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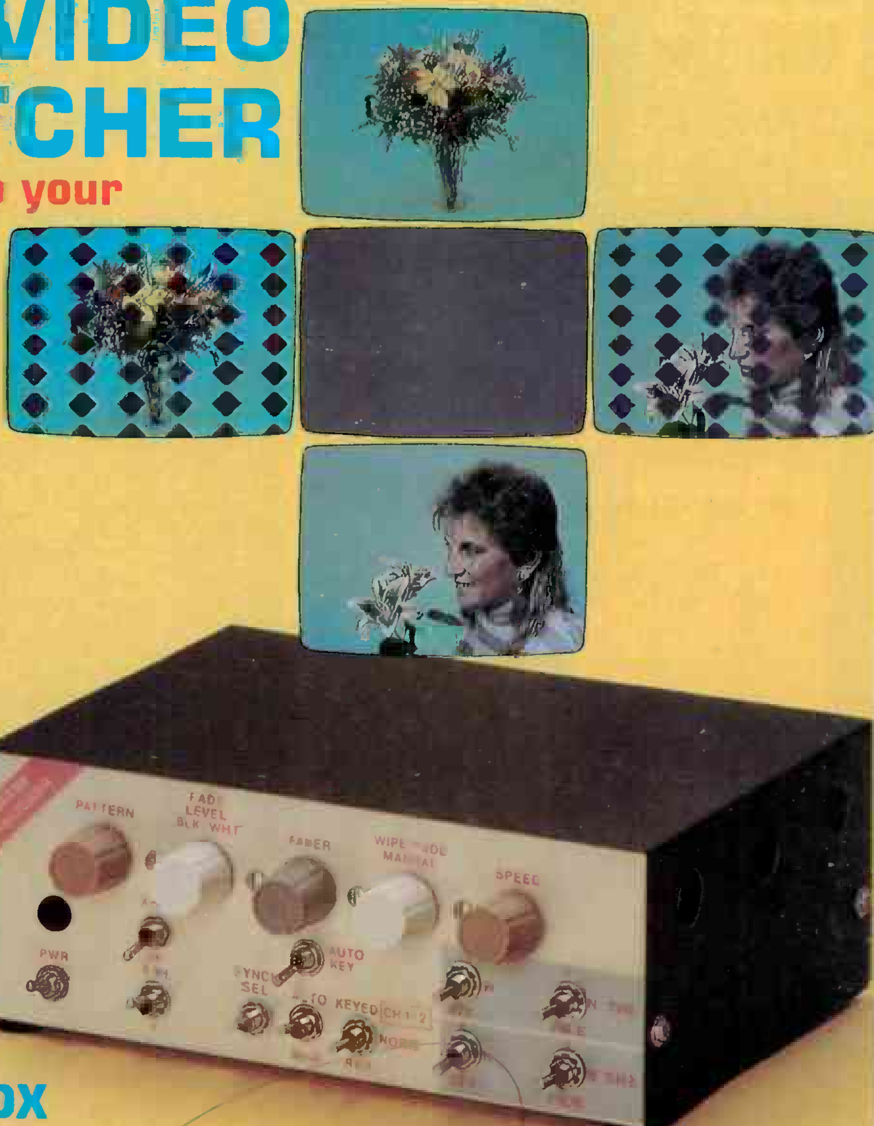

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November 1989 Radio-Electronics

Vol. 60 No. 11

BUILD THIS

TECHNOLOGY

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CIRCUITS

DEPARTMENTS

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AND MORE

ON THE COVER

While video camcorders have surged in popularity over the last couple of years, home video movies have become a hard sell. Camcorders make it so easy to record events that most people end up shooting much more tape than anyone is willing to watch. Only careful editing can bring those boring videos to life.

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WORKING WITH RELAYS
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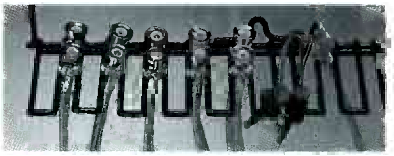

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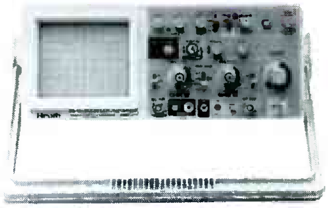

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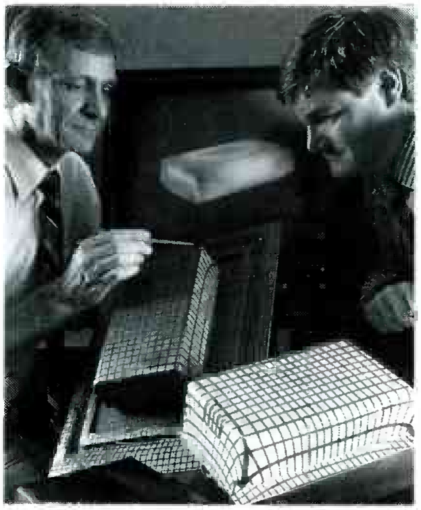
WHAT'S NEWS

Analytical software

Analytical software that eliminates much of the time- and money-consuming guesswork in designing molds for forming plastic parts is reported by engineers at the GE Research and Development Center at Schenectady, NY. The advanced software packages are used in developing parts made by blow-molding and thermoforming. Containers for milk, soda, and other liquids are among the familiar products made by blow-molding. Liners for refrigerators and instrument panels for cars are among the products made by thermoforming.

The new software was designed primarily for predicting wall thickness. "The plastic gets very thin where it has to stretch a lot, and there was no way of predicting just how thin it would get," says one of the engineers. "You'd have to make a mold and produce a part to find out."

The analysis is made after a designer has generated a computer model of a proposed mold. The user inputs data that describes the elevated-temperature "stress vs strain" behavior of the plastic being used, and the computer performs its "thinning" analysis. Special algorithms had to be developed to solve the equations used.



GE ENGINEERS, Dr. Horst G. DeLorenzi and Dr. Herman F. Nied examine test parts made with the help of the new advanced software that makes it possible to simulate the molding of a plastic component, using a mold that exists only in the computer's "mind." The computer simulation of the part (shown on the screen in the background) shows variations in its wall thickness, and points up any too-thin parts.

DAT update

Last month we reported that digital audio tape (*DAT*) decks were likely to hit the consumer market in the near future, after gaining recording-industry approval thanks to the addition of a built-in copy-protection device called *Solocopy*. A few days after that issue went to press, two separate DAT announcements proved us right—and wrong.

On July 28th, the Electronic Industries Association's Consumer Electronics Group (*EIA/CEG*) said that they would join the Recording Industry Association of America (*RIAA*) in suporting legislation for a new consumer DAT recorder system that allows copying, but limits subsequent reproduction of those copies. That same day, in London, leaders of the international recording and consumer-electronics industries announced a joint recommendation to governments calling for the implemention of that system—*not* Solocopy, but the Serial Copy Management System, or *SCMS*.

As its name implies, the system is a method for controlling "serial" digital copying, which high-speed pirating operations would use. Essentially, SMCS will allow any original prerecorded work to be copied indefinitely onto different blank DAT cassettes, but limits the number of digital-to-digital copies that can be made from the first-generation copies. The circuitry that controls the DAT deck's functions will be programmed to determine whether the music to be recorded is entering via the recorder's digital or analog inputs and to read certain codes contained in the material's subcodes.

All digital recordings and broadcasts have digital subcode channels that contain their "category codes" as well as a "copyright flag." The DAT machine uses a combination of the two to tell if copying is permitted. If the source and material are identified as being protected, an "identification code" of "1,0" is written onto the copy as it is being recorded; the "1,0" code prevents direct digital copying from that copy. If the source is identified and the material is not copy-protected, a "0,0" code will be assigned and future copying will not be limited. Because the technology does not exist at this time for the DAT deck to determine if music entering through the analog inputs is copy-protected, any material recorded via the analog inputs would generate a "1,1" code that would indicate that only one additional digital copy could be made from the first-generation copy.

Besides the EIA-RIAA support, SMCS is expected meet the approval of important consumer and retailer groups, including the Home Recording Rights Coalition, the Consumers Union, and the National Association of Retail Dealers of America (*NARDA*). The international group was made up of leading Japanese and European electronics manufacturers the RIAA, and the International Federation of the Phonographic Industry (*IFPI*). **R-E**

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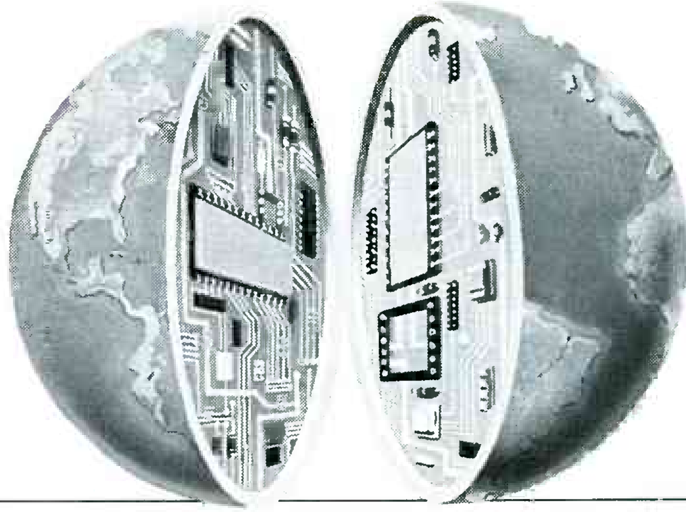

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VIDEO NEWS

DAVID LACHENBRUCH, CONTRIBUTING EDITOR

• **Ghostbuster.** Fifty years after the start of regular electronic television transmission, broadcasters and TV-set manufacturers are about to tackle the single most troublesome reception problem—multipath, or "ghosts." The *N*ational *A*ssociation of *B*roadcasters (*NAB*) has proposed to the *A*dvanced *T*elevision *S*ystem *C*ommittee (*ATSC*) a crash program to develop a ghost-elimination system, an idea that has been enthusiastically seconded by the television-receiver industry. Most of the proposed high-definition TV systems included ghost cancellation, accomplished by various means. The first anti-ghosting system to go into effect is being implemented this fall in Japan with Clearvision *e*xtended-*d*efinition *TV* (*EDTV*) broadcasts, but there is no reason why anti-ghosting can't be accomplished on the standard NTSC signal without EDTV or HDTV.

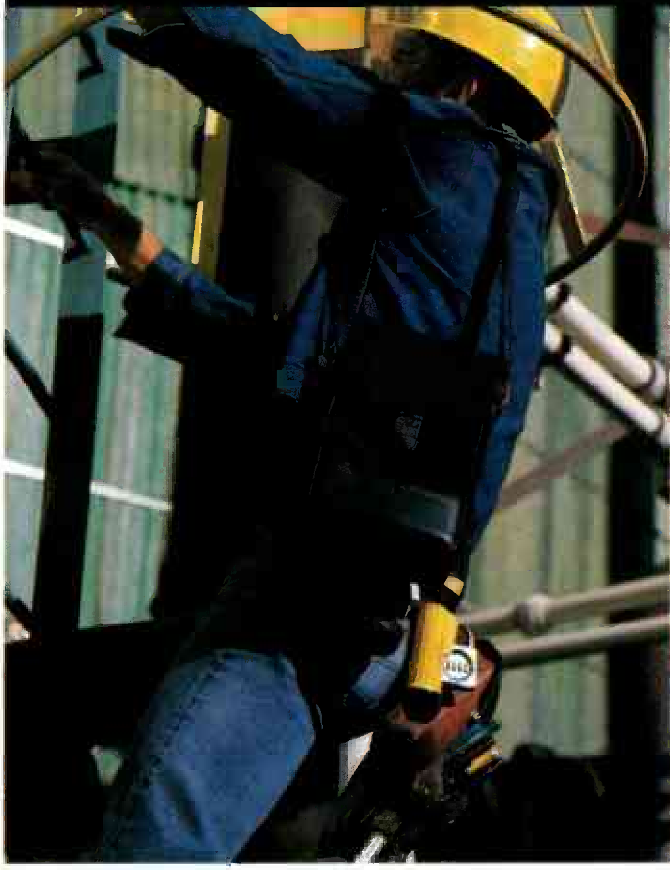
The Japanese system uses an invisible "training pulse" that is broadcast in the vertical blanking interval. It is very inexpensive for broadcasters to implement, although there are other anti-ghosting systems that act alone in the receiver without a broadcast pilot signal. The ATSC will examine all the proposed systems with a view to starting tests as soon as possible—and perhaps instituting an anti-ghosting program within the year. Although the system obviously would aid broadcasters, the cable system isn't immune to ghosts either. Many cable systems have difficulty in picking up clear signals off the air. In addition, there's the problem of ghosts generated internally within cable systems—not to mention direct-pickup ghosts in cities, where the signal reaches the antenna terminals directly from the station as well as from the cable system. Whatever, the ghostbuster will be welcome nationwide. Let's have it soon!

• **IDTV problems.** While the NAB loves the ghostbuster, it's not so sure it likes *i*mproved-*d*efinition TV (*IDTV*) sets. The latest hot products on the TV market, those sets convert interlaced scan to progressive scan, in effect doubling the number of lines in the picture. It's very obvious that when the two fields are displayed at the same time—as they are in IDTV—there could be some problems. TV stations transmit odd lines (1, 3, 5, and so forth) and then go back to the even lines (2, 4, 6, etc.). Progressive-scan IDTV sets rearrange the order of that presentation, deriving additional lines and presenting the lines in numerical sequence. They all use various means of compensating for motion that results from rearranging the timing of the picture elements. Because of the rearrangement of lines, the NAB complains that in some cases IDTV sets might cause distortion—particularly in cases where graphics are superimposed on the picture or in cases of rapid motion, as in ice hockey. In other cases, IDTV might present *too good* a picture; its redundant lines appear to show up poor-quality broadcast equipment. Set makers insist that there's nothing wrong with their IDTV sets—but the broadcasters want to talk it over.

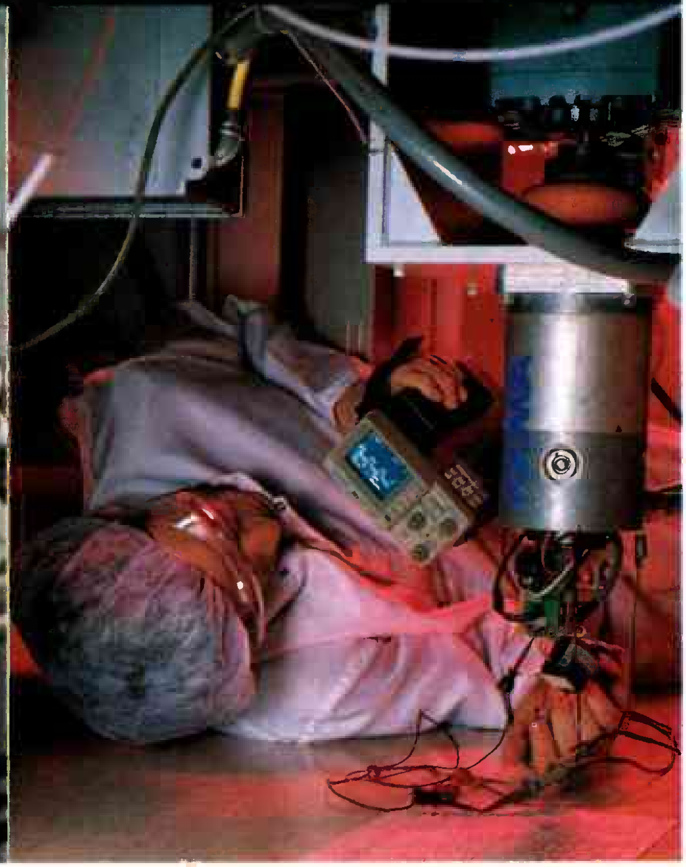
• **Dwindling monochrome.** Black-and-white television is nearing the end of the line. In the first five months of 1989, sales were down 38.1% from the same period in 1988. For January through May, sales to dealers totaled only 619,000 sets, according to the EIA. That's below the total for any good single sales month in the 1960's. Dealers are quick to say that the slump isn't due to any lack of customers but to the shortage of sets. With color prices declining and monochrome prices rising due to the scarcity of picture tubes, the black-and-white TV set now certainly appears to be a vanishing breed.

• **2-headed VCR.** Go-Video, the Arizona company that filed suit against most Japanese VCR manufacturers, says it will market a double-deck VCR by Christmas. (The lawsuits charged that the VCR manufacturers were refusing to sell finished products or parts for the dual decks.) The double-deck unit, made for Go-Video by Korea's Samsung, will list at $995 and contain two VHS decks for dubbing and editing. The deck will have special circuitry to prevent the copying of Macrovision-encoded cassettes. **R-E**

HIGH PLACES



TIGHT SPACES



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Although there are several ways to trigger a flash tube, all involve generating high voltages. Commercial flash units either step up the AC line voltage to whatever voltage the tube needs or use a switching supply to get the required AC voltage from a low-powered DC supply. The latter is the basis of most of the battery-powered flash units used in photography.

While it's certainly possible to build a circuit to drive the tube, it's not really worth it since commercial photographic flash units are available for less than the total price of the parts needed to build one. If you're really into building your own stuff, you can use the circuit shown in Fig. 1 as a starting point. The 200–300 VAC can be gotten from a standard step-up transformer. If you can't find one of them, you can try a transformer-based voltage converter that lets you use 120-VAC appliances in countries that have 220 VAC.

Make sure you get a converter that's built around a transformer and not one that uses diodes. Just use it backwards as a step-up transformer.

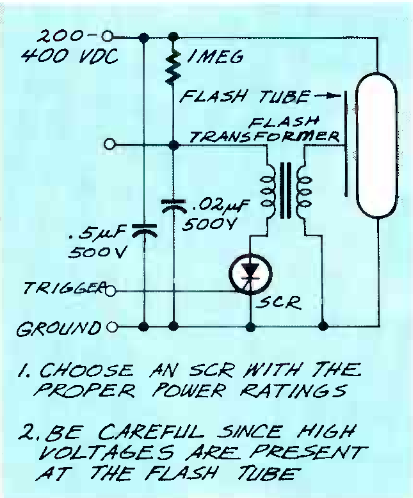


FIG. 1

If you do build your own circuit to power the tube, be very careful putting it together. Not only are you playing around with the line voltage but you're also stepping it up to over 200 VAC. Make sure everything is properly insulated, and be sure to put a fuse on the line.

While you're free to get the job done any way you want, remember that the original idea was to let you know when someone is entering the room, not learning to build a power supply for the strobe. It's a lot easier to get the job done by spending a couple of bucks on a small photoflash and an AC adapter.

AUTOMATIC SEPTIC PUMP

Our town sewer drains to the south, and my home is on a north slope. I have a septic tank and each day I have to manually turn on a switch to pump the liquid up the hill to the sewer. Is it possible to use some sort of sensor to turn the pump on automatically every time the tank is full? I'd like to have indicators to show whether the tank is full or empty, when the pump is operating, and so on. I can't use relays because the tank produces explosive gas.—M. Craghead, Jetmore, Kansas

There are several commercial systems available that will more or less do the job you're describing. The problem with most of them, however, is that they use a float system with a mechanical switch. That means that there's the possibility of a spark near the tank on the one hand, and, on the other, having to do the worst job in the world if (or, more correctly, when) the float sinks.

You said that you already have an SCR-triac setup to control the

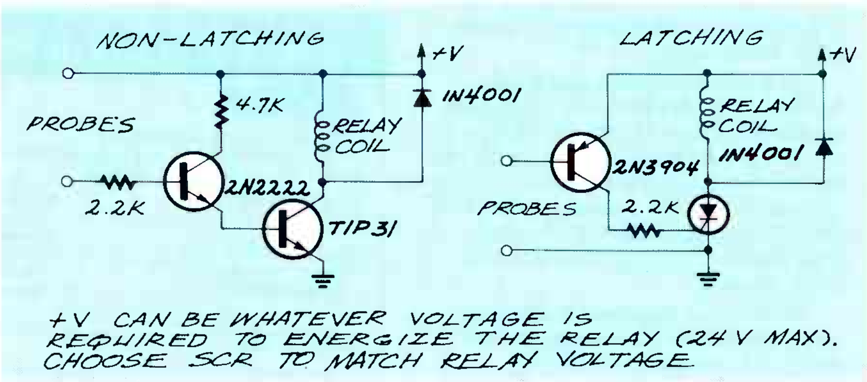


FIG. 2

pump, so the only piece you're missing is a circuit to trigger the system. What you're looking for is a liquid-level detector that meets the requirements of low voltage and minimal current draw.

Figure 2 contains two simple detector circuits that should work perfectly for you. Believe it or not, the most critical part of the whole thing are the probes. Since you're burying them down in the septic tank, you should choose a metal that won't be affected by any of the corrosive liquids found there. The cheapest alternative is to make the probes from stainless steel, but any other conductive material that isn't affected by corrosive liquids can be used.

Try to locate the detector circuit fairly close to the septic tank to keep the probe length as short as possible. You can put the circuit in a weatherproof enclosure, along with a transformer and rectifier, and bury it in the ground next to the power leads for the pump itself. The transformer-rectifier circuit can tap power from those leads, so that you can power the circuit locally.

The circuits will drive SCR's or relays. And while I do understand your concern about explosive gas, the circuitry doesn't have to be in the tank itself, so there's no reason why you can't use relays. Whatever you use to control the motor, make sure that it can handle the amount of power needed by the pump. **R-E**

RE-WIRING

I've recently bought a house in the country, and I plan on rewiring it because the original wire is quite old. Since the wiring is buried in the walls, I need some way of locating them. I'd like to be able to do that without knocking lots of holes in the walls. Is there some easy, inexpensive, way to do that?—B. MacDonnell, New York, NY

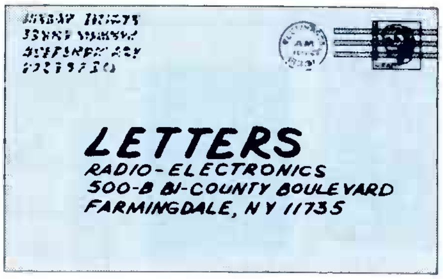
If you hunt through lots of magazines and catalogs, you'll probably find some expensive piece of equipment that can locate wires buried in the walls. But there's another way to do the job that's just as accurate, costs nothing, and uses equipment that you probably have around the house anyway.

All you need to find the wires is an old, noisy, electric appliance and a small transistor radio. The appliance can be any motor-driven device such as a hair dryer, drill, food processor, and so on. The only requirement is that it have a motor with brushes, and the more it arcs and spits, the better it is.

The reason you want a noisy motor is that it generates interference that can be picked up on a portable radio (or any other radio or TV for that matter). Turn on the appliance and run the radio across the area of the wall where you expect to find wiring. The louder the noise from the radio, the closer you are to the wires.

Don't be under the impression that this is just a juryrigged way to get the job done. Most of the dedicated equipment that's designed to find buried wiring works on exactly the same principle. **R-E**

LETTERS



NUCLEAR-WASTE MANAGEMENT

I have been working in the electronics field for over 50 years, and have been a reader and subscriber of **Radio-Electronics** for many years. I've never written to any publication before, but now I feel compelled to do so.

In the August 1989 issue, Don Lancaster seems to have been carried away by the more radical ecology nuts. His diatribe against nuclear power is a very short-sighted condemnation of one of the cleanest sources of power available today. His idea for a waste-disposal site is too facetious. Some people feel that solar power would be a better source of power, but he condemns that out of hand.

I feel that what is needed to make nuclear power really practical is very careful monitoring of all plant construction—no short cuts to save money. Then, for waste storage, the federal government could locate an isolated bowl in the western mountains and maintain well-supervised facilities. One day, some bright scientist will figure out a way to make good use of the waste. Then, all too soon, there will be a shortage of such material! It has happened before. Consider what happened to the left-over sludge from early oil refineries: Someone processed it and got paraffin. Today, very little waste is left to throw away. That is the way to go—instead of condemning things out of hand, think constructively!

EWALD HANSEN
White Plains, NY

Perhaps you're correct. But when we consider that the waste generated would have to be supervised for a period of time that will be much longer than any government has held power—indeed, longer than recorded history—we shudder.—Editor

SELLING SOLAR POWER SHORT

I found Don Lancaster's "Hardware Hacker" column concerning cold fusion (**Radio-Electronics**, August 1989) to be interesting, but I take exception to his view on solar cells.

His analysis of the hidden costs is wrong, since he is basing it on the premise that it would be too costly for a utility or a small power supplier. Photovoltaics are applicable to homeowners, not utilities, so costs for real estate and major support structures do not enter into the picture. (And the financing is considerably lower for those free cells he mentioned.)

The efficiency of modern cells is more like 14%, with stacked cells yielding 28–30%. I understand that there is a photovoltaic that uses a unique approach that can obtain efficiencies between 40–60%

P.S. Do you need my full address for my truckload of "free" solar cells?

JOE ZUIS
Brockton, MA

HDTV: A PESSIMIST VIEWPOINT

I have been very interested in your recent articles (**Radio-Electronics**, January and February 1989) concerning *High Definition* and *Improved Definition TV* (HDTV and IDTV).

I recently retired after a lifetime spent as a professional engineer in electronics, mostly military and space related. My interest in TV goes back to 1945, when I designed and built my own 10-inch receiver. I also designed and built my own color receiver in 1954. I am probably more aware than most people of the shortcomings of the NTSC system. I am also aware of what a wonderful achievement it was, more than 35 years ago, to come up with something that good.

As far as HDTV is concerned, unfortunately, I have a pessimistic viewpoint, which is not helped by the many competing systems. I am completely able to accept that excellent HDTV systems can be designed and built. I can even believe that it will be possible to agree upon one system, as was done with NTSC. I do not believe, however, that it can be sold to a mass market.

If one goes into any appliance store that has operating TV sets on display, one is amazed by the dreadful quality of the pictures on many of those receivers. That is usually the result of incompetent adjustment by the sales personnel, and is often made worse by poor incoming signals. Since the appliance store is in business to sell TV sets, one must conclude that the poor picture quality does not bother prospective customers. (If it did, the store would take steps to improve it, to avoid loss of sales.)

One can observe the same thing in many people's homes. The picture will often have grossly wrong color, or other major defects, which could be greatly improved by simple adjustment. However, most people do not notice, or care about, the poor picture quality.

A minority of people, myself in-

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The new 200 Series multimeter is protected from excess voltage or surges with a self-resetting fuse.

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Quickly probe a circuit board listening for audible tone changes that pinpoint the problem without glancing at the LCD.

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FEATURES	222	223
Audible Readout		•
Logic Pulse Detector		•
Fast Auto-Ranging	•	•
Self-Resetting Fuse	•	•
Auto-off Battery Saver	•	•
DC Voltage Accuracy	0.5%	0.25%
Warranty	2 years	2 years
Price	$129.00	$149.00

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CIRCLE 98 ON FREE INFORMATION CARD

ACE TROUB

Find trouble fast with the new 100 MHz 2247A from Tek. The new 4-channel 2247A packs more troubleshooting power for the money than any scope you can buy.

An integrated counter/timer and voltmeter let the 2247A perform more than a dozen voltage and time measurements automatically. And provide the crystal-controlled accuracy you need to debug digital systems in applications such as logic design, communications, manufacturing, and field service.

But that's just a hint of the time-saving automation built into the 2247A.

You also get Auto Setup, for one-button signal acquisition. The ability to store up to 20 front-panel setups, and recall them instantly. On-screen display of automatic time and voltage readings. Plus our unique SmartCursors,™ which give you virtually hands-off measurement of + peak, − peak, peak-to-peak, dc and gated volts.

This is the most extensive set of capabilities ever assembled in a low-cost portable scope – the 2247A is only **$2995**! And it's backed by Tek's standard 3-year warranty on all parts and labor.

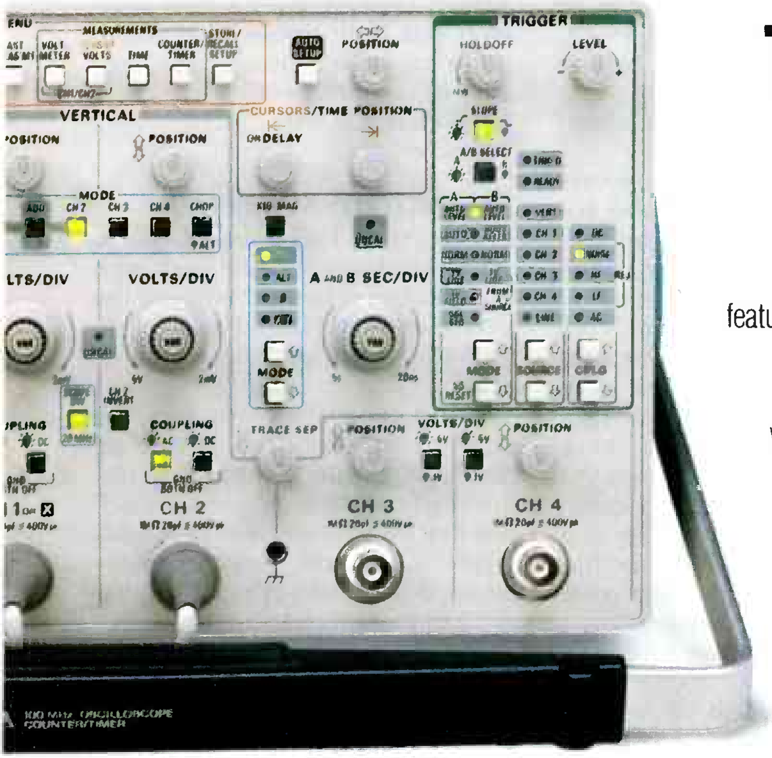
So if you want to find trouble fast, there's one sure way to do it. Look into the new 100 MHz 2247A from Tek.

Model Number	**2247A**	**2246A**
Bandwidth	100 MHz	100 MHz
No. of channels	4	4
Dual Time Base	Yes	Yes
Trigger Level Readout	Yes	Yes
Auto Setup	Yes	Yes
Store/Recall	Yes	Yes
SmartCursors	Yes	Yes
Time/Voltage Cursors	Yes	Yes
Voltmeter	Yes	Yes
Counter/Timer	Yes	No
Price*	$2995	$2595

 *Prices subject to change and valid in U.S. only. Educational discounts available on request.

BOB-001

LESHOOTER



Two more ways to find trouble.

Tek's 2246A and 2245A offer many of the performance features you'll find in the 2247A, at even lower prices.

Both are 100 MHz, 4-channel scopes with Auto Setup, time and voltage cursors, CRT readouts, dual time bases and versatile triggering. They're lightweight, rugged, and built to tough environmental standards for temperature, shake, shock and humidity.

Plus, they each have the easy-to-use front panel that's made Tek's 2200 Series the world's best-selling oscilloscopes.

2245A
100 MHz
4
Yes
No
Yes
No
No
Yes
No
No
$1995

And beyond the features, both have one more important thing in common with the 2247A-value. Because at **$2595** for the 2246A and **$1995** for the 2245A, you won't find better performance for the dollar.

Start looking for trouble today.

Peerless troubleshooting power is only a phone call away.

To order your 2247A, 2246A or 2245A or for more information and applications assistance, contact your Tek representative. Or call us direct at:

1-800-426-2200

Tektronix
COMMITTED TO EXCELLENCE

cluded, do care about picture quality. When I watch TV, I often find myself paying a lot more attention to the picture quality than to the programming. (Perhaps that is just as well, given the content of many of the programs!) However, HDTV will only be economically feasible if it can appeal to a truly mass market. I do not believe that mass market exists. People will buy gimmicks and convenience features—remote controls, VCR's, simultaneous viewing of two or more pictures, etc.—but most people do not really care about quality.

That is also evident if one remembers the failure of the so-called 1,000-line high-definition system that was broadcast in the Paris, France region for several years. TV sets that use the VIRS signals broadcast by major networks to adjust the receiver continuously, largely overcoming many propagation defects, have not caught on. That is despite the fact that they can and do often considerably improve quality at a very low cost. Stereo TV sound has been much less than a great commercial success; many receivers that do use it employ dreadful loudspeakers.

Improved definition, using present-day NTSC signals, has some very severe limitations; but it has the overwhelming virtue of being possible without a truly mass market. A market of a few hundred thousand IDTV receivers per year would make it commercially viable. HDTV needs a market of at least 10 million receivers per year, in addition to a single agreed-upon system and a very large investment by broadcasters.

I'm sorry to have to take this pessimistic viewpoint, but I fear it is a very valid one.

L.D. THOMAS
Georgetown, DE

IDTV is already a limited commercial success. North American Philips, for one, has been selling more IDTV sets than they can manufacture. Roughly 40 percent of all TV's being sold today are stereo equipped. That's not unsuccessful. Wait until sports fanatics see the Super Bowl on a wide screen with high-quality audio, which HDTV will provide. Don't worry. It will sell.—Editor

DE-MYSTIFYING MIDI

I enjoyed reading your articles on MIDI. I've been interested in knowing more about the subject, but I always found the explanations to be too complicated. The article, "Musical Instrument Digital Interface," (**Radio-Electronics**, August 1989) has been a great help, as it was both informative and—more important—it was also very easy to comprehend.

MATTHEW KREVAT
Brooklyn, NY

ALTERED AUDIO AMP

The March 1989 issue was up to **Radio-Electronics**' usual very high standards. I especially enjoyed the article entitled "High-Powered Hi-Fi Audio Amp for Your Home or Car."

What caught my eye was the power converter used to step up the voltage from 12 volts to 75 volts for the final stage (page 53). Winding that transformer may prove difficult. (Of course, you can always break down and buy one, but that isn't as much fun.)

My alternative method, shown in Fig. 1, borrows a page from the old-time radio power supplies used in cars in the 1920's and '30's. The heart of the supply is two DPDT relays that are rated at 5 volts. You might have to fool with some of the values to get it to work properly, but the design is very forgiving, and if you know your P's and Q's with a VOM you might not need a scope.

Each relay is wired as a free-running astable oscillator, and because you can just about pick the coil resistance you like best, getting the right value for the commutating capacitor is not a real problem.

Note that this commutating capacitor is made from the two 100 µF electrolytic capacitors with the IN4001 diodes across them. This combination simulates a non-polarized (NP) capacitor. Note that the cathodes of the diodes, and the positive (+) ends of the capacitors face one another.

The frequency of oscillation is usually about 1 kHz, which causes the relays to hum faintly. That

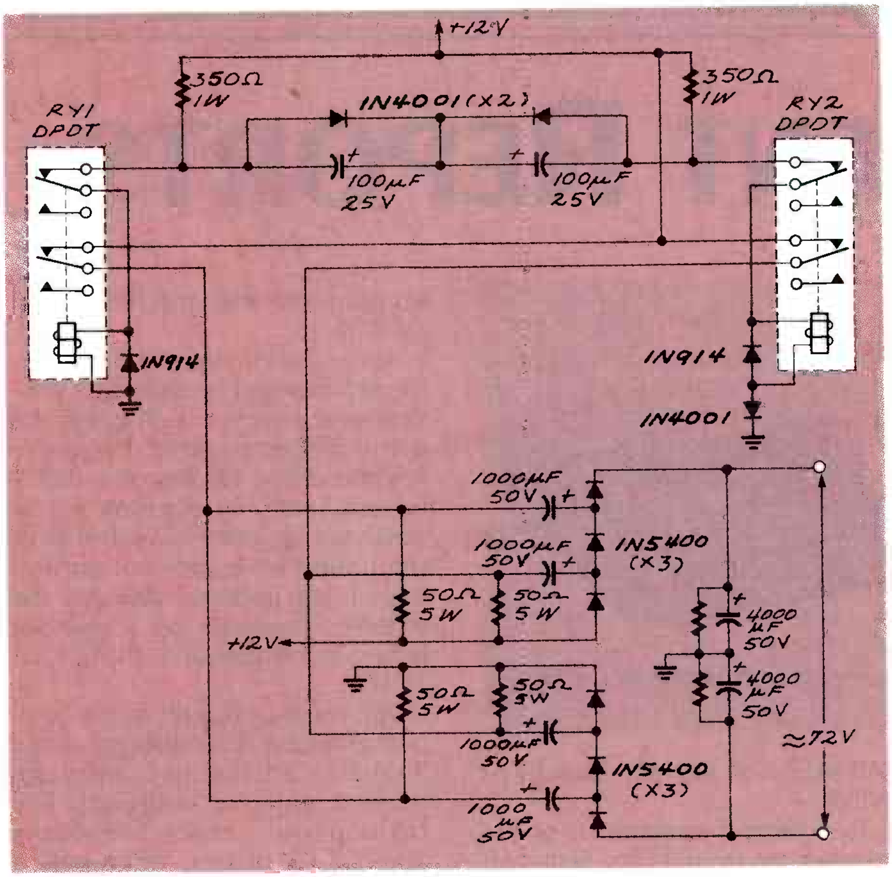


FIG. 1

humming is usually not very loud, and if the circuit is used in a car, it can be placed under the hood or in the trunk.
JIM PARSONS
Rapid City, SD

RESPONSE FROM THE RIGHT

Please stick to pure science and technology in your "Letters" column. Please don't print letters the like of Paul Schick's on HDTV (**Radio-Electronics**, July 1989).

We get enough sour grapes from the liberal air-heads in the editorial pages of our newspapers. Those kinds of statements have their hidden agenda passed off as tongue-in-cheek humor.

That kind of garbage is out of place in a prestigious magazine such as **Radio-Electronics**.
DONALD C. ROSS
San Jose, CA

RECOMMENDED READING

I have been a subscriber to **Radio-Electronics** for a long time. I served in the U.S. Navy for 30 years, both as an enlisted man and as an officer, but always in some field of electronics.

A series of articles titled "Annals of Radiation" recently appeared in the June 12, June 19, and June 26 issues of the *New Yorker* magazine. Please look that series of articles over and, if you think it is warranted, recommend it to all your readers. I feel that everyone who is planning a career in the electrical field, those already in the field, and every young person who is planning to start up a home and a family should be aware of the extremely valuable information that is presented in those articles.

I was exposed to heavy doses of RADAR microwave radiation during my many years in the Navy, and I recently had a brain tumor removed. Reading those articles made me wonder.
ROY A. NORMAN
LCDR USN, Retired
Brunswick, GA

We have read those articles and are very concerned about some of the issues they raised. We feel that they should be required reading for not just some people, but for everyone.—Editor

EQUIPMENT REPORTS

ACE Communications AOR AR-2515 Communications Receiver

One radio for scanner buffs and SWL's!

CIRCLE 42 ON FREE INFORMATION CARD

SHORTWAVE LISTENERS AND SCANNER enthusiasts have always been divided into two camps. One is interested in DX-ing and in getting news and views from around the world. The other is looking for the faster-paced excitement that comes from hearing real-time action on the local police, fire, and other public-service bands. But a new piece of equipment may bring the two camps closer together: the AOR *AR-2515* communications receiver from ACE Communications (10707 East 106 St., Indianapolis, IN 48256). It is one of the few receivers that gives the shortwave listener the frequency coverage and performance he desires, while delivering speed, coverage, and memory capability to the scanner buff.

The *AR-2515* boasts a frequency coverage from 5 MHz to 1500 MHz, which includes international shortwave broadcasts, amateur bands, TV audio, FM broadcasts, VHF aircraft, various government communications, NOAA weather broadcasts, VHF aircraft, cellular telephone, and more. (We should point out that reception of various frequencies covered by the receiver, including cellular frequencies, is forbidden by the Electronic Communications Privacy Act of 1986.) Three operating modes are supported: AM, Wide-band *FM*, (WFM) and Narrow-band *FM* (NFM).

The memory capabilities of the receiver are impressive. Sixty-two banks of 32 frequencies each provide a total of 1984 scannable frequencies. Any number of banks can be linked for scanning. So, for example, you can scan one band of 32 frequencies, or you can link all 62 banks and scan through the almost 2000 frequencies in memory. An additional 18 banks are provided for search pairs; banks 63 through 79 can contain the upper and lower frequency limit for searching out new and unknown frequencies that are in use in your area.

The scanning speed of the receiver is, at best, about 36 channels per second. That decreases if the frequencies in a scanning bank are widely separated, or if mode changes are required, etc. If you're willing to ignore the decrease in scanning speeds, you can create some interesting and useful banks. For example, we filled one bank with some frequencies in which we were often interested. It included the local National Weather Service broadcasts, WWV shortwave broadcasts, and a couple of local FM broadcast stations. While those might be considered to be unusual scanner frequencies, they do point out the versatility of the *AR-2515*.

Alternatively, in search mode, the scanner can be used as a conventional receiver. Tuning can be accomplished by direct-frequency keypad entry, turning the rotary tuning knob, or pushing up or down tuning buttons. Each click of the tuning knob, or each push of the tuning buttons, changes the receive frequency by a user-selected increment of 5, 10, 12.5, or 25 kHz.

The receiver is built into a compact gray case that measures about 7 × 5-1/2 × 2-1/2 inches (although it's not really rectangular). The front panel, which measures about 3 × 5 inches, tilts upward and is crowded with 23 pushbuttons, three rotary knobs, an LCD frequency display, and an LED signal-strength meter. Despite the crowded appearance, the controls are surprisingly easy to use.

Computer interface

One of our favorite features of the *AR-2515* is its computer interface. The receiver can communicate with any personal computer that offers an RS-232 interface. Rates of 300, 1200, or 9600 baud are supported. While ACE does have a communications package available, any general communications software is adequate.

The interface allows you to control all of the functions of the receiver from your computer keyboard, except for volume and squelch. You can upload complete banks of frequencies, change operating modes, switch scanning banks, and even turn on the LCD light.

