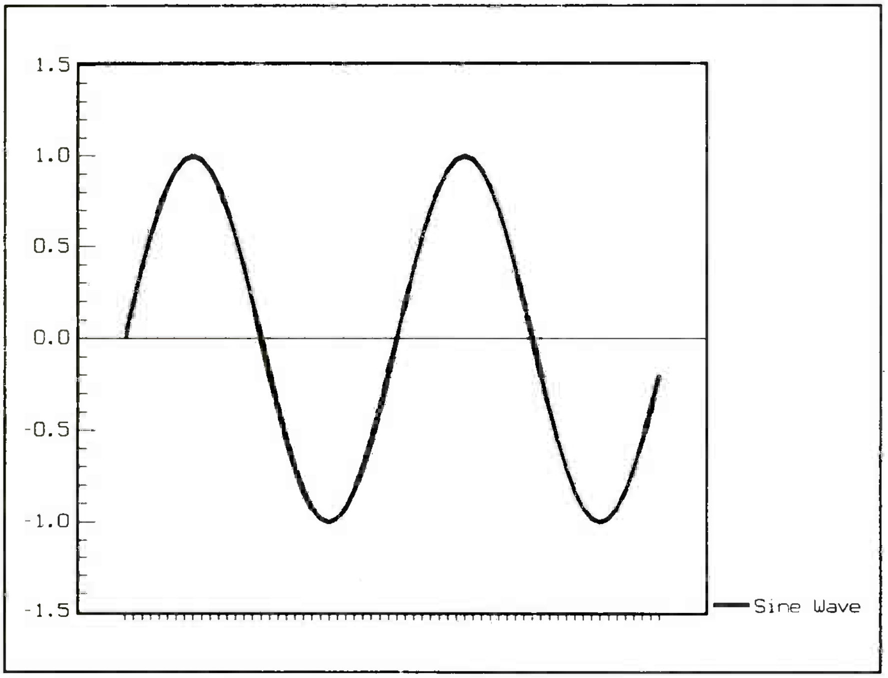


Fig. 3. *THIS GRAPH REPRESENTS two cycles of a sine wave. The data was generated by the BASIC program shown in Listing 2.*

64 equally spaced points over two full cycles. There is no "frequency" inherent in that representation. Frequency enters the picture only when you assume that each point represents some increment of time, which could be picoseconds, microseconds, seconds, minutes, months, or whatever you choose.

For example, let's say you want Fig. 3 to represent a sine wave of 1 kHz. Then you would assume that each point represents an increment of 1 ms (the period, 1/1000 Hz) divided by the number of points covering one cycle (32 points/cycle in this case), giving 0.03125 ms per point. The amount of time per point is generally referred to as the sampling interval.

Simple analysis operations

Once you have an array of data—however you get it—you can begin analyzing it with waveform-processing techniques.

For example, you might want to scale the data upward or downward in value. Let's say you want to double the value of every array element. That can be done by multiplying the array by a constant as shown in Listing 3.

Or say you want to know the average (mean) value of the data stored in an array with *n* elements. That's a simple computation. Just add up all the values in the array and divide the result by *n*. For the sine wave in Fig. 3, that would be done as shown in Listing 4.

The RMS (root-mean-square) value of that waveform could be computed in a similar manner as shown in Listing 5.

When computing average, RMS, or similar values from waveform data arrays, keep in mind the definitions of the calculations and how they apply to the data. For example, you would expect the average value of a sine wave (or similarly symmetric waveform) to be zero. But that will be the case only if array SWAVE contains an integral number of sine wave cycles. If SWAVE contains a nonintegral number of cycles, say 1.5 cycles, the average value of the array would be nonzero by an amount determined by the extra half cycle. To get the correct value in that case, you would have to restrict the calculations to just the array elements covering an integer number of cycles.

