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DECEMBER 1989

TECHNOLOGY - VIDEO - STEREO - COMPUTERS - SERVICE

HOLIDAY ELECTRONICS GIFT GUIDE

# BUILD THIS PROGRAMMABLE PHASOR PROPERTY GUARD

This high-tech deterrent produces a painful blast of disorientating shock waves

**CIRCUIT COOKBOOK**
We de-mystify phase-locked loops with plenty of practical examples

**BUILD A PC-BOARD ETCHING SYSTEM**
A must for making your own printed-circuit boards at home

**WORKING WITH RELAYS**
How to select solid-state relays and how to design your own

**BUILD A VIDEO SCENE SWITCHER**
Add professional wipes and fades to your home video movies

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Vol. 60 No. 12

## BUILD THIS

## TECHNOLOGY

## COMPUTERS

## CIRCUITS

## DEPARTMENTS


ComputerDigest

RGB-to-NTSC CONVERTER

EDITOR'S WORK-BENCH

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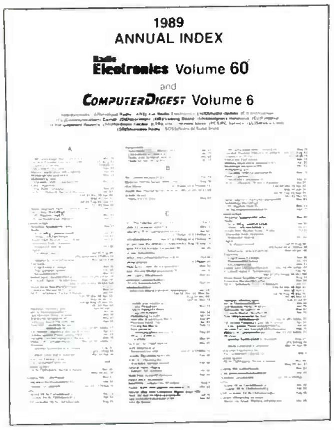

1989 ANNUAL INDEX

Radio-Electronics Volume 60

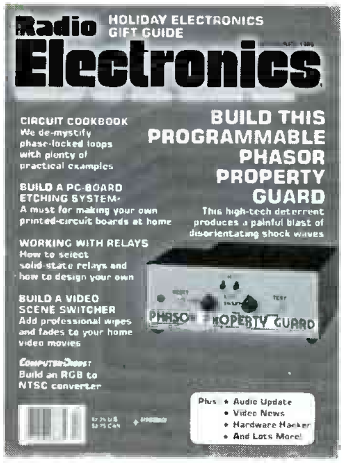
and

ComputerDigest Volume 6

**The 1989 Annual Index will appear in the January 1990 Issue.**

## AND MORE

## ON THE COVER



Radio Electronics

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Plus
- Audio Update
- Video News
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- And Lots More!

Have you ever wished for a more effective way to combat thieves? If you worry about your car or your home being burglarized, you can turn to electronics for some peace of mind. While most people are willing to settle for a simple noise maker to scare off a burglar, most burglars work quickly enough so that an alarm is not too much of a threat—but not our alarm.

Our alarm generates painful and disorienting blasts of high-pitched—and even ultrasonic—sound that are sure to send most burlgars running. The frequency and range of the sound are user-programmable, and the entire circuit is easy to build. For more details, turn to page 37.

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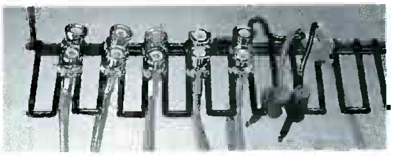

Our new BNC cable set provides you with 10 handy coax cables for connections to instruments and other equipment. Included are two 3 ft. BNC male/dual E-Z hook connectors, three 1-1/2 ft. BNC male/ BNC male connectors, two 2 ft. BNC male/BNC male connectors, and a rack that you can mount on your workshop wall for convenient cable storage. An outstanding value at less than $3.00 a cable.

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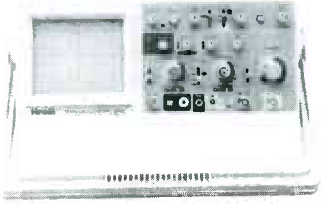

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# WHAT'S NEWS

## Magnetic resonance images take place of X-rays

Reports on trials of a new experimental approach to imaging three-dimensional areas of the human body without X-rays were made by General Electric scientists at the recent Society of Magnetic Resonance in Medicine (SMRM) conference in the Netherlands.

The new technique, known as "phase contrast magnetic resonance angiography," produces images of flowing blood that outline the veins and arteries through which the blood is flowing. The faster the blood flows, the brighter the image that appears on the Magnetic Resonance (MR) scanner's display screen. Because the image changes due to volume of blood flow, the MR method requires no injections of X-ray-absorbing fluids to highlight the vessels—often an uncomfortable process for the patient.

With the noninvasive GE MR approach, it is possible to acquire data representing all points within a three-dimensional area—commonly termed volume—the head, neck, or whatever. All blood vessels within that area can be seen from any orientation, and the volume can then be rotated to give views from front, back, top, bottom, or oblique angles.

One of the papers presented at the SMRM meeting in the Netherlands dramatized the advantage of MR angiography's 3-D capability. A patient with multiple intercranial aneurysms was evaluated both with X-rays and MR. The resulting MR images clearly showed the aneurysms that were visible on the X-ray screen and also an extra one not discovered by X-rays. The additional aneurysm was found by rotating the 3-D image to an orientation that provided an unobstructed view.

THIS VIEW SHOWING ALL THE MAJOR blood vessels of the hand was made without X-rays. It used a GE-developed technique known as "phase contrast magnetic resonance angiography." The GE technique—totally noninvasive and painless—enables viewers to see flowing blood and thereby delineate the veins and arteries through which it is flowing. The faster the blood flows, the brighter it appears on the MR scanner's display.

## Smart cards will respond to owner's voice

Based on the premise that no two voices are alike, Bellcore has devised a technology for personalized "smart cards" that work with spoken commands. The owner would "train" such a card—which contains integrated circuits and software—to recognize only his or her voice.

Bellcore's recently patented experimental system behind the "speaker-verification" concept could provide increased credit-card security and expedite other transactions involving an access card.

Bellcore's prototype speaker-verification system uses an integrated circuit card to store data about its owner's unique speech patterns (speech templates) and other pertinent information. Data is loaded into the card when its owner "trains" the speaker-verification software to recognize his or her voice before using the card for the first time.

The system works with special voice-recognition software that could be built into equipment that it's used in, including telephones, or bank terminals equipped with a microphone. The software could also be stored in a centralized computer in a remote location such as a telephone company central office.

A speaker-verification system would be exceptionally easy to use since most commands are simply spoken. Commands range from securing access to the system to dialing pre-programmed telephone numbers.

For example, Once a smart card is programmed with its user's voice, a speaker-verification telephone call could proceed as follows:

The user would first insert the card into any speaker-verification terminal, which would extract the user's name, speech templates, and any special commands and billing information. When prompted, the users would speak the verification password. The password would be translated into digital form, and verified by the computer which would compare the voice against the pre-programmed speech templates.

Once verified as the proper user, you would be able to simply speak a command to initiate a sequence of events. For example, the command "Call Mom" could instruct the phone to generate the call, assuming the command and corresponding telephone number were stored in the smart card.

Bellcore plans to make the technology available for licensing, and believes that it will be quickly developed for many consumer and commerical uses. **R-E**

# How to build a high-paying career, even a business of your own, in computer programming.

**CARL BARONE,**
**NRI PROGRAMMER/ANALYST**

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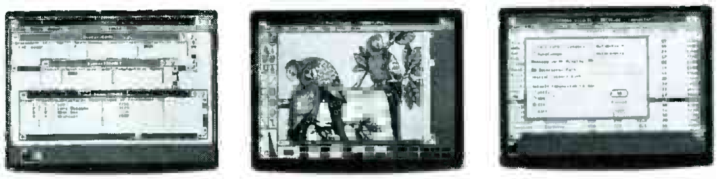

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# VIDEO NEWS

**DAVID LACHENBRUCH,**
CONTRIBUTING EDITOR

- **Widescreen TV.** In a major move toward the implementation of high-definition TV, Thomson Consumer Electronics announced at the recent Berlin Audio-Video Fair that it would introduce TV sets with widescreen proportions next fall. Thomson is Europe's second largest manufacturer of TV sets (after Philips). Its brands include Thomson in France; Telefunken, Saba, and Normende in Germany; and Ferguson in England. Thomson also sells RCA and GE TV sets in the United States, but says that its introduction of widescreen sets here will depend upon the American consumers' demand.

Widescreen TV's have an aspect ratio of 16:9, close to the proportions of Cinemascope movies, as compared with 4:3 for standard TV sets. HDTV broadcasting is expected to use widescreen proportions, and the European satellite broadcasts in the extended-definition D2-MAC system are expected to include some widescreen pictures as well as standard-aspect transmissions.

Thomson's first widescreen sets will use a new picture tube, now in pilot production, measuring 34 inches diagonally. In height, the 34-inch tube is the equivalent of a standard 28-inch type. The new set, which will sell for about $5,000, will be a "multi-format multi-standard" model, which can receive broadcasts in all of the world's TV-transmission standards—those are PAL, SECAM, and NTSC.

In addition, the set will be able to tune directly to D2-MAC satellite programs, displaying widescreen pictures when transmitted, or standard-dimension programs from any source. When tuning regular, standard European broadcasts, it will be capable of doubling the number of fields from 50 to 100, eliminating flicker. At the touch of the remote control, it can enlarge a standard-aspect TV picture to display a "cinema" version, filling the widescreen tube by cutting of a portion of the picture's top and bottom. Alternatively, it can show a standard 4:3 picture at the left of the wide screen, with three smaller pictures from other channels (or a VCR) vertically in the space to the right of the main picture ("picture-outside-picture"). The new set also can enlarge to full-screen "letterbox" TV transmissions and recordings (which normally have black bands at the top and bottom of the screen to show all of the original movie's dimensions).

Europe's D2-MAC transmissions, which started this year, are designed to be the forerunners of the true HDTV. They achieve improvement in the picture by transmitting brightness and color signals separately. The goal of the combined European "Eureka" project is to start compatible HD-MAC 1,250-line widescreen service in 1992. A preliminary version of HD-MAC was being transmitted from satellite and distributed by fiber optics and cable at the Berlin show for demonstration purposes.

- **Audio-video CD's.** Two interactive audio-video compact-disc formats are racing toward the consumer market, both with products tentatively scheduled for 1990 or 1991. *C*ompact *D*isc *I*nteractive (*CD-I*), championed by Philips, can squeeze a whole dictionary of audio and still- or limited-action video on a 5-inch CD. *D*igital *V*ideo *I*nteractive (*DVI*), developed by GE and being readied for the market by Intel, claims up to 72 minutes of full-motion digital video, in addition to audio, on the same size disc. Both companies are aiming for $1,000 players at first, coming down rather quickly to somewhere round the $500 price level.

Manufacturers are still somewhat vague on what kind of programming they think will become popular, but Philips' subsidiary, American Interactive Media, has released a list of CD-I programs that are under development. Those include "A Visit to Sesame Street," "Children's Bible Stories," "Children's Musical Theater," "Clue," "Gardening," the "Grollier Encyclopedia," "Interactive Golf," "Kaleidoscope Music," "Oldies Juke Box," "Rand-McNally Family Atlas," "Rocket Ranger," "Sargon Chess," "Sinatra, my Father," "Stamps," "Time-Life Photography," and "Treasures of the Smithsonian." That list should give you some idea of what the new medium might be like. **R-E**

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# ASK R-E

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### BROKEN IC PIN

**I bought an 80287 Math Coprocessor for my PC/AT and broke pin 1 flush with the DIP surface while installing it, so there's nothing to connect to. I've written the manufacturer, but no answer. Do you have any ideas?—J. Dunbar, Camden, TN**

There's always a way to fix anything; let's talk about repairing IC legs in general, and then we'll deal with your 80287. Some methods will make a manufacturer cringe, some may make them cross the street and walk the other way when they see you, and others may just void your warranty. Putting a crutch on an IC is something that every hardware junkie does eventually. The best way is to replace the IC; however, trying to get a "recommended method" is like asking a car company how to repair a gas tank leak with bubble gum.

One of the staples of any electronics bench should be a collection of dead IC's, since the best replacement for one broken IC leg is another. Break the leg off a dead IC flush with the body of the DIP, and tin the end that was near the DIP. You neither need nor want much solder because the more you have, the more heat you'll need to melt it, and heat is the IC's deadly enemy.

Any electronics bench should have a collection of dead IC's, since the best replacement for one broken IC pin is another. Break off a dead IC pin flush with the package, and tin the package end. Don't use much solder; the more you have, the more heat you'll need, which may damage whatever IC you're trying to fix. Obviously, the best thing to do is replace it. Failing that, there are only two instances when you should fix it:

- It's three o'clock in the morning and you need it *NOW*!
- It's expensive.

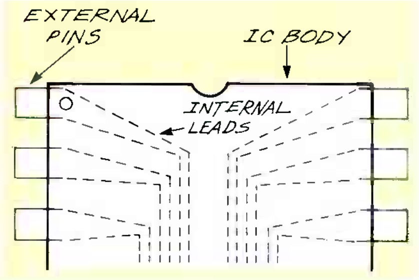

FIG. 1

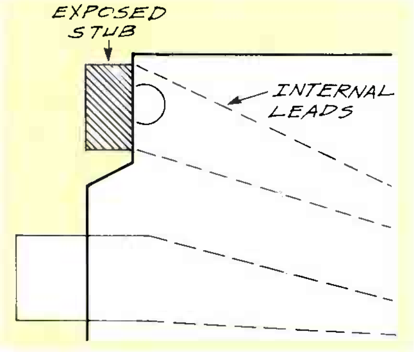

FIG. 2

If there's a stub left, just tin it and solder the new pin on. This can be tricky, since the new pin is small and will stick to the iron. You'll need a pair of tweezers and steady hands. Don't insist on perfect alignment with the rest of the pins, just get it close enough to fit in a socket. Align it after soldering, to minimize heat.

If the stub is flush with the DIP, first expose more metal; this can be done, but takes great care and *very* steady hands. Lock the IC *lightly* an alligator clip fixture for PC boards. If you don't have one, use an alligator clip held in a vise. Then, take a Dremel or X-acto Moto-Tool or similar motorized handtool with a fine, pointed, grinding wheel, and remove some of the case, exposing some of the internal continuation metal, as in Fig. 1. It's not aesthetic, but it works.

Although you can work either on the top or bottom of the DIP, the top presents less risk of damaging other pins. Keep the chip cool with freeze spray or a napkin soaked in ice water. Remember, grinding also generates heat. Limit the area you're grinding to the width of the pin, about 1/16-inch of metal, but *don't* bear down. Whatever the case material, grind a few seconds, and stop to both examine the DIP and cool it off. How much you'll have to do depends on the case.

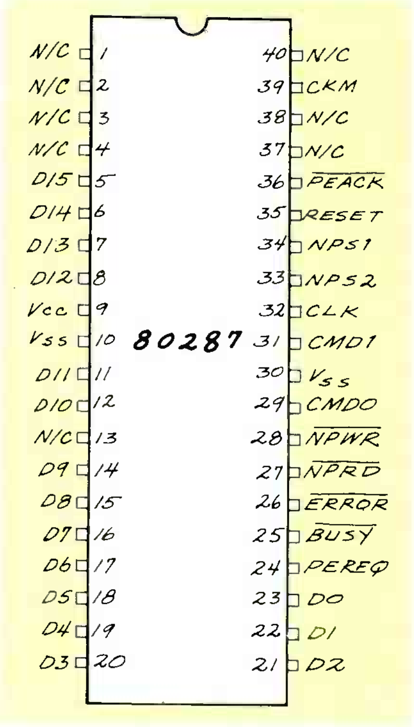

FIG. 3

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Ceramic is more resistant than plastic, but they leave no residue; plastic grinds quickly, but melts. Once you've got the metal exposed as in Fig. 2, tin it and solder to it.

For the 80287, when you break an IC pin, check whether it's used. Those for the 80287 are in Fig. 3, and you're lucky because pin #1 is labelled "N/C" (No Connection), so repairing it is pointless, all the more so since you might very well damage or overheat it needlessly. Even the slowest 80287 costs over $150. Since the only benefit is aesthetic, leave it alone. Besides, asymmetry is in vogue.

### MIKE INPUT ATTENUATOR

**I have a small cassette recorder to listen to tapes at work. I spent the extra money for record as well as play, since I'd like to use it for making the tapes I listen at work. The problem is, the machine only has a mike input, and the copies are garbled. I've tried using series resistors to cut the level, but they don't. I know there's some way, but I'm out of ideas.—D. Conklin, Princeton, NJ.**

You haven't sent in any specs on the recorder, but most have similar inputs. You're having a problem, since a series resistor only cuts current. To match signal line level to input mike level, cut the power of the input by dropping both voltage and current. The mike input needs about 200 μV at -72 dB, whereas standard outputs deliver about 300 mV, at a 10:1 mismatch. The problem is compounded if you've got low impedance 200-ohm mike inputs, not high impedance 50K inputs. Use one resistor for the signal current, and the other on the mike input voltage. You can use a transformer, but an resistive attenuator pad is easier. It does the same thing and might even fit inside the recorder.

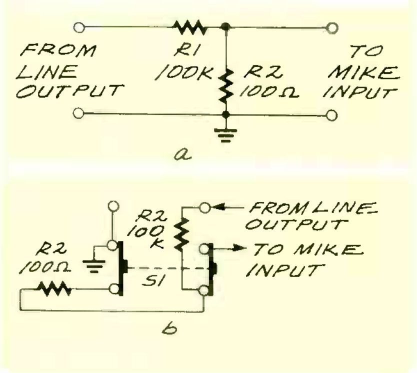
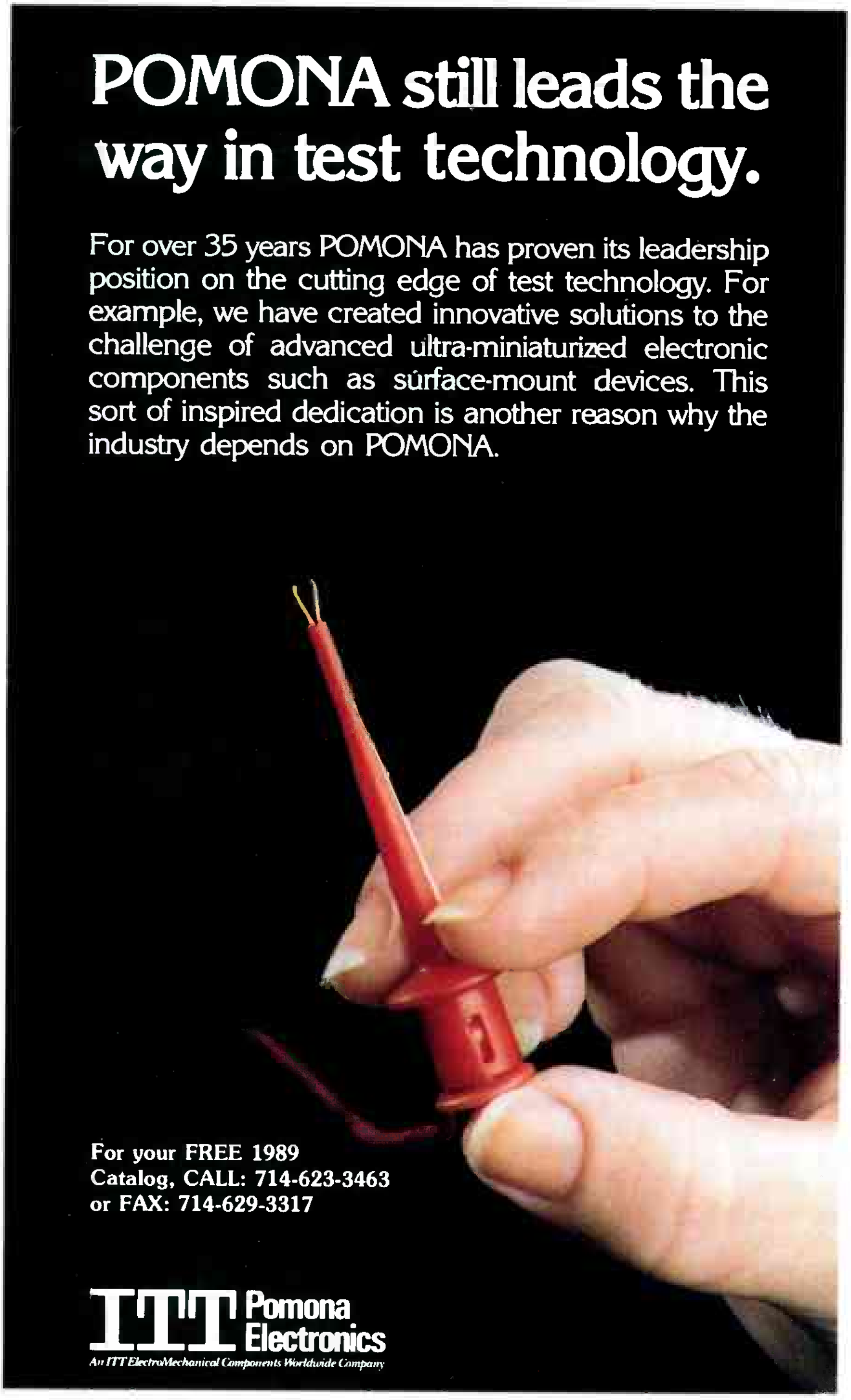


FIG. 4

Since I don't have the numbers on your mike input, you'll have to experiment. I used those in Fig. 4 to pad the mike input in my recorder, an old Sony TC-55 with low impedance mike input having 200 μV sensitivity at -72dB.

If there's enough room, use a DPDT switch as in Fig. 4. With the switch in the "Mike" position, the input is in it's original condition. When you put the switch to "Line," the signal is first routed through R1 and then R2. Mount the resistors on the switch terminals to save space and keep the signal path short. Standard ¼- or ⅛-watt resistors are fine. **R-E**



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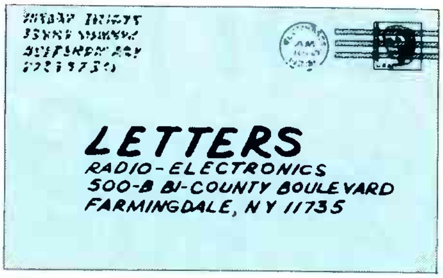
# LETTERS



## SPECTRUM MONITOR CORRECTIONS

There are a few corrections and clarifications to "Build this Spectrum Monitor," which appeared in the September and October 1989 issues of **Radio-Electronics.** The tuner is a Zenith part No. 175-02292A. You can buy it from PTS Corp., 5233 S. Hwy 37, Bloomington, IN 47401, (800) 333-7871. Cost from PTS is $33.45 including shipping and handling.

In the tuner diagram (Fig. 2 in the September issue), some of the nomenclature is not consistant with the schematic: PL5 is incorrectly labeled as PL1, PL6 as PL2, C41 as C1, and L3 as L1. In Fig. 4, the unlabeled electrolytic beneath R20 is C35.

Several performance aspects were unclear: Maximum frequency resolution is about 5 kHz. Rotating the center tune clockwise (CW) increases the center frequency, and vice-versa. The sweep controls horizontal scale; fully CW, it's about 10 MHz/div, if the center frequency isn't near the tuner extremes. Rotating it counterclockwise (CCW) expands the scale to about 5 MHz/div at midrange, but it's not calibrated. Setting the sweep fully CCW exceeds the monitor's capability.—*Editor*

## ASK RE AGAIN

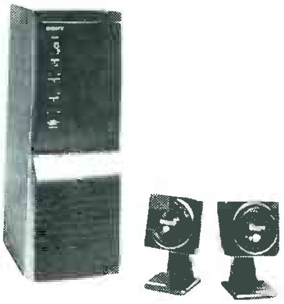
There is a mistake in "Ask RE," **Radio-Electronics**, October, 1989. In the "I Need Values" letter, a schematic was given for a device that turns on a tape recorder when a telephone handset is taken off-hook. The bridge rectifier, which makes the device polarity-independent, should be "rotated" 90 degrees with respect to the rest of the circuit. In other words, the inputs and outputs of the bridge should be transposed—*Editor*

## ONE READER'S OPINION

I would like to respond to your recent request (**Radio-Electronics**, July 1989) for reader's votes on the "PC Service" section, and to voice my opinion on HDTV.

First, I vote to go back to putting artwork for the PC boards on pages with nothing printed on the other side. The way that it is presented now is worthless in most cases. I would also like to comment about your artwork for large (usually digital) PC boards. Because they are so complex and must be reduced to fit the page, they are usually unusable because tracks run together. As an alternative, perhaps you could make full-size, clean artwork available to readers by mail, at a small cost.

Now...HDTV. I think the whole idea of HDTV is a valiant effort for a needless cause. If equipment costs as much as is predicted, I certainly will not buy any. Why do you need more resolution on television, anyway—for sports nuts to see the lines on the football field clearer? I see no need to upset the whole industry for the relatively few who will go to big-screen TV (that, admittedly, requires better resolution). It seems that there is always a desire for companies to make more money, hidden behind so-called better products for the average consumer, and it winds up



## MISTAKEN IDENTITY

In the August 1989 "New Products" column, we featured a television and a speaker system from Sony and mistakenly described both as incorporating Sony's *Sound Retreival System* (SRS) technology. Actually, SRS is used only in the Sony *XBR* line of television sets and in several high-end Trinitron sets; their *SRS* speaker systems do not incorporate SRS technology. The *SRS-D3K* speaker system, shown here and in the original "New Products" column, costs $299.95; the correct price for the *SRS-77G* system is $199.95. Our apologies for the confusion.—*Editor*

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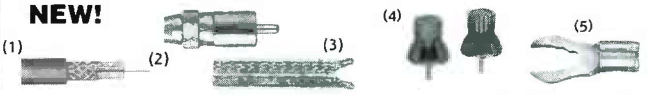

- (1) **Oxygen-Free Copper A/V Cable.** 6mm dia., 6 ft. #278-1271 . . . 5.95
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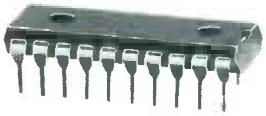
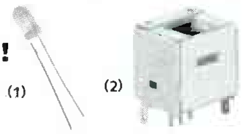


**VCP200.** Great experimenter's item—control circuits with your voice, or conduct research in robotics and computer technology. Recognizes spoken orders, even when different people give the commands. Five motion and two on/off or yes/no commands. Clipped analog input so A-to-D conversion circuit is not required. Few external parts needed. 20-pin DIP. #276-1308

### LED and IR Module

**NEW!**



(1) **NEW! Jumbo Bright LED.** 5000 mcd! #276-086 . . . . . . 4.99

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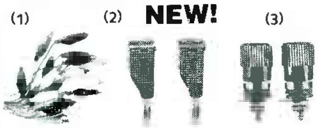
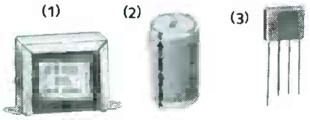


(1) **14″ Jumper/Test Cables.** 'Gator clips. #278-1156, **Set of 10/3.99**

(2) **NEW! Stackable Banana Clips.** #274-734 . . . **Set of 2/1.59**

(3) **Multipurpose Posts.** 2 red, 2 black. #274-661 . . . **Set of 4/2.19**

### Supply Parts

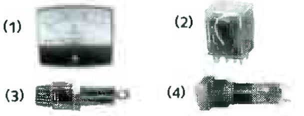


(1) **Power Transformer.** Secondary: 18 volts. #273-1515 . . . . **8.99**

(2) **Electrolytic Capacitor.** 4700 µF. #272-1022 . . . . . . . . . . . . **3.59**

(3) **Full-Wave Bridge Rectifier.** 400 PIV, 4A. #276-1173 . . . . . **1.99**

### Builder's Helpers



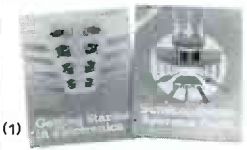
(1) **Panel DC Voltmeter.** 0-15VDC. #270-1754 . . . . . . . . **7.95**

(2) **10A Relay.** #275-217 . . . **5.99**

(3) **Fuse Holder.** #270-364, **1.29**

(4) **SPDT Lighted Switch.** 3 amps at 120VAC. #275-676 . . . . . . **6.49**

### Electronics Books



**NEW!**

(1) **Getting Started in Electronics.** #276-4013 . . . . . . . . . . . . **2.49**

(2) **NEW! Semicon Ref Guide.** 1990 edition! Lists over 80,000 types and their Radio Shack equivalents. #276-4013 . . . . . . . . **3.99**

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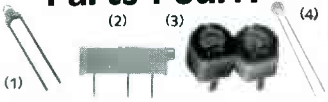


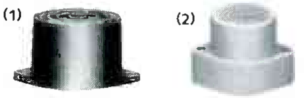
(1) **Thermistor.** #271-110 . . . **1.99**

(2) **15-Turn Trimmer Pot.** PC mount. ³⁄₄W. 1k #271-342, 10k #271-343, 20k #271-340. **Each 1.49**

(3) **Pkg. 2 Trimmer Caps.** 6-50 pF. PC-mount. #272-1340 . . . . **2/1.59**

(4) **Pkg. 50 Picofarad Caps.** 1-33 pF. #272-806 . . . . . . . . . . . . . **6.95**

### Chime and Buzzer



(1) **Doorbell Chime.** Produces musical "ding-dong". Rated 6 to 18VDC, 80 dB at 12VDC. #273-071 . . . . . . . . . . . . . . . **8.99**

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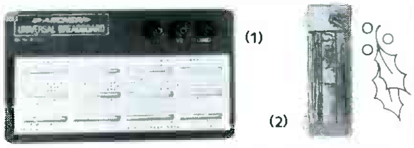
### Breadboard & Jumpers



(1) **Universal Solderless Breadboard.** Accepts DIPs, components and jumper wires (kit below recommended). #276-169 . . . . . . . . . . . . **19.95**

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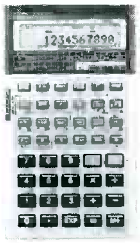

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NORMAN STOBERT
*Berrien Springs, MD*

### WORKING LIKE NEW

Thanks so much for the articles, "New Radios, New Problems, New Solutions," by Gary McClellan (**Radio-Electronics**, July and August 1989). By using some of the suggestions in those articles, I was able to fix a Delco radio that I couldn't find parts for and a Sansui car stereo that had been "butchered" by some other technician. You saved my neck! Let's have more articles like those.

JIM PRIOR
*St. Paul, MN*

### RADIATION RISKS

Like Roy Norman, whose letter appeared in the November issue of **Radio-Electronics**, I was impressed with the series of articles called the "Annals of Radiation" that appeared in three consecutive issues of *The New Yorker* ("Power Lines," June 12; "Radar," June 19; and "Video Displays," June 26). As an artist who works with electronics, a repair technician, a teacher, and a hobbyist, I found the series to be extremely sobering. I think the material is a "must read" for all of us involved in electronics—as well as those who aren't.

Those articles carefully document research showing at least a doubling of the incidence of leukemia in people living two houses or less from utility-pole-mounted stepdown transformers. The dangers seem to be caused by the magnetic fields and I want very much to build some sort of device that can accurately measure those fields. The important frequencies are 60 Hz, 120 Hz, and 15.7 kHz. I would like the meter to read directly in Milli-Guass units.

I think that this is also important in light of **Radio-Electronics**' recent articles on brain-wave experimentation both with computers (September, October, and November 1988) and with meditation goggles (April 1989). *The New Yorker* series discussed research in which cats were exposed to 147-MHz radio waves. They found that unmodulated radio waves of 1 mW/sq. cm. didn't cause any problems, but when they were modulated at brain-wave frequencies, significant electrical disturbances in the cats' brains were observed. The experiment was repeated on chicks and was definitely shown to cause serious calcium-ion and immune-system problems in their brain tissue.

I know that the knee-jerk response to that sort of stuff is to ignore it—after all, it is very harrowing news. But it would be sad if that happened.

FRED WOLFLINK
*Brookline, MA 02146*

### THE GREAT WIRE DEBATE

Concerning the "great wire debate," I conducted experiments similar to those done by Mr. Kiley (**Radio-Electronics**, "Letters," August 1989). In my case, I compared the performance of both 18-SEG

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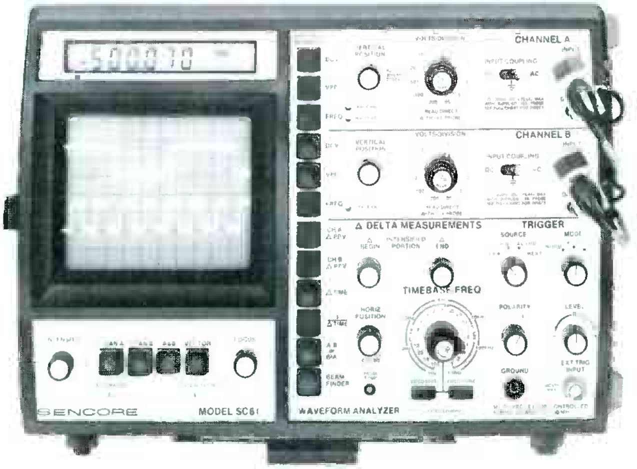


twin cable and that of standard 5-A PVC line cord 20 feet in length. I also compared performance between working into an actual commercial loudspeaker and a purely resistive load, as well as making direct measurements at the output of the amplifier. Extrapolating for the difference between Mr. Kiley's tests and mine, I arrived at exactly the same conclusions as Mr. Kiley did.

I did, however, find that there was some contact resistance in the speaker connections that far outweighed the resistance of the wire. Checking for the cause I found that, although the external connections to the speaker used standard binding posts, the connections to the driver itself were made via inexpensive slide-on lugs, and that merely jiggling them slightly resulted in variations in the overall resistance of the setup. That was in line with my general experience that poor-quality connectors are far more often the cause of signal degeneration than wire characteristics per se.

No "premium-wire pusher" has ever presented any evidence for his claims, and to my knowledge, no blind group-listening-test results have ever been published (certainly not by the wire pushers!). Fortunately, there are signs that professional audio engineers are increasingly debunking the wire manufacturers' absurd claims.

I would like to express my appreciation for Larry Klein's many contributions to common sense in those matters and for **Radio-Electronics'** consistent objectivity and independent stance in all of the subjects it tackles—which is a tribute to its faithfulness to the principles of its founder, the late Hugo Gernsback. In these days of blatant scams, it is one of the few publications I know that I can always trust.

JOHN COX
*Vancouver, B.C., Canada*

### BEHIND THE TIMES?

I've read **Radio-Electronics** for more than 20 years, and you've had quite a few interesting articles in that time.

Lately quality has gone down, and I think your magazine should adapt itself to today's and tomorrow's technology and stop looking only at the technology of 5 or 10 years ago. Hobbyists used to be innovators, inventors of new electronic toys. Most hobbyists have only magazines like yours to inform them of new microchips, and you don't seem to do your job very well.

It seems to me, by your articles on microprocessors, that the news takes a long time to reach your magazine. Take the 68705 for instance. I've used that chip for seven years, and first noticed an article on it in your magazine this year. What about the 8096, 8098, TMS370, uPD7810, uPD7810, uPD7811, HD64180, HD647180, HD64180S, V25, H8, HPC, 68701, 68HC11, 8051, 8751, and 8031, to name a few?

The most amusing article I've seen in years is the one on PLC in the September issue. ("Programmable Architectures: The Next Breakthrough?") What are GAL's, PEEL's, or EPLD's, might I ask? It sounds like an article that must have been written in the early 1970's. I can understand that EPLD's are rather new, but I've used them for three years and their EEPROM counterparts for two years, and I've yet to see **Radio-Electronics** write anything about them.

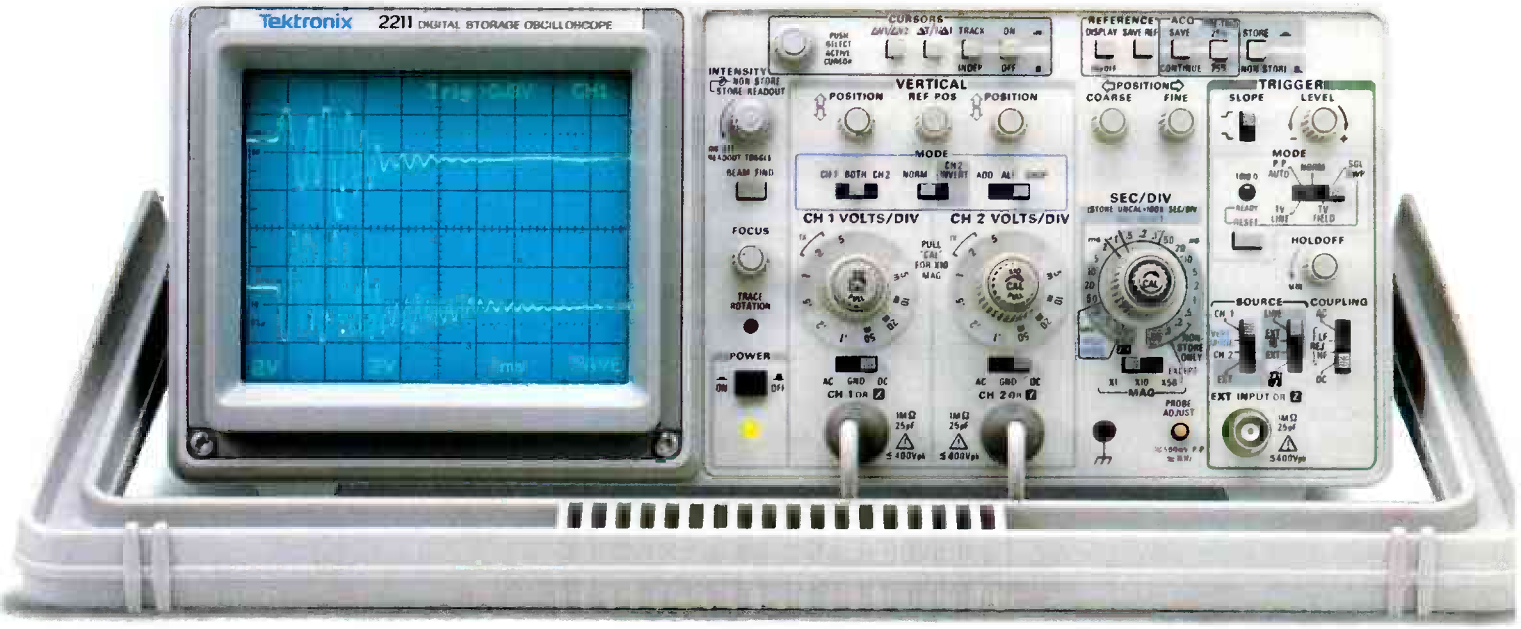
I was rather surprised to see that the EPROM used most often in your articles appears to be the 2716. Don't you know that the 2716 is an obsolete part? The king in the electronic world nowadays is the 27C256. If I were to design anything with a 2716 my boss would think that I was nuts.

MICHAEL CATUDAL
*Silver Creek, NY*

*We try to keep our construction projects buildable. That often precludes using the latest and greatest parts in a project. If a 2716V (which costs about $4.00) will do the job, why would you use a 27C512 that costs three times as much?*

*Your point on covering new technology is well taken. We hope that some of the articles we have planned for the coming year answer at least a few of your complaints.—Editor* **R-E**

# BEST FOR LO



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Productivity-enhancing features are in abundant supply. For instance, all measurements and front-panel scale factors appear on the CRT. Waveform cursors automatically calculate time and voltage. A 4K record length and X50 magnification give you excellent timing resolution, plus analog-quality displays. And trigger levels can be read directly on the screen.

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BOB-005

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|---|---|---|---|---|
| **Bandwidth** | 50 MHz | 20 MHz | 50 MHz | 20 MHz |
| **Storage Bandwidth** | 1 MHz | 1 MHz | N/A | N/A |
| **Sample Rate** | 20 MS/s/ch | 10 MS/s/ch | N/A | N/A |
| **Vert. Sensitivity** | 500 μV/div | 5 mV/div | 500 μV/div | 5 mV/div |
| **Cursors/Readout** | Yes | No | No | No |
| **Hardcopy Interface** | Yes | Option | No | No |
| **Record Length** | 4K/ch | 2K/ch | N/A | N/A |
| **Vertical Resolution** | 8 bit | 8 bit | N/A | N/A |
| **Price*** | $2495 | $1495 | $1095 | $695 |

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YOU CAN NOW ADD LOGIC ANALYZERS to the list of electronics test equipment that has made the transition from being esoteric and expensive to being rudimentary and relatively inexpensive. As microprocessor-based equipment became ubiquitous, having the proper tools to service them became essential to technicians. Helping to fill that need was a handheld, 16-channel, 20 MHz logic analyzer from Precision Motion (3563 Sueldo Building J, San Luis Obispo, Ca 93401).

Precision Motion's logic analyzer is optimized for—but not limited to—debugging ROM-based hexadecimal code. It features true 20-MHz data acquisition capability, a data-storage memory for 1023 samples both before and

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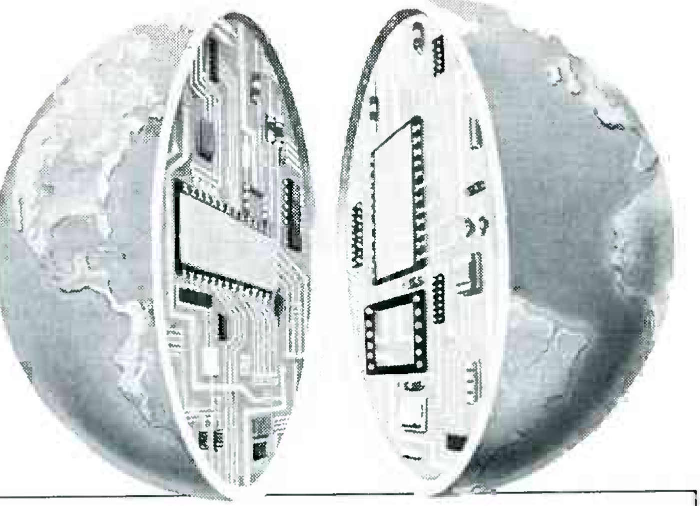

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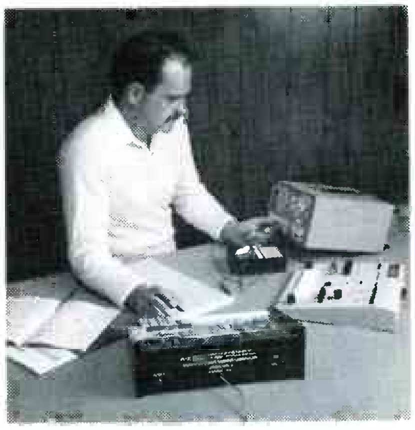

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after the trigger, a Centronics-compatible printer interface, and data-management functions.

The analyzer is housed in a gray plastic case that measures roughly 7×4×1 inches. The front panel is dominated by a 24-key membrane keypad, a 2-line by 16-character LCD readout, and 6 terminals for inputs and outputs. A DB-25 parallel printer port is provided at the side of the analyzer, while the top edge of the unit offers a test-cable connector and power-supply input. A 5-volt regulated wall-transformer power supply is provided with the analyzer.

The 28-pin IC test clip is well suited for connection to either 24- or 28-pin EPROM's. The test clip can connect up to 14 of the EPROM's address lines to the analyzer. The data on those lines (0–13) form the hexadecimal data words that are shown on the display. Two additional inputs are provided on the front panel for lines 14 and 15. Those data are displayed separately, unless specifically appended to the data word. The analyzer directly supports 2758, 2716, 2732, 2764, 27128, and 27256 EPROM's. Some earlier EPROM's, specifically those that use −5 and +12 volts, cannot be hooked up directly to the analyzer.

Once the analyzer is connected to the circuit under test, and the proper ROM is selected and the clock is properly selected, then the analyzer is ready to do its job taking data. Once started, the analyzer continuously loads hexadecimal data words into its memory. The memory will hold the 1023 most recent words, writing over any old data. Once the selected trigger word is stored, the following 1023 data words are stored. The total memory of the analyzer is 2047 words.

Once the data words are stored, they data words can be easily viewed. The analyzer display will start from the trigger position. Left and right arrow keys can be used to scroll through the memory. Shortcuts are provided to move through the memory more quickly, and a search function is provided for finding a particular data word.

Outputting the contents of the data memory to a printer is simply a matter of setting the cursor to the memory position where you want the output to start, and then issuing the print command. The next 500 hexadecimal data words will be output to a Centronics-compatible printer in a format of 10 columns of 50 words each. A timing-diagram format can also be printed. If that option is chosen, a 16-channel graphic diagram for 101 clock periods will be output. The contents of channels 14 and 15 can be output separately. Turning the analyzer into a handheld two-trace, two state storage scope.

Other features of the analyzer include a hexadecimal/decimal calculator/converter, a pre-trigger arm function, and a stopwatch.

We've only scratched the surface of the capabilities that the Precision Motion logic analyzer delivers. We found the features, the small package, and the $1495 price of the analyzer impressive, and we're almost looking forward to having a microprocessor-based system break down so we can put it back to work. **R-E**

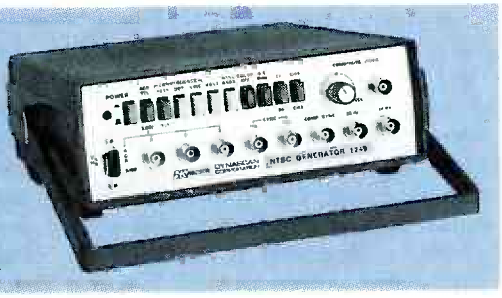
TELEVISION HAS COME A LONG WAY IN a short time. Somewhere in the past couple of years the television business was transformed into the video industry. And where once screens were only filled with images designed to entertain, today's tubes display everything from Martian invaders at a quarter a pop to stock quotes at considerably higher prices.

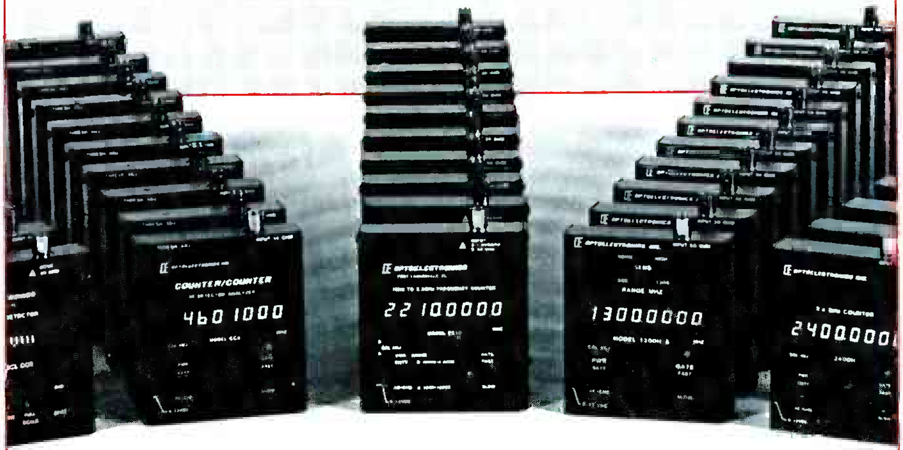
The increased sophistication of video monitors has led to the need for more sophisticated diagnostic tools to maintain them. Once upon a time the instruments needed to service televisions were often bigger and more expensive than the televisions themselves. BK Precision (6470 W. Cortland St., Chicago, IL 60635) has always had a line of video test gear and anyone involved in servicing video equipment should certainly be familiar with it.

Their model *1249* is their low-end video-signal generator. Despite a relatively low cost, it can produce just about every signal needed to test, service, and adjust a wide variety of NTSC compatible monitors and television sets. The instrument can generate standard NTSC color bars, split image bars, staircase, and an assortment of line and dot patterns useful for set-ups and convergence.

All the patterns the *1249* can generate are available on several outputs, from composite video, to a 45.75 MHz IF, to modulated RF on either channel three or four. This is a great convenience for tracing problems since the same signal can be injected at different points in the video chain. Being able to single-step your way from the antenna input to the final video amplifier makes it much easier to pinpoint problem areas in tuners and video circuits. Since all the outputs are buffered, they can all be used simultaneously. This means you don't have the hassle of plugging and unplugging cables as you work your way through video circuitry.

To make the instrument as versatile as possible, all the important frequencies are generated from a single master clock and the individual components of the video signal are brought out to separate front panel BNC connectors. This is really convenient if you're using an oscilloscope because, for example, you can trigger off H while snooping around a suspect monitor and you can be fairly sure of stable traces.





Besides producing NTSC signals, the *1249* also generates a 30 Hz TTL level signal, (useful for servicing VCR's), and a 4.5 MHz signal which is exactly what's needed for locating audio isolation problems in a TV tuner. The *1249* has a DB9 connector on the front panel with pinouts identical to IBM color cards and, since there's a front panel switch to choose either TTL level or .8 volt signals, the instrument can be used to service some computer color monitors.

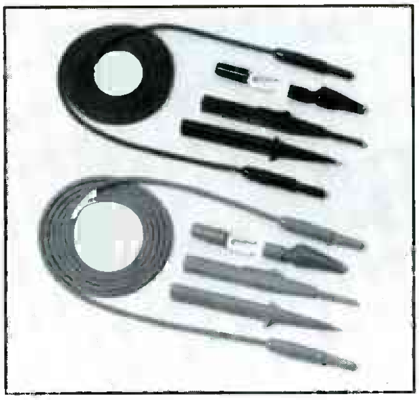
There are some computers that produce RGB video that's reasonably close to NTSC, so if you service a lot of these monitors, the *1249* can make your bench time more efficient. Even though this instrument is sold as an standard NTSC generator (PAL is a factory option), the fact that someone at B+K decided to add a PC-compatible video output means they had an eye on the field of computer monitors. That's commendable, but if you're looking for an instrument strictly to help service computer monitors, the *1249* is a poor choice.

Most of the computer video being generated today is far from being NTSC compatible. Horizontal scan frequencies vary all over the place and the NTSC standard produced by the *1249* is just too low if you're trying to troubleshoot anything other than a small handful of computer monitors. Even something as common as a PC monochrome monitor needs a signal with a horizontal scan frequency of about 18 kHz and the newer high resolution color monitors are up beyond 35 kHz.

To be fair about it, the *1249* was designed around the NTSC standard so it's hitting below the belt to criticize it for doing only the job it was designed to do. The RGB outputs are a convenience that come in handy for occasional servicing—and, I suppose that if they save you the hassle of having to make a special cable, they're worth the front panel space they occupy.

The documentation that comes with the meter is terrific. Packed in the small instruction booklet is a lot more than just switch details and setup procedures. Several pages have been devoted to a history of NTSC video, an extremely detailed analysis of the signal itself, and a complete glossary of video terms. The manual has clear instructions on everything from turning the unit on to how to adjust the output by tweaking the trimmers inside the case. You also get an oversized schematic of the unit - something most companies don't provide - and a complete parts list. Just about the only complaint I have with the paperwork is that B+K doesn't put the IC values on the schematic, only the part designations (IC1, IC2, etc.). They are, or course, in the parts list but it's always more convenient to have them right there on the schematic.

The bottom line is that the *1249* is a good value for its $517 list price. The unit is easy to use, reliable, generates rock steady signals, and you don't need a second mortgage on your home to buy one. If you're in the market for an NTSC generator, the *1249* is well worth taking a look at. **R-E**



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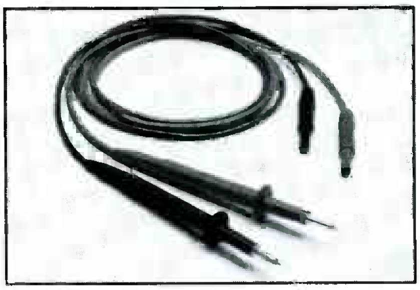

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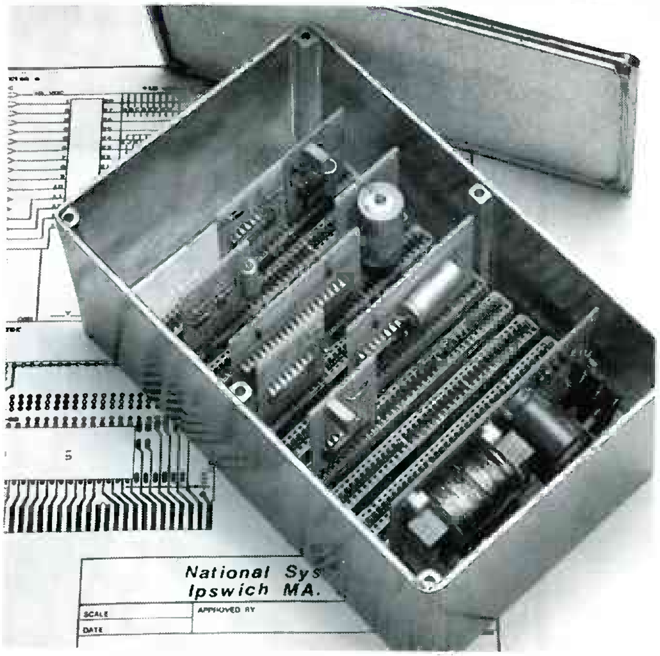
# NEW PRODUCTS

**PACKAGING SYSTEM.** For anyone who's looking for a way to speed up breadboard assembly, or is building a limited-run production device, or simply doesn't have the time or resources for PC boards, the *E-Z Buss* system might provide the solution. The modular electronic-packaging system from *National System, Inc.* offers everything needed to quickly and easily build a reliable, reproducible electronic assembly, including module cards for commonly used analog and digital electronic functions, a mounting connector base, "fill-in-the-blank" documentation forms, and a heavy-duty aluminum enclosure that makes for a professional-looking package.

The module cards can be ordered separately on an "as-needed" basis. They come in three sizes (depending on the size and complexity of your circuit's design). Universal logic and component cards are available, as well as dedicated amplifier, timer, resistor, and power-supply cards. The cards each come with a schematic diagram, top-view layout drawing, and a blank parts list. A connector assignment chart and a blank wire-run list simplify base wiring.

The *E-Z Buss* connector base provides a platform on which as many as 30 separate module cards can be installed. The gold-plated module-card connectors have wire-wrap tails that allow up to three wraps per connector. The base itself, which has provisions for input and output block connectors, is clearly numbered with tail positions to permit quick and easy interconnection wiring between modules.

The *E-Z Buss* connector base costs $150.00, module cards range in price from $10.00 to 20.00 (including documentation forms), and the enclosure costs $65.00. Part kits are also available for the power-supply card only.—**National System, Inc.**, 17 Hammatt Street, Ipswich, MA 01938; 508-356-1011.



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**MICROPROCESSOR TRAINER KIT.** If you've ever considered building a computer from scratch, but weren't quite sure how to go about it, the *Elenco* model *MM-8000 Micro Master Trainer* kit could come in handy. Requiring no prior computer knowledge, the simple, easy-to-understand instructions teach you to write in machine language. The kit demonstrates how to write into RAM's and ROM's and run an 8085 microprocessor that uses the same machine language as an IBM PC. It teaches you how to write the basic instructions to get the 8085 started, and how to store those instructions in permanent memory in a 2816$E^2$ PROM. The *Micro Master Trainer* explains the workings of input and output ports and computer timers. You are shown how to build a keyboard and to scan a keyboard and display. The kit contains all parts, assembly, and also comes with a lesson manual.

The *Micro Master Trainer* kit costs $129.00.—**Elenco Electronics, Inc.**, 150 West Carpenter Avenue, Wheeling, IL 60090.

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**BASE/MOBILE SCANNER.** Offering 100 channels and complete public-service-band coverage, *ACE Communications'* model *AR950* can be conveniently mounted under an automobile's dashboard with the supplied mounting bracket, or used in a fixed location with its AC wall-plug adapter. The scanning radio provides coverage of the 27–54-MHz, 108–174-MHz, 406–512-MHz, and 830–950-MHz bands. Those include all of the police, fire, and emergency bands, as well as the new services now available above 800 MHz in 12.5-, 25-, and 30-kHz increments.

CIRCLE 12 ON FREE INFORMATION CARD

The compact (2⅛ × 5⅞ × 7¼ inches) receiver's 25 front-panel keys can be used to program five banks of 20 channels. Pairs of upper and lower limits for bands to be searched can be stored in five separate search-memory locations. Three permanent memories, which don't lose program information if the power is disconnected, are

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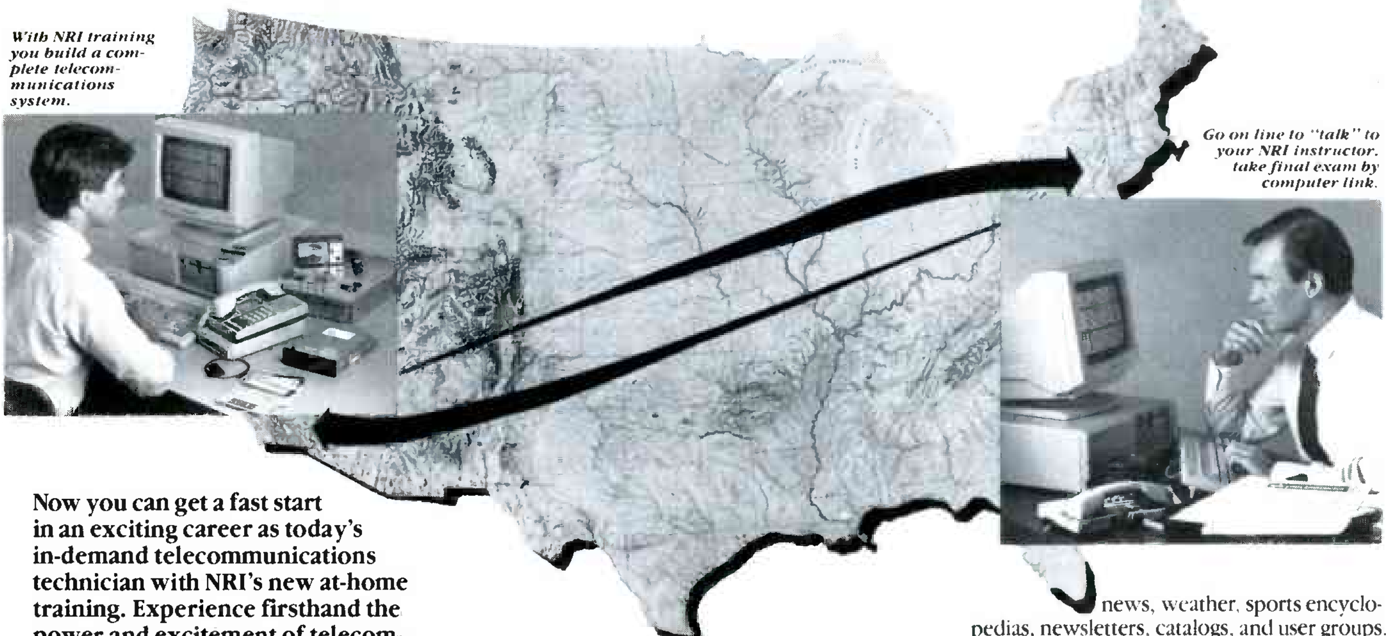

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The *AR950* also features first-channel priority, keyboard lockout, BNC-antenna connector. Two antennas—a telescopic type and a flexible rubber one optimized for 800 MHz—are included, as are a fused DC power cord, an AC wall-plug adapter, and all mounting hardware.

The *AR950* scanning receiver has a suggested retail price of $299.00.—**ACE Communications**, Monitor Division, 10707 East 106th Street, Indianapolis, IN 46256.

**SYNTHESIZED FREQUENCY SOURCE.** *Teledata Systems' WAVEBOX 100* frequency source is easy enough to use for educational and production applications, and has exceptionally high accuracy and stability—10-ppm (0.001%) accuracy over a 1-Hz to 100-kHz frequency range—for an instrument in its price range. Foolproof thumbwheel switches are used to dial up the output frequency directly.

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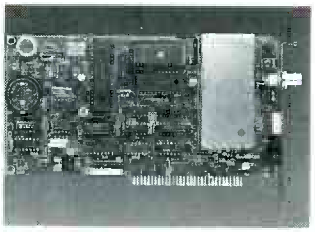
Intended for power, audio, telecommunications, and ultrasonic frequency testing, the *WAVEBOX 100* has 1-Hz resolution over the entire range. The sinewave output is variable up to 20-volts peak-to-peak with a ±10-volt offset, and an auxiliary TTL/CMOS-level square-wave output is also provided. Total harmonic and non-harmonic distortion is better than 40 dB.

The *WAVEBOX 100* synthesized frequency source has a suggested retail price of $325.00.—**Teledata Systems**, 68 Reservoir Road, New Milford, CT 06776.

**COMPUTER TIME STANDARD.** Providing reliable, traceable, and accurate time for IBM PC's and compatibles, *Coordinated Time Link's CTS-10* computer time standard decodes time information from WWV/WWVH radio signals from the National Institute of Science and Technology (*NIST*). Those signals are synchronized to the NIST atomic clock. With the *CTS-10* board installed, any application running on the PC automatically incorporates the correct time.