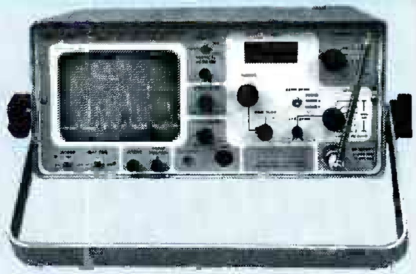
Perhaps the most useful attribute of the communications capability is that it allows the receiver to send important information to the computer. Our favorite command puts the receiver in an auto-

continued on page 32

AVCOM PSA-65A Spectrum Analyzer

An inexpensive, quality spectrum analyzer from 2 MHz–1 GHz.

CIRCLE 43 ON FREE INFORMATION CARD



VERY LIKELY, MANY OF YOU HAVE always wanted a *professional* spectrum analyzer, whether for troubleshooting, or experimentation. However, every time you've looked at a catalog and seen prices that start in the $10–20K range, your jaw drops. Unless you're in a large corporate firm with mega-buck budgets, you've probably had *no* chance of getting one until now.

With the Model PSA-65A 2 MHz–1 GHz Spectrum Analyzer from AVCOM Corp. (500 Southlake Blvd., Richmond, VA 23236), *that* problem is *over*. The basic cost is $2,675, and many reasonably priced accessories, like an FM demodulator ($185), high-performance attachable log-periodic antennas (about $239), and carrying case ($89.95) are available. At 11.5- × 5.5- × 13.5 inches and a weight of 18 pounds, it's as portable as a standard portable oscilloscope.

General controls and jacks

The PSA-65A has numerous, convenient, and well-labeled controls. They're all on the front panel, and grouped according to function in a color-coded gray-and-white format. The PSA-65A is powered by 120- volt, 60-Hz AC, but can run using an internal gel-cell battery with recharger. The POWER switch has BAT, STANDBY, and LINE positions. The battery charger (BAT CHG) can operate in any POWER SWITCH position, and needs about three hours to charge sufficiently for prolonged use.

The AUDIO DEMOD potentiometer is the volume control for listening to AM or FM broadcasts, and has a built-in SPST ON/OFF switch. However, the PSA-65A won't let you observe a spectrum and listen to audio simultaneously. That would require having two separate tuners, one to be swept through the observable spectrum, and the other tuned to the center frequency.

An earphone jack is provided (AUDIO OUT), and an AUX jack is for present and future optional accessories. The SWEEP RATE control varies the speed of the sweep-rate generator. For maximum accuracy in vertical amplitude measurements, the sweep is set as slow as possible. A BNC jack is used for RF INPUT from 2 MHz–1 GHz range, and a maximum power of 15 dBm, or 31.6 mW.

Vertical amplitude controls

The CRT is located in the upper left of the front panel, and the graticule is calibrated vertically in dBm and dBmV, and horizontally in dBmV. Those two units are dB relative to a milliwatt (mW) and a millivolt (mV), respectively. The PSA-65A has VERTICAL POSITION and REFERENCE LEVEL knobs, and a VERTICAL SENSITIVITY switch to select between 10 dB/div or 2 dB/div (for both dBm and dBmV). The *reference level* allows vertical expansion by vertically moving the signal-noise floor, and is calibrated with the *vertical sensitivity* set to 10 dB/div, but not 2 dB/div.

Horizontal and tuning controls

The main function switch on the PSA-65A is ZERO SPAN, which determines whether the instrument is operating in AUDIO, NORM, or MOMEN mode. In AUDIO mode, the PSA-65A displays an AM or FM broadcast by quadrature detection, at the frequency indicated on the 4-digit CENTER FREQUENCY MHZ LCD. The quadrature detector is mainly for FM, but also demodulates AM intelligibly.

In NORM mode, the PSA-65A displays a frequency spectrum, being calibrated when the VAR SPAN knob is in the CAL position. As it's rotated toward ZERO SPAN, the observed spectrum segment on the CRT expands horizontally about the center frequency, narrowing in bandwidth. The ZERO SPAN + XSC SETTING OF THE VAR SPAN knob is an ideal, because the time waveform on the CRT is never a pure sinusoid, since the horizontal SPAN control has a finite nonzero bandwidth filter for each setting (more below).

The AUDIO mode automatically gives a ZERO SPAN display. The MOMEN mode momentarily does so, to let the user alter the center TUNING frequency easily. In NORM mode, there's a 0.5 second lag between moving the TUNING knob, and the corresponding update of the LCD.

In the AUDIO and MOMEN modes, no such lag exists, and any TUNING knob rotation is instantly reflected on the LCD. The center frequency is controlled by two potentiometers, one a 10-turn version for main TUNING, and a single-turn FINE TUNE control. The FINE TUNE appears to have a range of about 7 MHz, but is asymmetric and nonlinear in effect.

For each horizontal SPAN setting, there's a nonzero filter bandwidth resolution, which gives rise to the time effects observed at ZERO SPAN (discussed shortly). The resolution is 3 MHz at 100 MHz/div, 1 MHz at 50 MHz/div, 300 kHz at 10 MHz/div, 150 kHz at 5 MHz/div, and normally 75 kHz at either 1 MHz/div or 200 kHz/div. The user can also opt for an additional 10 kHz filter for the 200 kHz/div setting, if desired.

One good way to observe the effects of those filters is by observing a TV station spectrum. The AM video is always 4.5 MHz below the FM audio. If you center the video on the CRT with the VAR SPAN control set to CAL, and then rotate it to ZERO SPAN, you'd see the actual time waveform, just as if you were using an oscilloscope.

That waveform would be completely visible as the VAR SPAN is rotated toward ZERO SPAN. In the CAL position, you'd see the spectrum, but possibly also see a spurious representation of the time

continued on page 32

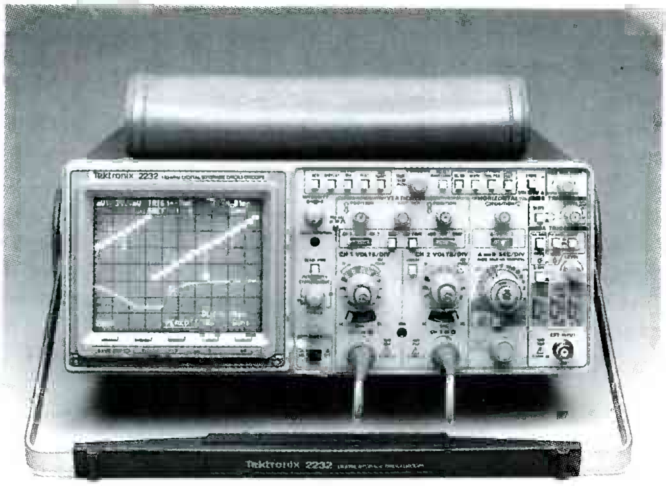
NEW PRODUCTS

ANALOG/DIGITAL STORAGE SCOPE. With the help of custom IC's, the *Tektronix' 2232* portable analog/Digital Storage Oscilloscope (*DSO*) delivers a 100-MS/s sample rate and a 100-MHz bandwidth. Its proprietary peak-detection capability allows for glitch capture as narrow as 10 ns at all sweep speeds, including dual-channel operation.

The scope has several features designed to make it easy to use, including on-screen readout of scale factors and cursor measurements of voltage and time. Bezel buttons provide quick access to saved reference waveforms and the full range of menu selections. Trigger-level readout allows the user to set the voltage level for the trigger point and read it directly on screen, which can save a lot of time in single-shot waveform-capture and "babysitting" (unattended monitoring) applications. For added triggering flexibility, both low- and high-frequency reject capabilities assure a stable, usable trigger even on noisy or complex signals.

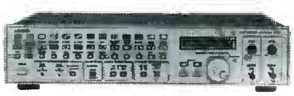
With both analog and digital capabilities, and 100-MS/s sampling, the DSO is a versatile general-purpose instrument. Its analog operation allows the display of complex waveforms such as video signals and realtime update of changing signals. Digital capabilities include waveform storage, peak detection, and pretriggering. When troubleshooting digital devices, the sampling rate allows the capture of single-shot events up to 10 MHz. With the DSO's ability to store as many as 29 waveform sets, users can build a library of saved waveforms. Known-good waveforms can be stored for reference, and unknown waveforms can be captured in the field and stored for later analysis. An RS-232-C interface option lets such waveforms be transferred by modem.

The *2232* portable digital storage oscilloscope has a list price of $5,495.00. The RS-232-C and GPIB interface options cost $300.00 each.—**Tektronix**, P.O. Box 1700, Beaverton, OR 97075; 1-800-426-2200.



CIRCLE 10 ON FREE INFORMATION CARD

VIDEO TEST GENERATOR. The model *408* gen-lockable NTSC video test signal generator from *Leader Instruments* provides over 80 test patterns in composite; S-VHS; RGB; and Y, R-Y, and B-Y output formats with RF channel coverage of all broadcast and cable channels. Multiburst, video sweep, SMPTE color bars, modulated and unmodulated staircase, raster, and crosshatch are just a sampling of the available test patterns.



CIRCLE 11 ON FREE INFORMATION CARD

A menu-driven, multipurpose data-control board with an LCD readout is used to set up channel frequencies and video-signal-driven specifications. Control of key video-signal levels—such as sync, burst, luminance, chrominance, and setup—is provided, along with RF-frequency selection. As many as 100 sets of video-level specifications and channels can be stored in memory and instantly recalled as needed.

The model *408* video test signal generator costs $3,395.00.—**Leader Instruments Corporation**, 380 Oser Avenue, Hauppauge, NY 11788.

16-BIT CONVERTER BOARDS. Designed to provide a full-featured, low-cost alternative to custom or microcomputer-based systems, *MetraByte's MBC-GAD* and *MBC-DAC* plug-in daughter boards for Macintosh II's and SE's offer high-resolution data sampling and conversion.

The *MBC-GAD* performs a 16-bit A/D conversion at a rate of 16,000 samples per second, with a resolution of 1 part in 65,536 and 0.003% measurement accuracy. The differential analog input may be configured for voltage ranges of ±2.5, ±5, or ±10 volts; 0 to 5 volts; or 0 to 10 volts. The analog input is accessible via a standard RCA phono connector or a 10-pin ribbon-cable connector. Two *MBC-GAD'S* can be installed on one motherboard to create multichannel subsystems.

CIRCLE 12 ON FREE INFORMATION CARD

The *MBC-DAC* provides two independent, 16-bit analog-output channels, which are capable of processing data at 100,000 samples per second to voltage accuracies of 0.006%. The voltage range of each output channel is fixed at ±10 volts, and the channels are accessible via a 10-pin ribbon-cable connector.

Both daughter boards can be driven from programs written in high-level languages, such as BASIC, PASCAL, C, or FORTRAN. When used with MetraByte's *MBC-625* motherboard, they provide high-speed, high-resolution data-acquisition capabilities for Macintosh users.

The *MBC-GAD* 16-kHz A/D converter and the *MBC-DAC* 100-kHz D/A converter cost $550.00 and $475.00, respectively. The *MBC-625* motherboard costs $1,290.00.—**MetraByte Corporation**, 440 Myles Standish Boulevard, Taunton, MA 02780.

AUDIO EXPANDERS. The *AX 101 CD* phono-input adapter and the *AX 100* auxiliary selector from *Johnson Electronics Labs* expand the input-selection capability of stereo amplifiers.

CIRCLE 13 ON FREE INFORMATION CARD

The phono-input adapter allows amplifiers that do not have a CD or auxiliary input to accept a CD player—or any other auxiliary device—through the magnetic phono input. Its passive-circuit design minimizes noise and distortion. The *AX 101 CD* features a selector switch for CD or phono operation, RIAA response accuracy to within 1 dB, and chrome-plated housing with removable mounting tabs for easy mounting.

The *AX 100* enhances amplifiers with limited input capability, increasing selection to as many as five different input sources. It is packaged in a fully-shielded, black ABS-plastic housing, and features silver-plated switch contacts, dual tape outputs, and a tape-monitor switch to allow monitoring of either recorder. Stereo cable is included.

The *AX 101 CD* phono-input adapter and the *AX 100* auxiliary selector cost $89.95 and $29.95, respectively.—**Johnson Electronics Labs, Inc.**, 409 Angus Blvd. #29N, Warner Robins, GA 31088.

SIGNAL GENERATOR/COUNTER. Combining a signal generator and a frequency counter in one unit, *Elenco's SG-9500* can generate RF frequencies from 100 kHz to 150 MHz and can measure external frequencies up to 150 MHz. Accuracy is ± count/±1 digit, and the RF output is 100-MV RMS, up to 35 MHz. A switch with fine-adjustment control lets the user select 0-dB or 20-dB output. The instrument features 1-kHz internal modulation, and input voltage is less than 50 mV.

CIRCLE 14 ON FREE INFORMATION CARD

The *SG-9500* signal generator with built-in frequency counter costs $349.00.—**Elenco Electronics Inc.**, 150 West Carpenter Avenue, Wheeling, IL 60090.

PC THUMBSCREWS. A variety of thumbscrews from *PC Pro* are custom-sized to fit XT's and AT's and make it easier for PC users to get inside their computers. *Thumbytes*, *Thumbits*, and *Thumbles* eliminate the need for the usual assortment of nutdrivers, slot- and Philips-head screwdrivers, and nuts and screws used to service personal computers. Color-coded plastic caps are mated to screws, resulting in durable thumbscrews that are available in an array of sizes and lengths for convenient replacement of slide-top and adapter-card hold-down screws.

Thumbytes and *Thumbits* provide flip-top ease for non-flip-top PC's. They are sold in sets of five, and fit virtually any slide-top case. *Thumbles* hold I/O cards tightly in place, and make it easier to remove cards. They are also sold in sets of five. Knurled grips make it harder to lose screws inside the computer. No tools are needed in order to access switches or jumpers after installation.

CIRCLE 15 ON FREE INFORMATION CARD

Thumbytes and *Thumbits* each cost $5.00 per set of five; *Thumbles* cost $10.00 per set of five.—**PC Pro Company**, P.O. Box 358, Allen, TX 75002.

"TEST" VIDEODISC. *Reference Recording's* "A Video Standard," is a disc for the set up and alignment of home-entertainment systems. Containing comprehensive audio and video test signals and a wide variety of audio and video demonstration material, the laser videodisc is intended to help consumers optimize their home-viewing experience, and retrieve from video programs exactly what the producers put in.

The videodisc was produced by Joe Kane, who chairs the *Society of Motion Picture and Television Engineers (SMPTE)* Working Group on Monitor Calibration, which is responsible for setting NTSC standards for picture quality. The videodisc was produced in D1, the 4:2:2 component digital-video format that is the most advanced recording system available for the current 525-line video system. For the highest possible accuracy, most of the audio test tones were computer generated by Dolby Laboratories, and converted to analog for the first time at the videodisc player.

CIRCLE 16 ON FREE INFORMATION CARD

The disc's test features include instructions for analyzing viewing-device quality along with specific test signals for the individual display parameters that combine to form a good picture. Comprehensive calibration instructions are provided, along with the necessary test signals and video-system calibration signals. For audio tests, there are digitally-generated audio tones and sweep signals, specific test signals for digital-to-analog converters; a dynamic-range tone-level check; frequency information from 15 Hz to 21 kHz; and instructions on how to use the test tones.

The videodisc also provides demonstration features concerning the transfer of film to video, analog and digital video graphics, electronic video effects and animation, and reference pictures for skin-tone and color fidelity. Audio demon-

continued on page 95

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SCANNING RECEIVER

continued from page 24

frequency mode. In that mode, whenever the scanner stops at a new station, the frequency and signal strength of the station are output to the computer. We found this novel way of searching for new scanner frequencies to be quite efficient.

The *AR-2515* comes equipped with a telescopic antenna, DC power cord, AC adapter, and an owner's manual that, while adequate, could be much more informative. ACE Communications offers several accessories, including a wide-band amplifier and an external BFO (Beat-Frequency Oscillator) for making SSB (Single SideBand) transmissions intelligible.

The suggested price of the *AR-2515* scanning communications receiver is $695. While we certainly cannot call that inexpensive, we do feel confident calling it a bargain. **R-E**

SPECTRUM ANALYZER

continued from page 25

waveform superposed on it, for certain settings of the horizontal SPAN. That is because of the techniques used to design the instrument, not because of modulation.

Thus, VAR SPAN doesn't really produce a 0 Hz span, since that would be a pure monochromatic tone. The TV waveform containing the sync pulses is really a time-dependent voltage, whereas the video spectral peak is a true frequency-dependent amplitude (voltage or power). If you repeat for the audio, you'll see the time-dependent audio waveform, and it'll change amplitude and frequency as the sound varies. However, the presentation, while that of an oscilloscope, not a spectrum analyzer, is untriggered and drifts across the screen.

Horizontal calibration

The horizontal needs to be calibrated each time the instrument is turned on and/or the HORIZ POSITION is moved, which can be somewhat tricky if not done carefully. The user tunes a signal peak onto the center of the graticule, with the VAR SPAN knob set to the CAL position. The user then rotates the VAR SPAN knob counterclockwise, watching that peak. It'll expand in width, but should, ideally, remain centered, and not deflect to either side.

If it does deflect, then as the VAR SPAN is rotated, the user alternates between the VAR SPAN and HORIZ POSITION knobs, to recenter the now-expanding peak. The reason for alternating between them is that as the peak expands, it's maximum becomes more difficult to locate, since the display appears to be flatter. Thus, rotating each knob in turn gives greater accuracy and control, and an opportunity to maintain a visual reference on the maximum as the peak changes shape.

Once completed, with the VAR VAR SPAN set to ZERO SPAN and the

continued on page 81

BUILD THIS

VIDEO SCENE SWITCHER

Make your next transition a smooth one!

WILLIAM SHEETS and RUDOLF F. GRAF

IF YOU'RE LIKE MOST VIDEO-CAMERA owners, you've built up an inventory of hours and hours of home video movies. If you like to show your movies to others, you've undoubtedly found that even your best friends won't sit through an hour-long video of your son's first birthday. The solution is to edit your tapes into groups of short scenes. The trick is to do it with professional results.

The problem that arises is how to make the transitions between scenes or sources as smoothly as possible, without visually or a esthetically disturbing transitions. Our Video Scene Switcher is the key to smooth transitions.

In order to switch between video channels with a minimum of disturbance, several technical requirements must be met:

- Sources must be identical in polarity and type (for example, both NTSC with negative sync)

- Sources must have the same levels. That requirement can be met using gain adjustments.

- Color-burst phase must match in order to reduce color shifts between scenes.

- Terminations and impedance matching must be considered in order to reduce reflections and "ghosting."

- The time phases of the sources must be constant and have a fixed relationship. The sync pulses must coincide both in time of occurrence and frequency, both vertical and horizontal.

Most of the time there is no problem in meeting the first four requirements, as they are under direct control of the system operator. However, the last requirement, that the video sources have sync pulses in phase, does present a problem. That's because, when using two separate VCR's, a VCR and a camera, or a VCR and an over-the-air source, there is generally no relationship between sync phases.

The term "genlock" is used to describe the act of using a master synchronization source to control the sync phase of other sources. Some video equipment has genlock inputs but, most of the time, the availability of two genlocked sources cannot be relied on.

When the signal source to a video monitor, TV receiver, or VCR is suddenly switched, the synchronizing circuits of the video device experience a discontinuity of input, in frequency, phase, or both, depending on

the moment of switching in most instances. If, by chance, the vertical and horizontal sync pulses of both sources are coincident in time (in phase) at the moment of switching, there will be no noticeable disturbance. If, however, they are not (the usual case), a momentary loss of synchronization will occur. Depending on the characteristics of the sync system in the video device in use, a momentary flicker, jump, tear, or roll will occur in the picture—it's objectionable, esthetically unpleasant, gives an "amateur" look to a program, and should be eliminated.

A common way to deal with the problem is to fade to balck, or some other level. During this interval, switching takes place, and since the screen is black, no transient effects are noticed. After a predetermined time, the new video is switched in and then the fade from black to program is performed.

There are other methods that can be used. A black-over can be "keyed" into the picture; for example, a black over can be wiped across the picture, much like a curtain, either horizontally or vertically, or both (diagonally). A black-over can also be broken up like a series of vertical or horizontal strips that gradually enlarge, covering the picture with the effect of a Venetian blind. By doing that vertically and horizontally at the same time, black

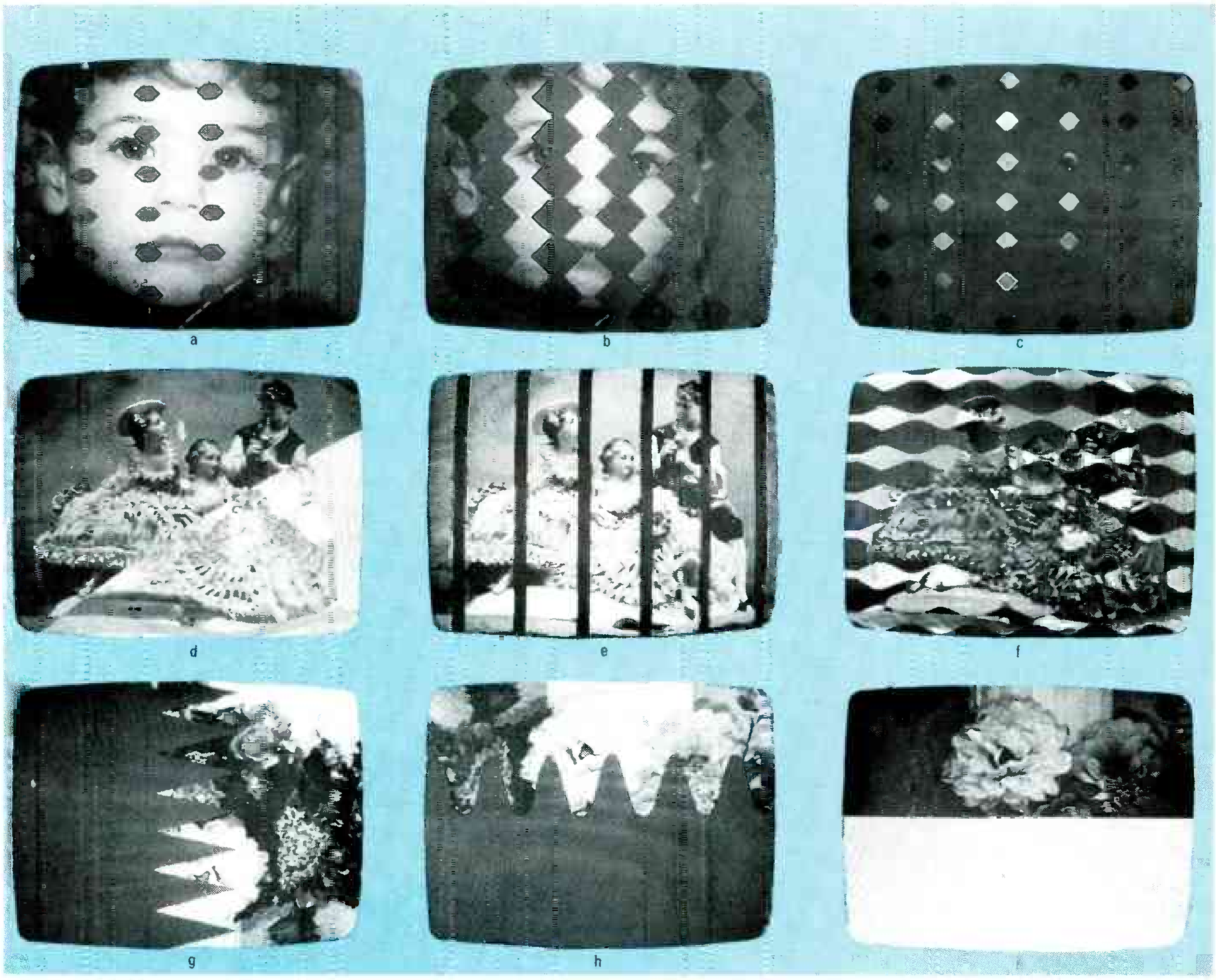


FIG. 1—VARIOUS FADES, WIPES, AND EFFECTS can be keyed into the picture. You don't have to stick to simple horizontal or vertical fades, as complex fades are also possible; see how Danny disappears in *a*, *b*, and *c*. A diagonal wipe from regular video to effects video is shown in *d*, expanding vertical bars "consume" the picture in *e*, expanding diamond-like patterns in *f*, and *g*, *h*, and *i* show three additional wipe patterns.

dots appear in the picture that expand in size to first overlap and then completely obscure the picture. Figure 1 shows those patterns.

The act of "keying" is actually video switching using waveforms that are tied to the sync pulses or other picture elements, such as the luminance level (luminance keying) or chroma level (chrominance keying). By producing such waveforms, a great variety of switching and special effects can be produced. Note that the effects are performed steadily on the video, and that the sync pulses must remain unaltered during the switching process.

For wipes, keying, or other switching between two sources without an intermediate fade, the two sources must be genlocked or synchronous. There is no easy way around that, save for a large video buffer memory, or some form of synchronizing storage system. However, that shouldn't be considered a serious limitation, since many fade-to-black techniques have a pleasing effect, and they provide a more defined differentiation between scenes.

Basic operation

The Scene Switcher basically consists of two parts, as shown in the block diagram in Fig. 2. A video switching system is used to switch in various video effects, fade levels, and to select channel 1 (CH1) or channel 2 (CH2), and a waveform generator is used to generate keying waveforms to drive the analog switches at precisely timed intervals.

There are two video channels (CH1 and CH2), but we will describe the operation of only CH1, because the two are identical. Each channel has two switch-selected inputs, main or auxiliary, and each channel is fed to a splitter circuit that separates the video and sync components. That way, the video can be processed separately from the sync. The sync is not processed in any way.

The video from CH1 first passes through an analog switch (NORMAL/EFFECTS) that either passes it or selects CH1 video that has been altered by an external special-effects unit (for example, the Video Palette described in the September and October 1987 issues of **Radio-Electronics**). Since the video from the special-effects unit is inherently synchronous with the CH1 video, direct switching is possible, and you can wipe the altered scene over the original one.

Next, the video is fed to another

analog switch, the FADE SELECTOR. The output of that switch is either unaltered video or a DC background level from the *fade level generator*, which is variable between black (about zero volts) and white (1 to 1.5 volts). That is determined by the setting of the FADE LEVEL control, which gets its switch signals from the control panel and the *keying generator*. During a line-scan internal, several switching actions may take place, causing various pattern configurations to be generated on the monitor screen.

Next, the video goes to a switch network that routes it to either side of the FADER control, or selects CH1 or CH2. Both analog switches are driven by the keying waveform from the keying generator and control panel: switching may take place several times during a line scan, depending on the effects desired. The output from the FADER control is fed to a *summing amplifier*, and mixed with appropriate sync. The system output is composite video.

The keying generator consists of a set of sawtooth-wave generators. Sync from CH1 or CH2 is fed to a phase-locked loop, where constant outputs of 15.74 kHz and 60 Hz are generated, phase locked to the video input waveform. Those outputs are fed to the horizontal and vertical sawtooth generators.

The generators each produce two waveforms; a sawtooth at eight times the input frequency and a sawtooth at the input frequency. The sawtooth waveforms are fed to a comparator, whose "trip" level is adjustable. The sawtooth is compared to the trip level from the keying control, which may be manual, or automatic.

When the sawtooth exceeds the trip level, the comparator switches. Since the sawtooth level varies synchronously with the horizontal, or vertical, or both sweeps, varying the trip level causes the comparator to switch at varying points in either the horizontal or vertical scan. Therefore, since the comparator output is the keying waveform, we can control the position of the switching at any desired point in either the horizontal or vertical scan cycle.

The switching waveform is fed to the control panel and then to the correct analog switches in the video channels. Several switching patterns can be generated, using the ×1 or ×8 vertical, the ×1 or ×8 horizontal, or various combinations.

The circuit features external access capability to the switch signals and sync outputs via emitter followers. That permits using an external computer or microprocessor to generate other switching patterns than we have here, if desired. That is left as a project for the experimenter or computer hobbyist.

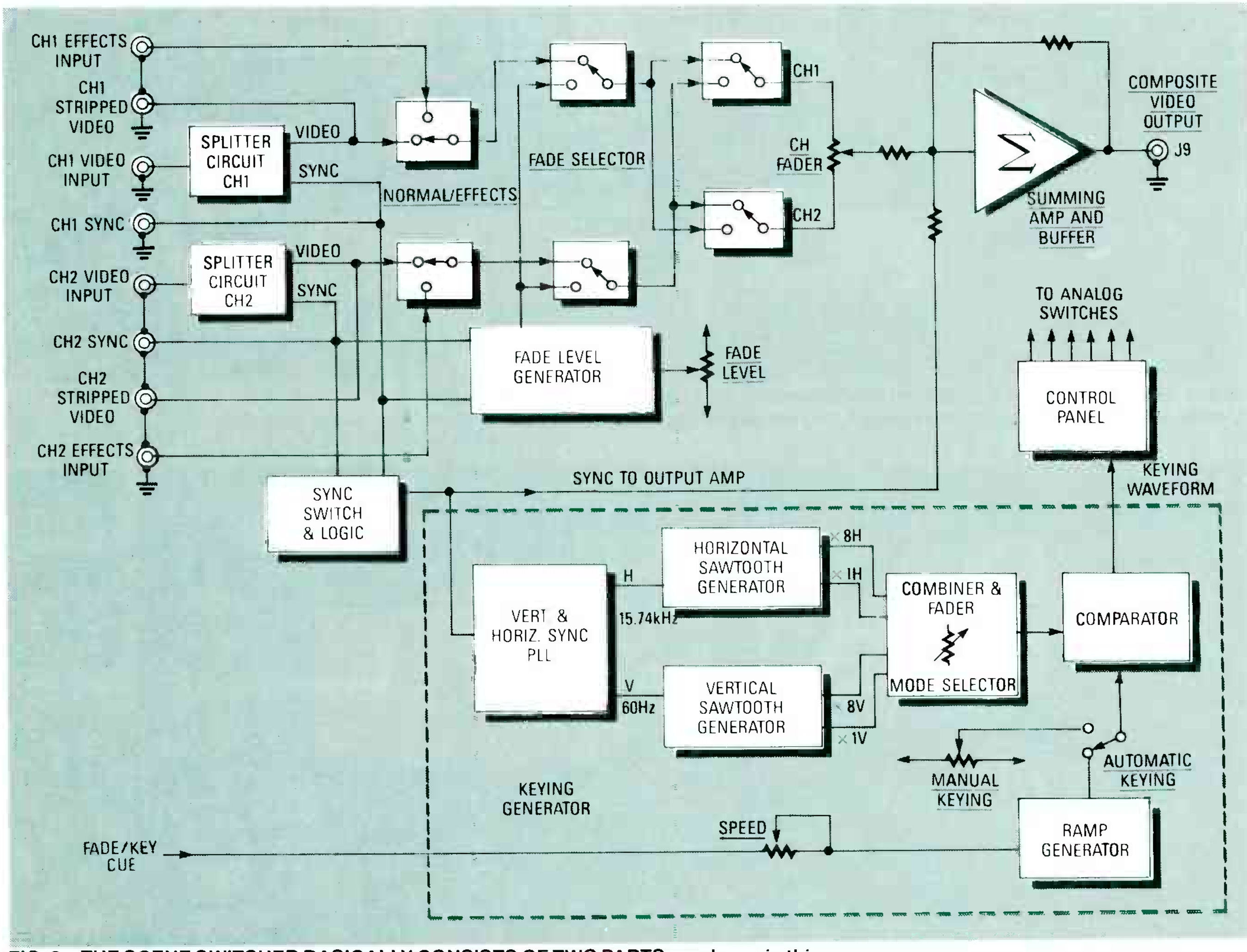


FIG. 2—THE SCENE SWITCHER BASICALLY CONSISTS OF TWO PARTS, as shown in this block diagram. A video switching system is used to switch in various video effects, fade levels, and to select channel 1 (CH1) or channel 2 (CH2). A waveform generator is used to generate keying waveforms to drive the analog switches at precisely timed intervals.

Circuitry

Due to the large amount of circuitry, very detailed descriptions of every circuit will not be given. Only a single example of each essential block will be described in detail, since much of the circuitry is repetitive.

Referring to Fig. 3, video is fed through C1 and filter R1-C2 (to remove excess noise) to sync-separator IC1, an LM1881N; it separates the horizontal and vertical sync from the video. Composite horizontal sync (negative-going pulses) appears at pin 1, and is then fed to IC2-a, the horizontal-delay multivibrator, in which R5, R6 and C6 determine the period.

The multivibrator produces an 8-microsecond pulse triggered by the leading edge of the sync pulse. The 8-microsecond pulse is used to initiate another pulse generated by IC2-b, which is active only during the line-scan portion (the video) of the video waveform. The IC2-b pulse is used to gate the video-only component from the composite video waveform (R7, R8, and C7 set the width of the pulse at 53 microseconds).

IC3-a and IC3-b perform a similar function on the vertical sync pulses from pin 3 of IC1; IC3-a is the delay and IC3-b generates a 16-microsecond pulse which is active during individual fields of the TV signal. During vertical-retrace intervals, it is desirable *not* to gate on the composite video, so horizontal multivibrator IC2-b is locked out during the vertical-blanking interval, when pin 10 is low.

Figure 4 shows the sync selector and PLL block. When SYNC SELECT (pin 2) of IC4 is high SYNC 1 selected, and when it's low SYNC 2 is selected.

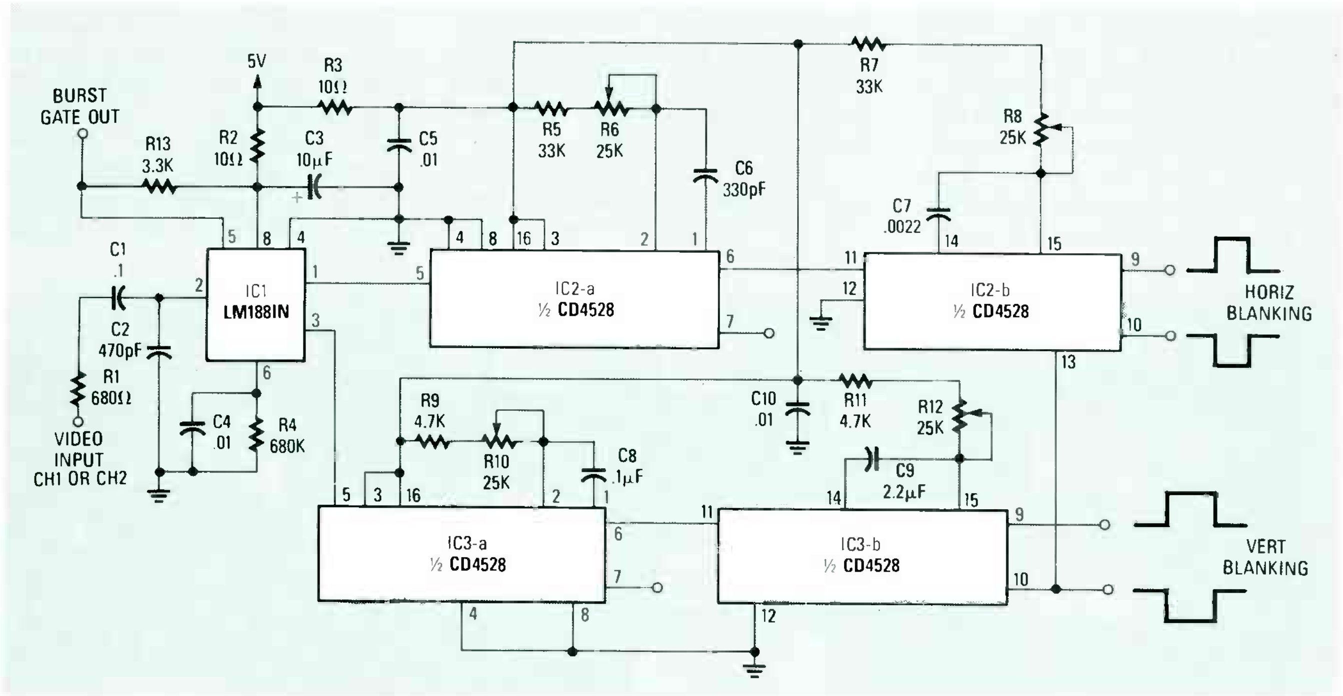


FIG. 3—SHOWN HERE IS A SYNC SPLITTER. Video is fed to pin 1 of sync-separator IC1. Composite horizontal sync appears at pin 1, and composite vertical sync appears at pin 3.

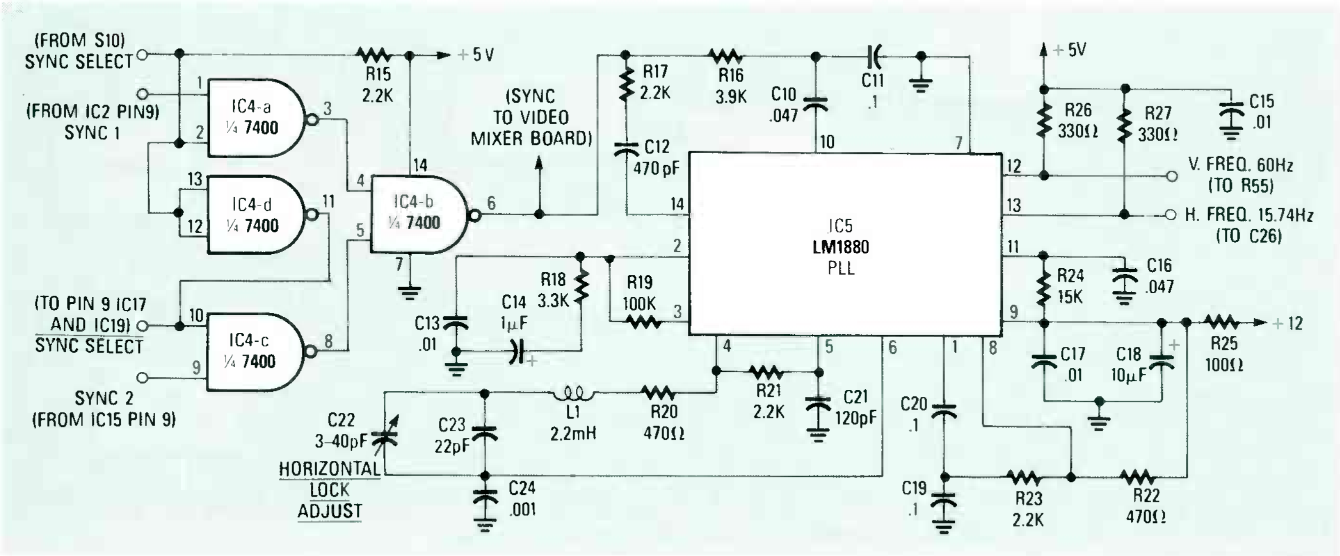


FIG. 4—SYNC SELECTOR AND PLL BLOCK. When pin 2 (SYNC SELECT) of IC4 is high, SYNC 1 selected, and when it's low SYNC 2 is selected.

PARTS LIST

All resistors are ¼-watt, 10%, unless otherwise indicated
R1, R201—680 ohms
R2, R3, R29, R62–R64, R134, R135, R127, R128, R140, R141, R143–R150, R202, R203—10 ohms
R4, R204—680,000 ohms
R5, R7, R205, R207—33,000 ohms
R6, R8, R10, R12, R42, R45, R47, R49, R206, R208, R210, R212—25,000 ohms, potentiometer
R9, R11, R32, R33, R36–R40, R52, R53, R58, R59, R130, R209—4700 ohms
R15, R17, R21, R23, R28, R30, R31, R34, R41, R54–R56, R61, R100, R101, R104, R105, R112, R114, R118, R123, R124, R138a–R138f—2200 ohms
R16—3900 ohms
R13, R18, R213—3300 ohms
R19, R102, R103, R106, R111, R120–R122, R136—100,000 ohms
R20, R22—470 ohms
R25—100 ohms
R26, R27, R139a–R139f—330 ohms
R35, R57—5000 ohms, potentiometer
R43, R50, R51—1000 ohms
R44—1 megohm
R46, R48, R113, R116, R119, R126, R129, R131, R142—10,000 ohms
R60—47,000 ohms
R132—68 ohms
R108, R133—82 ohms
R115, R125—2000 ohms, potentiometer
R110, R117, R137—22,000 ohms
R24—15,000 ohms

Capacitors
C1, C8, C11, C19, C20, C33, C34, C40, C101, C208—0.1 µF, Mylar
C2, C12, C202—470 pF, ceramic disc
C3, C18, C27, C30, C35, C36, C37, C38, C41, C47, C50, C203, C307, C309, C311—10 µF, 16 volts, electrolytic
C4, C5, C13, C15, C17, C32, C43–C45, C48, C49, C101, C102, C105, C106, C109–C116, C204, C205, C302, C303, C305, C306, C308, C310—0.01 µF, ceramic disc
C6, C206—330 pF, NPO
C7, C207—0.0022 µF, Mylar
C9, C209—2.2 µF, tantalum
C10 C16, C26, C28—0.047 µF, Mylar
C14 C42—1 µF, 35 volts, electrolytic
C21—120 pF, ±5%, NPO
C22—3–40 pF, trimmer
C23—22 pF, NPO
C24, C25, C29, C39—0.001 µF, Mylar
C31—470 pF, NPO
C103—5 pF, NPO
C104, C107—2–18 pF, trimmer
C301—4700 µF, 25 volts, electrolytic
C304—2200 µF, 25 volts, electrolytic

Semiconductors
IC1, IC14—LM1881N video sync separator
IC2 IC3, IC15, IC16—CD4528B dual monostable multivibrator
IC4—7400N quad 2-input NAND gate
IC5—LM1800N PLL FM stereo demodulator
IC6, IC9—LM565N PLL IC
IC7, IC10—74C93 4-bit binary counter
IC8, IC11, IC12—TLO81 wide-bandwidth JFET-input op-amp
IC13, IC21, IC22—LM318N op-amp
IC17–IC20—CD4053B analog multiplexer/demultiplexer
IC301—LM7812 12-volt regulator
IC302—LM7805 5-volt regulator
IC303—LM7905 −5-volt regulator
D1, D100—1N914B diode
D301–D303—1N4007 rectifier diode
Q1–Q3, Q5, Q6, Q101, Q103a–f, Q105—2N3904 NPN transistor
Q4, Q102, Q104a–f—2N3906 PNP transistor

Other components
L1—2.2 mH coil
T1—120VAC/24VAC, 500 mA transformer
J1–J10—RCA jack
S1–S3—SPDT switch
S4, S10, S11—SPST switch
S5–S9—SPDT with center off
Miscellaneous: project case, wire, line cord, solder, etc.