LISTING 3

```
200 FOR I=1 TO N
210 SWAVE(I)=SWAVE(I)*2
220 NEXT I
```

LISTING 4

```
300 AVG=0
310 FOR I=1 to N
320 AVG=AVG+SWAVE(I)
330 NEXT I
340 AVG=AVG/N
350 PRINT AVG
```

The key point here is that your program simply operates on the numbers that you give it, nothing more, and nothing less. It makes no assumptions about the meaning of those numbers.

Calculus made simple

The greatest attribute of array or waveform processing is that it dramatically simplifies what would otherwise be extremely difficult calculations. Take calculus for example. Pencil-and-paper integration of anything but the simplest functions can be a nightmarish task. But with array

LISTING 5

```
400 AVG=0
410 FOR I=1 TO N
420 SWAVE(I)=SWAVE(I)*SWAVE(I)
430 AVG=AVG+SWAVE(I)
440 NEXT I
450 AVG=AVG/N
460 RMS=SQR(AVG)
470 PRINT RMS
```

processing, any function represented by a series of numbers can be quickly and easily integrated or differentiated.

Integration, for example, is the process of computing the area under a curve. In array processing, that means multiplying each element of the array by the sampling interval value (e.g. the time increment represented by each sample). Integration is then completed by computing at each point the sum of the samples preceding that point. Listing 6 shows one example.

In that program segment, FUNC is the array containing the waveform or function values to be integrated, and INTEGRAL is the array containing the results of integrating FUNC. If, for example, FUNC has 30 elements ($n = 30$), if all elements are equal to one (1), and if the sample interval is one ($dt = 1$), the computed values for INTEGRAL will be 0, 1, 2, 3,...29. The computation assumes that there are no values (and thus zero area) preceding element number one. Hence, element one always has a value of zero and element two equals the first incremental area (0 + 1). Alternatively, you could assume that the first element of INTEGRAL should contain the first incremental value of FUNC, in which case the FOR loop should start incrementing from one rather than two.

To differentiate a function, you simply compute the point-by-point slope (rise over run) of the array values. The general formula is: $m = (Y_2 - Y_1)/(X_2 - X_1)$. Listing 7 shows one way to make the computation.

If FUNC is a ramp of values running from 0 to 29, as obtained from the preceding integration example, the values computed for DIFF will all be equal to 1. That is to be expected since the differentiation operation is the inverse of integration.

As a point of interest, notice that the differentiation routine uses a FOR loop running from 1 to $n - 1$. The reason is that for n points, there are only $n - 1$ intervals between those points over which slopes can be computed. Also, there isn't a final interval for computing the value of n. To get around that problem, the last value (the value for n) is assumed to be equal to the preceding value ($n - 1$).

A sampling of statistics

Until now all of our examples have been of calculations on array values. Sometimes, however, especially in statistics, the analysis may be more a matter of searching out specific array values or rearranging array values to cast a new slant on the data.

For example, after accumulating a large array of data, you may need to find the maximum or minimum value of data and its location in the array. Finding maximum, minimum, and midpoint values is a common requirement when analyzing pulse waveforms for rise time, fall time, width, etc. Maximum, minimum, and midpoint values are also useful in analyzing stock market data. Listing 8 shows how to search an array (X) for its maximum value.

In that example, MAX will contain the maximum value found in the array and MAXPT will contain the array element number where that maximum was found. If you want to find the minimum value, simply change the less-than sign in line 820 to a greater-than sign. (You'll probably want to change the variable names to MIN and MINPT as well.)