The time-standard device, which plugs directly into the PC, automatically accommodates daylight-saving time, leap years, leap seconds, and other time anomalies. Menu-driven software provides easy installation of user-defined port addresses and interrupt levels. The *CTS-10* features time-zone selection, 12-/24-hour selection, adjustable on-screen display, and color selection. The correct time is maintained during power outages by on-board capacitive and battery backup. Remote diagnostics provide convenient evaluation and troubleshooting capabilities.



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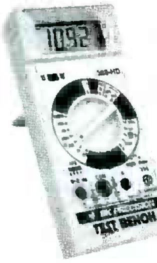
The *CTS-10*, including software, has a single-unit price of under $200.00.—**Coordinated Time Link**, 921 Bluebonnet Drive, Sunnyvale, CA 94086.

**FREQUENCY COUNTER.** Billed as an "affordable, general-purpose instrument with a high frequency



range," *B&K-PRECISION's* model *1804* features measurement to 550 MHz, an 8-digit LED display, a low-pass filter, 1- and 0.1-second gates, and an overflow indicator. It has a direct range of 5 Hz to 100 MHz and a prescale range of 10 MHz to 550 MHz. Using the 1.0-second gate, it has resolution of 1 Hz in direct mode and 10 Hz in prescale mode; with the 0.1-second gate, direct and prescale resolutions are 10 and 100 Hz, respectively. Accuracy with the 1.0-second gate is ± time base accuracy ± 1 count; with the 0.1-second gate accuracy is ± time base accuracy ± 2 counts.

CIRCLE 15 ON FREE INFORMATION CARD

The counter's input impedance in the direct range is 1 megohm, shunted by less than 40 pF. For the prescale range, impedance is 50 ohms to match communications applications. Sinewave sensitivity for the direct range is 30-mV rms for 5 Hz–30 MHz; 50-mV rms for 30–80 MHz; and 100-mV rms for 80–100 MHz. Prescale-range sensitivity is 50-mV rms for 10–550 MHz. The input filter is a switch-selectable 100-kHz low-pass filter.

The model *1804* frequency counter has a suggested list price of $295.00.—**B&K-PRECISION**, Maxtec International Corporation, 6470 West Cortland Avenue, Chicago, IL 60635.

**IC REMOVER.** Using the *IC Remover* from *Video Repair School*, you can quickly salvage integrated circuits from surplus PC boards. With a little practice, a 40-pin IC and be de-soldered in as little as 8 seconds, and more than 300 IC's can be de-soldered in an hour.

The *IC Remover* is a set of eight special de-soldering tool bits that screw onto the tip of a *Radio Shack* or *Ungar* soldering iron. The tips fit 8- to 40-pin IC's, and can be used to remove IC's from double-sided and multilayered boards without damaging the board. Because the IC's are heated so briefly, they are not damaged either, and can then be reused in other applications.

The *IC Remover* set of eight IC-desoldering bits (soldering iron not included) costs $89.95.—**Video Repair School**, P.O. Box 121, Glen, MS 38846.

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**SWR/WATTMETER.** You can monitor SWR, forward, and reflected power at a single glance with the *MFJ-815B* lighted cross-needle SWR/wattmeter, which provides both peak- and average-reading functions. There are two user-selectable power ranges for forward and reflected power (2000 watts forward/500 watts reflected and 200 watts forward/50 watts reflected). The *MFJ-815B* shows SWR from 1:1 to 8:1, and covers 1.8 to 30 MHz with 10% accuracy. The instrument is

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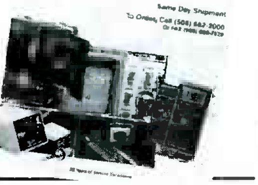

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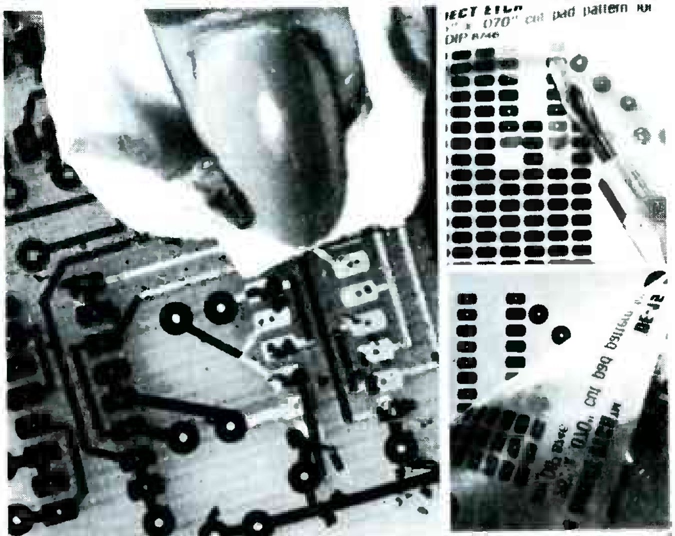

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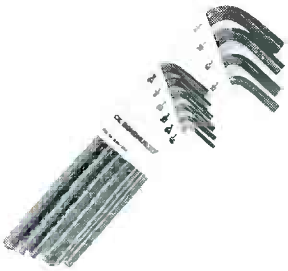

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The *BLX-10* hex-key set (Item No. 10938) has a suggested list price of $7.99.—**Bondhus Corporation**, 1400 East Broadway, P.O. Box 660, Monticello, MN 55362.

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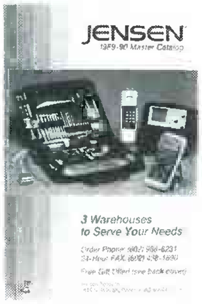
# NEW LIT

**1989–1990 MASTER CATALOG.** *Jensen Tools'* full-line catalog is full of essentials for electronics technicians, servicemen, and hobbyists—tool kits and cases, power and hand tools, soldering and desoldering equipment, measuring devices, telecommunications products, computer and test equipment, vacuums and cleaners, and circuit board and static control equipment. The catalog contains 14 pages of new products. The *Jensen 1989–90 Master Catalog* is free upon request.—**Jensen Tools Inc.**, 7815 South 46th Street, Phoenix, AZ 85044-5399; 602-968-6231.



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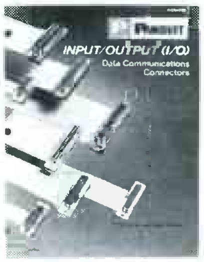

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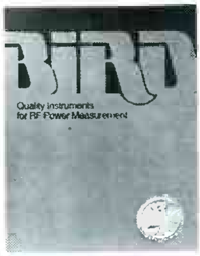
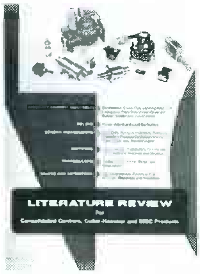


CIRCLE 23 ON FREE INFORMATION CARD

**CATALOG OF CATALOGS.** *Eaton Corporation's Literature Review* outlines 61 product catalogs and brochures that are being offered for Consolidated Controls, Cutler-Hammer, and MSC Products. Each catalog is described in detail, to simplify selection. They cover relays, sensor instruments, switches, transducers, valves and actuators, and aircraft cockpit controls. The *Literature Review* is free.—**Eaton Corporation**, Aerospace & Commercial Controls Division, 4201 North 27th Street, Milwaukee, WI 53216; 414-449-7483. **R-E**



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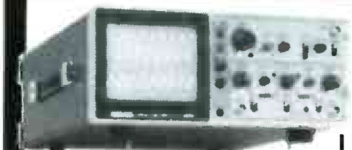

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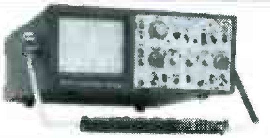

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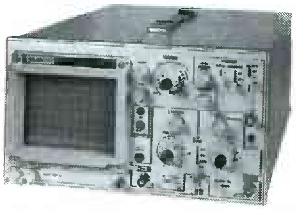

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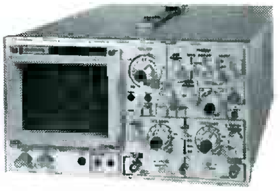

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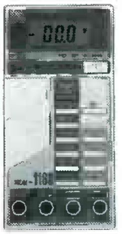

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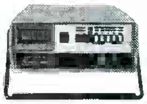

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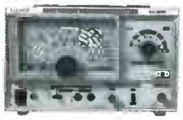

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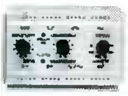

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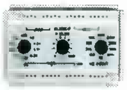

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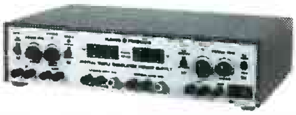
**Digital Triple Power Supply** **XP-765**



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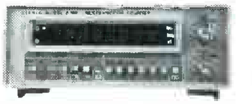

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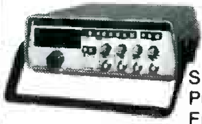

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Pulse, Ramp, .2 to 2MHz
Freq Counter .1 - 10MHz

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**ROBERT IANNINI**

# PROGRAMMABLE PHASOR PROPERTY GUARD

*Now you can protect your valuables by scaring criminals away with an unbearable ear-piercing sound.*

LET'S FACE IT. MOST OF US HAVE BEEN THE victim of some form of theft at one time or another. The chances are that either you personally, your house, your car radio, or your whole car has at one time been robbed. And, while a car armed with an ordinary siren-type alarm is better-protected than if it had nothing at all, most people won't even look away from what they're doing when they hear a car alarm go off. And most thieves are not at all frightened by them either. More important, a thief can be out of the car so fast that by the time someone does something about it, it's too late.

That's where the Phasor Property Guard comes in. It's not just an alarm; it emits sound that is actually painful to listen to. It's sound output can be adjusted from an inaudible yet painful ultrasonic level, to an ordinary alarm-type sound, to a level that's so loud and irritating, that not even the world's best car thief could stand to listen to it as he tries to steal your car or car stereo. Be warned, though, that continued exposure to the sound can permanently damage your hearing.

## Operation

The Property Guard is intended as a property- or home-protection device. It generates high-pressure ultrasonic sound that is triggered when an unauthorized intrusion is detected. The unit can be triggered by a trip wire or closed system such as taped glass windows and doors, where a break or open triggers the unit. The unit also contains a switch input that can be used with a pressure-sensitive switch activated when someone enters a room or building. A positive voltage from equipment such as an IR intrusion detector, motion detector, sound detector, etc., can also be used to trigger the unit.

The sound produced by the unit can cause certain adverse effects to the intruder. They may be paranoia, severe headaches, disorientation, nausea, cranial pain, upset stomach, or just plain irritating discomfort. Most people are affected in one way or the other, with younger women unfortunately being the more sensitive. External adjustments allow the user to select clearly audible sounds that serve as an alarm or the higher-frequency energy that produces the discomfort and other effects.

Sound-pressure level is less than 130 dB, and will not produce permanent damage if exposure is kept to a minimum. Therefore, prolonged exposure is not encouraged. A rule of thumb is to keep exposure down to less than 1 hour to any frequency less than 20 kHz at a sound pressure of 105 dB or over.

The system consists of a central control unit that can power up to 6 remotely located transducers, which can be positioned to take advantage of potential entrance and intrusion areas. Be sure to take into consideration that each transducer can produce up to 118 dB at a distance of 1 meter. Sound-pressure levels are logarithmic, so every time the distance from a transducer is doubled, the sound pressure is attenuated by factor of −3 dB.

## Circuitry

If you look at Fig. 1, the detection circuits monitor inputs J1, J2, and J3, and, when they sense an intrusion, they energize control-relay RY1 via drive-transistor Q5. Note that the relay controls power ($V_{CC}$) to the driver stage shown enclosed in the dashed lines. Diodes D2–D6 guarantee full "off" and "on" functions of the circuit while D7 clips the voltage spike produced when the coil of RY1 is turned off. A set of relay contacts are

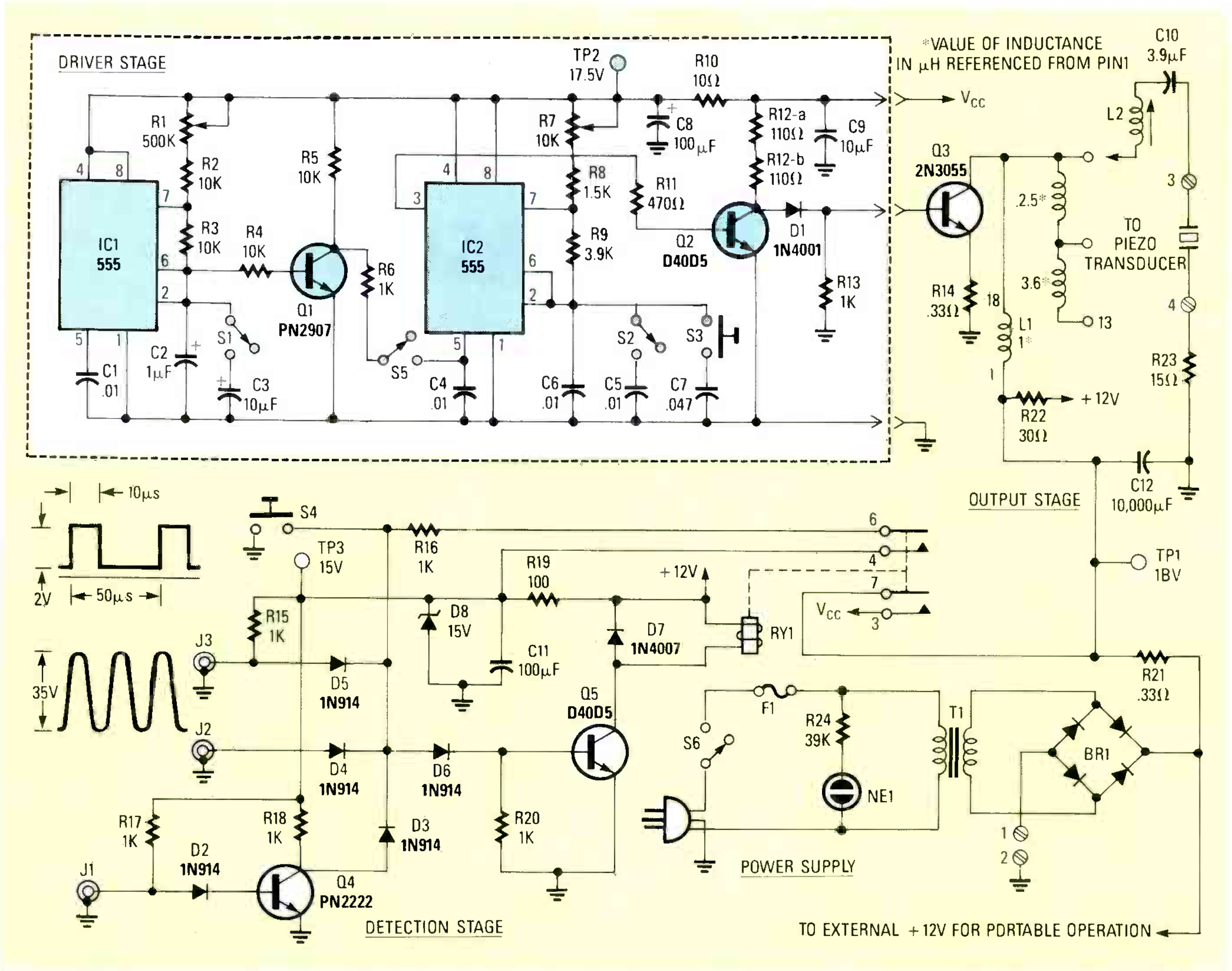


**FIG. 1—SCHEMATIC OF THE PHASOR PROPERTY GUARD. Detection circuits sense an intrusion from J1, J2, or J3.**

used to "hold on" the circuit once triggered. A pushbutton switch (S4) allows resetting of the circuit by grounding the positive "hold on" voltage at the diode junctions.

As for the driver circuitry (inside the dashed lines), a 555 timer (IC2) is connected as an astable free-running multivibrator whose frequency is externally controlled by potentiometer R7. Resistor R8 selects the range limit of R7, while R9 selects the duty cycle or symmetry of the pulses. Capacitor C6, along with those resistors determines the frequency range of the device. A low-range switch (S2) decreases the frequency by switching C5 into the circuit. A test switch (S3) connects C7 across C6, thus dropping the frequency to approximately ⅕, producing a clearly audible tone for verification and test purposes.

The square-wave output of IC2 pin 3 is resistively coupled to Q2 through R11. The collector of Q2 is DC biased by R12-a and R12-b. The square-wave output signal is then fed into power amplifier Q3 via D1. The collector of Q3 is DC biased by the choke-coil/transformer combination, L1. Resistor R14 helps stabilize the stage. The amplified square waves are fed to the transducer via resonating-coil L2 and DC-blocking-capacitor C10. The resonating coil is selected to tune out the inherent capacitance of the transducer at the upper frequency limit—usually around 20 kHz. A sinusoidal wave is generated that allows the transducers to operate at a higher peak power level than would the equivalent-voltage square wave because less power is going into the harmonics that would make up the square wave. Resonant peaking of the voltage is also obtained. The transducers, unlike their electromagnetic counterparts, have a tendency to draw high current at higher frequencies. That effect is compensated to an extent by power-resistor R23. Note the wave shape shown is at a fixed frequency of 20 kHz.

Timer IC1 is similarly connected as an astable running multivibrator, and is used to produce the sweeping voltage necessary for modulating the frequency of IC2. IC1 is activated by S5 (the switch-half of R1/S5), and the sweep repetition rate is controlled by R1 (the potentiometer-half of R1/S5). Resistor R2 limits the range of the repetition time. Resistor R3 selects the duty cycle of the pulse while capacitor C2 sets the sweep time range. A slow sweep range is selected by S1 connecting C3 to the circuit. The ramp-voltage output of IC1 at pins 2 and 6 is resistively coupled via R4 to inverter transistor Q1. The output of Q1 is fed to pin 5 of IC2 and provides the modulation voltage necessary to generate the sweeping frequency action required. Note that the signal is easily disabled via S5, which is a convenience when initially setting or checking the range of IC2, as it eliminates the constant varying frequency.

Power is supplied to the system by a conventional step-down transformer T1, bridge-rectifier BR1 and filter-capacitor C12. Power is controlled by S6, which is part of the frequency-control potentiometer R7. A neon indicator lamp (NE1) tells when the system is energized (R24 is a current-limiter for NE1). A remote-control option is available via pins 1 and 2 of the terminal strip; pins 1 and 2 must be connected for normal operation. A three-wire line cord is shown, but a two-wire cord will suffice as the power supply voltages are under 25 volts.

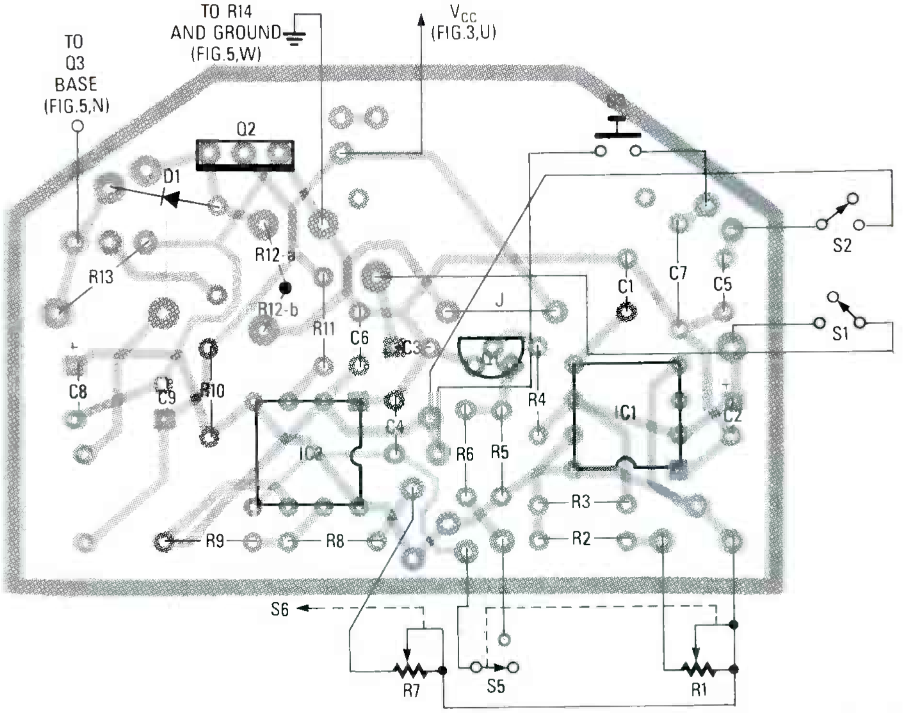


**FIG. 2—DRIVER-BOARD PARTS PLACEMENT. Most of the resistors are vertically mounted.**

## Construction

The Property Guard consists of a driver board that's assembled on a PC board and a detection board that's assembled on a piece of perfboard. Both are installed inside a metal cabinet with various controls and other hardware mounted to it. A parts-placement diagram for the driver board is shown in Fig. 2. Most of the resistors are vertically mounted. Always leave at least 1/16-inch lead between the body of a component and the PC board.

As for the detection board, a suggested layout is shown in Figs. 3 and 4; simply mount the components on the perfboard and hardwire the jumpers as indicated by the dashed lines. Assemble the resonator coil L2 by winding 40 turns of no. 18 enameled wire in a solenoidal format on a 2-inch long piece of 5/8-inch outside-diameter cardboard form. Wrap the coil with tape, or hold the turns together with shellac, varnish, etc. The ferrite core (FER1) included in the kit

### PARTS LIST

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

R1—500,000 ohms, potentiometer/switch (S5)

R2, R3, R4, R5—10,000 ohms

R6, R13, R15, R16, R17, R18, R20—1000 ohms

R7—5000–10,000 ohms, potentiometer/switch (S6)

R8—1500 ohms

R9—3900 ohms

R10—10 ohms, 1/2-watt

R11—470 ohms

R12-a and R12-b—220 ohms total (2 110-ohm 3-watt resistors connected in series)

R14, R21—0.33 ohms, 5 watts

R19—100 ohms

R22—30 ohms, 2 watts

R23—15 ohms, 10 watts (see text)

R24—39,000 ohms

**Capacitors**

C1, C4—0.01 µF, 25 volts, ceramic disc

C2—1 µF, 25 volts, electrolytic

C3, C9—10 µF, 25 volts, electrolytic

C5, C6—0.01 µF, polystyrene (use 0.0068 µF for higher frequency)

C7—0.047 µF, 25 volts, ceramic disc (use lower value for higher frequency)

C8, C11—100 µF, 25 volts, electrolytic

C10—3.9 µF, 350 volts, paper

C12—10,000 µF, 16 volts, electrolytic (larger value acceptable)

**Semiconductors**

IC1, IC2—555 timer IC

D1—IN4001 50-volt diode

D2, D3, D4, D5, D6—IN914 small signal diode

D7—IN4007 15-volt diode

D8—15-volt Zener diode

Q1—PN2907 PNP transistor

Q2, Q5—D40D5 NPN power transistor

Q3—2N3055 NPN power transistor, TO3 package

Q4—PN2222 NPN transistor

BR1—5-amp bridge rectifier

**Other components**

S1, S2—switch DPDT switch

S3, S4—momentary pushbutton

RY1—12-volt DPST relay

L1—AF choke/transformer (see text)

L2—resonator (see text)

T1—12-volt, 2-amp transformer

F1—1-amp fuse

J1–J3—RCA-type jack

NE1—neon lamp

FER1—3 × 1/2 ferrite core

TD1, 2, 3, 4—Piezo directional transducers

**Miscellaneous:** line cord and retainer bushing, wire nuts, metal cabinet, perfboard (3 1/2 × 4 1/4 inches), dual TO3 heat sink, TO3 mounting kit (see Fig. 5), tape, neon-lamp holder, small vinyl strap, no. 24 hookup wire, no. 20 hookup wire, hardware, 4-lug screw terminal strip, fuse holder, PC board, etc.

**Note: The following items are available from Information Unlimited, PO Box 716, Amherst, NH 03031: assembled and tested driver board (Fig. 2), part no. PPG3A (includes all switches and controls), $59.50; assembled and tested detection board (Figs. 3 and 4), part no. PPG3B, $39.50; L1 multitap transformer, $34.50; L2 resonator, $19.50; TD1–TD4 Piezo directional transducers, $12.50 ea. For overseas operation on 220 volts, it is suggested that you use transformer no. STDWTR, or obtain any 220-to-110-volt, 50/60 ohm 50 VA unit.**

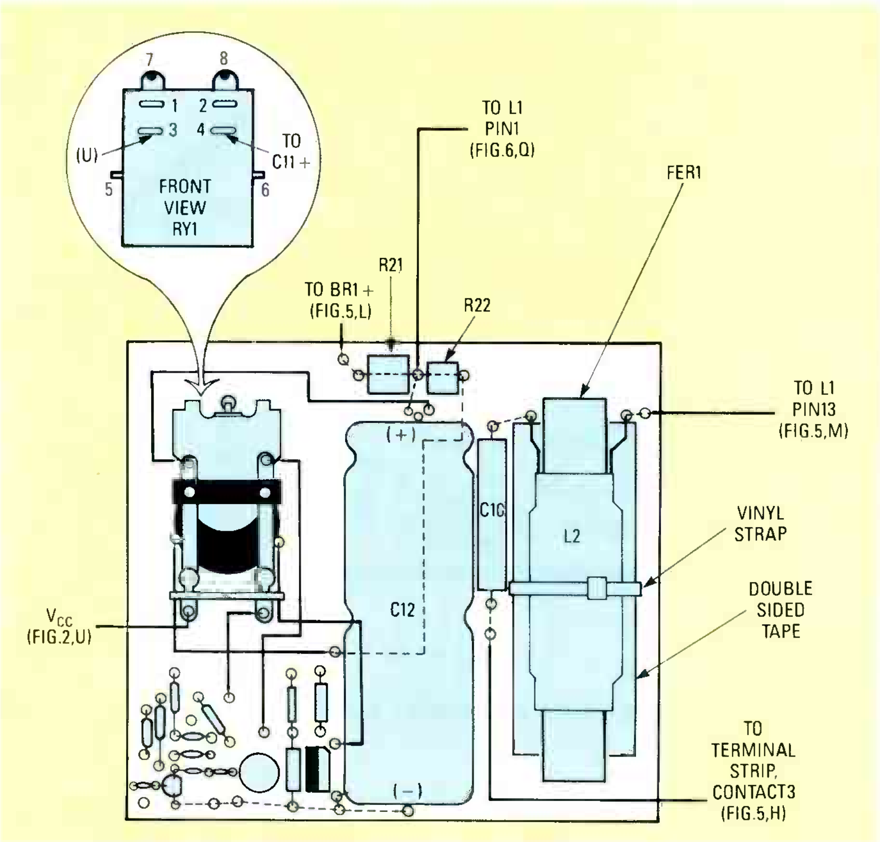


**FIG. 3—A SUGGESTED LAYOUT for the detection board. Mount the components on perfboard as shown.**

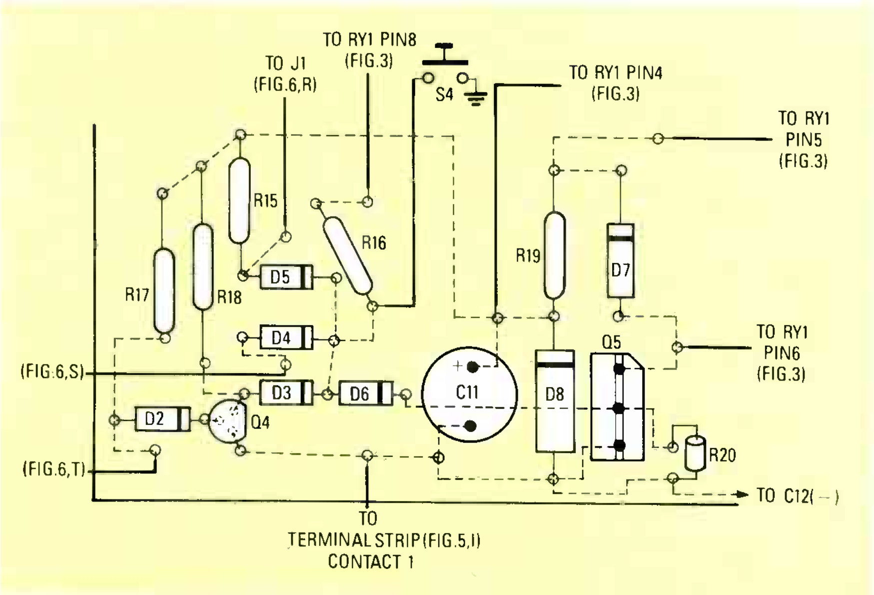


**FIG. 4—DETAILED VIEW of the detection board. Hardwire the jumpers as indicated by the dashed lines.**

should be inserted inside the cardboard tube. Note that L2 is secured to the perfboard by a piece of foam tape and a small nylon strap. Bring the leads out from T2 as shown Fig. 3. Note the wiring of relay RY1. Use appropriate pieces of vinyl-covered no. 22 wire for leads from the relay to the board.

Assemble and wire the cabinet as shown in Figs. 5 and 6. Be careful to allow sufficient clearance for the contacts of the terminal strip. Note that a hole about the size of a half-dollar must be made in the cabinet directly under Q3 for the wires to pass through. Use the drawings as a reference for the location of all holes and components. It's a good idea to test-position each component before drilling or cutting. Note the mounting of power resistors R14 and R23; R14 must be sealed in RTV or electrical putty to prevent contact of 115V circuits. Do not connect the lead to Q3's base at that point.

Assemble Q3 with its mounting kit as shown in Fig. 5, and mount it on the heatsink. Note that the body of Q3 must be insulated from the heat sink. Check it with a meter to prevent damage to the circuitry.

Assemble the choke-coil/transformer combination L1 by winding 15 turns of no. 18 wire between pin 1 and 18 on the bobbin, 10 turns between 18 and 6, and 5 turns between 6 and 13. Wind all sections in same direction. Those are taps for setting the output level desired. Assemble the ferrite "E" cores with the brass "U" bolt to secure it to the cabinet.

Since the choke is for feeding DC current to Q3 and to maintain a blocking effect to the AC signal, an air gap may be required if more than 4 transducers are powered by the system. It is suggested that you wind 10 more turns on the core and space the ferrite "E" cores with a piece of scotch tape placed one layer thick on each leg of one of the "E" core pieces. Note that the preassembled units do not use an air gap.

## Checkout

Check your wiring for accuracy, the quality of solder joints, short circuits, pinched wires, debris, etc. Now place a jumper across contracts 1 and 2 of the terminal strip, and ground J3. Plug the unit into a 120-VAC outlet and turn it on. Check TP1 for 3–4 volts higher than what's shown in Fig. 1 (that's because there's no load on it now). Also check for 15 volts at TP3. Relay RY1 should be deenergized, and TP2 should be at zero volts. Momentarily unground J3 and then reconnect it; RY1 should energize. Measure 15 volts at TP2. Push the reset switch (S4) and make sure TP2 drops to zero.

Momentarily ground J1 and again note RY1 energizing. Measure 15 volts at TP2; push S4 and make sure TP2 drops to zero. Momentarily apply a 5–10-volt level to J2 through a 1K resistor and repeat the previous step. That verifies the detection stage of the device.

Energize the system by removing

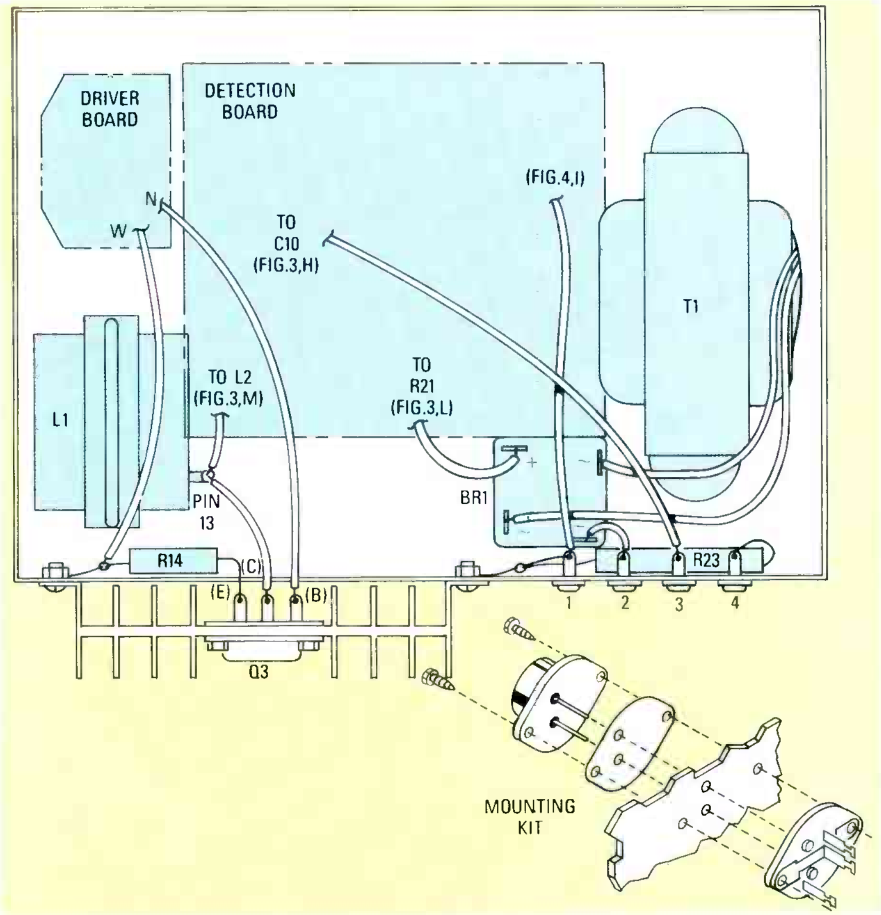


**FIG. 5—CABINET WIRING. First make all of these connections, before continuing with Fig. 6.**

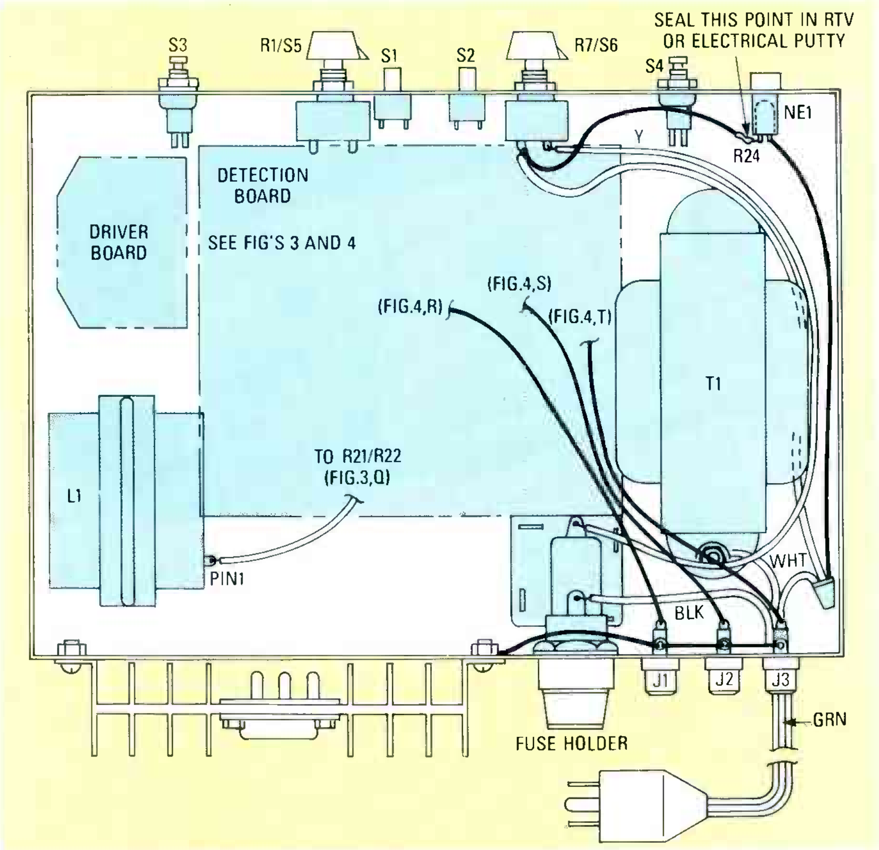


**FIG. 6—FINISH THE WIRING as shown here. Be careful to allow sufficient clearance for the contacts of the terminal strip.**

the ground connection to J3. Turn S5 to "off," rotate R7 fully clockwise, open up S2, connect a scope to the collector of Q2, and note the approximate wave shape as shown; the voltage will be approximately 15 volts p-p. Those settings should be at the maximum frequency obtainable. If the frequency varies much from 20 kHz, it will be necessary to change the value of R8 or C6; a higher value for lowering the frequency and vice versa.

Rotate R7 fully counter-clockwise and note the frequency dropping from 20 kHz to 10 kHz. Close S2 and note frequency range dropping from approximately 10 kHz to 5 kHz. Check the action of test-switch S3 and make sure that all frequencies decrease by a factor of 4 to 5.

Preset all controls for maximum frequency, and turn on S5 to initiate sweeping action. Close S1 and rotate R1 fully counter-clockwise. Note the frequency sweeping from 20 kHz to approximately 25 kHz. Sweep rate will increase by approximately ×10 when S1 is open. A change will also occur when varying R1. That checks the frequency and sweep ranges of the device. Note that the frequency readings may vary, and can be compensated for, if necessary, by changing circuit values.

Connect the base of Q3 to the driver board via jumper lead (N). Connect up to 4 transducers in parallel to contacts 3 and 4 of the terminal strip. Note that if only 1 or 2 transducers are used, it will be necessary to change R23 from 15 ohms to 40 ohms for output compensation.

Apply power and connect a scope across the transducer(s). The wave shape should be close to a sine-wave. The wave shape deteriorates as the frequency is lowered. Double check the test points with the system in full operation, noting the values given in Fig. 1.

Adjust the ferrite core inside L2 for maximum voltage at maximum frequency and secure it in place. The core may not be needed if four or more transducers are used, as the induction of the coil by itself is usually sufficient.

You will note that L1 is shown with several tap connections intended to produce more output. Tap 18 is the factory setting and is intended for continuous use; the voltage across the

*(Continued on page 76)*

# VIDEO SCENE SWITCHER

WILLIAM SHEETS and RUDOLF F. GRAF

*Time to finish this project.*

WE LEFT OFF LAST MONTH WITHOUT finishing the discussion on the circuitry operation. So let's finish describing the circuitry, and then get to building and aligning the unit. Before we begin, though, please note that there are a couple of corrections that you'll want to make to last month's article. First, in Fig. 3, pin 13 of IC3 and its corresponding channel-2 component, IC16, should be connected to +5 volts for proper operation. Second, the correct value for R9 and R209 should be 15K. When we left off we were explaining Fig. 5, so would you please refer back to that figure in last month's issue.

Ramp-generator IC12 is used to generate a slowly varying DC voltage for slow fades, wipes, or key-ins. It is fed either positive or negative signals through R44. The speed (rate) of the ramp depends on the setting of the speed control R42. By varying R42, either a slow or fast key transition can be obtained. R47 is used where manual control of key transition is desired. Q3 and Q4 feed either +5 or −5V DC to R42, depending on the logic level at the junction of R37 and R36.

Figure 6 shows the video switching circuits; IC17–IC20 are CMOS analog SPDT switches. Each has three sections that can be switched at over 1-MHz and can handle signals up to 5 MHz with 50 dB isolation. They are controlled by a logic level at the input. All switches are in "up" positions (N.C.) when logic level is zero, and "down" (N.O.) when logic level is high.

Channel-1 video is input to pin 15 of IC17 (IC1 is fed from that point as well), where it is split into video and sync. IC17 is driven by IC2 in the keying section. Sync and video are available separately at J2 and J7. In Fig. 6, an "EF" followed by a letter represents an emitter-follower circuit; one is shown in detail inside dashed lines in Fig. 6. IC18-a selects either input video or effects video (derived externally from video 1). IC18 selects either CH1 or a DC level between −0.5 and +1.5 volts from R115 used in a fadeout; it is blanked during sync intervals so as to not upset sync levels. Transistors Q100–Q102, D100, and R112–R118 generate the required waveform.

IC18-c and IC20-c are configured as a DPDT switch to switch between CH1 and CH2 for direct fades, wipes, or key-ins (genlock sources are required). Switched video from both channels is fed to fader R125. The output of R125 is taken to summing amplifier IC21, together with sync from IC17-b and IC19-b (sync is selected for the channel in use). Frequency-compensation components R119 and C107 maintain correct burst phase. The output of IC21 is a complete inverted video signal. It's fed to IC22 for re-inversion and then to J9 via termination-resistor R132.

The unit requires ±5, and +12-volts DC. The ±5-volt supplies must be at least 500 mA. Two IC regulators, an LM7805 for +5 and an LM7905 for −5, together with a 12-volt AC transformer and bridge rectifier can be used. The +12 volts for the PLL on the keyer board (IC5) need be only 50 mA, but it should be well filtered. A suitable power-supply is shown in Fig. 7.

The two PC boards can be constructed using the Parts-Placement diagrams of Figs. 8 and 9. Foil patterns for the two PC boards are provided in PC Service. Just be very careful when soldering, so that you don't create any problems for yourself when you go to calibrate the unit. Check off each part as you install it, and inspect your work as you go along to minimize headaches later on.

After you've assembled and checked out the two boards, you must wire them along with the switches, RCA jacks, control potentiometers, and power supply as shown in Fig. 10. There are a lot of connections to be made, so be patient, take your time, and do a careful job.

Any suitable control-panel layout can be used. Just make sure that leads

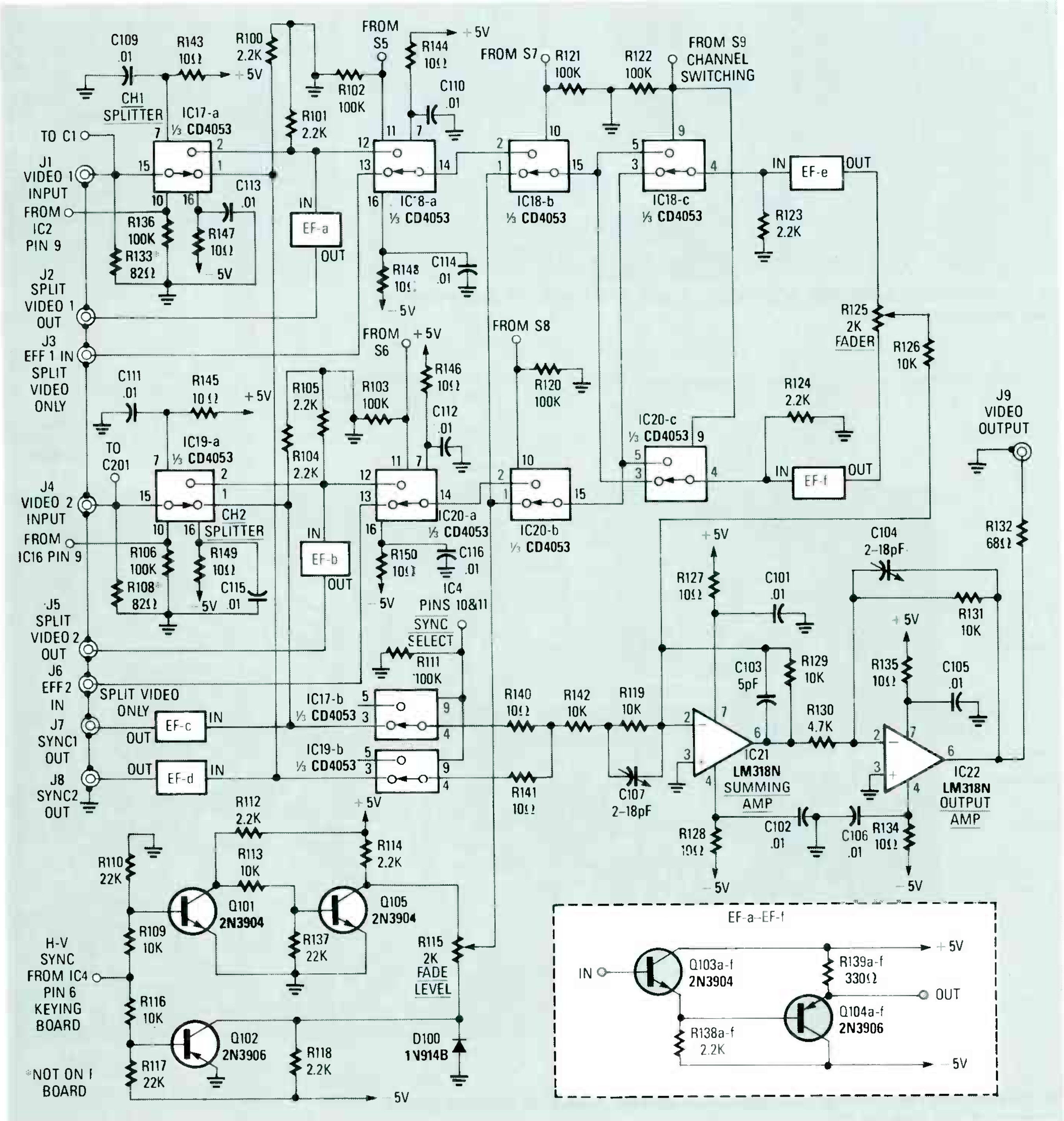


**FIG. 6—THE VIDEO SWITCHING CIRCUITS. Each analog switch (a CD4053) has three sections that can be switched at over a 1-MHz rate, controlled by a logic level at the input. An "EF" followed by a letter represents an emitter follower circuit; one is shown in detail inside the dashed lines.**

are kept as short as possible and separated from each other to minimize crosstalk. The prototype that you see pictured in this article is mounted inside a metal cabinet. While a metal cabinet is preferred for its shielding, any other kind will do, as long as everything fits inside.

## Checkout and alignment

After the unit is all together, and you've inspected the boards for soldering defects, turn the unit on and make sure that none of the IC's get hot. Then check all points for proper voltages—+5, −5, and +12. You will need an oscilloscope for the following checks, and we will go over the procedures for CH1 only, but the procedures are identical for CH1 and CH2.

Apply a 1-volt p-p negative-sync NTSC video signal to J1, and verify negative sync pulses at about 5-volts p-p at IC1 pin 1. Adjust R6 so that IC2

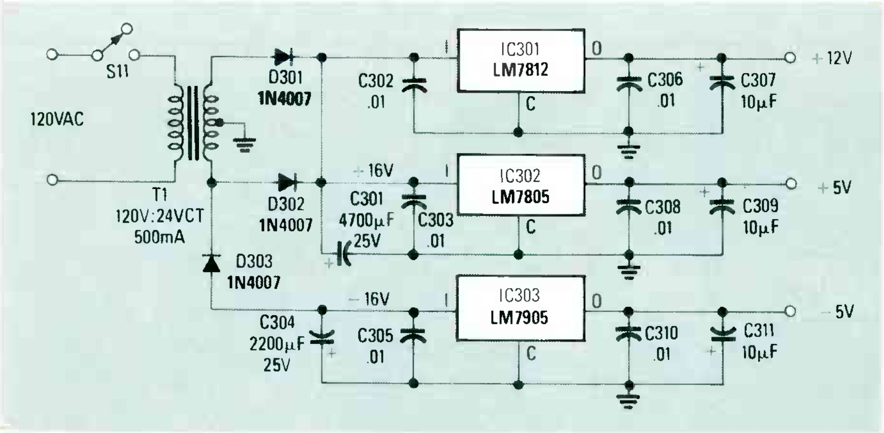


FIG. 7—THE SCENE SWITCHER REQUIRES ±5 AND +12-VOLTS DC. The prototype's power supply is shown here.

**Note: A kit consisting of the two PC boards, the parts that mount on them, and the front-panel potentiometers is available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804, for $137.50. The kit does *not* contain other parts that mount off the board, such as the switches, RCA jacks, power supply components, project case, etc. A set of two PC boards is available separately for $27.50. Add $2.50 to either order for postage and handling. New York residents must include sales tax.**

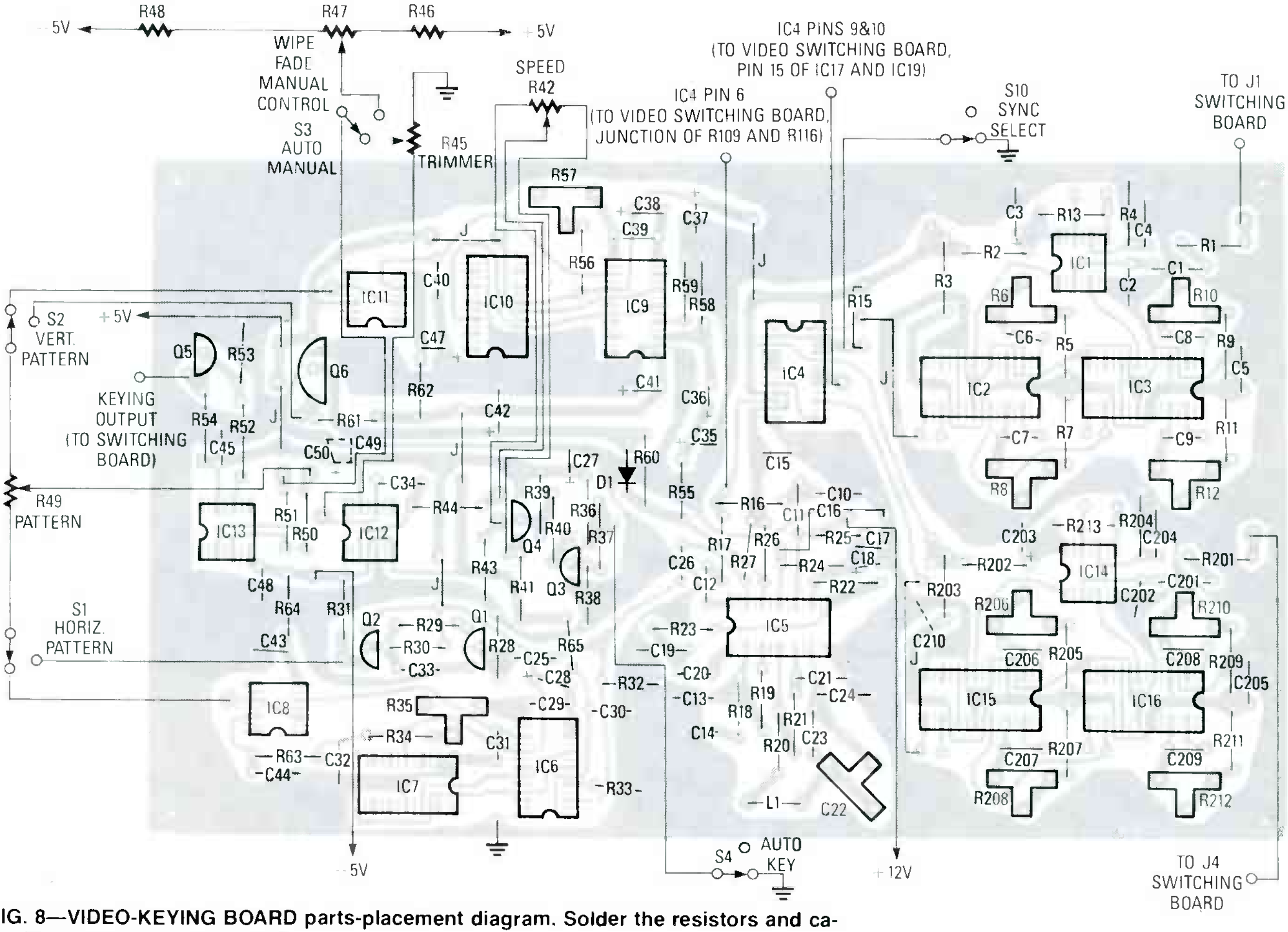


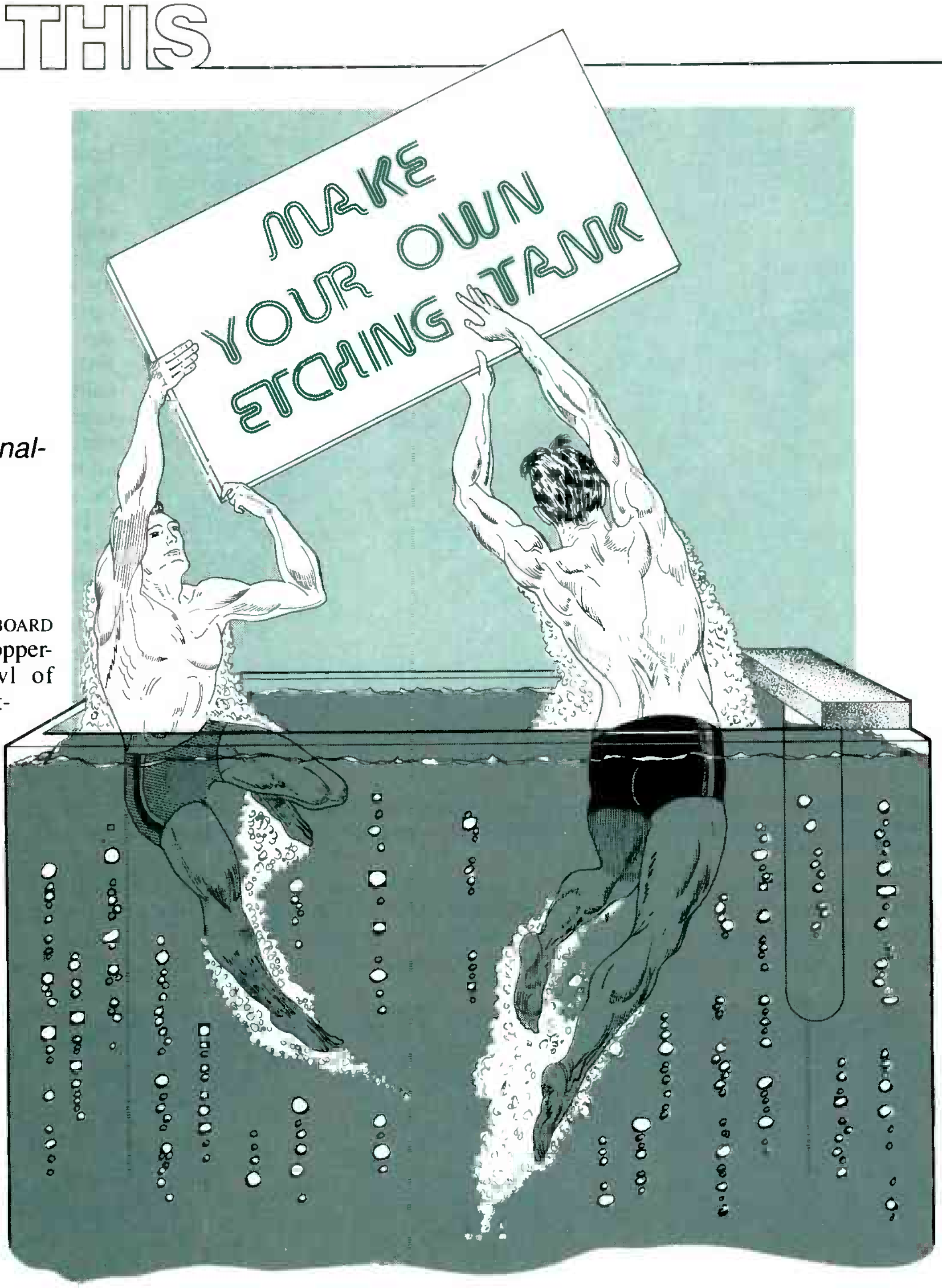
FIG. 8—VIDEO-KEYING BOARD parts-placement diagram. Solder the resistors and capacitors first, and then the IC's.

pin 6 (IC2-a) shows an 8-µs pulse and adjust R8 so that pin 9 (IC2-b) shows a 53 µs-pulse. Check for a 60-Hz vertical-sync pulse at IC1 pin 3. Adjust R10 for 0.5–0.6-ms pulses at IC3-a pin 6, and adjust R12 for a 16-ms pulse at IC3-b pin 9. (Start out with R12 at its minimum-resistance setting). Make sure that S10 (SYNC SELECTING) is in the CH1 position, and then check for sync pulses at pin 6 of IC4. Connect the scope to IC5 pin 13 and, using a non-metallic tool, adjust C22 so that the pulses are synchronized to the video signal. Check for 60-Hz pulses at IC5 pin 12.

Connect the scope to IC8 pin 4, and adjust R35 for a 126-kHz sawtooth wave. Now connect the scope to IC11 pin 6, and adjust R57 for a 480-Hz sawtooth. Verify a 15.7-kHz horizontal sawtooth at the junction of R31 and the emitter of Q2, and a 60-Hz vertical sawtooth across C42. Now check the waveform at the wiper of R49: it should be a mixture of two of the four previous waveforms, depending on the settings of S1, S2, and R49.

Check for ±2.5 volts at the wiper of R47, and also for between +4 and −4 volts at IC12 pin 6. When you activate S4, the voltage should slowly

*continued on page 54*



*It's easy to build a low-cost, professional-type PC-board etching system.*

**TONY LEWIS**

MAKING A PRINTED-CIRCUIT BOARD by simply plunking the copper-clad board into a bowl of etchant is usually an irritating and time-consuming project, even if you try to speed things up by heating the etchant in a Pyrex bowl on the stove. But build yourself a professional-type etching system that has automatic heater control and air-burst agitation, and your PC boards will be done before you can figure out how to drill or cut the holes. Best of all, the total cost will be about half that of a comparably equipped commercial system.

## System design

Etching a printed-circuit board is usually a time-consuming task for even the smallest of boards, because copper etchants require two things to work properly: heat and agitation. Traditional methods of heating the solution include warming its container on a hotplate or stovetop, immersion in a hot-water bath, or even by placing the etchant in a microwave oven. Of course, due to the chemical action of the etching solution, only plastic or glass containers are used—usually large flat bowls with the copper board immersed in the fluid. That is an acceptable method for single-sided boards, but double-sided boards must be removed frequently and turned over to monitor the etching process. Also, the etchant emits fumes when heated; and although the fumes aren't dangerous, they really don't belong in the kitchen.

Effective etching also requires agitation, which is usually provided by constantly moving the container and the board back and forth while they are being heated. Since the board is probably in the horizontal position, dissolved copper is likely to pile up on the board unless you are very enthusiastic in your agitation. So etching a typical board may take from 20 to 60 minutes, even if you continuously push the copper-clad board around the bottom of the container of hot etchant. Between the agitation and the heat, it's not a pleasant job.

## Build a tank

To minimize the etching time, while also reducing your concentration and effort, you should use an etching system that incorporates its own source of heat and agitation. Systems with heaters and air bubblers (for agitation) sell for about $60 and

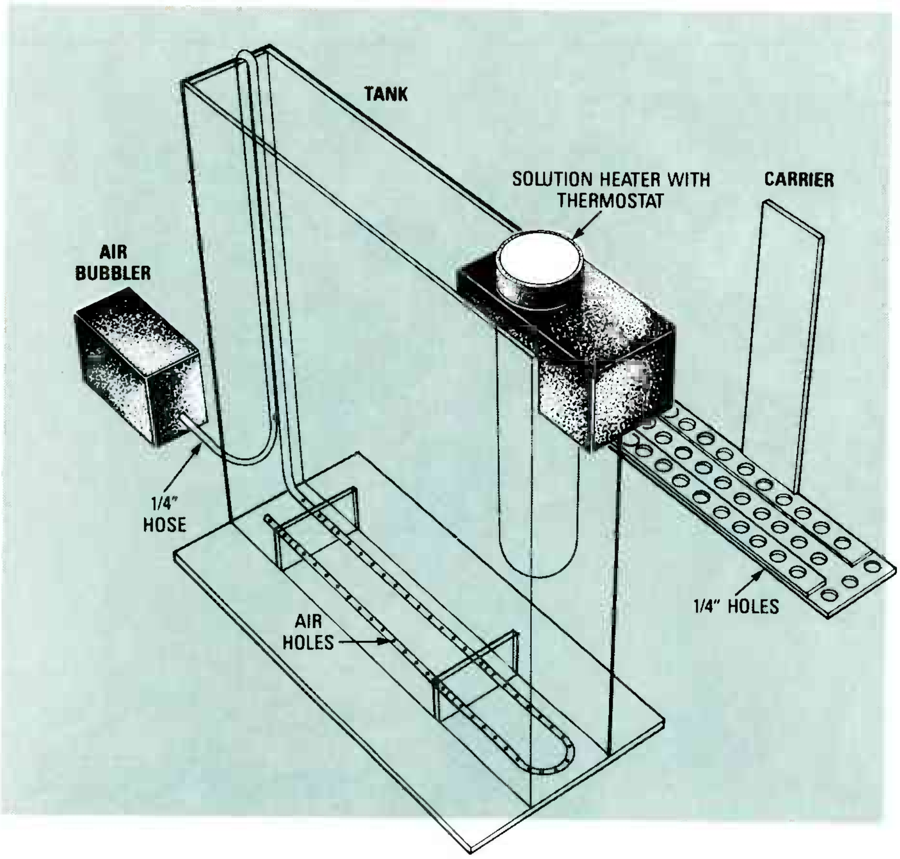


**FIG. 1—THESE ARE THE MAIN COMPONENTS of our professional-type PC-board etching system. The air bubbler, the hose, and the solution heater, are available at stores that sell aquarium supplies.**

up. As an alternative, we'll show you how to design and build a professional-type etching system, such as the one shown in the photographs, that uses Plexiglas to form both the etching tank and the PC-board carrier. By constructing the entire system yourself, your total costs should come out under $30, and you'll probably avoid an oversized tank by designing the system to fit your individual needs.