Note: A partial kit consisting of the two PC boards and *only* the parts that mount on them is available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804, for $137.50. The kit does *not* contain *any* of the parts that mount off the board, such as the switches, control potentiometers, 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.

Sync from pin 4 of IC4 is fed to a filter network (R16, R17, C10, C11, C12) and then to IC5, an LM1880 PLL. Components C13, C14, R18, and R19 help determine loop parameters: R20, R21, C22–C24, and L1 are for the internal oscillator of IC5 operating at 503 kHz; and C19, C20, R22, and R23 are feedback components.

R24 and C16 are vertical-timing components necessary for correct operation of IC5, and R25, C17, and C18 are supply decoupling components. A signal at the horizontal frequency appears across R26. Capacitor C22 is adjusted for lockup with the SYNC 1 or SYNC 2 input. The outputs (pins 12 and 13) are fed to sawtooth generator circuits for vertical and horizontal frequencies, respectively.

The keying circuits are shown in Fig. 5. There are four circuits—two for horizontal and two for vertical. Horizontal square-wave pulses at the junction of C25 and C26 are differentiated by C25 and R28. Therefore, Q1 is momentarily forward biased during sync intervals, and C33 is thus discharged through R29. When Q1 is cut off, C33 charges toward +5 volts through R30 until discharging again at the next sync pulse. Q2 and R31 form an emitter follower to interface the waveform, which is a sawtooth of about 1–2 volts at the horizontal frequency, to HORIZONTAL PATTERN SELECT switch, S1.

Vertical sync pulses (very short and negative-going) are directly integrated by R60 and C42, and D1 provides a discharge path. Emitter-follower Q6 and R61 feed S2, the VERTICAL PATTERN SELECT switch.

The triangle waves needed to produce keying waveforms are obtained from PLL circuits IC6, IC7, and IC8 for horizontal, and IC9, IC10, and IC11 for vertical. Only the horizontal circuitry will be discussed, as the two are similar except for component values, and their operation is identical.

Horizontal sync is fed through C26 to an LM565 PLL, which is biased by R32 and R33, and supply bypassed by C27 and C30 for the ±5V lines. C28 is a loop filter capacitor and C29 suppresses spurious responses. The VCO frequency at pin 8 is nominally 126 kHz (480 Hz for the vertical circuit). It is set by R34, R35, and C31. The VCO output at pin 4 of IC6 is fed to the pin-8 input of IC7, a 74C93 four-stage counter. Only three stages

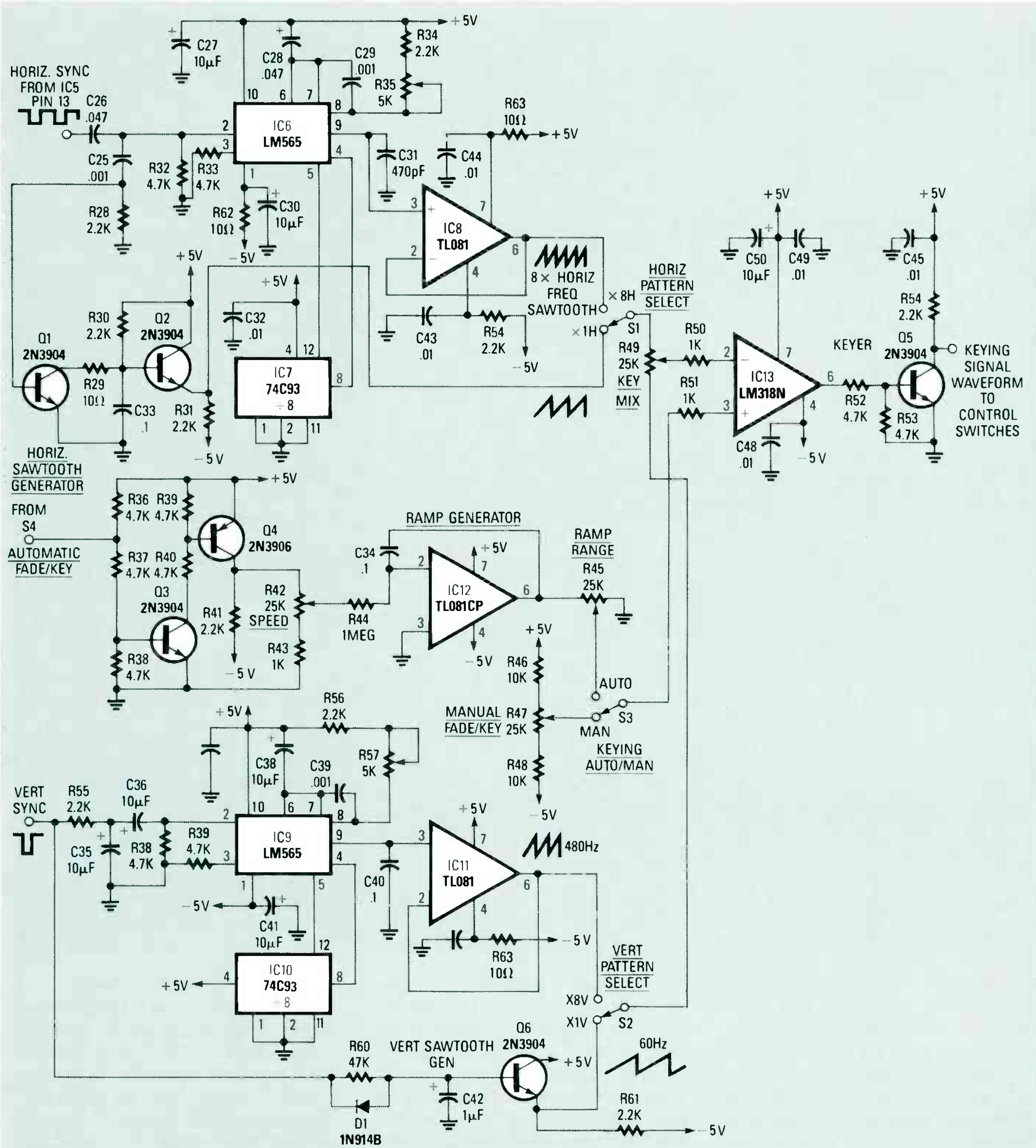


FIG. 5—THERE ARE FOUR KEYING CIRCUITS; two for horizontal and two for vertical.

are used to get a divide-by-8. The divide-by-8 output (IC7 pin 12) is fed back to IC6 pin 5, the phase detector input. Therefore, under lock conditions, the VCO frequency at pin 9 will be 126 kHz (8 × 15.74) and will be a triangle wave. IC8 is a buffer amplifier and delivers the triangle wave to S1.

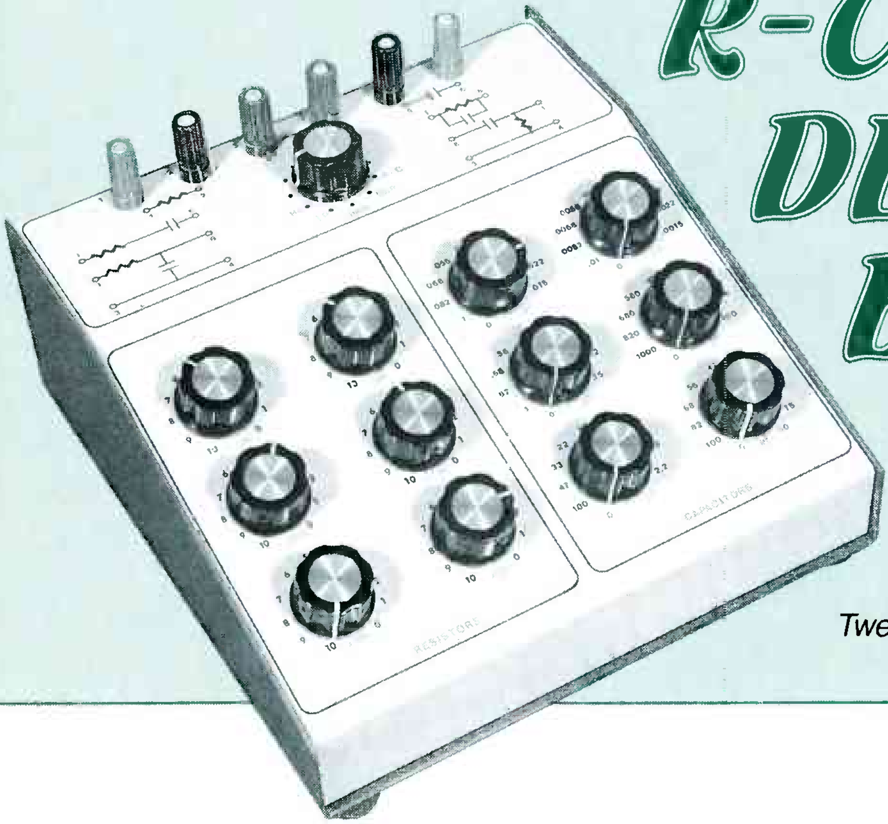
Potentiometer R49 is a mixer control that taps any combination of two out of the four available waveforms (V, 8V, H, and 8H). The resultant proportion can be varied to achieve various key patterns. The resulting waveforms are fed to comparator IC13 via R50.

IC13 is biased to a threshold by a DC voltage from S3 and voltage divider R46–RR48, or by a slowly varying DC voltage from pin 6 of IC12, as selected by S3. The output of IC13 feeds Q5 via R52 and R53. The output Q5 is a square wave whose duty cycle depends on the signals for S3 and R49. It is used to drive the keying switches in the video mixer circuit.

We'll continue next month with further descriptions of the keying circuits. Then we'll move on to construction details and present printed-circuit patterns, troubleshooting information, and more. **R-E**

BUILD THIS

R-C DECADE BOX



Tweak your circuits to perfection using our RC decade box.

MICHAEL A. LASHANSKY

IF YOU DESIGN YOUR OWN PROJECTS, you've probably waded through a sea of resistors and capacitors, looking for one that makes a circuit work; if not, you're lucky. Many professionals use resistor or capacitor decade boxes instead. Suppose the problem is an op-amp feedback resistor, but you're not sure. You can substitute the decade box into the circuit. By setting different values, you can monitor performance for the right value. Most resistor versions cost about $100, and capacitive versions about $200. Ours costs a fraction of that, and can either replace resistors or capacitors, or let you create a series or parallel RC network.

Resistor substitution

Figure 1 shows the decade box schematic. Note that rotary switches S1–S6 are in series, with the pole of each connected to the first position of the next. As they're rotated over positions 0–10, an additional resistor goes in series. At position 10, the total is the sum of all resistors connected, and zero at position 0. Each switch is an increasing power of 10, hence the term "decade box". So, S1–S6 cover 100 ohms (ten 10-ohm resistors), 1K (ten 100-ohm resistors), 10K, 100K, 1 Megohms, and 10 Megohms; a total of 11.1111 Megohms.

Any value can be selected from 10 ohms to 11.1111 Megohms, with a minimum step of 10 ohms. If you'd like to have 1-ohm steps, use 1-ohm resistors for S1, 10-ohm resistors for S2, 100-ohm resistors for S3, etc., up to 100K resistors for S6, for a total of 1.11111 Megohms in 1-ohm increments. All resistors must be 1% tolerance, and fuse F1 provides current protection. The worst case in terms of power dissipation occurs with a single ¼-watt 10-ohm resistor, shown in Fig. 2. If more than one resistor is used, power-handling capability increases by 250 mW times the number of series resistors, so five ¼-watt versions will handle 1.25 watts.

Capacitor substitution

The capacitor section of the RC decade box connects all selected capacitors in parallel, since capacitors in parallel add in value. The ranges of switches S7–S12 decrease in order of magnitude by a factor of 10, as the switch number increases; the total range is 100 μF–10 pF. An open terminal on each switch (position 0) provides a way to eliminate the capacitor for that switch from the parallel combination, so that a parallel combination of up to six capacitors can be selected.

Suppose that an LC tank oscillator has a known resonant frequency with a 0.022 μF capacitor in place. Since the resonant frequency of an LC tank is: $f = 1/2\pi\sqrt{LC}$, then f is inversely proportional to the square root of both L and C. If you set S9 to 0.022 μF and turn S10 to 0.0015 μF, the total capacitance is 0.0235 μF, which isn't a sufficient difference to cause a change in frequency. Turning S10 to 0.0022 μF gives a total capacitance of 0.0242 μF, which is sufficient to decreases the oscillator frequency.

Thus, the upper capacitance value the oscillator can tolerate *and which is within the resolution of the decade box to provide* is 0.0235 μF, 5% above 0.022 μF. To find the lower capacitance limit, set S9 to the 0.015

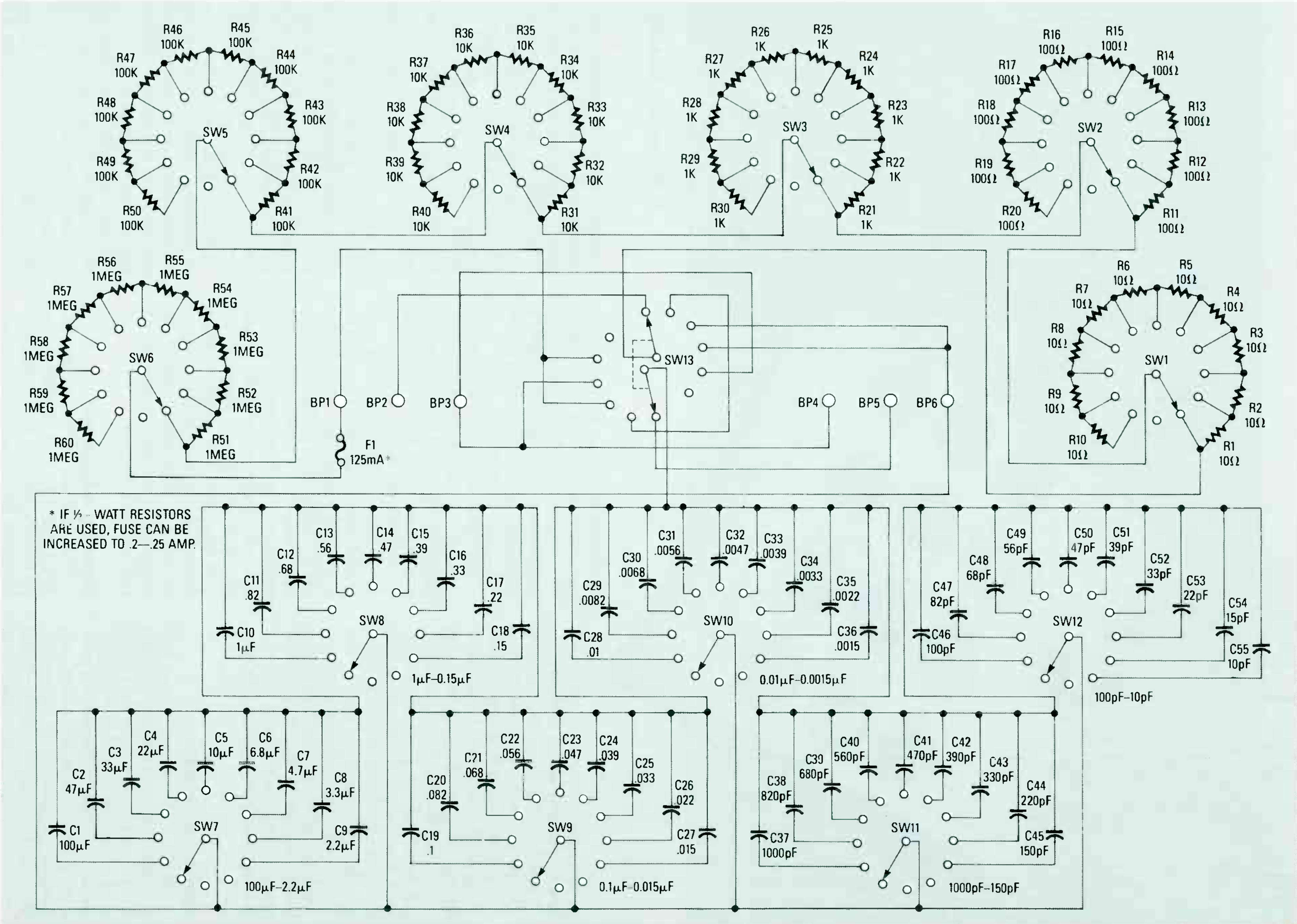


FIG. 1—THE CENTER TERMINAL OF A ROTARY SWITCH is called the pole, and the outside pins are called terminals or positions. The box uses *S*ingle-*P*ole 12-*P*osition (SP12P) rotary switches.

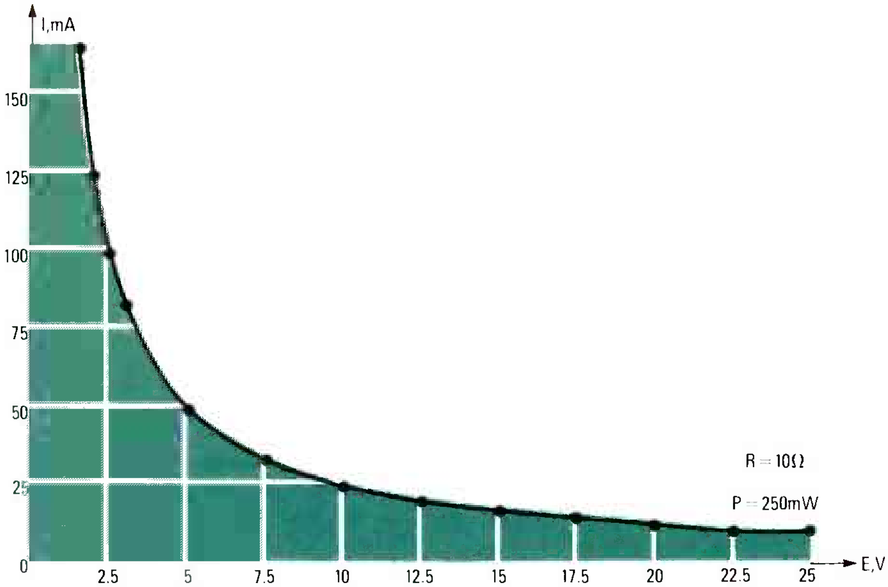


FIG. 2—CURRENT VS VOLTAGE CURVE for ¼-watt resistor dissipating 250 mW.

μF, and decrease S10 now, instead of increasing it as before. Individual capacitor tolerances determine the accuracy of the capacitive section, just like for the resistive section. The prototype capacitors were selected using a capacitance meter; use only 5–10% tolerance or better.

If you can't find a specific value, combine two or three capacitors in parallel until you get close enough to the right value. You should stay away from ceramic disks. Many catalogs list ceramic disks at 10% tolerance, which isn't really bad, or even 20% or +80%– – 20% of rated value. If you don't use a capacitance meter, you'll never be sure you're using the right values. The best are silver mica, polypropelyne, metallized polyester, or military ceramic; all have 5% tolerance, and some 2% or better.

Finding 2.2–100 μF nonpolarized electrolytics can be somewhat difficult. Since you may not be able to guarantee that one terminal on the decade box will always be positive and the other always negative, you need to use them in order to prevent the possibility of damage. If you can't find them, make your own from polarized versions; Fig. 3 shows how. The diodes you use depend on the power you want the decade box to be able to handle; for small-signal, you should use something like a 1N4148; for higher power, you should use a 1N4001. Electrolytics have poor tolerances, 50% variation being common, so be careful. Those used in the prototype were within 10%.

Filter networks

In addition to variable resistance or capacitance values, our decade box can configure RC networks using S13, as in shown Fig. 4. The listing of which terminals correspond to what function appears in Table 1. The different filter functions are as follows:

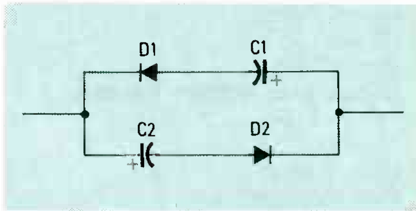


FIG. 3—CREATE A NONPOLARIZED capacitor from two polarized types, using 1N4148 diodes for small-signal purposes, and 1N4001 rectifiers for higher power.

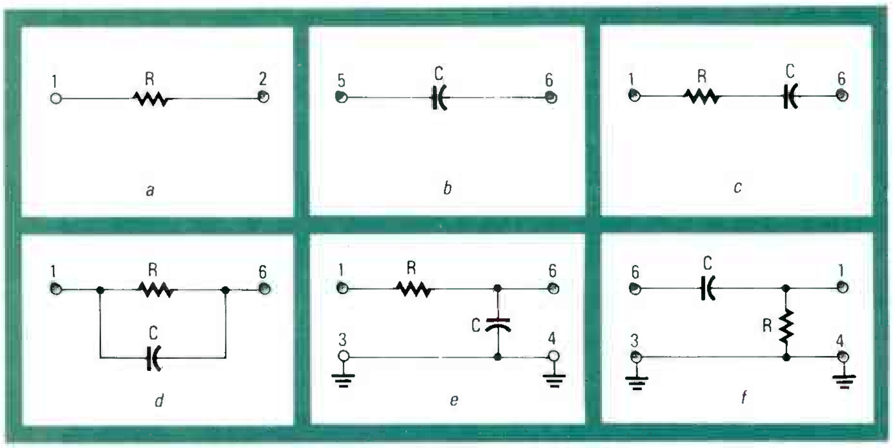


FIG. 4—THE VARIOUS CONFIGURATIONS are set using S13: *(a)* resistor only and *(b)* capacitor only (both in position R/C); *(c)* series RC (position SER); *(d)* parallel RC (position PAR); *(e) Low-Pass Filter* (position LPF); and *(f) High-Pass Filter* (position HPF). The terminal numbers listed are those of binding-posts BP1–BP6.

TABLE 1—DECABOX TERMINAL CONNECTIONS

Configuration	S13 Position	IN/GND	OUT/GND
Resistance	R/C	IN: BP1	OUT: BP2
Capacitance	R/C	IN: BP5	OUT: BP6
Series RC	SER	IN: BP1	OUT: BP6
Parallel RC	PAR	IN: BP1	OUT: BP6
Low Pass Filter (Integrator)	LPF	IN: BP1 GND: BP3	OUT: BP6 GND: BP4
High Pass Filter (Differentiator)	HPF	IN: BP6 GND: BP3	OUT: BP1 GND: BP4

- Position R/C (Fig. 4-*a*) is pure resistance or capacitance mode. The resistance is between binding-posts BP1 and BP2, the capacitance between binding-posts 5 and 6.
- Position SER (Fig. 4-*b*) selects a series RC network between BP1 and BP6.
- Position PAR (Fig. 4-*c*) selects a parallel RC network between BP1 and BP6.

PARTS LIST

All resistors are ¼-watt, 1%.
R1–R10—10 ohm
R11–R20—100 ohm
R21–R30—1000 ohm
R31–R40—10,000 ohm
R41–R50—100,000 ohm
R51–R60—1 megohms
Capacitors, nonpolarized electrolytics, 10%.
C1—100 μF
C2—47 μF
C3—33 μF
C4—22 μF
C5—10 μF
C6—6.8 μF
C7—4.7 μF
C8—3.3 μF
C9—2.2 μF
Capacitors; military ceramic, 5%
C10—1 μF
C11—0.82 μF
C12—0.68 μF
C13—0.56 μF
C14—0.47 μF
C15—0.39 μF
C16—0.33 μF
C17—0.22 μF
C18—0.15 μF
C19—0.1 μF
C20—0.082 μF
C21—0.068 μF
C22—0.056 μF
C23—0.047 μF
C24—0.039 μF
C25—0.033 μF
C26—0.022 μF
C27—0.015 μF
C28—0.01 μF
C29—0.0082 μF
C30—0.0068 μF
C31—0.0056 μF
C32—0.0047 μF
C33—0.0039 μF
C34—0.0033 μF
C35—0.0022 μF
C36—0.0015 μF
C37—1000 pF
C38—820 pF
C39—680 pF
C40—560 pF
C41—470 pF
C42—390 pF
C43—330 pF
C44—220 pF
C45—150 pF
C46—100 pF
C47—82 pF
C48—68 pF
C49—56 pF
C50—47 pF
C51—39 pF
C52—33 pF
C53—22 pF
C54—15 pF
C55—10 pF
Other components:
S1-S12—SP12P rotary switch, Radio Shack 275-1385
S13—2P6P rotary switch, Radio Shack 275-1386
BP1–BP6—nylon binding posts, Radio Shack 274-662
F1—125 mA fuse
Miscellaneous: Panel-mount fuse holder (Radio Shack 270-362), undrilled case (GC Electronics B-00210BG-BR), knobs (Radio Shack 274-416), 20–22-gauge solid hookup wire.
Notes: A complete kit of parts with all resistors, capacitors, switches, binding posts, fuse holder, hookup wire, case, and knobs is available from Tristat Electronics, 66A Brockington Cres, Nepean, Ontario Canada, K2C 5L1. Please specify the range of resistors and the wattage rating desired, whether ¼-, ½-, or 1-watt versions. Kits are $110.00 with ¼-watt resistors, $120.00 with ½-watt resistors, and $130.00 with 1-watt resistors, with an additional $7.00 sor shipping/handling. US funds, please.

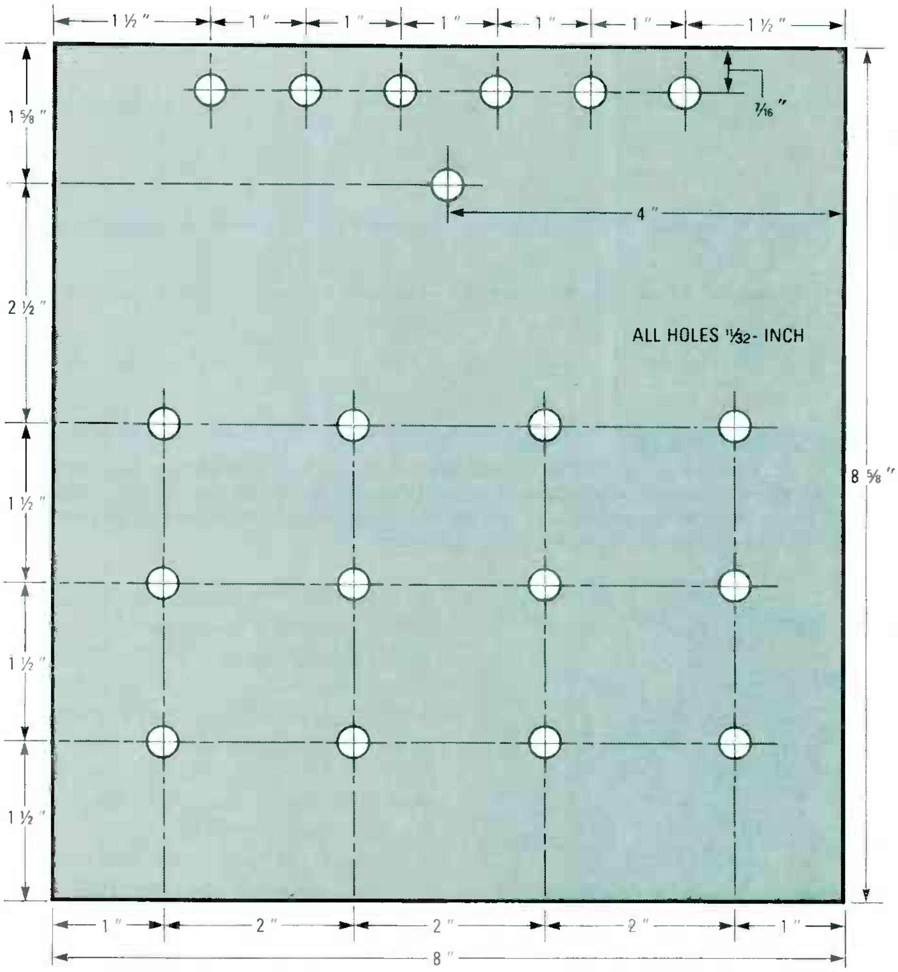


FIG. 5—WHEN YOU DRILL THESE HOLES, make sure the drill bit dosen't wander or the holes won't perfectly line up.

- Position LPF (Fig. 4-*d*) selects an RC *Low-Pass Filter* (LPF) or integrator, with input between BP1 (signal) and BP3 (ground), and output between BP6 (signal) and BP4 (ground).
- Position HPF (Fig. 4-*e*) creates an RC *High-Pass Filter* (HPF) or differentiator, with input between BP6 (signal) and BP3 (ground), and output between BP1 (signal) and BP4 (ground).

Construction

Keep wiring and component leads as short as possible. Long wires only

continued on page 79

THERE IS NOTHING MORE FRUSTRATING than not knowing where you are going. Consider ancient mariners, nervously navigating mysterious waters, unsure of what lay ahead in their travels. They soon learned to read the heavens and were eventually assisted by the mysterious powers of the navigational compass. Now consider the modern mobile robot, unsure of where it is going, anxiously prodding with tactile sensors and acoustic ranging equipment. It, too, is a little relieved by the information contained in its compass system. All of us have probably experienced the utility of a delicately balanced magnetic needle, carefully suspended on a cork floating in water—a most typical compass experiment from our grammar school days.

Of course modern technology has overshadowed our first experience with the compass. The compass design met a major milestone when the gyro-stabilized remote-indicating compass was introduced during World War II. Suddenly, navigation was automated, freeing the pilot from routine maneuvering. But modern technology has further improved on that massive electro-mechanical device, and now there are new, affordable alternatives for your next robotic project.

We introduce our Digi-Compass project. Actually it's a Radio Shack electronic flux-gate compass, intended for automobile use, with added circuitry that provides it with an output that can be fed directly into a personal computer. That makes it suitable for applications such as a computer-controlled model airplane, an automobile navigation assistant, or a video camera that intelligently films your journey.

Magnetohydrodynamics

The iron-nickel core of our planet generates a weak magnetic field. The phenomenon is due to a large moving and highly conductive liquid mass in Earth's core. The study of magnetohydrodynamics (MHD) suggests that by applying an electrical current under those conditions, a magnetic

DIGI-COMPASS

Is your house rotating...what about your computer?

THOMAS E. BLACK

field is produced (conversely, applying a magnetic field will produce an electrical current). The magnetic field is what causes compasses to point North.

It should be noted that magnetic North is somewhat different than true North (due to what's called magnetic declination), and it may even wander over time. It is also dependent on your geographical location. You can determine the difference between magnetic North and true North by consulting a *US Geological Survey* (USGS) topographical map. True declination is computed as:

(Map-indicated declination + (annual drift rate × (current date − mappublish date)))

There is also a magnetic inclination, which is the vertical component of Earth's magnetic field. Compass accuracy can be severely affected by its horizontal position, so it is important to keep your compass as level as possible.

Flux-gate magnetometer

There are a number of different methods used in modern solid-state compasses, but one of the most practical is the *flux-gate magnetometer*. Although the difficulties in building such a device have eliminated by integrating an off-the-shelf flux-gate automotive compass into the Digi-Compass, we will discuss the theory behind the device.

Many magnetic materials exhibit linear magnetization up to a certain flux level. At that point they saturate and lose their magnetic properties.

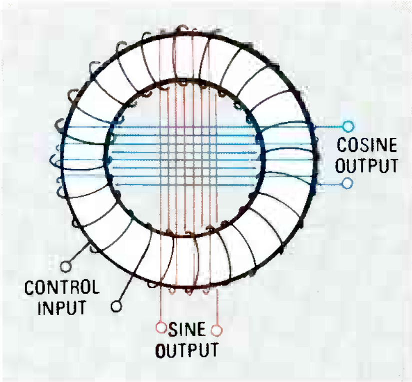


FIG. 1—A TYPICAL FLUX-GATE magnetometer is constructed by wrapping control, sine, and cosine windings on a toroidial core.

Unsaturated magnetic material will pull in magnetic flux lines, whereas saturated material will not (it completely ignores magnetic fields). So, if you gate Earth's magnetic fields into and out of saturation, they will alternately be concentrated and ignored. If you place a sense winding near your magnetic material, you can measure the strength of Earth's fields entering or leaving the material. The magnitude of the signal is proportional to the Earth's field strength along the axis that has been sensed.

As shown in Fig. 1, a typical flux-gate magnetometer is constructed by carefully wrapping *control*, *sine*, and *cosine* windings on a *toroidial* core (a donut-shaped core made of iron particles). The sine and cosine windings give us quadrature outputs, which are analog outputs that are separated by 90 degrees. The toroidial core must be carefully chosen for the proper "square" saturation curve. The combination of materials and winding direction prevent the drive current that is induced into the saturation-control winding from being picked up by the sense windings. External circuitry also protects against that condition, which would cause measurement errors. Extra windings and circuitry can be added to minimize magnetic inclination—bulky gyro mechanisms contain a similar feature.

The two quadrature signals pick up magnetic pulses that are related to the sine and cosine of the surrounding magnetic fields. External circuitry switches the control winding on and off at a low frequency, and the resulting ratios of the integrated sine and cosine output voltages provide the data necessary to interpret direction.

Inside the flux-gate compass, the sine and cosine voltage outputs are used to steer an *air-core resolver* (see Fig. 2). The resolver consists of a pointer and magnet, both attached to a freely rotating axle. Surrounding the magnet are two coils oriented at right angles with one another. The magnet will align itself with the vector sum of the two magnetic fields generated by the coils, which is a direct product of the currents applied to them. Therefore, by varying both the polarity and magnitude of the coil voltages, the axle assembly can be made to rotate a full 360 degrees.

The compass was intended to be mounted in a environment with some vibration (car, boat, etc.) to aid the movement, as it tends to stick. While sitting on your workbench, the compass may have to be tapped occasionally while moving the sensor. Fortunately, our digital interface ignores the position of the electro-mechanical movement, so it does not suffer from that mechanical problem.

Digi-compass interface

Because the Digi-Compass must have as universal a computer interface as possible, it is designed to be used with an IBM PC or compatible, and communication to the compass occurs through the standard LPT1, LPT2, or LPT3 printer ports. The software is provided as a learning tool, and it would not be difficult to adapt the Digi-Compass to any computer that has four available I/O lines. The two programs available for the Digi-Compass provide both a graphic display of compass direction as well

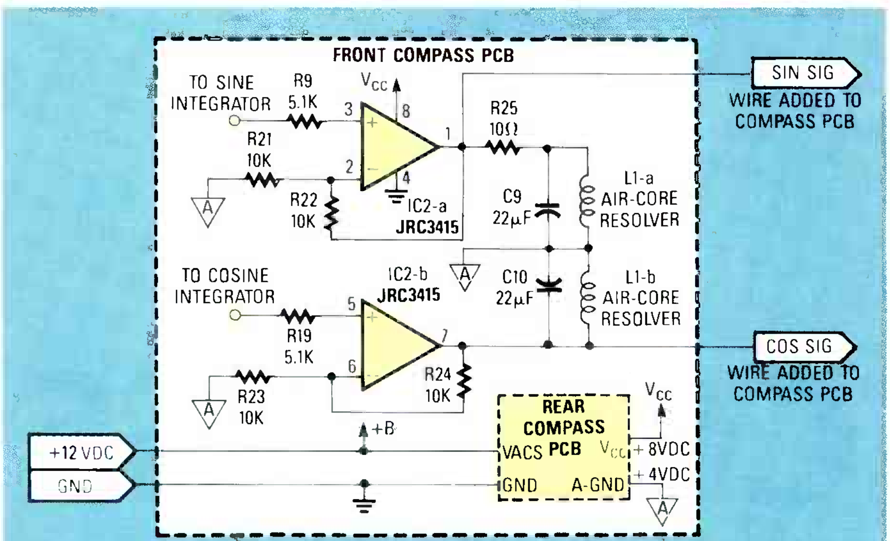


FIG. 2—INSIDE THE FLUX-GATE COMPASS, the sine and cosine voltage outputs are used to steer an air-core resolver.

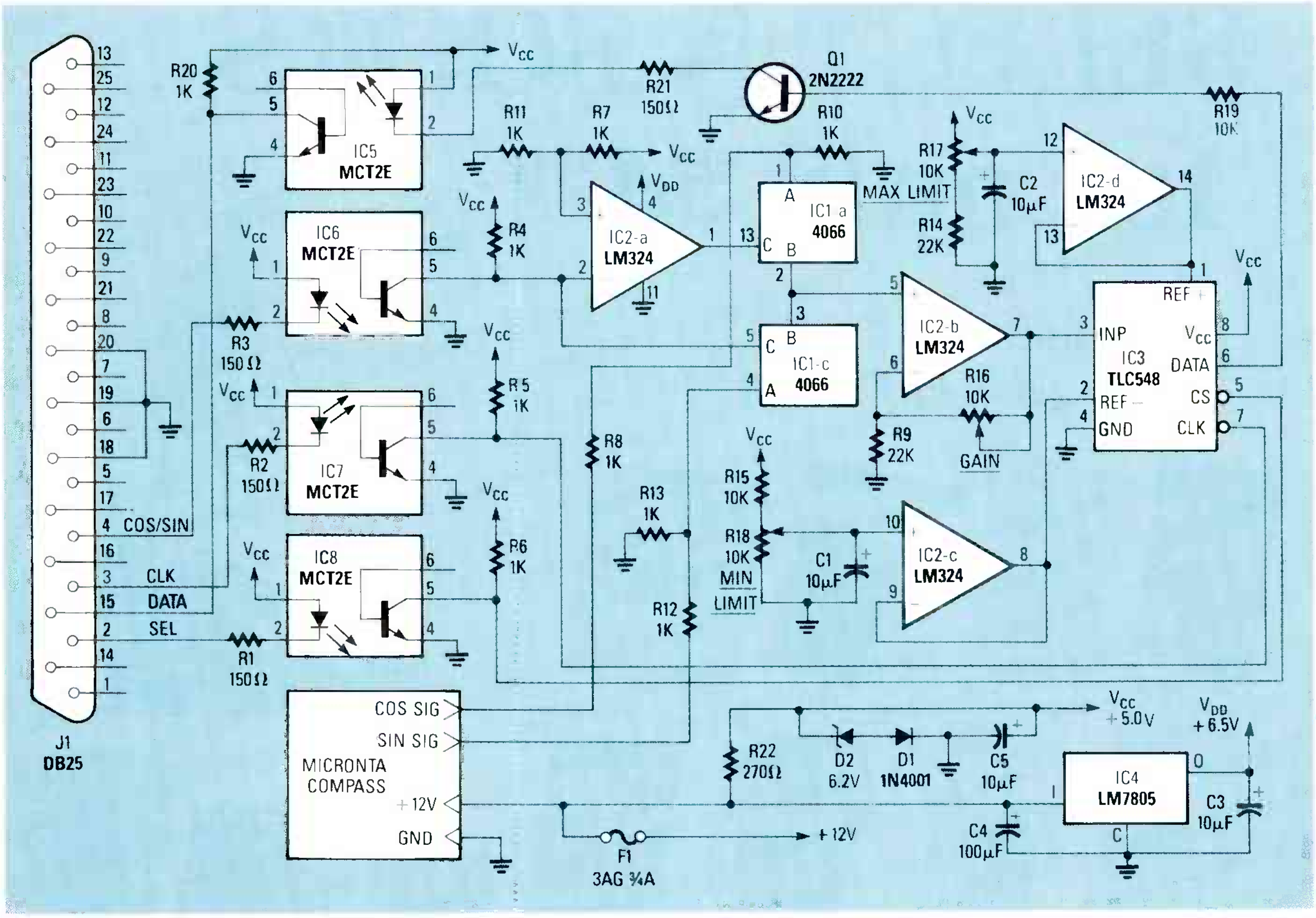


FIG. 3—SCHEMATIC OF THE DIGITAL-COMPASS INTERFACE. Two signals taken from the compass (cos and SIN) are use to generate direction-related data, which is then fed into a computer.

as a simple text-only display of directional degrees (from 0 to 360).

The interface circuitry used to monitor the compass's output is rather simple. All that is required is an *A*nalog-to-*D*igital *C*onverter (ADC) for each compass output. To keep the cost down, only one eight-bit ADC is used, and it is multiplexed between the two outputs. The eight-bit resolution of the ADC is adequate for the chosen off-the-shelf compass, and it provides more than two degrees of resolution. In order to use a standard IBM-compatible printer port with its limited I/O lines, a serial ADC that needs only four I/O lines was used (twice as many would be required on a typical eight-bit ADC).

As shown by the interface schematic in Fig. 3, the printer port is connected to the Digi-Compass interface circuitry by four opto-couplers. They provide some isolation between the computer and the compass but, most significantly, provide a high degree of noise immunity on long cable distances, which can typically exceed 25 feet.

The COS/SIN control line is used to switch between the sine (Y) and the cosine (X) compass output voltages. When the control line is high, the cosine voltages are available to the ADC, and when it is low the sine voltages are available.