It should be noted that, in the

LISTING 6

```
600 PRINT "ENTER SAMPLE INTERVAL VALUE"
610 INPUT DT
615 SUM=0
620 FOR I=2 TO N
630 FUNC(I)=FUNC(I)*DT
635 SUM=SUM+FUNC(I)
640 INTEGRAL(I)=SUM
650 NEXT I
```

LISTING 7

```
700 PRINT "ENTER SAMPLE INTERVAL VALUE"
710 INPUT DT
720 FOR I=1 TO N-1
730 DIFF(I)=(FUNC(I+1)-FUNC(I))/DT
740 NEXT I
750 DIFF(N)=DIFF(N-1)
```

LISTING 8

```
800 MAX=X(1)
810 FOR I=2 TO N
820 IF MAX<X(I) THEN MAX=X(I)
830 IF MAX=X(I) THEN MAXPT=I
840 NEXT I
```

LISTING 9

```
145 DIM HIST(44)
150 FOR N=1 TO 44
155 FOR I=1 TO COUNTE-1
160 IF N1(I)=N THEN HIST(N)=HIST(N)+1
165 IF N2(I)=N THEN HIST(N)=HIST(N)+1
170 IF N3(I)=N THEN HIST(N)=HIST(N)+1
175 IF N4(I)=N THEN HIST(N)=HIST(N)+1
180 IF N5(I)=N THEN HIST(N)=HIST(N)+1
185 IF N6(I)=N THEN HIST(N)=HIST(N)+1
190 NEXT I
195 NEXT N
```

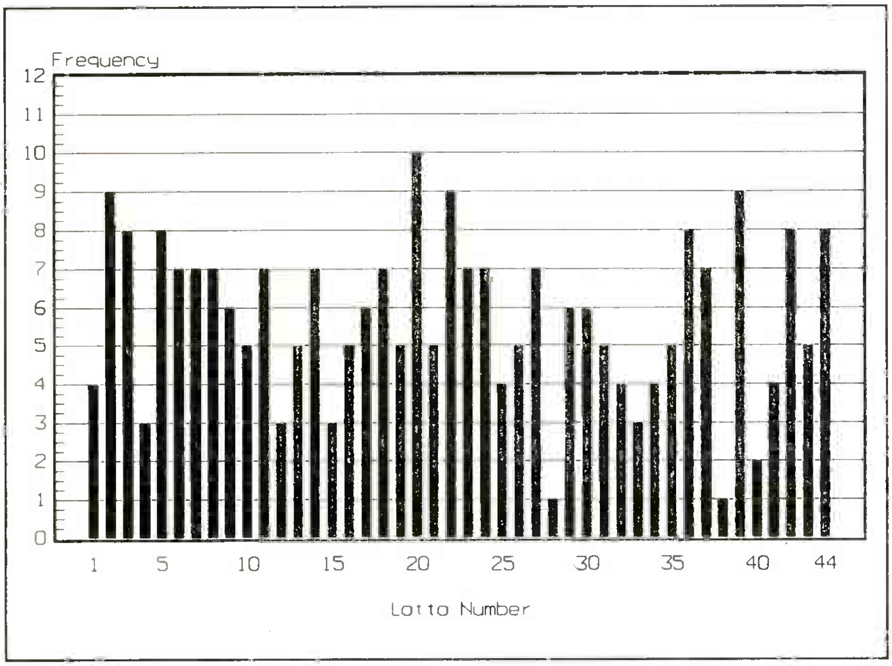


Fig. 4. THIS HISTOGRAM SHOWS THE FREQUENCY with which numbers from 1 to 44 appeared in 42 drawings of a state lottery.

MAX search, if array X contains several values equal to MAX, only the last occurrence of the maximum will be retained in MAXPT. Capturing the location of each maximum point could be done by using an array for MAXPT.

Another way to provide insight into data is with a histogram. A histogram shows you how many times each value occurs in an array. For example, running a histogram on a series of winning lotto numbers will tell you how often each number occurred. For example, Figure 4 shows a histogram plot of number frequencies from a series of 42 winning lotto numbers. The 42 sets of winning numbers were compiled and stored in six arrays (N1–N6). Listing 9 shows a BASIC program that increments the values in each of the 44 bins in HIST depending on the values in the corresponding bins of *n*.