The major components of the PC-board etching system are shown in Fig. 1. The individual bits and pieces of plastic that are used to make the tank are shown in Fig. 2. For best control of the etchant's temperature, the solution heater should have an adjustable thermostat. Although heaters are available through mail-order firms, they can also be purchased locally from stores that carry aquarium supplies. Whatever you use, make certain that the heater has a device that allows it to be clipped to the side of the etchant tank.

Depending on the initial temperature of the solution, a 100-watt heater will raise the temperature 100°F in 30 to 45 minutes. If you purchase a heater with a smaller capacity—one with a lower wattage rating—the heat-up time for the solution will be extended proportionally.

The air bubbler and its hose can also be purchased either through the mail or from local aquarium-supply stores. The cost should be under $10. The air bubbler should be sized for at least a 15-gallon aquarium: The larger the flow capacity, the better the performance. Make sure that you buy enough clear plastic air hose so that it will will fit inside the tank and also

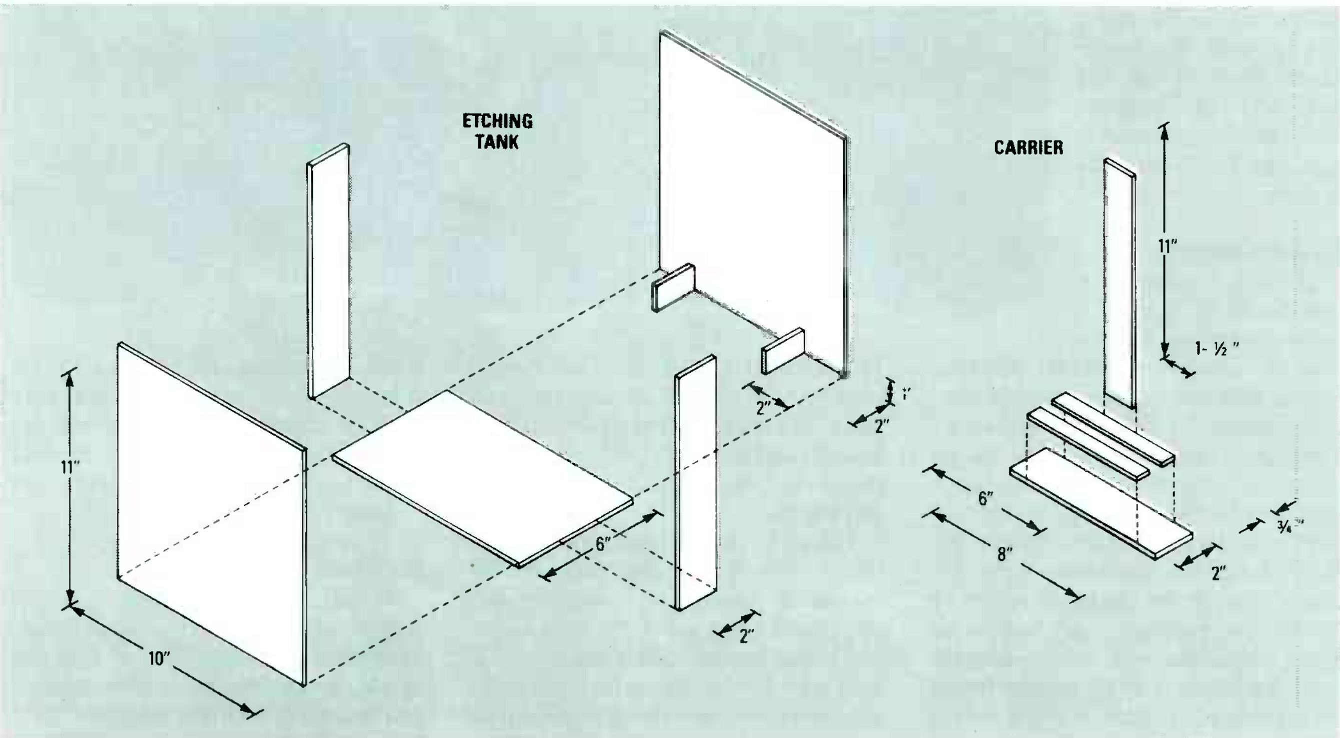


**FIG. 2—THESE ARE THE INDIVIDUAL plastic components that are used to make the tank and the carrier.**

**FIG. 3—A SHEET OF PLEXIGLAS,** a cutting tool, adhesive, and some aquarium materials are all that's needed.

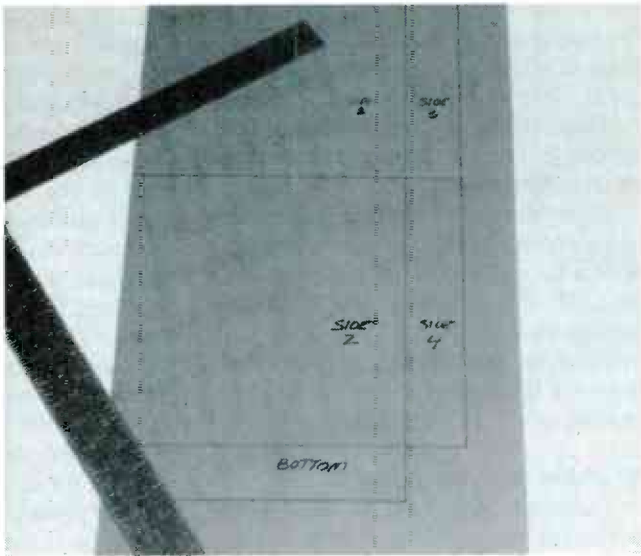


**FIG. 4—DRAW YOUR TANK PIECES** on a sheet of paper first. Then transfer them to the paper backing of the Plexiglas.

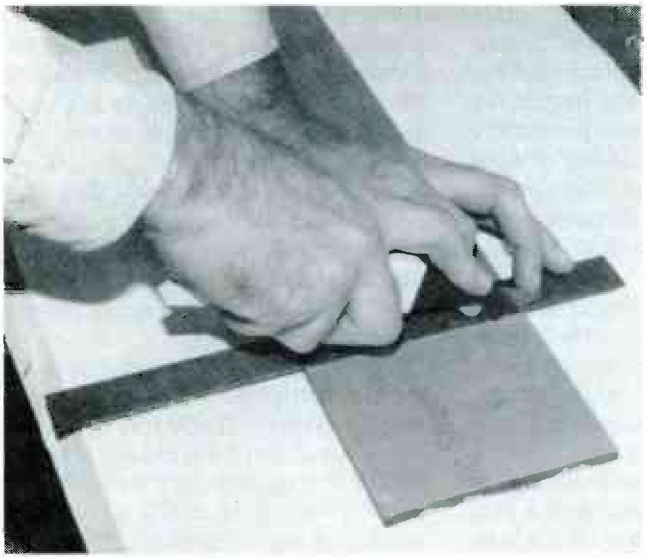


**FIG. 5—DON'T TRY TO CUT THE PLEXIGLAS** with a saw. Instead, use a straightedge to guide the scoring tool.

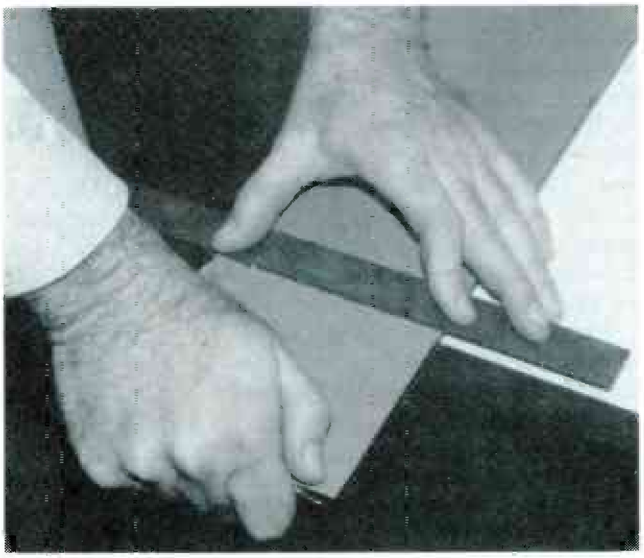


**FIG. 6—POSITION THE SCORE LINE** on the edge of a table, hold the plastic firmly, and then snap the plastic in two.

allow the bubbler to be placed in a convenient location.

The Plexiglas used for the tank should be $\frac{3}{16}$—$\frac{5}{16}$ inch thick. Thinner sheets tend to crack too easily, and thicker sheets are harder to work with. You'll need about three square feet of the Plexiglas, preferably in a 1 × 3-foot sheet form. Always buy more Plexiglas than required, to allow for practice and mistakes. Of course, you'll want to use clear Plexiglas so you'll get a good view of the PC board when it's immersed in the etchant. If you live in a metropolitan area, there's probably a local plastics dealer listed in the phone book who can supply the Plexiglas. If not, most hardware stores carry Plexiglas—or can advise you where to get it.

Other items that you'll need include Plexiglas adhesive and a cutter. To build the tank you'll also need a long metal straightedge, a carpenter's or Tee square to draw precise corners, a table or a surface having a sharp edge, and possibly some small C-clamps. A variable-speed drill, assorted drill bits, and sandpaper or a file will also come in handy

**PC-BOARD MATERIALS**

**Active Electronics, PO Box 9100, Westboro, MA 01581 (800) 343-0874**

**Datak Corporation, 3117 Paterson Plank Rd., N. Bergen, NJ 07047 (201) 863-7667.**

**Injectorall, 110 Keyland Court, Bohemia, NY 11756 (516) 563-3388**

**Kepro Circuit Systems, 630 Axminister Dr., Fenton, MO 63026-2992 (800) 325-3878**

**Radio Shack stores**

Figure 3 shows the the tools and materials that you'll need. The Plexiglas is the "dark" sheet upon which everything else is placed. It's dark because it's supplied with protective paper stuck on both sides to make sure that the Plexiglas doesn't get scratched during construction.

### The tank first

The tank should be designed on paper first, then cut and assemble the components from the Plexiglas sheet. Don't hesitate to stop and make a new part if you make an error while cutting the components, because once Plexiglas is glued together it's glued for good. If you follow the procedures outlined below, you should be able to assemble a leak-tight working system in less than a weekend.

If you use the Plexiglas component sizes shown in Fig. 2, you'll end up with a 10 × 11 × 2-inch tank that sits on a 10 × 6-inch base, and a carrier having an 8 × 2-inch base. The two small strips of Plexiglas on top of the carrier's base form a groove for the bottom of the PC board to rest in.

## Working with Plexiglas

Plexiglass isn't hard to work with as long as you're aware of some of the tricks of the trade. The first step, as shown in Fig. 4, is to carefully measure and mark your sheet of Plexiglas. Since the Plexiglas comes with a peel-off paper backing on both sides, simply mark the cutting layout directly on the backing. Because you will be cutting out more than one section at a time, a long straightedge, preferably metal, is necessary. Also, a carpenter's square is invaluable for both drawing the cutting lines and for making perfectly square corners.

Whenever possible, line up the sections having common dimensions; for example, the left and right sides and the base should have a common width. Don't forget to account for the thickness of the Plexiglas when determining the dimensions. Check and double-check all the dimensions, and double-check the corners for squareness. Also check the precut edges and corners of the Plexiglas itself; don't assume that they're cut straight and square at the factory.

Before cutting the sheet of Plexiglas, practice on an extra piece or two just to get the hang of the special cutting technique. Actually, the term "cutting" is a misnomer because you will *score* rather than cut the Plexiglas. If you try to cut the Plexiglas using a conventional saw you will quickly discover one of Plexiglas' annoying characteristics: it melts. If you try to cut or drill the plastic quickly it begins to melt locally in the area of the blade or the drill bit, and will quickly foul the saw or drill. By slowly scoring the surface multiple times, then breaking the Plexiglas on the score line, you can create a smooth edge with very little effort.

Figure 5 shows the tools needed to cut the Plexiglas: a *plastic knife* (which is not made of plastic, but is designed to cut plastic—available for under $4), and a metal straight edge to guide the knife as it scores a groove. Draw the knife along the line you marked on the paper in a smooth, slow fashion, without pressing down too much. As a general rule, score the Plexiglas a minimum of 36 times in one direction, then a minimum of 36 times on the same line in the opposite direction. Before stopping, check the edges of the plastic on both ends; the groove should be about one-half the depth of the sheet of Plexiglas.

Next, break the edge. As shown in Fig. 6, position the plastic with the scored line on the edge of a table. Use one hand and a straightedge, or a similar solid object, to hold the plastic down. Using your other hand, press firmly down on the part to be broken off. The Plexiglas will bend slightly, then suddenly snap in two. Inspect the edges. If they're not perfectly smooth, they can be sanded or filed down. Do not leave any ridges on the edge, because they will cause problems when you're trying to seal the tank.

Generally, sections longer than six inches are hard to cut properly the first time when hand-holding the Plexiglas. Clamps and a straightedge, rather than hand pressure, are better for holding long pieces.

Drilling Plexiglas isn't difficult if you use a variable-speed drill and a little patience. Mark the area where the hole is to be drilled, then drill a pilot hole using a small-diameter bit. Note that the faster you drill, the more likely the Plexiglas will be to melt and wrap itself around, and clog the drill bit. After drilling the pilot hole, start drilling slowly with a ¼-inch bit. Don't press down too hard, or the plastic may crack. For best results, place the Plexiglas on a piece of soft wood when drilling.

As shown in Fig. 7, straighten a length of the plastic air-bubbler hose and drill small-diameter (0.04—0.06-inch) holes spaced about one inch apart. Seal one end of the hose with silicone or RTV sealant and allow it to dry overnight. To ensure that the hose will bubble correctly, connect it to the air bubbler and test the hose underwater in a sink. Drill more holes if there are not enough bubbles, but keep the holes evenly spaced so that the printed-circuit board will not get too much agitation in one section.

## Tank assembly

Remove any ridges from the edges of the Plexiglas pieces before gluing them together. Although it is possible to use epoxy or other adhesives to hold the sections together, we recommend an adhesive that is specifically intended for use on Plexiglas. The stuff is not really an adhesive as much as it is a solvent. Capillary action causes the adhesive to rapidly spread between the two pieces of Plexiglas. The adhesive slightly dissolves both pieces of Plexiglas, which then solidifies into a "weld." A small amount of adhesive will go a long way, so you'll need a convenient dispenser, such as a syringe (hypodermic), which is available from drug stores for about $1 each. The syringe allows precise dispensing of the amount and location of the adhesive. Once you have the Plexiglas sections aligned, slowly inject the adhesive at the joint without pushing the Plexiglas out of position. The adhesive will flow under the joint and begin to "melt" the plastic slightly, which helps seal the two Plexiglas pieces together watertight—even if they have small imperfections on the edges.

Note: Many states require a doctor's prescription in order to purchase a syringe. If you live in one of those backward-thinking states, purchase a syringe-type fine-oil dispenser, which is really a syringe whose tip has been blunted.

Figure 8 shows a square being used to hold two sections of Plexiglas perpendicular to each other while being glued. Make sure that the two sections are as square as possible, or you'll have trouble fitting the other sections later. After applying the adhesive, press the two sections together and hold them in position for a minute or two. Then allow them to set up undisturbed for at least 15 minutes or longer. When the adhesive dries completely, the joint will be as solid as the Plexiglas itself.

Another reason to use Plexiglas adhesive is that it dries completely clear, which makes for a better appearance of the final product. Once you've applied the adhesive to one side of the joint, go back and apply it to the other side of the joint, and allow it to set up. That will give the joint a better seal and added strength.

Place one of the larger Plexiglas

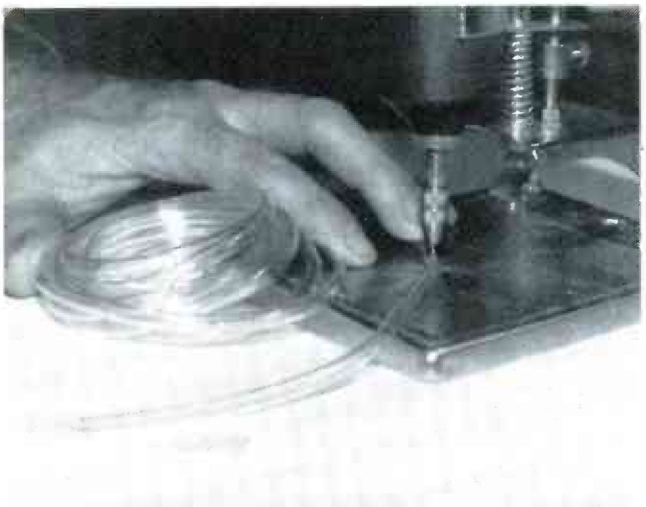


FIG. 7—STRAIGHTEN THE PLASTIC AIR HOSE and drill a series of small holes spaced approximately one inch apart.

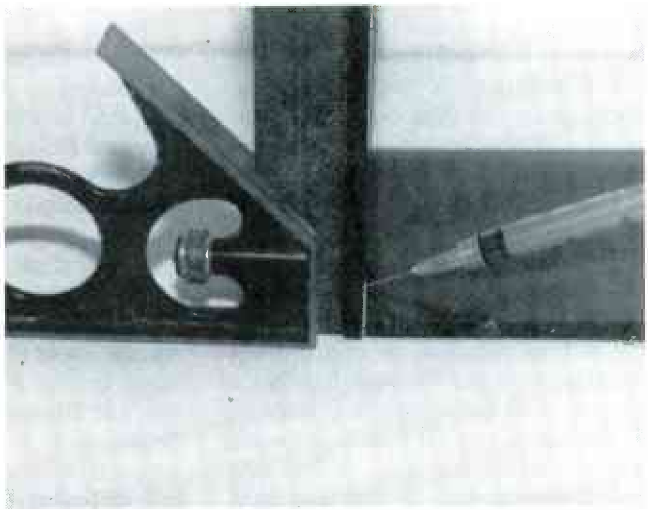


FIG. 8—SQUARE THE PLASTIC SECTIONS using a machinist's square. Then, apply the Plexiglas adhesive.

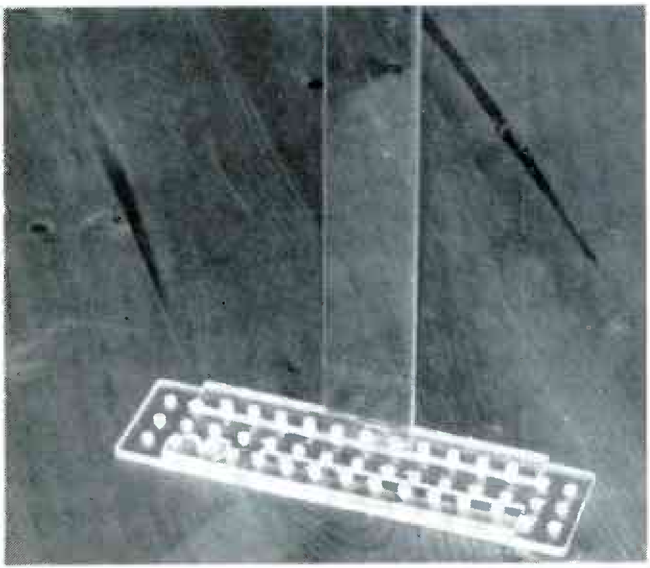


FIG. 9—THE HOLES DRILLED in the bottom of the carrier allow the air bubbles to pass through to the printed-circuit board.

FIG. 10—HANG THE HEATER from the side of the tank, connect the air bubbler, and check for an even bubble distribution.

sides on a flat surface. Using the previous procedures, position one of the smaller sides so that it is perpendicular to the flat piece. Note and correct any ill-fitting edges, and also make certain that the two pieces are of the same height. When you are sure that the pieces have a good fit and are properly supported, slowly begin injecting the Plexiglas adhesive on the inside interface of the two pieces. Note that the adhesive will probably move faster along the interface than you do. When all of the interface has been injected with adhesive, press down lightly on the vertical piece for a minute or two while maintaining its perpendicular position. Release the pressure and recheck for proper position. The adhesive will set up in about 15 minutes, but allow at least 30 minutes before attempting any more work. After drying, the interface should look clear, with a few minor bubbles. If a bubble appears to run from one side to another, a second injection of adhesive may be necessary. When you're satisfied with the adhesive injection process on one side of the interface, repeat the process for the other side.

With one small side in place, repeat the procedure for the other small side. Your tank should now have three sides, and be capable of standing upright. Position the partially assembled tank over the center of the base section. Once again, make sure there's a tight fit between the Plexiglas pieces before applying adhesive to both sides. Then install the two small supports in the bottom of the tank. But before installing the supports, drill two evenly spaced ¼-inch holes in each support for the air-bubbler tubing. Temporarily set the supports in the bottom of the tank (using tape to hold them in place) and position the last side on top. Check to make sure that the last side will fit tightly with the base and the two smaller sides, and that the supports do not cause the piece to bulge out. It's too late to correct measuring errors after the supports are glued in place.

When you're satisfied with the fit all around, glue the supports to the base and to the side. (You will not be able to glue them to the last side that's installed.)

Run the bubbler's hose through the holes in the supports—try not to create kinks in the hose. Install the final side of the tank after the hose is properly installed and all the other joints are sealed from both sides.

With the tank in a vertical position, first inject the adhesive to the interface at the base and press down lightly while holding the sides together. Then, place the tank on its side and apply adhesive to the two side interfaces. To ensure a good seal, place a heavy object (about five pounds) on top to apply even pressure.

## Checkout

The tank is no good if it can't hold the etching solution, so check it out thoroughly. After the tank has had a chance to set up overnight, place it in a sink and slowly fill it with hot water while watching for leaks. If leaks do occur, drain and dry the tank and reapply Plexiglas adhesive in the areas of the leaks. If necessary, a small amount of adhesive can be poured along the inside corners to enhance sealing from the inside. If you discover that you have a gap between two Plexiglas pieces that the adhesive will not seal, then epoxy or contact cement may have to be applied from the outside to stop the leak. Do not use silicone or RTV sealer, because they may weaken or leak after repeated exposure to the hot etchant.

Another possible way to solve the leaks that the less-than-perfect craftsman is bound to get is to mix some DATAKOAT liquid, or other 100% acrylic coating, with some solvent-type acrylic adhesive. The resulting material should seal even relatively large leaks.

The printed-circuit board carrier, shown in Fig. 9, is easier and less critical to make than the tank. Cut the base, the two top pieces, and the handle. To ensure that the carrier will move in and out of the tank without hitting the walls, the width of the carrier's base is slightly less than the width of the two small sides. As shown, glue the two top strips over the center of the base so that they provide a groove to hold the bottom of the circuit board as it rests in the tank. Carefully drill a series of evenly spaced ¼-inch holes in the base assembly. Then, glue the handle on top.

Finally, as shown in Fig. 10, install the solution heater and bubbler to test your system. The carrier should be able to move in and out of the tank without hitting the air hose or the heater. With the carrier in place, and the bubbler running, the bubbles should be evenly distributed along the base of the tank.

## Custom size

The main advantage to building your own etching system is that you can customize the tank to your needs; it should be customized for your anticipated PC-board sizes. There is no need to oversize the tank because that wastes etchant and takes longer to heat up. If your boards are usually wide and short, or you don't need a tall tank, it is possible to redesign the tank so that the heater is inserted horizontally near the bottom of the tank, above the bubbler hose. An ordinary hole saw from the hardware store will do the trick. In that case, one of the supports will need a corresponding hole drilled to accommodate the heater. However, a horizontal heater assembly is really not advised unless absolutely required because the area around the heater/side joint might be prone to leaks.

## Using the system

Two types of etchants are available for hobbyist and technician use: ferric chloride, and sodium or ammonium persulfate. Ferric chloride is generally available and is economical to use. However, it should be used only in a well-ventilated room, and it can stain badly—which can be a problem if the etching tank is upset. The persulphates come in crystal form and have several advantages over ferric chloride in that they will not attack stainless steel, they are totally ineffective when cold, solutions are clear when first used, and they give an indication of their copper absorption by turning blue. Like ferric chloride, the more the persulfate solution is reused, the slower the etching process will become.

Another important advantage of persulfates is that they are not as aggressive as ferric chloride in the etching process, and will not undercut the PC-board's traces. That is especially important if you work with printed-circuit board patterns having line widths of 0.032-inch or smaller, such as computer-memory boards. (Nothing is quite as frustrating as having the etchant dissolve some lines on one side of a board while you were examining the other side.)

For comparison purposes, four 2 × 4-inch single-sided boards having identical patterns were etched in heated ferric chloride and ammonium persulfate, both with and without the bubbler running. For ferric chloride, the etching time with the bubbler off was 16 minutes; 9 minutes with the bubbler on. For ammonium persulfate, the etching time was 19 minutes with the bubbler off; 11 minutes with the bubbler on. (Etching times will vary, depending upon the board pattern, the number of times the etchant was reused, etc.) Also, monitoring the etching process in the tank was easier using the ammonium persulfate solution, because it is clear.

Note that our test etching times are considerably faster than when agitating a Pyrex dish over a heater or the stove. Often, the bubbler results in a 40% reduction in etching time compared to simple hand agitation. Also, keep in mind that the faster a board is etched, the less likely the chance that the etchant will attack the sensitizer and undercut edges of the traces, thus ruining the board.

If you'd like to use persulfate as an etchant, it is available from Kepro Circuit Systems, and Active Electronics. Other major mail-order firms such as Datak, carry powdered ferric chloride and others carry ferric-chloride solutions.

Those of you who choose to work with ferric chloride will want a way to get rid of the spent etching solution. The best way is to mix it with a solution of lye (sodium hydroxide). The copper and iron will precipitate. The remaining solution is salt water and excess lye. Pour the salt water down the drain. Let the copper and iron hydroxide dry out, and then dispose of with your tin cans, etc.

Our etching system should give years of trouble-free service, while saving you many hours of time spent in etching PC boards. If you want additional information on making PC boards, see the following articles that have appeared in **Radio-Electronics:** "Making Your Own PC Boards" (Feb. 1988); "Designing Double-Sided PC Boards" (Sep.–Oct. 1985); "Etch Your Own PC Boards" (Dec. 1982, Feb. 1983). Also, Bob Grossblatt has been covering PC-board design and production in his "Drawing Board" column since August of this year, and Don Lancaster's "Hardware Hacker" column in this issue looks at a novel approach to PC board design. Now you have no excuse for not putting the PC Service pages to work, or building that design you've been working on and meaning to prototype! **R-E**

# Radio Electronics HOLIDAY GIFT GUIDE

ELECTRONICS HAS CERTAINLY CHANGED THE WAY WE LIVE. IF nothing else, it has made the holiday shopping season a little easier to deal with! The array of consumer products is so great, that you are sure to find something for everyone.

We've compiled a subjective list of what we would buy for our families—or ourselves—from the plethora of products available in the consumer-electronics market. We looked at video and audio products, computer-related products, and electronics for people who take their electronics seriously. We didn't pick products for their price, nor did we pick them because they were the "best." We picked the products because we felt they offered something unique, something fun, or something innovative.

We don't pretend that our list is comprehensive—we're sure that we've neglected to mention some of the products that deserve recognition. Despite that, we hope that this guide proves helpful by, at the very least, giving you some new ideas.

## Video products

### • Integrated Video System

For those on an unlimited budget, we'd like to suggest the Bang & Olufsen *Video System 5000*, an integrated video system that is capable of multiroom operation. It can be teamed with any Bang & Olufsen audio system to form an interactive audio/video system in anywhere from one to sixteen rooms. The *Video System 5000* integrates a 26-inch TV monitor and a Super-VHS digital VCR with a motorized, remote-controlled stand and an audio/video remote control. As you might expect, the *Video System 5000* doesn't come cheap. But if you're contemplating installing a through-the-house A/V system, that probably doesn't matter much. The entire system, including the motorized stand retails for $4290.

### • LCD projection TV

For those more concerned about picture size than high-tech convenience, Sharp's LCD projection system is the answer. It's quite a change from traditional projection sets. First of all, it's portable. The projector weighs about 30 pounds, and projects a bright, clear picture on either a wall or screen. The unit's magnification can be varied, producing a picture from 25 to 100 inches (measured diagonally). The key to the system's size and performance are three small LCD panels inside the unit. The 3-inch twin TFT (*T*hin *F*ilm *T*ansistor) panels form the red, green, and blue components of the video picture. The projector does not require any convergence adjustment, and it features two video inputs and and Super-VHS compatibility. The price for this first-of-its kind TV is $6500.

- **Self-Powered Subwoofer**

Perhaps you already have a big-screen TV but you don't feel that you're getting the big-screen feeling. Maybe you've even tried surround sound and still don't feel that you've been successful in creating the home theater experience. Don't give up yet. Audiophiles and videophiles have created a demand for accurate low-frequency sound reproduction. Pioneer Electronics has answered the demand with their *S-W1000* switchable, self-powered subwoofer and center-channel speaker system. The *S-W1000* subwoofer system features a magnetically shielded design and low-distortion 12-inch wooofer powered by a built-in switchable power amplifier. An extra amplifier is provided for center-channel Dolby Pro-Logic Surround Sound applications. Switchable roll-off frequency settings of 50, 90, or 140 Hz are available. The subwoofer system is available at a suggested retail price of $500.

- **Talking Remote Control**

While we hope that no one reading this magazine has trouble programming his VCR, we're sure you've heard family members muttering under their breath as they go through the sometimes frustrating procedure. Until now, you've probably never heard your VCR talk back. But the Optonica *Voice Coach* remote control from Sharp will vocally guide users through the proper programming procedure. The Voice Coach comes with the Super-VHS *VC-G990U* VCR. Full remote operation is featured, including remote eject. The *VC-G990U*, with the *Voice Coach*, is available for $999.95.

- **Videotape Editor**

As camcorder sales have skyrocketed over the last couple of years, the need for an easy-to-use editing system has become evident. *DirectED Plus*, from Videonics, combines the functions of a video editor, titler, special-effects generator, and video librarian. *DirectED* works with just about any VCR that uses an infrared remote control. Both a recording and a playback VCR are required to assemble your finished video production. *DirectED Plus* sells for $549.95. For professional video producers, *ProED*, a computerized multifunction edit controller is available for less than $1000.

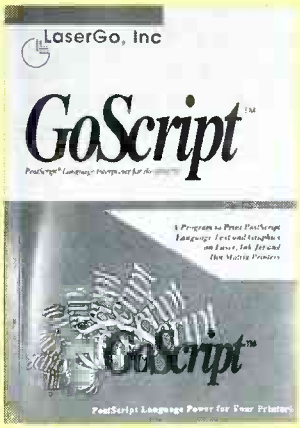
- **VCR Survival Kit**

VCR maintenance is simple. Simply keep it clean. Unfortunately, not many people follow even that simple advice. You can help them along with the *GE Survival Kit*. The kit includes a head cleaner, a dust cover, and a GE T-120 video tape. While we generally don't recommend head cleaners for VCR's, giving someone this kit might do the favor of stressing the importance of cleanliness for long VCR life. *The GE Survival Kit* retails for $19.95.

## Audio products

- **10th Anniversary Walkman**

The last ten years have seen a lot of changes in audio. Most people would point to the CD player as the most important development of the decade. But we think that the Sony Walkman has done more to bring an appreciation of good



audio to the masses than anything else. In honor of the tenth anniversary of the introduction of the Walkman, Sony has introduced a special edition AM/FM stereo Cassette player, the *WM-F701C*. It features digital synthesized tuning, 14 station presets, remote control, and auto reverse. It all fits in a cassette case-sized package and carries a price that only a Walkman fanatic could love: $379.95.

- **Airplane Headphone.**

The Walkman introduced a whole segment of society to good stereo sound. Of course, in doing so, it made people realize how bad some of their audio sources were. Take airplane headphones as an example. They're uncomfortable to begin with, and sound awful, too. Air travelers will be happy to discover *Jetman*, a small audio amplifier with ear-bud style mini stereo headphones. A small microphone module plugs into the headphone jack of a typical airline seat, filters the sound, and converts it to electronic signals. The signals are amplified by a stereo amplifier and output to stereo headphones. When you can't find any of the airline's music that suits your tastes, you can always plug Jetman's earphones into the Walkman that you brought on board. Jetman sells for $34.95

- **Big Sound, Small Speakers**

The major change in home-stereo systems over the last decade is that they've gotten smaller and less obtrusive. That's to be expected with the electronics portion, but getting big sound from small speakers always proved to be a problem. The Bose *Acoustimass 3*, however, seems to have solved the problem. Acoustimass technology, developed by Dr. Amar Bose, uses two moving air masses (acoustic masses) rather than a moving driver cone to launch low-frequency sound energy into the room. The Acoustimass module can be hidden anywhere in a room, even under furniture. Two curved wedge-shape enclosures, measuring 3½ × 4½ × 4½ inches, complete the loudspeaker system, which sells for $599.

- **Amplified AM/FM Antenna**

When most people think of stereo components, antennas usually don't enter into things. That may change with the Parsec *ARC*, or Amplified Receiving Component. The *ARC* is contains an amplified, directional AM antenna and omnidirectional FM antenna. The amplifier uses GaAsFET circuitry for low-noise, hi-gain operation. The FM section provides a gain of better than 30 dB, AM better than 15 dB. Both AM and FM sections are tunable for optimum performance, and the gain is adjustable. Since most receiver manufacturers pay little attention to the AM sections of their receivers, an antenna that offers a way to improve AM reception is a welcome sight. The suggested retail price of the *ARC* is $149.95.

- **Hi-Fi Phono Plugs**

If you're looking for some "stocking stuffers" for the audiophile in your family, you might consider *Pro-Fi* connectors from Neutrick. These connectors incorporate a special retracting ground shell. Thus, the ground makes contact first, and breaks contact last, ensuring a noise-free connection of equipment. Grounding noise is not only annoying, of course, but can also cause speaker damage if the amplifier is operating while the connections are being made. The connectors range in price from $17.14 to $24.96, depending on finish.

## Computer Products

- **Palm-top Computer**

It's finally happened: You can buy a PC-compatible computer that fits in your shirt pocket. The Atari *Portfolio*, which the company calls a "palm-top" computer, weighs one pound and is smaller than a VHS video cassette. The keyboard is too small to touch type on, but it's arranged in a standard QWERTY format for quick data entry. The Portfolio comes with 128K of RAM standard, and plug-in solid-state RAM cards can add up to 128K of memory. The screen is a 40-line by 8-line liquid-crystal display. A wide variety of add-ons are expected soon, including a parallel interface that will allow for connection to full-sized PC's. A Lotus 1-2-3 work-alike spreadsheet is built in, as are standard pocket-computer functions such as an address book, appointment calendar, editor, and more. This may be the first pocket computer that really makes sense. It sells for $399.95.

- **Tower Computer Case**

While small computers make some people happy, others are always looking for more room. For example, we're always playing around with some new card, and always running out of slots or drive bays. We think we've finally found a case for our computer that will help: Jameco Electronics' JE2010. It not only accepts all

*continued on page 78*

**SCENE SWITCHER**

*continued from page 44*

change, and R42 should vary the rate of change. Set R45 at the center of its range, and set S3 to manual.

Place the scope at the collector of Q5; you should see the keying waveform. The waveform will disappear if you rotate R49 to its extremes, and you will see either 0 or +5 volts at either extreme.

Place S5–S9 in the "normal" position; you should get video at J9 that you can check with a monitor. Adjust C104 for optimum sharpness. Adjust C107 for correct burst phase, as indicated by proper flesh tones on a video image. Place S8 in the "fixed" position, and vary R125. You should be able to fade to a level set by R115.

### Using the switcher

Switches S5–S9 determine exactly what signal is applied to each side of the fader control. For example, suppose a fade to black is desired. In that case, FADE SELECT (S7) would be set so that CH1 video passes directly to one side of FADER CONTROL (R125). S8 would be placed in the fixed position, which applies a fixed DC level (set via the FADE LEVEL CONTROL) to the opposite side of the FADER CONTROL. By rotating the FADER CONTROL, a mix of CH1 video and the DC fade level is sent to the output amplifier, and manual fading is performed.

If a fade from CH1 to CH2 is desired, both CH1 and CH2 fade selectors must be placed in the normal position. If a fade from CH2 to CH1 is desired, S7 and S8 must be placed in the fixed and normal position. S9 swaps CH1 and CH2, reversing the connections to each side of the fader control. If the fader control is set at one extreme, and CH1 is coming through, then moving S9 to the "reverse" position instantly routes CH2 into the output amplifier.

In the "keyed" positions, S5–S9 apply a waveform to electronically switch the video for wipes, transitions, and fades. Switches S1 and S2, in combination with R49 determine the particular pattern. Switch S3 selects the manual fade/key mode where R47 manually controls the effect, or the auto-key mode where the ramp generator produces the effect; S4 initiates the transition or effect, but has no effect in the manual position of S3. Switches S5 and S6 select the effects channel or other video inputs that are synchronized to CH1 or CH2. **R-E**

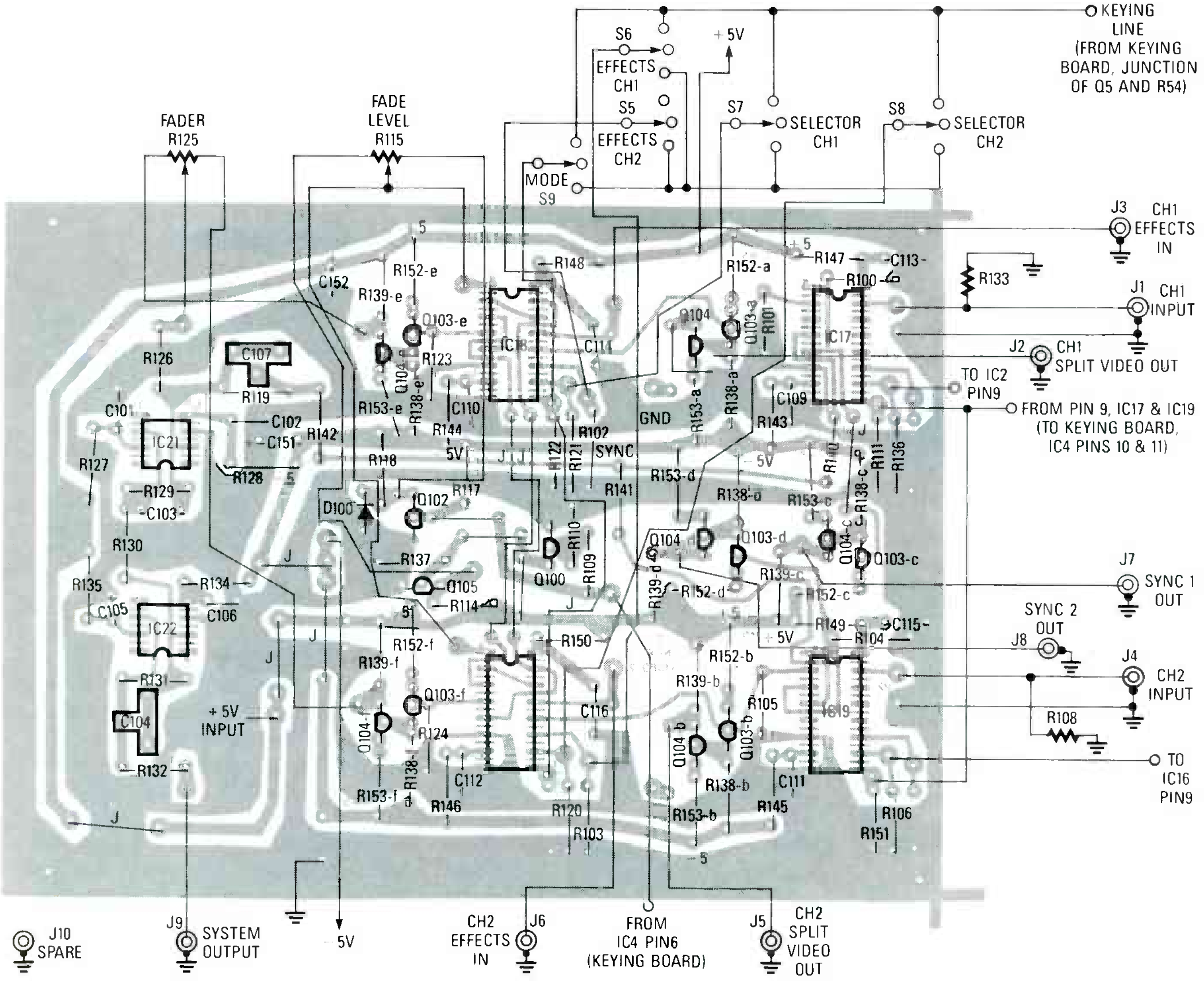


**FIG. 9—VIDEO-SWITCHING BOARD parts-placement diagram. Check your work as you go along, to lessen the likelihood of any problems.**

# CMOS PLL'S

*An in-depth look at a particularly versatile CMOS IC, the 4046 micropower CMOS phase-locked loop.*

R.M. MARSTON

THE 4046B MICRO-POWER *P*HASE-*L*OCKED *L*oop (PLL) is one of the most versatile of all CMOS IC's. PLL's can be used in frequency synthesis, tracking, multiplication, and coherent communication systems. Although the PLL concept has been around for some time using discrete components, the IC was needed to make the idea practical.

The 4046B also has a number of useful, independently accessible elements, very similar to the layout of the 555 IC timer. Its VCO (*V*oltage-*C*ontrolled *O*scillator) is the most versatile and cost-effective version available, producing a symmetric square wave with an upper frequency limit over 1 MHz, and capable of being scanned over a 1,000,000:1 frequency range. It can be gated on and off via an INHIBIT terminal, and produces a biphase output when used with one of the two internal *P*hase *C*omparators (PC's). Several practical applications will be covered later.

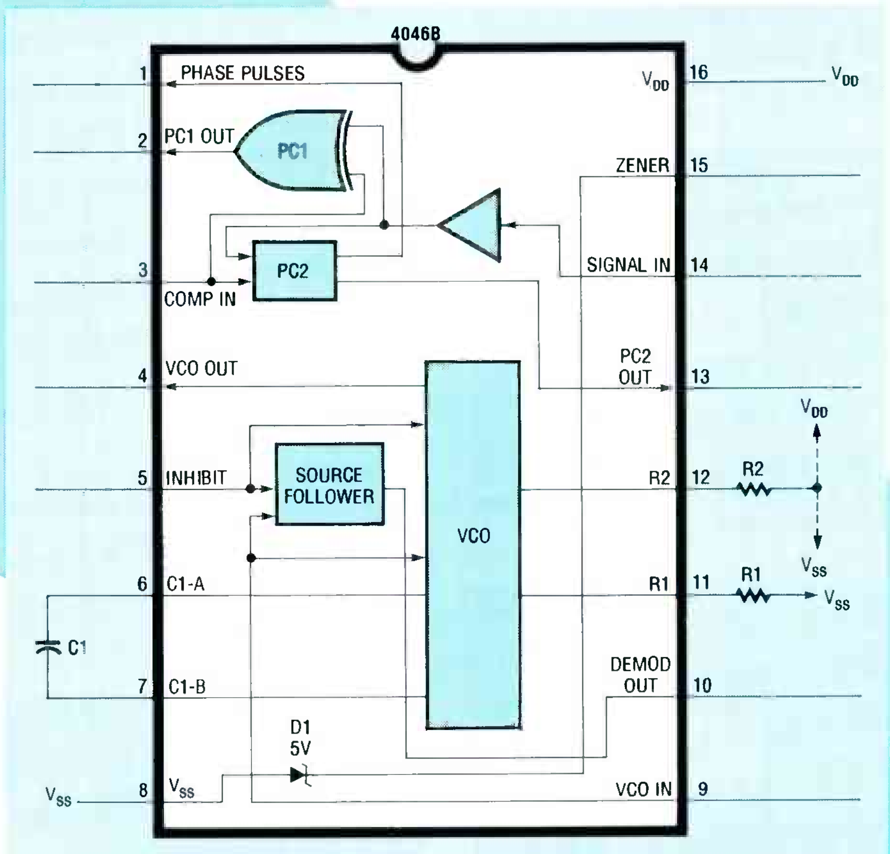


FIG. 1—INTERNAL BLOCK DIAGRAM of the 4046B micro-power CMOS PLL.

## 4046B basics

Figure 1 shows the internal block diagram and pinouts of the 4046B, with two different PC's, a Zener diode, and the VCO. PC1 is a simple XOR gate with good noise rejection, but needs square waves on pins 3 and 14, and has only a narrow capture-frequency range (span). PC2 is an edge-triggered logic/bistable memory version with a tristate output, can be driven by grossly asymmetric waveforms on pins 3 and 14, and has very wide span but somewhat poor noise rejection. The reason is that an XOR gate, being level-triggered, must have a lower frequency response than the edge-triggered/bistable version.

The VCO is wide-range, with a maximum operating frequency over 1 MHz determined by the voltage on pin 9, the capacitor between pins 6 and 7 (50 pF minimum), and R1 and R2. Also, R2 presets the minimum operating frequency, and can be eliminated in many applications. The symmetric square-wave VCO OUT appears on pin 4.

The VCO IN, pin 9, has almost infinite input impedance, and is driven from a high-impedance source. The source follower can be externally monitored on pin 10 without loading that source. The INHIBIT terminal, pin 5, is normally tied to $V_{SS}$, enabling both the VCO and source follower; both are disabled when pin 5 is grounded. The 5-volt Zener provides supply regulation if needed.

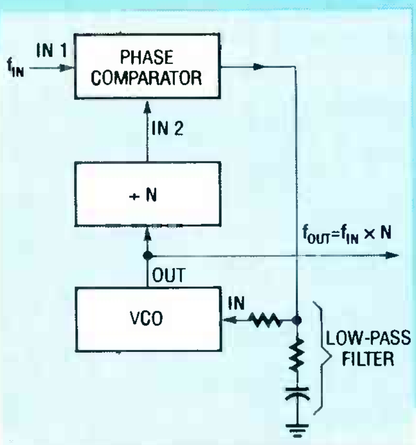


FIG. 2—BASIC PLL, WITH DIVIDE-BY-N COUNTER for frequency synthesis. For N=1 no frequency multiplication occurs, and the action is just that of a PLL.

## PLL basics

Figure 2 shows the basic 4046B PLL configuration, including frequency multiplier/synthesizer capability. Each PC has two inputs, INI

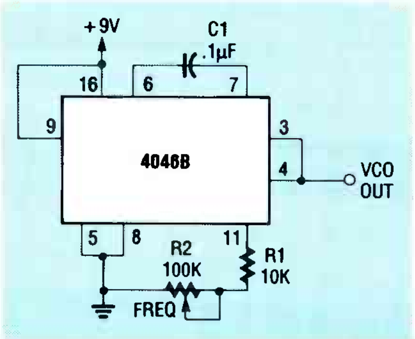


**FIG. 3—SIMPLE VARIABLE-FREQUENCY (200 Hz–2 kHz) square-wave generator.**

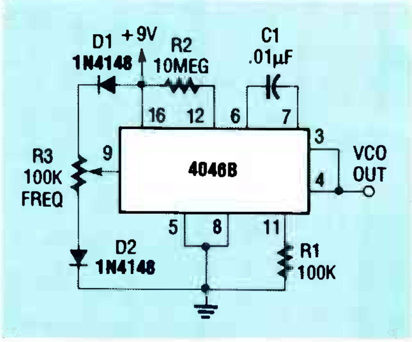


**FIG. 4—WIDE-RANGE VCO, fully variable from 0 Hz–1.4 kHz.**

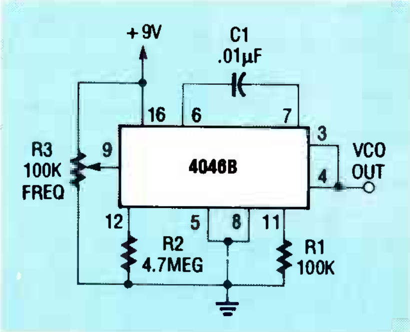


**FIG. 5—RESTRICTED-RANGE VCO, variable from 60 Hz–1.4 kHz via R2.**

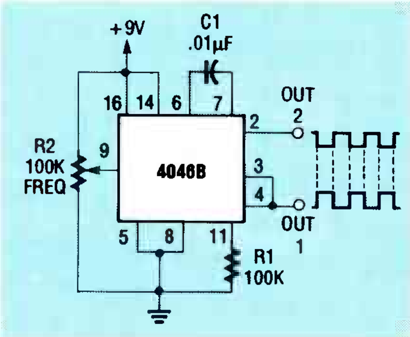


**FIG. 6—A BIPHASE WIDE-RANGE VCO.**

being fed using an external input, and IN2 by the VCO output through the divide-by-N counter. Of course, if N = 1 then no frequency multiplication occurs, and the action is just that of a PLL alone. The output is directly proportional to the phase difference between IN1 and IN2, smoothed via the *L*ow-*P*ass *F*ilter (LPF), and fed to IN2.

If the VCO frequency is less than that of IN1, the PC output goes positive, and the resulting filtered voltage increases the VCO frequency until it tracks IN1 in frequency and phase. If the VCO frequency is greater than that of the external input, the PC output decreases, causing the VCO output to phase-lock to IN1.

That may not seem immediately useful. However, the VCO generates a clean, symmetric output waveform, even if the external input waveform is noisy and asymmetric. Also, because the LPF has a finite time constant, the VCO tracks the *mean* phase and frequency of a rapidly-varying external input. A PLL can track and clean up slowly-varying external inputs, or track the center frequency of an FM signal and provide a demodulated signal at the PC output.

The VCO frequency adjusts so that the divider output frequency matches that of the external input, and the VCO frequency equals $N \times f_{IN}$. If the external input comes from a precision source (a crystal), signals of any frequency can be synthesized with equal precision using the appropriate N value. Some practical versions will be examined later.

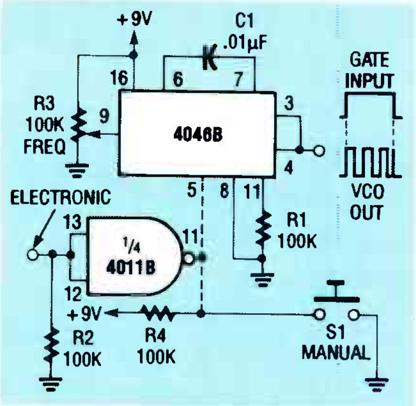


**FIG. 7—GATED WIDE-RANGE VCO, using either S1 or an external inverter.**

## VCO circuits

Figure 3 shows the simplest way to use the 4046B VCO. The voltage-control input (pin 9) is tied permanently high and the circuit acts as a basic square-wave oscillator, with variable frequency over a 10:1 range via R2. The VCO output (pin 4) is tied to the PC input (pin 3); if pin 3 is allowed to float, the PC's resonate at

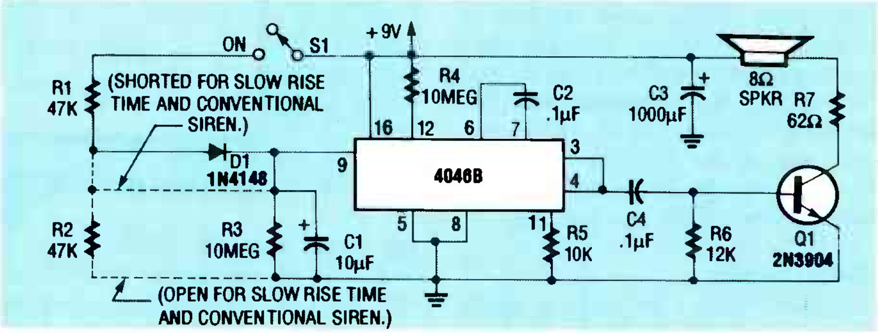


**FIG. 8—AN ELECTRONIC SIREN. For normal wailing tone, short D1 and open R2. For fast rise and slow fall in frequency, include D1 and R2.**

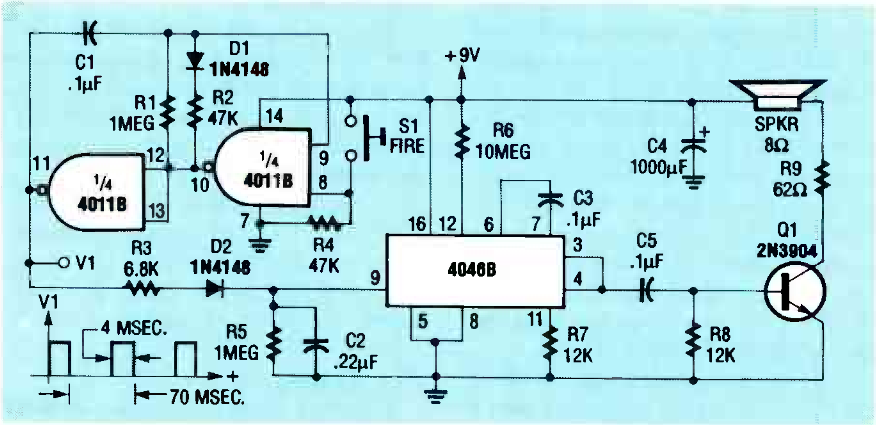


**FIG. 9—PHASOR-SOUND GENERATOR CIRCUIT.**

about 20 MHz and superimpose a signal on the top part of the VCO output waveform.

Figure 4 shows how to use the 4046B VCO in wide-range mode. Here, R1-C1 determines the maximum frequency obtained, and R2 controls the actual frequency via pin 9. The frequency falls to a few cycles per minute with pin 9 grounded. The effective control range of pin 9 varies from roughly 1 volt above ground to 1 volt below $V_{DD}$. Also, R2 has a dead range (hysteresis) of several hundred mV at either end of its span, eliminated by D1 and D2. The minimum operating frequency is reduced to zero by R2 on pin 12, in which case the VCO output randomly settles in either logic state.

Figure 5 shows a restricted-range VCO; R2 going to ground determines the minimum operating frequency. Here, $f_{MIN}$ is determined by R2-C1, and $f_{MAX}$ by C1 and R1-R2 in parallel. By suitable selection of R1 and R2, the restricted-range VCO can span any range from 1:1 to near-infinity. The VCO can generate 180 degree out-of-phase square waves by connecting the VCO output to the PC1 input, taking the external input (pin 14) high, and taking the anti-phase output from pin 2, as in Fig. 6.

The 4046B VCO can be disabled by taking INHIBIT (pin 5) high. That lets the VCO be gated on and off externally. Figure 7 shows how the VCO can be either manually gated via pushbutton on pin 5, or by an external inverter from a 4011B NAND gate.

## Sirens and sound-effects

Figure 8 shows the 4046B VCO in a siren circuit. For a conventional wailing tone, short D1 and leave out R2. When S1 is closed, C1 charges exponentially via R1, and the VCO frequency rises from zero to a maximum value. When S1 is opened, C1 discharges via R2 and the operating frequency decays to zero. The VCO output is AC-coupled to the speaker via C4 and Q1. For a "quick-start" tone, leave D1 unshorted, and include R2. In that case, C1 charges rapidly to ½-$V_{DD}$ via R1-R2 and D1 when S1 closes, and discharges via R3 when S1 is opened.

Figure 9 shows a "phasor" sound generator. The 4011B astable is gated by S1 to produce 4-millisecond pulses at 70-millisecond intervals. Each pulse rapidly charges C2 via R3-D2, producing a high tone that decays fairly slowly as C2 discharges via R5; the process repeated on the arrival of each pulse.

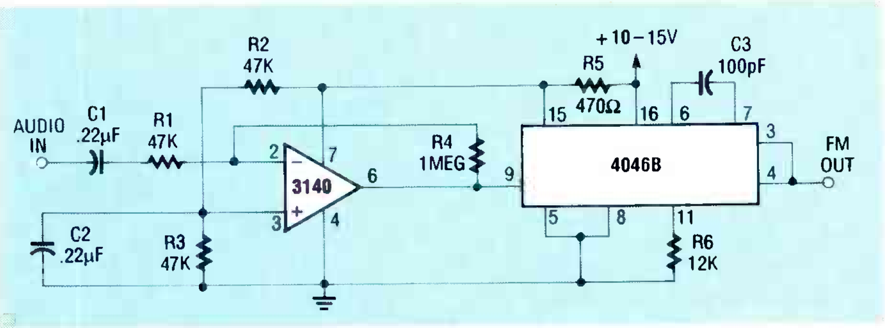


FIG. 10—FM GENERATOR using a 4046B and a 3140 op-amp, at 220 kHz.

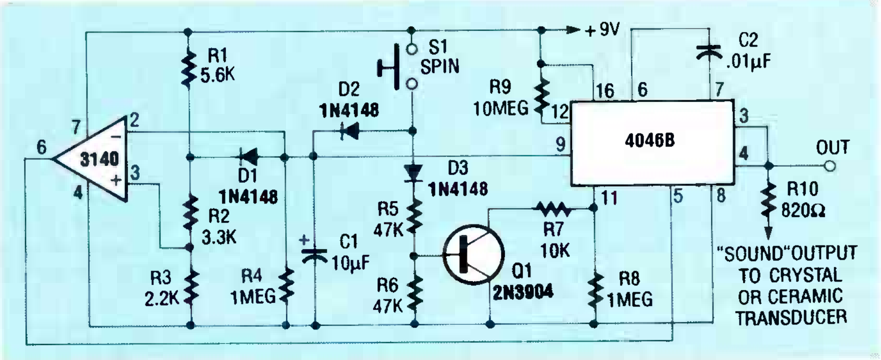


FIG. 11—RUN-DOWN CLOCK/SOUND GENERATOR, for use in dice or roulette games, where the output always settles in logic-0.

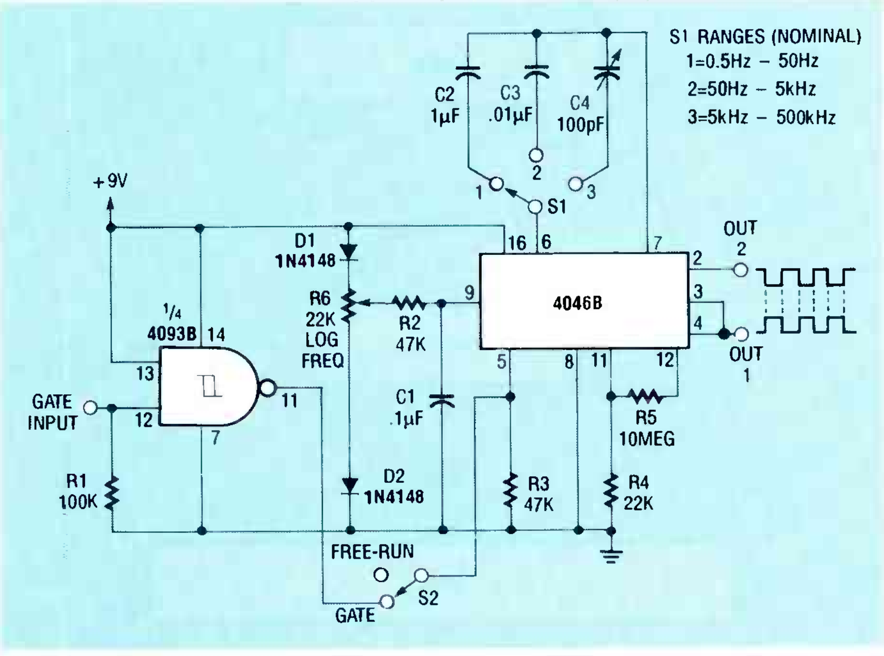


FIG. 12—UNIVERSAL CLOCK/SQUARE-WAVE GENERATOR over 0.5 Hz–500 kHz.

## Miscellaneous VCO circuits

Figure 10 shows a 220-kHz FM generator. The internal Zener on pin 15 of the 4046B provides a stable supply to the 3140 op-amp, biased at about 2 volts via R2-R3; the 2-volt VCO input on pin 9 of the 4046B is an amplified version (× 20) of the audio input, that modulates the VCO frequency.