With COS/SIN high (cosine mode), the analog switch IC1-c is on and IC1-a is off. Op-amp IC2-a is a used as an inverter—a somewhat abstract use for the device. The cosine voltage from the compass is attenuated by R8 and R10 before being passed by IC1-a. It is important to limit the compass voltages to less than 5-volts DC, or linearity will suffer. When COS/SIN is low (sine mode), IC1-c is off and IC1-a is on, and attenuation is provided by R12 and R13.

Gain control over the switched signal is provided by IC2-b before it is passed to IC3 (the TLC548 ADC), and it sets the minimum voltage applied to IC3. However, IC3 could be damaged if the analog input voltage exceeds $V_{CC}+0.3$ volts DC, but by using 6.8-volts DC to power the op-amp we have avoided the condition.

The LM324 op-amp's output can swing only to $V_{DD}-1.5$-volts DC, so as long as V_{DD} remains at or below 6.8 volts, no trouble will arise. The LM324 output can also go as low as 0 volts, a must for extending the dynamic range of the input. Be forewarned; other op-amps will behave differently, so be sure to observe that requirement.

As mentioned before, the ADC is a serial device. That means that the data, which is in single-bit form, is presented to the host computer over a series of host-provided clock cycles. It is up to the host to repack the data bits into byte form, a process that is performed in software. There are considerable hardware advantages to using that type of device, but such ADC's are not useful in high-speed applications due to the overhead in handling their data output.

The ADC (IC3) requires two reference voltages, a clock, and a select line. The two reference-voltage inputs set the analog input thresholds that result in minimum and maximum digital outputs (0 to 255 decimal). As we will see during calibration, R17 and R18 are adjusted to set those limits.

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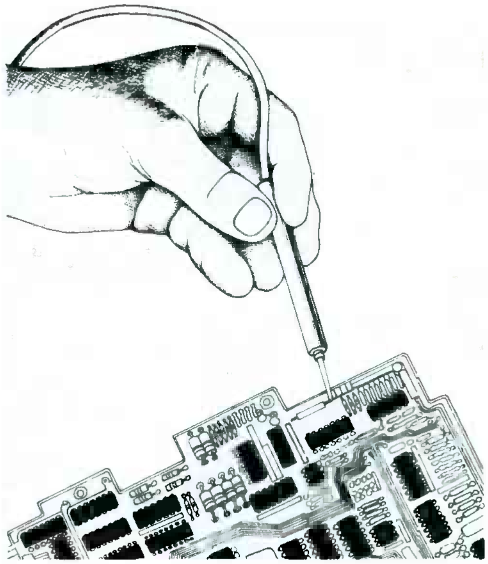

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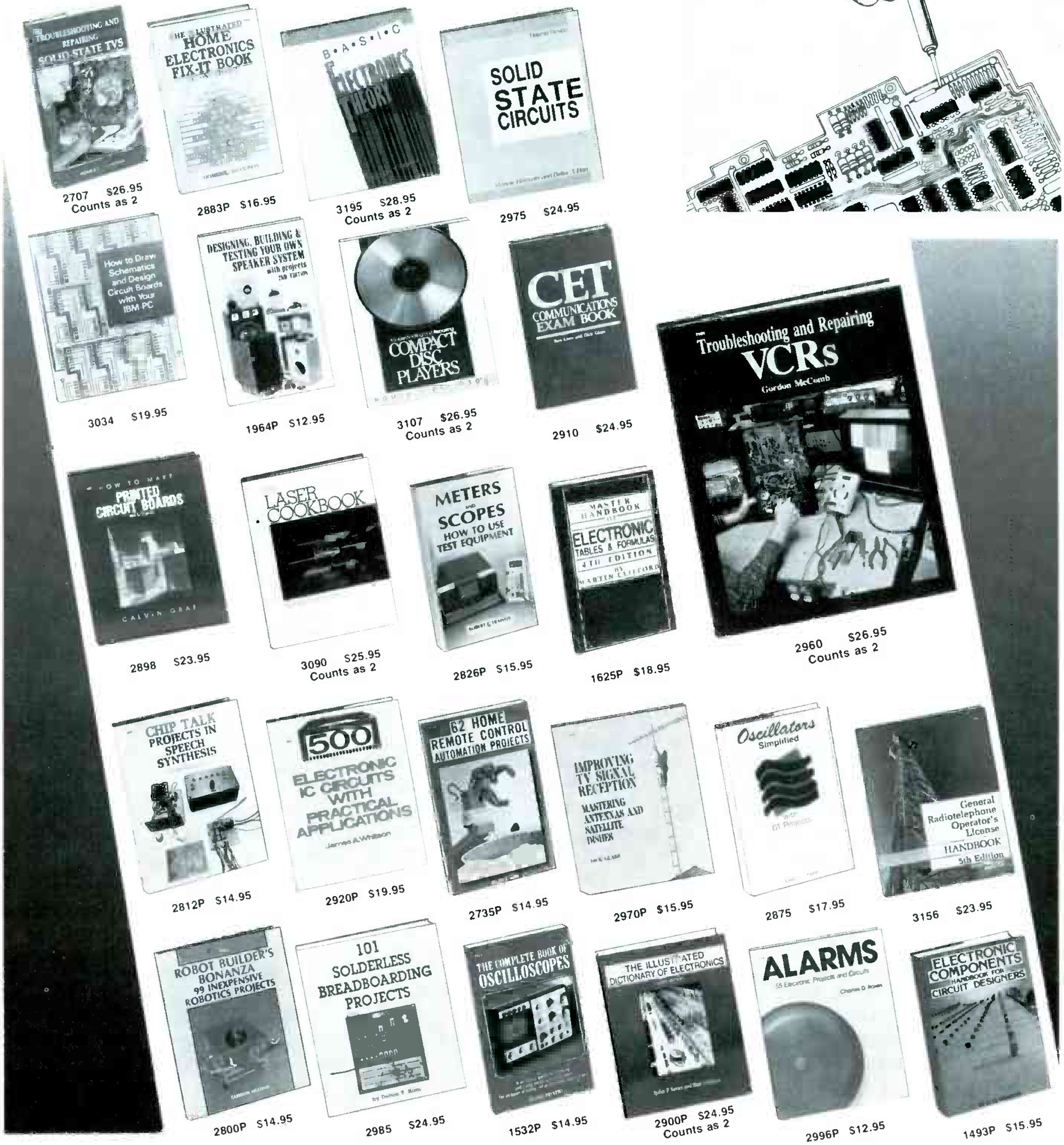

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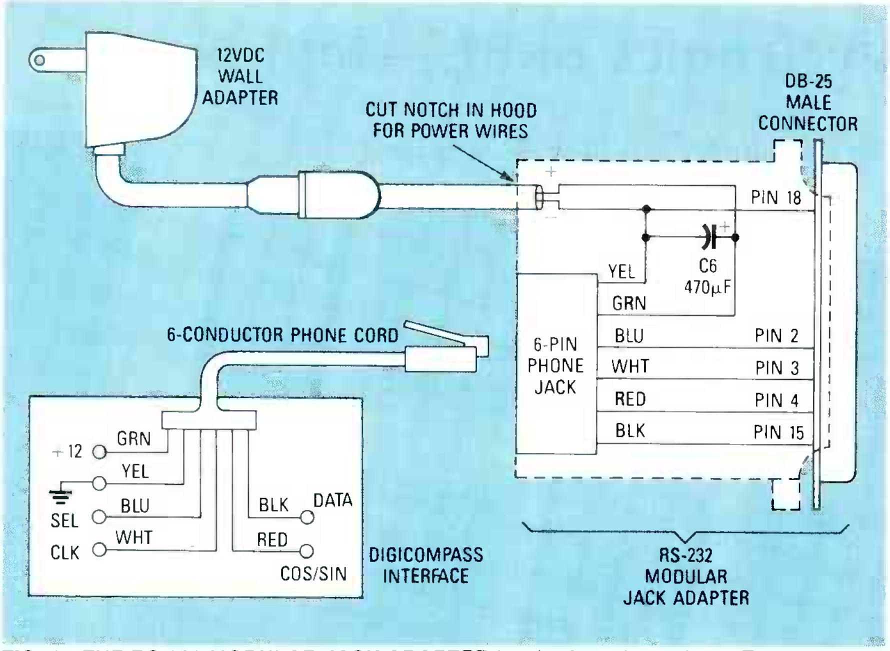

FIG. 4—THE RS-232 MODULAR JACK ADAPTER is wired as shown here. The capacitor will fit inside of the adapter.

The host then scales the digital numbers into meaningful units such as "volts," but that doesn't involve the Digi-Compass.

Conversion of the input voltage is initiated when the ADC's active-low CS line (chip select) goes low. The ADC then waits for two rising edges and then one falling edge of the CLK line before recognizing the CS condition (the delay debounces the CS input).

The most-significant bit (D7) then appears on the ADC's DATA OUTPUT line. The next seven clock pulses shift out the remaining bits, highest to lowest. The computer controls the clock and select line through one of the LPT printer ports, as we mentioned previously.

It is important to note that the data shifted out represents the voltage that was latched during the previous conversion. On the fourth falling edge of the clock the ADC samples the input voltage, which is not available until the next acquisition. That is not a problem if you continuously access the ADC, but in an input multiplexing mode such as that used in the Digi-Compass, you must always read the ADC twice, throwing out the first measurement.

In ideal applications, the TLC548 can provide conversions in less than 25 microseconds. However, in this project, acquisition is deliberately much longer due to limited bandwidth of the opto-couplers.

Construction

The Digi-Compass interface is suitable for perfboard construction using point-to-point wiring techniques. The prototype is mounted in a plastic enclosure (metal could affect the flux-gate sensor), which is attached to the bottom of the compass and serves as a base. If you mount the interface separately from the compass, use shielded wiring and keep the cable as short as possible.

If you intend to operate the interface board more than ten feet from your computer, you should mount IC5 and R20 at the computer end, perhaps inside of the DB-25's housing. That may not be necessary, depending on the environment the cable will be in.

Be sure to use sockets on the IC's just in case you need to replace one later. The voltage regulator does not need a heatsink, and a 6.8-volt Zener diode can be used instead of the 6.2-volt Zener (D2) and 1N4001 diode (D1) combination shown. Just make sure that you use a 12-volt DC power supply that can deliver at least 750 mA.

Connecting the interface involves dismantling the compass. Inserting a coin or a masking-taped screwdriver blade into the left and right sides of the bezel's groove and carefully twisting will allow the bezel to pop off. Of course you have just violated the compass's warranty, so be sure that it works correctly before you dismantle it. Remember that you are on your own once you take the compass apart.

Once inside the compass, find the 8-pin DIP IC (IC2 in Fig. 2) on the bezel-mounted circuit board marked "JRC3415" or "NJM3415" (R23 is right next to it on the PC board). Pin 7 of that IC is the COS SIG output and pin 1 is the SIN SIG output. Solder a labeled 10-inch 26AWG wire to each pin, and trim as necessary.

Find the 3-pin power connector at the rear of the horizontal PC board. Solder a 22AWG wire for +12-volts DC and one for ground directly to the pins—+12 is the middle pin and ground is the one toward the center of the circuit board (ignore the outer unused pin). You can double check for +12 and ground, as well as continuity in the newly installed power wires by temporarily plugging in the compass's factory cigarette-lighter plug and verifying proper voltages. Now you can remove the cigarette-lighter plug and throw it in your junkbox.

Pass the four new wires out of the compass cabinet through one of the vents on the bottom. Re-assemble the compass, being careful not to crush any wires. Temporarily connect +12 volts to the new power wires, and ver-

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise specified.
R1–R3, R21—150 ohms
R4–R8, R10–R13, R20—1000 ohms
R9, R14—22,000 ohms
R15, R19—10,000 ohms
R22—270 ohms, 1/2 watt, 10%
R16–R18—10,000 ohms, 15-turn trimmer potentiometer
Capacitors
C1–C3, C5—10μF, 16 volts, Tantalum
C4—100μF, 35 volts, electrolytic
C6—470μF
Semiconductors
IC1—CD4066 quad switch
IC2—LM324 quad op-amp
IC3—TLC548 serial ADC
IC4—LM7805 5-volt regulator
IC5–IC8—MCT2E opto coupler
Q1—2N2222 NPN transistor
D1—1N4001 1-amp, 50-volt diode (see text)
D2—6.2-volt, 1-watt Zener diode (see text)
Other components
J1—DB25 modular-jack adapter
F1—¾-amp fuse
Miscellaneous: Plastic cabinet (prototype used 4 × 2 7/16 × 1 1/16 inches), 12 VDC 1A power supply, Micronta high-accuracy auto compass, wire, sockets, perfboard, etc.

ify that both the sine and cosine outputs vary from about 1.5–7.5 volts as you move the sensor in different directions. Do not allow the two outputs to touch each other, power, or ground, and don't be concerned if your compass doesn't quite reach the mentioned voltages; they may be within a volt or two.

The DB-25 connector used for the prototype is actually an *RS-232 modular jack adapter*; its a male DB-25 connector on one side, and a 6-pin phone jack on the other. The DB-25 side plugs into your computer, and a 6-pin phone cord plugs into the jack side; the other end of the phone cord is wired to the interface circuitry. The green wire is used for +12, the yellow wire is ground, and the other four are for COS/SIN, CLK, DATA, and SEL. The prototype's color coding is shown in Fig. 4, but it doesn't matter as long as you connect the proper points in the interface circuitry to the proper pins of the DB-25 connector. A photograph of the finished adapter is shown in Fig. 5. Don't forget to install the 470µF capacitor (C6) inside the adapter.

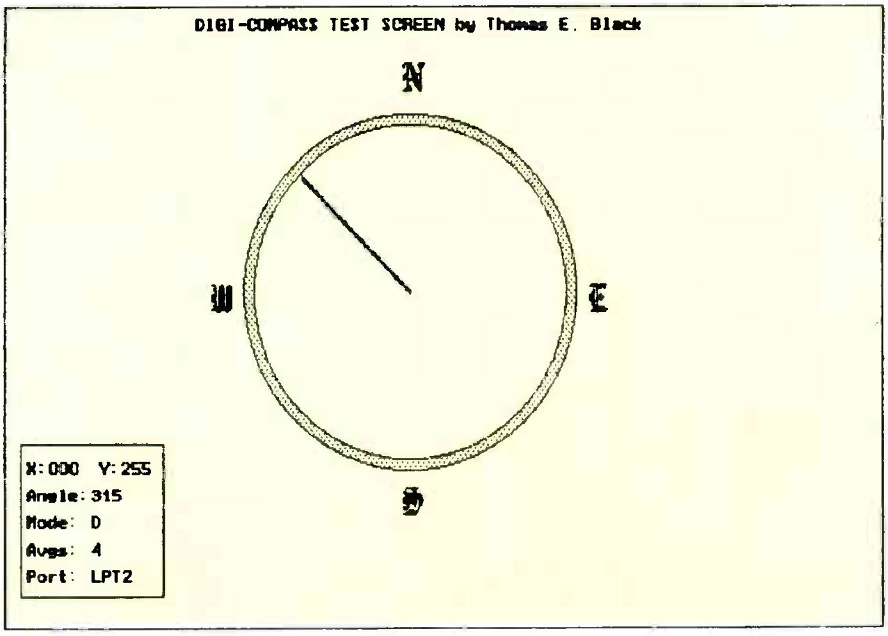

FIG. 6—THIS IS WHAT YOUR COMPUTER'S SCREEN will look like when operating the digital compass.

Software

Software is supplied in both compiled and ASCII text source code forms, and it is available for free as an archive file (COMPASS.ARC) on the RE-BBS (516) 293-2283. The source code should provide sufficient examples as to the methods used to access and convert the Digi-Compass data. Because of the graphics code in COMPASS.C, you may find the simpler TEXTCOMP.C source much easier to read. The two programs are meant to get you started in developing your own applications.

There is a graphics-based program and one that relies strictly on text output. As shown in Fig. 6, COMPASS.EXE produces a likeness of a handheld compass. The program requires an EGA graphics adapter and monitor, or a CGA adapter that can display the CGA high-resolution monochrome mode.

There are some clever features included in COMPASS.EXE. On startup, the program will attempt to automatically choose the printer port by exercising all of the BIOS configured LPT ports. If a properly operating compass is found, the respective printer port is selected. You can skip that feature by including "LPT1," "LPT2," or "LPT3" as the only argument to the program. Be sure to input a port name that is installed in your computer, or the program will not execute (appropriate error messages are echoed). Standard command-line syntax is: COMPASS LPTn, where "n" is the printer port desired (1, 2, or 3).

The data display in COMPASS.EXE provides current acquisition information. The X and Y values indicate the digitized cosine and sine values from the compass interface. The "angle" value is the number of degrees from North in the clockwise direction. It is interesting to note that North is both 0 and 360 compass degrees, depending on your heading.

The "mode" value shows when you are in the *D*igital, *A*nalog or *B*oth mode; it can be changed by pushing the "D," "A," or "B" keys. The digital mode is the default and it plots the compass needle using geometry based on the X and Y values. It shows compass direction in the form of a pivoting compass needle. The analog mode is capable of displaying both direction and magnitude of Earth's magnetic fields. While in the analog mode, if you rotate the flux-gate sensor off the horizontal plane you will see the compass needle length shrink and grow. The longer the needle length, the greater the magnetic field.

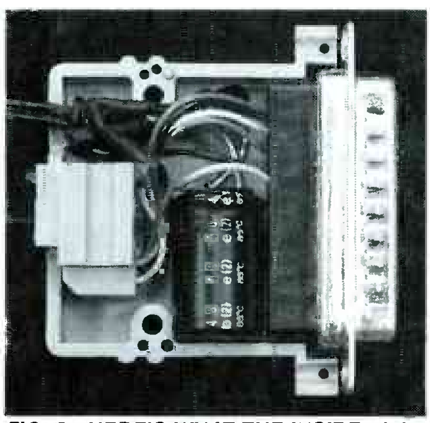

FIG. 5—HERE'S WHAT THE INSIDE of the adapter looks like.

There is considerable loss in accuracy while in the analog mode due to the software method in plotting the needle. The analog mode converts the X and Y values to Cartesian coordinates based on fixed center. The accuracy of the analog mode is only fair at best, but could be improved by optimizing the code. The angle value and the digital mode's compass needle are displayed with accuracy that exceeds the compass's electro-mechanical movement. You can display both the digital and analog needles at the same time while in the *B*oth mode.

The number of data acquisition averages can be changed by pushing the "" keys. When the average is at the minimum value of zero, the X, Y, and angle values will be somewhat unsteady. The values become increasingly more stable as you move to the maximum of thirty-one, but acquisition time will be very slow. The default of four is fine for most of the applications.

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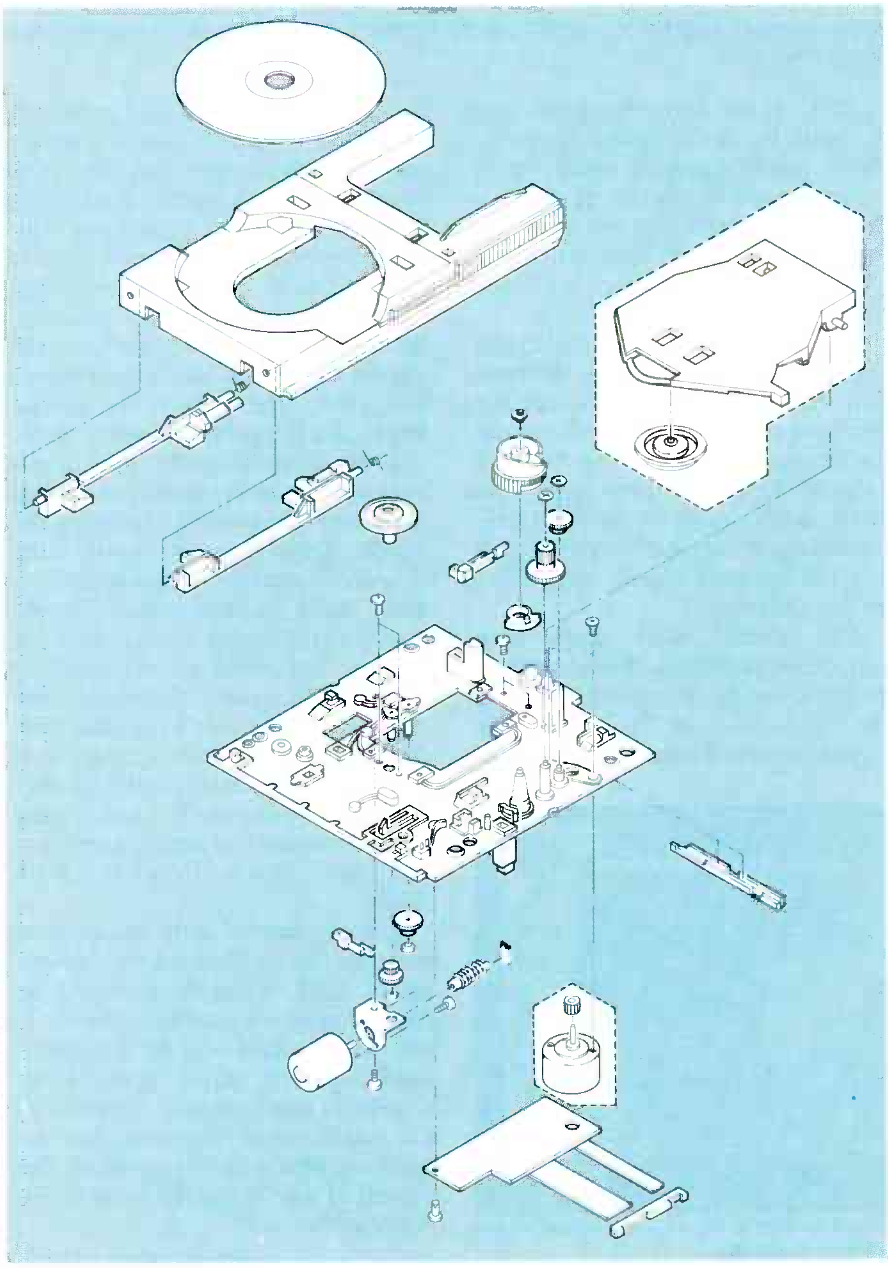
TECHNOLOGY

How To Repair CD PLAYERS

BRIAN PHELPS*

When servicing CD players, you need a good understanding of CD operation and basic troubleshooting ability.



THE CONTEST BETWEEN COMPACT DISK (CCD) players and phonographs is headed in the same direction as cassettes and 8-tracks. The quality, versatility, and simplicity of CD's make them ideal for audio. First introduced in 1983, CD growth has been comparable to that for VCR's, and all market indicators point to continued success. Lower prices and availability of disks has sparked a sales boom since 1985. With the large number in use, service shops need repair techniques. This article will examine CD basics, key stages to analyze, and test instruments.

CD basics

Discs are single-sided, store about 70 minutes of stereo audio, are played from the underside, and are read using laser pickups. Tracks begin near the disc center, and move outward as a program plays. The information is recorded as microscopic surface variations (pits and flats) representing *P*ulse *C*ode *M*odulation (PCM) audio, sync, and ID information. Audio is sampled at 44.1 kHz. Each sample undergoes 16-bit A/D conversion, giving a theoretical 98 dB dynamic range (most manufacturers claim 90–95 dB).

A CD player's laser pickup is never in physical contact with the disc, giving extreme accuracy, and no deterioration or mechanical noise as with records. The CD player carries separate stereo channels, but interlaced on a single track changing at fixed time intervals. The CD keeps step with those changes, and maintains high in-

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TABLE 1—SENCORE RECOMMENDED CD TEST EQUIPMENT

Type	Requirements	Sencore Gear	Tests
Dual Trace Scope	Bandwidth: DC-60 MHz Sensitivity: 50 mV	SC61 Waveform Analyzer	Clocks, Counters, D/A Converters, Audio, Power Supplies, Laser Diode, PLL's
Frequency Counter	Range: 250 MHz Sensitivity: 20 mV	FC71 Frequency Counter SC61 Waveform Analyzer	Clocks, PLL's, Oscillators
Audio Tester	Frequency: 0-15 kHz, variable Amplitude: 0-3 V	SG80 Stereo Generator VA62A Video Analyzer	For audio injection
Digital Voltmeter	Amplitude: 100 mV-1 kV DC Sensitivity: 1 mV Accuracy: .5%	DVM37, DVM65A Voltmeters	Power Supplies, Sled Drive, Resistance, Signal Amplitude
AC Leakage Tester	500 uA capability	PR578 "Powerite" Isolation Transformer	To test for AC line leakage to metal case
Audio Tester	Line level	PA81 Stereo Analyzer	To monitor quality and level of line outputs, and test audio stages
Variac	Isolation type, 0-140 V AC, variable with line monitor	PA57 "Powerite" Isolation Transformer	Power supply troubleshooting and providing isolation

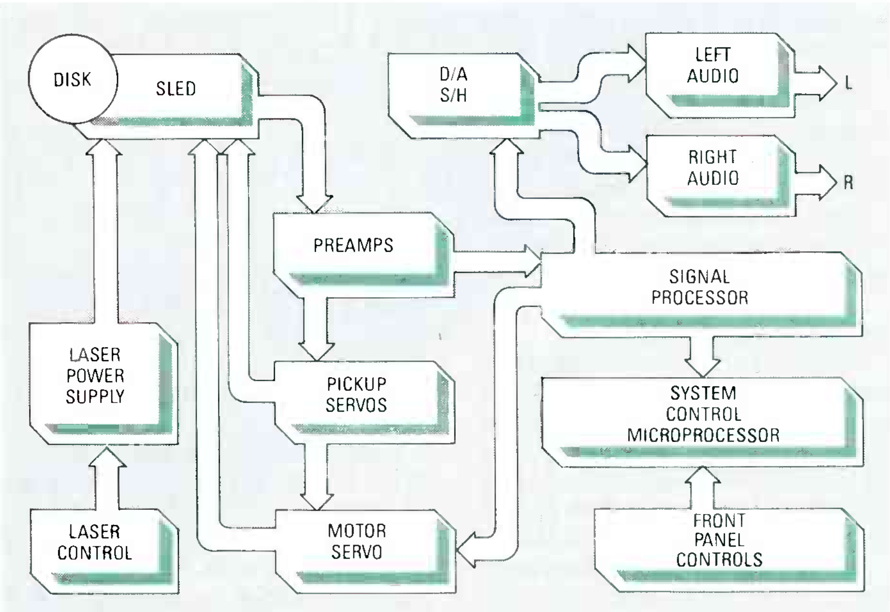


FIG. 1—USE A UNIVERSAL BLOCK DIAGRAM whenever troubleshooting, whether you're working on a CD player, VCR, or TV.

terchannel isolation above 90 dB. The optical pickup is focused on the disc surface by an objective lens, which is part of the pickup assembly.

As a disc is played, the beam follows the track by a servo-operated pickup motor. There are two basic pickup types; in one, the optics are mounted at the end of a rotating arm that moves from the center of the disc to the edge. In the other, a motor-driven slide or sled assembly is used. The output from the low-power laser diode is focused on the disc surface by the objective lens. Reflected light from the surface variations (low for pits, high for flats) passes through the optics into infrared photodiodes. The photodiode signal is what is then used to reproduce the original audio.

Tracking

Two error-signal sub-beams are produced by routing the laser through a glass diffraction grating ahead of and behind the main beam. After reflection from the disc, each is routed through the optics to photodetector diodes. The error signal from the two sub-beams is converted into an electrical signal and fed to an error-signal amplifier. If the disc tracking is precise, the error-signal amplifier output is zero. The slightest radial tracking error causes the input differential between the right and left error signals to produce an output, fed to the radial-tracking servo. That moves the object lens in order to correct the main-beam position.

Signal processing

Figure 1 shows a typical CD-player block diagram. The laser is applied to the disc optically, and reflected into photodiode detectors to produce audio, tracking, and focus signals. The

continued on page 82

BILATERAL SWITCHES

It looks like an IC, it's made out of semiconductor, but it works like a mechanical switch!

RAY MARSTON

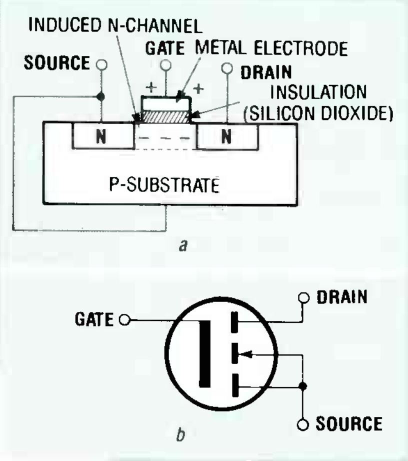


FIG. 1—IN *a*, AN N-CHANNEL E-MOSFET is shown. The channel must be enhanced with N-type charge carriers to turn the transistor on. The symbol for the E-MOSFET *(b)* shows broken lines between the source and drain, indicating that the transistor is normally off.

CMOS BILATERAL SWITCHES CAN BE REgarded as *S*ingle *P*ole *S*ingle *T*hrow (SPST) electronic switches. The toughest thing about bilateral switches is learning how and when to use them. And that's exactly what we're going to show you. Because, even though they function like mechanical switches, the differences between the two are many.

Conventional toggle switches have obvious limitations when it comes to high-speed switching. For example, the metal contacts within a switch tend to bounce for a millisecond or two before making a solid electrical connection, introducing glitches into digital circuits and pops into audio circuits. But don't throw out your mechanical switches just yet. That's because, even with all their problems, they're easy to use, readily available, and cheap.

On the other hand, a bilateral switch can be turned on and off several million times per second, they can pass both analog and digital signals in either direction, they can be controlled by digital-logic IC's, and they introduce no digital glitches or audio pops. When turned on, the CMOS switch behaves almost like a short-circuit (about 90–300 ohms); when turned off, it behaves almost like an open circuit (near-infinite impedance).

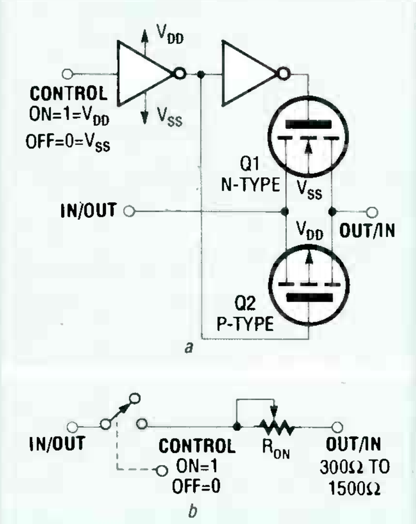


FIG. 2—CMOS BILATERAL SWITCH *(a)* imitates a mechanical on/off switch. When closed, the bilateral switch *(b)* has a series resistance of 300- to 1500-ohms.

Bilateral switches can be as simple as the 4016B and 4066B, which house four SPST switches, and as complex as the 4097B, which houses two single-pole eight-position switches (similar to an electronic SP8P rotary switch).

Enhancement MOSFET

Bilateral switches are integrated using *C*omplementary *M*etal-*O*xide *S*emiconductor (CMOS) technology. Figure 1-*a* shows an enhancement MOSFET (E-MOSFET), which is the type of transistor used in both CMOS digital IC's and bilateral switches.

In the N-channel *E*nhancement *M*etal-*O*xide *S*emiconductor *F*ield-*E*ffect *T*ransistor (E MOSFET), the substrate is made of P-type semiconductor with two N-type semiconductor wells; between the wells is the channel, and on top of the channel is a layer of glass (SiO_2–silicon dioxide) and a metal electrode; that's where the term "metal-oxide semiconductor" comes from. The metal electrode is called the gate, one well is called the source, and the other

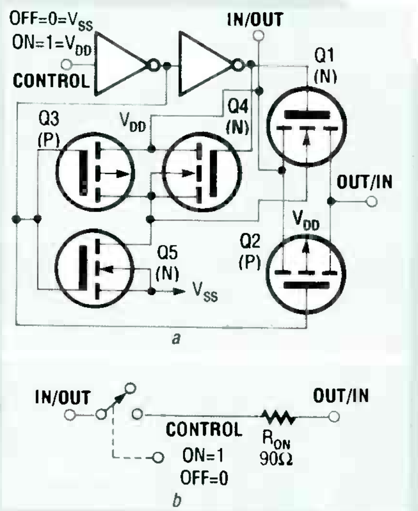


FIG. 3—IMPROVED CMOS BILATERAL switch *(a)* has a 90-ohm series resistance *(b)*.

is called the drain. Here's how it works.

E-MOSFET's are normally off devices. Electrons can *not* travel from the source to the drain because ordinarily there's no conducting channel between the wells. However, when a positive voltage is applied to the gate (with respect to the source), then a negative electrostatic field is induced into the channel (P substrate). That's because the metal gate and semiconductor act as a tiny capacitor with the silicon dioxide acting as a dielectric. The induced negative field increases the number of N-type minority-charge carriers in the P-substrate: essentially, turning a P-type semiconductor into an N-type semi-

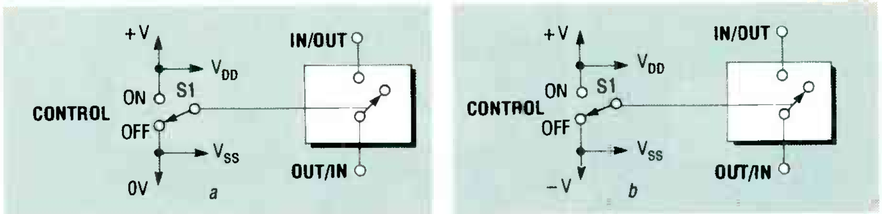


FIG. 4—TO CONTROL A BILATERAL SWITCH, use a single-polarity supply for digital signals *(a)*, and a split-polarity supply for analog signals *(b)*.

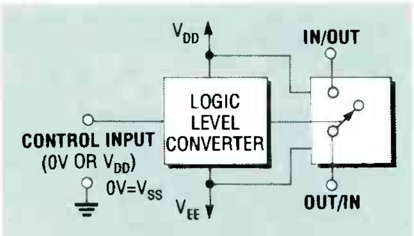


FIG. 5—SOME IC's FEATURE INTERNAL logic-level converters, so an analog switch is controllable via a single-ended input.

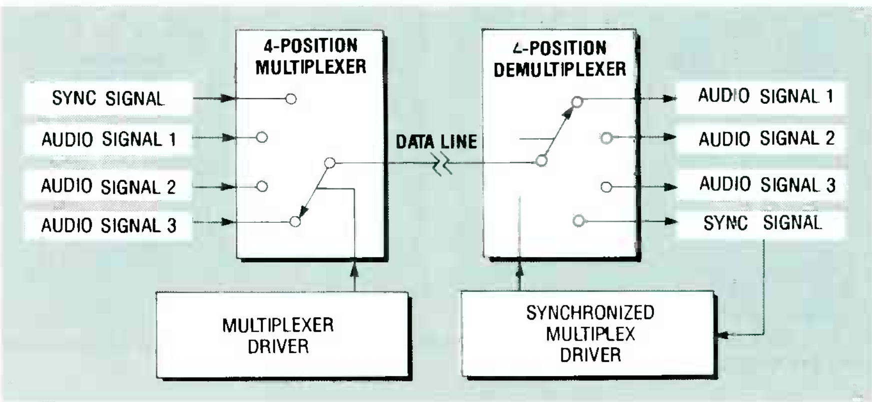


FIG. 6—A 4-POSITION MULTIPLEXER FEEDS three audio signals through a single data line. At the other end, a demultiplexer re-assigns the audio back into separate lines.

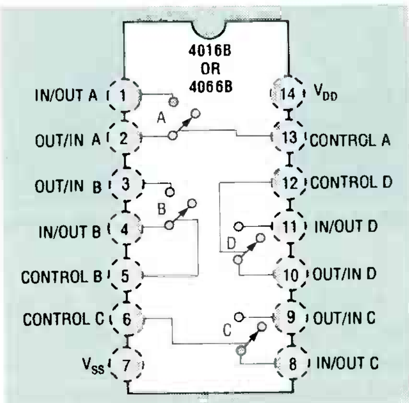


FIG. 7—THE 4016B AND 4066B each have four independent "SPST" switches.

conductor. Now electrons flow from the source to the drain through the induced channel.

In P-channel Enhancement MOSFET's, the substrate is made of N-type semiconductor material with two P-type semiconductor wells. When a negative voltage is applied to the gate (with respect to the source), a positive channel is induced between the source and drain, so the transistor turns on.

When P-channel and N-channel E-MOSFET transistors are connected back-to-back, they are said to be wired in inverse parallel or complementary pairs; hence the name CMOS.

Bilateral switches

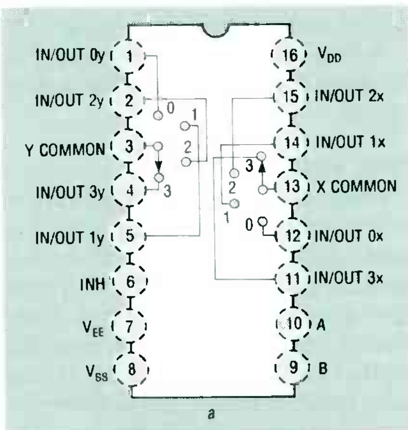
Figure 2-*a* shows the inside of a bilateral switch where an N-channel and P-channel MOSFET are wired in inverse parallel (drain-to-source and source-to-drain), and have their gates biased in anti-phase via a pair of inverters. When the control signal is at logic-level 0, the gate of Q2 is driven to V_{DD} and the gate of Q1 is driven to V_{SS}; under those conditions both MOSFET's are cut off, and an open circuit exists because the FET channels are not enhanced. When, on the other hand, the control signal is at logic level 1, the gate of Q2 is driven to V_{SS} and the gate of Q1 is driven to V_{DD}; under those conditions both MOSFET's are driven into saturation, and a near short-circuit exists because the FET channels are enhanced by the gate's electrostatic field.

Note that when Q1 and Q2 are saturated, signal currents can flow in either direction, provided that the signal voltages are within the V_{SS}-to-V_{DD} limits. The FET's source and drain can be used as either an input or output—thus the term bilateral (both directions) switch. In practical circuits, Q1 and Q2 exhibit a finite resistance (R_{ON}) when saturated, and the equivalent circuit in Fig. 2-*b* shows an R_{ON} that varies from 300 to as much as 1500 ohms; that resistance depends on the magnitude of the V_{SS}-to-V_{DD} voltage, and on the magnitude and polarity of the actual input signal.

Figure 3-*a* shows an improved version of the CMOS bilateral switch. An additional two FET's (Q3-Q4), which also act as a bilateral switch, are added in series with Q5, with Q1's source tied to Q5's drain. When the control input goes low, Q1's source sees V_{SS}, the Q3-Q4 bilateral switch is off, and the Q1-Q2 bilateral switch is also off. When the control input goes high, Q5 turns off, both bilateral switches Q3-Q4 and Q1-Q2 are enhanced (turned on) and, because they are in parallel, the R_{ON} resistance is reduced to about 90 ohms. That eliminates the variations in R_{ON}, as shown in the equivalent circuit of Fig. 3-*b*. The only disadvantage of Fig. 3 is that it has a slightly lower leakage resistance than Fig. 2.

Switch bias

Correctly biasing CMOS bilateral switches requires that you know two



INPUT STATES			ON CHANNEL	
INH	B	A	X	Y
0	0	0	0	0
0	0	1	1	1
0	1	0	2	2
0	1	1	3	3
1	X	X	NONE	

X = DON'T CARE

b

FIG. 8—THE 4052B HAS TWO SP4T bilateral rotary switches *(a)*; its truth table is shown in *b*.

things: The voltage polarity of the control logic, and the voltage polarity of the signal to be switched. For example, if the signal is analog, does it swing above and below ground, and if it's a digital signal, does it just go between ground and V_{CC}? Figure 4 shows two ways of biasing the bilateral switch.

To turn on (close) a bilateral switch, you must connect the control terminal to V_{DD}. To turn off (open) the same switch, connect the control terminal to V_{SS}. For switching digital signals, use them with a single-ended supply. Also, V_{DD} must be a positive voltage that's equal to or greater than the digital signal voltage, with a maximum of +18 volts. For switching analog signals, a split power supply must be used, so that the signal is held at half the supply voltage, which allows the signal to swing above and below ground. The positive supply rail goes to V_{DD}, and the negative rail goes to V_{SS}; both rails must be greater than the peak value of the input signal. Generally, the supply values used for bilateral switches are limited to ±9 volts.

Note that if a split power supply is used, the control logic must swing to the positive rail to turn the bilateral switch on, and to the negative rail to turn the switch off. That arrangement is inconvenient in many practical applications so, as shown in Fig. 5, some IC's (notably the 4051B to 4053B) have built-in logic-level converters. They allow a digital signal to be used as the on/off controlling logic, while still using a split supply in the circuit to correctly bias analog signals.

Time sharing

Bilateral switches are often used in multiplexer and demultiplexer circuits. Figure 6 shows the difference between the two types. A multiplexer allows information from a number of separate data lines to be sequentially applied to a single data line. On the other hand, a demultiplexer allows information from a single data line to be distributed to any number of separate data lines. For example, three separate audio signals can be multiplexed down a single cable, and then demultiplexed back into the three original audio signals at the other end. The benefit is obvious, in that only one data line is needed to carry numerous signals.

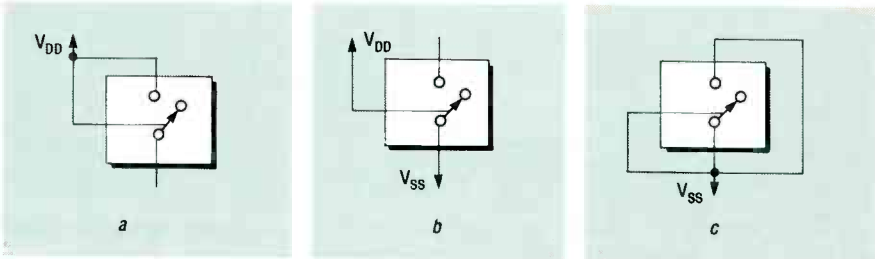


FIG. 9—UNUSED SECTIONS OF THE 4066B must be disabled using any one of connections *a* through *c*.