So what does the histogram data tell you? Well, out of 42 lotto drawings, lotto numbers 28 and 38 only came up once. Are 28 and 38 due to come up soon, or are they slightly defective lotto balls that will continue to come up less frequently than the others? How about lotto number 20? It came up more frequently than the others. Maybe 20 will continue that trend and should be included in your lotto picks as long as the trend continues. Perhaps, by showing you the "hot" and "cold" numbers, a histogram can weigh the odds slightly in your

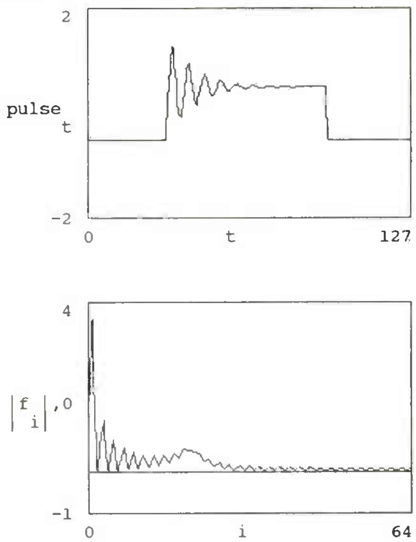


Fig. 5. MATHCAD lets you enter equations in an algebraic form, and then see plots of the results.

favor. Probably not—but it's fun to try anyway.

Histograms can also be used to analyze non-integer data as well (for example, digitized waveforms and stock market prices). When that is the case, you need to write a more complex histogram routine where "bins" are defined to cover a range of numbers (0–1, 1–2, etc.).

Into the stratosphere

Whatever your area of interest, you can create analysis programs to enhance and broaden your understanding. When you start out, your analysis routines should be kept relatively simple; the example routines presented here will get you started. But as you progress, you'll want to enhance those routines or create other more specialized routines of your own.

Whenever you modify an existing routine or create a new one, you should test it on known data. For example, a MAXimum search routine can be tested by setting one point in an array to a higher value than all others. You know what value you entered in the array and at what element, and those are the values the MAX routine should return. For routines that must interpolate values between points, such as a midpoint search routine, you may need to print the test array values and manually compute the midpoint value and location as a means of verifying the routine's operation.

The most important point is to begin by writing and testing your own waveform processing routines. The experience gained will build a strong fundamental understanding of numerical analysis methods, processes, and nuances.

Ultimately, however, you may want to concentrate less on programming and more on analysis. For this step, there are a number of PC software packages that provide sophisticated analysis capabilities, in both menu-driven and high-level equation-oriented programming formats. Figure 5 provides an example of equation-oriented programming with MathCAD.

continued on page 97

MORSE/RTTY DETECTOR

continued from page 52

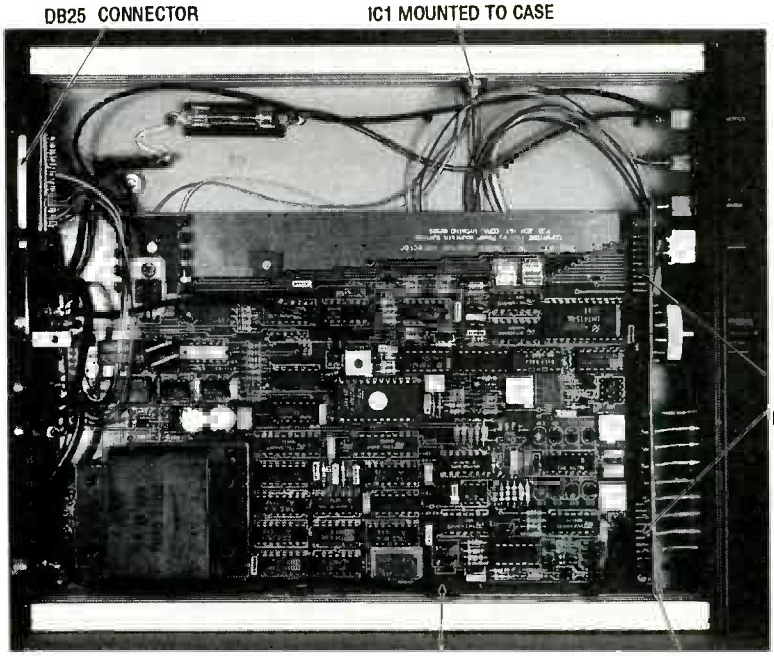


FIG. 7—THE BOARDS ARE INSTALLED as shown. Notice how the two right-angle headers hold the two boards together.

ment isn't very difficult.