Figure 11 shows a "run-down" clock generator used in dice and roulette games. When S1 is pressed, C1 charges via D2, while Q1 is biased on via D3-R5 and effectively connects R7 between pin 11 and ground. The VCO operates in the tens of kHz,

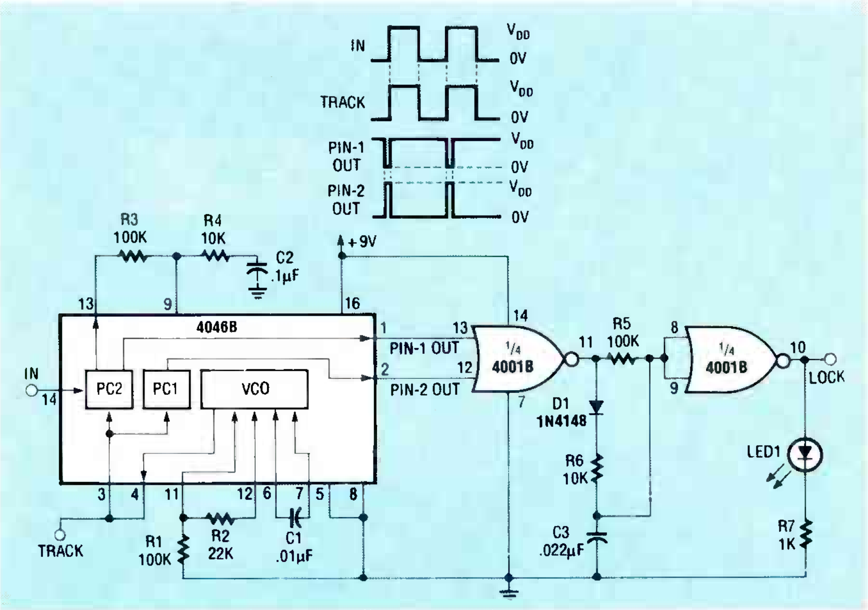


**FIG. 13—PRECISION NARROW-BAND TONE SWITCH (about 1.8–2.2 kHz) composed of a 4046B wide-range PLL signal tracker and lock detector using two 4001B NOR gates, showing waveforms obtained with the loop locked.**

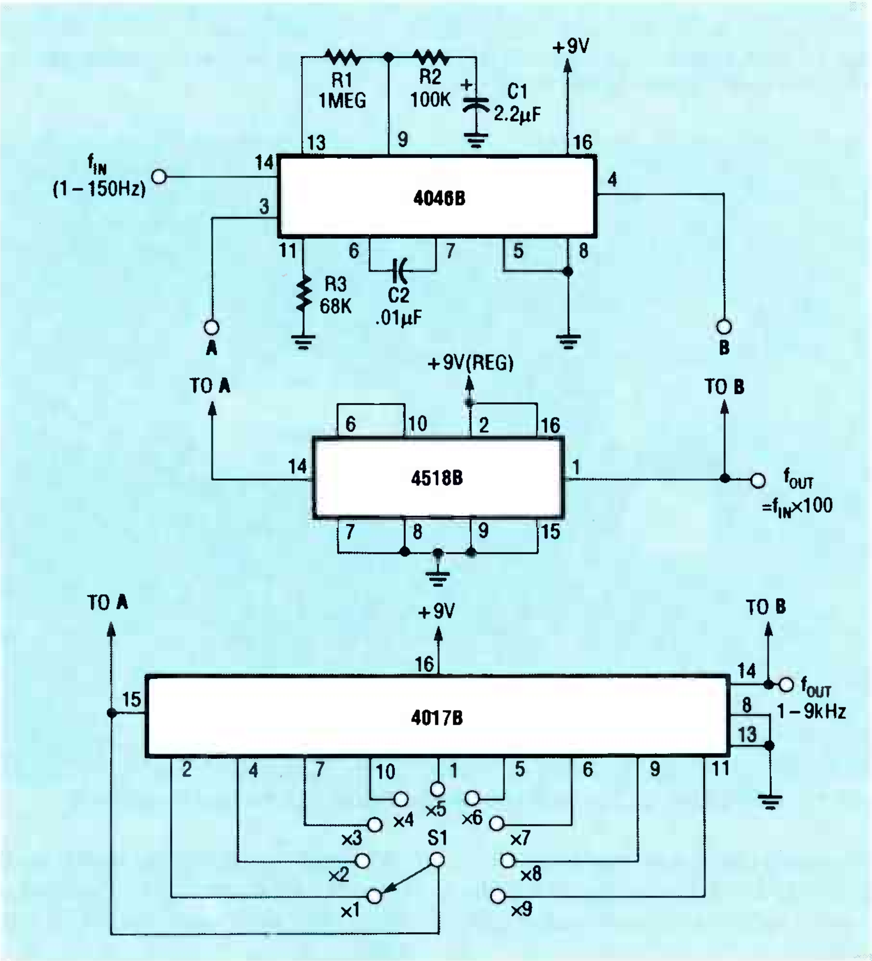


**FIG. 14—A 4046B PLL USED WITH EITHER a 4518B dual synchronous up counter as a ×100 low-frequency pre-scaler, or a 4017B decade counter as a simple ×1–×9 frequency synthesizer**

generating clock pulses until S1 is released. At that point, Q1 turns off and the VCO timing is governed by R8, while C1 rapidly discharges to ½-$V_{DD}$ via R1-R2-R3-D1, making the VCO operate at about 100 Hz. Next, C1 slowly discharges via R4, and the VCO frequency slowly decays to zero in about 15 seconds.

Figure 12 shows a simple but very useful 4046B VCO "universal" clock or square-wave generator, spanning 0.5 Hz–50 kHz in three switch-selected bands. A biphase output is provided, along with either free-running or gated modes.

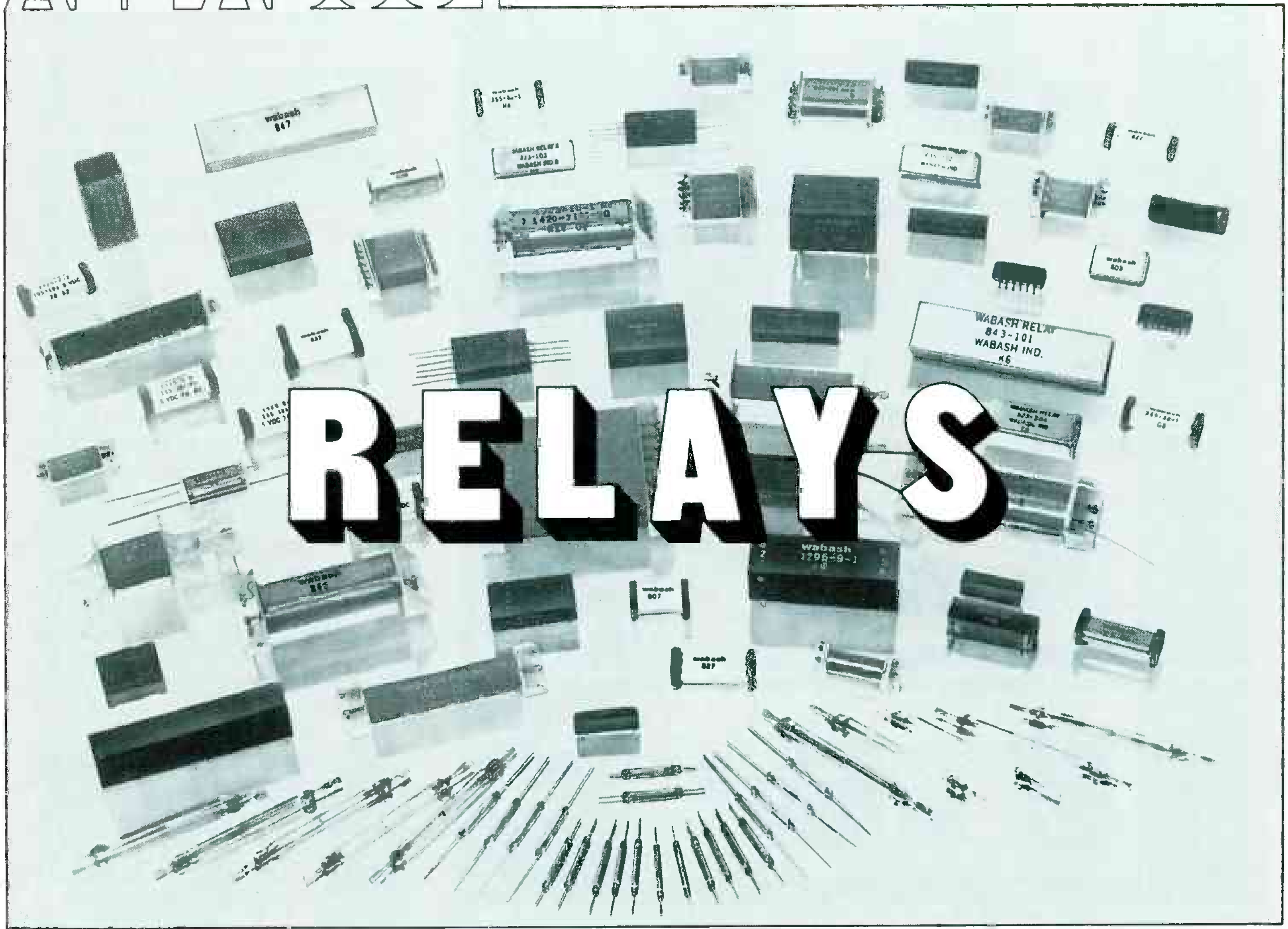
Figure 13 shows a PLL wide-range signal tracker combined with a "lock detector" in a precision narrow-band tone switch. The signal tracker captures and tracks any input within the approximate span 100 Hz–100 kHz, provided the input on pin 14 switches fully between logic-0 and logic-1. The circuit uses PC2, and can lock to any signal within the VCO span due to the wide range it provides.

Filter R3-R4-C2 is a sample-and-hold that determines signal capture, settling, and tracking times. The maximum VCO frequency is determined by R1×C1, the minimum by (R1+R2)×C1, and the pin-9 voltage for both. The VCO span, capture, and tracking ranges go from the VCO frequency with pin 9 grounded, to the maximum value with pin 9 at $V_{DD}$. In the lock detector, each PC output is a series of pulses with widths proportional to the phase difference between the two PC inputs. The PC1 output is low and the PC2 output is high, except for those pulses.

When the PLL is locked, the two PC outputs are almost perfect mirror images, and the output of IC1-a remains low, driving the output of IC1-b high and lighting LED1. If the loop isn't locked, the output of IC1-a is a series of positive-going pulses that rapidly charge C1 via D1-R6, forcing the output of IC1-b low, keeping LED1 off.

Figure 14 shows a 4046B with either a 4518B dual synchronous up/down counter in a ×100 frequency prescaler, or a 4017B decade counter as a ×1–×9 frequency multiplier, depending on which counter IC is connected between A and B. The prescaler can upconvert 1–150 Hz in to 150 Hz–15 kHz out; the 4518B contains a pair of decade counters configured as a divide-by-100. The frequency multiplier generates an output, the frequency of which is ×1–×9 that of the input. The 4017B is replaceable by a string of programmable decade counters to give a wider 10 Hz–1 MHz range. **R-E**

# ALL ABOUT RELAYS



## *Understanding Relays, Part II: Solid-state versions*

**HARRY L. TRIETLEY**

LAST MONTH, WE EXAMINED ELECtromechanical relays in depth. This month, we'll examine solid-state versions, including how to build your own. Like the electromechanical variety, solid-state relays use low-level signals to switch isolated loads. However, instead of mechanical contacts, solid-state models use transistors or thyristors (SCR's or triacs) to switch a load.

Control-to-load isolation is provided either by optoisolators or transformers. Solid-state relays are available in AC and DC versions; Fig. 1 shows typical block diagrams. All approaches shown use an optoisolator to separate the control and drive segments. Figures 1-*c* and 1-*d* need a rectifier and filter for AC input. Figures 1-*a* and 1-*c* use a drive circuit, an NPN transistor, Zener transient suppression, and reverse-biased inductive load diode for DC output. Figures 1-*b* and 1-*d* use a zero voltage switch, an RC snubber filter, and a triac for AC output.

Virtually all solid-state relays are *S*ingle-*P*ole *S*ingle- *T*hrow, *N*ormally *O*pen (SPST-NO) devices, where the outputs turn on in response to a control voltage. The majority take operating power from the control I/O, although some require separate DC logic power. The simplest DC input circuits use an LED optoisolator and series current-limiting resistor.

The resistor is usually sized for a 5-volt logic input, and results in a specified "ON" range of 3–6 volts DC. For wider operating ranges (typically 4–32 volts DC), the resistor is replaced by a constant-current diode. Then, AC input circuits rectify and filter the control input before applying it to the LED. Typical AC/DC LED currents are 5–20 mA.

### AC and DC outputs

The optoisolator photocurrent is amplified and used to drive whatever output device the relay is connected to, whether a transistor for DC outputs, a thryistor for AC, or a power MOSFET for either. The power for the drive circuitry is taken either from the output load or is supplied separately. In some MOSFET designs, the photocurrent is sufficient to drive the output device. Table 1 summarizes typical specifications.

Normally, DC output devices like those in Figs. 1-*a* and 1-*b* use an NPN

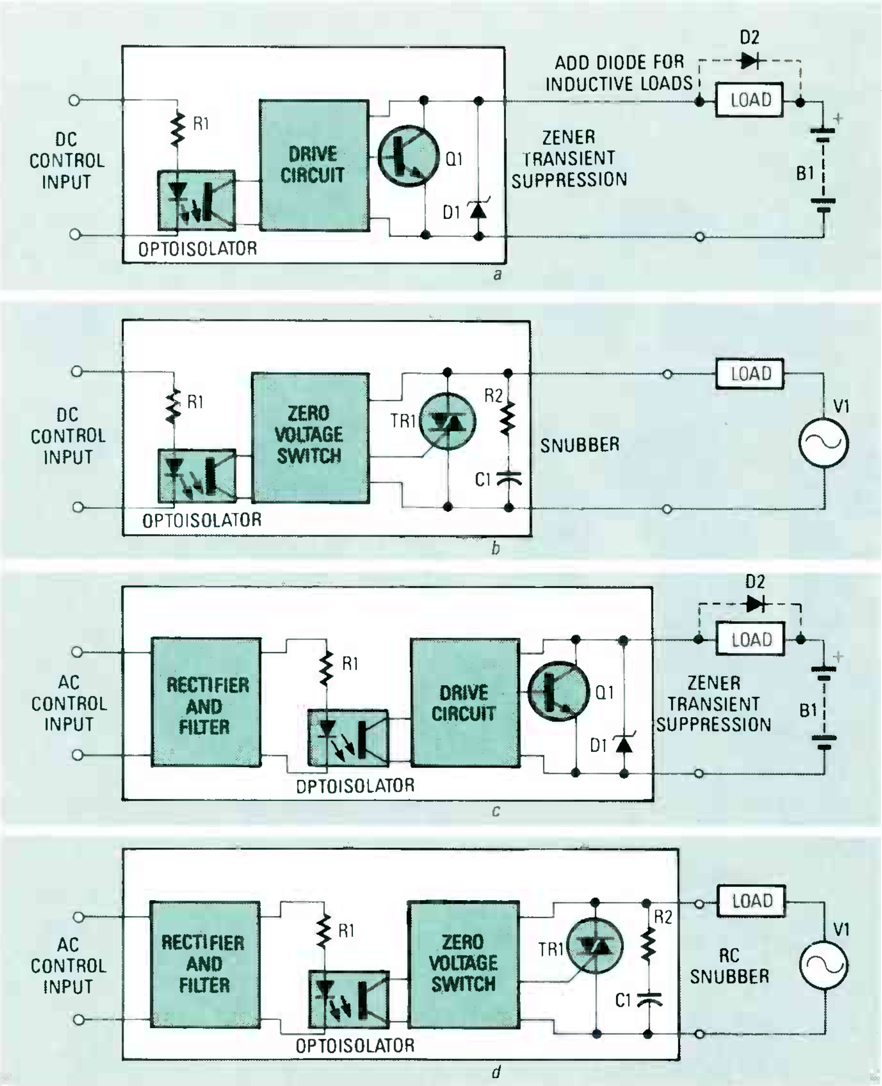


**FIG. 1—SOLID-STATE RELAY INPUTS AND OUTPUTS may be designed for AC/DC. All approaches shown use an optoisolator to separate the control and drive segments.**

transistor, and may include a Zener diode across the output for transient suppression. The transistor will drop some voltage in the "ON" state, and the drive circuit will need some current to operate. Typical output drop is 1–2 volts at the full rated load current, while the "OFF"-state leakage may range from approximately 10 µA–1 mA.

Most AC output devices include zero-voltage-switching circuitry. Logic detects when the AC load voltage crosses zero (changes polarity) and delays the triac turn-on pulse until then. The triac turns on at the next zero crossing after the input goes high. Once triggered, it remains on until its current goes to zero. Zero-voltage and zero-current switching minimize transients and *E*lectro*M*agnetic *I*nterference (EMI). The RC snubber in Figs. 1-*b* and 1-*d* suppresses rapid voltage changes that can inadvertently turn on the thyristor.

In some applications, having the output turn on instantly is desirable. Relays referred to as "random turn-on" are designed without zero-voltage switching. Turn-off still occurs at zero current, due to the inherent latching effect of thryistors. As with DC-output relays, the thyristor drops voltage while conducting, while the drive circuitry requires power to operate. In addition, the snubber passes AC leakage in the "OFF" state. Typical "ON"-state voltage is 1.6 volts, while "OFF"-state leakage is 2–10 mA for 60-Hz power.

With recent advances in power MOSFET's, solid-state relays can be designed with lower "ON"-state voltage drops, and greatly reduced "OFF"-state leakage. These MOSFET's offer bidirectional current flow, near-zero gate-drive current, no inherent source-to-drain offset voltage, and low "ON"-state resistance and "OFF"-state leakage.

Due to near-zero gate current, power MOSFET's can be driven directly from a series stack of photodiode junctions, as in Fig. 2. The "photovoltaic-generator" stack from International Rectifier shown in Fig. 3 is constructed using IC fabrication techniques, and exposes a series of photodiodes to LED illumination. No operating power is required from the load.

Most FET-output relays are housed in *D*ual-*I*nline *P*ackages (DIP's). Their main use is as a replacement for reed relays, where low offset and low leakage are important, and for control of low-power AC/DC loads. High-power AC loads are best controlled by thyristors, which are easily controlled for zero-voltage turn-on; they also offer inherent zero-current turnoff, and produce lower output-voltage drop at high currents.

However, FET design involves tradeoffs in voltage, current and resistance specs. In particular, high-voltage FET's have higher "ON"

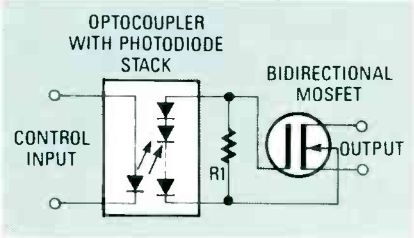


**FIG. 2—DUE TO NEAR-ZERO gate current, power MOSFET's can be driven directly by a series stack of photodiode junctions.**

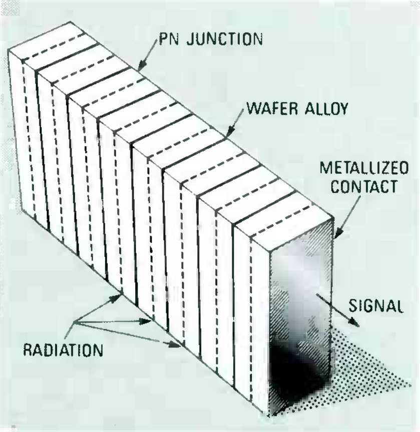


**FIG. 3—A PHOTODIODE junction stack, known as a photovoltaic generator, from International Rectifier. It's constructed using IC-fabrication techniques, and exposes a series of photodiodes to LED illumination. No operating power is required from the load.**

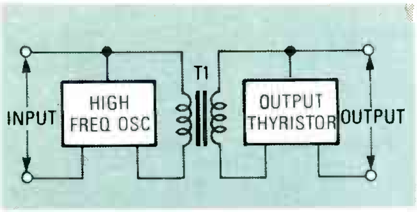


**FIG. 4—I/O ISOLATION may be provided by this transformer-coupled AC output oscillator relay. It's powered by a control input which drives a thyristor though a transformer.**

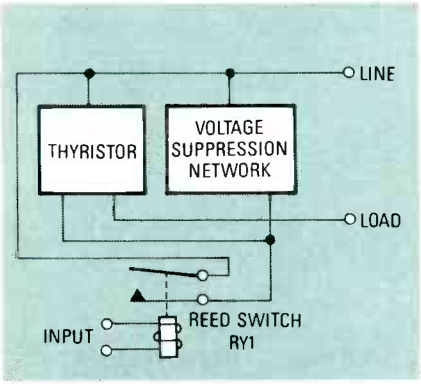


**FIG. 5—HYBRID RELAYS marry reed relay input with solid-state power output to control a thyristor. The reed contacts switch low power only, and turn-on time is that of the reed relay; about 1 msec.**

resistances, making them unsuitable for switching high-current line-voltage loads. Typical DIP relays have 70–500-mA current ratings, "OFF"-state leakage resistances of 100 Megohms or more, and "ON" resistances from about one ohm for a 60–100-volt rating, to 25–50 ohms for a 300–400-volt rating. Switching times range from 10–100 μsec.

## I/O isolation

The majority of solid-state relays use optoisolators. All offer at least 1.5-kilovolt RMS I/O breakdown, and 2.5- or 4-kilovolt ratings are common. Most of them have been rated, listed, or approved by safety agencies like UL, CSA, and VDE. Transformer coupling is also used to isolate solid-state relays.

Figure 4 shows a transformer-coupled AC-output relay; DC and AC/DC FET relays are also available with transformer coupling. The control input powers an oscillator, the output of which is coupled through a small pulse transformer to trigger the output thyristor. Circuitry of the type shown produces random turn-on operation; transformer-coupled relays generally don't include zero-voltage switching circuitry.

Transformer coupling allows faster switching. The oscillator frequency is typically 1–3 MHz, resulting in switching times as low as 1 μsec. Optoisolators exhibit slower response, with times for DC versions typically 10–100 μsec. They can be designed for slightly higher temperatures, being free of LED limitations. However, achieving breakdown voltages above 1.5 kilovolts is easier using optical techniques.

## Hybrid relays

Hybrid relays marry reed relays with a solid-state power output. Figure 5 shows a thyristor version; DC outputs are also offered. The hermetically sealed reed contacts switch only low power, and last 10 million operations or longer. The turn-on time is that of the reed relay, about 1 msec. Other hybrid relays are the reverse, using a solid-state input amplifier driving a reed-relay output, the obvious advantage being high input sensitivity. The term "hybrid" sometimes describes construction technique, rather than method of operation. In some catalogs you'll find hybrid solid-state relays with no mechanical components at all.

## Self-powered and buffered relays

So far, all the relays that have been discussed until now have been "self-powered," in that they take operating power from the applied signals. All models, whether optoisolated, transformer coupled, or hybrid, require approximately 5–50 mA at their inputs. Some, notably thyristor-output relays with zero-voltage switching, also take operating power from output loads, although none require separate power connections.

Buffered relays offer improved input sensitivity at the expense of needing separate DC power, and are usually used in systems that already include DC power supplies (not as stand-alone devices). Figure 6 shows a buffered DC-output relay. The input circuitry and the LED are powered from a separate logic supply, allowing the logic input current to be typically 25–250 μA.

## Package styles

Solid-state relays are generally grouped into DIP's, power relays, and I/O modules. DIP relays are available with transistor (DC), thyristor (AC), or MOSFET (AC/DC) outputs, and with optoisolator or transformer coupling. Most power relays are used to switch AC power, and use thyristor switching with optoisolator coupling. Transistor (DC) outputs and transformer coupling are also available.

I/O modules are always optocoupled, and don't offer MOSFET outputs; Fig. 7-*a* shows an IC DIP version, Fig 7-*b* a power version, and Fig. 7-*c* an I/O module. The DIP versions have transistor (DC), thyristor (AC), or MOSFET (AC/DC) outputs, and either optoisolator or transformer coupling. Most power types use thyristor switching with optoisolator coupling for AC power; transistor outputs and transformer coupling are available. I/O modules are always optocoupled, and don't offer MOSFET outputs. Their characteristics are summarized in Table 1.

DIP relays look just like IC's; most often, 8- or 14-pin DIP's. Rated load currents are a fraction of an ampere, with voltage ratings from 60–300 volts. Since many can fit on a PC board, they're very handy for interfacing logic signals to the outside world in digital control systems. MOSFET-output relays also make excellent replacements for reed relays in measurement and data-acquisition applications. Edge-mounted SIP (single-inline package) relays also are made. Military-grade relays are pack-

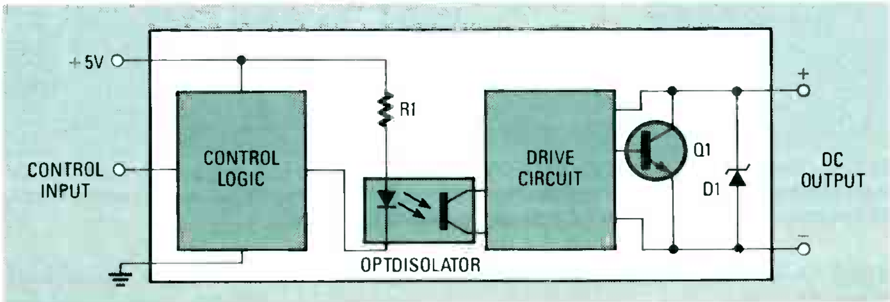


**FIG. 6—THE BUFFERED DC-OUTPUT RELAY ADDS externally-powered input circuitry to reduce control current requirements. The input circuitry and the LED are powered from a separate logic supply, letting the logic input current be 25–250 μA.**

### TABLE 1—SOLID-STATE RELAY OUTPUT SPECIFICATIONS

| Output | AC/DC | Package Style | Max. Load Currents | Max. Load Voltages | Voltage Drop (on) at Rated Load | Leakage Current (off) At 25° C |
|---|---|---|---|---|---|---|
| Bipolar Transistor | DC | Dual Inline (DIP) | 500 mA<br>50 mA | 60 VDC<br>250 VDC | 1 to 1.5 V | 20 μA |
| | | Input/ Output Module | 3.5 A<br>1 A | 60 VDC<br>200 VDC | 1.2 to 1.75 V | 10 μA to 1mA |
| | | Power | 2 to 20 A | 50 VDC | 1.5 to 2V | 5 to 15 mA |
| | | Power (High Voltage) | to 5 A | 250 VDC | 2 V | 10 μA |
| Thyristor (Triac or SCR) | AC | Dual Inline (DIP) | 0.3 to 1 A RMS (to 3 A RMS with heat sink) | 140 or 280 V RMS | 1.5 V max | 10 μA to 1mA |
| | | Input/ Output Module | 3.5 A RMS | 140 or 280 V RMS | 1.5 V max | 2 to 5 mA |
| | | Power | 10 to 40 A RMS | 140 to 480 V RMS | 1.5 V max | 2 to 15 mA |
| Power MOSFET | AC/DC | Dual Inline (DIP) | 100 to 500 mA (Some to 1 A) | 60 to 300 V | Resistance 0.25 to 50 ohms | Resistance typically 100 megohms |

**FIG. 7—THE THREE most common solid- state relay styles are the (*a*) IC DIP, (*b*) power, and (*c*) I/O module varieties.**

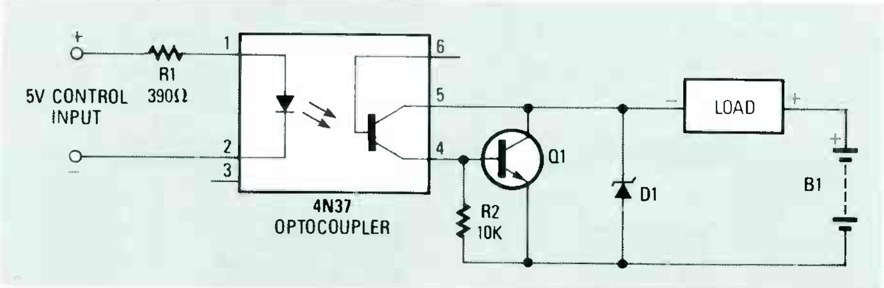


**FIG. 8—THIS BASIC DC IN, DC OUT I/O RELAY switches up to 5 amps at 60 volts DC. It's built around a Motorola 4N37 optoisolator, which passes up to 30 mA output with a 10 mA LED current, while providing 1.5 kilovolts peak I/O isolation.**

aged in hermetically-sealed TO-5 transistor cans.

Power relays look very similar to the one in Fig. 7, common sizes being about 2-3 inches on a side. Rated load currents are 10–40 amps, making them suitable for switching all but heavy industrial power loads. Smaller power relays are also available, including some PC board versions. I/O modules are used primarily in microprocessor-based data acquisition and control systems, although they can be used in other applications where they

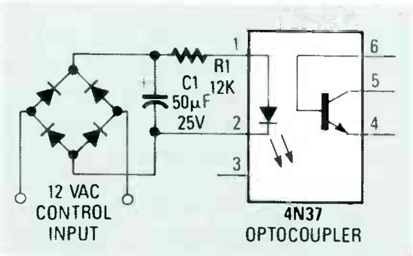


**FIG. 9—ADDING A DIODE BRIDGE and filter capacitor converts the control input to AC.**

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plug into mating multi-channel I/O boards; their normal size is about 1-2 inches on a side.

"Output" modules convert logic signals to AC/DC switched outputs, acting just like the relays examined thus far. They plug into racks of 4, 8 or 16, and can be connected to a computer or microprocessor to control power devices drawing up to 3.5 amps, or to drive power relays for heavier loads. "Input" modules do the reverse.

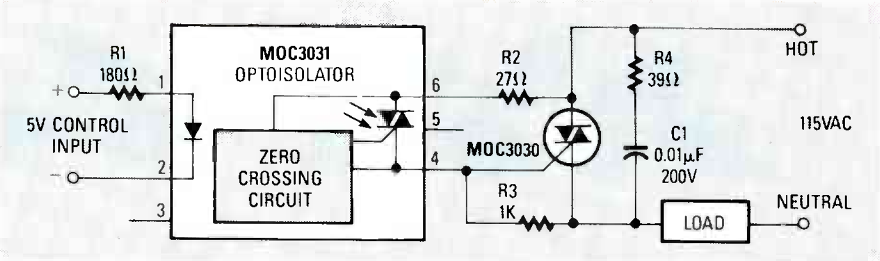

FIG. 10—THE MOTOROLA MOC3031 OPTOISOLATOR WITH built-in zero-voltage switching simplifies design of this solid-state AC output relay. The MOC3031 is optimized for use with 120-volt AC, and provides up to 7.5 kilovolts peak I/O isolation. However, you'll need to keep both input and output well separated.

### When to use solid-state relays

The advantages of solid-state relays are fast switching and no mechanical contacts to wear, burn, pit, or corrode, hence clean switching with no contact bounce, and immunity to shock and vibration. Their life should be unlimited, barring electrical surge or overload damage. Their low drive requirements often enable them to be driven directly from logic IC's.

Some have features like noise suppression or overload sensing. The latter shuts the relay off until it's reset, letting it act as a circuit breaker. Their I/O isolation equals that of mechanical versions, and there are no inductive coil surges. AC-output relays with zero-voltage and zero-current switching minimize EMI.

Their major disadvantage is that their outputs are never completely ON/OFF, as shown in Table 1. If the "ON" resistance or "OFF" leakage is of prime importance, use a mechanical device. Also, when switching power, remember that the load is never "OFF." The several-mA leakage current of AC power relays is a very real shock hazard.

### Switching AC loads

AC loads can be switched using either thyristors or power MOSFET's, the latter generally limited to loads under 1 amp. A thyristor is a regenerative, positive-feedback device which, upon triggering, conducts until the current through it goes to zero. When a thyristor is in the "OFF" state, the voltage across it changes rapidly, capacitive coupling within can produce a sufficiently high pulse to cause conduction. The RC snubber in Figs. 1-*b* and 1-*d* reduces the effect.

AC relays specify a maximum rate of change of typically 100–200 volts/μsec for power devices, and higher (500–1000 volts/μsec and above) for DIP versions and other small models. Normally, 100–200 volts/μsec is adequate for most loads, but inductive loads need special caution. Since a thyristor turns off when its current reaches zero, and an inductor's current lags its voltage, the supply voltage won't be zero when the relay turns off. When the relay opens, the supply voltage will appear across the thyristor, producing a very high rate of change.

Purely inductive loads are a problem for any relay or switch. Fortunately, most real loads such as motors are both inductive and resistive. For highly inductive loads, select a relay with a high rate-of-change rating. Some AC power relays specify maximum motor horsepower or a minimum load power factor.

Incandescent lamps have high initial currents due to the cold filament resistance. Most relays specify peak as well as steady-state surge current. For lamps, a relay should be capable of handling five times the lamp current for 1 sec. Transformers can also draw high initial currents, so you should allow for a one-half cycle surge current equal to the line voltage divided by the resistance of the transformer primary ($I = E/R$). Finally, most thyristor relays are designed for use only at or near 60-Hz.

### Building your own

Although solid-state models are readily available at moderate cost, you may want to design your own. That will not only afford greater packaging flexibility, but will let you tailor I/O characteristics. Low-cost optoisolator IC's make designing your own easy. Figure 8 shows a basic DC I/O model built around a Motorola 4N37 optoisolator, which passes up to 30-mA output with a 10-mA LED current, while providing 1.5 kilovolts peak I/O isolation.

The output characteristics depend mainly on the output transistor; the type you use depends on whether you want high power or minimum leakage current. With the 2N5337 shown, the relay can switch up to 60 volts and 5 amps DC; OFF-state leakage is a few microamps. The Zener protects against voltage transients and inductive turn-off. The input resistor is suited to 10 mA at 5 volts; increase for higher inputs. The LED drops 1.1 V, so:

$$R = (V_{IN} - 1.1 \text{ volts})/10 \text{ mA}.$$

The value isn't critical, although operation at lower currents will reduce available output current; the LED can handle up to 60 mA continuously. Figure 9 shows modifications for AC control. Building a zero-voltage-switching AC output relay is almost as easy, as in Fig. 10. The Motorola MOC3031 optoisolator provides built-in zero-voltage switching and triac driver circuitry optimized for 120 volts AC. It also provides up to 7.5 kilovolts peak I/O isolation, but you'll need to keep both the input and output well separated.

Figure 10 is from the Motorola spec sheet; R1 is selected for 20 mA at 5 volts. Or, you can add a bridge and filtering for AC control; R2, R4 and C1 provide "snubbing" of inductive loads. If the load is very inductive then increase R2 to 360 ohms. The breakdown voltage of C1 must be higher than the peak line voltage.

Output voltage and current capabilities depend on the triac used. The circuit shown will switch 120 volts at 15 amps RMS, if the triac is heat-sink mounted. Substitute optoisolator MOC3041 and triac MOC3040 for 240 volts RMS. OFF current through the snubber will be 400 μA at 120 volts. If the OFF leakage is important, and you'll be switching resistive loads like heaters or incandescent lamps, then the snubber can be reduced or eliminated. **R-E**

# AUDIO UPDATE

**LARRY KLEIN,**
AUDIO EDITOR

## Are there sonic differences among CD players?

LAST MONTH WE LOOKED AT THE AUDIO community's reactions, pro and con, to the introduction of the digital compact disc. Many dedicated audiophiles and LP collectors complained that, compared to LP's, many—if not most—CD's sounded harsh, constricted, and unmusical. Because the first transistor amplifiers produced the same sort of complaints, I tended to dismiss the critics as simply having emotional or financial vested interests in LP technology. Ultimately, it turned out that many CD's *did* sound bad—not because the music had been chopped into digital bits as the critics claimed, but simply because many recording and record-mastering engineers were unable to adapt to the different demands of the new medium. The many excellent-sounding CD's currently available are sufficient proof that there is nothing inherently wrong with the CD format.

### Player problems

One of the claims made in favor of the compact disc is that individual players that conform to the CD standard will all sound essentially alike when working correctly. In other words, a given data stream on a disc will produce from any player a wide-range audio signal with vanishingly low distortion, noise, and wow and flutter.

Leaving aside acknowledged differences in the players' ability to resist external shock and vibration and to ignore varying degrees of disc flaws, do all the machines sound essentially alike, as many of the more technical critics claim? As you might suspect, dedicated audiophiles claim that each brand and model of player sounds different. Their view is not surprising since those on the outer audio fringes regularly perceive differences that are not only imperceptible to ordinary mortal ears, but also usually defy measurement. But given the release of so many sonically flawed CD's, is it safe to say that the marketplace hasn't been subjected to equally flawed players?

Aside from the regular annual tests run by *Consumer Reports* there have been two fairly rigorous comparative-listening tests conducted by *Stereo Review*, a large mainstream hi-fi publication. The first tests appeared in the January 1986 issue and involved a disparate group of six players ranging in price from an under-$200 Emerson to a $1,300 Sony. The second series of comparative-listening tests (in the December 1988 issue) was performed on six pricey ($750–$2,500) "state-of-the-art" machines. All tests were carefully controlled, using specially qualified listeners working with the sophisticated ABX test device.

### Test techniques

Two players at a time were connected to the ABX test unit's input; its output was connected to a very-high-quality reference audio system. During each trial in the series of listening tests, a logic circuit in the ABX comparator randomly chose one of the two CD players to serve as X. The listener was instructed to take as much time as he liked switching between A, B, and X. His task was to decide whether the sound of player A or B was identical to that of the machine-selected X. The ABX's microprocessor kept track of its random choice of X for subsequent comparison with the listeners' written choices. For each listener, every player was compared with every other player for a total of 50 trials.

The beauty of the ABX system is that the listener is not forced to make value judgments, but is asked only to indicate whether he hears a difference between components A, B, and reference X, when X can be either A or B. If the listener can reliably identify A or B as sounding different from (or the same as) X, then it can be said that there is an audible difference between the two components under test. If the choices come out no better than chance, it is evident that the listener is not hearing a difference, even though he might believe he is.

### Test results

Since I would rather not drag the reader through a rather dull discussion of the design and statistical mathematics of the ABX double-blind test procedures, let it suffice to say that I have no complaints with either the test techniques or the statistical analysis used in the two series of tests. However, I do have a mild quarrel with some of the article's conclusions.

As with previous tests, the most

*continued on page 88*

# HARDWARE HACKER

Optical reprint sources
Hacker pc breakthough
Clock and doorbell chip
Faking double-sided boards
Printed circuit resource list

## PC-board breakthrough

**DON LANCASTER**

OUR STUPENDOUSLY MAJOR NEW breakthrough for this month is a brand new way of doing hacker printed-circuit boards that I'll call the *direct toner method*. Believe it or not, all you need is an iron and your favorite word processor.

This new process is ridiculously faster, simpler, and cheaper than any of the old ways. Since it's so new, we sure could use your personal help in further testing and debugging.

But first, let's review some of the older ways of making printed-circuit boards. We might start off by going over some...

### Circuit-board fundamentals

Printed circuit boards first became popular in the early 1950's because of their overwhelming advantages over point-to-point wiring. The PC wiring pattern was always the same, virtually eliminating wiring errors. Stray inductance and capacitance were much lower and far more uniform. And the manufacturing could be totally automated. Production times became much shorter, and labor costs dropped sharply. So did size and weight.

A printed-circuit board often will consist of an insulating *substrate* that has one or more layers of conducting patterns placed on or in it. Figure 1 shows some popular forms of printed-circuit boards.

You will find three main substrate materials in use today. They include phenolic, FR-4 (or G-10) glass epoxy, and CEM-1 composite epoxies. While phenolic is the cheapest, it does chip and shatter easily, and should be heated before punching or drilling. It is often used for single-sided layouts in toys, appliances, and any other high-volume applications. For us hackers, phenolic is nearly useless.

Glass epoxy is pretty near the same stuff that a fiberglass boat is made of. It has great electrical and mechanical properties, and is nearly ideal for any double-sided and multilayer boards. Hacker disadvantages are that glass epoxy costs more and dulls drills at an amazing rate. Carbide drills are just about mandatory for all but the shortest of production runs.

The CEM-1 material has only a pair of fiberglass layers impregnated into an epoxy body. Because it's cheaper and easier to drill than glass epoxy, it's a good choice for hacker use. It also drills and punches well. Glass-epoxy boards are well suited for all but the most precise and exacting needs. They even come in a wide variety of colors.

The simplest variation is a *single-sided* board. The substrate is most often 1/16th of an inch thick, and has a single layer of copper foil laminated to one surface only. Two popular thicknesses of copper are used. *One-ounce* copper is around 0.00135 inches thick; *two-ounce* copper is double that, or around 0.00270 inches thick.

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**Synergetics**
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Thatcher, AZ 85552
(602) 428-4073

Thus, one-ounce copper is a tad over one mil thick, and two-ounce copper is somewhat over two mils thick. Two-ounce copper is normally reserved for higher-current uses or where extreme reliability is needed.

On a traditional single-sided circuit board, most of the components get mounted on the bare side of the board, giving us a *component side* and a *foil side* to work with. That allows a dip, a reflow, or wave soldering of all the parts at once. The components tend to pull the foil toward the substrate, rather than trying to peel the foil from the board.

Single-sided boards limit both your minimum size and how much you can connect where, unless you go to an unacceptable number of interconnecting jumpers. Because of that, most modern boards are *double-sided*, and have foil on both surfaces. While the most common means of routing connections between the two board sides is with *plated-through holes*, hacker alternatives are eyelets, wire tabs, the component leads by themselves, or individual socket pins. *Mill-Max* is a leading source of low-cost socket pins, and *Stimpson* is a good eyelet source.

A double-sided plate-through

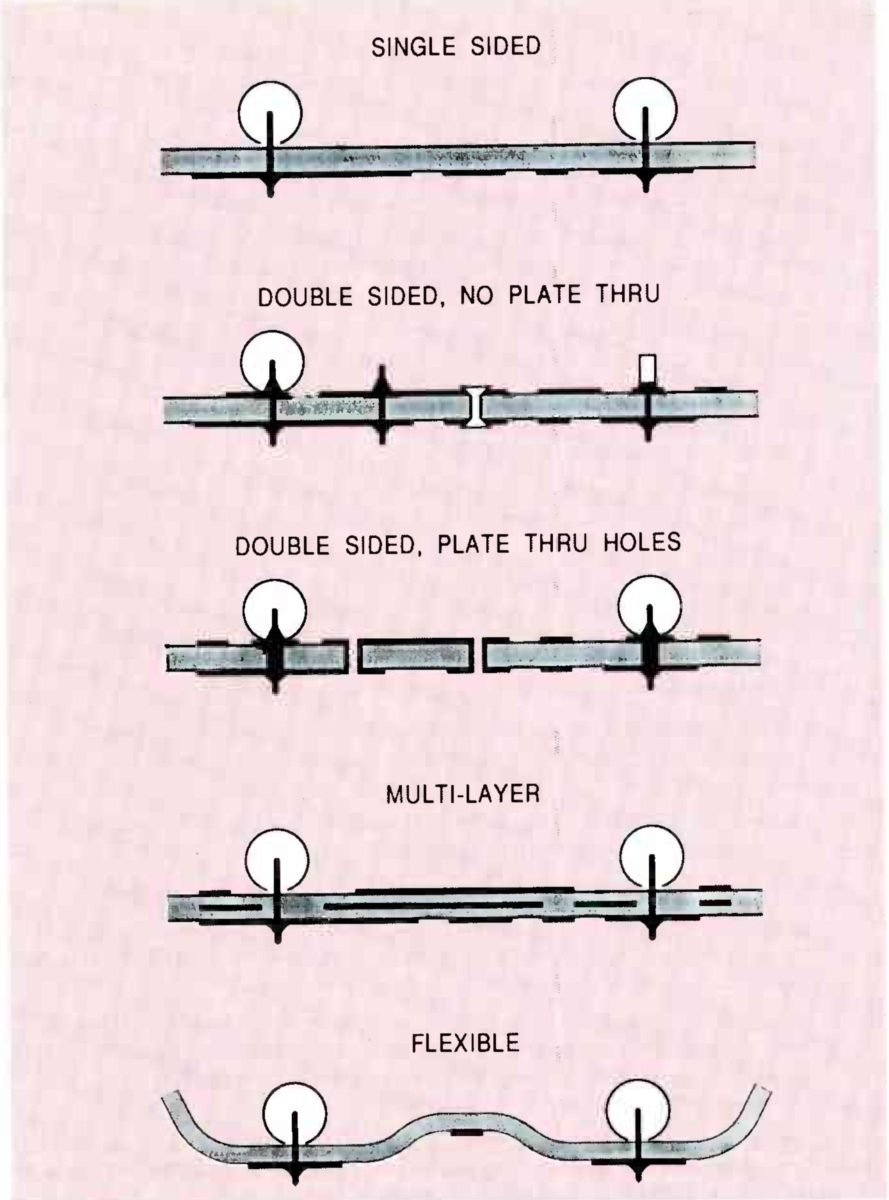


**FIG. 1—SEVERAL POPULAR TYPES of printed-circuit boards. Note that a double-sided plate-through board can be hacker-faked by using component leads, eyelets, wire tabs, or low-cost individual pin sockets.**

setup is beyond what most hackers would care to attempt. The tanks and such alone can set you back the better part of $10,000.00. Nasty chemicals are involved that are hard to get in small quantities. Worse yet, it takes a long time and involves several dozen steps, all of which have to function perfectly to ever get any product out at the far end. You could farm out a lot of prototype boards at $30 to $60 before you could ever justify the investment.

Fortunately, the latest of the *surface-mount* technology components tend to greatly minimize both the number of holes and the need for plate-through. So jumpers, eyelets, or individual socket pins are not really all that bad an alternative for your prototype boards.

The next step beyond double-layer boards are *multi-layer* boards, where circuitry is placed *inside* the substrate, as well as on both surfaces. Typically, there will be four layers. Your horizontal runs will dominate on the top surface, followed by a lower power-supply plane, a ground plane that is lower still, and the vertical runs that dominate the bottom surface.

As you might guess, all four-layer boards are quite expensive and are extremely hard to modify, but they do offer superior shielding and extreme component densities. Multi-layer PC boards as dense as 24 layers have been built. Quite often, the multi-layer PC board will be the most expensive part of an electronic system.

Flexible boards are also becoming popular. They are often thinner and use a *Kapton* substrate. Uses include mounting connectors, and for highly dense or unusual packaging. *Rogers Corp* is a leading source of flexible PC-board supplies.

## Creating a printed-circuit

There's a number of good ways to create a final printed-circuit board. In general, those methods that put new conductors on an insulating substrate are *additive*; those that remove unwanted conductors from unneeded areas are *subtractive*. Very often, both additive and subtractive techniques will be used in combination.

Four of the traditional board-production techniques include *direct, mechanical, silk screen,* and *photographic*.

In the direct method, an etch-resistant pattern is applied by hand to the printed-circuit stock. Most any paint, lacquer, instant transfer, or ink will work, as will the tape and dots intended for initial layout work. So does a fingerprint or spilled root beer. *Bishop Graphics* is a leading supplier of PC tape and dots, and *Datak* is one source for instant-transfer products. There are also some rubber-stamping layout aides being offered.

Actually, the direct method is more hassle than it is worth, and ends up just about totally useless. Some problems here are pattern alignment, preventing fingerprints, tape lifting, a lack of uniformity, and too many defects.

The mechanical methods physically remove unwanted copper, usually by routing, special drills, or by milling. They're another concept that looks much better on paper than in the real world. Several specialized systems are usable for the mechanical PC layouts. Invariably, they are both laughingly and obscenely overpriced.

The silk-screen PC method is quite simple and is widely used commercially, especially for single-sided boards of fairly low tolerances. The process is exactly the same as silk screening a T-shirt or a greeting card. Oversize artwork is created, usually at a 2:1 or sometimes a 4:1 scale. A litho negative gets shot from the artwork, which in turn creates a photo master for the screen. High-resolution screens are used, often in a 20XX density.

To print a board, etch-resistant ink is placed on the screen, and a squeegee is used to force the ink through the open portions of the screen. The board is then etched to remove all copper that is *not* covered by the inked image.

The advantages of the silk-screen method are that it is cheap, fast, and relatively low tech. One disadvantage is that the $30 setup charge per screen gets out of hand when you want only a single prototype board. A second is the inability to do very fine lines or precisely aligned work.

*Ulano* is one major source of silk-screen films. The screens themselves are available from such

1. Always do your layouts double sized (2X) on a blue gridded mylar sheet, available from any drafting supply house. Always work on a light box. Use only "real" printed circuit tape and dots. *Bishop Graphics* is one source.
2. Watch which side you tape from. Pin one of an integrated circuit is at the *lower left* when viewed from the top as shown in the data book. Pin one will be at the *lower right* when etched from the bottom board foil.
3. Never cut your tape with an X-acto knife! Instead, lay the knife down flat and pull the free end of the tape back against the blade. Always firmly mash the tape in place after routing. A teaspoon is ideal for this.
4. Never do your own photography! A litho negative costs only $3 at a jiffy printer, ad agency, or lithographers. This is the *only way* to get the proper precision and density.
4. Never coat your own boards! Always use commercially precoated dry film boards, such as those from *Kepro*.
5. Always use dry film photoresist, rather than spray-on or liquid coated KPR types. Otherwise, pinholes, dust, and uniformity will eat you alive.
6. If you must coat your own board, incredible cleanliness is essential. Thoroughyly scour the board with ultra fine steel wool and a chlorine activated (*Comet*) cleanser at least three times, spending not less than two minutes per square inch of board. Dry promptly and avoid all finger prints. If possible, follow up with a chemical copper cleaner. Then etch for a few seconds, rinse four times, dry, and use immediately.
7. Note that properly cleaned copper will allow an unbroken film of water to flow over it, and that it will *not* be copper colored at all. Instead, it will be a uniform hot pink.
8. Never print through the negative base! Always have the photo emulsion in direct contact with the dry film photoresist.
9. Never use a ferric chloride etchant! Always use ammonium persulfate.
10. Always etch at an elevated temperature, around 120 degrees Farenheit. A warming plate from a yard sale is ideal for this. Agitage the etchant with a gentle sloshing or bubbles from an aquarium pump.
11. Never etch with your foil side up!. Support the board vertically, or else *foil side down* at least 1/2 inch above the bottom of the etchant tray. A mirror *under* a glass etchant tray lets you view etching progress. Use only plastic or glass in contact with your etchant.

**FIG. 2—SOME REALLY DUMB MISTAKES are often made by hackers who do their own printed-circuit boards the "old way." Here is how to avoid the worst of the pitfalls of the traditional methods. But this is all ancient history, because...**

### PRINTED CIRCUIT RESOURCES

**Advance Process Supply**
400 North Noble Street
Chicago, IL 60622
(312) 829-1400
**Bishop Graphics**
5210 Lewis Road
Agoura Hills, CA 91376
(818) 991-2600
**Black Lightning**
RR 1-87 Depot Road
Hartland, VT 05048
(802) 359-2790
**Circuits Manufacturing**
500 Howard Street
San Francisco, CA 94105
(415) 397-1881
**Datak**
3117 Paterson Plank Road
North Bergen, NJ 07047
(201) 863-7667

**DuPont Riston**
3945 Freedom Circle F4
Santa Clara, CA 95054
(408) 562-9300
**Electronic Manufacturing**
17730 W Peterson Road
Libertyville, IL 60048
(312) 362-8711
**Electronic Packaging**
1350 E Touhy Avenue
Des Plains, IL 60018
(312) 635-8800
**Kepro Circuit Systems**
630 Axminister Drive
Fenton, MO 63026
(314) 343-1630
**Kodak**
343 State Street
Rochester, NY 14650
(716) 724-4000

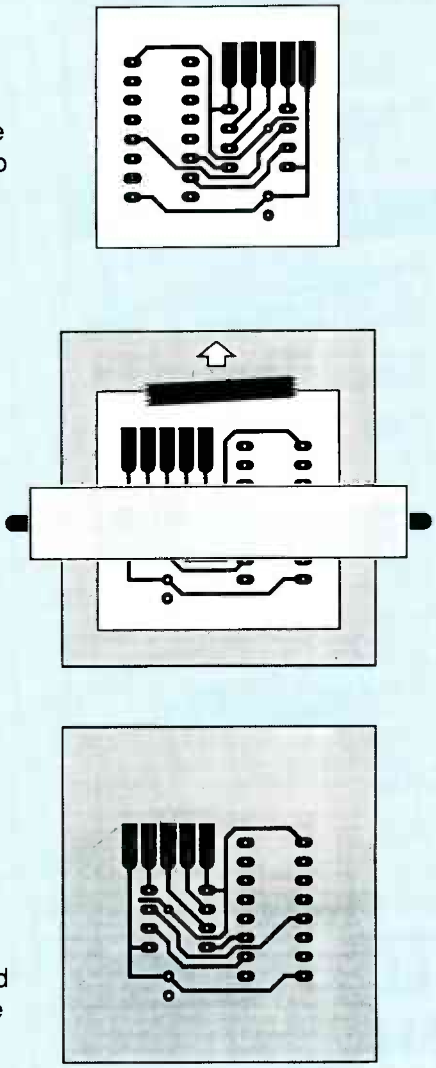
sources as *Dick Blick, Southern Sign Supply*, and *Advance Screen*. Two trade journals that serve the field are *Screen Printing* and *Signcraft* magazines.

At one time, printed-circuit boards were etched using a ferric chloride solution. Today, ferric chloride is a *very poor* choice of etchant. A much better etchant choice is ammonium persulfate. It is much cleaner, faster, and easier to use. Being a light blue solution, ammonium persulfate also lets you view the board as it is being etched. Etching best takes place at an elevated temperature, typically 120 degrees Fahrenheit. You could easily hit that temperature with a modified aquarium heater, a warming plate from a yard sale, or any of the strip heaters found on the surplus market.

Everything that comes in contact with the etchant must be glass or plastic. PVC is often usable. Ideally, your etchant should be sprayed onto the vertically held boards. Other ways to keep the etchant moving would be a simple manual sloshing or injecting air from an aquarium pump.

One really dumb mistake that most hackers make when etching their first PC boards is to place their board *face up* in the etchant solution. All that does is redeposit sediments and any crud removed from the board back on itself, leading to all sorts of nasty problems.

Instead, always support your boards vertically in the etchant, or else use surface tension to float



1

A thermal transfer toner image is PostScript laser printed onto a treated polyester sheet as a 1:1 reversed positive.

2

Heat and pressure fuse the toner directly to a thoroughly cleaned printed circuit board.

3

The pc board then gets etched in ammonium persulfate in the usual manner.

**FIG. 3—OUR BRAND NEW DIRECT TONER TRANSFER method can dramatically simplify and speed up making all of your hacker printed-circuits at a cost only of pennies per board. Here are the three key steps in this breakthrough process.**

**Lazer Products**
12741 E. Caley Ave. #130
Englewood, CO 80155
(303) 792-5277
**Meadowlake**
25 Blanchard Drive
Northport, NY 11768
(516) 757-3385
**Miller-Stephenson**
Box 950
Danbury, CT 06813
(203) 743-4447
**Mill-Max**
190 B Pine Hollow Road
Oyster Bay, NY 11771
(516) 922-6000
**Rogers Corp**
100 S. Roosevelt Avenue
Chandler, AZ 85226
(602) 961-1382
**Screen Printing**
407 Gilbert Avenue
Cincinatti, OH 45202
(513) 421-2050
**Sign Craft**
1938 Hill Avenue
Fort Myers, FL 33906
(813) 939-4644
**Southern Sign Supply**
127 Roesler Road
Glen Burnie, MD 21061
(301) 768-8600
**Stimpson**
900 Sylvan Avenue
Bayport, NY 11705
(516) 472-2000
**Surface Mount Technology**
17730 W. Peterson Road
Libertyville, IL 60048
(312) 362-8711
**Synergetics**
Box 809
Thatcher, AZ 85552
(602) 428-4073
**Thiokol Dynachem**
2631 Michelle Drive
Tustin, CA 92681
(714) 730-4200
**Thompson & Thompson**
23072 Lake Center #100
El Toro, CA 92630
(714) 855-3838
**Ulano Corp**
255 Butler Street
Brooklyn, NY 11217
(718) 622-5200

## NAMES AND NUMBERS

**Adobe PostScript**
1585 Charleston Road
Mountain View, CA 94039
(415) 961-4400

**All Electronics**
PO Box 567
Van Nuys, CA 91408
(800) 826-5432

**EG&G Reticon**
345 Potrero Avenue
Sunnyvale, CA 94086
(408) 738-4266

**Freedom of the Press**
900 Tech Park Drive #8
Billerica, MA 01821
(800) 873-4367

**Go Script/LaserGo**
9235 Trade Place, Ste A
San Diego, CA 92126
(619) 530-2400

**Kroy Kolor**
14555 N. Hayden Road
Scottsdale, AZ 85260
(800) 521-4997

**JKL Components**
13343 Paxton Street
Pacoima, CA 91331
(800) 421-7244

**Robert A Main & Sons**
555 Goffle Rd, Box 159
Wyckoff, NJ 07481
(201) 447-3700

**Rohm Corporation**
8 Whatney
Irvine, CA 92718
(714) 855-0819

**SPIE**
PO Box 10
Bellingham, WA 98227
(206) 676-3290

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

**Winzeler Inc**
7355 W. Wilson Avenue
Chicago, IL 60656
(312) 867-7971

1. Create a PostScript printed circuit artwork image on disk, using your favorite word processor and the sample routines of figure five and six, the full code found in my *PostScript Show and Tell*, or some suitable third party printed circuit layout package.
2. Run a positive, reversed 1:1 proof on a PostScript speaking laser printer, such as an *Apple LaserWriter IINT*. Many copy shops offer this service. Low cost PostScript printers are available through *Don Thompson*.
3. Optional step: Take a polyester based, laser printable overhead transparency material and lightly coat one side with *Miller-Stephenson* type MS-136 heated mold release agent. Mark the coated side.
4. PostScript laser print a 1:1 positive reversed (black = foil; right = left) onto the coated side of the polyester sheet, using a special thermal transfer (T-shirt) toner from *Black Lightning*, *Don Thompson*, or *Lazer Products*. Other graphic toners might also work; try them and see.
6. Sharpen and smooth the leading edge of an oversize piece of 1/16th inch printed circuit material with a file and steel wool , so that it can be sent through a fake *Kroy Kolor* machine without hurting the rollers. Use a 3/8 to 1/2 inch leading slope.
7. Thoroughly clean this oversize printed circuit board, scouring it three times with fine steel wool and *Comet* cleanser, followed by a chemical cleaner, followed by a brief etch. The board must be a uniform hot pink in color and must allow an unbroken stream of water to flow smoothly over it. Be sure to avoid any and all fingerprints.
8. Tape the leading edge of the polyester sheet *toner side down* to the copper side of the printed circuit board, using a suitable high temperature tape. Make sure the polyester sheet lies flat.
9. Run the board, image side up, through a preheated fake *Kroy Kolor* machine adjusted to a medium temperature. One source of these machines is *Lazer Products*. See the November 88 *Radio Electronics* or my *hardware Hacker II* reprints for details on building your own machine.
10. Optional step: Chill the board suddenly in a freezer before lifting the polyester sheet. Allow to warm to room temperature, then bake for fifteen seconds at 300 degrees F in a kitchen oven.
11. Etch in the usual manner in ammonium persulfate etchant.