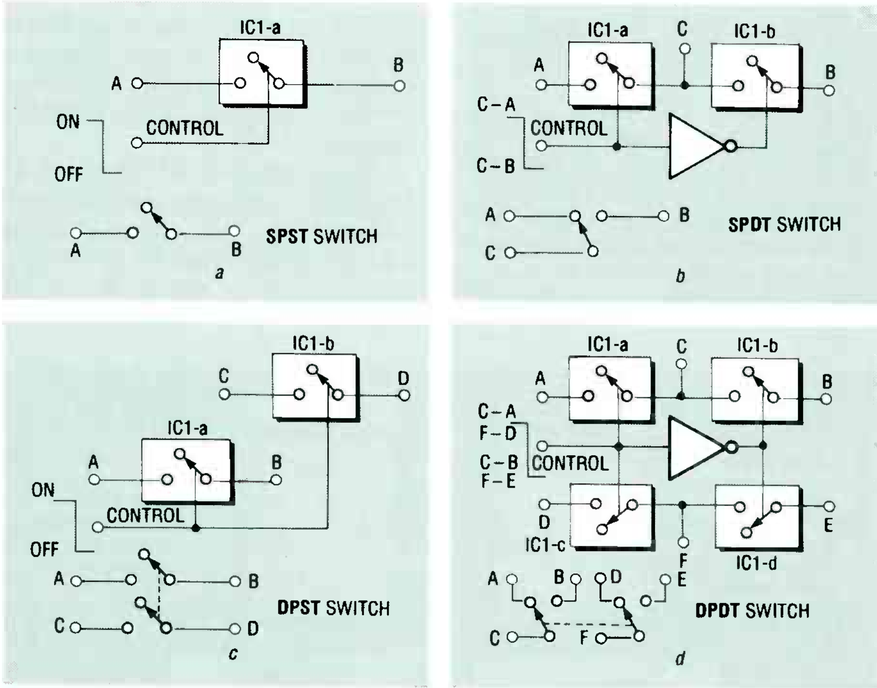


FIG. 10—IMPLEMENTATION OF THE FOUR BASIC SWITCHING FUNCTIONS (*a through d*) using the 4066B.

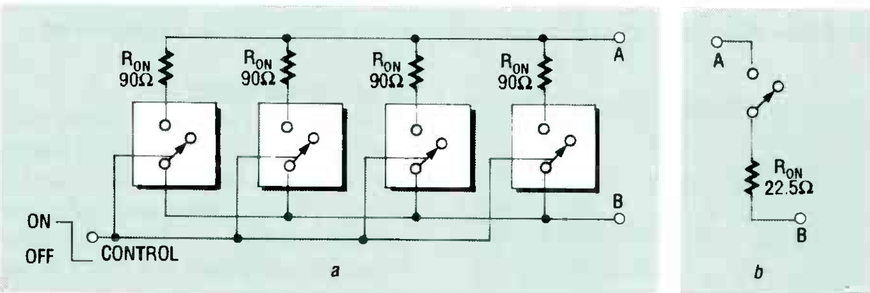


FIG. 11—BY PARALLELING FOUR SPST SWITCHES, the R_{ON} resistance can be reduced to only 22.5 ohms.

Best-known IC's

The best-known CMOS bilateral switches are the quad 4016B and 4066B. Both have four independently accessible SPST bilateral switches, as shown in Fig. 7. The 4016B uses the simple form of chip architecture shown in Fig. 2, and is recommended where low leakage impedance is most important. The 4066B uses the improved chip architecture of Fig. 3, and is recommended where a low R_{ON} resistance is most important.

Another well-known IC is the 4052B, which is a multiplexer/demultiplexer featuring built-in logic-level converters, and three power-supply pins (V_{DD}, V_{SS}, and V_{EE}). Figure 8 shows that IC. It's a dual 4-channel multiplexer/demultiplexer, and can be thought of as a ganged, double-pole, four-throw (DP4T) rotary switch. In practice, the V_{DD} is always taken to the positive rail, and V_{SS} is always grounded.

All digital control signals for channel-select, inhibit, and other similar functions, use those two rails as their logic reference. In digital applications, V_{EE} is grounded (tied to V_{SS}). In analog applications, V_{EE} must be taken to a negative supply rail, usually the negative value of V_{DD}, and must be limited to 18-volts peak-to-peak. Generally, though, a lower voltage is used.

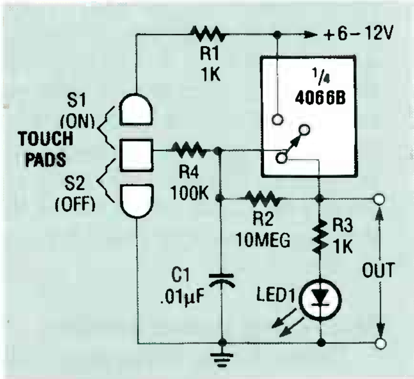


FIG. 12—HERE'S A LATCHING touch switch. Can you figure out how it works?

4016B/4066B IC's

A few simple precautions should be taken when using the 4016B and 4066B bilateral switches. Here they are:

1. Input and control signals must never go above V_{DD} or below V_{SS}.

2. Each unused switch must be disabled using one of the techniques shown in Fig. 9.

3. Figure 10 shows how to hook up a 4066B (or 4016B) to implement either SPST, SPDT, DPST, or DPDT switches. Those switching functions can be expanded or combined.

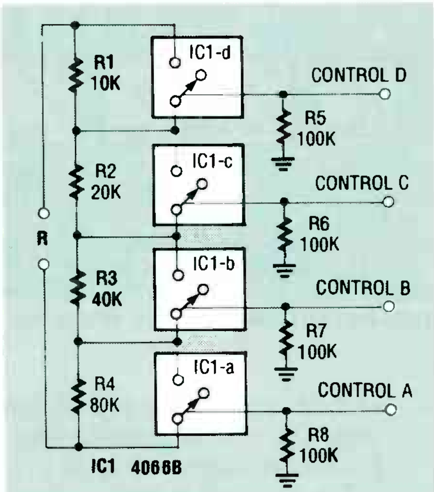
4. Each 4066B bilateral switch has a typical 90-ohm R_{ON} resistance. Figure 11 shows how four standard switch elements can be wired in parallel to make a single switch having only a 22.5-ohm R_{ON} resistance.

Touch switch

Figure 12 shows a self-latching touch switch. The switch current flows to ground via R3-LED1, and the control pin is tied to the top of R3 via R2. Thus when S1 is briefly touched, the control pin is pulled to the positive rail and the bilateral switch closes. The top of R3 is at supply-line potential and, because the control pin is tied to R3 via R2, the bilateral switch is latched closed. The switch can only be opened again by briefly touching S2, at which point R3 voltage falls to zero. Note that LED1 merely indicates the switch's state, and R1 prevents supply line shorts if S1 and S2 are both touched at the same time.

Digital control

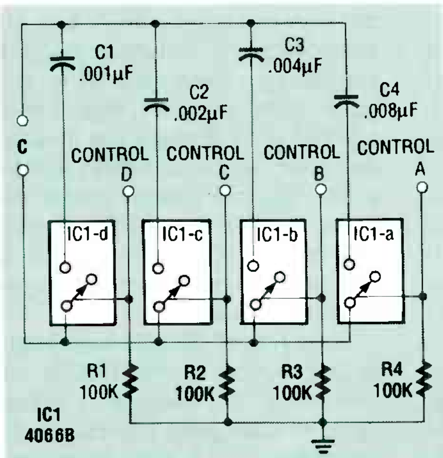
Bilateral switches are used to digitally-control electronic components.



A	B	C	D	R
0	0	0	0	150K
0	0	0	1	140K
0	0	1	0	130K
0	0	1	1	120K
0	1	0	0	110K
0	1	0	1	100K
0	1	1	0	90K
0	1	1	1	80K
1	0	0	0	70K
1	0	0	1	60K
1	0	1	0	50K
1	0	1	1	40K
1	1	0	0	30K
1	1	0	1	20K
1	1	1	0	10K
1	1	1	1	0K

0 = OPEN 1 = CLOSED

FIG. 13—DIGITAL CONTROL OF RESISTANCE made possible using bilateral switches.



A	B	C	D	C
0	0	0	0	0
0	0	0	1	1nF
0	0	1	0	2nF
0	0	1	1	3nF
0	1	0	0	4nF
0	1	0	1	5nF
0	1	1	0	6nF
0	1	1	1	7nF
1	0	0	0	8nF
1	0	0	1	9nF
1	0	1	0	10nF
1	0	1	1	11nF
1	1	0	0	12nF
1	1	0	1	13nF
1	1	1	0	14nF
1	1	1	1	15nF

0 = OPEN 1 = CLOSED

FIG. 14—DIGITAL CONTROL OF CAPACITANCE made possible using bilateral switches.

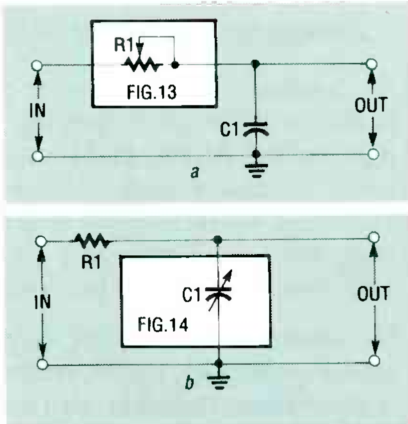


FIG. 15—ALTERNATE WAYS to make a digitally-controlled 1st-order low-pass filter.

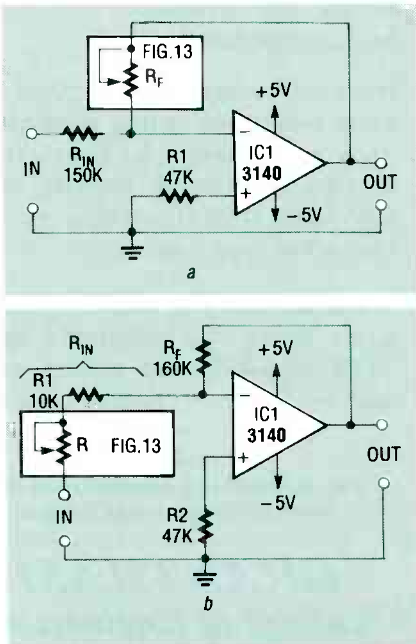


FIG. 16—OP-AMP GAIN CAN BE DIGITALLY CONTROLLED via the feedback resistor *(a)*, or input-resistor stage *(b)*.

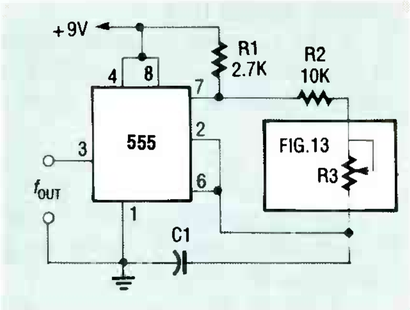


FIG. 17—555-TIMER FREQUENCY can be digitally controlled.

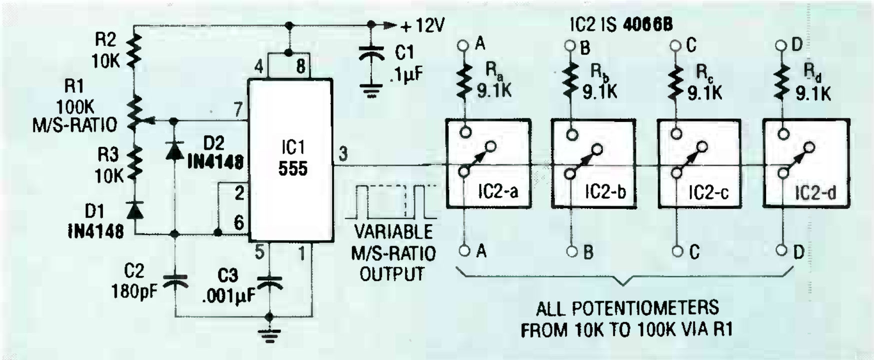


FIG. 18—YOU CAN VARY A MULTI-GANGED POTENTIOMETER from 10K to 100K by varying an astable's mark/space ratio.

That means that they can vary, in discrete steps, the effective value of resistance, capacitance, impedance, amplifier gain, oscillator frequency—you name it.

Figure 13 shows how four switches can make a digitally controlled resistor, which varies in sixteen steps of 10 kilohms each. As long as the four resistors are kept in the ratio 1:2:4:8...etc, the number of steps can be increased by adding more resistor/switch stages. Thus, a six-stage circuit having resistors in the ratio 1:2:4:8:16:32 will give resistance variation in 64 steps. Figure 14 shows how four switches can make a digitally controlled capacitor, which varies in sixteen steps of 0.001µF each. Again, the circuit can be expanded by adding more stages. The bilateral switches can be controlled manually, automatically by logic networks, by digital counters, or even by a microprocessor. Figure 15 shows how to form digitally controlled filter networks.

Op-amp gain can be controlled digitally by connecting Fig. 13 into the feedback or input path. Thus, in Fig. 16-*a*, the gain is varied from zero to unity in sixteen steps of $^1/_{15}$th each, giving a sequence of $^0/_{15}$, $^1/_{15}$, $^2/_{15}$... up to $^{15}/_{15}$ which is unity. Figure 16-*b* shows how to vary the gain from unity to × 16 in sixteen steps, giving a gain sequence of 1, 2, 3, 4,...16. Because the 3140 op-amp uses a split power supply, the 4066B must switch between the negative and positive supply rails. The frequency of a 555 astable oscillator can be varied; that is done by connecting Fig. 13 as shown in Fig. 17.

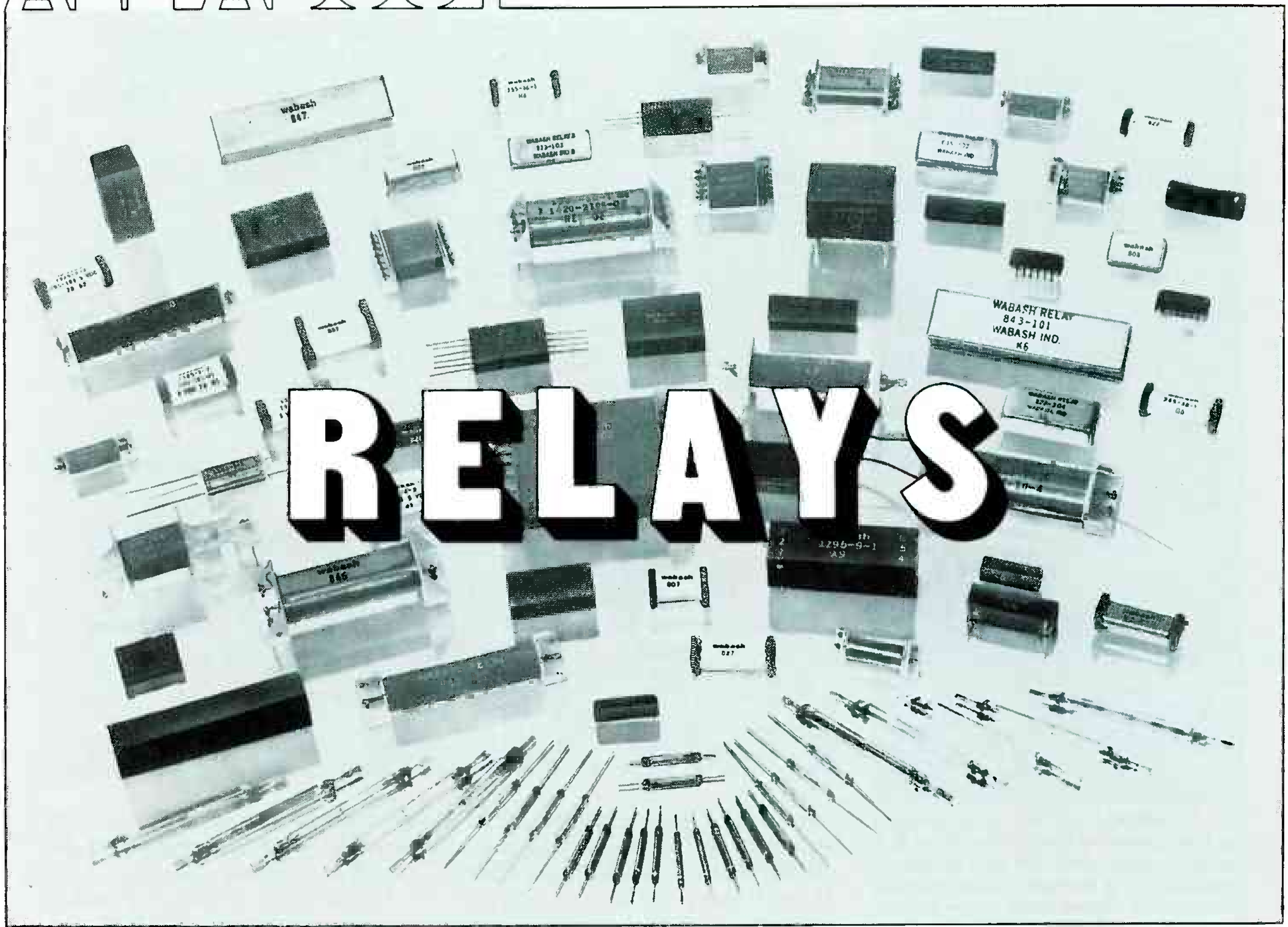
Multi-gang potentiometers

Figure 18 is an interesting circuit to analyze. It shows a synthesized 4-gang 10K-to-100K potentiometer that is useful at frequencies up to 15 kHz.

The 555 timer outputs a pulse train with a definite mark-space ratio (M/S ratio). As the pulse width decreases, the CMOS switch allows less of the low-voltage AC to pass through; thus simulating a high resistance. As the pulse width increases, more low-voltage AC goes through the switch per unit time, so the simulated resistance is low. The 555 timer is used to generate a 50-kHz rectangular waveform that has its M/S ratio variable from 11:1 to 1:11 via R1, which is used to control the 4066B.

If the timer's 50-kHz switching rate is fast relative to the 15-kHz signal frequency, the average or effective value of each gang resistance can be varied by the M/S-ratio potentiometer R1. Thus, if IC2-a is closed for 90% and open for 10% of each cycle (M:S ratio equals 9:1), the apparent (average) value of the R_A resistance will be 10% greater, or equal to 10 kilohms. If the duty cycle is reduced to 50%, the apparent R_A value will double to 18.2 kilohms. If the duty cycle is further decreased, so that IC2-a is closed for only 10% of each cycle, the apparent value of R_A will increase by a decade to 91 kilohms. **R-E**

ALL ABOUT RELAYS



Understanding relays, part I: Electromechanical versions

HARRY L. TRIETLEY

A RELAY IS AN ELECTROMAGNETIC switch, normally using the magnetic field from a coil to open or close one or more sets of contacts. Like resistors and capacitors, they're often taken for granted—until you need one! Then, you suddenly find yourself faced with a bewildering array of sizes, cases, contacts, power ratings, and features. No one version is correct for all applications, and the wrong one can cause poor performance or early failure. Most hobbyists don't use relays very often, and aren't aware of features and differences, but selecting the right one is no more difficult than selecting a resistor or capacitor. This article examines relays in great detail, explaining how they work, configurations, and applications.

Basic switching arrangements

Relay contacts are available in different switch configurations. The configuration of a switch is denoted by the numbers of *P*oles ("P") and *T*hrows ("T"). These can be indicated either by a number, or by the letters "S" (for *S*ingle) or "D" (for *D*ouble). Some different configurations are thus SPST, SPDT, DPDT, or multipole (3PST, 4PDT) versions. A relay's coil can either drive a few individual contacts, or several sets ganged together.

Figure 1 shows the four basic relay configurations. The version in Figure 1-*a* is *N*ormally *O*pen (NO) until the coil closes it, while that of Fig. 1-*b* is *N*ormally *C*losed (NC) until the coil opens it. Figures 1-*c* and 1-*d* use double-throw contacts, arranged as break-before-make in the first case and make-before-break in the second. The versions are referred to as Forms A–D, a relatively standard notation. The number of poles is added in front of the form letter, so the relays shown are 1A, 1B, 1C, 2C, and 1D. Relays can use multiple contact types, like 1A1B, 2A2C, etc. Other variations exist, but are all based upon those.

Form C momentarily opens both sets of contacts as the center contact moves from side to side; that prevents both sides of the switch from being shorted. Sometimes a circuit requires that the relay contacts not be left unconnected, even momentarily, in which case Form D is used. Applications of Form D include smooth, noise-free switching of current-limited audio or control-system signals,

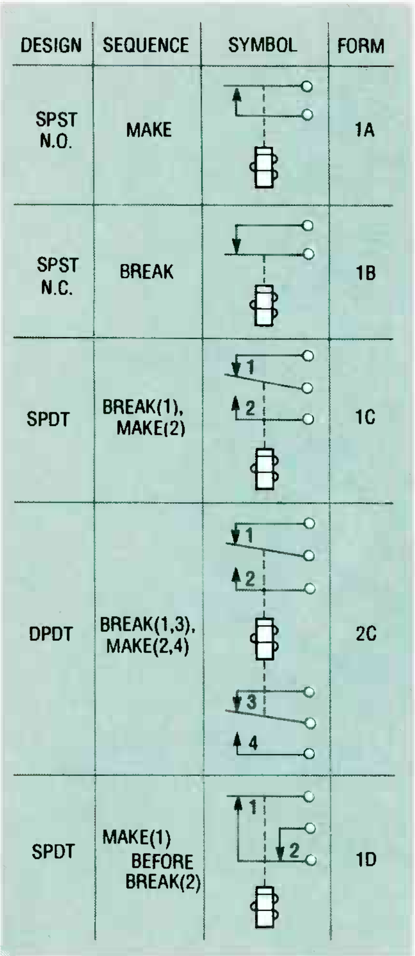


FIG. 1—RELAY-CONTACT arrangements are designated as Forms A–D. Form A is normally open until the coil closes it, while Form B is normally closed until the coil opens it. Forms C and D use double-throw contacts, arranged as break-before-make (Form C) or make-before-break (Form D).

TABLE 1—TYPICAL RELAY CHARACTERISTICS

STYLE	DIMENSIONS (INCHES)	CONTACT RATINGS	COIL, VOLTAGES AND POWER	SWITCHING TIMES
General Purpose Plug-in	1.2 to 2.0 H 0.9 to 1.5 W 0.9 to 1.4 D	3 to 10 A 28 VDC 120 or 240 VAC	6, 12, 24, 120 V 1.2 W DC 2 VA AC	15 to 30 msec
General Purpose Miniature	0.4 to 0.7 H 0.6 to 1.2 W 0.4 to 0.75 D	1 to 5 VA 28 VDC 120 or 240 VAC	5, 6, 12, 24, 48 VDC 0.5 to 1 W	5 to 10 msec
Reed	0.3 to 0.5 H 0.9 to 1.2 W 0.3 ro 0.8 D Also available in a DIP format	0.5 to 2 A 5 to 50 W 28 to 250 VDC & AC	5, 6, 12, 24 VDC 50 to 400 mW (Coils to 1 V available)	0.2 to 1 msec
Hermetic TO-5	0.3 to 0.9 H 0.6 to 1 W 0.3 to 0.5 D	0.5 to 5 A 28 VDC 115 VAC	4 to 32 VDC 120 mW	5 msec
Hermetic and other sealed	0.3 to 0.9 H 0.6 to 1 W 0.3 to 0.5 D	0.5 to 2A 28 VDC 115 VAC	5 to 115 VDC 100 to 400 mW	5 msec
RF	0.4 to 1 H 0.8 to 1 W 0.4 to 1 D	10 to 25 W RF hot To 150 W RF dry	5 to 50 VDC 250 mW	5 to 10 msec
Power	Dimensions typically 2 to 4 inches	10 to 40 A 120, 240 VAC & higher	6, 12, 24, 120 208, 240 V 2 to 5 W DC 6 to 20 VA AC	15 to 50 msec

or avoiding voltage spikes when switching inductive loads (more later). Naturally, Form-D contacts can't switch between two sources when shorting them could result in disaster.

A variety of styles

Relays switch signals ranging from microwatts of RF to megawatts of power; size can vary as much as construction techniques. The design varies with the application. Probably the most familiar relays are general-purpose and reed versions. Table 1 summarizes the most common types.

Figure 2 shows a typical general-purpose plug-in relay with socket. This type switches moderate power, 10–30 amperes at 120/240 volts AC. Octal tube-type sockets with circular pins are also available, as well as the flat-blade version shown. Its largest dimension is about 2 inches, and its dust cover provides a little protection, but the relay isn't sealed. Miniature general-purpose relays are epoxied into rectangular plastic potting shells, and have PC board pins. Typical dimensions are about 1 inch, and their controls can typically switch 1–5 amperes.

Reed relays like those in Fig. 3 can either be open or encapsulated, and are generally PC board-mounted DIP's. Figure 4 shows a single magnetic reed switch relay; very often, there's more than one inside a given model. The magnetic field brings the reeds together, and they're sealed in a glass envelope to protect them from contamination. Reed relays switch very fast (500 μsec), compared to 5–30 msec for general-purpose types.

Reed relays are intended for dry contact (as opposed to mercury wetted) and low-power switching. Typical contact ratings are 200–250 volts, 10–30 watts of switched power, with low voltage current ratings of 0.5–2 amps. Reed relays with up to six poles are available. High-voltage models switch up to 1 kilovolt, while mercury reed relays typically switch 100 watts. Coil voltages from 1–24 volts are available, with operating power demands at a fraction of a watt.

Probably the smallest commonly available models are the TO-5 versions. Some look just like transistors; others are square. The overall diameter or width is about 0.3 inch, with

FIG. 2—MANY GENERAL-PURPOSE relays use sockets, like this Potter and Brumfield unit.

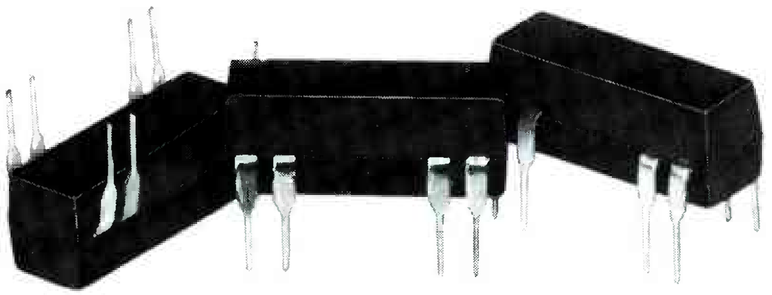


FIG. 3—REED RELAYS come in a variety of packages. They're usually small, PC board-mounted DIP's about 1 inch long.

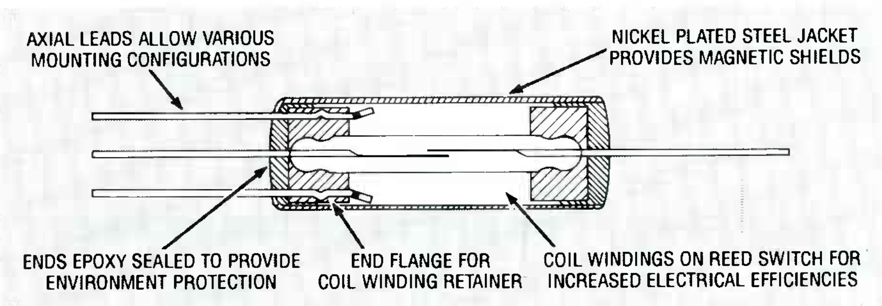


FIG. 4—AN HERMETICALLY-SEALED reed switch actuated by magnetic coil; the coil's magnetic field brings the reeds together. Reed relays can switch in 500 μsec, compared to 5–30 msec for general-purpose relays.

wire leads coming out the bottom of a 0.2-inch diameter circle. The contact specs are more limited than those for reed relays, typically 28-volts DC or 120-volts AC at about 1 ampere. Coil power is a fraction of a watt at up to 32- volts DC, and sometimes a little higher. They're hermetically sealed and work from −40–125°C. Some are available with built-in drive transistors and/or diode surge suppression.

Larger sealed relays switch up to 5 amperes. Housings include crystal-cans and plug-in housings. The hermetically-sealed RF relay with coaxial connectors in Fig. 5 matches the 50-ohm impedance of most transmission lines at frequencies from 500 MHz–2 GHz, depending on the model. Contact ratings of 150 watts are typical.

Power-switching relays are larger, almost always use open construction, and are used to switch all power levels up to multi-megawatt levels. Figure 6 shows a typical relay used in a power application like motor control. Overall dimensions of versions switching up to 30 amperes are 2–4-inches. Typical coil power is about 2 watts DC or 5–10 volt-amperes AC. "Contactors" for switching large motors provide the same function as power relays, but are specially constructed for heavy-duty switching. The contacts are moved by a solenoid that exerts considerably higher force than is normally used in non-power relay applications, instead of a fixed-core coil.

Choosing the right contacts

Obviously, low-level relays can't switch power, and, conversely, power relays won't reliably switch low-level signals. Contact choices are shown in Table 2. The right contacts are crucial for reliable operation. Power loads have self-cleaning contacts that have a tendency to arc and burn off oxidation or contamination. Low-level "dry" (non-wetted) circuits don't do that, and have to be clean; even a thin layer of contamination can prevent low-level signals from being switched.

Dry-circuit contacts use non-oxidizing materials or platings, operate with a wiping action so the contacts slide past each other, and are *bifurcated* (two branching parts). That means that a lengthwise slot in the middle of the contact splits it into two parts for the sake of electrical redundancy. Low-level bifurcated wiping relay contacts are typically gold-plated, or use other precious metals. The contacts in reed or hermetically-sealed relays don't need corrosion resistance, but are often made of precious metals like rhodium or ruthenium.

Power-switching relays need large contacts actuated with sufficient force to handle high currents and voltage. Arcing must be minimized, and electrical and thermal resistance must be low to minimize heating; button contacts are normally used. High-power versions normally use silver-cadmium oxide; it resists welding, has good arc-extinguishing characteristics, and is well suited for reactive or high-surge current loads, but not for switching voltages under 12 volts. Silver is good for medium-power loads and communication systems, but not under 6 volts. Since silver oxidizes easily, such contacts should

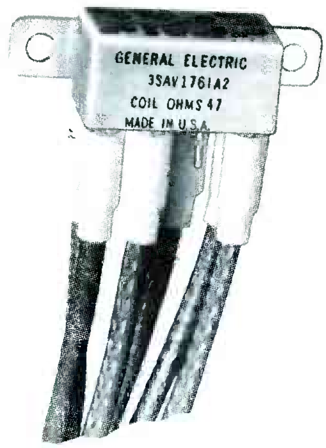


FIG. 5—THIS G.E. CORP. hermetically-sealed relay matches the characteristic RF impedance of a 50-ohm transmission line over the frequency range 500 MHz–2 GHz, and uses coaxial connectors instead of pins. Typical contact ratings are 150 watts.

FIG. 6—POWER RELAYS, switching up to 40 amperes, normally use open construction, for motor control. Overall dimensions of 30-ampere versions are 2–4-inches, and typical coil power is about 2 watts DC or 5–10 volt-amperes AC.

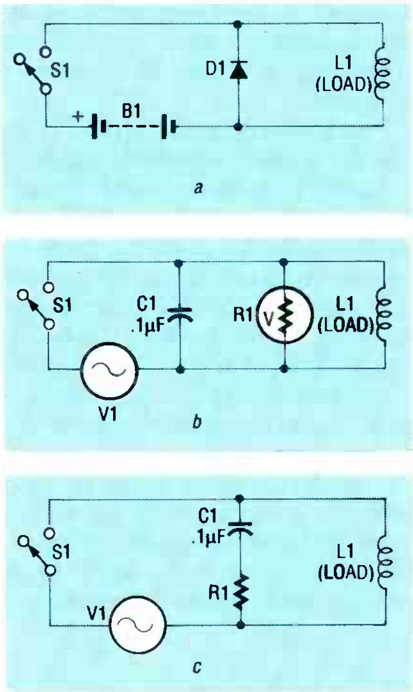


FIG. 7—WHEN SWITCHING inductive loads, surge suppression provides a current decay path when relay contacts open. For DC loads, use a reverse-biased diode as in (*a*). For AC loads, use an MOV (or resistor) and a capacitor as in (*b*).

FIG. 8—THIS LATCHING RELAY, the 589R from Potter and Brumfield, flips a mechanical toggle from side to side like a mechanical flip-flop, changing state when the coil is activated by a pulse.

be gold plated (flashed) for storage protection. The gold flash will wear with use, and the contacts then depend on wiping and burn-off for cleanliness in operation.

Silver palladium is less susceptible to oxidation; however, its burn-off resistance and conductivity are inferior to silver. It should be used only for low power, below 60 volts. In reed relays with mercury-wetted contacts, a thin film from a small pool of mercury (not the pool itself) shorts the contacts. The mercury film increases power-switching capacity and decreases contact resistance. One relay series, for example, is rated at 0.5 amp, 10-watts DC, and 0.1 ohm, using dry contacts; the mercury-wetted equivalent is rated at 2 amps, 50-watts DC, and 0.05 ohm. Contact life is higher as well for mercury versions, although they have to be maintained in particular positions.

Contact protection

Switching inductive loads creates special problems, since the current through an inductor can't be instantaneously stopped. If a coil is opened while current flows through it, its magnetic field collapses rapidly, inducing a large voltage, the polarity of which maintains current flow. That's the principle used in automotive ignitions or TV flyback transformers. The voltage can reach the kilovolt range, producing arcing and destroying contacts.

When inductive loads are switch-

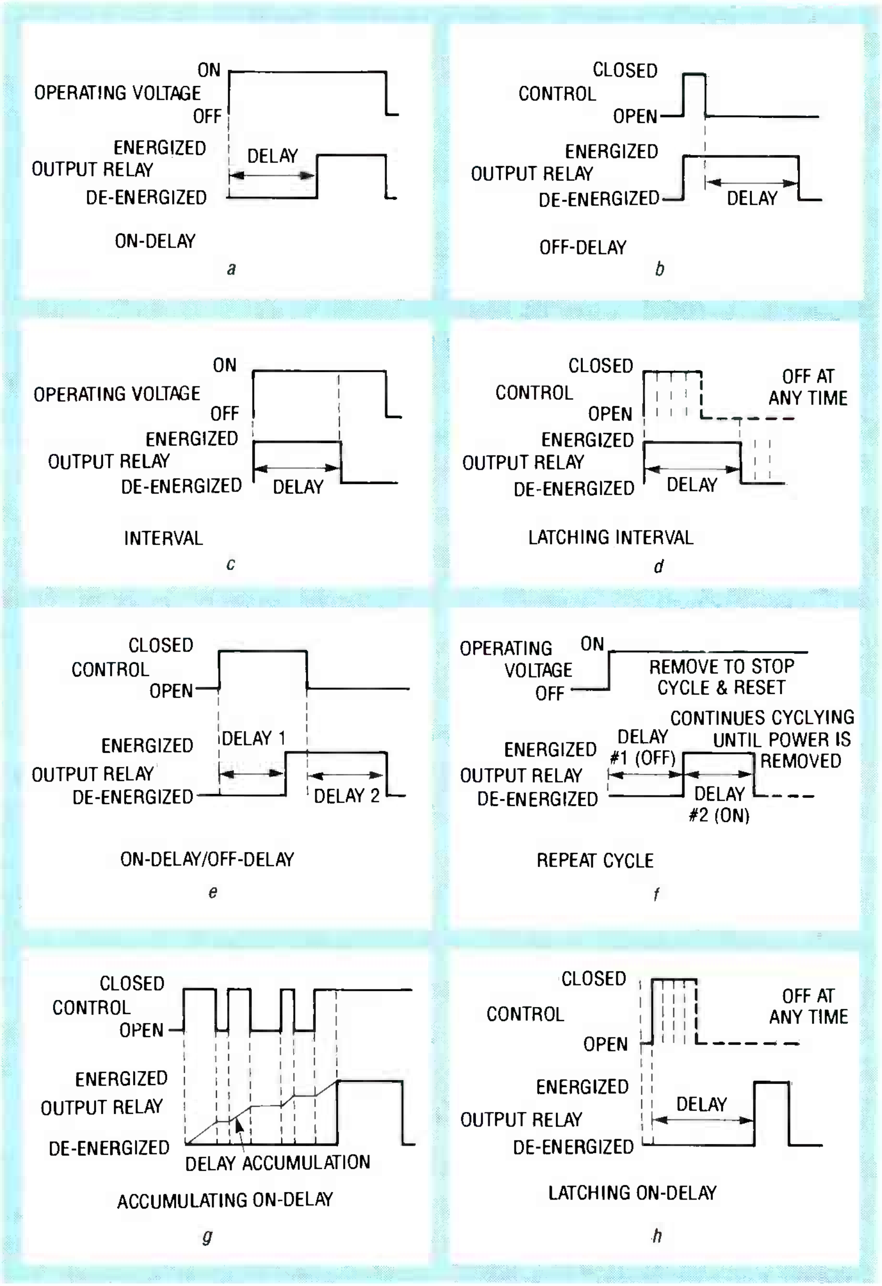


FIG. 9—TIME-DELAY RELAYS prolong actuation or dropout. The on-delay (*a*) turns on during the operating voltage and continues until it's removed. The off-delay (*b*) turns on when the control goes high, and begins its delay after control goes low. The interval (*c*) turns on when the operating voltage appears, and off before it ends. The on/off-delay (*e*) has two delays referenced to the leading/trailing control pulse edges. The repeat cycle's (*f*)second delay depends on the first. The accumulating on-delay (*g*) compares total control pulse duration with a reference. In the interval (*d*) and on-delay (*h*) latches, the control pulse turns off any time.

TABLE 2—CONTACT MATERIAL CHARACTERISTICS

CONTACT	APPLICATIONS	TYPICAL RATINGS	COMMENTS
Bifurcated, gold-plated, or gold overlay	"Dry" and low current. Measurement and signal switching.	0 to 0.2 A. Rated to 120 VAC, but best for 24 V or less.	Low, steady contact resistance.
Silver	Communications	2 to 5 A	Oxidizes easily. Should be gold-flashed for storage protection.
Silver cadmium oxide	Power, inductive and capacitive loads. High in-rush currents.	5 A and up	Resists welding. Good arc-extinguishing characteristics. Less suited below 12 V.
Mercury wetted	"Dry" and low current, long life, no contact bounce.	2 to 5 A	Position sensitive. (Typ. vertical +/− 30 degrees.)

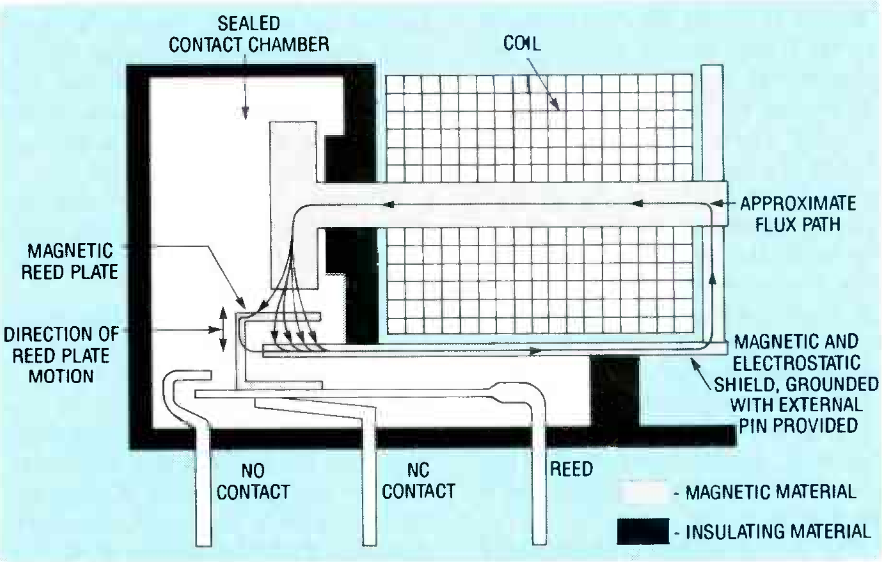


FIG. 10—THIS LOW-THERMAL-VOLTAGE reed relay uses silver conductors and pins outside the coil, gold-plated silver contacts, and careful shielding to minimize errors.

ed, surge suppression should be provided, by providing a current path once contacts open. For DC loads, a reverse-biased diode is often added as in Fig. 7-*a*. When the contacts open, load current will flow until it decays to zero. The diode's *P*eak *I*nverse *V*oltage (PIV) rating should exceed the supply voltage by at least 50%, and it should have a surge-current rating that is greater than the normal load curent. A resistor in series with the diode causes the current to decay more rapidly but will produce a larger voltage transient.

You might initially expect a larger resistance to impede current flow, as a capacitor would in series with a resistor. However, the time constant for an R-C combination is: $\tau_{CAP} = RC$, whereas for an inductor-resistor combination it's: $\tau_{IND} = L/R$. Note that τ_{IND} is inversely proportional to R, so as R increases, τ_{IND} decreases. The size of the transient can be easily determined using Ohm's Law:

$$V_{PEAK} = I_{LOAD} \times R_{SERIES}.$$

Figures 7-*b* and 7-*c* show one way to provide surge suppression for an AC load. Fig. 7-*b* uses a *M*etal-*O*xide *V*aristor (MOV) and a capacitor. The breakdown voltage ratings of the MOV and the capacitor must exceed the peak voltage of the AC supply. For 60-Hz power, the peak voltage is 1.414 times the RMS level. You can also omit the MOV and add a resistor in series with the capacitor, as shown in Fig. 7-*c*.