You will have a problem with that adjustment if your AC waveform doesn't have a 50/50 duty cycle. A low distortion sine-wave generator is the best for the job.

Potentiometer R67 sets the DC threshold for the LM311 Schmidt-trigger limiters, and the schematic indicates "1.9V." You want to set R67 for 1.9 volts on IC32 pin 7. The potentiometer should be adjusted for optimum performance on RTTY and CW on off-the-air signals. 1.9 volts should be close, if not exactly right.

If you want to use the FSK generator, then you need to use a frequency counter to set the two oscillators to 15,000 Hz and 13,300 Hz. Notice that those frequencies are ten times the actual output. Be certain that you use temperature-stable capacitors such as Mylar, polypropylene, or polystyrene for the 555 timer circuitry.

Remember that the MARK or idle frequency is the lower of the two. If you short JP4, then the output will stay at the SPACE (higher) frequency so you can make the adjustment. You can do the same thing by setting the NORMAL/INVERT switch to the "invert" position. The actual output frequencies will be 1500 Hz and 1330 Hz for SPACE and MARK frequencies, for 170-Hz shift.

The FSK output-level-set control, R90, should be adjusted for the best results with your particular transceiver.

Software

There is a CW receive program in the public domain, which works well with the detector on IBM PC's or clones. The software, MORSE.ARC, is also available on the RE-BBS (516-293-2283). If you order something from the source mentioned in the parts list, you'll be sent a free copy of that program, upon request. The BBS file also contains the source code for the EPROM.

The designers of the detector have also designed custom software for their decoder, along with software that will get you started on designing your own CW program, as well as on designing your own EPROM. See the Parts List for ordering information.

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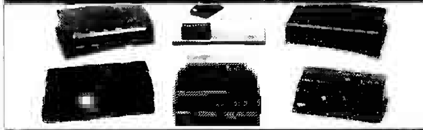

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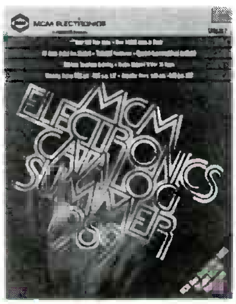

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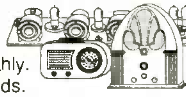

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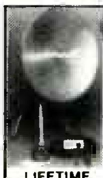

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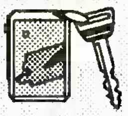

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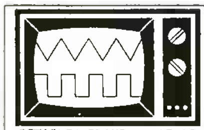

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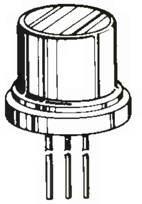

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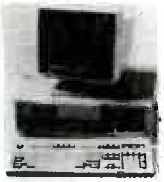

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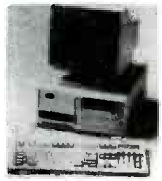

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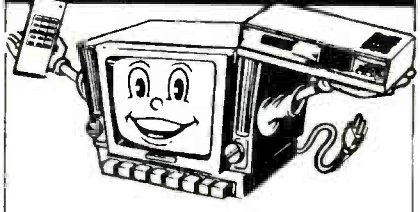

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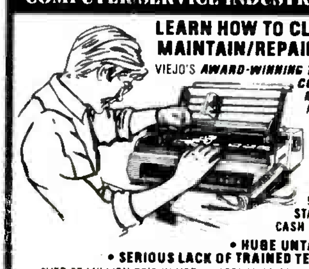

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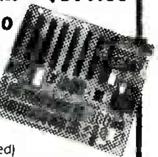