**FIG. 4—THE STEP-BY-STEP "BASELINE" process for the new toner transfer PC method. An ordinary iron can substituted for the Kroy Kolor machine, but the results may not be as good. Let us know your experiences here.**

```
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% (602) 428-4073. All rights reserved. Personal, non-commercial use permitted so long
% as this header remains both present and intact. Show & Tell disk costs $39.50.

/quadpixel {transform 4 div round 4 mul itransform} def

/setgrid {save /rubbersnap exch def /size exch def quadpixel exch quadpixel exch translate
size dup scale } def

/drawlines {72 300 div lw mul size div setlinewidth /hposs 0 def #hlines gs div 1 add cvi
{hposs 0 moveto 0 #vlines rlineto stroke /hposs hposs gs add def} repeat /vposs 0 def
#vlines gs div 1 add cvi {0 vposs moveto #hlines 0 rlineto stroke /vposs vposs gs add
def} repeat} def

/showgrid{gsave /#vlines exch def /#hlines exch def 106 45 {pop pop 0} setscreen 0.9
setgray /gs 1 def /lw 1 def drawlines  grestore} def

/1X {30 72 mul 300 div setgrid} def

/trace20 {6 30 div setlinewidth} def /trace50 {16 30 div setlinewidth} def /trace80 {24
30 div setlinewidth} def

/am {newpath moveto} def
/tdraw {rlineto currentpoint stroke moveto} def

/u {0 exch tdraw} def          /r+ {dup tdraw} def
/r {0 tdraw} def               /r- {dup neg tdraw} def
/d {0 exch neg tdraw} def      /l- {neg dup tdraw} def
/l {neg 0 tdraw} def           /l+ {dup neg exch tdraw} def

/black {0 setgray} def         /white {1 setgray} def

/xrpt{gsave aload pop /trips exch def /dist exch def /rproc exch def trips { gsave rproc
grestore dist 0 translate } repeat grestore} def

/yrpt{gsave aload pop /trips exch def /dist exch def /rproc exch def trips { gsave
rproc grestore 0 dist translate } repeat grestore} def

/hole {gsave 150 div /dia exch def newpath dia 2 div 0 360 arc white fill grestore} def

/icpad1v {save /psnap exch def trace50 2 copy gsave exch 0.2 sub exch am 0.4 r grestore
20 hole psnap restore} def

/edgeconu {gsave translate 0.4 0 moveto 0 -2 0.4 0 180 arcn 0 2 rlineto closepath fill
grestore} def

/feedpad {save /fpsnap exch def newpath 2 copy black 0.25 0 360 arc fill 18 hole clear
fpsnap restore } def

/circpad2 {save /fpsnap exch def newpath 2 copy black 0.30 0 360 arc fill 22 hole clear
fpsnap restore } def

/dip8v{gsave translate [{0 0 icpad1v} 1 4] yrpt [{3 0 icpad1v} 1 4] yrpt grestore} def

/dip16v{gsave translate [{0 0 icpad1v} 1 8] yrpt [{3 0 icpad1v} 1 8] yrpt grestore} def

1 setlinejoin 1 setlinecap
```

**FIG. 5—SOME SAMPLE POSTSCRIPT PC-LAYOUT routines that were excerpted from my PostScript Show & Tell disk. Just shove this listing into your favorite word processor as a prolog to your actual layout.**

the board *upside down* on the surface of the etchant. Another ploy is to add nylon spacers to your PC board so the foil faces *down* in your etching solution. Or else throw some nylon hex nuts in the etchant and sit the board upside down on the nuts. Once again, *never etch a PC board face up!*

A second stupid mistake that lots of hackers make is failing to clean the boards properly. It is not possible to clean a circuit board at home without spending at least *two minutes per square inch of board*. Begin by using *Comet* or another chlorine-activated cleanser with a fine steel-wool pad or *Scotchbrite* pad. Rinse thoroughly and wipe on an inner fresh turn of a new roll of paper towels. Repeat that at least three times, avoiding any and all fingerprints.

Note that fairly clean copper will allow an unbroken stream of water to flow over it without any running or beading. Your key secret is that a genuinely and totally clean copper will not be copper-colored at all. Instead, it will be certainly a uniform hot pink. Commercial copper cleaners, such as CU3 from *Kepro*, are a great help, but are somewhat expensive.

The ultimate final cleanliness step is to place the copper in ammonium persulfate and etch it for ten to fifteen seconds or so. Then thoroughly rinse three times and air dry immediately. If you get a uniform hot pink result, then your copper is clean enough for immediate use.

The photographic methods get rather complicated, but they can be used for arbitrarily fine lines and for all of the precision you will ever need. In fact, the same techniques are used to manufacture integrated circuits to a fraction of a micron accuracy. Note that there are 20 microns in a mil.

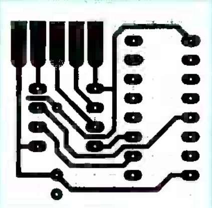
With the photo processes, a light-sensitive *etch resist* is placed on the thoroughly cleaned board. The resist is first contact-printed from a photographic negative and then developed. In the most popular *negative-acting* systems, those portions of the resist that receive light harden and remain; those that did not will dissolve out. Etching is done in the usual manner.

Traditionally, the spray-on photoresist was used, such as a KPR product from *Kodak*. These days, though, it is far simpler and far better to use a dry-film photoresist, such as the *Riston* materials by *DuPont*, or any of the *Laminar AX* products from *Thiokol*. Those dry films develop in trisodium phosphate, the garage-floor cleaner found at your local hardware store. They are quite resistant to pinholes, eliminate dust and drying problems, have highly visible images, and are always at the right thickness. Once sensitized, the boards must be kept dry, cool, and in total darkness. They also have a one-year shelf life.

The third most stupid mistake that hackers make is trying to use KPR instead of the new and infinitely better dry films. Mistake number four, of course, is trying to coat their own boards instead of using pre-coated ones. Excellent dry-film pre-coated boards are stocked by *Kepro*.

The cost of the dry-film resist by itself is around a dollar per square foot. Unfortunately, a fancy laminator is needed to bond the resist to the board. I have a hunch that a Kroy Kolor machine or one of its imitators can be substituted here. The required temperature is 234 degrees Fahrenheit. Let me know if you pick up any experience along those lines.

Double-sided plate-through boards often use a combination of processes. Typically, you start with a double-sided board. The holes are first drilled, and then they are plated through by additive techniques. The holes get chemically activated, and then seeded with an ultra-thin palladium plating. Electroless copper is then built up on the conductive palladium to a medium thickness, followed by a heavy copper plating up to the final wall thickness needed. The rest of the board is then processed through the usual double-sided photographic steps. Key hacker printed-circuit mistakes are summarized for you in Fig. 2.



```
% requires printed circuit sampler code of figure five

100 100 1X 11 11 showgrid trace20 10 2 am 1 l 0.75 l- 4.5 l 0.75 l+
2 l 6 u 10 5 am 0.75 l 1.5 l- 1.25 l 0.5 l- 2 l 0.5 l+ 0.75 u 1.25 l+ 7 4 am
0.75 l  0.5 l- 0.75 l 5 5.5 am 1 l+ 1.5 u 5 4.5 am 2 l+ 2 u 2 6.5 am 1.5
u 7 3 am 0.5 l- 2.75 l 0.75 l+ 0.5 u 0.75 l+ 2 3.5 am 1 l 10 9 am 0.75 l+
2.75 l 0.5 l- 2.75 d 1 l 6 6.5 am 2.15 d 0.35 l- 1.15 l 2 l+ 1 l 5 6.5 am
1.5 u 7 2 dip16v 2 3.5 dip8v [{1 10 edgeconu} 1 5] xrpt 3 2 circpad2
3 1 circpad2 3 5.5 feedpad showpage quit
```

**FIG. 6—A TYPICAL PC-TEST LAYOUT. Note how simple and short the code is. Omit the showgrid command to drop out the fine gray viewing grid. Be sure to preface this code with the PostScript routines of Fig. 5.**

## Printed-circuit resources

I've gathered some of the major PC-board resources into our first sidebar, as we've done in previous columns for other topics. Most of the products we have mentioned are available directly through those sources.

The best trade journal for printed circuits is *Circuits Manufacturing*. A few others are *Electronic Packaging and Production, Surface Mount Technology*, and their sister publication, *Electronic Manufacturing*. Be sure to let me know if there are other resources that you think should be added to the list.

## The direct-toner method

There's a new process on the block for hacker printed-circuits which is ridiculously simpler, faster, and far cheaper than any of the above. All you really need is a word processor and an iron. This new scheme is known as the *direct-toner method*. And it is new and undeveloped enough so that you might play a major role in making it work and shaping its future.

Very simply, copier or laser-printer toner is outstanding as an etch resist. Two decades ago, *Xerox* even had a product that directly printed on your copper PC boards from a 2:1 artwork original. A ways back, a new hacker product known as *Meadowlake* did attempt an iron-on toner system. Early versions of the product didn't turn out reliable enough and lacked stability.

But there is a brand new type of *thermal-transfer toner* now carried by several laser-printer supply houses. While the toner is intended for making iron-on T-shirt images, it transfers to copper beautifully and smudge-free, and is thus a key secret to the direct-toner process. Three sources of a thermal-transfer toner are *Black Lightning, Lazer Products*, and *Don Thompson*. *Black Lightning* does offer a free sample. Cost of the toner ranges from $90 to $180 per cartridge, which translates to a dime per board. Several of the other new graphics toners should also work well. Your help is needed in pinning down which ones are acceptable and which are not.

Figure 3 summarizes the key toner-transfer steps; that is followed by some detailed instructions in Fig. 4.

The best way I've found to create initial artwork is by using a PostScript speaking laser printer and my word processor. In fact, I have a complete package that does just that for Apple, Mac, and IBM users. Note that the original image must be a 1:1 reversed positive. That means that left is where right belongs and black is where you want your foil to *remain*. Naturally, since your image is disk-based, it is easy to change, and super easy to build up from a library of suitable Post-Script dictionary routines.

The image gets printed, again as a 1:1 reversed positive, onto a laser-printable Mylar or polyester overhead projection sheet. Just for luck, I'll previously apply a very thin coating of MS-136 *Heated Mold Release Agent* from *Miller-Stephenson*. That may or may not help, but it sure seems like a good idea, at least for now. It also may be a good idea to anneal or remelt the toner for a few seconds in an oven, after the image is transferred.

Too much reheating, of course, would lower the resolution. Although ten-mil lines on twenty-mil centers should be possible, I'd stick with double that as an initial lower limit.

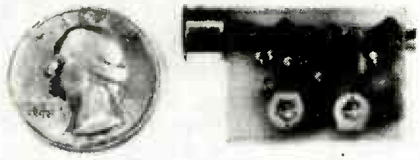
In theory, you could simply iron the toner directly onto a previously super-cleaned PC board. Instead, I modify the board by *sharpening* its leading edge, and run it through one of the imitation *Kroy Kolor* machines we looked at in **Radio-Electronics**, November, 1988. By the way, an improved and economical do-it-yourself version of that beast is in the works here at **Radio-Electronics**.

The benefits of the new way are obvious. You go from artwork to PC prototype amazingly fast. No cameras, chemistry, screens, or fancy equipment is needed. Without any fuss or bother. Just print and etch. And products such as *GoScript* and *Freedom of the Press* even let you fake PostScript on a dot-matrix printer, so "no printer" is no excuse.

The technique could also revolutionize running hacker PC projects. You show the PostScript code in the magazine and offer it downloadable off your BBS. Now, every hacker can end up with a precisely accurate original, rather than a third-generation copy.

Figure 5 shows some sample PostScript code from my PC layout stuff, while Fig. 6 shows a simple

# Radio-Electronics mini-ADS



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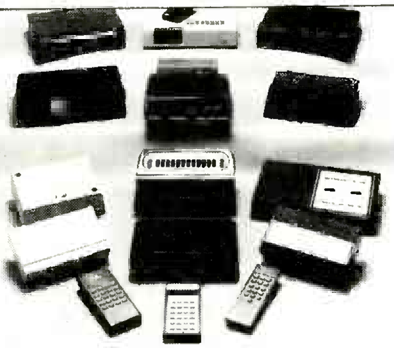

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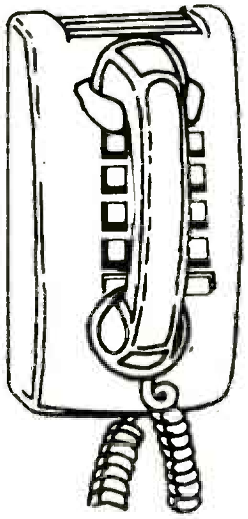

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actual layout that you can use to test out your own version of the direct-toner board method.

As I said before, this is a brand new technique that needs some further experimentation to perfect. So, for our first contest this month, just tell me anything you find out on your own about making a direct-toner PC board. There'll be the usual dozen or so *Incredible Secret Money Machine* books for best entries, along with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for the very best of all. Let's hear from you on this hot new topic.

### New tech literature

The hacker buy of the month has to be the new $3.75 speech synthesizer available as stock number ICA from *All Electronics.* It even includes a load-power sensing detector. There is one very tiny gotcha, though—the main thing the synthesizer has to say is "Your ice cream is ready." Oh, well.

The *EG&G Reticon* folks have three brand new data books out. They are their *Image Sensing Products, Solid State Cameras*, and the *Analog Signal Processing Integrated Circuits.* The latter covers analog delay lines, switched-capacitor filters, and some very useful ap-notes.

The BU2911 is an interesting new melody chip from *Rohm.* It provides a pair of folk songs and six different chime and siren sound effects. Uses? How about some clocks, doorbells, or alarms? Miniature fluorescent lamps from *JKL* are offered in various colors at very low prices; they also carry EPROM erasing lamps.

The *SPIE* folks have great bunches of reprints involving nearly everything optical, and covering laser scanning, CD ROM, holography, fiber optics, and I-R detection. Get their list number 6.

Turning to mechanical stuff, free molded-gear samples are obtainable from *Winzeler.* And *Robert A. Main* has a unique catalog of *Hooks, Points, and Teeth.* A sharp outfit fer sure. Tellyawhat. Their catalog number twelve is so unusual, that we'll make us a second contest out of it. Just come up with some off-the-wall use for any of the hooks, points, or teeth shown.

If you want to explore our new direct-toner hacker PC process further, or want to draw your own first-quality electronic schematic diagrams, isometric drawings, or architectural perspective sketches (including all lettering!) using nothing but your favorite word processor, check into my *PostScript Show and Tell,* that has scads of working code and detailed examples in it. Available for Apple, Mac, or IBM, it does need a PostScript speaking laser printer (or a software emulator).

As always, this is your column and you can get technical help and off-the-wall networking per the *Need Help?* box. The best calling times are weekdays 8–5, *MST.* **R-E**

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## PROPERTY GUARD

*continued from page 40*

transducer is approximately 40-volts p-p. Tap 6 may be used for frequencies below 20 kHz with "on" times no more than 20 minutes; voltage is approximately 50-volts p-p. Tap 13 is intended for intermittent use where "on" times are less than 3 minutes and the frequency well below 20 kHz. Those times may be longer when operating at lower frequencies. Never allow the transducers to get excessively warm. That completes the testing and adjustment of the system.

### Setup

The Phasor Property Guard is capable of operating in two modes. Mode 1 is at a frequency that is known to produce paranoia, nausea, disorientation, and many other physiological effects. Mode 2 allows using the system as an audible alarm to frighten off intruders or warn the user of an intrusion. Both modes may be used in combination, and are easily controlled by the user. Three separate jacks provide inputs for a broken trip wire or contact foil, a pressure or actuating switch, and a positive voltage pulse from other equipment.

The position of the transducers should be such that they direct their energy to the points of intrusion or access. They can be all directed to any target area, or be individually placed for multiple effect.

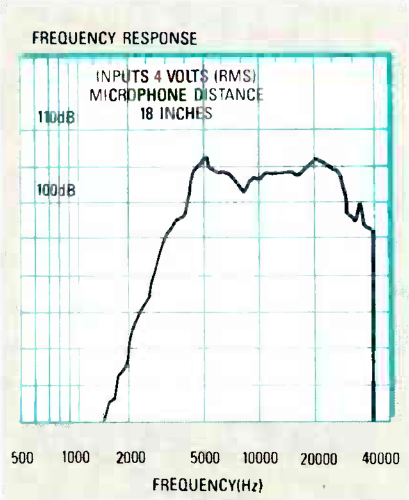

**FIG. 7—FREQUENCY RESPONSE of the piezoelectric transducers.**

The transducers used in this system are piezoelectric and are many times more efficient than the electromagnetic-type speaker. Their frequency response is shown in Fig. 7.

### Ultrasonics

Ultrasonic is a gray area in many respects when the application involves the control of animals or as an intruder deterrent. It is always best to consult with local municipal and state laws before using this device to protect home or property.

Do not operate at continuous high output at frequencies below 20 kHz. Daily sound pressure exposures in excess of one hour at 105 dB may lead to hearing impairment. When properly used, this device provides a limited liability deterrent. It should not cause permanent damage or trauma.

There have been numerous requests for information on the effect of these devices on people. First of all, an ultrasonic device should not be used unnecessarily on humans, because of the possibility of acoustically sensitive people being highly irritated.

Remember that the Property Guard cannot stop a person with the same effect as a gun, club, or more conventional weapon. It will, however, produce an extremely uncomfortable, irritating, and sometimes painful effect in most people. Although not everyone will experience the effect the same degree. Younger women are much more affected than older men, due to being more acoustically sensitive. The range depends on many variables, but is normally somewhere between 10 and 100 feet. **R-E**

# DRAWING BOARD

ROBERT A. GROSSBLATT

## Developing and Etching a PC board.

THE MAIN INGREDIENT IN MAKING good PC boards is consistency. Once you're past the layout phase, you're past the creative part. Converting the graph paper lines to copper foils is as mechanical as filling a gas tank. Just follow the rules, if you know what they are. The only problem is, I've never found them written down anywhere, and believe me, I've looked! Even the Kodak booklet I mentioned last month was vague about the things that were giving me problems.

All the information I've given you so far about PC board production is the result of trial and error. If you follow these steps, you've got a reliable method. The only steps left are developing and etching. While you might think these straightforward, there are some undocumented problems here also.

### Developing the board

By the time you're ready to develop, you may be lulled into a false sense of security. After all, it's basically the same process as developing lithographic film. That was easy, but there was so much latitude, you couldn't make a serious mistake without trying really hard. Developing copper, however, has unique problems.

Copper etchant is considerably more caustic than that for film. It may not exactly be aqua-regia, but it'll eat through almost any kind of plastic. Guaranteed, if you pour it into a plastic film tray, the bottom will vanish in 15 seconds, and the floor will be ruined; polyurethane and vinyl flooring are plastic, also. If you're wearing polyester, the consequences are too horrible to contemplate. So, the first rule for PC board development is: *The trays must be made of glass or metal or else*!

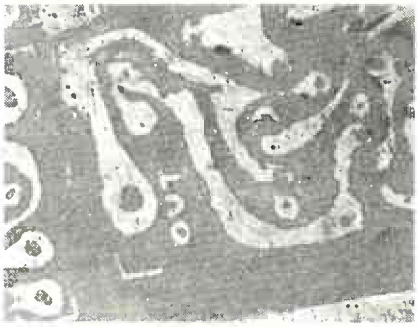

FIG. 1

Properly applied resist is much denser than film emulsion, and development is roughly logarithmic. With film, the image appears fairly quickly, and darkens slowly. The actual rate is irrelevant, since you can watch it happen and pull the film when it's done. With resist, however, you have to remember the chemical reaction rate, because you won't see anything happen on the PC board, making reliable development very difficult. The whole PC board process involves many variables, so a problem can be caused by any preceding steps. If the pattern dissolves, you can't tell why. The list of possible screwups gets longer as you go on. Just as with the earlier parts of the process, I finally doped out a reliable approach.

Put the exposed PC board in the developer *slowly*, and gently rock the tray at one shake per second for 20 secs. Then, remove the PC board at an angle so the excess developer can run off. Even though the board won't be fully developed, most of the unwanted resist should be loose enough to wash. All the resist, both pattern and excess, should be very soft now, so handle the PC board carefully, or you'll have to scrub the copper clean and start over.

Resist manufacturers all have suggested methods, from a water spray to dabbing with paper towel. The latter was told to me by a spray can manufacturer, and I still have difficulty believing that such stupid advice would be given. There's only one way, which I found after considerable trial and error. Before you start development, fill a sink or tray with *COLD* water, under 70°F (right from a tap), or it won't wash the off the excess. So, the second rule is: *Use only cold water and don't make waves*!

Be careful when washing the PC board; keep it perpendicular to the water as you dunk it and lift it out, and let the water run off momentarily. *DON'T* shake it, and for God's sake, *DON'T* use running water. If you reflect some light off it, you should start to see the pattern appear as the excess is removed. Keep dunking it until you can see the whole foil pattern. The cold water should slowly harden the resist on the board so don't wash the board for more than a minute. If you only see a partial pattern after a minute of washing, the board just needs more development.

Regardless of how the pattern looks after a 1-min cold water wash, develop for about thirty seconds more. Water and developer

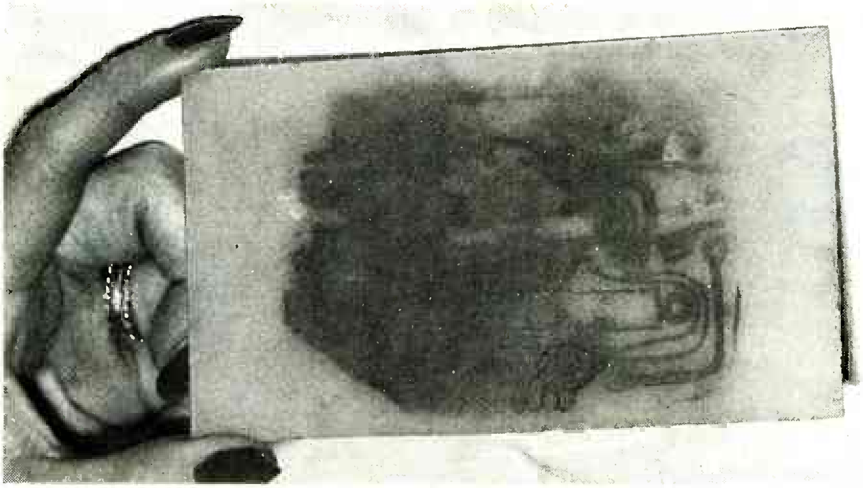

FIG. 2

don't mix, so shake the excess water off the board or just let it air dry thoroughly before you immerse it in the developer a second time. The water should have hardened the resist so should tolerate shaking at this point, it'll probably still be too soft to wipe or touch.

The second immersion in developer should eliminate all unwanted resist, and when the 30 secs is over, repeat the water wash. The pattern should appear much faster now, and be much easier to see, since the copper covered by the pattern should be totally free of resist. Repeat until the pattern is clear. The hardest part is knowing when the copper is free of all excess resist and developer. The difference in appearance between clean and coated copper is fairly evident, as in Fig. 1. Clean copper is reddish, and coated copper whitish. You'll understand when you see it.

## Etching the board

Once developing and washing is done, let the resist harden for 15 mins before dumping the PC board in the etchant. The etchant will dissolve metal, as quickly as the developer will plastic. All standard etchants like ferric chloride and ammonium persulfate will dissolve metal. There are some exceptions, like stainless steel, but don't experiment. Remember, the secret to success in this is consistency; find a way that works and keep it. We've now reached the third rule of board making: *Use only plastic or glass trays for the etchant!* It stains just about anything, especially the ferric chloride variety.

Put the board in a plastic or glass tray, *NOT METAL*, and heat the etchant to 100°F. Pour it on the PC board, wait 15 secs, then take the PC board out wash it. The brief contact with the etchant should start the copper removal. The reason for pulling it out so quickly is to let you examine the resist integrity. This is the time to examine the pattern for any breaks in the foils, excess resist, etc.

The foils can be repaired the same way you laid the pattern out on graph paper. Use drafting tape to cover breaks in the foils, and scrape away excess resist with an X-acto knife. When the pattern is right, put the board back in the etchant and rock the tray gently. *Don't* be violent about it, because you *don't* want to spill that stuff; cleaning it's a *big* job. We're not talking the Exxon Valdiz here, but it'd still be pretty bad.

The time needed depends on the etchant type, the amount, the number of times you've used it before, how much copper is involved, the temperature, and how the board is agitated; however, you shouldn't need over a half hour to finish. You'll have to keep pulling the PC board out to check it for foil breaks and excess resist, repairing with the drafting tape and X-acto knife. Most PC boards need work as they're being etched, but if you get something Fig. 2, it's shot.

Etchant has limited life, since the etched copper combines with the etchant chloride to give cupric chloride. When it gets black, it's saturated and must be dumped. **R-E**

## GIFT GUIDE

*continued from page 53*

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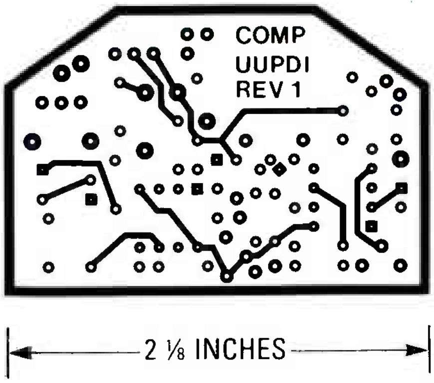
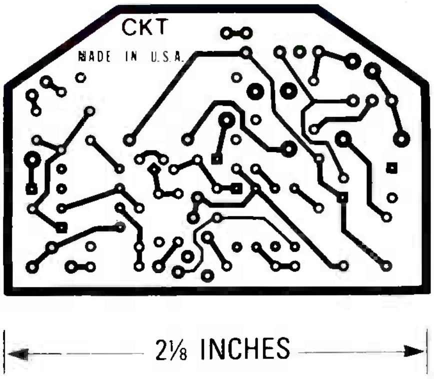
of the popular sizes of motherboards up through new 386 boards, but it has

*continued on page 88*

# PC SERVICE



DRIVER BOARD, COMPONENT SIDE.



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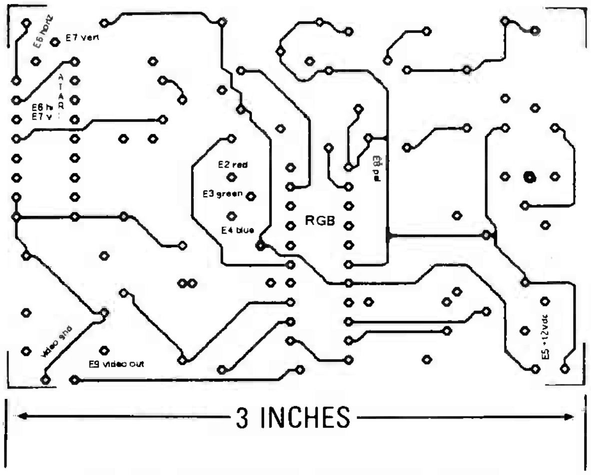

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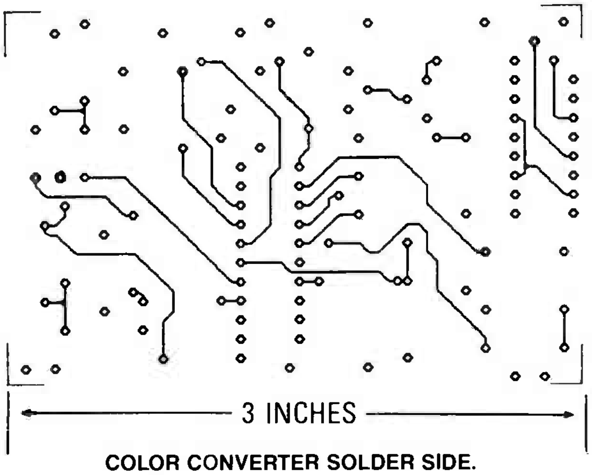

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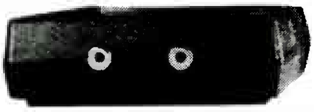

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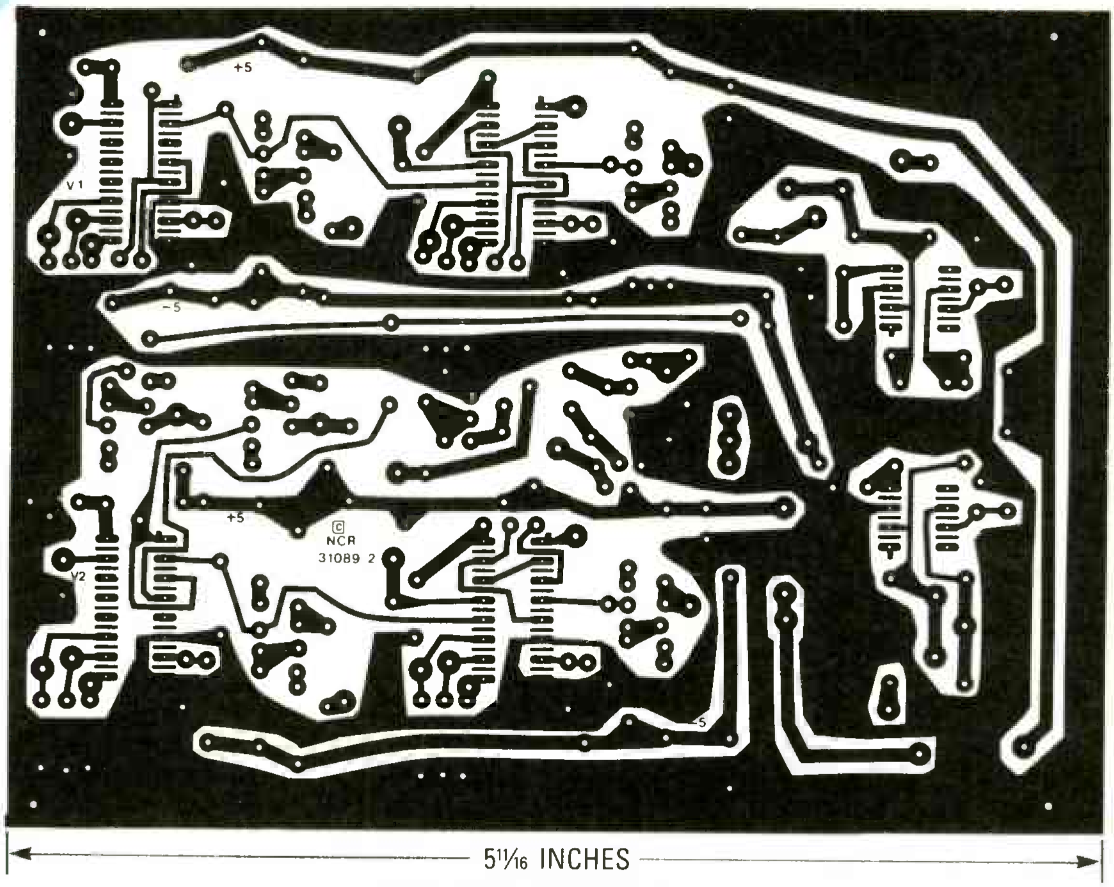
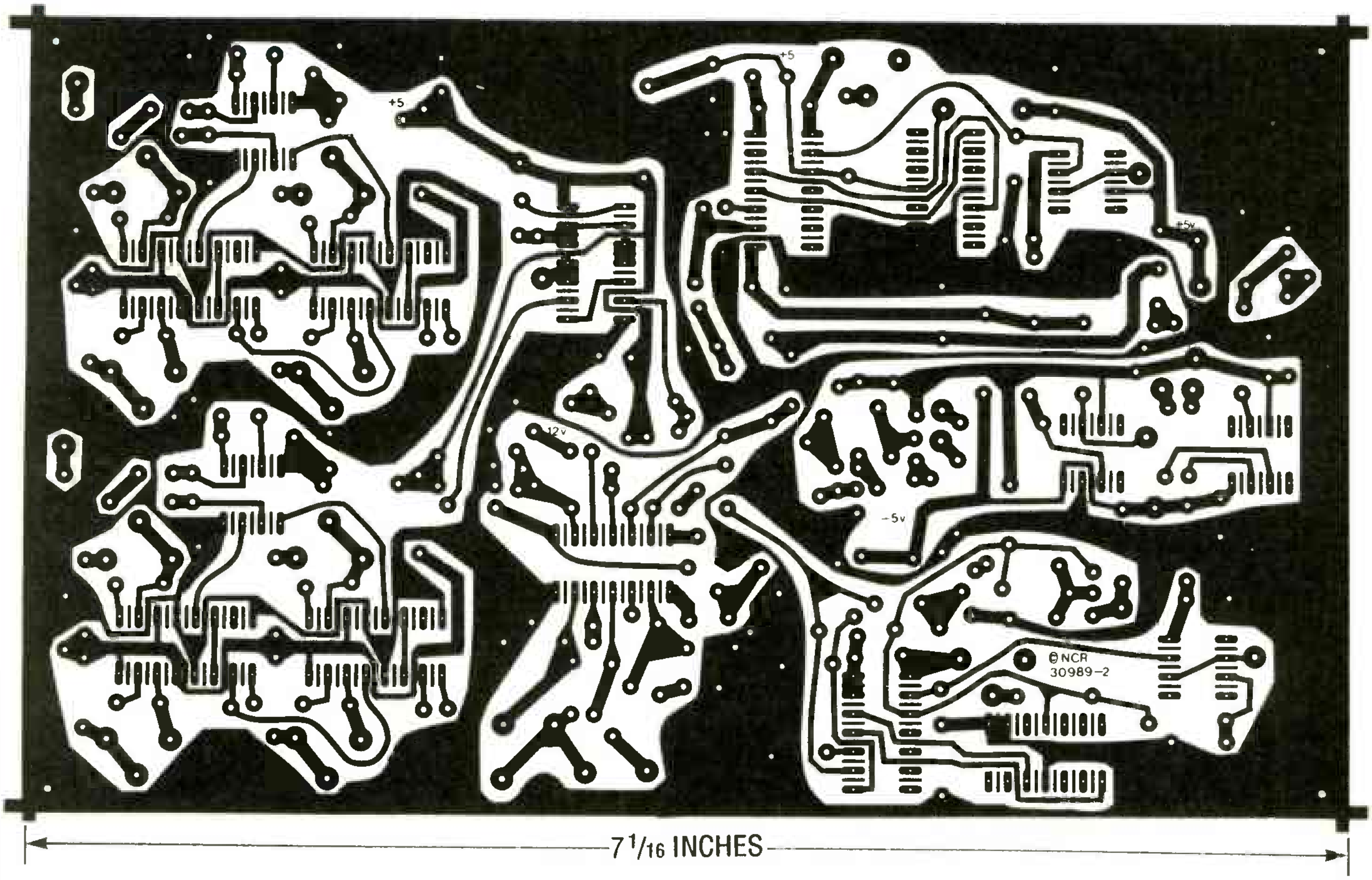


VIDEO SCENE SWITCHER BOARD.



VIDEO SCENE SWITCHER BOARD.

# COMPUTER DIGEST

# RGB-to-NTSC CONVERTER

High-quality computer video on your TV—for peanuts!

ROBIN BEK

Have you been searching for a low-cost alternative to a $300 color monitor? Or would you like to run your flight simulator on a big-screen TV? Great idea, but there are problems. Personal computers deliver digital signals that tell the TV when to turn the red, green, and blue guns in the CRT off and on. But TV's expect an analog signal that is a combination of the three color signals, the audio signal, horizontal and vertical sync pulses, and other things as well.

Even so, there's an easy (i.e., inexpensive) way of cutting your cake and eating it too. Our RGB-to-NTSC color converter is easy to build, costs less than $30, and is easy to tune using only a color TV and a voltmeter. The circuit was designed specifically for the Atari ST, but it could be used with any computer that delivers standard RGB video. Also, the circuit could be adapted to RGB-to-PAL operation for use with European PC's.

## Theory of operation

The problem with interfacing a computer to a TV is that the two use two totally different types of video systems. Computers typically deliver RGB video, which is composed of separate digital signals corresponding to the red, green, and blue guns in a color TV tube. In an RGB system, each signal is either on or off. Hence there is a certain number of combinations of on and off signals which correspond to colors ranging from white (all signals on) to black (all signals off). Because there are three signals, and each may assume only two values, there are $2^3$ possible combinations, or eight colors.

On the other hand, TV's generally expect a composite NTSC (National Television Standards Committee) video signal, which, as the name suggests, combines the three RGB signals, an audio signal, sync signals (and possibly others as well) into a single *composite* signal.

The advantage of composite video is that instead of using five wires, you use just one. The disadvantage of a single wire is loss of fidelity and increased circuit complexity. Fortunately, though, converting the two radically different signal systems is relatively easy (and inexpensive), thanks to modern technology.

Our circuit is built around Motorola's single-IC solution to the problem, the MC1377. The circuit is easy to build and tune; you really don't even need a scope unless you run into problems. However, you will need a voltmeter to verify the supply voltage and several test points.

## How it works

The MC1377 is a 20-pin IC. As shown in Fig. 1, pins 3, 4, and 5 accept the incoming RGB signals, which are separated into chrominance (color) and luminance (intensity) information.

*continued on page 85*

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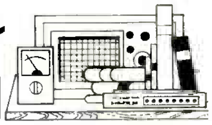
# EDITOR'S WORKBENCH



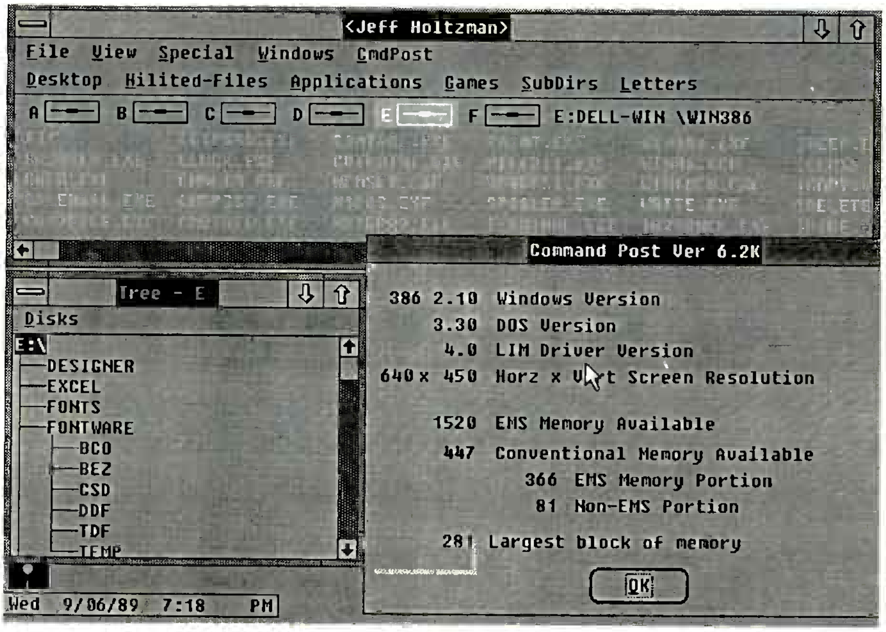
JEFF HOLTZMAN

**Wondering about Windows?**

The Graphical User Interface (GUI), once relegated to expensive engineering workstations or to toys like the early Macintosh, is gaining wider and wider acceptance from the PC community. There are two complementary reasons for the increasing popularity. First is that hardware has evolved to the point where we can buy computers with enough computing horsepower and memory to handle the greedy demands of GUI's.

Second is that some, but by no means all, of the necessary software is coming to market. The central hub from which those software elements radiate is Microsoft's famous (or infamous) product, Windows, shipments of which have surpassed the two million mark.

On the surface, Windows bears a strong resemblance to environments like that provided by the Mac, by Steve Jobs' NeXT computer, and similar products. That surface resemblance is so strong, in fact, that Apple's legal corps decided to sue Microsoft, even though Apple could no more claim to have invented the GUI than the cheeseburger. Fortunately, common sense seems to be winning out: the presiding judge has dismissed all but a few of Apple's claims.



```
386 2.10  Windows Version
    3.30  DOS Version
     4.0  LIM Driver Version
640 x 450  Horz x Vert Screen Resolution

    1520  EMS Memory Available
     447  Conventional Memory Available
            366  EMS Memory Portion
             81  Non-EMS Portion

     281  Largest block of memory
```

*FIG. 1*

So what is it about Windows that would make anyone even think of a resemblance between it and the Mac? And why do I say that the resemblance is at best only skin deep?

The points of resemblance are pretty obvious. Both Windows and the Macintosh Finder program present information to the user in a bit-mapped format. The user rolls a mouse about the desktop to select items from menus: those menu items initiate actions such as loading and saving files, etc. In addition, those menu items function pretty much the same from program to program, so that once you learn how to use one, you know them all—in theory, anyway.

The real differences between Windows and the Mac are slightly more subtle. The Mac, on the one hand, was designed around a single coherent philosophy that dictated nearly everything about the system. With the original Macs, software designers didn't have to worry about half a dozen or more video standards, half a dozen or more mouse protocols, and hundreds and hundreds of printers. Originally there was one video standard, one mouse, one keyboard, and one printer. Gradually, more and more options have appeared, but they have been smoothly integrated into an overall architecture.

Windows, on the other hand, was designed from the beginning as a compromise between multiple competing philosophies, and the effects of that compromise show up in Windows' famously laggard performance, difficulty of installation, and difficulty of use (more on that in a moment). When you have to support everything from CGA to one-megabit pixel monitors, it's not surprising that your video drivers aren't optimal.

Why is Windows difficult to use? Doesn't Windows work with a mouse, present bit-mapped graphics, and use drop-down menus, dialogue boxes, and the other hallmarks of the GUI?

Because of the necessity of supporting so many underlying types of hardware, Microsoft never got around to building a slick shell (like what you see for the Mac) for Windows. What you use to work with Windows is something called the MS-DOS Executive, which provides a very crude way of launching programs and maintaining disk files. Comparison with any decent DOS shell (X-tree, Norton Commander, etc.) will show you why I say crude.

At bottom you can think of the Mac as a fine piece of finished furniture, and of Windows as a stain-it-yourself piece from the bare-woods factory. Certainly, with care, you can sand it, stain it, varnish it, and polish it. But in the end you may not end up with the kind of product you really wanted.

To be fair, Microsoft is working on a new version of Windows (3.0) that should be out before the end of the year, and it should add a decent user interface (that, by the way, is rumored to bear a very strong resemblance to the forthcoming version of the OS/2 Presentation Manager). In the four years that have passed since Windows was introduced, however, at least four companies have introduced their own products that attempt to correct that user interface problem, and IBM has even given several of these products semi-official endorsements by including them in sales and educational promotions.

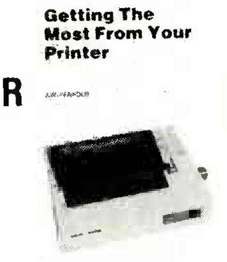
Because they're add-ons, however, these products (all of which I have tested) tend to be buggy and memory hungry. My personal favorite is a $20 shareware products called Command Post (shown in Fig. 1, and available on the RE-BBS at 516-293-2283, 300/1200, 8N1). With it you can customize your version of Windows, adding your own menus and items to the Windows environment. Command Post won't make a Mac out of your PC, but it does make certain common Windows operations much easier.

## Using Windows

Before proceeding, it might be useful to discuss why you'd even want to use Windows. Up until very recently, there were really only three reasons to ever use Windows:

- Designer (Micrografx), a CAD-like drawing program that is simply a joy to use; see Editor's Workbench, March 1989.
- Excel (Microsoft), a spreadsheet that greatly surpassed 1-2-3 in its ability to print nicely, and in its ability to consolidate worksheets.
- PageMaker (Aldus), the original desktop-publishing program.

However, Samna Corporation has introduced a word processor (Ami) for Windows, Crosstalk has likewise introduced a communications program, and Microsoft



is readying a version of Word for Windows that is due out by the end of the year. The point is that Windows is rapidly approaching critical mass—even more rapidly than OS/2, to IBM's chagrin.

Even if you're not specifically interested in one of those Windows applications, but are curious about where PC technology is headed, you should get a copy of Windows and play around with it long enough to see what its strengths are—and also its weaknesses.

### Problems with Windows

The biggest problem with Windows is the difficulty you have in upgrading hardware. Whenever you change your memory, video setup, or mouse, you must re-install the entire Windows package. When you do, a text file called WIN.INI, which functions like CONFIG.SYS does for DOS, is overwritten by a virgin copy from the installation disk. Consequently, valuable setup information may be lost during a re-installation. A technician on Microsoft's Windows help line told me he includes a line in his AUTOEXEC.BAT file that copies WIN.INI to a safe location every time he boots. I could have saved myself a great deal of heartache on a recent job if I had thought of that trick on my own.

Video hardware is another area that is painful to deal with. On the one hand, you want as much resolution as you can get. On the other, you don't want to wait half an hour each time the screen is redrawn—which means every time *anything* happens. I've worked with Windows on every IBM standard video system (CGA, EGA, and VGA), and none of them are good enough for professional day-to-day work. For professional use, the 800 × 600 Super VGA (SVGA) offers the best compromise between screen resolution, display speed, and cost. On the other hand, for occasional use, Hercules monochrome or monochrome VGA work nicely, especially if your final output is in monochrome.

However, if you're considering a SVGA system for professional use, make sure that it is compatible with your software. Yes, I know that the whole purpose behind Windows is to provide device-independence, so software designers (not to mention end-users!) don't have to worry about the hardware. In practice, however, it doesn't work out that way, particularly in the area of screen fonts.

For example, in setting up a desktop publishing system based on SVGA video and an HP LaserJet II, I had trouble installing fonts from two different manufacturers, and eventually had to settle for using the system at VGA level. Even at that level, some special symbols appeared on-screen differently than on paper. In addition, some text simply did not print on paper where it appeared on screen, which required several iterations of the "print, inspect, edit, print, inspect, edit" process. And don't even think about getting a decent printout when composing a document for one printer and printing it on another. So much for WYSIWYG.

A related problem is a software package that I use to capture graphics screens and either print them on a LaserJet or include in a desktop publishing file. The program translates screen colors into various shades of gray in a quite attractive manner. The problem is that it supports only standard video modes, not SVGA. Part of the reason is that there is no real standard for SVGA; several manufacturers have implemented bit and color planes in different ways, and small software outfits can't afford to support them all. Meanwhile, an industry group (VESA, headed up by NEC) has begun trying to define an SVGA standard. But what about all the cards sold until the standard emerges—if indeed it does?

## Memory woes

Depending on whether you have a 286 or a 386 processor, you buy a different version of Windows. However, in my case, I ended up running the 286 version on a 386, because the SVGA adapter did not come with a 386 software driver—only a 286 version. In addition, after the font fiasco, I ended up running the system in VGA mode anyway, which would have allowed me to use Windows/386—if I felt like installing (and transferring) the setup information in WIN.INI yet again.

In theory, Windows/386 sounds great: it will let you run even ill-behaved standard DOS applications (i.e., most DOS programs of consequence) in separate on-screen windows. However, Windows/386 won't load with 386MAX loaded, because both switch into protected mode to manage memory, and you can run only one protected-mode program at a time. So you can either play tricks loading different CONFIG.SYS files, or stick with Windows/286.

Another complaint regards Microsoft's documentation, especially that "explaining" installation trade-offs (how to allocate memory, for example). Part of the problem is that the documentation hasn't been updated in two or three years; let's hope it is in 3.0!

Given the amount of trouble I had setting up that system, why not stop fighting and switch to a Mac? Hardware cost is one big reason. A 20-MB hard disk for the Mac still costs almost twice what a PC drive costs, and larger capacity drives are even more expensive. There's also the question of selection. With the PC, I've got lots of choices for CPU, memory, video, and printer. And even though I complain about how those choices adversely affect Windows' performance and setup routines, I'd rather be able to make my own decisions.

One standard to watch is the OS/2 Presentation Manager. For a while it seemed that Windows would gradually be phased out as OS/2 PM gained popularity. Now it's not at all clear what will happen. There are rumors that an upcoming 386-specific version of OS/2 PM will run Windows applications as-is. That's an intriguing possibility, but almost certainly one that will not be realized in the near future. So it seems that DOS, Windows, and OS/2 are each going to have their own market niches.

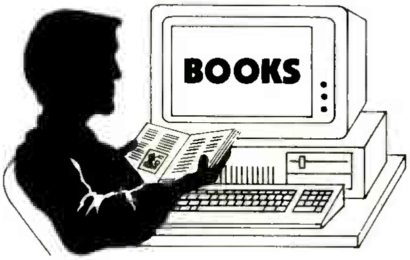
Ultimately, OS/2 would be the better solution, because it offers built-in support for many problems facing Windows users (memory management and low-level device-driver support). However, as few good Windows applications as we have, there are even fewer for OS/2. Again, though, that's rumored to change during 1990, as versions of Ventura and PageMaker and other programs are released.

At bottom, you've got to look at the problem of system configuration as an ongoing issue that's not likely to settle down in the near future. The point is to find a compromise that seems as though it will remain stable for awhile—a year or two at best. And try not to lock yourself into proprietary solutions that could become obsolete as new standards emerge.

In the ideal world, the Ultimate PC would have unlimited resources, would be extremely powerful, and yet would be easy to operate. That machine doesn't exist yet, and rather than complain about how far short current systems fall from the goal, we should look back ten years and see how far we've come. An editorial of that time expressed certainty that 16-bit microprocessors would never catch on because most people used personal computers for text processing, and eight bits are enough to adequately represent the necessary information! ◆CD◆

**ITEMS DISCUSSED**

- *Standard C* ($7.95), P. J. Plauger and Jim Brodie, Microsoft Press, 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717. (206) 882-8080.
  CIRCLE 46 ON FREE INFORMATION CARD
- *Microsoft Mouse Programmer's Reference* ($29.95), Microsoft Press, 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717. (206) 882-8080.
  CIRCLE 47 ON FREE INFORMATION CARD
- Command Post ($20 for license, $5 for disk, $10 for printed documentation), Wilson WindowWare, 3377 59th SW, Seattle, WA 98116. (206) 937-9335.
  CIRCLE 48 ON FREE INFORMATION CARD



## New from Microsoft

C programmers and would-be C programmers will want to check out *Standard C*, by P. J. Plauger and Jim Brodie. This concise, inexpensive (less than $10) book is a reference for the newly approved ANSI standard for the language. It's not a tutorial but a reference to those *printf* format specifiers you can never remember, as well as the hundreds of other elements of the language. The authors point out that although Standard C is an historical development of the C language, it should be treated as an essentially new language by programmers familiar with previous versions.

*Microsoft Mouse Programmer's Reference* contains reference information for programmers building menu-based mouse interfaces for text-mode programs, as well as graphics support. The book contains numerous test programs, and two disks containing object code libraries and sample programs in various languages (BASIC, C, Pascal, etc.). ◆CD◆

## RGB TO NTSC

*continued from page 81*

The chrominance (R – Y and B – Y) signals drive two double-balanced modulators that are 90° out of phase. The resulting signals are then combined in a chroma amplifier and bandwidth-reduced by an external bandpass transformer.

The luminance signal ( – Y) is fed through an external delay line before being combined with the chrominance signal. A composite sync signal is obtained by combining the horizontal and vertical sync signals before they enter the MC1377. Figure 2 shows the complete schematic diagram of the circuit. The power supply is not critical; the circuit shown in Fig. 3 will suffice.

### Construction

Because of the high frequencies involved, we recommend use of a PC board. Patterns are shown in PC Service; a kit is also available, as mentioned in the Parts List. If you use a PC board, Fig. 4. shows where to mount the components.

Whatever your construction method, place the components (especially T1 and IC2) as close as possible to the associated pins of IC1. In addition, make sure that the trimmer capacitor (C3) is mounted firmly and is accessible for adjustments. Mount LED1 so that it is visible when the unit is powered up.

Most of the components are readily available, but C13 and R7 are critical. Those two components set the timing for the color-burst signal at pin 1 of IC1. If they are off by as little as 5%, bye-bye color. Therefore, you should use a 2%20polypropylene capacitor for C13 and a 1% metal-film resistor

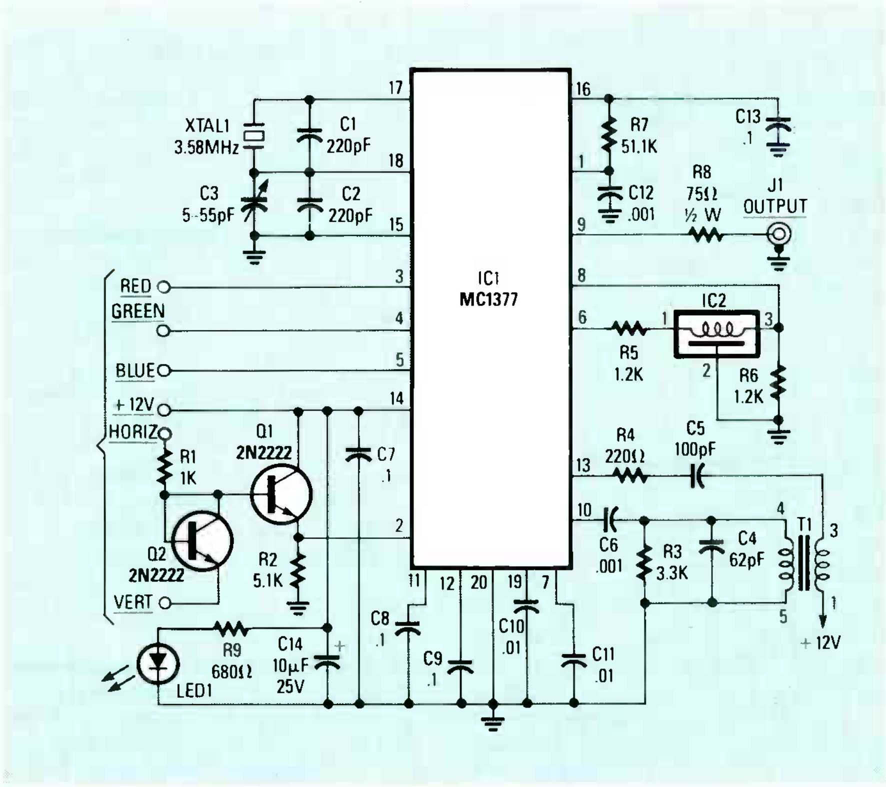


*Fig. 2 SCHEMATIC DIAGRAM of the RGB/NTSC converter.*

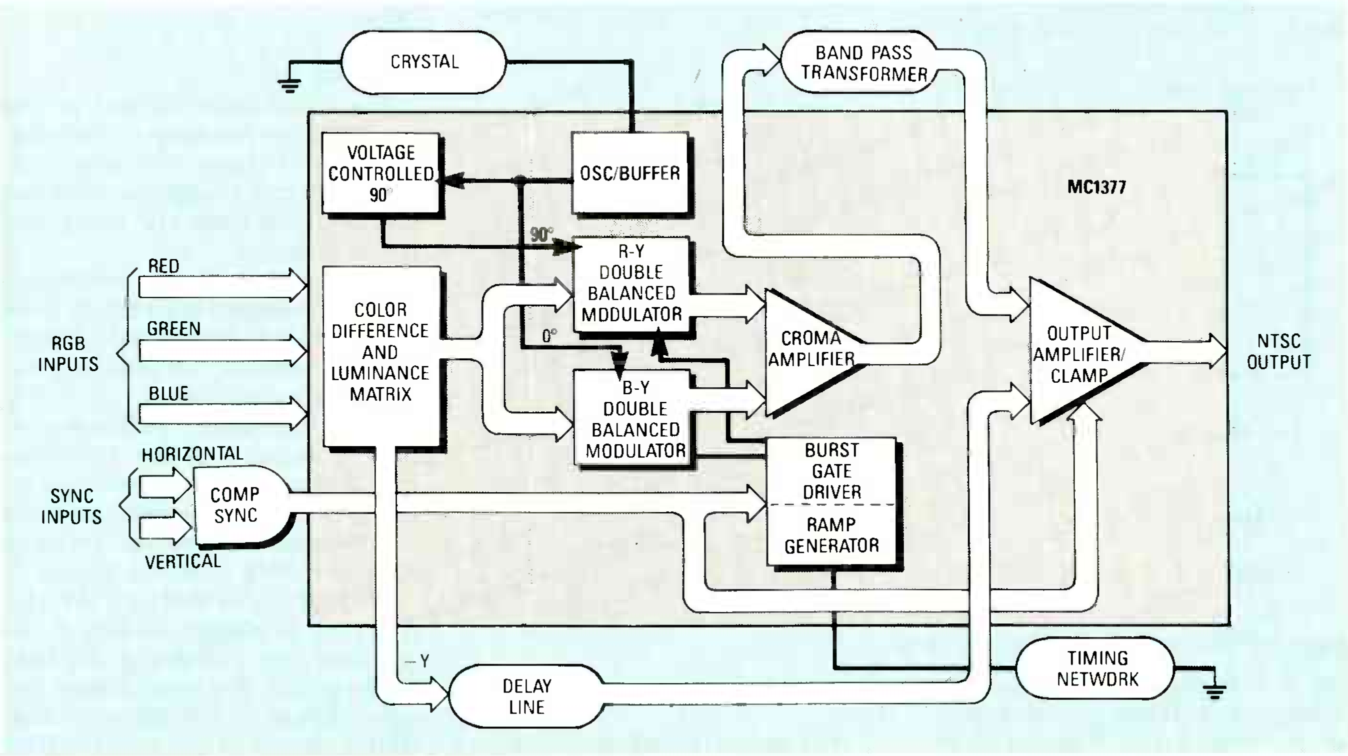


*Fig. 1 BLOCK DIAGRAM OF THE CONVERTER IC, a Motorola MC1377.*

## Parts List

### Resistors

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

| | |
|---|---|
| **R1** | *1000 ohms* |
| **R2** | *5100 ohms* |
| **R3** | *3300 ohms* |
| **R4** | *220 ohms* |
| **R5, R6** | *1200 ohms* |
| **R7** | *51. 100 ohms, metal film, 1%* |
| **R8** | *75 ohms, ½-watt* |
| **R9** | *680 ohms* |

### Capacitors

| | |
|---|---|
| **C1, C2** | *220 pF disc* |
| **C3** | *5–55 pF trimmer* |
| **C4** | *62 pF disc* |
| **C5** | *100 pF disc* |
| **C6** | *.001 µF disc* |
| **C7–C9, C13** | *0.1 µF disc* |
| **C10, C11, C15, C18** | *0.01 µF disc* |
| **C12** | *.001 µF polypropylene, 2%* |
| **C14** | *10 µF, 25-volt electrolytic* |
| **C16** | *2200 µF, 25-volt electrolytic* |
| **C17** | *1 µF, 16-volt electrolytic* |

### Semiconductors

| | |
|---|---|
| **IC1** | *MC1377 RGB to NTSC converter* |
| **IC2** | *DL122401D-1533 delay line (TDK)* |
| **IC3** | *CD4049 inverting hex buffer (optional, see Fig. 7)* |
| **IC4** | *LM7812 12-volt regulator* |
| **D1** | *1N5237 8-volt Zener diode (optional, see Fig. 7)* |
| **D2–D5** | *1N4002 diode* |
| **Q1, Q2** | *2N2222 NPN transistor* |
| **LED1** | *Panel-mount LED* |

### Other components

| | |
|---|---|
| **XTAL1** | *3.58MHz (for PAL use 4.43 MHz)* |
| **T1** | *166NNF-10264AG bandpass transformer (TOKO)* |
| **T2** | *120/12-volt AC transformer* |
| **S1** | *SPST power switch (120 VAC)* |
| **F1** | *¼-amp, 250-volt fuse* |
| **J1** | *Video output connector (see text)* |
| **J2** | *Female MIDI connector (optional 5-pin DIN)* |

### Miscellaneous

*PC board, cabinet, 59-ohm cable, line cord, RF modulator (optional), etc.*

**Note:**
*The folowing items are available from RGB, 32 Wilson Ave., Trumbull, CT 06611, (203) 374-7634, leave a message if no answer: Complete kit of parts including Atari video connector, $29.95; PC board only, $10.00. All orders add $2.50 postage and handling. Connecticut residents please include sales tax.*

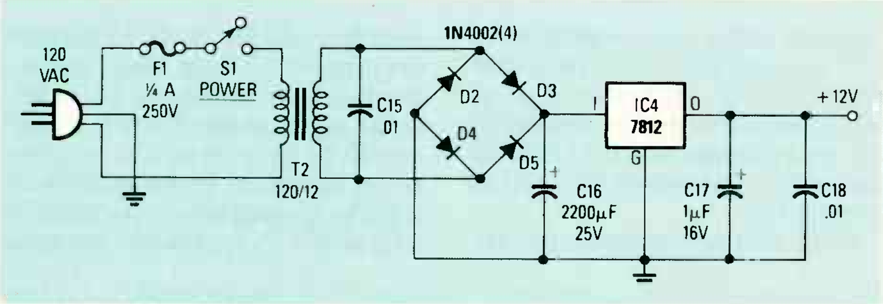


***Fig. 3** POWER SUPPLY for the converter.*

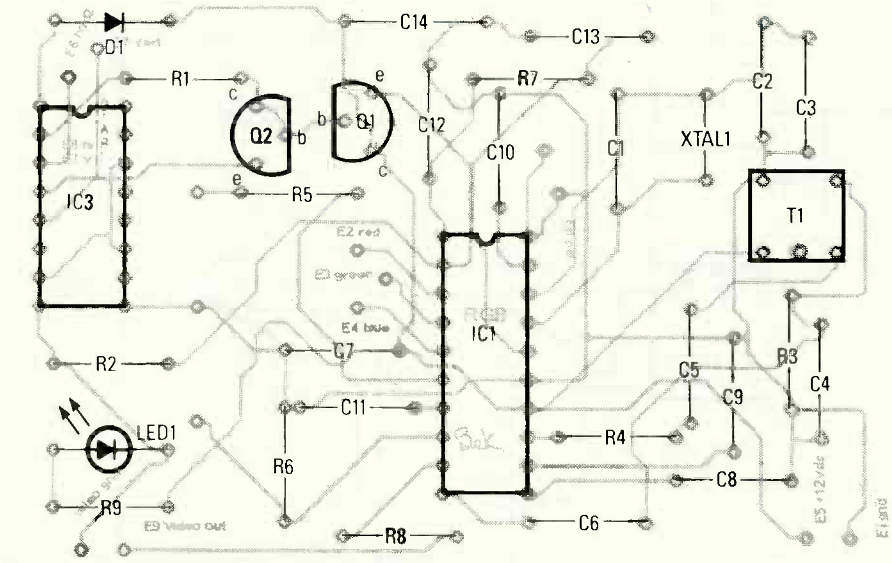


***Fig. 4** INSTALL ALL COMPONENTS as shown here.*

for R7. If you have access to a scope, you can use a potentiometer in series with R7, an inexpensive capacitor for C13, and tune the circuit to the correct frequency.