Even without an inductive load, high voltages will tend to arc across the contact as it opens. Once struck, the arc will continue via the ionized air until the voltage is removed. That is why many contacts rated for 120/240 volts AC are limited to only 28 volts DC. As a cure, some larger relays are available with a "blowout magnet" at each set of contacts. When properly installed, the magnetic field deflects the arc, just as a CRT's electron beam is deflected by magnetic coils, so that its path can't extend from one contact to the other. The arc is extinguished as soon as it forms; relays with powered blowout coils also are available.

Coil types

All relays can be used with DC. General-purpose and power relays are also offered with AC coils. Although some use internal rectifier diodes, most use coils and magnetic structures designed for AC. In AC operation, the relay switching time has to be long enough so that the relay doesn't "buzz" as the input voltage crosses zero. Most general-purpose and power relays are slow enough to avoid the problem. The coil is an inductor, so its current is out of phase with its voltage In Table 1, typical AC volt-ampere ratings are somewhat higher than the wattages of equivalent DC coils.

Specialty versions

Latching or impulse relays are mechanical flip-flops, changing state when their coils are activated by a momentary pulse. They're useful in battery and low-power applications, because they use power only when toggled, and they remember their state during power failures. The two types are the mechanical-toggle and magnetic-reed versions. Figure 8 shows a mechanical-toggle relay; the mechanism is the same as that used in push-on/push-off switches. The coil pulls the pin straight down, toggling the latch to the left. When deactivating, the pin moves up and rests in the upper right-hand notch. When next actuated, the toggle is pulled to the right.

Two-coil latching relays use one

continued on page 76

HARDWARE HACKER

More on cold fusion
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More on cold fusion

DON LANCASTER

IS COLD FUSION FOR REAL? MOST OF the researchers and most of the labs have loudly proclaimed "no" after all of their initial hasty and misdirected experiments failed. But a very few labs are now more convinced than ever that something really big is coming down.

At any rate, sources very close to the barber of an associate of a usually reliable spokesperson for a key fusion researcher feel that...

(1) Cold fusion is real and is in fact the explanation for both the continuous and "burst modes" of the excess heat production.

(2) The tritium reaction does all of the work, and enough tritium is produced to exactly be able to account for the excess heat.

(3) The ambient air can poison the reaction. Working in a very dry inert argon atmosphere is recommended.

(4) The palladium must be vacuum-refined and then recast, but *not* in a carbon mold. Any rework, such as an extrusion, is a not allowed.

(5) While palladium films as thin as 50 angstroms could be used, any impurities at all are a no-no. Platinum impurities as low as 0.01 percent spoil the material.

(6) All bubbles must absolutely get eliminated at the palladium surface. Pressurizing the heavy water can help bunches here.

(7) The deuterium ions must flow *through* the palladium. One approach might be to use a sintered palladium cylinder having an internal vacuum. Another might involve a three-element cell with an accelerating second anode of some sort.

(8) Operation above 175 degrees will dramatically drop the efficiency. Thus, a heat engine using some non-water fluid, such as ammonia, must be used to extract useful work. Fortunately, those OTEP (*O*cean *T*hermal *E*lectric *P*ower) people have already done all the groundwork for low-temperature differential heat engines.

(9) For a breakdown, excess fusion heat production well beyond 12:1 will probably be required, due to the inherently low efficiency of any heat engine forced to work with a low temperature differential. Thus, a little bit of excess heat is useless except possibly as a yuppie ski-boot heater.

(10) Other candidate materials do include zirconium, lanthanium, and titanium, but titanium does seem highly overrated at present.

(11) Yet another reasonably priced source for heavy water is the Canadian Atomic Energy Commission. I do not have their address so far. A free book if you do.

In reality, most of those observations are straight from the horse's whatever. Time will tell us which end of the horse we are dealing with.

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Meanwhile, besides all the original German work from the early 1920's, there is an obscure 1979 Australian patent #48901/79 on cold fusion.

While I personally feel that the patent appears to involve someone who seems to be a few chips shy of a full board, it sure will be interesting to see how many modern claims will be disallowed because of that apparent prior art.

Oh, yes, you might also want to look at US patents 3,983,882 and 4,107,008. Curiouser and curiouser.

On, now, to a popular help-line topic...

Stepper motors

There have been a lot of helpline requests lately for extra information on stepper motors. A stepper motor differs from an ordinary motor in that it rotates its shaft in a discrete and incremental stepping motion.

A stepper motor is thus ideal for any intermittent or precise motions, such as you would need for the platen feed on a dot matrix or daisywheel printer. Steppers are also useful for any slow-speed application, eliminating the cumbersome gear trains you would need with most ordinary high-speed motors. The steppers are also instantly reversible, and usually have a holding torque that can act as an internal brake. Steppers are handy for variable-speed uses, something that gets extremely tricky to do with most AC motor designs.

One type of stepper motor consists of a toothed magnetic rotor and a toothed iron stator. The

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number of teeth decides the *step angle* and the number of steps per revolution. In the absence of any electrical input, the rotor will lock to the stator by seeking out paths of minimum magnetic reluctance.

There are normally two groups of windings provided. The "A" winding is active one-third of the distance between teeth, while the "B" winding is active two-thirds of the distance between the teeth.

In typical use, a four-step process is used to advance to the next tooth position. The A winding first gets activated, attracting the toothed rotor one-third of the distance to the next tooth. Then the B winding is activated, attracting to the two-thirds point. Next, the A winding has its current reversed to further repel towards that two thirds point. In the final step, that current in the B winding gets reversed, repelling the rotor to its new and final position.

The speed gets determined by the number of steps applied per second. The direction is set by changing the roles of the A and B windings.

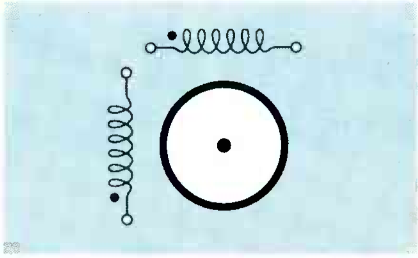

FIG. 1—IN A BIPOLAR (OR UNIFILAR) stepper motor, there is only a single grinding for each phase. Although the stepper itself is powerful and low-cost, the driver circuitry gets extra complicated, since a full-bridge circuit is needed—one that is able to send current in either direction. Bipolar stepper's often have four leads.

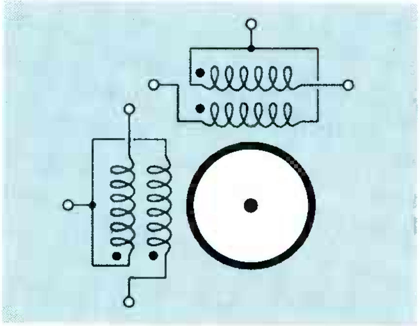

FIG. 2—IN A UNIPOLAR (OR BIFILAR) stepper motor, you will find a pair of windings for each phase. While that raises the cost and also reduces the available stepper power, your driver circuitry is far simpler and very much cheaper, since only a current sink is needed for each winding. A unipolar stepper often has six leads.

Other patterns of activating the A and B windings might give you various speed and torque options, as well as actually *microstepping*, the moving to a precise position *between* the rotor teeth.

As Figs. 1 and 2 show us, there are two different methods with which stepper motors are commonly wound. In a *bipolar* stepper there is only a single A winding and only a single B winding. That is cheaper and has more power, but requires you to electronically *reverse* the high current through both windings. Thus, what you gain in stepper economy, you lose in driver complexity.

In a *unipolar* or a *bifilar* stepper, there are two distinct A windings and two separate B windings. Each of the windings go in the opposite sense of the other, so a current in one winding will attract the rotor, while the same current in the other winding will instead repel the rotor. The unipolar windings are much easier to drive, but they cost more and offer less power.

You can usually tell which type of stepper you have by the number of leads. Assuming that all the leads are brought out separately, a bipolar stepper will have four wires, while a unipolar one will have six. For most hacker uses, the unipolar and bifilar windings are the best choice, since they are easier and cheaper to drive.

Good data sheets and ap-notes on steppers are available from *Airpax, Hayden, Superior Electric,* and most of the other suppliers. Bunches of technical articles and supplier ads for steppers appear in the *PCIM* and *Motion* trade journals, as well as the usual electronics insider magazines.

While new steppers are usually rather pricey, you can find lots of surplus ones in assorted sizes and voltages for as little as $2 through all the usual **Radio-Electronics** ads and similar surplus sources.

MODELMAKING RESOURCES

AIN Plastics
249 E. Sandford Blvd
Mt. Vernon, NY 10550
(914) 668-6800

Apache Reclamation
313 W. Apache St.
Pheonix, AZ 85003
(602) 254-0613

Bead Chain
110 Mountain Grove, PO Box K
Bridgeport, CT 06605
(203) 334-4124

BNF Enterprises
119 Foster Street
Peabody, MA 01961
(508) 531-5774

C & H Sales
2176 E. Colorado Blvd.
Pasadena, CA 91107
(213) 681-4925

Caplugs
2150 Elmwood Avenue
Buffalo, NY 14207
(716) 876-9855

Constantine
2050 Eastchester Road
Bronx, NY 10461
(212) 792-1600

Design News
275 Washington Street
Newton, MA 02158
(617) 964-3030

EDLCO
PO Box 5373
Asheville, NC 28813
(704) 255-8765

Edmund Scientific
101 E. Glouchester Pike
Barrington, NJ 08007
(609) 573-6250
Evergreen Scale Models
12808 NE 125th Way
Kirkland, WA 98034
(206) 823-0458
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195 Algonquin Road
Des Plaines, IL 60016
(312) 299-2222
Fine Scale Modeling
21027 Crossroads Circle
Waukesha, WI 53187
(414) 796-8776
Fomeboards
2211 N. Elston Avenue
Chicago, IL 60614
(312) 278-9200
W.W. Granger
5959 West Howard St.
Chicago, IL 60648
(312) 647-8900
Herbach & Rademan
401 East Erie Avenue
Philadelphia, PA 19134
(215) 426-1700
Hygenic Manufacturing
1245 Home Avenue
Akron, OH 44310
(216) 633-8460
Jerryco
601 Linden Place
Evanston, IL 60202
(312) 475-8440
K & S Engineering
6917 West 59th St.
Chicago, IL 60638
(312) 586-8503
Lindsay Publications
PO Box 12
Bradley, IL 60915
(815) 468-3668
Machine Design
1100 Superior Avenue
Cleveland, OH 44144
(216) 696-7000
McMaster-Carr
Box 54960
Los Angeles, CA 90054
(213) 692-5911
Milled Shapes
1701 North 33rd Ave.
Melrose Park, IL 60160
(312) 344-1220
Model Railroader
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Waukesha, WI 53187
(414) 796-8776
New Equipment Digest
1100 Superior Avenue
Cleveland, OH 44114
(216) 696-7000
Northeastern Scale Models
PO Box 727
Methuen, MA 01844
(508) 688-6019
Nuts and Volts
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Placentia, CA 92670
(714) 632-7721
Plastiglide
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Hawthorne, CA 90250
(213) 777-8108
Signcraft
1938 Hill Ave. PO Box 06031
Fort Meyers, FL 33906
(813) 939-4644
Sinclair & Rush
10315 Page Industrial Blvd.
St. Louis, MO 63132
(314) 426-4487
Small Parts
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Miami, FL 33238
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Special Shapes
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Stock Drive Products
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New Hyde Park, NY 11040
(516) 328-0200
Synergetics
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Thatcher, AZ 85552
(602) 428-4073
US Plastics
1390 Neubrecht Road
Lima, OH 45801
(419) 228-2242
oodworker's Store
21801 Industrial Blvd.
Rogers, MN 55374
(612) 428-2899

Two linear steppers

Take an ordinary stepper motor, but make it hollow at its center. Then add a threaded shaft through the middle, which gets driven from a nutplate on the stepper armature. As the stepper is stepped, the nutplate turns, which in turn advances or retards the threaded shaft.

All of which gives you a way to push or pull things in tiny and very accurate increments under computer control. With lots of force over fairly long strokes.

Uses? Animation tables, printed-circuit drills, a numeric-controlled milling machine, plotters, robotics, valve actuators, electronic engine controls, research projects, point-of-purchase displays, plus dozens of uses previously unthunk of.

Figure 3 shows you the *Hurst* model SLS linear actuator. It's a 12-watt unit that gives you 25 pounds of force in 2-mil (0.002 inch) increments, over an 8-inch actuating length.

While under $20 in quantity, single evaluation units cost around $55, unless you can locate a surplus one. That seems rather high, until you take that "Uh, compared to what?" factor into account.

On custom order, lead screws up to several feet long can be obtained. Note that there is no theoretical limit to the stroke you could get out of one of those, so long as a lead screw that length is available. Maintaining the precision and avoiding any binding would, of course, get far worse with increasing length.

Figure 4 shows you a smaller *Airpax* series 92100 unit. They are much smaller and give you a half-inch maximum stroke, in 2- or 4-mil steps, having a force slightly over one pound.

The price is around $25 each, but you might be able to find one nearly free at your local junkyard, as some automobiles use them for computerized carburetor idle adjustments. Unfortunately, I don't know which specific models to send you after. There are also some plain old throttle solenoids that look just about the same, so make sure you are getting a "real" stepper when you make your visit.

You can step them up to 400 steps per second, which means you can travel the half-inch stop-to-stop distance in something like 0.6 seconds. But you do lose force at the higher stepping rates.

We're using that one locally to adjust the teeth on a cotton picking machine. The stepper acts as sort of a micrometer, advancing until it touches each tooth. The number of steps needed then tells the mechanic how much shim to add.

If you don't know anything

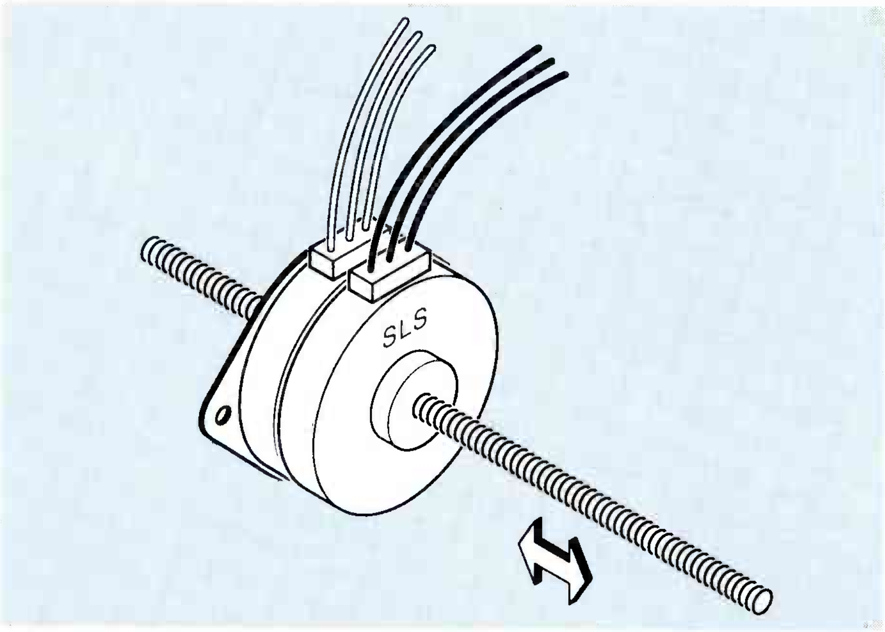

FIG. 3—THE HURST SLS LINEAR ACTUATOR is a real "sleeper" for hardware hacking. This easy-to-drive 12-volt, 12-watt unit offers 24 pounds of force in 2-mil (0.002) increments. What can you do with it that's new and really different?

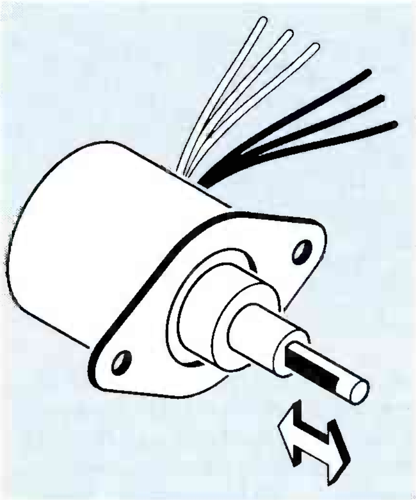

FIG. 4—THE AIRPAX 92100 is a smaller linear stepper motor having a ½-inch stroke. Similar units may be available at a junkyard as throttle idle controllers.

about cotton picking, what we have here is an easy and precise way to eliminate a most tedious and time-consuming job. If the teeth are too close, you destroy the machine. If they are too far away, your yield and your grade goes down.

A third source of linear actuators is *Eastern Air Devices*, but their military look and their refusal to include pricing in their mailings does not bode well for hackers.

Stepper drivers

Most of the stepper manufacturers have available driver circuitry for their devices, but those tend to be older hybrids that seem overpriced. Instead, there are several suppliers of single- and double-chip stepper-motor drivers. They include *Sprague*, *SGS*, and *Motorola*.

Figure 5 shows you a circuit for the *Sprague* UCN-4204B single-chip stepper driver. While I haven't yet been able to check the chip out (stay tuned), it looks like a typical modern circuit with 1.5 amps of drive capability and internal protection for both overheating and overcurrent. They are well under $4 in singles.

To use the circuit, you provide two inputs. The first is the direction input which decides whether your stepper will spin forward or backward. The second is a train of square-wave pulses that sets the speed in the chosen direction.

It is usually best to computer control your stepper driver. As we've seen, an otherwise unused Commodore 64 is ideal for that sort of thing, and their going rate is around $30 at a yard sale.

One microcontroller chip that I really like which includes dual low-level stepper drivers on-chip (among lots of other goodies) is the great M50734 by *Mitsubishi*. That dude cross-assembles beautifully on an Apple IIe or IIgs.

Three contests

Let's have three contests this month. There will be the usual *Incredible Secret Money Machine* prizes for the best dozen entries, with an all-expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

For the easy contest, just tell me something you would like to do with a linear stepping motor or a linear actuator. Or two or even three. Especially if they have twenty pounds of force in 2-mil increments.

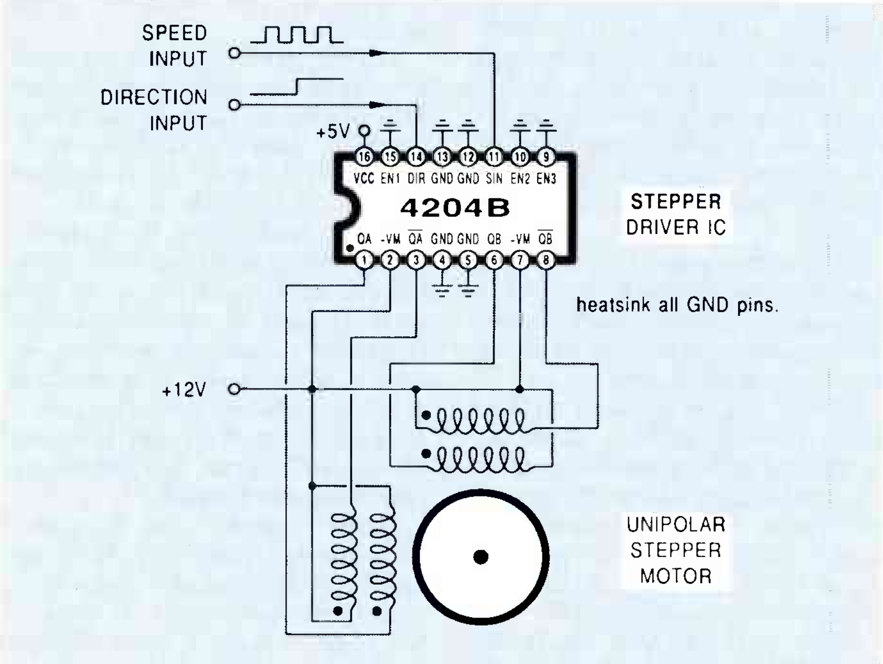

FIG. 5—LOW-COST SINGLE-CHIP stepper-motor drivers are readily available from Motorola, SGS, and Sprague, among others. Here's a popular Sprague driver.

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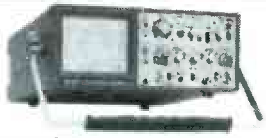

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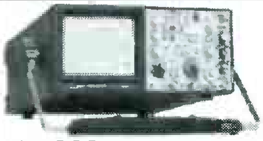

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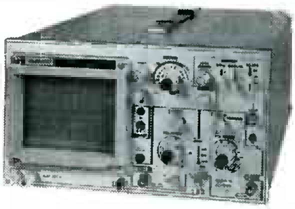
V-423	40MHz	D.T., 1mV sens, Delayed Sweep, DC Offset, Alt Mag	$1,025	$825	$200
V-660	60MHz	D.T., 2mV sens, Delayed Sweep, CRT Readout	$1,295	$1,145	$150
V-1065	100MHz	D.T., 2mV sens, Delayed Sweep, CRT Readout, Cursor Meas	$1,895	$1,670	$225
V-1100A	100MHz	Q.T., 1mV sens, Delayed Sweep, CRT Readout, DVM, Counter	$2,450	$2,095	$355
V-1150	150MHz	Q.T., 1mV sens, Delayed Sweep, Cursor Meas, DVM, Counter	$3,100	$2,565	$535

ELENCO PRODUCTS AT DISCOUNT PRICES

20MHz Dual Trace Oscilloscope



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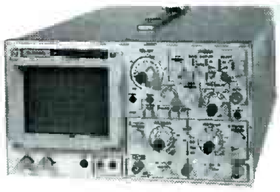

$495
MO-1252

- High luminance 6" CRT
- 1mV Sensitivity
- 6KV Acceleration Voltage
- 10ns Rise Time
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Top quality scopes at a very reasonable price. Contains all desired features. Two 1x, 10x probes, diagrams and manual. Two year guarantee.

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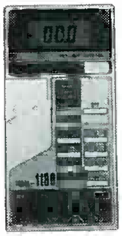

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MDM-1182 $29.95

- 3 1/2 LCD Display
- 27 Functions
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.05% DC Accuracy
.1% Resistance
with Freq. Counter
and deluxe case

Multimeter with Capacitance and Transistor Tester

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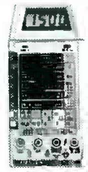
Reads Volts, Ohms, Current, Capacitors, Transistors and Diodes with case

Digital Capacitance Meter



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Zero control
with case

Digital LCR Meter

LC-1800
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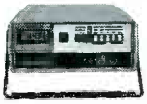
Measures
Coils 1uH-200H
Caps .1pf-200uf
Res .01-20M

Bench DMMS



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Temp range: 300F-900F
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9436 2,860 pins $35
All have color coded posts

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Works with most DMM

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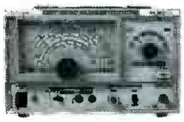

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AM Modulation of 1KHz
Variable RF output
SG-9500 with Digital Display and 150MHz built-in Freq Ctr $249

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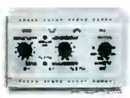
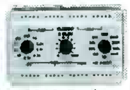
Convenient one hand operation
Measures DCV, ACV, Ohms
Audible continuity check, Data hold
with batteries and case

Function Generator Blox



#9600
$28.95
Provides sine, tri, squ wave from 1Hz to 1MHz
AM or FM capability

Decade Blox



#9610 or #9620
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#9610 Resistor Blox
47 ohm to 1M & 100K pot
#9620 Capacitor Blox
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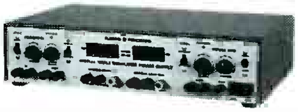
XP-765



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Fully Regulated, Short circuit protected with 2 Limit Cont., 3 Separate supplies
XP-660 with Analog Meters $175

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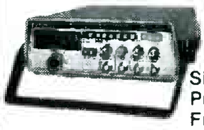
GF-8016 Function Generator with Freq. Counter



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GF-8015 without Freq. Meter $179

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CIRCLE 109 ON FREE INFORMATION CARD

For our intermediate contest, just tell me which makes and models of automobiles use linear stepping actuators as their idle controls.

For the hard contest, nobody talks very much about the electrical and mechanical *eficiency* of a stepping motor. *Why?* Could a very large and extremely efficient linear stepping motor be built?

That would dramatically improve solar water-pump design, as the pump stroke and speed could be exactly and continuously matched to both the available input solar power and the well characteristics. Which might enormously simplify and cheapen both the electronic and mechanical designs. Especially for remote and third-world applications.

Modelmaking resources

In any large electronics company, the model shop is that secret lair where all of the mockups, mechanical prototypes, breadboards, concept pieces, and one-of-a-kinds come from. As a hacker, you are your own model shop, so it is super important to know where to go to get all of the non-electronic bits and pieces you'll need to make hacking more hackable. Our new Modelmaking Resources sidebar shows you a few places to go for model info and supplies.

Naturally, you will want to check out your own local resources first. Those should include a good hardware store, a large junkyard, a real hobby shop, and a few electronic surplus houses that do not have a catalog and do not advertise in any national magazines. One regional example around here is the *Apache Reclamation and Salvage*. Ask any ham radio operator for a complete neighborhood list.

I've also found a local horse-trailer factory to be useful, es-

NAMES AND NUMBERS

Airpax
150 Knotter Drive
Cheshire, CT 06410
(203) 271-6000

Brookfield
240 Cushing St.
Stoughton, MA 02072
(617) 344-4310

Burr-Brown
6730 S. Tucson Blvd.
Tucson, AZ 85706
(602) 746-1111

Computer Shopper
5211 South Washington
Titusville, FL 32780
(407) 269-3211

Hayden Switch & Instrument
1500 Meridan Rd. PO Box 3329
Waterbury, CT 06705
(203) 756-7441

Heath Buyers Club
PO box 217
Benton Harbor, MI 49022
(616) 982-3789

Hurst Manufacturing
Box 326
Princeton, NJ 47670
(812) 385-2564

Linear Technology
1630 Mc Carthy Blvd.
Milpitas, CA 95035
(408) 432-1900

Mitsubishi
1050 East Arques Avenue
Sunnyvale, CA 94086
(408) 730-5900

Motion Magazine
Box 6430
Orange, CA 92613
(714) 974-0200

Motorola
5005 E. McDowell Rd.
Phoenix, AZ 85008
(602) 244-6900

PCIM
2472 Eastman Ave. B33
Ventura, CA 93003
(805) 658-0933

Precision Monolithics
1500 Space Park Dr.
Santa Clara, CA 95052
(408) 727-9222

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

SGS
100 East Bell Rd.
Phoenix, AZ 85022
(602) 867-6959

Sprague
363 Platinum
Worcester, MA 01605
(508) 795-1300

Superior Electric
383 Middle St.
Bristol, CT 06010
(203) 582-9561

Tektronix
Box 4600
Beaverton, OR 97076
(800) 426-2200

pecially when it comes to cheaply finding, shearing, and bending any heavier metal. You might want to substitute an air-conditioning outfit, a welder, or even a blacksmith shop here.

At any rate, one resource stands out head and shoulders above all others for hacker modelmaking. That is *Small Parts*, who stock everything your hardware store never heard of, besides custom-cutting small pieces of metal and plastic for you. All at fair prices, selling to anyone, with very low minimum orders.

A second major resource would have to be *JerryCo*, who have a mind-boggling assortment of low-priced mechanical and electronic surplus stuff. Competitors to JerryCo include *Edmund Scientific, BNF Sales, Herbach and Rademan*, and *C&H Sales*. And don't forget about the many other superb **Radio-Electronics** advertisers.

The "super hardware stores" that industry shops at include *McMaster-Carr* and *W.W. Granger*, both of whom have warehouses in most major cities. I guess I'd have to also include *Stock Drive Products* here for timing belts, gearing, and such, although their pricing is often on the high side.

While I know of no magazine or trade journal aimed directly at hacker modelmaking, seven of your "must have" publications include *Model Railroader, Fine Scale Modeling, Design News, Machine Design, Nuts and Volts, Signcraft*, and the *New Equipment Digest*. Don't tell NED who told you about all their great free samples each month.

For a wide-ranging assortment of fairly priced books on all aspects of prototyping and modelmaking, *Lindsay Publications* is a good choice.

For all the materials themselves in smaller sizes, try *K&S* for metal sheet, rod, and tubing; the *Evergreen* folks for custom-cut vinyl; *NorthEastern* for wood shapes that are precision precut into the magic sizes favored by model railroaders, architects, and doll-house builders; and *Milled Shapes* for any miniature brass extrusions.

For larger wood stuff, check into *The Woodworker's Store, Constantine*, or *Edlco*. Nothing sharpens up a prototype case better than making it from an exotic wood such as Bocote, Wenge, Cocobolo, or Padouk.

It used to be that cardboard was cardboard and posterboard was posterboard. But today, there are dozens of easily worked, sturdy, light, and good-looking high-tech sheet stocks especially designed for models and mockups. One leading distributor of those materials is *Fomeboards*.

Several random companies do fall into the "neat stuff" category, making them extremely valuable resources for modelmaking. Some of them include *Hygenic* for rubber sheeting and tubing; *Caplugs* or *Sinclair and Rush* for all sorts of unique closures; *Plastiglide* and *ITW Fastex* for unusual plastic items; *Bead Chain* for themselves; and *US Plastics* for plastic stock. Other obvious cheap plastic sources are the Lexan glazing sheets from any local glass cutter. If you have any modelmaking favorites of your own, please let us know so we can pass them on.

New tech literature

A design for a hackable very-low-noise FET amplifier appeared in the June 1989 *Review of Scientific Instruments* on page 1194. It is claimed to be 100 times better than anything else available. Other sources of low-noise amplifier info include *Precision Monolithics, Burr Brown* and *Linear Technology*.

Rohm has a pair of new data books available on all their absolutely outstanding hacker inte-

continued on page 97

AUDIO UPDATE

The sound of CD—Part I

LARRY KLEIN,
AUDIO EDITOR

THE ADVENT OF THE DIGITAL COMPACT disc was greeted by the major audio companies as the ultimate achievement of the audio art, the final step in the long and arduous march toward absolute recording fidelity. In their view, the dawn of digital meant that we no longer would be troubled by clicks, pops, hiss, and the other extraneous noises heard with LP's and tapes. Furthermore, wow and flutter and the other playback-speed irregularities inherent in all turntables and tape decks disappeared through the magic of digital processing. Distortion was reduced to the vanishing point, and dynamic range approached that of live music. In short, the sonic millennium had arrived.

Audio old-timers, such as myself, usually assume a wait-and-see attitude when faced with extravagant audio claims. But in the case of the compact disc, the fidelity claims seemed solidly based on accepted and well-understood (by some) digital technology. So it seemed that Audio Utopia was finally within our grasp, right? Wrong! No sooner had compact discs and their players reached the marketplace then the complaints started. We were told that CD recordings sounded shrill, harsh, unmusical, lifeless, or clinical; that they lacked warmth and depth; and, in general, were an insult to the critical ear. If many of the complaints sounded familiar, it was because we had heard them before—used by lovers of tube equipment (vacuuphiles?) to describe transistor amplifiers.

It became clear early on that the fidelity fundamentalists who published and read such underground magazines as *Absolute Sound* and *Stereophile* were not going to support CD. For those golden-eared self-appointed defenders of musical virtue, digital recording and playback was obviously the work of nefarious forces. And their anti-digital bias was backed up by a group of recording engineers who had financial and emotional investments in older technology—including direct-cut (no tape) disc masters.

Justified complaints

One can't be a frequent reader of U.S. and British audio publications without quickly becoming aware of their occasionally technically nonsensical views and evaluations. As a result, I've learned to be somewhat cynical about their judgments as to what sounds good, what doesn't, and how it got that way. So, considering the sources, my initial reaction was to disregard all the complaints about CD harshness—until I began to hear it myself!

The more vociferous CD critics claimed that the problem was inherent in the digital format. After all, how could anyone expect anything musical to survive being chopped into millions of digital bits and then reassembled as a series of smoothed-over adjacent square waves? But disregarding the theories advanced by the technically ignorant, exactly what was going wrong?

Several investigators compared some of the harsh-sounding early CD's to LP's cut from the same masters. In the comparative measurements, the CD's showed broad response peaks of about 2 dB extending from about 2 kHz right up to perhaps the high-frequency limits of the program. The audible effect of that type of response curve is certainly enough to trigger the complaints—but where did it come from? Was it an artifact of CD processing? Ironically, the hump in the CD response occurs because of LP processing!

When preparing an LP master tape, mastering engineers typically program equalize to "pre-compensate" for the normal high-frequency losses that occur in the disc-mastering and playback process. But when the same equalized master tape is used for the compact disc—which does not suffer equivalent high-frequency losses—the inappropriate high-frequency boosts are heard during playback as harshness.

It may seem hard to believe that incompetent audio engineering resulted in the release of so many harsh-sounding CD's, particularly since the ultimate success of the new CD format was to a large degree dependent on its superior sound quality. But the explanation seems reasonable to me, considering my experience over the years with lousy sounding LP's from major record companies when their engineers were *not* contending with a new technology.

In any case, proving that the spurious boost is the cause of the harsh, gritty quality troubling early CD's is a fairly simple task. All that is needed is an octave-band equalizer to pull down the response where incompetent engineering has boosted it. When that's done, CD's and LP's sound very much the same, except that CD's lack the spurious LP noises—and may not have the desired level of stereo ambiance.

The difference signal

The moment-to-moment differences between the right and left channels of the stereo signal provide the sense of space and ambiance around the recorded performance. By manipulating the L – R (Left minus Right) difference signal equipment, designers can artificially widen the sonic sound stage, create enhanced ambiance, or even produce a rear ambiance channel. It has usually been assumed that the recording process doesn't appreciably affect the L–R signal aside from the slight (and inaudible) loss of separation resulting from the transfer from master tape to disc or cassette.

Why, then, should listeners comparing a CD to an LP sometimes report a loss of ambiance and "air" surrounding the performers? The most likely explanation is that the cutter head in the mastering studio and/or the phono cartridge in the listener's record player exaggerates the vertical modulation in the record groove that carries the L–R information. Thus, paradoxically, the slightly lower level (–1 dB or so) of difference signal on the CD corresponds more accurately to the master tape than does the LP. How does cassette or open-reel tape enter into the picture? Perhaps the tape's wider separation audibly compensates for the lack of vertical modulation enhancement.

Bob Carver, who supplied me with some of the above data, has built into several of his Carver Corporation CD players a "Digital Time Lens" that regenerates the lost L–R signal and simultaneously equalizes the unwanted high-frequency boost out of harsh CD's. For CD's without problems, the circuit can be switched out.

Now that we've resolved the question (Ha!) of the sound of compact discs, next month we will examine the sound of CD players. Do they all sound essentially alike, as many critics claim? **R-E**

RELAYS

continued from page 63

coil to latch and a second to reset. Carrying the latching idea one step further, a coil, a ratchet, a cam, and several sets of contacts can be combined to create an impulse-driven sequencing relay. The cam is usually cut to provide a specific switching sequence for controlling operations; a home-appliance example might be a washing machine.

In a magnetically-latched reed relay, a small permanent magnet goes inside the coil. The magnet is strong enough to hold the reeds together once in contact, but not strong enough to pull them together initially. Energizing the coil with one polarity adds to the field and closes the reeds, which remain closed until the coil is energized with the opposite polarity. For applications where reversing coil polarity is inconvenient, two-coil latching reeds can be used. A similar idea using a weaker magnet is sometimes used in non-latching "polarized" relays to improve efficiency. The magnetic field reduces the coil current needed to actuate the contacts, but is weak enough to release them once the coil is deenergized.

The IC relay, recently introduced by Aromat, uses an IC, a capacitor, and a latching reed in a single package. The IC uses the capacitor to pulse the relay, latching when a control input goes high and resetting when the control goes low. Since coil power is drawn only when pulsed, average power use is very low. Time-delay relays provide delay in actuation, dropout, or both, as shown in Fig. 9.

The on-delay relay of Fig. 9-*a* pulls in during the operating voltage and remains energized until the operating voltage is removed. Off-delay relays as in Fig. 9-*b* need continuous power as well as a control input, energizing immediately after the control goes high, and beginning their turn-off delay after the control goes low. Interval relays, as in Fig. 9-*c*, energize immediately on the appearance of the operating voltage, and turn off prior to the end of the operating voltage. In the latching-interval type of Fig. 9-*d*, the control can turn off any time.

In the on-delay/off-delay version of Fig. 9-*e*, there are two independent delays, each referenced to the leading and trailing control-pulse edges. The repeat cycle version of Fig. 9-*f* has two delays, the second dependent on the duration of the first. The on-delay relay of Fig. 9-*g* finds the area under the pulses of the control by integration, which in this case is directly proportional to total control-pulse duration, and compares this accumulated value to a reference to determine when to energize the output relay. The output pulse-duration is independent of its turn-on time. Finally, in the latching on-delay version of Fig. 9-*h*, the control pulse can turn off at any time.

In the past, the delay was mechanical, but is now usually electronic, usually a variation on a monostable multivibrator. Mechanical time-delay relays used inertial masses for fraction-of-a-second delays, and motor-driven mechanisms for delays ranging from seconds to hours. Thermal mechanisms, less expensive but less accurate, were also used; some versions are still available.

Timing relays have progressed to the point now of including microprocessors, crystal timing, and thumb-wheel control. Those relays provide variable latching interval each time the input goes high, various counting modes, and other functions. Finally, low-offset reed relays minimize errors when switching millivolt and microvolt DC signals, providing optimum accuracy in data acquisition systems which switch signals from low-level transducers such as thermocouples and strain gauges. Figure 10 shows one such device by Thermosen, Inc. The contacts are outside the magnetic coil, eliminating the need for magnetic-alloy contacts, and permitting high-conductivity gold-plated silver contacts to be used.

One major problem in switching and handling low-level DC signals is unwanted thermocouple voltages. Any connection of unlike conductors forms a thermocouple, generating a voltage varying with temperature. Usually, the internal conductors are silver and the pins are silver alloy. The external pin-to-copper connections are located close together to ensure equal temperatures and thermocouple voltages. Internally, the physical separation of the contacts and the coil minimizes heat in the conductive path. The manufacturer states that the relay introduces a net thermal offset of less than 1 μV. R-E

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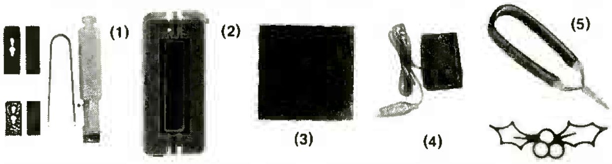

(1) **IC In/Out Tool Kit.** For 6 to 40-pin DIPs. #276-1581 .... 6.95

(2) **IC Pin Aligner.** #276-1594 ... 2.99

(3) **Conductive Foam.** 5 x 5" safety mat for your bench. #276-2400 ...... 1.29

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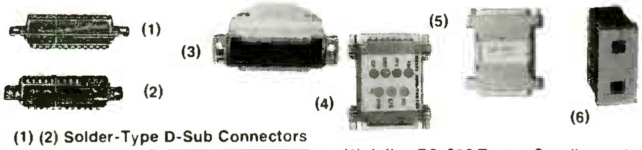
RS-232 Connectors, Accessories



(1) (2) Solder-Type D-Sub Connectors

Type	Cat No	Each
Male 9	276-1537	99
Female 9	276-1538	1 99

Type	Cat. No.	Each
Male 25	276-1547	1.49
Female 25	276-1548	2.49

(3) Metal-Shielded Connector Hoods.
9-Position. #276-1508 .... 2.19
25-Position. #276-1510 .... 2.79

(4) **Inline RS-232 Tester.** Spot line problems fast. #276-1401 .... **14.95**

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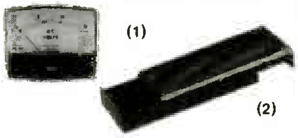

(1) **0-15 DC Voltmeter.** Mounts in $1^7/_8$" round hole. #270-1754 .... 7.95

(2) **Two-Piece Enclosure.** Easy to drill or shorten, if desired. Accepts PC board and 9V battery. $5^5/_8 \times 2^1/_4 \times 1^1/_{16}$". #270-257 .... 4.99

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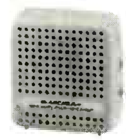

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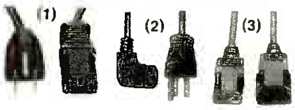

Top-quality, grounded 6-foot AC cords for computers, printers, business machines. UL listed.

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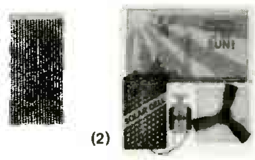
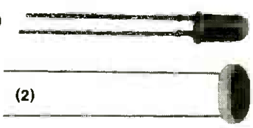


(1) **Silicon Solar Cell.** Produces about 0.3 amp at 0.55VDC. #276-124 ... 3.95

(2) **Solar Project Kit.** Includes mini solar panel, motor, propeller, project booklet. #277-1201 .... 10.95

Assortments



(1) **20 LEDs.** Assortment may include MV-5054, MV-50, RL-209 in red, green, amber, infrared. #276-1622 .... 1.98

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6	Female	274-155	1.69
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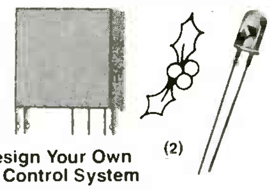

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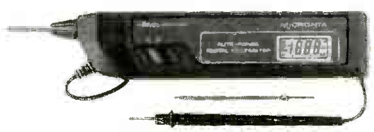

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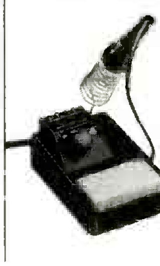

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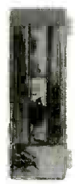

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DRAWING BOARD

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PC photography

ALTHOUGH THE FURTHER YOU GET IN making a PC board, the less thought is involved, things don't necessarily get easier. When you finally do the photographic part, you may be thinking less, but you'll be working just as hard. Don't forget Grossblatt's twelfth law: THINGS DON'T GET BETTER, THEY JUST GET DIFFERENT; a problem is a problem, no matter how you look at it.