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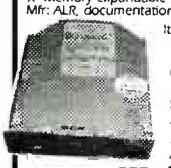

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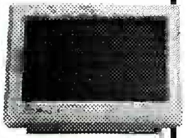

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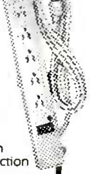

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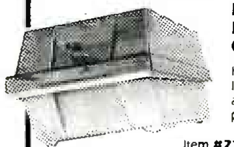

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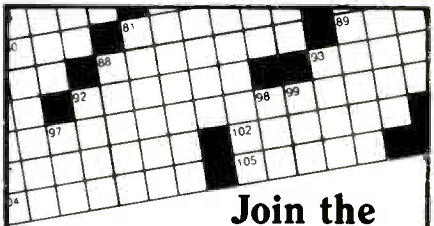

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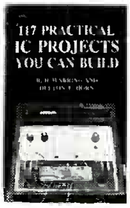

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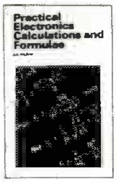

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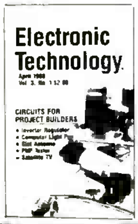

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WORKBENCH

continued from page 88

Notice in Fig. 5 how values are computed simply by stating an equation or function equivalence. For example, the average or mean value is subtracted from array PULSE by simply stating:

pulse := pulse − mean(pulse)

In the same manner, the maximum value in array PULSE can be assigned to variable *mx* by:

mx := max(pulse)

MathCAD is thus simple, quick, and clean, even for sophisticated functions such as the fast Fourier transform (FFT), which is the numerical-analysis equivalent of a spectrum analyzer, except that this spectrum analyzer can be applied to any array of numerical data. In fact, Fourier techniques and FFT's have been used to define and extract business-cycle information from economic indicators, stock market data, and weather data.

Analysis packages such as MathCAD offer a wide range of capabilities from simple to sophisticated. You can go from maximums and minimums to histograms, linear regressions, FFT's, Bessel functions, etc. However, don't let the power of sophisticated analysis subvert your common sense, or belie the importance of a fundamental understanding of the data being analyzed. That final point is perhaps best stated by Alfred North Whitehead (1861–1947), a prominent mathematician and philosopher, who said:

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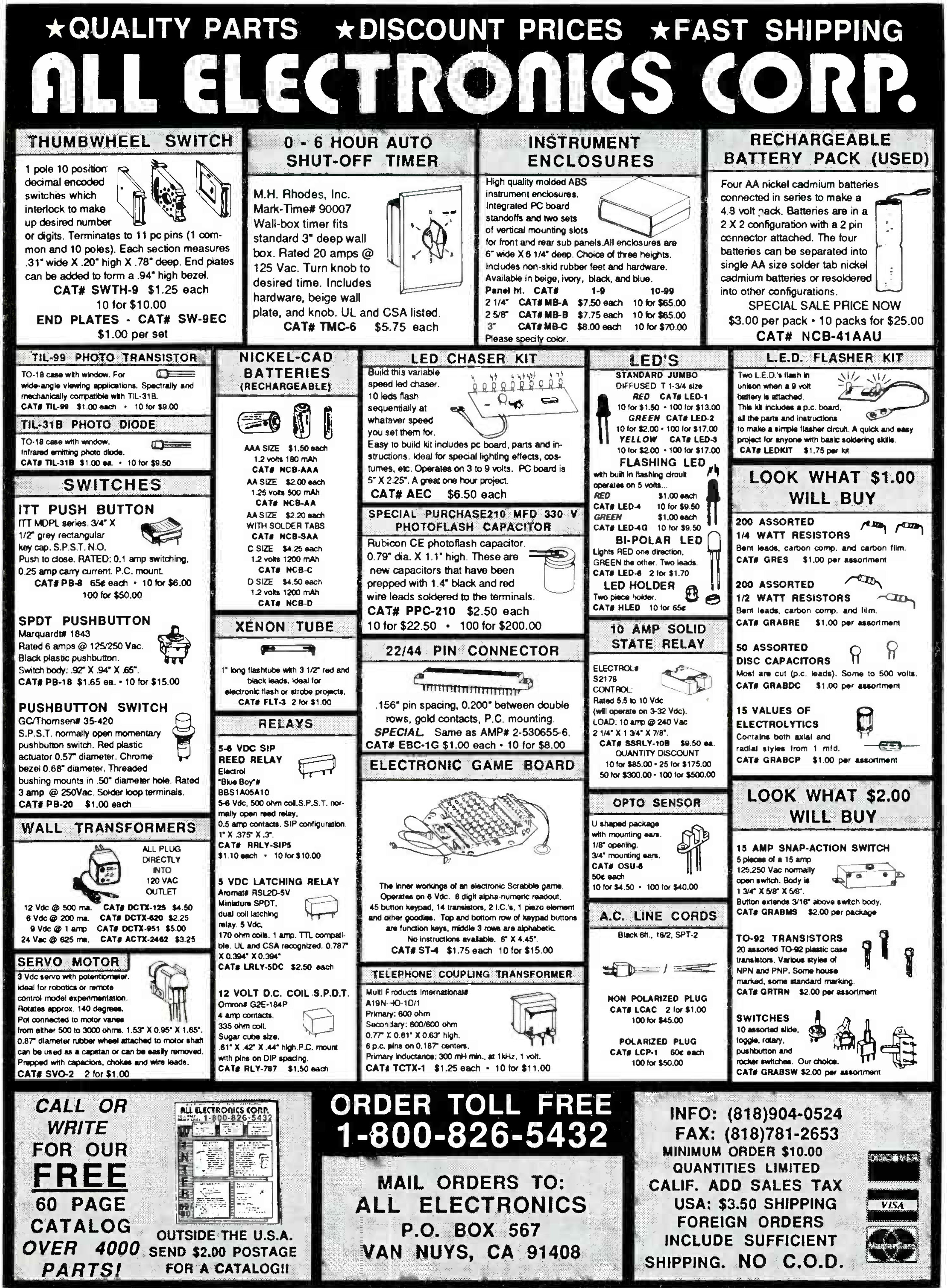

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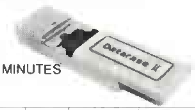

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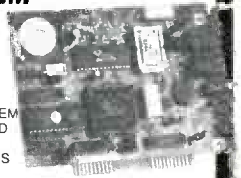

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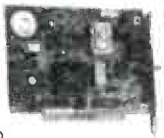

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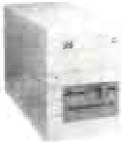

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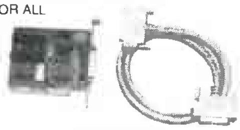

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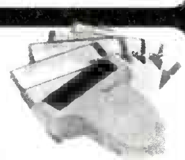

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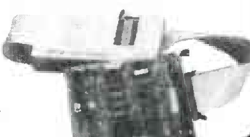

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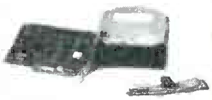

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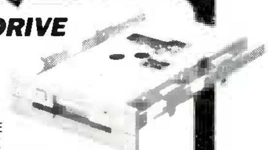

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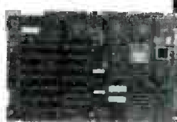

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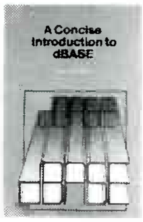

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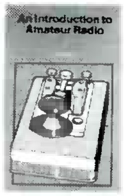

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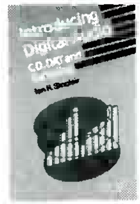

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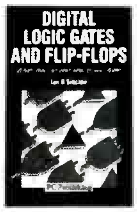

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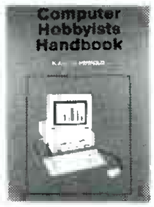