After soldering all components to the board, check your work carefully and correct any mistakes. Then apply power to the circuit, making sure polarity is correct. Upon power-up, LED1 should light. Measure the voltage at pin 9; it should be +3-volts DC, and pin 16 should be +8.2 volts. If the LED doesn't light or those voltages are incorrect, go back and check your connections.

## Hooking up

The most difficult part of the project is the hook-up to the computer. And that's not very difficult. Just don't forget to route the audio signal from the computer to the monitor.

The output of the converter should be routed with RG59 coax cable and terminated with a male RCA connector (depending on your television). If your TV doesn't have audio and video inputs, you can feed the video output of the converter into one of those cheap (preferably less than $5) RF modulators, and connect it to your TV's antenna inputs.

Pinout information for the Atari ST is shown in Fig. 5. To connect the circuit to an IBM CGA circuit, you must invert the sync signals. A simple way to do that is shown in Fig. 6-*a*; the IBM video pinout is shown in Fig. 6-*b*.

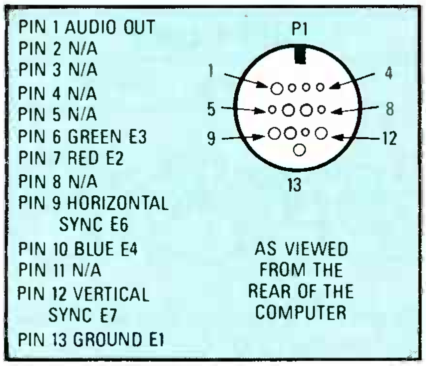


*Fig. 5 VIDEO OUTPUT connector of the Atari ST.*

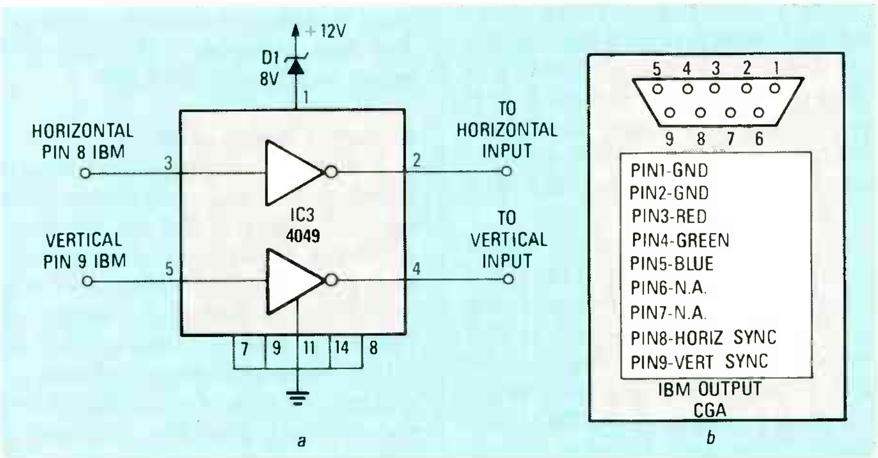


*Fig. 6 USE THIS CIRCUIT FOR AN IBM CGA video system. The gates invert the sync lines.*

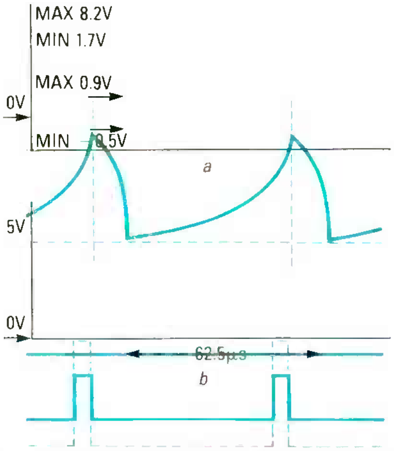


*Fig. 7 WAVEFORMS OF A PROPERLY OPERATING CONVERTER. At (a) is the signal at pin 2; at (b), the signal at pin 1.*

Turn on your computer and the converter, and place your TV in the monitor mode (or on channel 3 if you're using an RF modulator). You should see a computer image on the screen. If you don't, go back and check your connections again, especially the sync circuit (Q120and Q2).

There are two ways to adjust the converter. If you have a frequency counter, connect it to pin 17 and adjust C3 until the counter reads 3.579545 MHz. Without a counter, use a computer image of known color. For example, the bootup screen of the Atari is a bright green. Adjust C3 till you obtain that color.

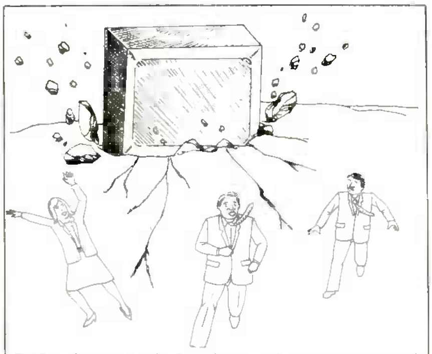
## Troubleshooting

There are two things to watch out for:

**No image.** Check the power supply, Q1, Q2, and connectors. If you have a scope, check pin 2 of IC1 for the waveform shown in Fig. 7-*a*.

**Image but no color.** Check pins 3, 4, and 5 of IC1 to make sure that all three of the RGB signals are getting through. Check pin 1 of IC1 for the waveform shown in Fig. 7-*b*. If adjusting C1 has no effect, then the RC network R7/C13 is out of tolerance. Either replace C13 with a more accurate capacitor or place a trimmer potentiometer in series with R7, and adjust the trimmer until the waveform is correct.

Good luck and enjoy your new computer-TV screen. ◆CD◆



*"Run for your lives! Its memory is expanding again!"*

## AUDIO UPDATE

*continued from page 67*

recent *Stereo Review* evaluations used both test signals and music. One particular test-disc signal proved particularly revealing: When listening to it, every one of the evaluators was able to distinguish each of the six players from all other players! The signal is on track 20 of the CBS CD-1 test disc, and is a 500-Hz dithered tone that fades from −60 to approximately −120 dB. When reproducing the lowest levels of that signal, and listened to at full gain, the players produced degrees and types of distortion and noise sufficient to allow almost 100% individual identifications during ABX testing.

The dithered 500-Hz test signal was specifically designed to reveal *very* low-level linearity problems in D/A converters—which it did very effectively. However, I would suggest that there is a sample-to-sample variability in the D/A-converter chips used in even top-of-the-line players that makes it hard to correlate any particular player's price and design with ultimate performance.

### The sound of music

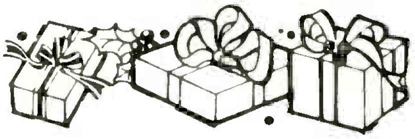
For anyone who has worked with both test signals and music in making audio evaluations, it will come as no surprise that the musical part of the listening tests proved to be very difficult. Even those players that were easily identified with the dithered test signal more-or-less sonically merged with the crowd on music tests. The statistical test results indicate that under carefully controlled test conditions using the finest available audio equipment in an acoustically designed listening room, some critical listeners can hear differences on some music some of the time. And even then, I suspect that the perceived differences stem from D/A quality-control problems (or lack of same) rather than from specific design configurations in the player mechanism or circuitry.

So what's the bottom line? In defense of test signals, it's been said

*continued on page 95*

## GIFT GUIDE

*continued from page 78*



6 available drive bays that are accessible from the front of the case. Now we can have two floppy drives, a tape backup drive, a half-height CD ROM drive, and two hard disks without juggling them in and out of the machine. The case, complete with a 250-watt power supply sells for $299.

- **Math Co-processor**

While computer buyers are always interested in speed, most people don't take full advantage of the machines they have. If you know someone who has an empty math co-processor socket, then you might consider a math co-processor such as Intel's 8087 or 80287. For people whose software requires heavy calaulations—spreadsheets, graphics, engineering software and the like—no other accessory will have as much impact on their overall computer operation as the addition of a math co-processor. The cost of a co-processor ranges from about $89 for a slow 8087 up to $240 for a 10-MHz 80287.

- **PostScript Interpreter**

When discussing the future of graphics printing, you won't get too many arguments if you suggest that the PostScript language is the way to go. Unfortunately, it doesn't come cheap. But *GoScript*, a new PostScript interpreter, gives PostScript compatibility to a number of common and inexpensive printers. It allows page-makeup and word-processing programs to be used to their full advantage. It's also an excellent way to learn PostScript programming. *GoScript* features up to 35 fonts that can be scaled to any size, and rotated to any angle. *GoScript* certainly can't replace a PostScript-compatible laser printer, but at $195, it a good way to get your money's worth out of an inexpensive printer. **R-E**

# MARKET CENTER

## FOR SALE

**PHOTOFACT** folders, under #1400 $4.00. Others $6.00. Postpaid. **LOEB,** 414 Chestnut Lane, East Meadow, NY 11554.

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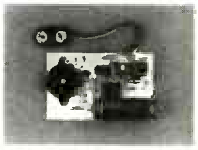

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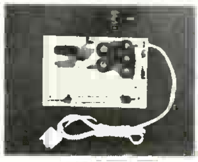

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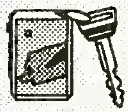

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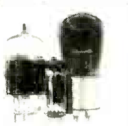

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# CABLE-TV

# BONANZA!

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| Quantity | Item | Output Channel | Price Each | TOTAL PRICE |
|---|---|---|---|---|
| | | | | |
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| | |
|---|---|
| SUBTOTAL | |
| Shipping Add $3.00 per unit | |
| COD & Credit Cards — Add 5% | |
| TOTAL | |

California Penal Code #593-D forbids us from shipping any cable descrambling unit to anyone residing in the state of California.

Prices subject to change without notice.

PLEASE PRINT

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Address ____________________ City ____________________

State ____________ Zip ____________ Phone Number (        ) ____________

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Acct # ____________________ Exp. Date ____________________

Signature ______________________________

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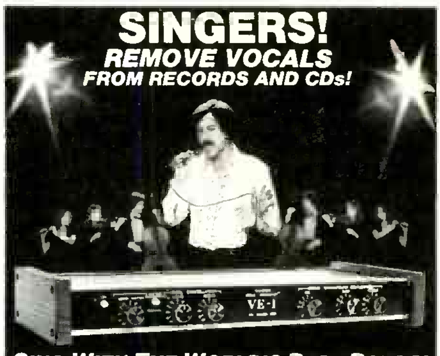

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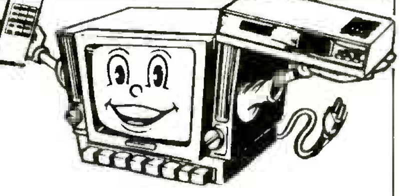

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| LF355 | 35 | 741CV | .29 | N5534 | .75 |
| LF356 | .85 | 747 | .50 | N5596A | 1.50 |
| LM358 | .45 | DAC0808 | 2 95 | SD6000 | 1.00 |
| LM370 | 1.60 | ADC0809 CNN | 8.95 | 8038 | 3.95 |
| LM380 | .85 | MC1310 | 1 00 | 8700CJ | 5.95 |
| LM384 | 1.60 | MC1350 | .90 | LM13080 | .95 |

### C/MOS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 74C00 | .25 | 74C915 | 1 10 | 4027 | .35 | 4072 | .20 |
| 74C04 | .25 | 4001 | 19 | 4028 | 65 | 4076 | .55 |
| 74C08 | .26 | 4002 | .20 | 4029 | 65 | 4077 | .28 |
| 74C10 | .25 | 4006 | .65 | 4030 | .35 | 4081 | 20 |
| 74C14 | .55 | 4007 | .20 | 4034 | 1.40 | 4082 | 20 |
| 74C20 | .25 | 4008 | .85 | 4035 | .65 | 4093 | 45 |
| 74C32 | .35 | 4009 | .35 | 4040 | .65 | 4099 | 1 40 |
| 74C42 | 1.10 | 4010 | .35 | 4041 | .75 | 4501 | 95 |
| 74C74 | .55 | 4011 | .19 | 4042 | .55 | 4503 | 45 |
| 74C76 | .60 | 4012 | .25 | 4043 | 85 | 4506 | 75 |
| 74C85 | 1.25 | 4013 | .35 | 4044 | .65 | 4510 | .65 |
| 74C86 | .35 | 4014 | .65 | 4045 | .85 | 4511 | .65 |
| 74C93 | 1.00 | 4015 | .28 | 4046 | .85 | 4512 | 75 |
| 74C157 | 95 | 4016 | .28 | 4047 | .65 | 4514 | 95 |
| 74C161 | .95 | 4017 | .45 | 4049 | .28 | 4515 | 1.60 |
| 74C174 | .95 | 4018 | .65 | 4050 | 28 | 4516 | 75 |
| 74C175 | .95 | 4019 | 35 | 4051 | .65 | 4518 | 85 |
| 74C193 | 1.25 | 4020 | .55 | 4052 | .65 | 4520 | 75 |
| 74C245 | 1.75 | 4021 | 65 | 4053 | 65 | 4528 | 75 |
| 74C901 | .35 | 4022 | .65 | 4060 | .65 | 4529 | 1.40 |
| 74C902 | .40 | 4023 | .25 | 4066 | .28 | 4538 | .95 |
| 74C903 | 80 | 4024 | .48 | 4068 | .35 | 4539 | 1.50 |
| 74C907 | .75 | 4025 | .25 | 4069 | .19 | 4541B | 1.20 |
| | | 4026 | 1.25 | 4070 | .28 | 4553 | 1.75 |
| | | | | 4071 | 20 | 4583 | .90 |
| | | | | | | 4585 | .75 |

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| | | | | | |
|---|---|---|---|---|---|
| 74HC00 | .35 | 74HC125 | .50 | 74HC245 | .80 |
| 74HC02 | .35 | 74HC133 | .50 | 74HC257 | .55 |
| 74HC04 | .35 | 74HC137 | .75 | 74HC259 | 60 |
| 74HC08 | .35 | 74CH138 | .70 | 74HC273 | .80 |
| 74HC10 | .35 | 74HC139 | .45 | 74HC354 | .95 |
| 74HC11 | .40 | 74HC153 | .55 | 74HC373 | .80 |
| 74HC20 | .35 | 74HC154 | 1.75 | 74HC374 | .80 |
| 74HC30 | 35 | 74HC157 | 50 | 74HC533 | 1.35 |
| 74HC32 | .35 | 74HC162 | 55 | 74HC534 | 1.35 |
| 74HC51 | .45 | 74HC163 | 55 | 74HC573 | 2.50 |
| 74HC58 | .50 | 74HC164 | .80 | 74HC595 | 2 50 |
| 74HC74 | .40 | 74HC174 | .60 | 74HC640 | 2.00 |
| 74HC75 | .40 | 74HC175 | .60 | 74HC4002 | 50 |
| 74HC85 | .70 | 74HC194 | 70 | 74HC4020 | 1 10 |
| 74HC86 | .40 | 74HC221 | 90 | 74HC4066 | .60 |
| 74HC107 | 35 | 74HC240 | 75 | 74HC4514 | 3 20 |
| 74HC109 | .40 | 74HC242 | .75 | 74HC4538 | 1 40 |
| 74HC112 | .40 | 74HC244 | 80 | 74HC4543 | 1.40 |

### 74LS SERIES

| | | | | | |
|---|---|---|---|---|---|
| 74LS00 | 17 | 74LS112 | .29 | 74LS241 | 65 |
| 74LS01 | 17 | 74LS113 | 33 | 74LS242 | .65 |
| 74LS02 | .17 | 74LS114 | .33 | 74LS243 | .65 |
| 74LS03 | 17 | 74LS122 | 70 | 74LS244 | .65 |
| 74LS04 | 17 | 74LS123 | .45 | 74LS245 | .75 |
| 74LS05 | .17 | 74LS125 | .35 | 74LS246 | 1 40 |
| 74LS08 | .17 | 74LS126 | .35 | 74LS247 | 1.00 |
| 74LS09 | .17 | 74LS132 | .39 | 74LS243 | .65 |
| 74LS10 | 17 | 74LS136 | .35 | 74LS251 | .45 |
| 74LS11 | .20 | 74LS137 | .90 | 74LS253 | 45 |
| 74LS12 | 27 | 74LS138 | .39 | 74LS257 | 39 |
| 74LS13 | .25 | 74LS139 | .39 | 74LS258 | 45 |
| 74LS14 | 36 | 74LS145 | .70 | 74LS259 | 1 20 |
| 74LS15 | .25 | 74LS147 | 1.00 | 74LS260 | .45 |
| 74LS20 | .17 | 74LS148 | .90 | 74LS266 | .55 |
| 74LS21 | .22 | 74LS151 | .39 | 74LS273 | .75 |
| 74LS22 | .22 | 74LS153 | .39 | 74LS279 | 39 |
| 74LS26 | .23 | 74LS154 | 1.50 | 74LS280 | 1 70 |
| 74LS27 | .23 | 74LS155 | .55 | 74LS283 | 55 |
| 74LS28 | 26 | 74LS156 | .45 | 74LS290 | 80 |
| 74LS30 | .17 | 74LS157 | .35 | 74LS293 | 80 |
| 74LS32 | .17 | 74LS158 | .20 | 74LS298 | 65 |
| 74LS37 | .26 | 74LS160 | .29 | 74LS299 | 1 25 |
| 74LS38 | .26 | 74LS161 | .49 | 74LS320 | 2 00 |
| 74LS40 | .17 | 74LS162 | .49 | 74LS322 | 3.00 |
| 74LS42 | .35 | 74LS163 | .49 | 74LS323 | 2 40 |
| 74LS48 | .65 | 74LS164 | .45 | 74LS365 | .39 |
| 74LS51 | .17 | 74LS165 | .65 | 74LS366 | .39 |
| 74LS54 | .22 | 74LS166 | .95 | 74LS367 | .39 |
| 74LS73 | .25 | 74LS169 | .90 | 74LS368 | .39 |
| 74LS74 | .24 | 74LS170 | .80 | 74LS373 | .75 |
| 74LS75 | 29 | 74LS173 | .49 | 74LS374 | .75 |
| 74LS76 | 29 | 74LS174 | .39 | 74LS377 | .75 |
| 74LS83 | .45 | 74LS175 | .39 | 74LS386 | .45 |
| 74LS85 | .45 | 74LS181 | 1.40 | 74LS390 | 1,10 |
| 74LS86 | .22 | 74LS190 | .49 | 74LS393 | .75 |
| 74LS9C | .39 | 74LS191 | .49 | 74LS398 | 2.50 |
| 74LS92 | .45 | 74LS192 | .65 | 74LS446 | 2.00 |
| 74LS93 | .45 | 74LS193 | .65 | 74LS541 | 1.40 |
| 74LS95 | .48 | 74LS194 | .65 | 74LS625 | 1 75 |
| 74LS96 | .49 | 74LS195 | .65 | 74LS645 | .95 |
| 81LS98 | 1.40 | 74LS196 | .55 | 74LS668 | 1.45 |
| 74LS107 | .35 | 74LS197 | .55 | 74LS670 | .95 |
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| .68UF 35V | 5/$1.00 | 30UF 6V | 5/$1.00 |
| 1UF 20V | 5/$1.00 | 33UF 15V | $ .50 |
| 2.2UF 20V | 5/$1.00 | 47UF 20V | $ .85 |
| 3.3UF 20V | 4/$1.00 | 68UF 20V | $1.00 |
| 4.7UF 20V | 4/$1.00 | 100UF 16V | $1.10 |
| 6.8UF 20V | 4/$1.00 | 330UF 10V | $1 75 |
| 10UF 20V | $ .40 | | |

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|---|---|---|---|
| LAS39U | $5 95 | 323K (LA1405) | $2.95 |
| 78L05 or 12 | $ .30 | LM337 | $2.75 |
| 78MO5, 12 or 15 | $ .40 | LM338K | $3.75 |
| LM305 | $ .75 | 340T-5,6,8,12, 15,18 or 24V | $ .45 |
| 309K | $1.25 | | |
| LM317T | $ .90 | 723 | $ 45 |
| 320T-5,12,15 or 24 | | | $ 55 |

| | |
|---|---|
| L1411-IR Detector | 3/$1.00 |
| FP 100 Photo Trans | $ .50 |
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| IL 5 Opto Isolators or MC1-2 | $ .60 |
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|---|---|
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|---|---|
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| 80287-8 | $195.00 |
| 80387-16 | $300.00 |

### FULL WAVE BRIDGE

| PRV | 2A | 6A | 25A |
|---|---|---|---|
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| 200 | .80 | 1 30 | 2 20 |
| 400 | 1.00 | 1 65 | 3 30 |
| 600 | 1 30 | 1 90 | 4 40 |

### DIP SWITCHES

| | | |
|---|---|---|
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| CTS 206-7 | 7 Position | 95 |
| CTS 206 8 | 8 Position | 95 |
| CTS 206 10 | 10 Position | 1 25 |

### SILICON POWER RECTIFIERS

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| 400 | .09 | 25 | .65 | 1.50 | 10.00 | 13.50 |
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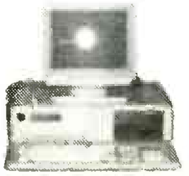
- Installation Guide & Manual



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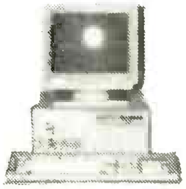
- 12" Amber Mono Monitor
- Installation Guide & Manual



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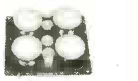
### 3-WAY 100W CROSSOVER



12 dB/octave rolloff. 800Hz, 5000Hz crossover points. 8 ohm. 100 watts RMS.

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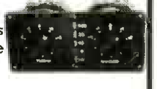
### SPEAKER CONTROL PANEL



Panel with 50 watt L-pads for tweeter and midrange and built-in LED power meter. 5"x 2 1/2" 100 watt version available

**#260-235** **$14.50** (1-5) **$12.90** (6-up)

### 12" POLY WOOFER

Super duty, 40 oz. magnet. 100 watts RMS, 145 watts max. 4 and 8 ohm compatible (6 ohm). 2" voice coil. fs = 25 Hz. QTS = .166, VAS = 10.8 cu ft. Response: 25-1500 Hz. Net weight: 9 lbs. Pioneer #A30GU40-51D

**#290-125** **$36.80** (1-3) **$34.50** (4-up)

### WALNUT SPEAKER CABINET KIT

Super quality, genuine walnut veneer cabinet. Kit includes: routed and mitred top, sides, and bottom in unfinished 3/4 walnut veneer. Cut your own custom holes in the front and rear to match your drivers. 15" x 24" x 11". Volume: 1.9 cubic feet.

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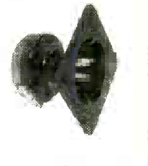
### PIONEER HORN TWEETER



Mylar dome. 2.93 oz. barium ferrite magnet. 8 ohm. Response: 1800-20000 Hz. 35W RMS, 50W max. fs = 2000 Hz. SPL = 106 dB. Pioneer #AHE60-51F

**#270-050** **$6.50** (1-9) **$5.90** (10-up)

### 12" SUB WOOFER

Dual voice coil sub woofer. 30 oz. magnet, 2" voice coils. 100 watts RMS, 145 watts max. fs = 25 Hz. 6 ohm (4 and 8 ohm compatible). SPL = 89 dB 1W/1M. Response: 25-700 Hz. QTS = .31, VAS = 10.3 cu. ft.. Pioneer #A30GU30-55D. Net weight: 6 lbs.

**#290-145** **$39.80** (1-3) **$36.80** (4-up)

### 15" THRUSTER WOOFER

Thruster by Eminence. Made in USA. Poly foam surround, 56 oz. magnet. 2-1/2", 2 layer voice coil. 150 watts RMS, 210 watts max. 4 ohm. fs = 23.5 Hz, QTS = .33, VAS = 17.9 cu ft. SPL = 94.8 dB 1W/1M. Net weight: 15 lbs.

**#290-180** **$43.50** (1-3) **$39.80** (4-up)

### GRILL FRAME KIT

With this kit you can make speaker grill frames up to 30" x 40". Kit includes 4 corner pieces, 2 "T" brackets, and 7 frame bars. Grill mounting kit included.

**#260-333** **$8.50** (1-9) **$7.80** (10-up)

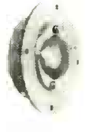
### 18" EMINENCE WOOFER

**MADE IN USA**

100 oz. magnet, 3" voice coil. 250 watts RMS, 350 watts max. 8 ohm, 30 Hz resonant frequency. 22-2700 Hz response. Efficiency: 95 dB 1W/1M. Paper cone, treated accordian surround. Net weight: 29 lbs.

**#290-200** **$98.90** (1-3) **$89.50** (4-up)

### TITANIUM COMPOSITE TWEETER



Titanium is deposited on a polymer dome to combine the advantages of both hard and soft dome technologies. 8 ohm. Ferro fluid cooled voice coil. fs = 1200 Hz, SPL = 90 dB 1W/1M. 50 watts RMS, 70 watts max. 4" round. Polydax part #DTW100T125.

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## AUDIO UPDATE

continued from page 88

that music is the worst kind of signal to use in evaluating components. I would reply that it's always possible to find a test signal that will reveal circuit misbehaviors that, in truth, have no audible consequences.

In any case, the proof of the acoustic pudding is in the listening. Several of the highest-scoring listeners in the group shared the opinion that the audible differences among the tested high-end players were essentially negligible. Based on the tests run by *Consumer Reports*, I would extend that view to include low-end players as well. In other words, once you've selected a player based on its features (and *that* might not be easy) you need not be concerned about the quality of its sound. *Consumer Reports'* opinion, based on a recent test of 26 models, is that they all sound "splendid." **R-E**

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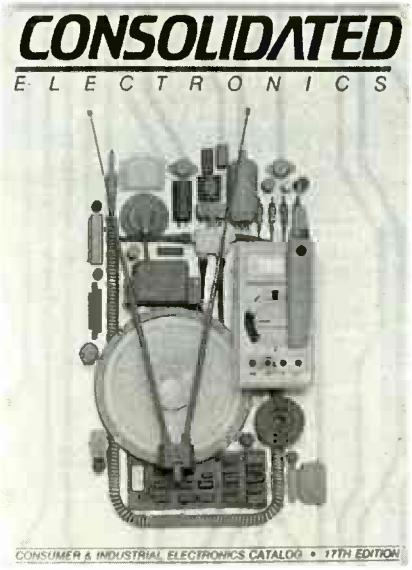

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|---|---|---|---|---|---|
| 7400 | 29 | 19 | 7474 | 39 | .29 |
| 7402 | .29 | .19 | 7475 | .49 | .39 |
| 7404 | .29 | .19 | 7476 | .45 | .35 |
| 7405 | .35 | .25 | 7483 | .59 | .49 |
| 7406 | .39 | .29 | 7485 | .65 | .55 |
| 7407 | .39 | .29 | 7486 | .45 | .35 |
| 7408 | .35 | .25 | 7489 | 2.25 | 2.15 |
| 7410 | .29 | .19 | 7490 | .49 | .39 |
| 7411 | .35 | .25 | 7493 | .45 | .35 |
| 7414 | .49 | .39 | 7495 | .59 | .49 |
| 7416 | .35 | .25 | 74107 | .29 | .19 |
| 7417 | .35 | .25 | 74121 | .39 | .29 |
| 7420 | .29 | .19 | 74123 | .49 | .39 |
| 7427 | 29 | .19 | 74125 | .49 | .39 |
| 7430 | .29 | .19 | 74147 | 1 99 | 1.89 |
| 7432 | .39 | .29 | 74150 | 1 35 | 1.25 |
| 7438 | .39 | .29 | 74151 | 39 | .29 |
| 7442 | .49 | .39 | 74154 | 1.35 | 1.25 |
| 7445 | .75 | .65 | 74161 | .69 | .59 |
| 7446 | .89 | .79 | 74173 | .79 | .69 |
| 7447 | .89 | .79 | 74174 | .59 | .49 |
| 7448 | 1.95 | 1.85 | 74175 | .59 | .49 |
| 7473 | 39 | 29 | 74193 | .79 | .69 |

## 74LS

| | | | | | |
|---|---|---|---|---|---|
| 74LS00 | .26 | .16 | 74LS139 | .49 | .39 |
| 74LS02 | .28 | .18 | 74LS151 | .49 | .39 |
| 74LS03 | .28 | 18 | 74LS153 | .49 | .39 |
| 74LS04 | .28 | .18 | 74LS154 | 1.29 | 1.19 |
| 74LS05 | .28 | .18 | 74LS157 | .45 | .35 |
| 74LS06 | .59 | 49 | 74LS161 | .49 | .39 |
| 74LS07 | .59 | .49 | 74LS163 | .49 | .39 |
| 74LS08 | .28 | .18 | 74LS164 | .59 | .49 |
| 74LS09 | .28 | .18 | 74LS165 | .75 | .65 |
| 74LS10 | .26 | .16 | 74LS166 | .89 | .79 |
| 74LS11 | .29 | .19 | 74LS173 | .45 | 35 |
| 74LS14 | .49 | .39 | 74LS174 | .39 | .29 |
| 74LS20 | .28 | .18 | 74LS175 | 39 | .29 |
| 74LS21 | .29 | .19 | 74LS191 | .59 | .49 |
| 74LS27 | .35 | .25 | 74LS192 | .69 | .59 |
| 74LS30 | .28 | .18 | 74LS193 | .69 | .59 |
| 74LS32 | .28 | .18 | 74LS194 | .69 | .59 |
| 74LS38 | .35 | .25 | 74LS221 | .69 | .59 |
| 74LS42 | .49 | .39 | 74LS240 | .59 | .49 |
| 74LS47 | .85 | .75 | 74LS241 | .59 | .49 |
| 74LS73 | .39 | .29 | 74LS244 | .59 | .49 |
| 74LS74 | .35 | .25 | 74LS245 | .79 | .69 |
| 74LS75 | .39 | .29 | 74LS257 | .49 | .39 |
| 74LS76 | .39 | .29 | 74LS259 | .99 | .89 |
| 74LS83 | .55 | .45 | 74LS273 | .89 | .79 |
| 74LS85 | .55 | .45 | 74LS279 | .49 | .39 |
| 74LS86 | .29 | .19 | 74LS367 | .49 | .39 |
| 74LS90 | 49 | 39 | 74LS373 | .79 | .69 |
| 74LS93 | .49 | .39 | 74LS374 | .79 | .69 |
| 74LS123 | .49 | .39 | 74LS393 | .89 | 79 |
| 74LS125 | .49 | .39 | 74LS541 | 1.29 | 1.19 |
| 74LS132 | .49 | .39 | 74LS590 | 5.95 | 5.85 |
| 74LS138 | 49 | .39 | 74LS688 | 2.39 | 2.29 |

## 74S/PROMS*

| | | | |
|---|---|---|---|
| 74S00 | .25 | 74S188* | 1.49 |
| 74S04 | .25 | 74S189 | 1.49 |
| 74S32 | .25 | 74S240 | 1.39 |
| 74S74 | .25 | 74S244 | .99 |
| 74S112 | .25 | 74S287* | 1.49 |
| 74S124 | 1.25 | 74S288* | 1.49 |
| 74S138 | .49 | 74S373 | .99 |
| 74S153 | .29 | 74S374 | 99 |
| 74S163 | .75 | 74S387* | 1.29 |
| 74S174 | .29 | 74S472* | 2.95 |
| 74S175 | .39 | 74S571* | 2.49 |

## CD-CMOS

| | | | |
|---|---|---|---|
| CD4001 | .19 | CD4051 | .59 |
| CD4002 | .19 | CD4052 | .59 |
| CD4007 | .19 | CD4053 | .59 |
| CD4011 | .19 | CD4060 | .65 |
| CD4012 | .25 | CD4066 | .29 |
| CD4013 | .29 | CD4069 | .25 |
| CD4015 | .29 | CD4070 | .29 |
| CD4016 | .29 | CD4071 | .19 |
| CD4017 | .49 | CD4072 | .19 |
| CD4018 | .49 | CD4073 | .19 |
| CD4020 | .59 | CD4081 | .19 |
| CD4021 | .49 | CD4093 | .35 |
| CD4024 | .45 | CD4094 | .89 |
| CD4027 | .35 | CD4503 | .39 |
| CD4028 | .49 | CD4511 | .59 |
| CD4029 | .69 | CD4518 | .75 |
| CD4030 | .35 | CD4520 | .69 |
| CD4040 | .65 | CD4522 | .75 |
| CD4042 | .49 | CD4528 | .69 |
| CD4043 | .59 | CD4538 | .79 |
| CD4046 | .65 | CD4543 | .79 |
| CD4047 | .65 | CD4584 | .49 |
| CD4049 | .29 | CD4585 | .69 |
| CD4050 | .29 | | |

## EEPROMS

| | | |
|---|---|---|
| 2816A | 2048x8 350ns (9V-15V) 5V Read/Write | 5.25 |
| 2816A-25 | 2048x8 250ns (9V-15V) 5V Read/Write | 5.49 |
| 2817A | 2048x8 350ns 5V Read Write | 6.95 |
| 2864A | 8192x8 250ns 5V Read Write (Pin 1, No R/B) | 10.95 |
| 2864A-30 | 8192x8 300ns 5V Read/Write (Pin 1 No R/B) | 9 95 |
| 2865A | 8192x8 250ns 5V Read/Write | 10.95 |
| 52B13 | 2048x8 350ns (21V) 5V Read Only | 1.49 |

## MICROPROCESSOR COMPONENTS

### Z80, Z80A, Z80B, SERIES

| Part No. | Price |
|---|---|
| Z80 | 1.25 |
| Z80A | 1.29 |
| Z80A-CTC | 1.65 |
| Z80A-DART | 4.95 |
| Z80A-PIO | 1.89 |
| Z80A-SIO/O | 3.95 |
| Z80B | 2.75 |
| Z80B CTC | 3.95 |
| Z80B-PIO | 3.95 |
| Z8681B1 | 4.95 |

### 8000 SERIES

| | |
|---|---|
| 8031 | 3.95 |
| 80C31 | 8 95 |
| 8035 | 1.25 |
| 8039 | 1.59 |
| 8052AHBASIC | 24.95 |
| 8080A | 1.95 |
| 8085A | 1.95 |
| 8085A-2 | 3.59 |
| 8086 | 3 95 |
| 8087 (5MHz) | 89.95 |
| 8087-1 (10MHz) | 169.95 |
| 8087-2 (8MHz) | 129.95 |
| 8088 (5MHz) | 4.95 |
| 8088-2 (8MHz) | 6.95 |
| 8155 | 2.49 |

### 8000 SERIES Continued

| Part No. | Price |
|---|---|
| 8155-2 | 3.75 |
| 81C55 | 4.25 |
| 8205 | 9 95 |
| 82C11 | 6.95 |
| 8212 | 1.99 |
| 8216 | 1.39 |
| 8224 | 1.49 |
| 8228 | 1.49 |
| 8237-5 | 4.25 |
| 8243 | 1.95 |
| 8250A | 4.95 |
| 8250B (For IBM) | 5.95 |
| 8251A | 1.95 |
| 8253 | 1.89 |
| 8253-5 | 1.95 |
| 82C53 5 | 3.95 |
| 8254 | 4 95 |
| 8255A-5 | 2.95 |
| 82C55A-5 | 4.49 |
| 8256 | 11.95 |
| 8259-5 | 2.25 |
| 8272 | 3.49 |
| 8274 | 4.75 |
| 8279-5 | 2.95 |
| 8282 | 2.95 |
| 8284A | 1.95 |

### 8000 SERIES Continued

| Part No. | Price |
|---|---|
| 8286 | 2.29 |
| 8741 | 9.49 |
| 8742 | 14.95 |
| 8748 (25V) | 7.95 |
| 8748H (HMOS)(21V) | 9.95 |
| 8749 | 9.95 |
| 8751H (3.5-12MHz) | 34.95 |
| 8755 | 13.95 |
| 80286 10 (10MHz)LCC | 29.95 |
| 80287-3 (5MHz) | 109.95 |
| 80287-8 (8MHz) | 209.95 |
| 80287-10 (10MHz) | 239.95 |
| 80386-16 PGA | 259.95 |
| 80387-16 (16MHz) | 349.95 |
| 80387-20 (20MHz) | 399.95 |
| 80387-25 (25MHz) | 499.95 |
| 82284 (8MHz) | 5.49 |
| 82288 (8MHz) | 6.95 |

### DATA ACQUISITION

| | |
|---|---|
| ADC0804LCN | 2.99 |
| ADC0808CCN | 5.95 |
| ADC0809CCN | 3.69 |
| ADC1205CCJ-1 | 20.95 |
| DAC0808LCN | 1.75 |
| AY-3-1015D | 4.95 |
| AY-5-1013A | 2.95 |

## STATIC RAMS

| Part No. | Function | | Price |
|---|---|---|---|
| 2016-12 | 2048x8 | 120ns | 2.95 |
| 2102 | 1024x1 | 350ns | .89 |
| 2112 | 256x4 | 450ns MOS | 2.49 |
| 2114N | 1024x4 | 450ns | 99 |
| 2114N-2L | 1024x4 | 200ns Low Power | 1.49 |
| 21C14 | 1024x4 | 200ns (CMOS) | .49 |
| 5101 | 256x4 | 450ns (CMOS) | 1 95 |
| 6116P-1 | 2048x8 | 100ns (16K) CMOS | 3.19 |
| 6116P-3 | 2048x8 | 150ns (16K) CMOS | 2.79 |
| 6116LP-1 | 2048x8 | 100ns (16K) LP CMOS | 3.59 |
| 6116LP-3 | 2048x8 | 150ns (16K) LP CMOS | 3.09 |
| 6264P 10 | 8192x8 | 100ns (64K) CMOS | 6.75 |
| 6264P-15 | 8192x8 | 150ns (64K) CMOS | 6 29 |
| 6264LP-10 | 8192x8 | 100ns (64K) LP CMOS | 6.95 |
| 6264LP-12 | 8192x8 | 120ns (64K) LP CMOS | 6.75 |
| 6264LP-15 | 8192x8 | 150ns (64K) LP CMOS | 6.49 |
| 6514 | 1024x4 | 350ns CMOS | 3.25 |
| 43256-10L | 32,768x8 | 100ns (256K) Low Power | 15.95 |
| 43256-15L | 32,768x8 | 150ns (256K) Low Power | 14.95 |
| 62256LP-10 | 32,768x8 | 100ns (256K) LP CMOS | 16.95 |
| 62256LP-12 | 32,768x8 | 120ns (256K) LP CMOS | 16.25 |
| 62256LP-15 | 32,768x8 | 150ns (256K) LP CMOS | 15.95 |

## DYNAMIC RAMS/MODULES

| | | | |
|---|---|---|---|
| 41256A9A-10 | 262,144x9 | 100ns 256x9 SIP (Has Leads) | 49.95 |
| 41256A9B-10 | 262,144x9 | 100ns 256x9 SIM | 59 95 |
| 421000A9A-10 | 1,048,576x9 | 100ns 1MEGx9 SIP (Has Leads) | 159.95 |
| 421000A9B-10 | 1,048,576x9 | 100ns 1MEGx9 SIM | 159.95 |
| 421000A9A-80 | 1,048,576x9 | 80ns 1MEGx9 SIP (Has Leads) | 169.95 |
| 421000A9B-80 | 1,048,576x9 | 80ns 1MEGx9 SIM | 169.95 |
| TMS4416-12 | 16,384x4 | 120ns | 5.95 |
| TMS4416-15 | 16,384x4 | 150ns | 5.49 |
| 4116-15 | 16,384x1 | 150ns (MM5290N-2) | 1.09 |
| 4128-15 | 131,072x1 | 150ns (Piggyback) | 4.49 |
| 4164-100 | 65,536x1 | 100ns | 2.75 |
| 4164-120 | 65,536x1 | 120ns | 2.39 |
| 4164-150 | 65,536x1 | 150ns | 2.15 |
| 41256-60 | 262,144x1 | 60ns | 6.95 |
| 41256-80 | 262,144x1 | 80ns | 5.75 |
| 41256-100 | 262,144x1 | 100ns | 3.95 |
| 41256-120 | 262,144x1 | 120ns | 3.69 |
| 41256-150 | 262,144x1 | 150ns | 3.25 |
| 41264-12 | 64Kx4 | 120ns Video RAM | 10.95 |
| 41464-10 | 65,536x4 | 100ns | 4.95 |
| 41464-12 | 65,536x4 | 120ns | 4.49 |
| 41464-15 | 65,536x4 | 150ns | 4 25 |
| 51258-10 | 262,144x1 | 100ns Static Column | 8.95 |
| 511000P-10 | 1,048,576x1 | 100ns (1 Meg) | 12.95 |
| 511000P 80 | 1,048,576x1 | 80ns (1 Meg) | 13.95 |
| 514256P-10 | 262,144x4 | 100ns (1 Meg) | 14.49 |
| 514258-10 | 262,144x4 | 100ns Static Column | 26.95 |

## EPROMS

| | | | |
|---|---|---|---|
| TMS2516 | 2048x8 | 450ns (25V) | 4.95 |
| TMS2532 | 4096x8 | 450ns (25V) | 5.95 |
| TMS2532A | 4096x8 | 450ns (12.5V) | 3.25 |
| TMS2564 | 8192x8 | 450ns (25V) | 6.95 |
| TMS2716 | 2048x8 | 450ns (-5V, +5V, +12V) | 6.49 |
| 1702A | 256x8 | 2K (1µs) | 4.25 |
| 2708 | 1024x8 | 450ns | 6.95 |
| 2716 | 2048x8 | 450ns (25V) | 3.49 |
| 2716-1 | 2048x8 | 350ns (25V) | 3.95 |
| 27C16 | 2048x8 | 450ns (25V) CMOS | 4.25 |
| 2732 | 4096x8 | 450ns (25V) | 3.95 |
| 2732A-20 | 4096x8 | 200ns (21V) | 3.95 |
| 2732A-25 | 4096x8 | 250ns (21V) | 3.75 |
| 27C32 | 4096x8 | 450ns (25V) CMOS | 4.25 |
| 2764-25 | 8192x8 | 250ns (21V) | 3.95 |
| 2764A-20 | 8192x8 | 200ns (12.5V) | 4.19 |
| 2764A-25 | 8192x8 | 250ns (12 5V) | 3.49 |
| 27C64-15 | 8192x8 | 150ns (12.5V) CMOS | 4.95 |
| 27128-20 | 16,384x8 | 200ns (21V) | 5.95 |
| 27128-25 | 16,384x8 | 250ns (21V) | 5.25 |
| 27128A-15 | 16,384x8 | 150ns (12.5V) | 6.95 |
| 27128A-20 | 16,384x8 | 200ns (12.5V) | 4.75 |
| 27C128-25 | 16,384x8 | 250ns (21V) CMOS | 5.95 |
| 27256-15 | 32,768x8 | 150ns (12.5V) | 8.49 |
| 27256-20 | 32,768x8 | 200ns (12.5V) | 5.49 |
| 27256-25 | 32,768x8 | 250ns (12.5V) | 4 95 |
| 27C256-15 | 32,768x8 | 150ns (12 5V) CMOS | 7.25 |
| 27C256-25 | 32,768x8 | 250ns (12 5V) CMOS | 5.49 |
| 27512-25 | 65,536x8 | 250ns (12.5V) | 7.25 |
| 27C512-15 | 65,536x8 | 150ns (12.5V) CMOS | 9.95 |
| 27C512-25 | 65,536x8 | 250ns (12.5V) CMOS | 7.49 |
| 27C010-15 | 131,072x8 | 150ns (12.5V) CMOS (1 Meg) | 19.95 |
| 68764 | 8192x8 | 64K 450ns (25V) (Chip Enable) | 14.95 |
| 68766-35 | 8192x8 | 64K 350ns (25V) (Output Enable) | 15.95 |

## 6500/6800 68000 Series

| Part No. | Price |
|---|---|
| 6402 | 3 75 |
| 6502 | 2 19 |
| 6502A | 2.59 |
| 65C02 (CMOS) | 6.95 |
| 6520 | 1.59 |
| 6522 | 2.95 |
| 65C22 | 4.25 |
| 6532 | 4.95 |
| 6551 | 2.69 |
| 65C802 (CMOS) | 15.95 |
| 6800 | 1.75 |
| 6802 | 2.95 |
| 6808 | 2.49 |
| 6810 | 1.25 |
| 6820 | 2.75 |
| 6821 | 1.75 |
| 68B21 | 2.25 |
| 6840 | 3.49 |
| 6845 | 2.75 |
| 6850 | 1.75 |
| 6852 | .75 |
| MC68000L8 | 9.95 |
| MC68000L10 | 11.95 |
| MC68008P8 | 8.49 |
| MC68010L10 | 19.95 |
| MC68020RC12B | 59.95 |
| MC68701 | 19.95 |
| MC68705P3S | 15.95 |
| MC68705U3S | 17.95 |
| MC68450L10 | 29.95 |
| MC68881RC16A | 129.95 |
| MC68881RC20A | 159.95 |

## Commodore

| | |
|---|---|
| WD1770 | 8.95 |
| SI3052P | .99 |
| 6504A | 1.19 |
| 6510 | 14.95 |
| 6526 | 13.95 |
| 6526A | 14.95 |
| 6545-1 | 3.95 |
| 6560 | 6.95 |
| 6567 | 24.95 |
| 6572 | 6.95 |
| 6581 (12V) | 12.95 |
| 6582 (9V) | 7.95 |
| 8502 | 7.95 |
| 8564 | 2.95 |
| 8566 | 6.95 |
| 8701 | 9.95 |
| 8722 | 8.95 |
| *82S100PLA** | 15.95 |
| 325572-01 | 17.95 |
| 901225-01 | 15.95 |
| 901226-01 | 15.95 |
| 901227-02 | 4.95 |
| 901227-03 | 15.95 |
| 901229-05 | 15.95 |
| 901460-03 | 1 95 |
| 901486-06 | 2.95 |

*No specs available
**Note: 82S100PLA = U17 (C 64)

## 74C/CMOS

| | | | |
|---|---|---|---|
| 74C00 | .25 | 74C174 | .39 |
| 74C02 | .25 | 74C175 | 39 |
| 74C04 | 25 | 74C192 | .99 |
| 74C08 | .25 | 74C194 | .49 |
| 74C10 | .19 | 74C221 | 1.79 |
| 74C14 | .49 | 74C240 | .99 |
| 74C32 | .45 | 74C244 | 1 49 |
| 74C74 | .49 | 74C373 | 1 49 |
| 74C85 | 1.29 | 74C374 | 1 49 |
| 74C86 | 29 | 74C911 | 5 95 |
| 74C89 | 2 95 | 74C912 | 7.95 |
| 74C90 | .99 | 74C915 | 1.19 |
| 74C151 | 1.75 | 74C917 | 3.95 |
| 74C154 | 2.95 | 74C920 | 3.95 |
| 74C157 | 1.49 | 74C921 | 3 95 |
| 74C160 | .49 | 74C922 | 3 95 |
| 74C161 | .49 | 74C923 | 3.95 |
| 74C162 | .49 | 74C925 | 4.95 |
| 74C173 | .49 | 74C926 | 5.95 |

## MISC. COMPONENTS

### TANTALUM CAPACITORS

| | | | | | |
|---|---|---|---|---|---|
| TM.1 | .1µf @ 35V | .19 | TM4.7 | 4.7µf @ 35V | .45 |
| TM1 | 1µf @ 35V | .19 | TM6.8 | 6.8µf @ 35V | .59 |
| TM2.2 | 2.2µf @ 35V | .25 | TM10 | 10µf @ 35V | .69 |

### POTENTIOMETERS

Values available (insert ohms into space marked "XX"): 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1MEG

| | | | | | |
|---|---|---|---|---|---|
| **43PXX** | 3/4 Watt, 15Turn | .99 | **63PXX** | 1/2 Watt, 1Turn | .89 |

### TRANSISTORS AND DIODES

| | | | | | |
|---|---|---|---|---|---|
| PN2222 | .13 | PN2907 | .13 | 1N4004 | .10 |
| 2N2222A | .29 | 2N4401 | .15 | 1N4148 | 07 |
| 2N3055 | .69 | 1N270 | .25 | 1N4735 | .25 |
| 2N3904 | .12 | 1N751 | .15 | C106B1 | .49 |

### SWITCHES

| | | | | | |
|---|---|---|---|---|---|
| JMT123 | SPDT, On On | 1.25 | 206-8 | SPST 16-pin DIP | 1.19 |
| MPC121 | SPDT, On-Off-On | 1.25 | MS102 | SPST, Momentary | .39 |

### D-SUB CONNECTORS

| | | | | | |
|---|---|---|---|---|---|
| DB25P | Male, 25-pin | .69 | DB25S | Female, 25-pin | .75 |

### LEDS

| | | | |
|---|---|---|---|
| XC556R T1¾, Red | .13 | XC556Y T1¾, Yellow | 17 |
| XC556G T1¾, Green | .17 | | |

### IC SOCKETS

| Low Profile | | Wire Wrap (Gold) Level #2 | |
|---|---|---|---|
| 8LP | .11 | 8WW | .49 |
| 14LP | .12 | 14WW | 65 |
| 16LP | .13 | 16WW | .69 |
| 24LP | .21 | 24WW | 1.19 |
| 28LP | .23 | 28WW | 1.39 |
| 40LP | .29 | 40WW | 1.89 |

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

## 74HC HI-SPEED CMOS

| Part No. | Price | Part No. | Price |
|---|---|---|---|
| 74HC00 | .19 | 74HC175 | .59 |
| 74HC02 | .19 | 74HC221 | .89 |
| 74HC04 | .19 | 74HC240 | .69 |
| 74HC08 | .19 | 74HC244 | .79 |
| 74HC10 | .19 | 74HC245 | .79 |
| 74HC14 | .29 | 74HC253 | .49 |
| 74HC30 | .25 | 74HC259 | .49 |
| 74HC32 | .25 | 74HC273 | .49 |
| 74HC74 | .29 | 74HC373 | .69 |
| 74HC75 | .35 | 74HC374 | .69 |
| 74HC76 | .35 | 74HC595 | 1.29 |
| 74HC85 | .55 | 74HC688 | 1.49 |
| 74HC86 | .29 | 74HC943 | 6.95 |
| 74HC123 | .59 | 74HC4040 | .79 |
| 74HC125 | .49 | 74HC4049 | .29 |
| 74HC132 | .49 | 74HC4050 | .29 |
| 74HC138 | .45 | 74HC4060 | .69 |
| 74HC139 | .39 | 74HC4511 | .99 |
| 74HC154 | 1.49 | 74HC4514 | 1.79 |
| 74HC163 | .39 | 74HC4538 | 1.19 |
| 74HC174 | .59 | 74HC4543 | 1.19 |

## 74HCT-CMOS TTL

| | | | |
|---|---|---|---|
| 74HCT00 | .17 | 74HCT139 | .39 |
| 74HCT02 | .17 | 74HCT157 | .29 |
| 74HCT04 | .19 | 74HCT174 | .29 |
| 74HCT08 | .17 | 74HCT175 | .29 |
| 74HCT14 | .29 | 74HCT240 | .69 |
| 74HCT32 | .19 | 74HCT244 | .49 |
| 74HCT74 | .29 | 74HCT245 | .49 |
| 74HCT86 | .25 | 74HCT373 | .49 |
| 74HCT138 | .39 | 74HCT374 | .39 |

## LINEAR

| Part No. | 1-9 | 10+ | Part No. | 1-9 | 10+ |
|---|---|---|---|---|---|
| TL071CP | .69 | .59 | DS14C88N | 1.19 | 1.09 |
| TL072CP | .79 | .69 | LM1489N | .49 | .45 |
| TL074CN | .99 | .89 | DS14C89N | 1.19 | 1.09 |
| TL081CP | 59 | .49 | LM1496N | .69 | .59 |
| TL082CP | .59 | .49 | LM1871N | 1.95 | 1.75 |
| TL084CN | .99 | .89 | LM1872N | 1 95 | 1.75 |
| LM307N | .45 | .39 | ULN2003A | .79 | .69 |
| LM308N | .65 | .59 | ULN2004A | .79 | .69 |
| LM309K | 1.49 | 1.25 | 26LS29 | 2.95 | 2.75 |
| LM310N | 1.49 | 1.25 | 26LS31 | 1.19 | .99 |
| LM311N | .49 | .39 | 26LS32 | 1.19 | .99 |
| LM317T | .69 | .59 | 26LS33 | 1 75 | 1.49 |
| LM318N | 1.09 | .99 | ULN2803A | 1.19 | .99 |
| LM319N | 1.29 | 1.19 | LM2901N | .39 | .29 |
| LM323K | 3.49 | 3.25 | LM2907N | 1.29 | 1.19 |
| LM324N | .39 | .35 | LM2917N (8 pin) | 1.75 | 1.49 |
| LM335Z | 1.49 | 1.25 | MC3470P | 1.29 | 1.19 |
| LM336Z | 1.09 | .99 | MC3479P | 3.95 | 3.75 |
| LM337T | 1.29 | 1.09 | MC3486P | 1.29 | 1.19 |
| LM338K | 4.49 | 4.25 | MC3487P | 1.29 | 1.19 |
| LM339N | .49 | .39 | LM3900N | .49 | .45 |
| LF347N | 1.49 | 1.25 | LM3905N | 1.29 | 1.19 |
| LM348N | .69 | .59 | LM3909N | .89 | .79 |
| LF351N | .49 | .39 | LM3914N | 1.95 | 1.75 |
| LF353N | .59 | .49 | NE5532 | 89 | .79 |
| LF356N | .89 | .79 | NE5534 | .89 | .79 |
| LF357N | .99 | .89 | 7805K | 1.29 | 1.19 |
| LM358N | .59 | .49 | 7812K | 1 29 | 1.19 |
| LM380N | .89 | .79 | 7815K | 1.29 | 1.19 |
| LM385Z1.2 | 1.75 | 1.49 | 7805T | .49 | .45 |
| LM386N-3 | .79 | .69 | 7812T | .49 | .45 |
| LM393N | 45 | .35 | 7815T | .49 | .45 |
| LF398N | 1.95 | 1.75 | 78L08 | .35 | .29 |
| LF411CN | .79 | .69 | 7905K | 1.49 | 1.25 |
| LF412CN | 1.29 | 1.19 | 7905T | 55 | .49 |
| NE555V | .35 | .29 | 75113 | 1.39 | 1.19 |
| XRL555 | .75 | .65 | 75150 | 1.29 | 1.19 |
| LM556N | .49 | .39 | 75154 | 1.29 | 1.19 |
| LM565N | .99 | .89 | 75174 | 2.95 | 2.75 |
| LM566CN | 1.29 | 1.19 | 75175 | 2.95 | 2.75 |
| LM567V | .75 | .65 | 75176 | 2.25 | 1.95 |
| LM723CN | .49 | .39 | 75451 | .45 | .39 |
| LM741CN | .35 | .29 | 75452 | .45 | .39 |
| LM747CN | .59 | .49 | 75492 | .89 | .79 |
| LM1458N | .39 | 35 | MC145406P | 2.95 | 2.75 |
| LM1488N | .49 | .45 | | | |

**PARTIAL LISTING • OVER 4000 COMPONENTS AND ACCESSORIES IN STOCK! • CALL FOR QUANTITY DISCOUNTS**

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# Worldwide • Since 1974

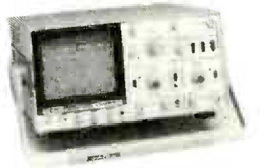
**QUALITY COMPONENTS • COMPETITIVE PRICING • PROMPT DELIVERY**

**15th ANNIVERSARY YEAR 1974 - 1989**

## TEST EQUIPMENT

### *GoldStar* 20MHz Oscilloscope

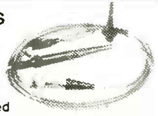
**NEW!**



• Large 6" rectangular display • High sensitivity: 1 mV/div • High accuracy: ±3% • Stable, low-drift design • Distortion-free waveform measurements • Special TV sync for quick measurements • Convenient X - Y operation mode

**GS7020**...............................**$399.95**

### Oscilloscope Probes

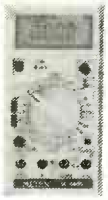


- Attenuation: x1 / x10
- Capacitance (LF180): 180pF / 22pF; (LF210): 40pF / 17pF

LF180 Pictured

| | | |
|---|---|---|
| **LF180** | 40MHz Oscilloscope Probe..... | **$19.95** |
| **LF210** | 100MHz Oscilloscope Probe.... | **$29.95** |

### *Metex* Digital Multimeters



M4650 Pictured

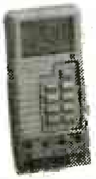
***Metex General Specs:***
- Handheld, high accuracy
- AC/DC Voltage, AC/DC Current, Resistance, Diodes, Continuity, Transistor hFE • Manual ranging w/overload protection

***M3650/B & M4650 only:***
- Also measures frequency and capacitance

***M4650 only:***
- Data Hold Switch
- 4.5 Digit

| | | |
|---|---|---|
| **M3610** | 3.5 Digit Multimeter................ | **$49.95** |
| **M3650** | 3.5 Digit w/Freq. & Capacitance | **$69.95** |
| **M3650B** | Same as M3650 w/Bargraph..... | **$79.95** |
| **M4650** | 4.5 Dig. w/Freq., Capacitance and Data Hold Switch ............ | **$99.95** |

### *Metex* Autoranging Jumbo Readout DMM



- AC/DC Voltage, AC/DC Current, Resistance, Diodes, Continuity and Frequency
- 3.75 Digit (.8" High)
- Ruggedized, Water-resistant case
- Easy-to-use pushbutton switches

**M80**...................**$59.95**

### A.R.T. EPROM Programmer

- Programs all current EPROMs in the 2716 to 27512 range plus the X2864 EEPROM • May be operated by any RS232 port w/ terminal emulation • Fully intelligent • ASCII command driven
- Menu driven software included

**EPP**..............**$179.95**

### *SPECIAL!* Monochrome Text Card

### *Sperry* Monochrome Display Adapter

- IBM PC/XT Compatible
- Allows for Connection between Computer and Monochrome Monitor
- Use for Text only
- Great for Network Servers and Dedicated Work Stations

**TEXT** ......................................**$12.95**

## *JAMECO IBM PC/XT 8MHz Turbo Compatible Kit With 256K RAM*

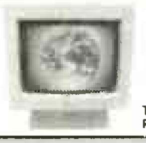
- *Free! WordStar EASY Word Processing and QAPLUS Diagnostic Software Included!*
- *Free! Now included with DR-DOS (Disk Operating System) Software*
- *256K RAM Included, Expandable to 640K*
- *AMI BIOS ROMs Included*
- *4.77 or 8MHz Operation*
- *Flip-Top Case w/150 Watt Power Supply*
- *360K Disk Drive*
- *Parallel Printer Port*
- *84-Key Keyboard*
- *Monochrome Amber Monitor*

*SAVE $88.95!*

**JE3002** IBM Compatible PC/XT 8MHz Turbo Kit............**$499.95**

## IBM COMPATIBLE DISPLAY MONITORS

| | | |
|---|---|---|
| **AMBER** | 12" Amber Mono....................... | **$99.95** |
| **HD55H** | 14" RGB 640x240..................... | **$249.95** |
| **TM5154** | EGA 14" 720x350..................... | **$369.95** |
| **JE1059** | EGA Monitor & Card................. | **$459.95** |
| **TM5156** | 14" VGA 720x480 ..................... | **$399.95** |
| **TM5157** | 14" Multiscan 800x600 ............... | **$469.95** |
| **JE2060** | VGA Monitor & VGA Card.......... | **$529.95** |



TM5156 Pictured

## *JAMECO* IBM PC/XT/AT COMPATIBLE CARDS

| | | |
|---|---|---|
| **JE1050** | Monochrome Graphics Card w/Parallel Printer Port (PC/XT/AT).......... | **$59.95** |
| **JE1052** | Color Graphics Card w/Parallel Printer Port (PC/XT/AT).................... | **$49.95** |
| **JE1055** | EGA Card w/256K Video RAM (PC/XT/AT)................................. | **$139.95** |
| **JE1071** | Multi I/O Card w/Controller & Monochrome Graphics (PC/XT)............ | **$119.95** |
| **JE1060** | I/O Card w/Serial, Game, Printer Port & Real Time Clock (PC/XT)........ | **$59.95** |
| **JE1062** | RS232 Serial Half Card (PC/XT/AT)............................................. | **$29.95** |
| **JE1065** | I/O Card w/Serial, Game and Parallel Printer Port (AT)...................... | **$59.95** |
| **JE1081** | 2MB Expanded or Extended Memory Card (zero-K on-board) (AT)...... | **$109.95** |
| **XTGEN** | 20/40MB Hard Disk Controller Card (PC/XT)................................ | **$79.95** |
| **JE1043** | 360K/720K/1.2MB/1.44MB Floppy Disk Controller Card (PC/XT/AT)..... | **$49.95** |
| **JE1044** | 360K Floppy/Hard Disk Controller Card (PC/XT)............................ | **$109.95** |
| **1003VMM2** | 360K/720K/1.2MB/1.44MB Floppy/Hard Disk Controller Card (AT)...... | **$149.95** |

## *SEAGATE* HALF-HEIGHT HARD DISK DRIVES

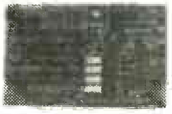
| | | |
|---|---|---|
| **ST225** | 20MB Drive only (PC/XT/AT) | **$224.95** |
| **ST225XT** | 20MB w/Controller (PC/XT) ... | **$269.95** |
| **ST225AT** | 20MB w/Controller (AT) ........ | **$339.95** |
| **ST238** | 30MB Drive only (PC/XT/AT) | **$249.95** |
| **ST238XT** | 30MB w/Controller (PC/XT) ... | **$299.95** |
| **ST238AT** | 30MB w/Controller (AT) ........ | **$389.95** |

ST225XT Pictured

***Seagate 40MB and 60MB Hard Disk Drives Also Available!***

## IBM PC/XT/AT COMPATIBLE MOTHERBOARDS

| | | |
|---|---|---|
| **JE1001** | 4.77/8MHz (PC/XT)...................... | **$89.95** |
| **JE1002** | 4.77/10MHz (PC/XT) .................... | **$99.95** |
| **JE3005** | Baby 8/12MHz (AT) ................... | **$199.95** |
| **JE3010** | Baby 8/16MHz *NEAT* (AT).......... | **$299.95** |
| **JE3020** | Baby 16MHz 80386 .................. | **$999.95** |
| **JE3025** | Baby 20MHz 80386 ................. | **$1199.95** |
| **JE3026** | Full-Size 25MHz 80386............. | **$1899.95** |



JE3025 Pictured

## IBM PC/XT/AT COMPATIBLE 3.5"/5.25" DISK DRIVES

| | | |
|---|---|---|
| **MF353B** | 3.5" 720KB (PC/XT/AT) ............ | **$99.95** |
| **356KU** | 3.5" 1.44MB (PC/XT/AT) .......... | **$109.95** |
| **JE1020** | 5.25" 360KB (PC/XT/AT) Black ... | **$89.95** |
| **JE1021** | 5.25" 360KB (PC/XT/AT) Beige ... | **$89.95** |
| **JE1022** | 5.25" 1.2MB (PC/XT/AT) Beige ... | **$99.95** |

JE1022 Pictured

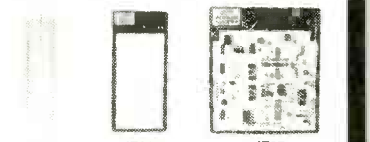
## IBM PC/XT/AT COMPATIBLE INTERNAL MODEMS

| | | |
|---|---|---|
| **1200B** | 1200/300 Baud Internal Modem w/ProComm Comm. Software (PC/XT/AT) .... | **$49.95** |
| **2400B** | 2400/1200/300 Baud Internal Modem w/ProComm Comm. Sfwr. (PC/XT/AT).. | **$99.95** |

***External Modems and Pocket-Size Modem Also Available!***

## PROTOTYPING PRODUCTS

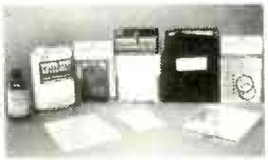
### *Jameco* Solderless Breadboards



| Part No. | Dim. L" x W" | Contact Points | Binding Posts | Price |
|---|---|---|---|---|
| JE20 | 6.5 x .75 | 200 | 0 | $2.95 |
| JE21 | 3.25 x 2.125 | 400 | 0 | $4.95 |
| JE22 | 6.5 x 1.325 | 630 | 0 | $5.95 |
| JE23 | 6.5 x 2.125 | 830 | 0 | $6.95 |
| JE24 | 6.5 x 3.125 | 1,360 | 2 | $12.95 |
| JE25 | 6.5 x 4.25 | 1,660 | 3 | $17.95 |
| JE26 | 6.875 x 5.75 | 2,390 | 4 | $22.95 |
| JE27 | 7.25 x 7.5 | 3,220 | 4 | $32.95 |

### *DATAK* Photo Etch PCB Kit

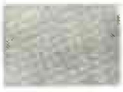
***Make your own circuit boards!***



The ER4 photo etch kit contains all the chemicals necessary for any hobbyist, engineer or student to create professional circuit boards. Contains: Print frame, photo copy film, resist developer, etch resist, 2 copper circuit boards, concentrated etchant, film developer and fixer, resist patterns and complete instructions. Must be shipped ground (surface).