Making the negatives

By this time you should have a camera negative of the PC board layout you made on graph paper. It may be full of dust spots ("hickies"), but they'll be taken care of later. Having the camera film doesn't mean you can trash the original artwork—close, but not quite. The next thing to be done are the actual camera film negatives; how much work that entails depends on whether you're using positive or negative resist. No matter what method you use, the first step is to enlarge the camera film and make a full-size print of the layout. An enlarger is best, but there's another way if you don't have one.

If you shot the layout with 35 mm film, you can put the film in a mount and use a slide projector instead of the enlarger *if* you're careful. Use glass mounts to make sure the projector bulb heat doesn't curl the film and distort the image. Put a red filter over the projector lens so you can position the unexposed film. You'll also need some way to make sure the unexposed film surface is perpendicular to the slide in the projector.

The enlargment setup you'll have to arrange is shown in Fig. 1. It's not as good as an enlarger, but it can work if the slide projector is set up properly and the room is dark enough. The print made this way will be actual size, so use lithographic film at least an inch larger than the PC board in both dimensions. This gives you an extra border to handle the negative and tape it to the PC board copper side.

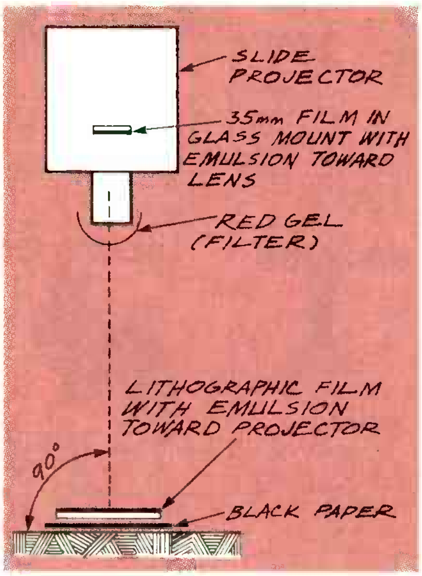

FIG. 1

Exposing and processing the film is easy, but making the final print *exactly* 1:1 will take work. Some people put dimension marks on the original artwork and measure them on the projected image. This is a good theoretically, but remember Grossblatt's eighth law: THEORY AND PRACTICE ARE ONLY THEORETICALLY RELATED.

The only way to *absolutely guarantee* actual size is to project the image onto graph paper from the same pad you used to create the artwork in the first place. Standard component spacing is done in 0.1-inch increments, making the graph paper a perfect negative template. Tape a piece of flat black paper on a wall, since you'll need a backing for the film when you make the actual exposure. If you use an enlarger, tape the black paper to the easel. The projector light will go right through the film; without a black surface to absorb it, there might be a second, spurious, image.

Put the graph paper on top of the black paper, the original camera film in the enlarger or projector, and adjust the projected image size. Varying the image will also change it's size so you'll have to adjust for a sharply focused image of correct size. You can use IC pads as a good way to check image size. Since they're on 0.1-inch centers, they should line up with the graph paper grid. Check the size at points all across the image to make sure of the enlargement. If one edge lines up but not its opposite, the image isn't being projected perpendicularly.

Exposure and development are done the same way as for the original camera film, the only difference being the exposure time since you're using a different light source and lenses. There's no exact time to use, but the film has incredible latitude; since you can watch it develop, better to overexpose than to underexpose.

A 1-minute exposure time is a good reference; the film is expensive, so experiment on small test pieces first. Once the film is developed and dried, you shouldn't need the original artwork any longer. If you modify the layout, you can always make a paper print of the film to make the changes. Besides, the adhesive on the tape and pads on the original eventually dries out and falls off the graph paper.

Next, clean any dust off the film using a magnifying glass and X-acto knife. Lay the film *emulsion* side on a piece of white paper and carefully scrape off the hickies and other contamination. Use tape and pads to add black to the film on the *base* side, *not* the emulsion, since the next step is to contact print the film with the emulsion side down.

If you use positive resist, you're finished with the photographic part of this process, but if you use negative resist, you still have to make a film negative. You can make PC boards reliably either way, but while negative resist takes an extra photographic step to make the film, it gives you another chance to clean it.

All the black on the positive becomes copper on the final board, so scraping away emulsion is equivalent to removing unwanted copper. When working with a negative, the clear areas become the copper so scraping emulsion is the same as adding copper.

Producing the negative is done by contact printing the positive on a piece of lithographic film. You can use the projector or the enlarger as the light source with the same exposure times. Put the two pieces of film *emulsion-to-emulsion*, and lock them in a contact frame. You can also use glass, but back the whole thing with black paper again; the PC board production setup is shown in Fig. 2.

Making the PC board

Once you've got the final print, you're ready to deal with the copper PC board; it has to be sensitized, exposed, and developed, before it can be etched. Cut yourself a piece of PC board at least an inch larger in each dimension than the printing negative. Before the PC board can be sensitized, the copper has to be *absolutely clean*.

The best way to clean the copper is by scrubbing with soap-filled

Continued on next page

RC DECADE BOX

continued from page 42

increase residual resistance and capacitance, and cause inductive effects at high frequencies. Solder resistors as close to the switch terminals as possible, and the fuse holder goes between BP1 and the pole of S6. Pin 1 of S6 is soldered to the pole of S5, pin 1 of S5 to the pole of S4, etc., ending with pin 1 of S2 being soldered to the pole of S1. The pole of S1 is soldered to pin 1 of S13.

Solder capacitors to each position on S7–S12, and their common leads to a single lug above the switch base. Connect all common lugs together and to pole 2 of S13. Solder all poles of S7–S12 together, and then to BP6. Drill the case as in Fig. 5.

Checkout

Visually inspect all wiring and soldering; to complete the checkout, use an ohmmeter and capacitance meter. Turn S13 to position R/C, set S1–S6 to zero, place an ohmmeter between BP1 and BP2, and measure the residual resistance; it should be under 1 ohm. As you rotate S1, the meter should increment by the value of the connected resistors. Set S1 to 0, and repeat for S2–S6. After S1–S6 are tested, set each to 1-6, in turn. The meter should indicate the sum of each switch times its multiplier, or 1.11111 megohm, 2.22222 megohm, etc., up to 11.1111 megohm. Repeat for the capacitance section.

Turn S13 to the SER position and measure the capacitance between BP1 and BP6; you won't be able to measure resistance in this position. In the PAR position, measure both resistance and capacitance between BP1 and BP6. In the LPF position, measure the resistance between BP1 and BP6, and the capacitance between BP6 and BP4. With S13 set to HPF, measure the resistance between BP1 and BP4, and the capacitance between BP6 and BP1. The decade box should now be finished.

Once you've gotten everything working, using the resistance or capacitance sections is straightforward. Just set S13 to the desired position, and use the terminals indicated in Fig. 4 and Table 1. The RC filters can be used to either eliminate unwanted circuit noise, or perform pulse shaping and delays. R-E steel wool and hot water. You'll leave fine scratches, but make sure they're linear, *not* circular; development will be easier if this is the case. Dry the board with paper towel (watch out for lint), and handle it only by the edges or skin oil will ruin your work.

Resist comes in both spray cans and bottles. I don't use spray cans because they have a habit of spitting, are expensive, and have limited shelf life. I bought a quart bottle of Kodak Photo Resist (Catalog #189-2074) about eight years ago, I've made a lot of boards with it, and it's still half full. The same with the developer; I bought a gallon of Kodak Photo Resist Developer (Catalog #176-3572) at the same time and still have half left. All of the chemicals you use have some level of toxicity. Work in a well-ventilated area, and keep the containers well sealed.

Pouring the resist on the PC board is simple, but more is too much. Pour a few drops on the copper and cover the surface by slowly tilting the board from side to side. You can use a small brush, but keep the strokes short, and make sure no air bubbles or contamination get trapped on the surface. Once covered, set it at an angle to let the excess run off. The resist is only sensitive to a narrow band of UV, so you can keep a fairly bright light on while you're working.

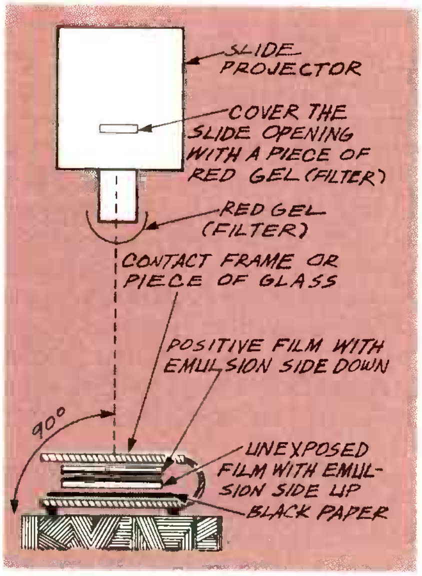

FIG. 2

The resist dries quickly, but you can speed things along with a hair dryer. This tends to get resist trapped in the upper part of the liquid and makes exposure and development much easier. Use about a 100° F (medium setting on most models) because the resist loses photosensitivity if it's too hot. Make the exposure by putting the negative on the board, locked in the contact frame.

I use an old sun lamp to expose the board for 7 minutes at about 2 feet, but any light source between 300–400 nanometers in wavelength will work, like mercury vapor (found in most sun lamps), or type-BL UV fluorescent lamps.

Applying the resist and making the exposure are critical to making the PC board, so you can never get too much information. Kodak makes a great booklet called "Photofabrication Methods with Kodak Photo Resists" (Catalog #P-246), that even has answers to questions you never thought of; get it. Next month, we'll finish off, and discuss what can be done to make the PC board manufacture less of a hassle. **R-E**

SPECTRUM ANALYZER

continued from page 32

peak again centered, the user then sets the VAR SPAN to CAL. The peak should compress to its minimum observable width, and the user moves the HORIZ POSITION knob to recenter the peak one final time. If done properly, rotating the VAR SPAN control toward ZERO SPAN should expand, but result in no horizontal deflection. The procedure should become habit after a couple of trys.

The graticule and CRT

The vertical axis is calibrated in both dBm and dBmV; there's a 49 dB difference between the two scales. The top horizontal line of the graticule indicates numbers in both dB and dBmV, the reason being that the graticule was a holdover from an earlier instrument. The numbers indicate the interpretation associated with the top horizontal line, for the various three lower settings of the REFERENCE LEVEL knob; the upper setting (20 dBm or 69 dbmV) isn't represented. The PSA-65A also updates the CRT every 5 seconds, causing it to flash briefly.

Conclusion

Even with the minor limitations like the TUNING knob lag on the LCD in NORM mode, the nonlinearity of the FINE TUNE knob, the reverting to a time-dependent display in the ZERO SPAN position of the VAR SPAN knob, and the need for horizontal calibration, this is a *very* impressive instrument for the price. It allows spectrum-analyzer capability at a fraction of normal cost, and will popularize the concept of using one as a complement to an oscilloscope. AVCOM is certainly moving toward their goal of putting a low-cost spectrum analyzer on every RF technician's workbench.

At $2675, the PSA-65A is a definite bargain. Even if you think that you don't need a spectrum analyzer, we're sure this one would prove you wrong. R-E

DIGI-COMPASS

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The "port" value shows the currently used LPT port. You can switch between the available LPT ports by pushing the "P" key. That is extremely handy while debugging the compass or if you have two compasses attached to your computer.

The text-only program, TEXTCOMP.EXE, must be used if your display adapter is not compatible with COMPASS.EXE. It too will auto-configure the LPT port and provide default acquisition averages. You can include the LPT port on the command line as well as the number of acquisition averages to perform (up to 255). To include the average argument, you must include the LPT port argument. Standard syntax is: TEXTCOMP LPTn10, where "n" is the printer port desired (1, 2, or 3), and "10" is the number of averages (0–255).

Calibration

All adjustments must be made on a flat non-metallic surface, and the compass unit must be calibrated according to the manufacturer's instructions first. Keep the compass sensor away from the compass display, computer equipment, metal objects, etc. Any magnetic fields generated by electronic equipment or appliances, or nearby ferrous metals could affect the calibration accuracy of your Digi-Compass. Also, do not use a metal screwdriver to adjust the compass or your adjustments will be meaningless; use the supplied non-magnetic adjusting tool.

To run the text-based compass program, plug the interface into the parallel printer port of an IBM PC/XT/AT. On the command line type "TEXTCOMP LPTx" (where x is a 1, 2, or 3, depending on the port used). Be sure to specify directory paths as required. For example, suppose you plugged Digi-Compass into LPT1 and had TEXTCOMP.EXE on a floppy in the A drive. At the command prompt, you would type "A:TEXTCOMP LPT1."

To calibrate the interface unit, adjust the "max-limit" potentiometer (R17) to 4.15-volts DC at pin 1 of IC3 and the "min limit" potentiometer (R18) to 1.15-volts DC at pin 3 of IC3. With the interface unconnected from the computer, carefully direct the flux-gate sensor exactly to the Northeast, keeping the sensor perfectly horizontal. Adjust the "gain" potentiometer (R16) on the interface so that pin 2 of IC3 is 4.25-volts DC.

Aim the sensor up to 5 degrees towards the North, and then up to 5 degrees to the East, and verify that the voltage does not exceed the adjustments—otherwise re-adjust. When aiming the sensor for the 5-degree test, ignore all measurements beyond the 5 degrees.

With the Digi-Compass interface connected to the computer and TEXTCOMP.EXE running, verify that at the Northeast direction, when the X and Y readouts match (±2), that the highest value is 220 (±5). Adjust R17 to set the highest value. Next, verify that at the Southwest direction, when the X and Y readouts match (±2), that the lowest value is 30 (±5). If necessary, adjust R18 on the interface to set the lowest value. Now go back and recheck those steps, as they are interactive. Verify that the compass readings match the computer's readouts while in the "digital" mode. The Digi-Compass interface is now adjusted. **R-E**

CD PLAYERS

continued from page 53

detector outputs are fed to a preamp and a data strobe to differentiate between logic-highs and logic-lows and extract sync. The data processor demodulates signal data, does error detection/correction, and performs overall signal processing control.

All CD's have some provision for interleaving error-correction information into signal data when a disc is recorded, minimizing the effect of audio dropouts. The loss is distributed over various smaller gaps in the final audio. "Filling in" missing information on either side of a gap isn't difficult; the D/A converter follows the signal processing, and the restored analog is then restored to pure two-channel audio by a *S*ample-and-*H*old (S/H), and applied to the two stereo channels.

Proper test equipment

When servicing CD players, the entire laser pickup has to be replaced in the event of a failure; optics are rarely adjustable, except for the drive motor, drive belt, or gears. According to a recent EIA publication, the laser pickup is most prone to failure due to wear. CD test equipment is similar to that used in standard audio. Sencore Electronics has many CD servicing products (see Table 1), but they don't have a laser-power meter. While such meters are available, you can get by without one by testing the detector diode outputs; if incorrect, the defect is in the laser pickup.

You'll need a test disc, available from some CD manufacturers, and a standard disc with prerecorded high-precision test signals. Play it and note the CD's response, using the indicated instruments, if possible. The test disc is used to make any CD adjustments. You can use any known good disc and a stereo power amplifier analyzer for a final check and to demonstrate the player for a customer.

Servicing CD players requires that you know what the basic function of each section of the circuitry does. You will, of course, also need your basic electronics troubleshooting skills. Aside from that, all you really need is a little mechanical know-how; just study the mechanical operation of the player, and you'll probably find the defective part. **R-E**

THOROUGHLY MODERN MODEMS

Recent advances in modem technology make it harder than ever to pick the right modem. Here's how.

TJ BYERS

ISDN paints an attractive picture of communications in the next century, but for now we'll have to live within the confines of the Public Switched Telephone Network for our communications needs. And that means improving the speed and performance of existing modem technology.

Fortunately, modem technology has kept pace with increasing PC speeds. Using advanced data compression and encoding techniques, in only a few years modem communications has gone from 300 bits per second (bps) to 9600 bps—with some modems having data throughput exceeding 30,000 bps.

Unfortunately, the lack of a single high-speed modem standard makes it impossible to pick just any modem from your dealer's shelf and expect it to talk to anybody else's modem. Many models use proprietary transmission modes that can only talk to modems of their own kind.

So how do you know if one modem can talk to anther modem from a different manufacturer? By understanding how modems differ, as we shall see.

Establishing the ground rules

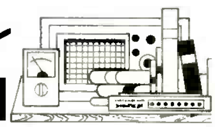
A modem has two basic functions. The first is to convert binary data into analog signals for transmission over standard telephone lines, and the second is convert analog signals back into binary data suitable for a computer. The first process is called modulation, and the second, demodulation, hence the name modem (MOdulation/DEModulation).

To ensure that modems from different manufacturers can communicate, standards for encoding, transmission, and decoding have been established, first by AT&T and more recently by the CCITT (Cooperative Committee for International Telephone and Telegraph).

At speeds as high as 2400 bps, the protocols are well defined and universally accepted, and virtually all modems within this class can communicate with one another. It's beyond 2400 bps that problems begin.

continued on page 86

EDITOR'S WORKBENCH



386 Power On A 286 Budget

You want a 386, but your pocketbook says no. End of discussion? Maybe not, depending on what you want that 386 for. If it's raw speed you're after, you're out of luck. But if intelligent memory management puts a gleam in your eye, you'll find a Canadian product called the All ChargeCard highly interesting.

Briefly, the All ChargeCard is a small module that you install between the 80286 microprocessor and your system board. The basic product costs about $400, but unless your 286 is a PGA type (most non-IBM machines aren't) and readily accessible, you'll need a $100 adapter kit. Figure 1 shows the module surrounded by various adapters and tools included with the kit.

By itself, the ACC doesn't change operation of your system one iota. But with the accompanying software, the ACC lets you pull 386-like tricks on your 286. Such as?

- Increase DOS size to 736K (in color systems not running graphics programs, or 704K in mono systems).
- Speed up system operation by ROM "shadowing" (running the BIOSes from RAM, rather than ROM, which is slower).
- Use memory above 640K for DOS's FILES, BUFFERS, and LASTDRIVE storage areas.
- Use memory above 640K to load device drivers—including RAM-hungry network drivers.

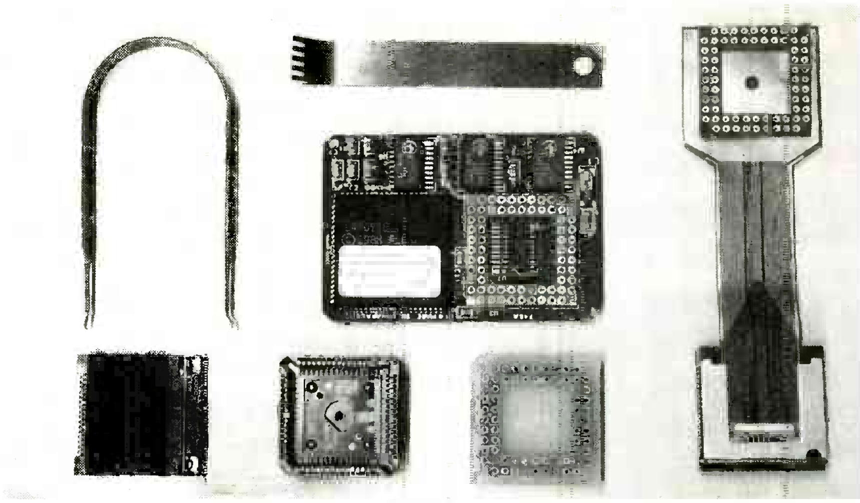


FIG. 1

- Use memory above 640K to load TSR's: SideKick, DOS's MODE program, Smart Key—you name it.
- Convert some or all extended memory into fully register-compatible EMS 4.0 memory, which is great for running OMNIVIEW and Windows.
- Add EMS 4.0 page frames above 640K to let Windows run more efficiently.

The disadvantages? Cost is one. At $500, the ACC is just a few hundred dollars cheaper than the least expensive 386SX system boards that are currently on the market. And even with the ACC, a 286-based system will *never* be able to run 32-bit software, nor will it be able to take advantage of full 32-bit address and data buses.

Installation

Installation can be difficult, depending on the physical configuration of your system. If the microprocessor is soldered to the system board, you're simply out of luck. Best is a PGA type, which is used in IBM AT's and a few other compatibles. (All Computers has a list of machines and corresponding CPU socket types.) The PGA type has rigid pins that allow you to insert the IC into machined socket pins. Most machines, however, use LCC or PLCC types, which require the adapter kit.

In my test system (an AST Premium/286 with a PLCC socket), installation was fairly easy. My CPU socket is located near the left edge of the system board, not under the hard disk drive or disk controller, as with some compatibles. The module protrudes high enough above the system board to interfere with expansion cards, but by inserting my ⅔-length Paradise VGA card in the matching expansion slot, I didn't have to sacrifice any slots. Prying the CPU out of its socket was quite difficult, even with the special tool supplied by the company. (The heatsink visible in the photos was supplied by me simply because I happened to have it, not because the company recommends it.)

After installing the card, you'll want to set up any non-DOS memory in your system as extended memory (that normally addressed linearly above the 1MB mark) to let the ACC do its tricks. You may have a problem if your system board forces you to allocate 384K of memory as extended memory.

After completing the physical installation, you can boot your PC and run as normal. However, to reap the benefits of the ACC, you must install a device driver in your CONFIG.SYS file. Depending on the options you specify there, you can backfill memory to the 640K mark or higher, specify the amount of memory to allocate as EMS and as extended, enable ROM shadowing, etc. To maximize contiguous DOS memory you should remove the FILES, BUFFERS, and DEVICE statements from your CONFIG.SYS and run All's corresponding programs from AUTOEXEC.BAT.

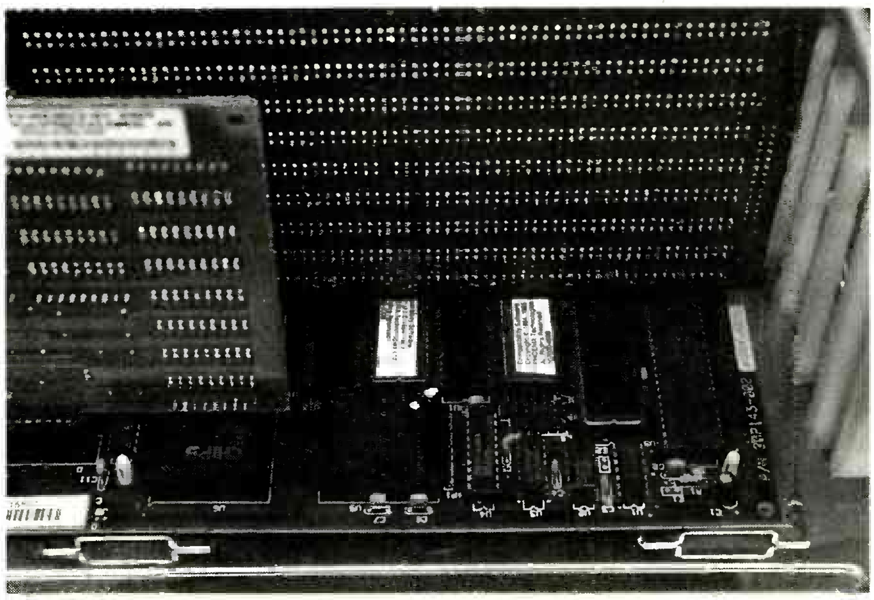


FIG. 2

The real world

I found the All ChargeCard a pleasure to use. With it, I ran OMNIVIEW (a multi-tasking environment) and was able to download files (using ProComm Plus) from an on-line information service at the same time as I wrote this review. In addition, the card increased my DOS memory space by about 25K, and if I gave up the ability to run graphics programs, by about 120K.

The ACC may seem kind of "kludgy" but it's been through several design iterations (early versions required you to modify your application programs), and most of the kinks have been worked out. Even so, there are still a few. For example, you can't reset your machine by pressing Ctrl-Alt-Del or even a hard' reset switch: instead, you must run a small program that clears the ACC's registers and then performs the normal DOS reset sequence (i.e., JMP FFFF:0000). The problem is that you don't always have access to the DOS command line when you want to reset your machine (for example, if a program has hung your system). In that case, your only recourse is to power down and back up.

A somewhat more serious problem is that the ACC doesn't handle DMA operations properly. To increase transfer speed, tape backup units often grab direct control of the DMA hardware. That can be a problem with the All software running, because physical and logical memory no longer correspond to one another. The company supplies a program that is supposed to solve the problem, but it left my machine with only 372K of DOS memory, which was not enough to run my Irwin 785 tape drive. My only recourse is to remove the All EMS driver from CONFIG.SYS, reboot, run the backup software, restore the driver, and reboot again. And that's a real pain. Of course, if you don't use software that takes direct control of the DMA hardware, it won't be a problem for you.

All in all, then, the All ChargeCard is quite an intriguing device. At half the price, it would be a steal. However, at the $500 level, it's just under 386SX system board and accelerator card prices (which will undoubtedly continue to fall), so choosing between the two is difficult. If compatibility with future 386 software is important to you, you'd be better off avoiding the ACC. But if you want to upgrade now at the lowest possible cost, the All ChargeCard won't disappoint you. CD

Insults A La Carte

Creating insults is an all-but-lost art. Anyone can string together a bunch of four-letter expletives, but that's not what I'm talking about. Rather, things like: *You boring mound of septic camel manure* or *You bungling tub of soppy buzzard barf* or . . . well, you get the idea. If you admire such crafty use of language, but find it difficult to create such gems yourself, get a copy of Insults2, a public domain-program. It's available from the author directly for $5, or free from many BBSes, including RE's (516-293-2283, 300/1200 bps, 8/N/1). The author also sells a related product, called Pranks, for $20. Pranks is a collection of programs you can run on an unsuspecting user's PC to make him think there is something seriously wrong with it. Pranks is neither public domain nor shareware, and it must be ordered directly from the author. CD

ITEMS DISCUSSED

- Insults2 ($5), Pranks ($20). Modern Advisory Institute, P.O. Box 11632, Salt Lake City, UT 84147. (801) 569-0730.
  CIRCLE 48 ON FREE INFORMATION CARD
- All ChargeCard ($399), Adapter kit ($100), All Computers Inc., 1220 Yonge Street, Second Floor, Toronto, Ontario, Canada M4T 1W1. (416) 960-0111.
  CIRCLE 47 ON FREE INFORMATION CARD

MODERN MODEMS

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One problem is simply the 2700-Hz bandwidth of the telephone line. Another is the incompatible compression methods modem manufacturers use to maximize throughput. Low-speed modems have the advantage because their 2400-Hz bandwidth easily fits into the voice band. To move the data faster, however, we must increase the coding density of the carrier by using more complex coding methods (see sidebar).

Unfortunately, the transmitted waveform gets more intricate as coding density increases, and the hardware needed to differentiate between signal changes and line noise grows more complex and expensive. The solution is to change transmission method so the waveform is simpler. However, it's nearly impossible to get two modem makers to agree on a common transmission mode and data-encoding method.

Competing techniques

The first attempts at creating a high-speed modem saw modem makers modifying cheap 9600-bps modems already in common use by fax machines. Those modems, which use the CCITT V.29 transmission mode, provide one-way (half-duplex) data transmission over normal phone lines. But for two modems to talk to each other and carry on a two-sided conversation, they must have a full-duplex link. Two methods are commonly used to make the V.29 modem behave like a full-duplex modem: ping-pong duplexing and statistical duplexing.

In ping-pong duplexing the two modems take turns talking, like two persons carrying on a normal conversation. The first modem begins by turning its transmitter on and sending data. After a prescribed amount of time, control of the phone line is given to the other modem, which now transmits data until its turn expires. The process continues with the two modems swapping packets of data back and forth in rapid, scheduled succession. The disadvantage is that valuable time is wasted if one modem has nothing to send.

Hayes is the most popular manufacturer using ping-pong duplexing (which they have labeled V.32 HDX) with its V-series Smartmodem 9600. However, at 9600 bps, the Hayes modem can talk only to another Hayes modem—not even a 9600 bps modem from another manufacturer that uses the ping-pong method. (The Smartmodem 9600 is compatible with standard modems at lower speeds, however.)

Statistical duplexing uses a high-speed V.29 data channel and a low-speed reverse channel to keep the two modems in touch. The reverse channel is a full-duplex service channel that operates at about 300 bps and is used to let each of the modems know the status of the other. Based on their communication needs, the high-speed data channel is assigned to one or the other. That arrangement is akin to one person in a conversation doing most of the talking—like a teacher who is occasionally interrupted by a student asking questions. Data buffering prevents loss of data when the data channel isn't immediately available.

Statistical duplexing makes better use of the link, but the data still only travels in one direction at a time. The current record holder for statistical data throughput is U.S. Robotics' Courier HST, with a claimed data rate of 14,400 bps.

Echo cancellation

The fastest and most popular high-speed transmission method is CCITT's V.32 full-duplex protocol. A V.32 modem can send and receive data simultaneously because it places both conversations on the line at the same time and uses echo cancellation to sort them out.

Although the two signals clash and interfere with each other, the method works because each modem knows what it is sending. It's like the way we are able to carry on a conversation at a noisy cocktail party by tuning out ev-

MODEM SOUP

Modem jargon is replete with acronyms, coined words, and mysterious V.*xx* codes. Here is a list of the most common modem terms and their meanings. The definitions are grouped by category.

TRANSMISSION MODES

V.32 9600 bps, full-duplex, trellis encoding w/echo cancellation

V.32 HDX 9600 bps, ping-pong duplex, QAM encoding, used by Hayes

V.29 9600 bps, half-duplex, QAM encoding, for use with dial-up fax

V.27 4800 bps, half-duplex, DPSK encoding

V.22 2400 bps, full-duplex, QAM encoding

V.22 1200 bps, full-duplex, DPSK encoding

V.21 300 bps, full-duplex, FSK encoding

Bell 208 4800 bps, half-duplex, DPSK encoding

Bell 212 1200 bps, full-duplex, DPSK encoding

Bell 103 300 bps, full-duplex, FSK encoding

ENCODING/DECODING

Trellis Modified Quadrature Amplitude Modulation

QAM Quadrature Amplitude Modulation

DPSK Differential Phase-Shift Keyed modulation

FSK Frequency-Shift Keyed modulation

DATA COMPRESSION

V.42 Pending CCITT standard, compliant with MNP 2-4 error correction only

MNP 9 Includes all the features of MNP 7 plus V.32 operation

MNP 7 Includes all the features of MNP 5 plus look-ahead frequent-character recognition

MNP 5 Provides sequential and frequent character data compression

ERROR CORRECTION

V.42 CCITT standard, compliant with MNP 2-4

MNP 4 Includes all the features of MNP 3 plus automatic variable data packet sizing

MNP 3 Synchronous framing using CRC

MNP 2 Asynchronous framing using parity bit checking

HOW MODEMS TALK OVER PHONE LINES

Sending digital data over analog phones lines may seem complicated, but it's not really. The technology is based on a modulated audio-frequency carrier (like the RF carrier used by radio and TV) that fits within the confines of the phone network's voice band. The trick is encoding the carrier for reliable communications over the wide range of changing line conditions that are usually experienced on the dial-up telephone network.

Although early modems used frequency-shifted keyed (FSK) modulation to get the message across, modern modems rely on phase-shift encoding.

The simplest phase-shift encoding scheme, called differential phase-shifted keying (DPSK), has two oscillators running 90 degrees apart. According to the value of the binary bit, the encoder chooses between one of the two oscillators at predetermined intervals to produce a waveform similar to that shown in Fig. 1.

The direction of the phase shift itself doesn't determine the value of the data bit. Instead, the bit value is determined by the algebraic sum of the vector components. The two oscillators are 90 degrees apart, so that gives us four vector possibilities (+1, +1; +1, −1; −1, −1,; −1, +1), as shown in Fig. 1. Consequently, if we want to encode a 1 onto the carrier, we must shift the phase difference so that the algebraic sum lands in quadratures +1, +1 or −1, −1. Phase shifts that place the vector in quadratures +1, −1 or −1, +1 cancel to zero. Encoding is done using an exclusive NOR gate, and the signal is decoded using a phase-locked loop (PLL). Both the Bell 212A and V.22 1200-bps modems use DPSK encoding.

With DPSK encoding, the vector sum is scaled to unity (+1). However, if we scale the quadrature components to fractions so that the vector sum assumes

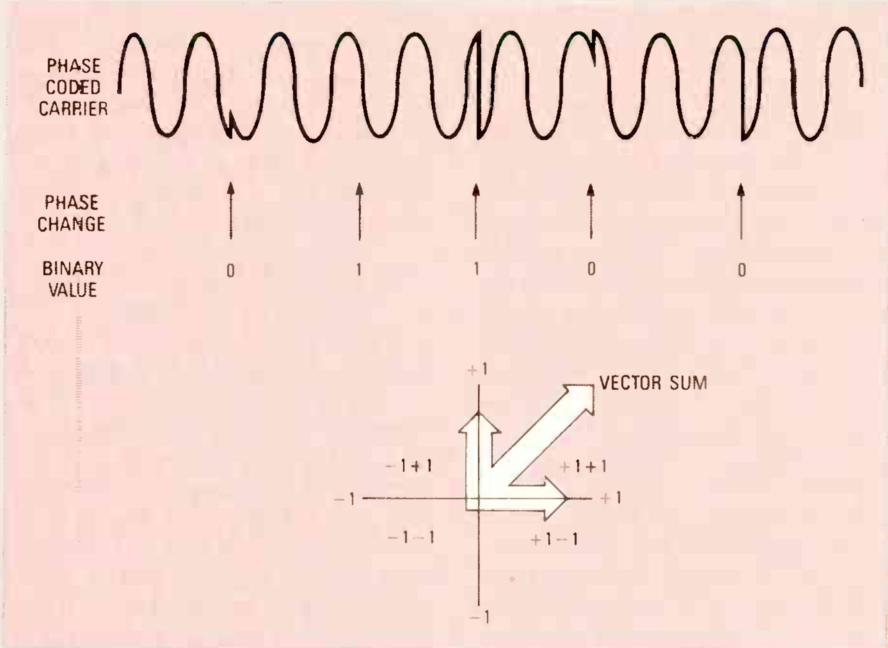

FIG. 1—PHASE-SHIFT KEYED MODULATION is a popular technique in older (less than 1200 bps) modems.

a value somewhere between zero and unity, we can achieve greater coding density. This scheme is called quadrature amplitude modulation (QAM) and is the secret behind successful high-speed modem data encoding.

The first of the popular modems to use QAM was the V.22 modem—the same 2400-bps modem that is sold by Hayes and just about everybody else.

In V.22, the vectors are scaled so that there are 16 vectors rather than four, which means the quadratures can now represent four bits of data instead of two. When this encoding scheme is used on a 1200-Hz carrier, it means the carrier can be modulated at 600 baud and still leave us enough room for two carriers, one at 1200 Hz and one at 2400 Hz, for full duplex operation at 2400 bps.

However, 16-point QAM is the limit for normal dial-up phone communications. Beyond that, the line noise overwhelms the smaller discrete signal changes unless complex—and expensive—decoding hardware is used at the receiver. The economical answer to faster communications rates is to increase the frequency of the carrier. But by doing so, the telephone's voice band can accommodate only one carrier.

An example of this transmission mode is V.29, the CCITT standard that is used by fax machines around the world. It uses a 2400-Hz carrier to provide faithful communications at 9600 bps, but provides only half-duplex operation.

The V.32 modulation technique is very similar to V.29 except that it provides full-duplex operation at 2400 Hz by using echo cancellation. Moreover, as a bonus of the complex data processing required to make echo cancellation work, V.32 is able to offer 32-point QAM encoding. Instead of the expected eight bits of data, however, the eight vectors are trellis-encoded to provide five bits of data. Presently, the fifth bit is used to provide information for the purposes of error correction, which means that the data throughput of V.32 32-point vector is the same as it is with a 16-point vector. But now that 32-point QAM encoding is out of the bag, it may signal the beginning of yet another round of modem rate increases. We're certainly looking forward to seeing that!

erything but what we want to hear. By creating inverted signals of its output and feeding them back into the receiver, the modem can sort out the mess through voltage cancellation. When the transmitter's output goes positive, the receiver's reference voltage goes negative, resulting in a zero voltage at the input of the receiver for that signal. Once the local signal has been canceled, what remains is the signal from the other modem.

It's sounds simple in theory, but actually it's difficult to implement because of defects in the phone network. Voltage reflections from phone connectors, switching relays, and the receiving modem itself cast echoes onto the line that confuse the receiver. V.32 uses complex digital signal processors (DSP's) to locate and remove those echoes, but at the expense of added hardware.

Until recently, the cost of a V.32 modem exceeded $2000. But more and more manufacturers are building V.32 modems, and prices are dropping below $1000. Unlike the ping-pong and statistical protocols discussed above, a V.32 modem can talk to any other V.32 modem, provided both use echo cancellation.

Data compression

A ploy frequently used to increase data throughput without inventing a new modem protocol is data compression. Data compression doesn't change the way your modem works, only the way the data is packaged before it is sent. For example, if you had a data compressor with a 4-to-1 compression ratio, you could achieve an effective throughput of 9600 bps using a standard 2400 bps modem.

Data compressors shrink data by looking for repeated characters or patterns in the data string and replacing them with unique control characters. The compressed data is then sent over the phone line. At the other end, the control characters are expanded back into their original sequence.

However, data compression is based on a software algorithm, and unless you use the same algorithm both to compress the data and to expand it, you'll end up with gibberish. Although several modem manufacturers offer data compression, about half of them use a proprietary algorithm that is compatible with machines made only by them.

Only the MNP Class 5 data compression method created by Microcom has garnered much popular support among modem manufacturers. MNP Class 5 works by identifying runs of identical characters, such as spaces or tabs in a table, and sending them as a shorter sequence. MNP data compression also counts the number of times a character appears in a document, like the letter "e", and renames those that are frequently used with a code that's shorter than its ASCII equivalent.

Microcom's newest data compression algorithm, MNP Class 7, includes all the features of MNP Class 5, plus it takes advantage of predictable character sequences (such as the fact that *u* usually follows *q* in English) and replaces them with a single control character.

Average speed increases for MNP data compression are twice the normal data rate for Class 5 and up to three times the normal data rate for MNP Class 7. In fact, Microcom's 9600-bps QX/V.32c modem can throughput data at speeds in excess of 33,000 bps when using MNP Class 7 data compression.

Error correction

At any speed, modem transmissions are prone to error simply because of the noisy phone environment in which they must work. But as the speed of the modem increases, so does the error rate. Several methods are available for error detection and correction.

The simplest appends a ninth

TEACHING OLD MODEMS A NEW TRICK

If you'd like to take advantage of the new MNP error correction and data compression technology, but wince at the thought of having to buy a new modem to get it, you'll be happy to hear about MagicSoft's MTE communications software.

MTE allows you to add MNP 4 error correction plus MNP 5 data compression to your existing modem without making any changes to its hardware. Moreover, MTE isn't just a device driver that you attach to your existing communications program, but a complete communications package.

MNP operation is automatic—and V.42 compatible. The program queries the responding modem for MNP compatibility, then configures itself to the highest common MNP level. The MNP link can be made between any modem that has MNP built into it, or one that uses software to implement MNP (like modems from Zoom Telephonics). Once the link is established, communications proceed at data rates up to two times that of normal. If the responding modem doesn't have MNP protocol, MTE defaults to the highest common standard data rate.

The MTE communications program is versatile, yet simple to use because of a user interface that supports both hot keys and Lotus-style menus. MTE also supports a wide variety of link protocols, including two versions of XMODEM and three versions of YMODEM. Other features include a log that records the length of the phone call and macros for automatic logon to on-line services (CompuServe, etc.).

Perhaps best of all is the Mini-Host feature that allows the program to function as a simple bulletin board or as a sophisticated unattended modem. Anyone who calls while your system is in the Mini-Host mode will be able to use your MTE program to do a variety of tasks, including uploading and downloading files from the program's SEND and RECV directories.

So if you'd like to give your present 2400-bps modem 4800-bps performance, MTE may be just the ticket.

bit, called a parity bit, to the data byte. The value of the parity bit is determined by the number of 1s in the data byte. If the count is even, the parity bit is one; if the count is odd, the parity bit is zero. At the receiving end, the number of 1s in the data byte are counted again and compared to the value of the parity bit. If the two don't agree, a data error is declared and the byte is sent again.

A faster method is to use cyclic redundancy checking (CRC). In this method, a string of bytes is grouped together in a packet and then processed by an algorithm that produces a sum representative of the group. This CRC number is then sent along with the group. At the receiver, the received data packet is processed by the same algorithm and the results compared to the CRC value. As before, a difference between the two values prompts a retransmission of the data packet.

Obviously, CRC error checking is more efficient than parity-bit error checking because you don't have to process each byte individually. However, you still have to send new data to replace defective data. A high error rate significantly reduces the efficiency of CRC error checking.

The newest modulation technique, V.32, offers an optional fifth bit (trellis encoded). The value of the fifth bit is a logical derivative of the other four and represents a checksum that is similar to a parity bit of a byte. This extra bit gives the receiving modem the opportunity to use error correcting—not error detecting—techniques to recover the original data from the flawed signal with a considerable savings in time because retransmission is unnecessary.

As with data compression, everybody has an opinion on the best method for error detection and correction. And unless the method used is supported by both modems, it won't work. The most popular methods are MNP Classes 2 through 4 from Microcom. Recently, however, CCITT has approved its V.42 error detection (with data packet retransmission on error) standard that includes compatibility with MNP Classes 2–4.