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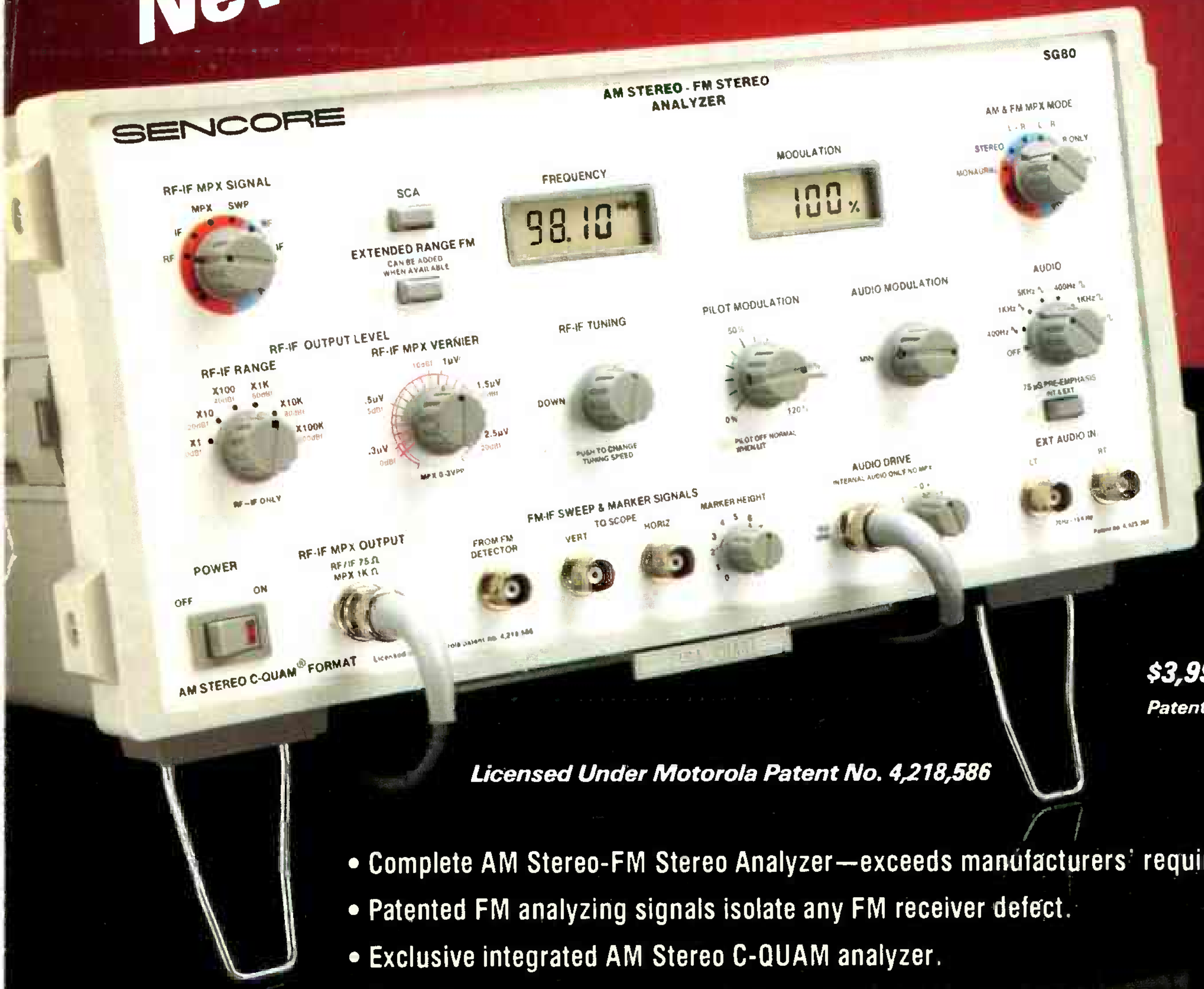

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