**ER4** Photo Etch PCB Kit.....................**$37.95**

### *Jameco* Prototype PC Boards



JE401 Pictured

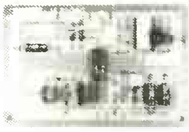
Specs: Laminated glass epoxy .062" thick 2 oz. copper clad with solder tin finish. All holes are .042" dia. on .10" x .10" grid pattern.

| | | |
|---|---|---|
| **JE401** | 4.5"x6.5" 1-sided 3-hole pad pattern ...... | **$9.95** |
| **JE403** | 4.5"x6.5" 1-sided pwr & gnd busses ...... | **$9.95** |
| **JE405** | 4.5"x6.5" 1-sided general purpose ........ | **$9.95** |
| **JE407** | 5"x13.25" 2-sided general purpose....... | **$19.95** |
| **JE417** | 4.2"x6.5" PC/XT 1/2 card proto board... | **$19.95** |
| **JE421** | 4.75"x3.7" IBM PC/XT Card Extender .. | **$19.95** |

## ENGINEERING/DATA BOOKS

| | | |
|---|---|---|
| **21035** | Sams TTL Cookbook (88) ........... | **$14.95** |
| **21398** | Sams CMOS Cookbook (88) ........ | **$19.95** |
| **22453** | Sams Op-Amp Cookbook (88) ...... | **$21.95** |
| **270645** | Intel 8-bit Controller Hndbk. (89) .... | **$19.95** |
| **270646** | Intel 16-bit Controller Hndok. (89) ... | **$19.95** |
| **270647** | Intel 32-bit Controller Hndbk. (89) ... | **$19.95** |
| **104100** | NSC Linear Data Book Vol. 1 (88) .. | **$14.95** |
| **104200** | NSC Linear Data Book Vol. 2 (88) .... | **$9.95** |
| **104300** | NSC Linear Data Book Vol. 3 (88) .... | **$9.95** |
| **ICM89** | 1989 IC Master (3 Volume Set) ... | **$119.95** |

## EDUCATIONAL KITS



JE2206 Pictured

**JE310/315:** Fiber optics kits demonstrate the principles of fiber optic system design. Complete step-by-step instructions, theory of operation and tutorial info. incl.

**JE2206:** Function generator kit provides three basic waveforms: sine, triangle and square wave. Frequency range: 1Hz to 100kHz

| | | |
|---|---|---|
| **JE310** | Fiber Optics Experimenter Kit | **$19.95** |
| **JE315** | Advanced Fiber Optics Kit.... | **$29.95** |
| **JE2206** | Function Generator Kit......... | **$19.95** |

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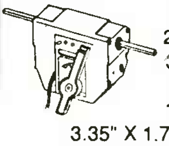
# ALL ELECTRONICS CORP.

## 3 to 6 Vdc MOTOR with GEARBOX

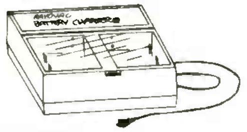


Probably designed for childs toy. Lever selects 2 forward and one reverse speed. 1st gear aprox. 120 rpm/6vdc, 2nd gear aprox. 300 rpm/6vdc, Reverse aprox. 120 rpm/6vdc.

3.35" X 1.75" X 3.25"

**CAT# DCM-10 $6.00**

## *SPECIAL !!!* NICKEL CADMIUM BATTERY CHARGER

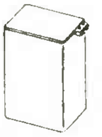


Rayovac# CH-4

Recharges up to four AA, C, D or two 9 volt nickel cadmium rechargeable batteries. LED charging indicator. **CAT# UNCC**

$10.00 each • 12 for $108.00

## 6 VOLT D.C. 9.5 AMP/HOUR GEL-CELL



Elpower# 695

6 volt, 9.5 amp/hour rechargeable gel-cell battery.

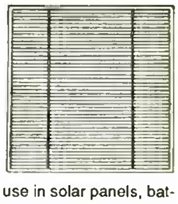
4.25" X 2.75" X 5.5".

Quick connect terminals.

**CAT# GC-695**

$15.00 each

## SOLAR CELL

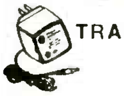


4 inch square silicon solar cell. Produces 0.3-0.45 volts @ 1500 ma in direct sunlight. Solder together in series or parallel for higher voltage or amperage. Ideal for use in solar panels, battery chargers and solar energy products.

**CAT# SCEL $3.50 each**

25 for $75.00

## WALL TRANSFORMERS



ALL PLUG DIRECTLY INTD 120 VAC OUTLET

| | | | |
|---|---|---|---|
| 6 Vdc @ 200 ma. | CAT# | DCTX-620 | $2.25 |
| 9 Vdc @ 250 ma. | CAT# | DCTX-925 | $2.50 |
| 12 Vac @ 930 ma. | CAT# | ACTX-1293 | $3.50 |
| 18 Vac @ 1 amp. | CAT# | ACTX-1885 | $3.50 |

## SWITCHES

### ITT PUSH BUTTON

ITT MDPL series. 3/4" X 1/2" gray rectangular key cap. S.P.S.T. N.O. Push to close. RATED: 0.1 amp switching, 0.25 amp carry current. P.C. mount. **CAT# PB-8**

65¢ each • 10 for $6.00 • 100 for $50.00

### 10 POSITION MINI-ROTARY

Grayhill# 56P36-01-1-10N-C

Mini rotary switch. Non-shorting. 1 deck, 10 positions. .125" dia. shaft X .375" long. .377" behind the panel depth. P.C. pins.

**CAT# MRS-10** WAS $2.50 NOW $1.50 each

### SPDT PUSHBUTTON

Marquardt# 1843

Rated 6 amps @ 125/250 Vac.

Black plastic pushbutton.

Switch body: .92" X .94" X .65".

**CAT# PB-18** $1.65 each - 10 for $1.50 each

### PUSHBUTTON SWITCH

GC/Thornsen# 35-420

S.P.S.T., normally open momentary pushbutton switch. Red plastic actuator .57" dia. Chrome bezel .68" diameter. Threaded bushing mounts in .50" diam. chassis hole. Rated 3 amp @ 250 Vac. Solder loop terminals.

**CAT# PB-20** $1.00 each

## LOOK WHAT $1.00 WILL BUY

### 200 ASSORTED 1/4 WATT RESISTORS

Bent leads, carbon comp. and carbon film.

**CAT# GRES** $1.00 per assortment

### 200 ASSORTED 1/2 WATT RESISTORS

Bent leads, carbon comp and carbon film.

**CAT# GRABRE** $1.00 per assortment

### 50 ASSORTED DISC CAPACITORS

Most are cut (p.c. leads). Some to 500 volts

**CAT# GRABDC** $1.00 per assortment

### 15 VALUES OF ELECTROLYTICS

Contains both axial and radial styles from 1 mfd.

**CAT# GRABCP** $1.00 per assortment

## LED'S

**STANDARD JUMBO**

DIFFUSED T 1-3/4 size

***RED*** **CAT# LED-1**

10 for $1.50 • 100 for $13.00

***GREEN*** **CAT# LED-2**

10 for $2.00 - 100 for $17.00

***YELLOW*** **CAT# LED-3**

10 for $2.00 - 100 for $17.00

### FLASHING LED

with built in flashing circuit operates on 5 volts...

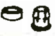
| | |
|---|---|
| *RED* | $1.00 each |
| **CAT# LED-4** | 10 for $9.50 |
| *GREEN* | $1.00 each |
| **CAT# LED-4G** | 10 for $9.50 |

### BI-POLAR LED

Lights RED one direction, GREEN the other. Two leads.

**CAT# LED-6** 2 for $1.70

### LED HOLDER



Two piece holder.

**CAT# HLED** 10 for 65¢

## RELAYS

### 12 VOLT D.C. COIL S.P.D.T.

Omron# G2E-184P 4 Amp contacts 335 ohm coil.

Sugar cube size.

.61" X .42" X .44" high.

P.C. mount with pins on DIP spacing.

**CAT# RLY-787** $1.50 each

### 5 VOLT DC SIP RELAY

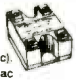
Gould, Allied Control# SR-1A-5VDC

SPST-normally open SIP reed relay. 95 ohm coil. 2 amp contacts. .9" X .29" X .39" high. Housing resists fluorocarbon and chlorinated commercial solvents.

**CAT# RLY-SIP6**

$1.00 each • 10 for $8.50

## 10 AMP SOLID STATE RELAY



ELECTROL# S2181

CONTROL:

Rated 5.5 to 10 Vdc (will operate on 3-32 Vdc).

LOAD: 10 amp @ 240 Vac

2 1/4" X 1 3/4" X 7/8"

**CAT# SSRLY-10B** $9.50 each

*QUANTITY DISCOUNT*

10 for $85.00 • 25 for $175.00

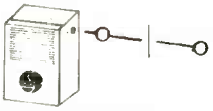
50 for $300.00 • 100 for $500.00

## XENON TUBE

1" long flashtube prepped with 3 1/2" red and black leads. Ideal for electronic flash or strobe projects.

**CAT# FLT-3** 2 for $1.00

## DOOR/WINDOW ALARM



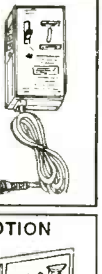
Protects doors and windows from intruders.

Opening of door or window pulls pin from alarm module and triggers loud buzzer. Simple installation. Operates on 2 AA batteries (not included). Plastic case is 3.32" X 2.29" X 1.19". Ivory with brushed aluminum face.

**CAT# DWA** $2.00 each

5 for $9.00

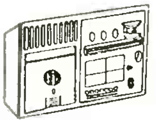
## SOUND AND VIDEO MODULATOR



TI# UM1381-1. Designed for use with T.I. computers. Can be used with video cameras, games or other audio/video source. Built in A/B switch enables user to switch from T.V. antenna without disconnection. Operates on channel 3 or 4. Requires 12 Vdc. Hook up diagram included.

**CAT# AVMOD** $5.00 each

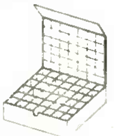
## LIGHT ACTIVATED MOTION SENSOR



This device contains a photocell which senses sudden change in ambient light. Could be used as a door anunciator or modified to trigger other devices. 5 1/2" X 4" X 1". Operates on 6 Vdc. Requires 4 AA batteries (not included)

**CAT# LSMD** $5.75 per unit

## 1/4 WATT RESISTOR KIT



Ideal for the workshop, this 1/4 watt resistor kit contains 10 pieces each of 42 of the most popular values (420 pieces total). Includes a divided box and a parts locator.

**VALUES in this kit are:**

1 ohm, 10 ohm, 39 ohm, 47 ohm, 51 ohm, 68 ohm, 100 ohm, 130 ohm, 150 ohm, 180 ohm, 220 ohm, 330 ohm, 470 ohm, 560 ohm, 680 ohm, 1K, 1.2K, 1.5K, 2K, 2.2K, 2.7K, 3K, 4.7K, 5.1K, 5.6K, 10K, 15K, 22K, 30K, 33K, 39K, 47K, 56K, 68K, 100K, 120K, 150K, 220K, 470K, 1 MEG, 5.1 MEG, 10 MEG

The resistors alone would sell for $21.00.

Complete kit • **CAT# REKIT-14 $17.00**

## PIEZO WARNING DEVICE

Murata Erie # PKB8-4A0

High pitched audible alarm. Operates on 3 - 20 Vdc @ 20 ma. 1" high x 7/8" dia. P.C. board mount.

**CAT# PBZ-84** $1.75 each

## NICKEL-CAD BATTERIES (RECHARGEABLE)

*SPECIAL!!* AAA SIZE

Panasonic# P-18AAA

1.2 volt @ 180 MAh

**CAT# NCB-AAAX** $1.50 each

10 for $13.50 - 100 for $125.00

AA SIZE $2.00 each

1.25 volts 500 mAh

**CAT# NCB-AA**

AA SIZE $2.20 each

WITH SOLDER TABS

**CAT# NCB-SAA**

C SIZE $4.25 EACH

1.2 volts 1200 mAh

**CAT# NCB-C**

D SIZE $4.50 each

1.2 volts 1200 mAh

**CAT# NCB-D**

## TRANSISTORS

ORDER BY PART #

**PN2222 NPN**

TO-92 5 for 75¢

**PN2907 PNP**

TO-92 5 for 75¢

**2N3055 NPN**

TO-3 $1.00 each

**MJ2955 PNP**

TO-3 $1.50 each

**MJE2955T PNP**

TO-220 75¢ each

**MJE3055T NPN**

TO-220 75¢ each

**TIP31 NPN**

TO-220 75¢ each

**TIP32 PNP**

TO-220 75¢ each

**TIP121 NPN**

TO-220 75¢ each

**TIP126 PNP**

TO-220 75¢ each

## WIDE BAND AMPLIFIER

NEC# UPC1651G. 1200 Mhz @ 3 db.

Gain: 19db @ f=500 hz. 5 volt operation.

Small package 4mm dia. X 2.5 mm thick.

**CAT# UPC-1651** 2 for $1.00

10 for $4.50 • 100 for $35.00

## N-CHANNEL MOSFET

IRF-511 TO-220 case

**CAT# IRF 511**

$1.00 each • 10 for $9.00

**LARGE QUANTITY AVAILABLE**

## STROBE KIT

Variable rate strobe kit, flashes between 60 to 120 times per minute. Will operate on either 6 or 12 Vdc depending upon how you wire the circuit. Comes complete with P.C. board and instructions for easy assembly. **CAT# STROBE-1 $7.50 each**

## TELEPHONE COUPLING TRANSFORMER

Multi Products International# A19N-HO-1D/1

Primary 600 ohm

Secondary: 600/600 ohm

.77" X .61" X .63" high.

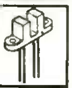
6 p.c. pins on .187" centers.

Primary inductance:

300 mH min., at 1kHz, 1 volt.

**CAT# TCTX-1** $1.25 each • 10 for $11.00

## OPTO SENSOR



U shaped package with mounting ears. 1/8" opening. 3/4" mounting holes. **CAT# OSU-6** 50¢ each

10 for $4.50 • 100 for $40.00

## OPTO ISOLATOR

Sigma# 301T1-12B1. Signal applied to the input is coupled by means of light to isolated photo conductive cell. High reliability switching. 12 volt input.

**CAT# OP-301** $1.50 each

## A.C. LINE CORDS

Black 6ft., 18/2, spt-2

NON POLARIZED PLUG

**CAT# LCAC** 2 for $1.00 - 100 for $45.00

POLARIZED PLUG

**CAT# LCP-1** 60¢ each • 100 for $50.00

## 14.7 VOLT TRANSFORMER

Sprite Industries# CS-510A. 14.7 volt, 60 hz, 8.82 Va. 1.61" high X 1.95" X 1.47". Mounting holes on 2.32" centers.

**CAT# TX-147** $3.00 each

10 for $27.00 • 100 for $250.00

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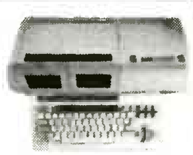
## *ADAM* COMPUTER



*(Less printer)*
No wiring necessary, just plugs together. Hook-up diagram incl. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply & one cassette. Capable of running CP/M; has built-in word processor. Item **#7410**

*Complete* – **$129.00**

*ADAM* 5 1/4" DISK DRIVE
Item **#12830** - *New* *Special* – **$175.00**

*ADAM* PRINTER
Item **#8839** *New* — **$69.50**

DATA DRIVE Item **#6641** **$19.95**

PRINTER POWER SUPPLY
Item **#6642** **$14.95**

ASCII KEYBOARD
Item **#6643** **$19.95**

CONTROLLERS (Set of 4)
Item **#7013** **$9.95** RFE

*ADAM* CASSETTES
Incl. Smart Basic, Buck Rogers & blank cassette. Item **#7786**
*Baker's Dozen* — **$19.95**

*NEW* BLANK TAPES
Item **#20868** *4 for* **$10.00**

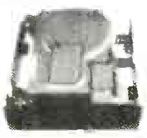
*SMART BASIC* PROG. MANUAL
Item **#20875** *New* – **$14.95**

*ADAM* DAISY PRINT WHEEL
Item **#13305** **$3.95**

*ADAM* SOFTWARE SET
Includes Expertype, Recipe Filer, Smart Letters & Forms, and Zaxxon.
Item **#21746** *New* – **$29.95**

**CALL OR WRITE FOR NEW 1990 CATALOG**

## 3 1/2", 20Mb., HALF-HEIGHT HARD DISK DRIVE



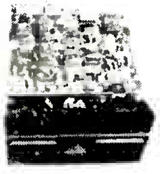
*(ST225 Compatible)*
Universal 5 1/4" mounting. For PC/XT/AT compatible computers. Average access time: 62 msec. Mfr — Lapine #LT2000.

Item **#15853** *RFE* – **$179.00**

*Western Digital Controller Card*
For above drive.
Item **#10150** **$89.00**

## 5 1/4" FULL-HEIGHT DISK DRIVE

*(IBM® Compat.)*



**48 TPI, 40 Track, Double Side/Double Density**
Mfr.– CDC 9409T
Item **#7928** **$79.00** *New*
2 for **$150.00** *New*

## JVC 20Mb INTERNAL TAPE BACK-UP w/CONTROLLER

Includes Sysgen Interface Card (#3044-001), manuals & software. JVC #MTD-520H
Item **#23821** *New* – **$199.00**

## 1200-BAUD MODEM

Operates at 300 & 1200 baud. Bell 103, 212A; CCIT-V.22 compatible. Built-in MNP. Internal speaker, error correction. RS-232C cable connects unit to your computer. 7 status lights, volume control, AC, & 2 phone jacks, incl. AC plug & phone wire. ***(Mfrs' Close Out!)*** Microcom SX/1200
Item **#24034** *New* – **$59.95**

## ATARI HOME COMPUTERS...

- ★ *Capable of running over 2,000 Atari programs (including music composition)*
- ★ *Memory: 64K RAM, 24K ROM (Operating system, plus "Atari Basic" programming language)*
- ★ *CPU: 6502C Microprocessor; Clock speed: 1.79 Mhz.*

★ ★ ★ ★ ★

**1200XL**
67-key, full-stroke keyboard. W/ built-in diagnostic self tests, including: Memory, Audio/Visual, & Keyboard tests. Owner's guide, TV switchbox, AC power adaptor, & "Atari Basic" guide also included.
Item **#24144** *RFE* – **$59.95**

**800XL**
62-key, full-stroke keyboard includes: 4 special-function keys & 29 graphics keys. Owner's guide, TV switchbox, AC power adaptor, & "Atari Basic" guide also included.
Item **#24141** *New* – **$49.95**

## 3M DATA CARTRIDGE

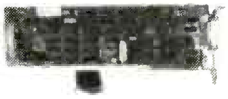
**Reliable, Low Cost Data Storage!**

- Backcoated tape reduces static attraction, ensures long-term data protection.
- Unique cover mounting reduces warpage, ensures correct head/tape alignment, protects data.
- High-speed drive roller increases operating speed, extends cartridge life.

| Model | Unformatted Length | FTPI | Storage Capacity |
|---|---|---|---|
| #DC300A | 300 ft. | 3200 | 2.9 Mb. |

Item **#24781** *RFE* – **$9.95**

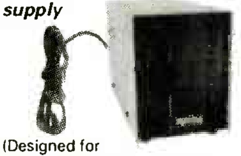
## PC/XT/AT-COMPATIBLE MULTI-FUNCTION BOARD



Contains the following: Parallel port, real-time clock w/battery back up. 2K programmable RAM. 2 optically coupled interface adaptors. Software & schematic included.
Item **#24153** *New* – **$29.95**

## ATARI DISK DRIVES

***5 1/4" External w/power supply***



(Designed for 800LX/1200XL Computers!)

**360K (DS/DD)**
Percom #RFD40-S1.
Item **#24151** *New* — **$79.95**
or 2 for **$150.00**

**180K (SS/DD)**
Percom #AT88-S1
Item **#24152** *New* — **$59.50**
or 2 for **$100.00**

## CAMCORDER CASE

Carry your camcorder & accessories safely!
Will accommodate the following cameras: Matsushita, Panasonic, GE, Quasar, Magnavox, Sylvania, NEC, & Philco. Lightweight, black molded plastic; shoulder strap incl. OA Dim.: 17" W x 11" H x 9" deep. Mfr – Travel Master #TC-1711.
Item **#22909** *New* – **$19.95**

## MULTI-ACCESS REMOTE CONTROL

***One remote controls your TV, VCR & Cable Converters!***

Operates by infrared signals, this wireless remote eliminates the need for 2 or 3 boxes. Operates all major brands of TVs. Easily programmed by setting 2 sets of DIP switches. Gemini #MAC10
Item **#24055** *New* – **$39.95**

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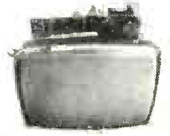
## *HIGH RESOLUTION* TTL MONITORS...

**12VDC • Open Frame**



**9" Green Phosphor**
Schematic included. Mfr: Audiotronics/Elston
Item **#17198** *New* – **$19.95**

**12" Green Phosphor**
Schematic included.
Item **#6811** *New* – **$19.95**

**12" Black & White**
Schematic included. Mfr: Zenith
Item **#21930** *New* – **$24.95**

## LEAD ACID, RECHARGEABLE BATTERIES

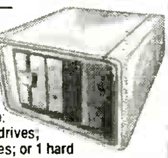
**12V @ 2.5 Ah**
Dim.: 2.61" x 5.27" x 2.34"
Item **#24351** *New* – **$15.95**

**12V @ 6 Ah**
Dim.: 5.89" x 2.53" x 3.67"
Item **#24352** *New* – **$19.95**

**12V @ 15 Ah**
Dim.: 7.05" x 2.96" x 6.51"
Item **#24354** *New* – **$39.95**

## EXTERNAL DISK DRIVE CHASSIS *W/60W power supply*

*(Fan cooled — *Disk drives not incl.)*



Can accommodate: **2 full-height drives; 2 floppy drives; or 1 hard drive & 1 floppy drive.** Input: 115/230V, 50/60 Hz. Orig. for Burroughs computer. Dim.: 11 x 8"H x 12"D
Item **#14541** **$59.50**

**5-1/4" FULL-HEIGHT FLOPPY DRIVE**
Items **#1893** **$139.00**

## MS DOS / CPM COMPUTER

***"High Resolution"*** ***"Graphics Capability"***

- ★ ***IBM Compatible!***
- ★ ***Capable of running MS/DOS 3.2***

256K, expandable (chips must be hard-wired in). Complete with 15" monochrome monitor (amber), 93-key Swedish keyboard (most characters are in English).

*(Disk drives not included!)*
Uses 1 or 2 DS/Quad Density Disk Drives.

*Can be used with our Disk Drive Chassis, item #14541, & DS/Quad Density Disk Drive, item #1893 (see ad at left).*

Operates on 115 or 230V. Built-in printer output (serial or parallel). Hook-up diagram included! Manufactured for Compis in Sweden.
**Item #21934**
*New* – **$199.00**

*(Manufacturers' closeout — we cannot accept returns on this item.)*

## 14" COLOR MONITOR *(CGA — IBM Compatible!)*

Input: 115/230V, 50/60 Hertz (automatically switchable). Resolution: 640 x 240 (RGB-horiz. x vert.). **Complete w/CGA card** and IBM interface cables. Built-in stand. Dot pitch: .31. Mfr – Hitachi; made for Data General. Item #22475

***Special Offer...*** *New* – **$199.00**

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### 7400 TTL

| Part | Price |
|---|---|
| 7400N | .35 |
| 7401N | .35 |
| 7402N | .35 |
| 7403N | .35 |
| 7404N | .35 |
| 7405N | .43 |
| 7406N | .48 |
| 7407N | .48 |
| 7408N | .43 |
| 7409N | .43 |
| 7410N | .43 |
| 7414N | .50 |
| 7416N | .35 |
| 7417N | .35 |
| 7420N | 33 |
| 7426N | 35 |
| 7427N | .43 |
| 7430N | .30 |
| 7432N | .35 |
| 7437N | .40 |
| 7438N | .40 |
| 7440N | .48 |
| 7442N | 55 |
| 7445N | .98 |
| 7446AN | .98 |
| 7447AN | 1.20 |
| 7450N | 42 |
| 7451N | .48 |
| 7453N | .34 |
| 7459N | .30 |
| 7460N | .34 |
| 7473N | .48 |
| 7474N | .48 |
| 7475N | .50 |
| 7476N | .48 |
| 7485N | .70 |
| 7486N | .48 |
| 7489N | 7.50 |
| 7490N | .55 |
| 7493AN | .55 |
| 7495N | .63 |
| 74107N | .53 |
| 74109N | .53 |
| 74121N | 60 |
| 74123N | 58 |
| 74125N | 60 |
| 74132N | .75 |
| 74145N | 1.03 |
| 74148N | 1 10 |
| 74150N | 1.58 |
| 74151AN | .63 |
| 74153N | 83 |
| 74154N | 1 58 |
| 74155N | .60 |
| 74157N | .60 |
| 74161AN | .75 |
| 74164N | .75 |
| 74166N | .90 |
| 74173N | 1.00 |
| 74174N | .83 |
| 74175N | .83 |
| 74180N | 90 |
| 74181N | 2.50 |
| 74182N | 1.15 |
| 74184N | 3.45 |
| 74185AN | 3.37 |
| 74191N | .90 |
| 74193N | .90 |
| 74194N | .90 |
| 74197N | 1.05 |
| 74251N | 1.17 |
| 74365N | .65 |
| 74367N | .70 |
| 74368N | .70 |
| 75450N | .70 |
| 75451N | .50 |
| 75452N | .50 |
| 75453N | .50 |
| 75454N | .50 |
| 75491N | 1.00 |
| 75492N | 1.12 |
| 75493N | 1.38 |
| 75494N | 1.38 |

### 74LS00 TTL

| Part | Price |
|---|---|
| 74LS00N | .32 |
| 74LS02N | .32 |
| 74LS03N | .32 |
| 74LS04N | .31 |
| 74LS05N | .32 |
| 74LS08N | .32 |
| 74LS09N | .32 |
| 74LS10N | .32 |
| 74LS11N | .32 |
| 74LS12N | .32 |
| 74LS14N | .45 |
| 74LS15N | .36 |
| 74LS20N | .32 |
| 74LS21N | .32 |
| 74LS26N | .32 |
| 74LS27N | .32 |
| 74LS30N | .32 |
| 74LS32N | .32 |
| 74LS37N | .33 |
| 74LS38N | .33 |
| 74LS42N | .60 |
| 74LS51N | .45 |
| 74LS55N | .38 |
| 74LS73AN | 42 |
| 74LS74AN | .42 |
| 74LS75N | .42 |
| 74LS78N | .52 |
| 74LS83AN | .66 |
| 74LS85N | .66 |
| 74LS86N | .39 |
| 74LS90N | .51 |
| 74LS93N | 51 |
| 74LS107AN | .48 |
| 74LS109AN | .45 |
| 74LS112AN | .45 |
| 74LS122N | .68 |
| 74LS123N | .63 |
| 74LS125AN | .48 |
| 74LS126AN | 60 |
| 74LS132N | .63 |
| 74LS136N | .54 |
| 74LS138N | 54 |
| 74LS139N | .60 |
| 74LS151N | .51 |
| 74LS153N | .57 |
| 74LS154N | 1.44 |
| 74LS155N | .60 |
| 74LS156N | .57 |
| 74LS157N | .54 |
| 74LS158N | .54 |
| 74LS161AN | .69 |
| 74LS163N | .69 |
| 74LS164N | .69 |
| 74LS169N | 1.23 |
| 74LS174N | .57 |
| 74LS175N | .57 |
| 74LS190N | .81 |
| 74LS191N | .81 |
| 74LS193N | .91 |
| 74LS195AN | .78 |
| 74LS221N | .93 |
| 74LS240N | .66 |
| 74LS241N | .66 |
| 74LS243N | .66 |
| 74LS244N | .66 |
| 74LS245 | .68 |
| 74LS249N | 1.24 |
| 74LS251N | .60 |
| 74LS253N | .60 |
| 74LS257BN | .60 |
| 74LS258BN | .60 |
| 74LS279N | .54 |
| 74LS283N | .78 |
| 74LS290N | .90 |
| 74LS293N | .40 |
| 74LS352N | 1.17 |
| 74LS365AN | .54 |
| 74LS366AN | .54 |
| 74LS367N | .54 |
| 74LS368AN | .60 |
| 74LS373N | .66 |
| 74LS374N | .66 |
| 74LS670N | 1.44 |
| 81LS95N | 1.91 |
| 81LS96AN | 1.89 |
| 81LS97AN | 1.89 |
| 81LS98N | 1.89 |

### 74S00 TTL

| Part | Price |
|---|---|
| 74S00N | .35 |
| 74S02N | .35 |
| 74S03N | .35 |
| 74S04N | .35 |
| 74S05N | .35 |
| 74S08N | .35 |
| 74S09N | .38 |
| 74S10N | .38 |
| 74S11N | 38 |
| 74S15N | 50 |
| 74S20N | .38 |
| 74S22N | 54 |
| 74S30N | .46 |
| 74S32N | .46 |
| 74S40N | 46 |
| 74S51N | .45 |
| 74S64N | .45 |
| 74S65N | .55 |
| 74S74N | .43 |
| 74S86N | .45 |
| 74S112N | .50 |
| 74S113N | 50 |
| 74S114N | .82 |
| 74S133N | .45 |
| 74S134N | .71 |
| 74S135N | 1.12 |
| 74S138N | .88 |
| 74S139N | 85 |
| 74S140N | .58 |
| 74S151N | .85 |
| 74S153N | 85 |
| 74S157N | .85 |
| 74S158N | .85 |
| 74S161N | 2 38 |
| 74S163N | 2.38 |
| 74S174N | 63 |
| 74S175N | .63 |
| 74S181N | 2.48 |
| 74S182N | 1.75 |
| 74S188N | 1 70 |
| 74S194N | 1.43 |
| 74S195N | 1.43 |
| 74S240N | 1.63 |
| 74S241N | 1.63 |
| 74S243N | 3 50 |
| 74S244N | 1.63 |
| 74S251N | 1.05 |
| 74S253N | 90 |
| 74S257N | 1.30 |
| 74S258N | 90 |
| 74S280N | 1.68 |
| 74S283N | 1.63 |
| 74S287N | 2 00 |
| 74S288N | 1.70 |
| 74S373N | 1.75 |
| 74S374N | 1.75 |
| 74S387N | 1.95 |
| 74S472N | 4.80 |
| 74S473N | 4.80 |
| 74S474N | 4.80 |
| 74S475N | 4 80 |
| 74S570N | 3 75 |
| 74S571N | 3.75 |
| 74S572N | 4.50 |
| 74S573N | 5.00 |
| 74S940N | 3.50 |
| 74S941N | 3.50 |

### 74C00 CMOS

| Part | Price |
|---|---|
| 74C00N | .45 |
| 74C02N | .45 |
| 74C04N | .28 |
| 74C08N | .45 |
| 74C10N | .45 |
| 74C14N | 33 |
| 74C20N | .45 |
| 74C30N | .45 |
| 74C32N | .48 |
| 74C42N | 1.05 |
| 74C48N | 1.33 |
| 74C73N | 65 |
| 74C74N | .63 |
| 74C76N | .65 |
| 74C83N | 1.60 |
| 74C85N | 1.60 |
| 74C86N | .28 |
| 74C89N | 5.00 |
| 74C90N | 1.23 |
| 74C93N | 1.23 |
| 74C95N | 1.50 |
| 74C107N | 65 |
| 74C150N | 3.98 |
| 74C151N | 2.60 |
| 74C154N | 3.98 |
| 74C157N | 2 60 |
| 74C160N | .83 |
| 74C161N | .83 |
| 74C162N | .83 |
| 74C163N | .83 |
| 74C164N | 1.23 |
| 74C165N | 1.23 |
| 74C173N | 80 |
| 74C174N | .55 |
| 74C175N | .55 |
| 74C192N | 1.10 |
| 74C193N | 1.10 |
| 74C195N | .78 |
| 74C221N | 1.50 |
| 74C240N | 1.98 |
| 74C244N | 1.98 |
| 74C373N | 2.23 |
| 74C374N | 2.23 |
| 74C901N | .55 |
| 74C902N | .55 |
| 74C903N | 55 |
| 74C904N | .55 |
| 74C905N | 8.25 |
| 74C906N | .55 |
| 74C907N | .55 |
| 74C908N | 1.33 |
| 74C909N | 2.45 |
| 74C910N | 6.88 |
| 74C911N | 10.45 |
| 74C912N | 10.45 |
| 74C914N | 95 |
| 74C915N | 1.63 |
| 74C917N | 10.45 |
| 74C918N | 1.60 |
| 74C922N | 4.23 |
| 74C923N | 4.23 |
| 74C925N | 6.38 |
| 74C926N | 6.38 |
| 74C927N | 6.38 |
| 74C928N | 6 38 |
| 74C932N | 1.23 |
| 74C941N | 1.98 |
| 74C945N | 11.25 |
| 74C947N | 11.25 |
| 80C95N | .55 |
| 80C96N | .55 |
| 80C98N | .55 |
| 82C19N | 3.98 |

### 74HC00 CMOS

| Part | Price |
|---|---|
| 74HC00N | .28 |
| 74HC02N | .28 |
| 74HC04N | .28 |
| 74HC08N | .28 |
| 74HC10N | .28 |
| 74HC11N | .28 |
| 74HC14N | .39 |
| 74HC20N | .28 |
| 74HC27N | .28 |
| 74HC30N | .28 |
| 74HC32N | .28 |
| 74HC42N | 72 |
| 74HC73N | 39 |
| 74HC74AN | .36 |
| 74HC75N | .39 |
| 74HC76N | .50 |
| 74HC85N | 85 |
| 74HC86N | .45 |
| 74HC107N | .53 |
| 74HC112N | .53 |
| 74HC113N | .53 |
| 74HC123N | .98 |
| 74HC125N | .48 |
| 74HC126N | .53 |
| 74HC133N | .38 |
| 74HC138N | .45 |
| 74HC139N | .45 |
| 74HC147N | .73 |
| 74HC151N | 55 |
| 74HC153N | .55 |
| 74HC154N | 1.13 |
| 74HC157N | .63 |
| 74HC158N | .63 |
| 74HC160N | .68 |
| 74HC161N | .63 |
| 74HC162N | 63 |
| 74HC163N | .63 |
| 74HC164N | 63 |
| 74HC165N | .63 |
| 74HC174N | .58 |
| 74HC175N | .58 |
| 74HC193N | .78 |
| 74HC194N | .78 |
| 74HC195N | .78 |
| 74HC221N | 1.10 |
| 74HC240N | .75 |
| 74HC241N | .75 |
| 74HC242N | .78 |
| 74HC243N | .78 |
| 74HC244N | .75 |
| 74HC245N | .82 |
| 74HC251N | .80 |
| 74HC253N | 65 |
| 74HC257N | .63 |
| 74HC259N | 75 |
| 74HC266AN | .38 |
| 74HC280N | .90 |
| 74HC299N | 1.35 |
| 74HC354N | 1.10 |
| 74HC356N | 1 10 |
| 74HC365N | .78 |
| 74HC366N | .78 |
| 74HC367N | .78 |
| 74HC368N | .78 |
| 74HC373N | .75 |
| 74HC374N | .75 |
| 74HC390N | 70 |
| 74HC393N | 70 |
| 74HC533N | 98 |
| 74HC534N | .98 |
| 74HC564N | 1.53 |
| 74HC574N | 1.10 |
| 74HC640N | 1.75 |
| 74HC643N | 1.75 |
| 74HC688N | .88 |
| 74HC4002N | .28 |
| 74HC4020N | .93 |
| 74HC4040N | .93 |
| 74HC4049N | .70 |
| 74HC4050N | .70 |
| 74HC4060N | 1 10 |
| 74HC4075N | .28 |
| 74HC4078N | .30 |
| 74HC4306 | 1.64 |
| 74HC4514N | 1.50 |
| 74HC4538N | 1.05 |
| 74HC4543N | 1.37 |

### 4000 CMOS

| Part | Price |
|---|---|
| 4001BCN | .27 |
| 4002BCN | .40 |
| 4006BCN | .63 |
| 4007CN | .28 |
| 4008CN | .65 |
| 4009CN | .35 |
| 4010CN | .38 |
| 4011BCN | .28 |
| 4012BCN | .28 |
| 4013BCN | .30 |
| 4014BCN | .70 |
| 4015BCN | .55 |
| 4016BCN | 30 |
| 4017BCN | .70 |
| 4018BCN | .70 |
| 4019BCN | .35 |
| 4020BCN | .80 |
| 4021BCN | 60 |
| 4022BCN | .55 |
| 4023BCN | .28 |
| 4024BCN | .45 |
| 4025BCN | .28 |
| 4027BCN | .33 |
| 4028BCN | .55 |
| 4029BCN | .75 |
| 4030CN | .30 |
| 4031B | .83 |
| 4034BCN | 1.13 |
| 4035BCN | .75 |
| 4040BCN | .60 |
| 4041CN | .63 |
| 4042BCN | .63 |
| 4043BCN | .63 |
| 4044BCN | .63 |
| 4046BCN | .65 |
| 4047BCN | .75 |
| 4048BCN | .35 |
| 4049CN | .33 |
| 4050BCN | .33 |
| 4051BCN | .55 |
| 4052BCN | .55 |
| 4053BCN | .55 |
| 4060BCN | .58 |
| 4066BCN | .33 |
| 4071BCN | .28 |
| 4072BCN | .50 |
| 4073BCN | .28 |
| 4075BCN | .28 |
| 4081BCN | .28 |
| 4082B | 28 |
| 4089BCN | 1.00 |
| 4093BCN | .30 |
| 4099BCN | .78 |
| 4503BCN | .33 |
| 4510BCN | .80 |
| 4511BCN | .80 |
| 4512BCN | .80 |
| 4514BCN | 1.08 |
| 4515BCN | 1.08 |
| 4516BCN | .83 |
| 4518BCN | .83 |
| 4519BCN | .48 |
| 4520BCN | .73 |
| 4522BCN | .90 |
| 4526BCN | 1 03 |
| 4527BCN | .88 |
| 4528BCN | .83 |
| 4529BCN | .83 |
| 4541BCN | .78 |
| 4543BCN | .90 |
| 4723BCN | 95 |
| 4724BCN | 83 |

### Linear

| Part | Price |
|---|---|
| LF347N | 1.20 |
| LF351N | .60 |
| LF353N | 1.05 |
| LF355N | 1.20 |
| LF356N | 1.20 |
| LF357N | 1.50 |
| LF398N | 3.36 |
| LF411CN | 1.05 |
| LF412CN | 1.74 |
| LF441CN | .90 |
| LF444CN | 1.80 |
| LF13741N | .78 |
| LM10CLN | 2.70 |
| LM11CLN | 2.55 |
| LM34CZ | 6.00 |
| LM35CZ | 6.00 |
| LM301AN | .57 |
| LM307N | .75 |
| LM308N | 90 |
| LM311N | .54 |
| LM317K | 4.95 |
| LM317LZ | .92 |
| LM317MP | .86 |
| LM317T | .99 |
| LM318N | 1.65 |
| LM319N | 1.50 |
| LM320LZ-5.0 | .72 |
| LM320LZ-12 | .60 |
| LM320LZ-15 | .72 |
| LM320MP-5 | 2.25 |
| LM320MP 12 | 1.90 |
| LM320MP 15 | 1.95 |
| LM322N | 2.40 |
| LM323K | 8.25 |
| LM324N | .54 |
| LM325N | 5.12 |
| LM326N | 6.00 |
| LM327N | 3.38 |
| LM329DZ | .81 |
| LM331N | 5.25 |
| LM334Z | 1.65 |
| LM335Z | 2.10 |
| LM336Z 2.5 | 1.20 |
| LM336Z 5.0 | 1.20 |
| LM337K | 7.65 |
| LM337MP | 1.80 |
| LM337T | 1 95 |
| LM338K | 10.20 |
| LM339N | .51 |
| LM340KC-5 | 2.10 |
| LM340KC-12 | 2.10 |
| LM340KC-15 | 2.10 |
| LM340T-5 | .87 |
| LM340T-12 | .87 |
| LM340T-15 | .79 |
| LM341P-5 | .90 |
| LM341P 12 | 1.00 |
| LM341P-15 | 90 |
| LM346N | 1.65 |
| LM348N | .90 |
| LM349N | 1.35 |
| LM350K | 7 50 |
| LM350T | 4.95 |
| LM358N | .51 |
| LM359N | 2.40 |
| LM380N | 1.50 |
| LM380N 8 | 1.50 |
| LM381N | 2.61 |
| LM382N | 1.86 |
| LM383AT | 4.05 |
| LM384N | 2.55 |
| LM386N 1 | .81 |
| LM387N | 1.65 |
| LM389N | 1.38 |
| LM390N | 1.32 |
| LM391N 60 | 2.00 |
| LM391N 100 | 2.40 |
| LM392N | .75 |
| LM393N | .51 |
| LM395P | 2.40 |
| LM395T | 3.00 |
| LM395K | 10.50 |
| LM396K | 21.00 |
| LM555CN | .75 |
| LM556CN | .90 |
| LM565CN | 1.95 |
| LM566CN | 1 58 |
| LM567CN | 1.11 |
| LM709CN | .75 |
| LM723CN | .75 |
| LM725CN | 2.70 |
| LM733CN | 84 |
| LM741CN | .51 |
| LM747CN | .72 |
| LM748CN | .72 |
| LM1458N | .54 |
| LM1496N | 1.50 |
| LM1800N | 1.95 |
| LM1801N | 1.35 |
| LM1812N | 12.30 |
| LM1830N | 2.55 |
| LM1870N | 3.00 |
| LM1871N | 2.40 |
| LM1872N | 2.55 |
| LM1875T | 5.25 |
| LM1889N | 2.16 |
| LM2900N | 1.50 |
| LM2901N | .60 |
| LM2902N | .60 |
| LM2903N | .57 |
| LM2904N | .57 |
| LM2905N | 3.90 |
| LM2907N | 1.80 |
| LM2907N-8 | 2.70 |
| LM2917N | 2.25 |
| LM2917N 8 | 2.25 |
| LM2924N | 2.61 |
| LM2931Z-5.0 | .66 |
| LM2931T 5.0 | .95 |
| LM2931CT | 1.65 |
| LM3046N | 1.35 |
| LM3080N | 1.26 |
| LM3086N | .84 |
| LM3089N | 2.55 |
| LM3301N | .99 |
| LM3302N | .99 |
| LM3401N | 1.02 |
| LM3524N | 3 75 |
| LM3900N | .59 |
| LM3905N | 1.80 |
| LM3909N | 1.50 |
| LM3911N | 2.25 |
| LM3914N | 2.85 |
| LM3915N | 2.85 |
| LM3916N | 2.85 |
| LM78L05ACZ | .48 |
| LM78L12ACZ | .54 |
| LM78L15ACZ | .54 |
| LM7905CT | .93 |
| LM7912CT | .96 |
| LM7915CT | .96 |
| LM13080N | 1.80 |
| LM13600 | 1.44 |
| MF10CCN | 4.20 |
| AN7805 | .75 |
| AN7806 | .75 |
| AN7807 | .75 |
| AN7808 | .75 |
| AN7809 | .75 |
| AN7810 | .75 |
| AN7812 | .75 |
| AN7815 | .75 |
| AN7818 | .75 |
| AN7820 | .75 |
| AN78L04 | .43 |
| AN78L05 | .43 |
| AN78L06 | .43 |
| AN78L07 | .43 |
| AN78L08 | .43 |
| AN78L09 | 43 |
| AN78L10 | .43 |
| AN78L12 | .43 |
| AN78L15 | .43 |
| AN78L18 | .43 |
| AN78L20 | .43 |
| AN78L24 | .43 |
| AN78M05 | .63 |
| AN78M06 | 63 |
| AN78M07 | .63 |
| AN78M08 | .63 |
| AN78M09 | 63 |
| AN78M10 | .63 |
| AN78M12 | 63 |
| AN78M15 | .63 |
| AN78M18 | .63 |
| AN78M20 | .63 |
| AN78M24 | .63 |
| AN7905 | .75 |
| AN7906 | .75 |
| AN7907 | .75 |
| AN7908 | 75 |
| AN7909 | .75 |
| AN7910 | .75 |
| AN7912 | .75 |
| AN7915 | .75 |
| AN7918 | .75 |
| AN7920 | .75 |
| AN7924 | .75 |
| AN79L04 | .43 |
| AN79L05 | .43 |
| AN79L06 | .43 |
| AN79L07 | 43 |
| AN79L08 | .43 |
| AN79L09 | .43 |
| AN79L10 | .43 |
| AN79L12 | .43 |
| AN79L15 | 43 |
| AN79L18 | .43 |
| AN79L20 | .43 |
| AN79L24 | .43 |
| AN79M05 | .63 |
| AN79M06 | .63 |
| AN79M07 | .63 |
| AN79M08 | .63 |
| AN79M09 | .63 |
| AN79M10 | .63 |
| AN79M12 | .63 |
| AN79M15 | .63 |
| AN79M18 | .63 |
| AN79M20 | .63 |
| AN79M24 | .63 |

### Memory

| Part | Price |
|---|---|
| MM2147N | 17.50 |
| MM5257N | 2.40 |
| 74C200N | 9.37 |
| 74C910N | 6.87 |
| 74S188N | 1.70 |
| 74S189N | 2.10 |
| 74S287N | 2.00 |
| 74S288N | 1.70 |
| 74S289N | 2.10 |
| 74S387N | 1.95 |
| 74S472AN | 4.80 |
| 74S473AN | 4 80 |
| 74S474AN | 4.80 |
| 74S475AN | 4.80 |
| 74S570N | 3.75 |
| 74S571N | 3 75 |
| 74S572N | 4.50 |
| 74S573N | 4.50 |

### Micro.

| Part | Price |
|---|---|
| COP402N | 7.75 |
| COP470N | 4.13 |
| COP498N | 5.38 |
| COP499N | 5.38 |
| DP8212N | 3.38 |
| DP8216N | 2.75 |
| DP8224N | 3 75 |
| DP8226N | 2.25 |
| DP8228N | 6.88 |
| DP8238N | 6.88 |
| DP8300N | 6.87 |
| DP8303AN | 2.13 |
| DP8304BN | 1.88 |
| DP8307AN | 3.25 |
| DP8308N | 2.74 |
| DP8310N | 5 88 |
| DP8311N | 5.88 |
| INS8035LN 6 | 3.50 |
| INS8035N-11 | 3.38 |
| INS8039N-6 | 3.25 |
| INS8039N 11 | 5.63 |
| INS8154N | 17.50 |
| ISP 8F/352 | 25.00 |
| MM58167AN | 10.63 |
| MM58174AN | 10.25 |
| NSC800N | 18.25 |
| NSC800 1 | 9 25 |
| DM8334N | 2 25 |

### A/D & D/A

| Part | Price |
|---|---|
| ADC0803LCN | 7.38 |
| ADC0804LCN | 4.50 |
| ADC0805LCN | 5.00 |
| ADC0808CCN | 8 13 |
| ADC0809CCN | 4.75 |
| ADC0816CCN | 18.00 |
| ADC0817CCN | 11.25 |
| ADC0833CCN | 5.00 |
| ADC1001CCJ | 32.00 |
| ADC3511CCN | 8.25 |
| ADC3711CCN | 8.25 |
| ADD3501CCN | 8.88 |
| ADD3701CCN | 8.88 |
| DAC0800LCN | 1.85 |
| DAC0807LCN | 1.58 |
| DAC0808LCN | 1 65 |
| DAC0830LCN | 6.90 |
| DAC0832LCN | 3.88 |
| DAC1020LCN | 7.50 |
| DAC1022LCN | 5.75 |
| MM5369AAN | 1.63 |
| MM5369EST | 1.63 |

### Interface

| Part | Price |
|---|---|
| DS1488N | .85 |
| DS1489AN | 1.20 |
| DS1489N | .85 |
| 75450N | .87 |
| 75451N | .70 |
| 75452N | .70 |
| 75453N | .70 |
| 75454N | .70 |
| 75491N | 1.00 |
| 75492N | 1.12 |
| 75493N | 1.37 |
| 75494N | 1.37 |

## SILICON TRANSISTORS

| Digi-Key Part No. | Pac Price |
|---|---|
| 2N3117 | 1.37 |
| 2N3055 | 1.47 |
| 2N3439 | 1.75 |
| 2N3440 | 1.40 |
| 2N3700 | 1.00 |
| 2N3724 | 1.06 |
| 2N3903 | .23 |
| 2N3904 | .23 |
| 2N3905 | .14 |
| 2N3906 | .23 |
| 2N3962 | 1.16 |
| 2N4030 | 1.12 |
| 2N4032 | 1.12 |
| 2N4033 | 1.24 |
| 2N4036 | 1.40 |
| 2N4037 | 1.40 |
| 2N4123 | .23 |
| 2N3124 | .23 |
| 2N4125 | .23 |
| 2N4126 | .23 |
| 2N4208 | 1.25 |
| 2N4209 | 2.10 |
| 2N4234 | 2.10 |
| 2N4235 | 2.30 |
| 2N4236 | 2.30 |
| 2N4237 | 2.30 |
| 2N4238 | 2.30 |
| 2N4239 | 2.30 |
| 2N4400 | .23 |
| 2N4401 | .23 |
| 2N4402 | .23 |
| 2N4403 | .23 |
| 2N4410 | .36 |
| 2N4896 | 2.90 |
| 2N5086 | .28 |
| 2N5087 | .28 |
| 2N5088 | .28 |
| 2N5089 | .28 |
| 2N5210 | .29 |
| 2N5224 | .24 |
| 2N5225 | .23 |
| 2N5226 | .23 |
| 2N5227 | .23 |
| 2N5320 | 2.30 |
| 2N5321 | 2.60 |
| 2N5322 | 2.30 |
| 2N5323 | 1.84 |
| 2N5400 | 31 |
| 2N5401 | .31 |
| 2N5415 | 1.80 |
| 2N5416 | 2.00 |
| 2N5457 | .60 |
| 2N5550 | .30 |
| 2N5679 | 2.55 |
| 2N5680 | 2.50 |
| 2N5681 | 2.60 |
| 2N5682 | 2.60 |
| 2N5769 | .32 |
| 2N5771 | 1.25 |
| 2N5772 | .31 |
| 2N5830 | .65 |
| 2N5831 | .70 |
| 2N5833 | .75 |
| 2N5961 | .51 |
| 2N6715 | .35 |
| 2N6725 | .49 |
| 2N6727 | .35 |
| 2N697 | 1.30 |
| 2N718A | 1.15 |
| 2N1132A | 2.04 |
| 2N1613 | .92 |
| 2N1893 | 1.14 |
| 2N2218 | .95 |
| 2N2218A | .95 |
| 2N2219 | .76 |
| 2N2219A | .76 |
| 2N2221 | .80 |
| 2N2221A | .80 |
| 2N2222 | .60 |
| 2N2222A | .60 |
| 2N2369 | .60 |
| 2N2369A | .60 |
| 2N2405 | 1.45 |
| 2N2484 | .84 |
| 2N2904 | .95 |
| 2N2904A | .95 |
| 2N2905 | .76 |
| 2N2905A | .76 |
| 2N2906 | .80 |
| 2N2906A | .80 |
| 2N2907 | .60 |
| 2N2907A | .60 |
| 2N3013 | .90 |
| 2N3014 | 1.10 |
| 2N3019 | 1.04 |
| 2N3020 | 1.04 |
| 2N3053 | 1 04 |
| 2N3107 | 1 30 |
| 2N3108 | 1.30 |
| MPS2907A | .23 |
| MPS2924 | .36 |
| MPS3392 | .24 |
| MPS3393 | .27 |
| MPS3565 | .23 |
| MPS3638A | .23 |
| MPS3641 | .30 |
| MPS3646 | .52 |
| MPS3704 | .27 |
| MPS5172 | .23 |
| MPS5551 | .65 |
| MPS6514 | .24 |
| MPS6515 | .28 |
| MPS6520 | .24 |
| MPS6560 | .41 |
| MPS6561 | .45 |
| MPS918 | .45 |
| MPSA10 | .27 |
| MPSA12 | .52 |
| MPSA13 | .52 |
| MPSA14 | .30 |
| MPSA42 | .45 |
| MPSA43 | .45 |
| MPSA92 | .45 |
| MPSA93 | .45 |
| MPSL01 | .38 |
| PN2222 | .24 |
| MPSL51 | .36 |
| PN2222A | .23 |
| PN2369 | .25 |
| PN2369A | .25 |
| PN2484 | .30 |
| PN2907 | .23 |
| PN2907A | .23 |
| PN3251 | .39 |
| PN3565 | .28 |
| PN3566 | .31 |
| PN3567 | .28 |
| PN3569 | .24 |
| PN3639 | .30 |
| PN3640 | .30 |
| PN3641 | .30 |
| PN3643 | .23 |
| PN3644 | .32 |
| PN3645 | .32 |
| PN4121 | .35 |
| PN4122 | .32 |
| PN4248 | .34 |
| PN4249 | .34 |
| PN4250 | .34 |
| PN4250A | .40 |
| PN4258 | .30 |
| PN4274 | .29 |
| PN4275 | .29 |
| PN4355 | .36 |

## SILICON TRANSISTORS

## 1 AMP SILICON RECTIFIERS

| Part No. | Description | Pkg. | 1 | 10 | 1000 | 1,000 |
|---|---|---|---|---|---|---|
| 1N4001 | 50 PIV | DO-41 | — | .70 | 5.60 | 49.00 |
| 1N4002 | 100 PIV | DO 41 | — | .75 | 6.00 | 52.50 |
| 1N4003 | 200 PIV | DO-41 | — | .80 | 6 40 | 56.00 |
| 1N4004 | 400 PIV | DO 41 | — | .85 | 6.80 | 59.50 |
| 1N4005 | 600 PIV | DO 41 | — | .88 | 7.00 | 61.25 |
| 1N4006 | 800 PIV | DO-41 | — | .98 | 7.80 | 68 25 |
| 1N4007 | 1000 PIV | DO-41 | — | 1.08 | 8.60 | 75.25 |

## 5% CARBON FILM RESISTORS

Available in 1/8, 1/4 & 1/2 Watt

**How To Order:** Take any standard resistor value (i.e. 3.2) and add an "E" for 1/8 watt or a "Q" for 1/4 watt or an "H" for 1/2 watt (i.e. 3.2Ω for 3.2Ω 1/4 watt), this is the Digi-Key part number.

| Pricing | 5 | 200 | 1,000 |
|---|---|---|---|
| 1/8 Watt | .25 | 6.40 | 25.00 |
| 1/4 Watt | .25 | 3.40 | 13.00 |
| 1/2 Watt | .25 | 3.50 | 16.00 |

### 1/8 Watt Resistor Assortments

| | | |
|---|---|---|
| RS112 | Set of 5 each of the 73 standard 5% 1/8 watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohm (365 total pieces). | $9.90 |
| RS212 | Set of 5 each of the 72 standard 5% 1/8 watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pieces). | $9.90 |

### 1/4 Watt Resistor Assortments

| | | |
|---|---|---|
| RS125 | Set of 5 each of the 73 standard 5% 1/4 watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohm (365 total pieces). | $9.90 |
| RS225 | Set of 5 each of the 72 standard 5% 1/4 watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pieces). | $9.90 |