Shifting gears

Time was when each modem had a niche in life. If you were a 1200-bps modem, you communicated at 1200 bps exclusively; 4800-bps modems could only talk with another 4800-bps modem.

Then Hayes came out with its Smartmodem that could communicate with both 300-bps and 1200-bps modems, and eventually 2400-bps modems. Instead of having to buy a separate modem for each speed, you needed only one.

That same-one-does-it-all concept is even stronger today. Although you can find stand-alone 9600-bps modems, you're more likely to find modems that support all popular speeds under 9600 bps.

However, you'll notice that the operative word here is "popular." As mentioned earlier, not all 9600-bps modems are compatible, and you have to pay as much attention to five-speed modem standards as you do stand-alone high-speed modem standards.

Something for everybody

Whether or not you're in the market for a high-speed modem, you'll find many of the features pioneered by this market trickling down into the next generation of low-speed modeems.

At the top of the list will be error correction and data compression. For example, if you choose a 2400-bps modem that offers MNP Class 5 data compression, you'll be able to talk to comparably-equipped 2400-bps and 9600-bps modems at data rates up to 4800 bps.

Yes, choosing a modem today isn't nearly as simple as it was just a year ago. But then again, you're getting a lot more for your money so no one's complaining too loudly. ◆CD◆

THE RACAL-VADIC 9632VP modem has CCITT V.32/V.22 and Bell 212/103 compatibility with MNP through Class 5 for 19,200 bps performance.

PRODUCT INFORMATION

MTE ($79)
MagicSoft, Inc.
P.O. Box 396
Lombard, IL 60148
(312) 953-2374

MODEM MANUFACTURERS

Cermetek Microelectronics
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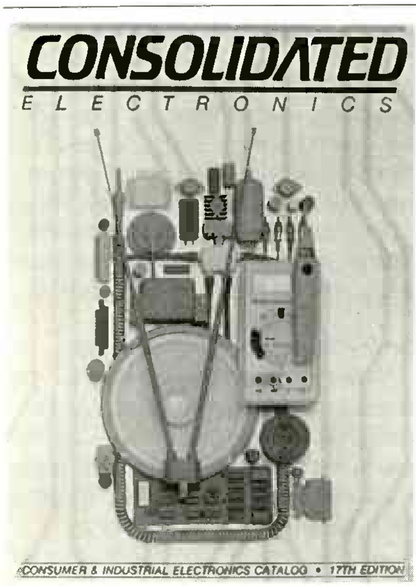

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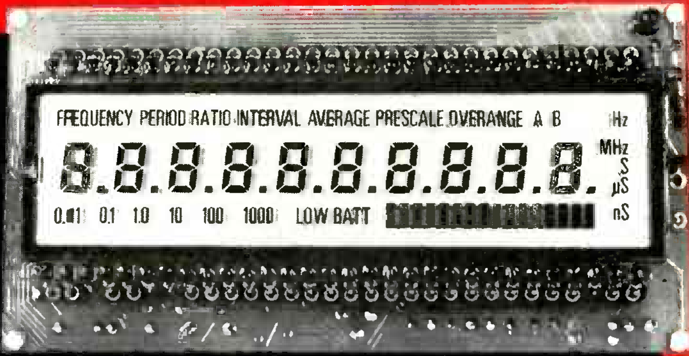

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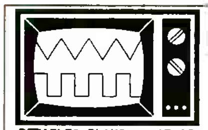

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CIRCLE 178 ON FREE INFORMATION CARD

NEW PRODUCTS

continued from page 28

strations are also provided.

"A Video Standard" (catalog number *LD-101*) has a suggested retail price of $59.99.—**Reference Recordings**, Box 77225X, San Francisco, CA 94107; Tel. 415-359-8721.

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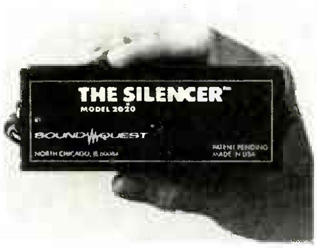

CIRCLE 17 ON FREE INFORMATION CARD

model is designed for use with high-end stereo systems that have additional amplifiers. It interrupts the stereo signal before it reaches the amplifier.

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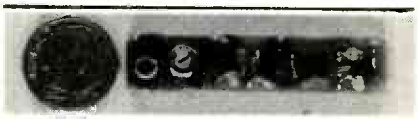

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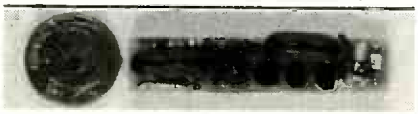

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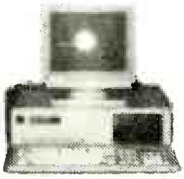

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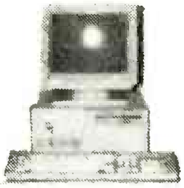

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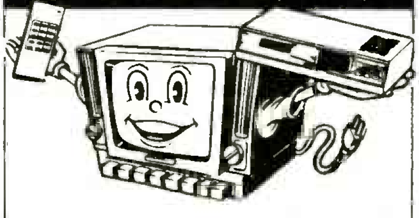

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HARDWARE HACKER

continued from page 73

grated circuits. Try to get the fat Japanese book as well as the thin English one.

Heath Electronics is a brand-new hacker publication. They are looking for authors, but their payment rates are chintzy. For more info, contract Ed Mosher at the *Heath Buyers Club*.

A free printer on spectrum analysis is available from *Tektronix*, while *Brookfield* has lots of free ap-notes available on viscosity measurement and control.

Turning to my own products, I've just finished my new *Introduction to PostScript* videotape, and have now book-on-demand published a series of reprints from my *LaserWriter Corner*, originally found over in *Computer Shopper* magazine. Included are over three dozen free and unique PostScript fonts. For those of you starting up your own hacker tech venture, you might want to check into my *Incredible Secret Money Machine* book.

As always, this is your column and you can get technical help and off-the-wall networking per the Need Help? box. **R-E**

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8748 (25V)		7.95
8748H (HMOS)(21V)		9.95
8749		9.95
8751H (3.5-12MHz)		36.95
8755		13.95
80286 10 (10MHz)LCC		49.95
80287-3 (5MHz)		109.95
80287-8 (8MHz)		209.95
80287-10 (10MHz)		259.95
80386 16 PGA		279.95
80387-16 (16MHz)		395.95
80387-20 (20MHz)		459.95
80387-25 (25MHz)		569.95
82284 (8MHz)	~~9.49~~	7.95
82288 (8MHz)	~~9.95~~	7.95

DATA ACQUISITION

ADC0804LCN		3.25
ADC0808CCN	~~5.95~~	5.49
ADC0809CCN		3.69
ADC1205CCJ-1		18.49
DAC0808LCN	~~1.75~~	1.49
AY-3 1015D		4.95
AY-5-1013A		1.95

STATIC RAMS

Part No.	Function			Price
2016 12	2048x8	120ns	~~3.75~~	2.95
2102	1024x1	350ns		.89
2112	256x4	450ns MOS	~~2.49~~	1.95
2114N	1024x4	450ns	~~.99~~	.79
2114N-2L	1024x4	200ns Low Power		1.49
21C14	1024x4	200ns (CMOS)		.49
5101	256x4	450ns (CMOS)	~~2.49~~	1.95
6116P-1	2048x8	100ns (16K) CMOS	~~3.95~~	3.19
6116P-3	2048x8	150ns (16K) CMOS	~~3.49~~	2.79
6116LP-1	2048x8	100ns (16K) LP CMOS	~~4.39~~	3.59
6116LP-3	2048x8	150ns (16K) LP CMOS	~~3.95~~	3.09
6264P-10	8192x8	100ns (64K) CMOS	~~9.95~~	9.49
6264P-15	8192x8	150ns (64K) CMOS	~~9.25~~	7.49
6264LP-10	8192x8	100ns (64K) LP CMOS	~~10.95~~	10.25
6264LP-12	8192x8	120ns (64K) LP CMOS	~~10.49~~	8.95
6264LP-15	8192x8	150ns (64K) LP CMOS	~~10.25~~	7.95
6514	1024x4	350ns CMOS		3.75
43256-10L	32,768x8	100ns (256K) Low Power	~~26.95~~	23.95
43256-15L	32,768x8	150ns (256K) Low Power	~~25.25~~	22.95
62256LP-10	32,768x8	100ns (256K) LP CMOS	~~27.95~~	24.95
62256LP-12	32,768x8	120ns (256K) LP CMOS	~~27.25~~	24.25
62256LP-15	32,768x8	150ns (256K) LP CMOS	~~26.25~~	23.95

DYNAMIC RAMS

421000A9A-10	1,048,576x9	100ns 1MEGx9 SIP	~~399.95~~	229.95
421000A9B-10	1,048,576x9	100ns 1MEGx9 SIM	~~209.95~~	195.95
421000A9A-80	1,048,576x9	80ns 1MEGx9 SIP	~~419.95~~	229.95
421000A9B-80	1,048,576x9	80ns 1MEGx9 SIM	~~239.95~~	225.95
TMS4416-12	16,384x4	120ns	~~6.75~~	5.95
TMS4416-15	16,384x4	150ns	~~6.25~~	5.49
4116-15	16,384x1	150ns (MM5290N-2)	~~1.39~~	1.25
4128-15	131,072x1	150ns (Piggyback)		4.49
4164-100	65,536x1	100ns	~~3.49~~	3.29
4164-120	65,536x1	120ns	~~2.95~~	2.85
4164-150	65,536x1	150ns	~~2.59~~	2.49
41256-60	262,144x1	60ns	~~9.25~~	8.49
41256-80	262,144x1	80ns	~~7.95~~	6.95
41256-100	262,144x1	100ns	~~7.25~~	6.49
41256-120	262,144x1	120ns	~~6.95~~	6.19
41256-150	262,144x1	150ns	~~6.49~~	5.89
41264-12	64Kx4	120ns Video RAM		12.95
41464-10	65,536x4	100ns	~~14.49~~	8.95
41464-12	65,536x4	120ns	~~11.95~~	8.25
41464-15	65,536x4	150ns	~~10.95~~	7.95
51258-10	262,144x1	100ns Static Column	~~13.95~~	8.95
41256A9A-10	262,144x9	100ns 256x9 SIP	~~149.95~~	69.95
41256A9B-10	262,144x9	100ns 256x9 SIM	~~74.95~~	64.95
511000P-10	1,048,576x1	100ns (1 Meg)	~~19.95~~	19.49
511000P-80	1,048,576x1	80ns (1 Meg)	~~22.95~~	21.75
514256P-10	262,144x4	100ns (1 Meg)	~~24.95~~	22.95
514258-10	262,144x4	100ns Static Column		31.95

EPROMS

TMS2516	2048x8	450ns (25V)	~~5.95~~	4.95
TMS2532	4096x8	450ns (25V)		5.95
TMS2532A	4096x8	450ns (12.5V)	~~4.49~~	3.25
TMS2564	8192x8	450ns (25V)		6.95
MS2716	2048x8	450ns (-5V, +5V, +12V)	~~6.95~~	6.49
1702A	256x8	2K (1μs)	~~4.95~~	4.25
2708	1024x8	450ns	~~6.95~~	5.95
2716	2048x8	450ns (25V)	~~3.75~~	3.25
2716-1	2048x8	350ns (25V)	~~3.95~~	3.49
27C16	2048x8	450ns (25V) CMOS	~~4.25~~	3.75
2732	4096x8	450ns (21V)		3.95
2732A-20	4096x8	200ns (21V)	~~4.25~~	3.95
2732A-25	4096x8	250ns (21V)	~~3.95~~	3.75
27C32	4096x8	450ns (25V) CMOS	~~4.35~~	4.25
2764-20	8192x8	200ns (21V)		4.25
2764-25	8192x8	250ns (21V)		3.59
2764A-25	8192x8	250ns (12.5V)	~~3.69~~	3.39
27C64-15	8192x8	150ns (12.5V) CMOS		5.95
27128-20	16,384x8	200ns (21V)	~~6.49~~	5.95
27128-25	16,384x8	250ns (21V)	~~5.95~~	4.95
27128A-15	16,384x8	150ns (12.5V)		7.75
27128A-20	16,384x8	200ns (12.5V)	~~5.25~~	4.75
27C128-25	16,384x8	250ns (21V) CMOS	~~5.95~~	5.49
27256-15	32,768x8	150ns (12.5V)		8.95
27256-20	32,768x8	200ns (12.5V)	~~6.25~~	5.49
27256-25	32,768x8	250ns (12.5V)	~~5.49~~	4.95
27C256-15	32,768x8	150ns (12.5V) CMOS	~~7.95~~	7.25
27C256-25	32,768x8	250ns (12.5V) CMOS	~~5.49~~	4.95
27512-20	65,536x8	200ns (12.5V)		10.95
27512-25	65,536x8	250ns (12.5V)		9.95
27C512-25	65,536x8	250ns (12.5V) CMOS	~~9.49~~	8.49
27C1024	131,072x8	200ns (12.5V) CMOS (1 Meg)	~~24.95~~	19.95
68764	8192x8	64K 450ns (25V) (Chip Enable)		19.95
68766-35	8192x8	64K 350ns (25V) (Output Enable)		16.95

6500/6800 68000 Series

Part No.		Price
6402	~~3.95~~	3.49
6502	~~2.65~~	2.25
6502A	~~2.75~~	2.59
65C02 (CMOS)		7.75
6520		1.95
6522		2.95
65C22		4.25
6532	~~5.49~~	4.95
6551	~~2.95~~	2.69
65C802 (CMOS)	~~15.95~~	14.75
6800	~~1.95~~	1.49
6802		2.95
6808		1.95
6810	~~1.25~~	.99
6820		2.75
6821	~~1.75~~	1.49
68B21	~~1.95~~	1.75
6840	~~3.49~~	2.95
6845	~~2.75~~	2.49
6850	~~1.95~~	1.49
6852	~~.75~~	.59
MC68000L8	~~9.95~~	8.49
MC68000L10	~~11.95~~	8.95
MC68010L10	~~39.95~~	29.95
MC68020RC12B		89.95
MC68701		17.95
MC68705P3S		9.95
MC68705U3L	~~10.95~~	9.49
MC68705U3S	~~10.95~~	9.49
MC68450L10	~~49.95~~	29.95
MC68881RC16A		129.95
MC68881RC20A		169.95

Commodore

WD1770	~~8.95~~	7.49
SI3052P	~~1.25~~	.99
6504A		1.19
6510		14.95
6526		14.95
6526A		15.95
6545 1	~~3.95~~	2.95
6560	~~10.95~~	8.95
6567		24.95
6572	~~10.95~~	7.95
6581 (12V)		12.95
6582 (9V)	~~12.95~~	9.95
8502		7.95
8564	~~4.95~~	2.95
8566	~~9.95~~	7.95
8701		9.95
8722	~~10.95~~	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	Sale	.19	74C174	Sale	.39
74C02	Sale	.19	74C175	Sale	.59
74C04	Sale	.19	74C192	Sale	.99
74C08	Sale	.19	74C194	Sale	.49
74C10	Sale	.15	74C221		1.79
74C14		.49	74C240	Sale	.75
74C32	Sale	.19	74C244		1.79
74C74		.49	74C373	Sale	1.49
74C85		1.49	74C374	Sale	1.49
74C86	Sale	.19	74C911		6.95
74C89	Sale	2.95	74C912		7.95
74C90		.99	74C915	Sale	1.19
74C151	Sale	1.49	74C917	Sale	3.95
74C154	Sale	2.75	74C920	Sale	3.95
74C157	Sale	1.25	74C921	Sale	2.95
74C160	Sale	.49	74C922		3.95
74C161	Sale	.49	74C923		3.95
74C162	Sale	.49	74C925		5.49
74C173		.59	74C926		5.95

MISC. COMPONENTS

TANTALUM CAPACITORS

TM.1/35 .1μf @ 35V	.19	TM4 7 35 4.7μf @ 35V	.45
TM1/35 1μf @ 35V	.19	TM6 8 35 6.8μf @ 35V	.49
TM2.2/35 2.2μf @ 35V	.25	TM10 35 10μf @ 35V	.59

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	.12
2N2222A	.29	2N4401	.12	1N4148	.07
2N3055	.65	1N270	.25	1N4735	.29
2N3904	.12	1N751	.15	C106B1	.49

SWITCHES

JMT123 SPDT, On-On	1.19	206-8 SPST 16 pin DIP	1.25
MPC121 SPDT, On-Off-On	1.19	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	XC556C T1¾, Clear/Red	.17

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #2	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	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	SALE	.17	74HC175		.59
74HC02	SALE	.17	74HC221	SALE	.69
74HC04	SALE	.17	74HC240	SALE	.59
74HC08	SALE	.17	74HC244		.79
74HC10	SALE	.19	74HC245	SALE	.69
74HC14		.29	74HC253	SALE	.39
74HC30	SALE	.19	74HC259		.49
74HC32	SALE	.25	74HC273	SALE	.49
74HC74	SALE	.29	74HC373		.69
74HC75	SALE	.29	74HC374	SALE	.59
74HC76	SALE	.29	74HC595		1.29
74HC85		.55	74HC688	SALE	1.25
74HC86	SALE	.25	74HC943	SALE	7.95
74HC123	SALE	.49	74HC4040	SALE	.79
74HC125		.49	74HC4049	SALE	.25
74HC132	SALE	.39	74HC4050	SALE	.25
74HC138		.45	74HC4060	SALE	.69
74HC139	SALE	.35	74HC4511	SALE	.99
74HC154		1.49	74HC4514		1.79
74HC163	SALE	.39	74HC4538	SALE	.99
74HC174		.59	74HC4543	SALE	.99

74HCT-CMOS TTL

74HCT00	SALE	.15	74HCT139	SALE	.29
74HCT02	SALE	.15	74HCT157	SALE	.19
74HCT04	SALE	.17	74HCT174	SALE	.25
74HCT08	SALE	.15	74HCT175	SALE	.25
74HCT14		.29	74HCT240	SALE	.59
74HCT32	SALE	.17	74HCT244	SALE	.49
74HCT74	SALE	.25	74HCT245	SALE	.49
74HCT86	SALE	.15	74HCT373	SALE	.45
74HCT138		.39	74HCT374	SALE	.45

LINEAR

TL071CP	.59	LM1489N	.45
TL072CP	.79	DS14C89N (CMOS)	1.19
TL074CN	.99	LM1496N	.69
TL081CP	.49	LM1871N	1.95
TL082CP	.49	LM1872N	1.95
TL084CN	.89	ULN2003A	.75
LM301N	.35	XR2206	3.95
LM307N	.39	XR2211	2.95
LM308N	.59	XR2240	1.49
LM309K	1.25	26LS29	2.25
LM310N	1.29	26LS31	.99
LM311N	.39	26LS32	.99
LM317T	.65	26LS33	1.49
LM318N	.99	ULN2803A	1.19
LM319N	1.29	LM2901N	.25
LM323K	3.49	LM2907N	1.29
LM324N	.35	LM2917N (8 pin)	1.79
LM335Z	1.39	MC3470P	1.19
LM336Z	.99	MC3479P	3.95
LM337T	1.09	MC3486P	1.19
LM338K	4.49	MC3487P	.99
LM339N	.39	UDN3613M	.39
LF347N	1.49	LM3900N	.49
LM348N	.69	LM3905N	1.19
LF351N	.39	LM3909N	.89
LF353N	.49	LM3914N	1.79
LF356N	.79	NE5532	.69
LF357N	.89	NE5534	.69
LM358N	.49	7805K (LM340K-5)	1.29
LM380N	.89	7812K (LM340K-12)	1.29
LM386N-3	.89	7815K (LM340K-15)	1.29
LM393N	.39	7805T (LM340T-5)	.45
LF398N	1.95	7812T (LM340T-12)	.45
LF411CN	.79	7815T (LM340T-15)	.45
LF412CN	1.29	7905K (LM320K-5)	1.35
NE555V	.29	7905T (LM320T-5)	.49
XRL555	.59	75113	1.19
LM556N	.45	75150	1.19
LM565N	.89	75154	1.19
LM566CN	1.19	75174	2.95
LM567V	.75	75175	2.95
LM723CN	.39	75176	2.29
LM741CN	.29	75451	.39
LM747CN	.49	75452	.39
LM1458N	.35	75492	.79
LM1488N	.45	MC145406P	2.95
DS14C88N (CMOS)	1.19		

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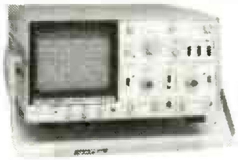
15th ANNIVERSARY YEAR 1974 - 1989

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

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

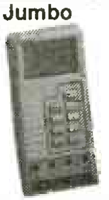
M3650/B & M4650 only:
• Also measures frequency and capacitance

M4650 only:
• Data Hold Switch
• 4.5 Digit

M4650 Pictured

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**

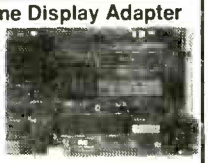
A.R.T. EPROM Programmer

• 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

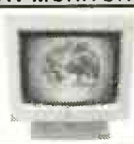
- *Free! QAPLUS Diagnostic Software Included!*
- *PC Write Word Processing Software Included!*
- *256K RAM Included, Expandable to 640K*
- *AMI BIOS ROMs Included*
- *4.77 or 8MHz Operation*
- *Flip-Top Case w/150 Watt Power Supply*
- *360K Disk Drive*
- *Parallel Printer Port*
- *84-Key Keyboard*
- *Monochrome Amber Monitor*

SAVE $108.06!

JE3002	IBM Compatible PC/XT 8MHz Turbo Kit ~~$499.95~~	**$479.95**
EZDOS	MS/PC-DOS Compatible Operating System................	$49.95
EZDOSP	Same as above with TrueBASIC..............................	$69.95

IBM COMPATIBLE DISPLAY MONITORS

AMBER	12" Amber Mono.		$99.95
HD55H	14" RGB 640x240		$249.95
TM5154	EGA 14" 720x350......	~~$399.95~~	$369.95
JE1059	EGA Monitor & Card..	~~$519.95~~	$499.95
TM5155	14" Multiscan 800x560	~~$649.95~~	$499.95
QC1478	14" VGA 720x480......	~~$449.95~~	$399.95
JE2055	VGA Monitor & Card..	~~$649.95~~	$599.95



NEW

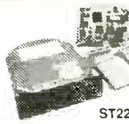
QC1478 Pictured

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)....................................	$159.95
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
JE1061	RS232 Serial Half Card (PC/XT)..	$29.95
JE1062	RS232 Serial Half Card (AT)..	$34.95
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)......	$99.95
JE1041	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)............................	$129.95
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

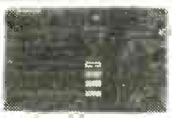


ST225XT Pictured

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)	~~$109.95~~	$99.95
JE3005	Baby 8/12MHz (AT)	~~$329.95~~	$299.95
JE3010	Baby 8/16MHz *NEAT* (AT)	~~$469.95~~	$399.95
JE3020	Baby 16MHz 80386 (AT)	~~$1199.95~~	$999.95
JE3025	Baby 20MHz 80386 (AT)		$1199.95
JE3026	Full Size 25MHz 80386 (AT)		$1999.95



JE3025 Pictured

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

352KU	3.5" 720KB (PC/XT/AT)	$109.95
356KU	3.5" 1.44MB (PC/XT/AT)...........	$129.95
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

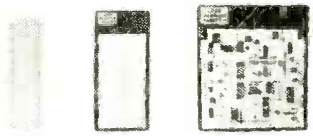
IBM PC/XT/AT COMPATIBLE INTERNAL MODEMS

1200H	1200/300 Baud Internal Modem w/MaxiMite Comm. Software (PC/XT/AT)......	$69.95
2400H	2400/1200/300 Baud Internal Modem w/MaxiMite Comm. Sfwr (PC/XT/AT)	$129.95

External Modems and Pocket-Size Modem Also Available!

PROTOTYPING PRODUCTS

Jameco Solderless Breadboards

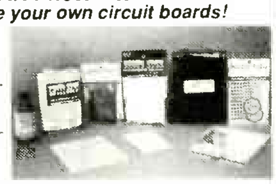


JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6.5 x .75	200	0	$1.95
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	$7.95
JE24	6.5 x 3.125	1,360	2	$12.95
JE25	6.5 x 4.25	1,660	3	$19.95
JE26	6.875 x 5.75	2,390	4	$24.95
JE27	7.25 x 7.5	3,220	4	$34.95

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.....................**$34.95**

Jameco Prototype PC Boards

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 Pictured

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 Hndbk. (89)...	$19.95
270647	Intel 32-bit Controller Hndbk. (89)...	$19.95
400041	NSC Linear Data Book Vol. 1 (88) ..	$14.95
400042	NSC Linear Data Book Vol. 2 (88)	$9.95
400043	NSC Linear Data Book Vol. 3 (88)	$9.95
ICM89	1989 IC Master (3 Volume Set) ...	$119.95

EDUCATIONAL KITS

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

JE2206 Pictured

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

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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
7442A	.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	.63
74154N	1.58
74155N	.60
74157N	.60
74161AN	.75
74164N	.75
74165N	.90
74173N	1.00
74174N	.63
74175N	.63
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	.47
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	.80
74LS151N	.55
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	.81
74LS195AN	.78
74LS221N	.93
74LS240N	.86
74LS241N	.66
74LS243N	.66
74LS244N	.86
74LS245	.68
74LS249N	1.24
74LS251N	.60
74LS253N	.60
74LS257N	.60
74LS258N	.60
74LS279N	.54
74LS283N	.78
74LS290N	.80
74LS293N	.40
74LS352N	1.17
74LS365AN	.54
74LS366AN	.54
74LS367N	.54
74LS368AN	.60
74LS373N	.66
74LS374N	.66
74LS670N	1.44
81LS95N	1.91
81LS96AN	1.88
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	.55
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	.83
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
74S288N	2.00
74S289N	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	.45
74C08N	.45
74C10N	.45
74C14N	.33
74C20N	.45
74C30N	.45
74C32N	.48
74C42N	1.05
74C48N	1.33
74C73N	.85
74C74N	.63
74C76N	.85
74C83N	1.60
74C85N	1.60
74C86N	.28
74C89N	5.00
74C90N	1.23
74C93N	1.23
74C95N	1.50
74C107N	.85
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	4.73
74C923N	4.95
74C925N	6.38
74C926N	6.38
74C927N	6.38
74C928N	6.38
74C932N	1.23
74C941N	1.98
74C945N	11.25
74C947N	11.25

Part	Price
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
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74HC162N	.63
74HC163N	.63
74HC164N	.63
74HC165N	.63
74HC174N	.58
74HC175N	.58
74HC190N	.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
74HC534N	.98
74HC540N	.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	.60
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
4068BCN	.28
4069BCN	.28
4070BCN	.28
4071BCN	.28
4072BCN	.28
4073BCN	.28
4075BCN	.28
4076BCN	.28
4077BCN	.28
4081BCN	.28
4082B	.28
4089BCN	1.00
4093BCN	.30
4099BCN	.78
4503BCN	.33
4508BCN	.80
4510BCN	.80
4511BCN	.80
4512BCN	1.08
4514BCN	1.08
4515BCN	.83
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	1.56
LM567CN	1.11
LM709CN	.75
LM723CN	.75
LM72 CN	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	.69
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
MF10 CN	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
2N5861	.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	.36
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
PN4356	.37
PN4888	.56
PN4889	.70
PN4916	.36
PN4917	.36

1 AMP SILICON RECTIFIES

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. 3.2Q 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.	Price 1	Radial Lead Digi-Key Part No.	Price 1
6.3/47	P6301	.25	—	—
6.3/100	P6302	.26	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	.15
16/100	P6332	.41	P6227	.21
16/220	P6333	.47	P6228	.24
16/330	P6334	.53	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	.79
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	.44	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	2.45	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
180/100	—	—	P6182	1.25
160/220	—	—	P6183	2.10
250/1.0	—	—	P6184	.40
250/2.2	—	—	P6185	.42
250/3.3	—	—	P6186	.42
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	—	—	P6199	2.04

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	1.25
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	1.28
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
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
P4304	.022µf/25	.64
P4305	.033µf/25	.64
P4307	.047µf/25	.79
P4311	.1µf/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

Part No.	Cap./Volt.	Price
P4400	10/500	1.13
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	5.16
P2084	220/10	9.63
P2033	1.5/16	.28
P2034	2.2/16	.31
P2035	3.3/16	.31
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	9.06
P2096	100/16	6.96
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	1.69
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	2.26
P4725	0.1/100	2.30
P4726	0.12/100	2.42
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	4.33
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	1.06
P4561	.0068/50	1.06
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	X046	HC-18	9.65	79.50
1.8432	X066	HC-33	3.96	33.00
1.8432	X067	HC-18	4.44	37.00
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	X055	HC-18	1.62	13.50
8.000	X056	HC-18	1.62	13.50
9.8304	X074	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	X076	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	13.50
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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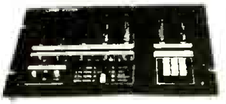
PROFESSIONAL COLOR LIGHT CONTROLLER SM-328 ★



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.

MULTIPURPOSE MELODY GENERATOR TA-50A / B / C ▲

TA-50A / B Complete kit $11.84 Assembled & tested $16.58

TA-50C Complete kit $12.65 Assembled & tested $17.71

The TA-50 melody generator uses the latest CMOS ROM technology. It plays 8 to 10 different tunes depending on the model. It operates on two AA size batteries due to its small current demand. You can adapt the generators to door bells, musical boxes, electronic clock alarms and many more. There are three models to choose from as listed below.

SPECIFICATIONS: Output power: 500mW • Output impedance: 4 to 8ohms • Power requirements: 1.5 to 5 volts DC @ 100ma • Dimensions: 2.8" x 2.4" x 0.6"

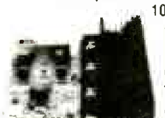
TA-50A — Jingle Bell, Silent Night, Rudolph The Rednosed Reindeer, O Come, All Ye Faithful, Santa Claus Is Coming To Town, Joy To The World, I Wish You A Merry Christmas, Hark, The Herald Angels Sing.

TA-50B — London Bridge Is Falling Down, Are You Sleeping, Joy Symphony, Wiegenlied, Row Your Boat, Happy Birthday, Home Sweet Home, Melody on Purple, Bamboo.

TA-50C — L'eau Vive (Living Water), Home on the Range, Romance De Amor, Comin' Thro' The Rye, Wedding March, Happy Birthday, Humoresque, Lorelei, The Last Rose of Summer, Love Song From Sikang.

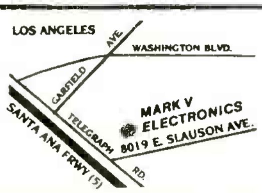
300W HI-FI POWER AMPLIFIER (MONO) TA-3600 ▲▲▲

Assembled & tested **$110.00**
Completed Kit **$86.00** Transformer **$38.00**
10,000 UF 80V E. Cap **$20.00**



The TA-3600 is an extremely high power amplifier specifically designed to reproduce the high dynamic range available on compact discs. It has low noise, high stability, low distortion, extended frequency range and high efficiency in a compact package. Two of these units with appropriate power supply and pre-amplifier are required for stereo reproduction.

SPECIFICATION: 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.



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 ▲	35.60	
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 OC 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	Assembled
SM-43	3½ Multi-Functional Led D.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	79.00	90.00
FC1000A	1 GHz Frequency Counter		192.00

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

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

DYNAMIC NOISE REDUCTION UNIT SM-666 ▲

Complete kit $26.00, Assembled & tested $34.00

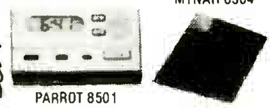
NEW

The SM-666 Dynamic Noise Reduction Unit is designed to reduce noise during playback from casette tapes, LP records and compact discs, as well as FM radio broadcasts. An National Semiconductor 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 Kohm • Noise reduction: 10dB • Power supply: 9 to 12V recommended • Operating current: 27mA MAX

TALKING CLOCK ▲

NEW LOW PRICE



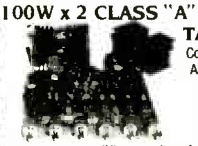
MYNAH 8504

PARROT 8501

1. Talk: Push button for voice announcement of time. 2. Read out: Twelve hours system display for hour, minute, second (by color flash), AM & PM. 3. Display: Three display modes of time, alarm time & date. 4. Alarm: On / off switch with thirty seconds voice alarm. 5. Snooze: Reminder voice alarm of thirty seconds after 4 minutes of first voical alarm. 6. Volume: Two level of voice output. 7. Language available: English

PARROT 8501 .... **$12.00**
MYNAH 8504 .... **$12.00** (NOT A KIT)

STEREO PRE-MAIN AMPLIFIER 100W x 2 CLASS "A" DC



TA-1500 ▲▲▲

Complete kit $73.70
Assembled & tested $95.81

The TA-1500 amplifier is a stereo pre-amplifier and power amplifier featuring low noise integrated circuits in the pre-amplifier section. A fully regulated power supply insures stable, low distortion operation of this section. The power amplifier section features fully complementary power output transistors and direct coupled circuit configuration. The output transistors are fully protected by an automatic bias circuit and the loudspeakers are fully protected against damage by a fast acting speaker disconnect relay circuit. An additional feature, not found on many similar amplifiers, is provision to use a microphone with the amplifier.

This amplifier requires only the addition of an external power transformer for a fully operational unit.

SPECIFICATIONS: Power output: 80 watts per channel into 8ohms, 100 watts per channel into 4ohms • Total harmonic distortion: Less than 0.03% • Frequencv response: Aux input, 5 to 50,000hz +0.2dB, +2dB • Frequency response: Power amplifier section, DC to 200khz • Sensitivity: Phono: 2.5mV @ 47K, Aux: 150mV @ 47K, Mic: 6mV @ 10K • Output: Tape: 150mV @ 47K, Pre-amp: 1V @ 600ohms • Power transformer: 26V to 32V AC x 2 @ 6A

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41256-150	262144x1	150ns	16	4.49
41256-120	262144x1	120ns	16	4.99
41256-100	262144x1	100ns	16	5.49
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This month's topic is floppy drive compatibility. There are 360K 5-1/4", 720K 3-1/2", 1.2Meg 5-1/4" and 1.44Meg 3-1/2" drives, any of which can be used on most PC's and PC clones. *Recent improvements in floppy controllers make using high density drives on 8088-based machines a viable option.*

To simplify, we'll eliminate the redundant choices. A 1.2Meg drive can work with both high density 1.2Meg floppies and low density 360K floppies.* A high density 3-1/2" 1.44Meg drive can use both the high density 1.44Meg and the low density 720K disks. Unless you know that you will never need high density capability, a good universal standard is one 3-1/2" and one 5-1/4" high density drive.

Now for the bomb! Big Blue uses a different method to distinguish between 720K and 1.44Meg drives. While most of the manufacturers look for and detect the High Density hole in a high density diskette, they read the data to make that determination. This causes a problem when a Low Density disk without the hole is written in the high density mode. So if you get a 3-1/2" disk that a friend says is formatted at 1.44Meg, make sure it has a High Density hole or it probably won't read in your clone.

Derick Moore, Director of Engineering

*An infrequent problem can occur when a 360K drive is written in a 1.2Meg drive and is then read in a 360K drive.

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2764	8192x8	450ns	12.5V	28	3.49
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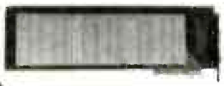

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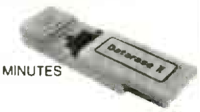

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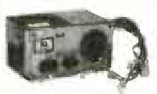

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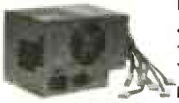

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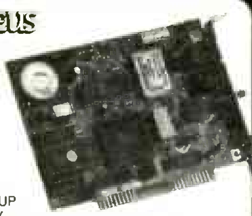

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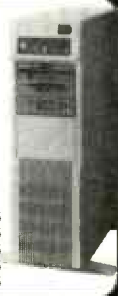

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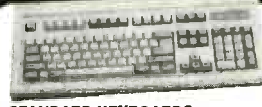

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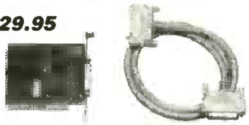

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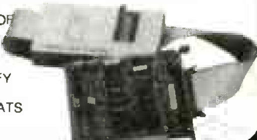

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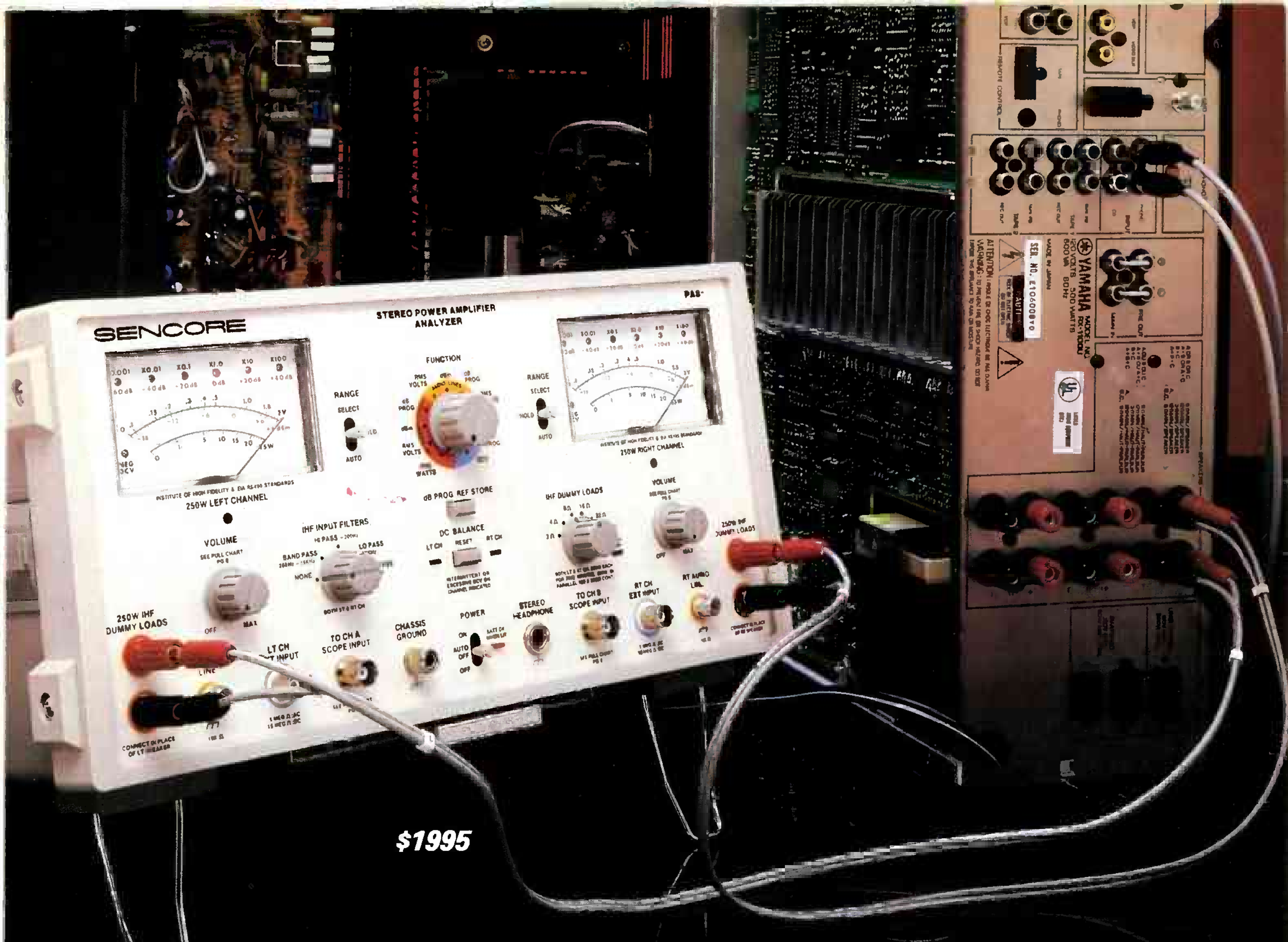

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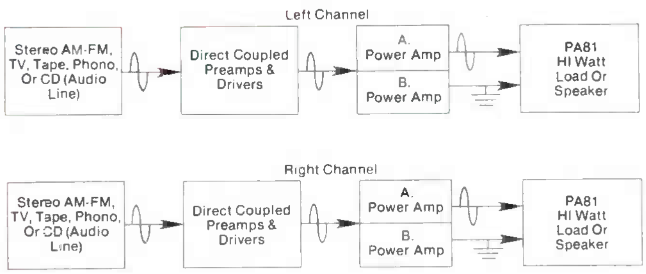

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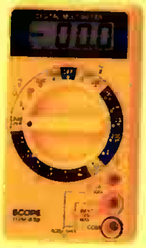

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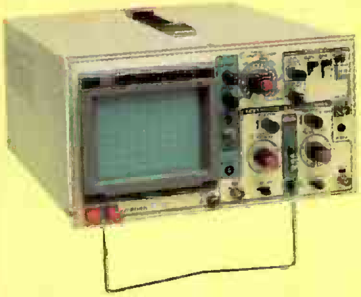

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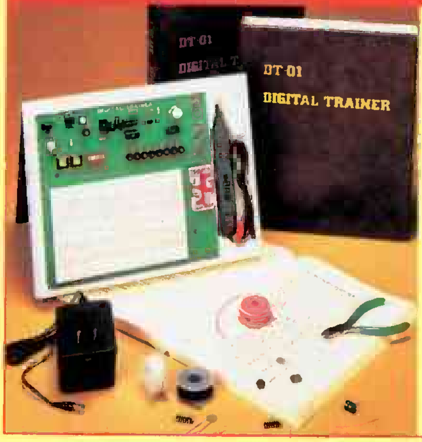

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