### 1/2 Watt Resistor Assortments

| | | |
|---|---|---|
| RS150 | Set of 5 each of the 73 standard 5% 1/2 watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohms (365 total pieces). | $9.90 |
| RS250 | Set of 5 each of the 72 standard 5% 1/2 watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pieces). | $9.90 |

## 5% WIREWOUND REC. RESISTORS

Available in 5 & 10 Watt

**How To Order:** Take any standard resistor value (i.e. 7.5) and add "W5" for 5 watt, or add a "W10" for 10 watt (i.e. 7.5W5 for 7.5Ω 5 watt), this is the Digi-Key part number.

| Pricing | 1 | 10 | 100 | 500 | 1,000 |
|---|---|---|---|---|---|
| 5 Watt | .36 | 3.25 | 26.90 | 100.80 | 162.00 |
| 10 Watt | .41 | 3.78 | 31.90 | 118.00 | 212.00 |

### 5 Watt Metal Resistor Assortments

| | | |
|---|---|---|
| RS105 | 5 each of values 0.30Ω to 0.91Ω (300 total pieces) | $20.10 |
| RS205 | 4 each of values 1.0Ω to 9.1Ω (384 total pieces) | $31.30 |
| RS305 | 4 each of values 10Ω to 91Ω (384 total pieces) | $31.30 |
| RS405 | 4 each of values 100Ω to 2.0KΩ (288 total pieces) | $31.30 |

### 10 Watt Resistor Assortments

| | | |
|---|---|---|
| R110 | 2 each of all 10 watt standard resistor values listed in the Digi-Key catalog. (168 total pieces) | $58.95 |

## 5% METAL OXIDE FILM RESISTORS

Available in 1 & 2 Watt

**How To Order:** Take any standard resistor value (i.e. 1.5K) and add a "W1" for 1 watt, or add a "W2" for 2 watt (i.e. 1.5KW1 for 1.5KΩ 1 watt), this is the Digi-Key part number.

| Pricing | 1 | 5 | 100 | 500 | 1,000 |
|---|---|---|---|---|---|
| 1 Watt (0.47-0.91Ω) | .21 | .98 | 12.60 | 56.00 | 101.50 |
| 1 Watt (1.0-1.0MΩ) | .15 | .70 | 9.00 | 40.00 | 72.50 |
| 2 Watt (0.47-0.91Ω) | .23 | 1.06 | 13.15 | 59.40 | 109.40 |
| 2 Watt (1.0-1.0MΩ) | .18 | .85 | 10.50 | 47.50 | 87.50 |

### 1 Watt Metal Resistor Assortments

| | | |
|---|---|---|
| RS101 | 5 each of values 0.47Ω to 56Ω (255 total pieces) | $26.95 |
| RS201 | 5 each of values 62Ω to 7.5KΩ (255 total pieces) | $26.95 |
| RS301 | 5 each of values 8.2KΩ to 1.0M (255 total pieces) | $26.95 |

### 2 Watt Resistor Assortments

| | | |
|---|---|---|
| RS102 | 5 each of values 0.47Ω to 56Ω (255 total pieces) | $29.95 |
| RS202 | 5 each of values 62Ω to 7.5KΩ (255 total pieces) | $29.95 |
| RS302 | 5 each of values 8.2KΩ to 1.0M (255 total pieces) | $29.95 |

## 1% METAL OXIDE FILM RESISTORS

Available in 1/4 Watt

**How To Order:** Take any standard resistor value (i.e. 1.69K) and add an "X" (i.e. 1.69KX), this is the Digi-Key part number.

| Pricing | 5 | 200 | 1,000 |
|---|---|---|---|
| 1/4 Watt | .50 | 7.80 | 30.00 |

### 1/4 Watt Metal Film Resistor Assortments

| | | |
|---|---|---|
| RS1X | 5 each of values 10Ω to 97.6Ω (480 total pieces) | $29.95 |
| RS2X | 5 each of values 100Ω to 976Ω (480 total pieces) | $29.95 |
| RS3X | 5 each of values 1.00KΩ to 9.76KΩ (480 total pieces) | $29.95 |
| RS4X | 5 each of values 10.0KΩ to 97.6KΩ (480 total pieces) | $29.95 |
| RS5X | 5 each of values 100KΩ to 1.00MΩ (480 total pieces) | $29.95 |

## PANASONIC® SU SERIES

Miniature Aluminum Electrolytic Capacitors

| WV/Cap. (VDC)/(µF) | Axial Lead Digi-Key Part No. | Axial Lead Price 1 | Radial Lead Digi-Key Part No. | Radial Lead Price 1 |
|---|---|---|---|---|
| 6.3/47 | P6301 | .25 | — | — |
| 6.3/100 | P6302 | .28 | P6201 | .16 |
| 6.3/220 | P6303 | .35 | P6202 | .21 |
| 6.3/330 | P6304 | .42 | P6203 | .22 |
| 6.3/470 | P6305 | .46 | P6204 | .23 |
| 6.3/1,000 | P6306 | .64 | P6205 | .38 |
| 6.3/2,200 | P6307 | .81 | P6206 | .62 |
| 6.3/3,300 | P6308 | .95 | P6207 | .81 |
| 6.3/4,700 | P6309 | 1.13 | P6208 | 1.01 |
| 6.3/6,800 | P6310 | 1.48 | P6209 | 1.22 |
| 6.3/10,000 | P6311 | 1.97 | P6210 | 1.62 |
| 6.3/15,000 | P6312 | 2.67 | P6211 | 2.64 |
| 6.3/22,000 | P6313 | 3.82 | — | — |
| 10/22 | P6314 | .21 | — | — |
| 10/33 | P6315 | .27 | P6212 | .14 |
| 10/47 | P6316 | .28 | P6213 | .14 |
| 10/100 | P6317 | .33 | P6214 | .16 |
| 10/220 | P6318 | .41 | P6215 | .22 |
| 10/330 | P6319 | .49 | P6216 | .24 |
| 10/470 | P6320 | .53 | P6217 | .33 |
| 10/1,000 | P6321 | .73 | P6218 | .42 |
| 10/2,200 | P6322 | .99 | P6219 | .75 |
| 10/3,300 | P6323 | 1.16 | P6220 | .87 |
| 10/4,700 | P6324 | 1.49 | P6221 | 1.19 |
| 10/6,800 | P6325 | 1.86 | P6222 | 1.62 |
| 10/10,000 | P6326 | 2.65 | P6223 | 2.31 |
| 10/15,000 | P6327 | 3.79 | — | — |
| 10/22,000 | P6328 | 5.10 | — | — |
| 16/22 | P6329 | .27 | P6224 | .14 |
| 16/33 | P6330 | .28 | P6225 | .15 |
| 16/47 | P6331 | .33 | P6226 | .16 |
| 16/100 | P6332 | .29 | P6227 | .21 |
| 16/220 | P6333 | .47 | P6228 | .24 |
| 16/330 | P6334 | .63 | P6229 | .31 |
| 16/470 | P6335 | .63 | P6230 | .39 |
| 16/1,000 | P6336 | .82 | P6231 | .50 |
| 16/2,200 | P6337 | 1.13 | P6232 | .95 |
| 16/3,300 | P6338 | 1.49 | P6233 | 1.24 |
| 16/4,700 | P6339 | 1.75 | P6234 | 1.62 |
| 16/6,800 | P6340 | 2.14 | P6235 | 2.31 |
| 16/10,000 | P6341 | 4.04 | — | — |
| 16/15,000 | P6342 | 5.16 | — | — |
| 25/10 | P6343 | .21 | — | — |
| 25/22 | P6344 | .26 | P6236 | .15 |
| 25/33 | P6345 | .29 | P6237 | .16 |
| 25/47 | P6346 | .34 | P6238 | .20 |
| 25/100 | P6347 | .42 | P6239 | .22 |
| 25/220 | P6348 | .49 | P6240 | .33 |
| 25/330 | P6349 | .57 | P6241 | .42 |
| 25/470 | P6350 | .66 | P6242 | .50 |
| 25/1,000 | P6351 | .89 | P6243 | .82 |
| 25/2,200 | P6352 | 1.35 | P6244 | 1.24 |
| 25/3,300 | P6353 | 1.71 | P6245 | 1.74 |
| 25/4,700 | P6354 | 2.55 | P6246 | 2.48 |
| 25/6,800 | P6355 | 3.79 | — | — |
| 25/10,000 | P6356 | 4.95 | — | — |
| 35/4.7 | P6357 | .21 | P6247 | .14 |
| 35/10 | P6358 | .26 | P6248 | .14 |
| 35/22 | P6359 | .29 | P6249 | .20 |
| 35/33 | P6360 | .35 | P6250 | .21 |
| 35/47 | P6361 | .42 | P6251 | .23 |
| 35/100 | P6362 | .46 | P6252 | .26 |
| 35/220 | P6363 | .56 | P6253 | .42 |
| 35/330 | P6364 | .66 | P6254 | .53 |
| 35/470 | P6365 | .72 | P6255 | .65 |
| 35/1,000 | P6366 | 1.03 | P6256 | .97 |
| 35/2,200 | P6367 | 1.71 | P6257 | 1.74 |
| 35/3,300 | P6368 | 2.24 | P6258 | 2.48 |
| 35/4,700 | P6369 | 3.47 | — | — |
| 35/6,800 | P6370 | 4.88 | — | — |
| 50/0.47 | — | — | P6259* | .13 |
| 50/1.0 | — | — | P6260* | .13 |
| 50/2.2 | — | — | P6261* | .13 |
| 50/3.3 | P6371 | .21 | P6262* | .14 |
| 50/4.7 | P6372 | .26 | P6263* | .14 |
| 50/10 | P6373 | .29 | P6264* | .16 |
| 50/22 | P6374 | .35 | P6265* | .22 |
| 50/33 | P6375 | .41 | P6266* | .23 |
| 50/47 | P6376 | .45 | P6267* | .24 |
| 50/100 | P6377 | .49 | P6268* | .38 |
| 50/220 | P6378 | .70 | P6269* | .53 |
| 50/330 | P6379 | .79 | P6270* | .77 |
| 50/470 | P6380 | .95 | P6271* | .90 |
| 50/1,000 | P6381 | 1.38 | P6272* | 1.34 |
| 50/2,200 | P6382 | 2.52 | P6273* | 2.38 |
| 50/3,300 | P6383 | 3.63 | — | — |
| 50/4,700 | P6384 | 4.79 | — | — |
| 63/0.47 | P6385 | .21 | P6274 | .14 |
| 63/1.0 | P6386 | .21 | P6275 | .14 |
| 63/2.2 | P6387 | .21 | P6276 | .15 |
| 63/3.3 | P6388 | .26 | P6277 | .16 |
| 63/4.7 | P6389 | .29 | P6278 | .16 |
| 63/10 | P6390 | .34 | P6279 | .18 |
| 63/22 | P6391 | .42 | P6280 | .24 |
| 63/33 | P6392 | .47 | P6281 | .27 |
| 63/47 | P6393 | .47 | P6282 | .40 |
| 63/100 | P6394 | .59 | P6283 | .53 |
| 63/220 | P6395 | .78 | P6284 | .77 |
| 63/330 | P6396 | .92 | P6285 | .97 |
| 63/470 | P6397 | 1.12 | P6286 | 1.14 |
| 63/1,000 | P6398 | 1.75 | P6287 | 1.74 |
| 63/2,200 | P6399 | 3.53 | — | — |
| 63/3,300 | P6400 | 4.83 | — | — |
| 100/0.47 | P6401 | .21 | P6288 | .21 |
| 100/1.0 | P6402 | .21 | P6289 | .22 |
| 100/2.2 | P6403 | .26 | P6290 | .23 |
| 100/3.3 | P6404 | .29 | P6291 | .24 |
| 100/4.7 | P6405 | .34 | P6292 | .26 |
| 100/10 | P6406 | .42 | P6293 | .31 |
| 100/22 | P6407 | .48 | P6294 | .40 |
| 100/33 | P6408 | .54 | P6295 | .46 |
| 100/47 | P6409 | .57 | P6296 | .52 |
| 100/100 | P6410 | .82 | P6297 | .81 |
| 100/220 | P6411 | 1.22 | P6298 | 1.09 |
| 100/330 | P6412 | 1.54 | P6299 | 1.32 |
| 100/470 | P6413 | 2.02 | P6300 | 1.89 |
| 100/1,000 | P6414 | 3.94 | — | — |
| 160/0.47 | — | — | P6415 | .23 |
| 160/1.0 | — | — | P6416 | .24 |
| 160/2.2 | — | — | P6417 | .27 |
| 160/3.3 | — | — | P6418 | .36 |
| 160/4.7 | — | — | P6419 | .37 |
| 160/10 | — | — | P6178 | .46 |
| 160/22 | — | — | P6179 | .65 |
| 160/33 | — | — | P6180 | .85 |
| 160/47 | — | — | P6181 | 1.13 |
| 160/100 | — | — | P6182 | 1.25 |
| 160/220 | — | — | P6183 | 2.15 |
| 250/1.0 | — | — | P6184 | .40 |
| 250/2.2 | — | — | P6185 | .42 |
| 250/3.3 | — | — | P6186 | .43 |
| 250/4.7 | — | — | P6187 | .43 |
| 250/10 | — | — | P6188 | .61 |
| 250/22 | — | — | P6189 | .87 |
| 250/33 | — | — | P6190 | .98 |
| 250/47 | — | — | P6191 | 1.28 |
| 250/100 | — | — | P6192 | 2.19 |
| 450/1.0 | — | — | P6193 | .47 |
| 450/2.2 | — | — | P6194 | .55 |
| 450/3.3 | — | — | P6195 | .73 |
| 450/4.7 | — | — | P6196 | .79 |
| 450/10 | — | — | P6197 | .98 |
| 450/22 | — | — | P6198 | 1.57 |
| 450/33 | — | — | [illegible] | [illegible] |

## DISC CAPACITORS

| Part No. | Cap./Volt. (pf)/(V) | Price 10 |
|---|---|---|
| P4000 | 10/500 | .71 |
| P4002 | 15/500 | .64 |
| P4003 | 18/500 | .64 |
| P4004 | 22/500 | .64 |
| P4005 | 27/500 | .64 |
| P4006 | 33/500 | .64 |
| P4007 | 39/500 | .64 |
| P4008 | 47/500 | .64 |
| P4009 | 56/500 | .64 |
| P4010 | 68/500 | .71 |
| P4011 | 82/500 | .71 |
| P4141 | 1000/25 | .98 |
| P4142 | 1500/25 | .98 |
| P4143 | 2200/25 | .98 |
| P4144 | 3300/25 | .98 |
| P4145 | 4700/25 | 1.09 |
| P4146 | 6800/25 | 1.09 |
| P4147 | 10000/25 | 1.13 |
| P4148 | 15000/25 | 1.20 |
| P4149 | 22000/25 | 1.20 |
| P4150 | 33000/25 | 1.76 |
| P4152 | 1000/50 | 1.09 |
| P4153 | 1500/50 | 1.09 |
| P4154 | 2200/50 | 1.09 |
| P4155 | 3300/50 | 1.09 |
| P4156 | 4700/50 | 1.20 |
| P4157 | 6800/50 | 1.24 |
| P4158 | 10000/50 | 1.24 |
| P4159 | 15000/50 | 1.35 |
| P4160 | 22000/50 | 1.95 |
| P4100 | 100/500 | .68 |
| P4102 | 150/500 | .68 |
| P4103 | 180/500 | .68 |
| P4104 | 220/500 | .68 |
| P4105 | 270/500 | .68 |
| P4106 | 330/500 | .68 |
| P4107 | 390/500 | .68 |
| P4108 | 470/500 | .79 |
| P4109 | 560/500 | .79 |
| P4110 | 680/500 | .79 |
| P4111 | 820/500 | .79 |
| P4112 | 1000/500 | .94 |
| P4114 | 1500/500 | .94 |
| P4116 | 100/1K | 1.28 |
| P4117 | 120/1K | 1.28 |
| P4118 | 150/1K | 1.28 |
| P4119 | 180/1K | 1.28 |
| P4120 | 220/1K | 1.28 |
| P4121 | 270/1K | 1.28 |
| P4122 | 330/1K | 1.99 |
| P4123 | 390/1K | 1.99 |
| P4124 | 470/1K | 1.99 |
| P4125 | 560/1K | 1.99 |
| P4126 | 680/1K | 1.99 |
| P4127 | 820/1K | 2.25 |
| P4128 | 1000/1K | 2.25 |

## DISC CAPACITORS

| | | |
|---|---|---|
| P4129 | 1200/1K | 2.25 |
| P4130 | 1500/1K | 2.25 |
| P4131 | 1800/1K | 2.25 |
| P4132 | 2200/1K | 2.93 |
| P4133 | 2700/1K | 2.93 |
| P4134 | 3300/1K | 2.93 |
| P4135 | 3900/1K | 4.46 |
| P4136 | 4700/1K | 5.36 |
| P4137 | 5600/1K | 5.36 |
| P4138 | 6800/1K | 8.44 |
| P4139 | 8200/1K | 8.44 |
| P4140 | 10000/1K | 8.44 |
| P4161 | 10000/50 | .86 |
| P4162 | 22000/50 | .94 |
| P4163 | 47000/50 | 1.01 |
| P4164 | 100000/50 | 1.13 |
| DH682 | 6800/50 | .90 |
| P4200 | 1000/100 | .68 |
| P4202 | 1500/100 | .68 |
| P4203 | 2200/100 | .79 |
| P4205 | 3300/100 | .79 |
| P4206 | 4700/100 | 1.09 |
| P4209 | 6800/100 | .71 |
| P4300 | .01µf/25 | .56 |
| P4303 | .022 µf/25 | .64 |
| P4305 | .033 µf/25 | .64 |
| P4307 | .047 µf/25 | .79 |
| P4311 | .1 µf/25 | 1.61 |
| P4418 | 1000/25 | .75 |
| P4419 | 1500/25 | .75 |
| P4420 | 2200/25 | .75 |
| P4421 | 3300/25 | .75 |
| P4422 | 4700/25 | .75 |
| P4423 | 6800/25 | .83 |
| P4424 | 10000/25 | .83 |
| P4425 | 15000/25 | .90 |
| P4426 | 22000/25 | .94 |
| P4427 | 33000/25 | .94 |
| P4428 | 47000/25 | 1.55 |
| P4429 | 68000/25 | 1.73 |
| P4430 | 100000/25 | 1.91 |
| P4431 | 1000/50 | .86 |
| P4432 | 1500/50 | .86 |
| P4433 | 2200/50 | .86 |
| P4434 | 3300/50 | .86 |
| P4435 | 4700/50 | .86 |
| P4436 | 6800/50 | .94 |
| P4437 | 10000/50 | 1.01 |
| P4438 | 15000/50 | 1.01 |
| P4439 | 22000/50 | 1.09 |
| P4440 | 33000/50 | 1.73 |
| P4441 | 47000/50 | 1.73 |

NPO NPO NPO NPO NPO NPO NPO NPO

| | | |
|---|---|---|
| P4400 | 10/500 | .68 |
| P4402 | 15/500 | .79 |
| P4403 | 18/500 | .79 |
| P4404 | 22/500 | .79 |
| P4405 | 27/500 | .79 |
| P4406 | 33/500 | .98 |
| P4407 | 39/500 | .98 |
| P4408 | 47/500 | 1.13 |
| P4409 | 56/500 | 1.13 |
| P4410 | 68/500 | 1.28 |
| P4411 | 82/500 | 1.91 |
| P4412 | 100/500 | 1.91 |
| P4413 | 120/500 | 1.91 |
| P4414 | 150/500 | 2.03 |
| P4415 | 180/500 | 2.70 |
| P4416 | 220/500 | 2.70 |

## TANTALUM CAPACITORS

| Part No. | Cap./Volt. (µF)/DC | Price 1 |
|---|---|---|
| P2011 | 4.7/6.3 | .31 |
| P2012 | 6.8/6.3 | .34 |
| P2013 | 10/6.3 | .42 |
| P2014 | 15/6.3 | .50 |
| P2015 | 22/6.3 | .60 |
| P2016 | 33/6.3 | .72 |
| P2017 | 47/6.3 | .85 |
| P2018 | 68/6.3 | 1.18 |
| P2019 | 100/6.3 | 1.82 |
| P2020 | 150/6.3 | 3.60 |
| P2094 | 220/6.3 | 7.85 |
| P2095 | 330/6.3 | 11.65 |
| P2022 | 2.2/10 | .28 |
| P2023 | 3.3/10 | .31 |
| P2024 | 4.7/10 | .34 |
| P2025 | 6.8/10 | .42 |
| P2026 | 10/10 | .50 |
| P2027 | 15/10 | .60 |
| P2028 | 22/10 | .72 |
| P2029 | 33/10 | .85 |
| P2030 | 47/10 | 1.18 |
| P2031 | 68/10 | 1.82 |
| P2032 | 100/10 | 3.60 |
| P2083 | 150/10 | 6.98 |
| P2084 | 220/10 | 9.63 |
| P2033 | 1.5/16 | .23 |
| P2034 | 2.2/16 | .31 |
| P2035 | 3.3/16 | .33 |
| P2036 | 4.7/16 | .42 |
| P2037 | 6.8/16 | .50 |
| P2038 | 10/16 | .60 |
| P2039 | 15/16 | .74 |
| P2040 | 22/16 | .88 |
| P2041 | 33/16 | 1.18 |
| P2042 | 47/16 | 1.82 |
| P2043 | 68/16 | 3.60 |
| P2086 | 150/16 | 9.08 |
| P2096 | 100/16 | 6.98 |
| P2044 | 1.5/25 | .31 |
| P2045 | 2.2/25 | .34 |
| P2046 | 3.3/25 | .42 |
| P2047 | 4.7/25 | .54 |
| P2048 | 6.8/25 | .65 |
| P2049 | 10/25 | 1.06 |
| P2050 | 15/25 | 1.19 |
| P2051 | 22/25 | 1.68 |
| P2052 | 33/25 | 2.36 |
| P2053 | 0.1/35 | .27 |
| P2054 | 0.15/35 | .27 |
| P2055 | 0.22/35 | .27 |
| P2056 | 0.33/35 | .27 |
| P2057 | 0.47/35 | .27 |
| P2058 | 0.68/35 | .28 |
| P2059 | 1.0/35 | .31 |
| P2060 | 1.5/35 | .34 |
| P2061 | 2.2/35 | .42 |
| P2062 | 3.3/35 | .51 |
| P2063 | 4.7/35 | .65 |
| P2064 | 6.8/35 | .90 |
| P2065 | 10/35 | 1.19 |
| P2066 | 15/35 | 1.88 |
| P2099 | .047/35 | .43 |
| P2100 | .068/35 | .43 |
| P2101 | 22/35 | 2.56 |
| P2102 | 33/35 | 4.46 |
| P2103 | 47/35 | 13.36 |
| P2067 | 0.1/50 | .28 |
| P2068 | 0.15/50 | .30 |
| P2069 | 0.22/50 | .30 |
| P2070 | 0.33/50 | .30 |
| P2071 | 0.47/50 | .33 |
| P2072 | 0.68/50 | .37 |
| P2073 | 1.0/50 | .50 |
| P2074 | 1.5/50 | .84 |
| P2075 | 2.2/50 | .90 |
| P2076 | 3.3/50 | 1.48 |
| P2077 | 4.7/50 | 1.89 |
| P2078 | 6.8/50 | 3.90 |
| P2104 | 10/50 | 5.40 |
| P2093 | 15/50 | 8.37 |

## PANASONIC® V SERIES

Stacked Metalized Film Capacitors

| Part No. | Cap./Volt (µF)/VAC | Price 10 |
|---|---|---|
| P4513 | 0.01/50 | 1.23 |
| P4514 | 0.012/50 | 1.26 |
| P4515 | 0.015/50 | 1.28 |
| P4516 | 0.018/50 | 1.32 |
| P4517 | 0.022/50 | 1.35 |
| P4518 | 0.027/50 | 1.38 |
| P4519 | 0.033/50 | 1.41 |
| P4520 | 0.039/50 | 1.44 |
| P4521 | 0.047/50 | 1.47 |
| P4522 | 0.056/50 | 1.54 |
| P4523 | 0.068/50 | 1.63 |
| P4524 | 0.082/50 | 1.73 |
| P4525 | 0.1/50 | 1.68 |
| P4526 | 0.12/50 | 1.88 |
| P4527 | 0.15/50 | 1.95 |
| P4528 | 0.18/50 | 2.01 |
| P4529 | 0.22/50 | 2.10 |
| P4530 | 0.27/50 | 2.45 |
| P4531 | 0.33/50 | 2.79 |
| P4532 | 0.39/50 | 3.10 |
| P4533 | 0.47/50 | 3.45 |
| P4534 | 0.56/50 | 4.14 |
| P4535 | 0.68/50 | 4.83 |
| P4536 | 0.82/50 | 5.74 |
| P4537 | 1.0/50 | 6.62 |
| P4713 | 0.01/100 | 1.81 |
| P4714 | 0.012/100 | 1.38 |
| P4715 | 0.015/100 | 1.81 |
| P4716 | 0.018/100 | 1.81 |
| P4717 | 0.022/100 | 1.85 |
| P4718 | 0.027/100 | 1.89 |
| P4719 | 0.033/100 | 1.93 |
| P4720 | 0.039/100 | 1.96 |
| P4721 | 0.047/100 | 2.03 |
| P4722 | 0.056/100 | 2.10 |
| P4723 | 0.068/100 | 2.23 |
| P4724 | 0.082/100 | 2.25 |
| P4725 | 0.1/100 | 2.30 |
| P4726 | 0.12/100 | 2.57 |
| P4727 | 0.15/100 | 2.65 |
| P4728 | 0.18/100 | 2.75 |
| P4729 | 0.22/100 | 2.94 |
| P4730 | 0.27/100 | 3.34 |
| P4731 | 0.33/100 | 3.81 |
| P4732 | 0.39/100 | 4.22 |
| P4733 | 0.47/100 | 4.71 |

## PANASONIC® B SERIES

Polyester Capacitors

| Part No. | Cap./Volt. (µf)/VAC | Price 10 |
|---|---|---|
| P4551 | .001/50 | 1.05 |
| P4552 | .0012/50 | 1.05 |
| P4553 | .0015/50 | 1.05 |
| P4554 | .0018/50 | 1.05 |
| P4555 | .0022/50 | 1.05 |
| P4556 | .0027/50 | 1.05 |
| P4557 | .0033/50 | 1.05 |
| P4558 | .0039/50 | 1.05 |
| P4559 | .0047/50 | 1.05 |
| P4560 | .0056/50 | 1.05 |
| P4561 | .0068/50 | 1.05 |
| P4562 | .0082/50 | 1.05 |

## QUARTZ CRYSTALS

| Freq. MHz | Digi-Key Part No. | Case | Pricing 1 | Pricing 10 |
|---|---|---|---|---|
| 1.000 | X045 | HC-33 | 10.08 | 84.00 |
| 1.0000 | X066 | HC-18 | 9.65 | 79.50 |
| 1.8432 | X046 | HC-33 | 3.96 | 33.00 |
| 1.8432 | X067 | HC-18 | 3.42 | 28.50 |
| 2.000 | X001 | HC-33 | 3.78 | 31.50 |
| 2.0000 | X068 | HC-18 | 3.24 | 27.00 |
| 2.4576 | X047 | HC-33 | 3.78 | 31.50 |
| 2.4576 | X069 | HC-18 | 3.06 | 25.50 |
| 2.5000 | X070 | HC-18 | 3.42 | 28.50 |
| 3.000 | X048 | HC-33 | 3.78 | 31.50 |
| 3.2768 | X022 | HC-18 | 1.73 | 14.40 |
| 3.579545 | X005 | HC-33 | 2.34 | 19.50 |
| 3.579545 | X049 | HC-18 | 1.62 | 13.50 |
| 3.6864 | X071 | HC-18 | 1.62 | 13.50 |
| 3.700 | X012 | HC-6/U | 2.60 | 22.00 |
| 4.000 | X006 | HC-18 | 1.62 | 13.50 |
| 4.0320 | X072 | HC-18 | 1.62 | 13.50 |
| 4.194304 | X007 | HC-18 | 1.62 | 13.50 |
| 4.91520 | X050 | HC-18 | 1.62 | 13.50 |
| 5.000 | X051 | HC-18 | 1.62 | 13.50 |
| 5.0688 | X052 | HC-18 | 1.62 | 13.50 |
| 5.1850 | X053 | HC-18 | 1.62 | 13.50 |
| 5.9904 | X073 | HC-18 | 1.62 | 13.50 |
| 6.000 | X026 | HC-18 | 1.62 | 13.50 |
| 6.144 | X054 | HC-18 | 1.62 | 13.50 |
| 7.3728 | X074 | HC-18 | 1.62 | 13.50 |
| 8.000 | X056 | HC-18 | 1.62 | 13.50 |
| 9.2160 | X075 | HC-18 | 1.62 | 13.50 |
| 10.000 | X057 | HC-18 | 1.62 | 13.50 |
| 11.0592 | X078 | HC-18 | 1.98 | 16.50 |
| 12.000 | X058 | HC-18 | 1.62 | 13.50 |
| 15.000 | X059 | HC-18 | 1.62 | 13.50 |
| 16.000 | X077 | HC-18 | 1.62 | 13.40 |
| 18.000 | X060 | HC-18 | 1.80 | 15.00 |
| 18.432 | X061 | HC-18 | 1.80 | 15.00 |
| 20.000 | X062 | HC-18 | 1.98 | 16.50 |
| 22.1184 | X063 | HC-18 | 1.98 | 16.50 |
| 48.000 | X065 | HC-18 | 1.98 | 16.50 |

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## PROFESSIONAL COLOR LIGHT CONTROLLER SM-328 ★

Assembled & tested **$150.00**

The SM-328 professional color light controller is keyboard programmable forease of use, it allows full control of intensity and flash rate. It has four separate channels with capacity of 1170 watts per channel. Total wattage capability is 4.68 killowatts. This is equivalent to bulbs or 9365-watt colored bulbs and is sufficient for the largest halls and auditoriums. ● Independent input signal control ● Professional styled control panel ● 4 independent outputs ● 4 independent dimmer controls ● Chaser speed controls ● Automatic chaser operation ● 4 preset chaser programs ● Clockwise chaser control ● Anti-clockwise chaser control.

*SPECIFICATIONS: Input sensitivity (music model): 100mV, (music & program): 2V ● Output power: 1170W per channel 4680W total ● Power requirement: 105-120V, 60hz ● Dimensions: 14.32" wide, 9" high, 3.19" deep.*

## SURROUND SOUND PROCESSOR SM-333 ▲▲

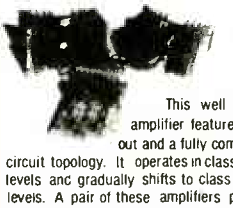
Assembled & tested **$83.00**

Completed kit **$62.00**

The new SM-333 surround sound processor is a full featured unit that is designed to provide your system with the ultimate musical realism. It has inputs for VCR, Video Disc and Compact Disc and can also be used with FM tuners, tape decks and LP discs – in fact anything that can be connected to your pre-amplifier. It also has front panel control of dynamic noise reduction, surround level, effect and time delay up to 50 milliseconds. Rear panel outputs for front and rear stereo speaker amplifiers. The unit may be purchased as a kit or fully assembled ready to plug in.

*SPECIFICATIONS : Frequency response : 20hz to 20khz ● Total harmonic distortion : Front channel : 0.05%, Rear channel : Less than 0.25% ● Input signal voltage : 0.1 to 3.5V ● Output : Front channel : 0.1 to 3.5V, Rear channel : 6.6V ● Delay time : 5 to 50 milliseconds ● Input impedance : 47K ● Power requirements : 110 / 220 VAC, 50 / 60hz ● Dimensions : 14.2" wide, 4.82" deep, 2.1" high.*

## 100W DYNAMIC CLASS A MAIN POWER AMPLIFIER TA-1000A▲▲



Assembled & tested **$80.58**

Complete kit **$59.69**

This well designed and stable amplifier features DC coupling through out and a fully complementary symmetry circuit topology. It operates in class A at low and medium levels and gradually shifts to class AB operation at high levels. A pair of these amplifiers provide 200 watts of super high fidelity sound reproduction.

*SPECIFICATIONS : Power output : 100 watts into 8 ohms, 125 watts into 4 ohms ● Frequency response : 10hz to 100khz ● Total harmonic distortion : Less than 0.008% ● Signal to noise ratio : Better than 80dB ● Sensitivity: 1V ● Power requirements : 35 to 45VDC @ 3amp ● Suggested rack mount cabinet : Mark V LG1924 or LG1925*

## DIGITAL VOICE MEMO TA-28 MK II ▲▲

NEW

Kit / Assembled & tested

**$30 / 40**

*FEATURES : Solid State Record / Play Back ● Power / Record LED Indicator ● 4 Bit ADPCM Algorithm ● 8 Bit AD / DA Converter ● 256K Memory Capacitor ● 8 SEC or 16 SEC Record Time ● Sampling Frequency 8KHz or 4KHz ● Included Condensor Mic & Speaker ● Built in Low Pass Filter ● Low Power Consumption ● Supply Voltage : 5 – 6 DC ● Dimensions: 3½" x 2⅛" x 1"*

### AMPLIFIERS

| MODEL | DESCRIPTION | KIT | Assembled |
|---|---|---|---|
| TA-001 | 1W Mini-Amplifier ▲ | $ 5.07 | |
| TA-006 | 6W Mini-Amplifier ▲ | 6.90 | |
| TA-007 | 12W Mini-Amplifier ▲ | 11.20 | |
| TA-10 | Stereo Pre-Amp. w/magnetic mic amp. ▲ | 8 20 | |
| TA-28MK2 | Digital Voice Recorder ▲▲ | 30.00 | $ 40 00 |
| TA-50A/B | Multi-Purpose Melody Generator ▲ | 11.84 | 16 58 |
| TA-50C | Multi-Purpose Melody Generator ▲ | 12.65 | 17.71 |
| TA-120MK2 | Class "A" Main Power Mono Amp. ▲▲ | 31.25 | |
| TA-300 | 30W Multi-Purpose Single Channel Amp. ▲ | 20.00 | |
| TA-302 | 60W Stereo Power Booster ▲▲★ | 50.00 | 70.00 |
| TA-322I | 50W + 50W IC Stereo Amp. w/led level display ▲ | 35.50 | |
| TA-323A | HQ 30W + 30W Stereo Amp. ▲ | 29.50 | |
| TA-377A | FET Stereo Pre-Amp. ▲▲▲ | 59.95 | 75.00 |
| TA-400 | 40W Solid State Mono Amp. ▲ | 28.00 | |
| TA-477 | 120W Mosfet Power Mono Amp. ▲▲ | 68.00 | |
| TA-800 | 80W + 80W DC Pre-Main & Power Amp. ▲▲ | 60.92 | |
| TA-802 | 80W + 80W DC Stereo Main Power Amp. ▲▲ | 45.94 | |
| TA-820A | 60W + 60W OCL DC Pre-Main Stereo Amp. ▲▲ | 48.00 | |
| TA-1000A | 100W Class "A" Main Power Mono Amp. ▲▲ | 59.69 | 80.58 |
| TA-1500 | 100W x 2 Class "A" DC Stereo Pre-Main Amp. ▲▲▲ | 73.70 | 95.81 |
| TA-2400A | Electronic Echo & Revelation Amp. ▲▲▲★ | 93.30 | 116.80 |
| TA-2500 | HQ Pre-Amp. w/10 band graphic equalizer ★ | | 90.00 |
| TA-2800 | Hi-Fi Bi-Fet Pre-Amp. w/3 way tone control ▲▲ | 48.90 | |
| TA-3000 | Stereo Simulator ▲▲ | 33.20 | 43.38 |
| TA-3600 | 300W HQ Hi-Fi Power Mono Amp. ▲▲▲ | 86.00 | 110.00 |

### MISCELLANEOUS

| MODEL | DESCRIPTION | KIT | Assembled |
|---|---|---|---|
| TY-1A | Battery Flourescent Light Driver ▲ | $ 5.19 | |
| TY-7 | Electronic Touch Switch ▲ | 7.15 | |
| TY-8 | ELectronic Lotto ▲ | 15.00 | |
| TY-11A | Multi-Functional Control Switch ▲ | 5.19 | |
| TY-12A | Digital Clock w/timer ▲ | 16.63 | |
| TY-13 | Color Led Audio Level Meter ▲ | 20.15 | |
| TY-14 | Electronic Shock ▲ | 6.25 | |
| TY-18 | High Precision Sound Control Switch ▲ | 9.22 | |
| TY-20 | V Shape Color Led Level Meter ▲▲ | 21.45 | |
| TY-23B | 3 Channel Color Light Controler ▲▲▲★ | 71.50 | $82.50 |
| TY-25 | Stereo Loudspeaker Protector ▲ | 12.65 | |
| TY-35 | FM Wireless Microphone ▲ | 9.22 | |
| TY-36 | AC/DC Quartz Digital Clock ▲ | 18.00 | |
| TY-38 | Sound/Touch Control Switch ▲ | 12.00 | |
| TY-41MK111 | Infrared Remote Control Unit ▲▲▲ | 15.00 | 25.00 |
| TY-41MKV | Infrared Remote Control Unit ▲▲▲ | 20.00 | 35.00 |
| TY-42 | Bar/Dot Level Meter ▲▲ | 24.15 | |
| TY-43 | 3½ Digital Panel Meter ▲ | 33.00 | 46.20 |
| TY-45 | 20 Steps Bar/Dot Audio Level Display ▲▲ | 38.45 | |
| TY-47 | Superior Electronic Roulette ▲▲ | 19.46 | |
| SM-222 | 7 Bands Graphic Equalizer ▲▲▲★ | 26.80 | 38.80 |
| SM-328 | 4 Channel Professional Color Light Controller ★ | | 150.00 |
| SM-333 | Audio/Video Surround Sound Processor ▲▲▲★ | 62.00 | 83.00 |
| SM-666 | Dynamic Noise Reduction △ | 26.00 | 34.00 |
| T-1 | LCD Thermometer Clock w/in-outdoor sensor ★ | 22.00 | |
| T-2 | LCD Thermometer Clock w/ F & C measurement ★ | 19.80 | |
| # 8501 | Parrot Talking Clock ★ | 12.00 | |
| # 8504 | Mynah Talking Clock ★ | 12.00 | |

### POWER SUPPLIES

| MODEL | DESCRIPTION | KIT | Assembled |
|---|---|---|---|
| TR-100A | 0-15V 2A Regulated DC Power Supply | 59.50 | 69.50 |
| TR-355A | 0-15V 5A Regulated DC Power Supply | 12.92 | |
| TR-355B | 0-30V 3A Regulated DC Power Supply | 12.92 | |
| TR-503 | 0-50V 3A Regulated DC Power Supply | 14.76 | |

### INSTRUMENTS

| MODEL | DESCRIPTION | KIT | |
|---|---|---|---|
| SM-43 | 3½ Multi-Functional Led O. P. M. | 34.50 | 43.00 |
| SM-48 | 4½ Hi-Precision D. P. M | 38.00 | 48.00 |
| SM-48A | 4½ Hi-Precision D. P. M. w/ stndrd case | 41.20 | 52.00 |
| SM-100 | 150MC Digital Frequency Counter | | 90.00 |
| FC1000A | 1 GHz Frequency Counter | 192.00 | 43.00 |

### METAL CABINETS

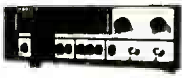
| MODEL | DESCRIPTION | MATCHING | EA SET |
|---|---|---|---|
| LG-1273 | 3" x 12" x 7" | TA-2800, TA-377A | $20.16 |
| LG-1684 | 4" x 16" x 8" | TA-322i, TA-323A, TA-377A | 24.64 |
| LG-1924 | 4" x 19" x 11.5" | TA-802, TA-820A, TA-1500, TA-120, TA-800, TA-1000A | 30.00 |
| LG-1925 | 5" x 19" x 11.5" | TA-477, TA-800, TA-1500, TA-1000A | 33.00 |
| LG-1983 | 2¾" x 19" x 8" | TA-377A, TA-2800, TA-2200, TA-120MK II | |

### TRANSFORMERS

| MODEL | DESCRIPTION | MATCHING | PIECE |
|---|---|---|---|
| # 001 | 56V CT to 60V CT 6A | TA-800, TA-802, TA-820A, TA-1000A, TA-1500 | $25.00 |
| # 002 | 72V CT 3A | TR-503, TA-322i, TA-323A, TA-400 | 19.00 |
| # 003 | 80V CT 6A | TA-477 | 24.00 |
| # 004 | 48V CT 6A | TA-120 | 19.00 |
| # 005 | 52V CT 3A | TR-355B | 12.00 |
| # 006 | 36V CT 5A | TR-355A | 13.60 |
| # 007 | 112V CT 8A | TA-3600 | 38.00 |

## 8-DIGIT 1 GHZ MULTI-FUNCTION COUNTER FC-1000A ★

Assembled tested & CAL **$192.00**



The FC-1000A is a multi-function 10 hertz to 1ghz dual-range frequency counter. It can measure frequency, period and total events. Readout is a large 0.5" 8- digit, 7-segment LED display. It utilizes two crystal oscillators which can be individually calibrated for maximum long term accuracy against a frequency standard such as WWV transmissions. Additional features include a valuable self-check mode and a two step input attenuator.

*SPECIFICATIONS : Frequency range : 10hz to 10mhz, 10mhz to 10mhz, 100mhz to 1000mhz ● Resolution : 1000hz to 0.1hz depending on range ● Accuracy : ±1 digit, ± time base error ● Period measurement : 10hz to 10mhz ● Period measurement resolution : $10^{-7}$ to $10^{-10}$ seconds depending on gate time ● Totalization measurement : 10hz to 10mhz ● Totalization display : 99999999 ● Sensitivity : 15mV 10hz to 70mhz, 30mV 70mhz to 100mhz, 15mV 100mhz to 1000mhz ● Input impedance : 1 megohm 10hz to 100mhz, 50ohms 100mhz to 1000mhz ● Attenuation : X1, X10 ● Power requirements : 110 to 120VAC, 60hz or 220VAC, 50 to 70hz ● Dimension : 3" high, 9.69" wide, 7.87" deep.*

## DYNAMIC NOISE REDUCTION UNIT SM-666 ▲

Complete kit **$26.00**

Assembled & tested **$34.00**

NEW

The SM-666 Dynamic Noise Reduction Unit is designed to reduce noise during playback from casete tapes, LP records and compact discs, as well as FM radio broadcasts. An National Semi-conductor LM1894 integrated circuit is used to achieve a noise reduction of 10dB. The SM-666 has the great advantage that it can be used with all musical formats on playback whereas existing noise reduction systems such as Dolby B and C operate with magnetic tapes only. The output of the unit is connected directly to the system amplifier input as shown in the schematic. The unit can be switched out or bypassed if desired in order to compare the noise reduction advantage when playing a noise signal.

*SPECIFICATIONS : Input signal level: 3.5 V RMS MAX ● 20 K ohm ● Noise reduction : 10dB ● Power supply: 9 to 12V recommended ● Operating current: 27mA MAX*

## 4½ HI-PRECISION D. P. M. SM-48A ▲▲▲

Complete kit **$41.20**

Assembled & tested & CAL **$52.00**

SM-48 Digital Panel Meter employs a high-quality analog-digital converter (ADC) as its main device and employs 14mm high LED display as 4½ digit display. The required external components of SM-48 are very little. Both construction and alignment are so simply. Only need a few resistors that can turn it into a DC voltmeter or ammeter. The range is wide and highly stable. Beside this unit has different usages according to which input circuit you are applied. In order to upset the stability and accurecy, 50pp/°C temperature compensated voltage reference diode is employed to make this meter working in the best way within 0° to –70°C.

*SPECIFICATION : 4½ Digit 14mm red large display with overload flash ● Multi-functions : including BCD, BUSY, STROBE output, very suitable for micro computer. ● Memory system can hold the input reading for comparison and monitor. ● Range : DC voltage DC ± 1mV – ± 2000V, DC current DC ± 1uA – ± 20A ● Accuracy : DC ± 0.025% ± 2 digit ● Power : DC 5 – 6V at 200mA ● Dimensions: 3¼" (W) x 1⅞" (H) x 4 1/16" (D)*

## 300W HI-FI POWER AMPLIFIER (MONO) TA-3600▲▲▲

Assembled & tested **$110.00**

Complete Kit **$86.00** Transformer **$38.00**

10,000 UF 80V E. Cap **$20.00**

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*SPECIFICATIONS : Power output : 300 watts sine wave 540 watts music power ● Frequency response : Total harmonic distortion : Less than 0.05% ● Sensitivity : 1Vms at 47K ● Power requirements : 60 to 75VDC at 8amp.*

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**30 DAY MONEY BACK GUARANTEE • 1 YEAR WARRANTY ON ALL PRODUCTS • TOLL-FREE TECHNICAL SUPPORT**

## MEMORY

### DYNAMIC RAMS

| PART# | SIZE | SPEED | PINS | PRICE |
|---|---|---|---|---|
| 4164-150 | 65536x1 | 150ns | 16 | 2.49 |
| 4164-120 | 65536x1 | 120ns | 16 | 2.89 |
| 4164-100 | 65536x1 | 100ns | 16 | 3.39 |
| TMS4464-12 | 65536x4 | 120ns | 16 | 9.95 |
| 41256-150 | 262144x1 | 150ns | 16 | 3.99 |
| 41256-120 | 262144x1 | 120ns | 16 | 4.49 |
| 41256-100 | 262144x1 | 100ns | 16 | 4.99 |
| 41256-80 | 262144x1 | 80ns | 16 | 5.49 |
| 41256-60 | 262144x1 | 60ns | 16 | 7.99 |
| 414256-100 | 262144x4 | 100ns | 20 | 14.95 |
| 414256-80 | 262144x4 | 80ns | 20 | 16.95 |
| 1 MB-120 | 1048576x1 | 120ns | 18 | 13.95 |
| 1 MB-100 | 1048576x1 | 100ns | 18 | 14.95 |
| 1 MB-80 | 1048576x1 | 80ns | 18 | 15.95 |

### SIMM/SIP MODULES

| PART# | SIZE | SPEED | TYPE | PRICE |
|---|---|---|---|---|
| 41256A9B-12 | 256K x 9 | 120ns | SIMM/PC | 49.95 |
| 41256A9B-80 | 256K x 9 | 80ns | SIMM/PC | 59.95 |
| 421000A8B-10 | 1MB x 8 | 100ns | SIMM/MAC | 159.95 |
| 421000A9B-10 | 1MB x 9 | 100ns | SIMM/PC | 159.95 |
| 421000A9B-80 | 1MB x 9 | 80ns | SIMM/PC | 169.95 |
| 256KX9SIP-80 | 256K x 9 | 80ns | SIP/PC | 69.95 |
| 256KX9SIP-60 | 256K x 9 | 60ns | SIP/PC | 79.95 |
| 1MBX9SIP-80 | 1MB x 9 | 80ns | SIP/PC | 179.95 |

### STATIC RAMS

| PART# | SIZE | SPEED | PINS | PRICE |
|---|---|---|---|---|
| HM6116LP-2 | 2048x8 | 120ns | 24 | 4.99 |
| HM6264LP-15 | 8192x8 | 150ns | 28 | 8.95 |
| HM6264LP-12 | 8192x8 | 120ns | 28 | 9.95 |
| HM43256LP-12 | 32768x8 | 120ns | 28 | 21.95 |
| HM43256LP-10 | 32768x8 | 100ns | 28 | 24.95 |

## MATH COPROCESSORS

intel **5 YEAR WARRANTY**

### 8-BIT COPROCESSORS

| | | |
|---|---|---|
| 8087 | 5 MHz | 89.95 |
| 8087-2 | 8 MHz | 129.95 |
| 8087-1 | 10 MHz | 169.95 |

### 16-BIT COPROCESSORS

| | | |
|---|---|---|
| 80287 | 6 MHz | 139.95 |
| 80287-8 | 8 MHz | 209.95 |
| 80287-10 | 10 MHz | 239.95 |
| 80C287 | 12 MHz | 299.95 |

### 32-BIT COPROCESSORS

| | | |
|---|---|---|
| 80387-16 | 16 MHz | 359.95 |
| 80387-SX | 16 MHz | 319.95 |
| 80387-20 | 20 MHz | 399.95 |
| 80387-25 | 25 MHz | 499.95 |
| 80387-33 | 33MHz | 649.95 |

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## 74 SERIES LOGIC

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|---|---|---|---|---|---|
| 7400 | .19 | 74LS32 | .18 | 74LS245 | .79 |
| 74LS00 | .16 | 74LS73 | .29 | 74LS273 | .79 |
| 74LS02 | .17 | 7474 | .33 | 74S288 | 1.69 |
| 7404 | .19 | 74LS74 | .24 | 74LS322 | 3.95 |
| 74LS04 | .16 | 74S74 | .49 | 74LS367 | .39 |
| 74S04 | .29 | 74LS138 | .39 | 74LS373 | .79 |
| 7406 | .29 | 74LS155 | .59 | 74LS374 | .79 |
| 7408 | .24 | 74LS163 | .39 | 74LS393 | .79 |
| 74LS08 | .18 | 74LS240 | .69 | 74LS682 | 3.20 |
| 7432 | .29 | 74LS244 | .69 | 74LS688 | 2.40 |

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| 8088 | 5.99 |
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| 8251A | 1.69 |
| 8253-5 | 1.95 |
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| 8255-5 | 2.49 |
| 8741 | 9.95 |
| 8748 | 7.95 |
| 8749 | 9.95 |
| 8755 | 14.95 |

### 6500

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|---|---|
| 65C02* | 7.95 |
| 6522 | 2.95 |

### V-20

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| V20-8 | 8.95 |
| V20-10 | 11.95 |
| V30 | 13.95 |

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| 1793 | 9.95 |
| COM8116 | 8.95 |
| MC146818 | 5.95 |
| MM58167 | 9.95 |
| INS8250 | 6.95 |
| NS16450 | 10.95 |
| LM317T | .69 |
| NE555 | .29 |
| LM741 | .29 |
| 7805T | .49 |
| 7812T | .49 |
| 75150 | 1.95 |
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| 14411 | 9.95 |

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| 1.8432 | 5.95 |
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| 16R4 | 2.95 |
| 16R6 | 2.95 |
| 16R8 | 2.95 |
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| 20R4 | 4.95 |
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Some programs benefit more than others, in particular, those that make heavy use of Floating Point, Trigonometric, Logarithmic and Exponential calculations show the most improvement. CAD, spreadsheets, some databases, and Mandlebrot programs are frequently written to use a co-processor if it's available.

How much your application will speed up depends on the ratio of time spent on math calculations versus other operations. A 3 to 10 times improvement is not uncommon certain operations are even faster.

The co-processor you need is specific to the type and speed of processor. For 8088/86 and 80386 based machines, the general rule is to use an 8087 or 80387 of the same speed as the processor, i.e. an 80386-25 requires an 80387-25.

80286 based machines frequently use a co-processor running at 2/3rds the processor speed, i.e. an 80286-12 requires an 80287-8.

Derick Moore, Director of Engineering

## EPROMS

| PART# | SIZE | SPEED | Vpp | PINS | PRICE |
|---|---|---|---|---|---|
| 2708 | 1024x8 | 450ns | 25V | 24 | 4.95 |
| 2716 | 2048x8 | 450ns | 25V | 24 | 3.49 |
| 2716-1 | 2048x8 | 350ns | 25V | 24 | 3.95 |
| 2732A | 4096x8 | 250ns | 21V | 24 | 3.95 |
| 2764 | 8192x8 | 450ns | 12.5V | 28 | 3.49 |
| 2764-250 | 8192x8 | 250ns | 12.5V | 28 | 3.69 |
| 2764-200 | 8192x8 | 200ns | 12.5V | 28 | 4.25 |
| 27C64 | 8192x8 | 250ns | 12.5V | 28 | 4.95 |
| 27128 | 16384x8 | 250ns | 12.5V | 28 | 4.25 |
| 27128A-200 | 16384x8 | 200ns | 12.5V | 28 | 5.95 |
| 27256 | 32768x8 | 250ns | 12.5V | 28 | 4.95 |
| 27256-200 | 32768x8 | 200ns | 12.5V | 28 | 5.95 |
| 27C256 | 32768x8 | 250ns | 12.5V | 28 | 5.95 |
| 27512 | 65536x8 | 250ns | 12.5V | 28 | 8.95 |
| 27C512 | 65536x8 | 250ns | 12.5V | 28 | 9.95 |
| 27C101-20 | 131072x8 | 200ns | 12.5V | 32 | 29.95 |

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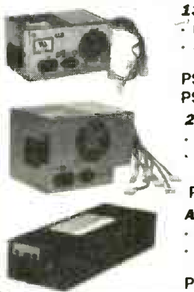
|---|---|---|---|---|
| PE-140 | NO | 9 | 8,000 | $ 89 |
| PE-140T | YES | 9 | 8,000 | $139 |
| PE-240T | YES | 12 | 9,600 | $189 |
| PL-265T | YES | 30 | 9,600 | $255 |

## POWER SUPPLIES



### 135 WATT POWER SUPPLY

- UL APPROVED
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PS-135 ........................ $59.95
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| JDR-PR16 | 16 BIT WITH I/O DECODING LAYOUT | 49.95 |
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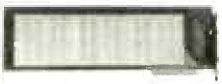
| EXT-80286 | 16-BIT FOR 286/386 MOTHERBOARDS | 39.95 |
| EXT-16 | MICROCHANNEL 16-BIT | 69.95 |
| EXT-32 | MICROCHANNEL 32-BIT | 99.95 |

## PC BREADBOARD-ON-A-CARD



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| DB25P | .69 | DB25S | .75 |
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| IDE34 | .89 |
| IDS20 | .65 |
| IDS34 | .75 |
| IDB09P | 1.39 |
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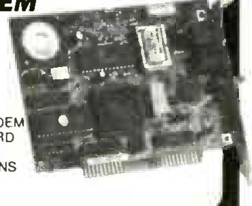
## 4800/2400 BAUD FAX/DATA MODEM



**$119**

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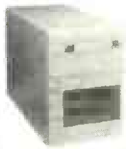

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**CASE-120**

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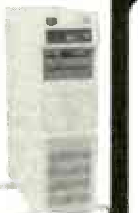

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- SERIAL PS/2 COMPATIBLE.

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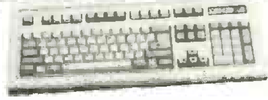

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| **K103-A** | AUDIBLE "CLICK" STYLE | $84.95 |
| **MAX-5339** | MAXI-SWITCH W/TACTILE FEEDBACK | $84.95 |

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**30 MB $219**
**40 MB $339**
**60 MB $389**
**80 MB $569**

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**30 MB $279**

| SIZE | MODEL | AVG. SPEED | FORM FACTOR | DRIVE ONLY | XT KIT | AT F/H KIT |
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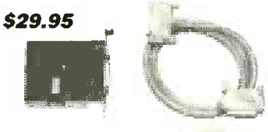

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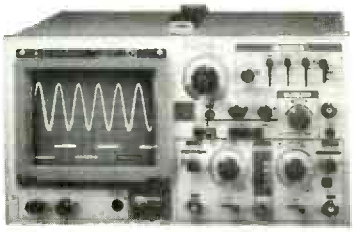

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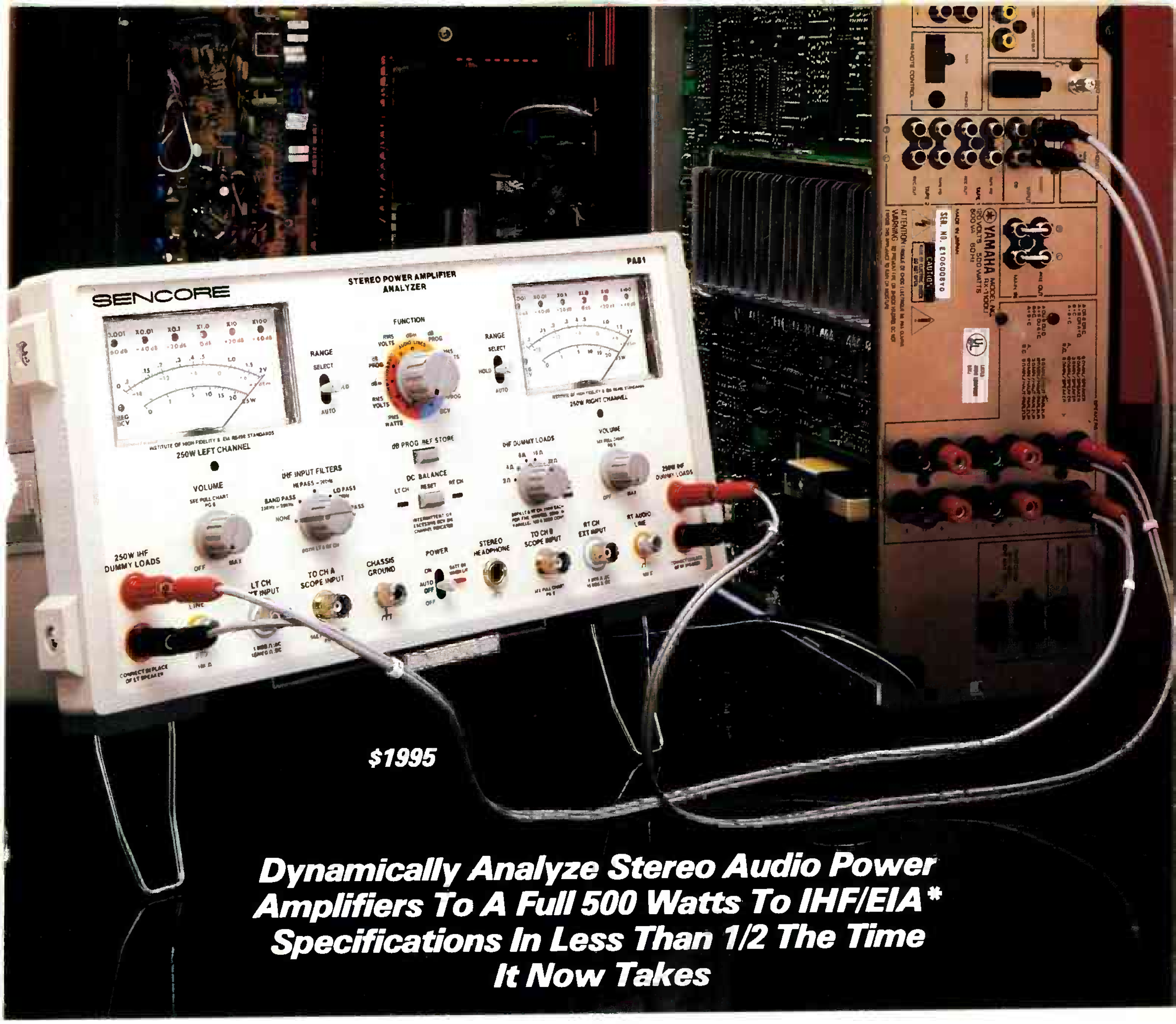

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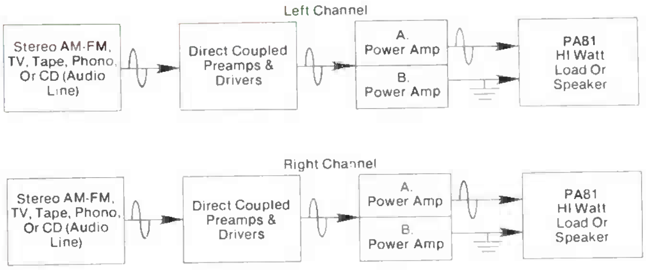

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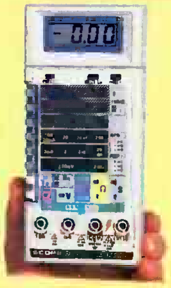

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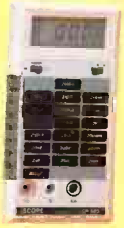

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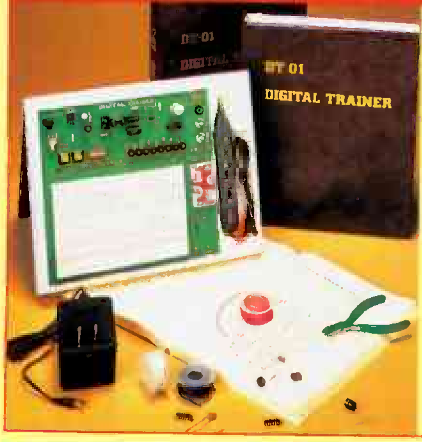

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