

# Radio Electronics

MAY 1992

TECHNOLOGY - VIDEO - STEREO

## BUYER'S GUIDE TO DIGITAL MULTIMETERS

All you need to know  
before you buy your  
next DMM

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Easy-to-Build  
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is a fun project!

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for the 1802 microprocessor

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### SOLID STATE RELAY

Why buy expensive, commercially made solid-state relays at a fraction of the price?

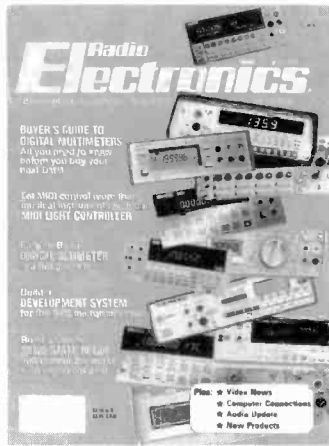
Why buy expensive, commercially made solid-state relays at a fraction of the price? This article discusses the benefits of building your own solid-state relay. It covers the components needed, the circuit design, and the construction process. It also provides a list of parts and a bill of materials.

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## ON THE COVER



The digital multimeter is the backbone of the modern test bench, and today's DMM's provide better performance and more features than ever. How do you go about selecting the instrument that best suits your testing needs? Your first step should be to read our Buyer's Guide from start to finish. You'll learn how DMM's work, and how to put them to work for you. Read about the latest models from the major manufacturers. Once you know how they differ—and what those differences mean to your work and to your wallet—you'll be ready to make an informed decision. Turn to page 31 for the details.

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# WHAT'S NEWS

*A review of the latest happenings in electronics.*

## High-power semiconductor laser

A series of reliable, 150-mW laser diodes that oscillate at wavelengths between 800 and 870 nanometers has been developed at Sanyo Electric Company's Semiconductor Research Center in Allendale, NJ. The high-powered lasers are expected to enhance processing speeds in erasable optical-disc memories and image-processing equipment and to be used in satellite communication. In addition, they can be used as pumping sources for blue laser-light generation when they are used with a second harmonic generation (SHG) device.

Blue-spectrum lasers with sufficient power are critical to information-intensive applications as long-playing, high-definition, moving-image video storage as well as for full-color image processing. An SHG device doubles the frequency of an infrared-spectrum laser when the light from the laser passes through a special crystal in the device, halving the wavelength of the beam and moving it from infrared to visible blue on the color spectrum. A blue laser's beam illuminates about 25% of the area on a receptor surface—quadrupling the recording density on a laser disc and significantly improving resolution in laser image-processing applications. The Sanyo development overcomes previous

obstacles to blue-laser light generation by providing a high output power to compensate for the power loss inherent in the SHG process. The 860-nm lasing wavelength can be produced for phase-matching conditions at room temperature using a typical SHG device.

The laser diodes are fabricated using a relatively uncomplicated two-step, liquid-phase epitaxy process. Adjustments made to layer thickness, lasing cavity length, and the crystalline active layer insure reliable high-power output and suppress temperature rise, which helps prevent degradation or catastrophic damage. Stable continuous wave operation at 150 mW has been confirmed for more than 5000 hours at room temperature, and for over 2000 hours at 50°C. PIN photodiodes for monitoring light-output are built into the assembly.

Three models operating at 800, 830, and 860 nm will initially be produced, with volume production expected by mid-1992.

## Safer gold electroplating method

A process allowing intricate gold electroplating on microelectronic devices, developed by Researchers at Sandia National Laboratories (Albuquerque, NM), uses a plating solution that is safer than the conventional cyanide-based solutions.

While gold has many properties that make it attractive for use in manufacturing microelectronics—high corrosion resistance, high conductivity, high melting point, and ability to form good electrical contacts—standard gold-plating solutions can release large amounts of poisonous cyanide gas if the solution becomes too acidic. The cyanide-based solutions are so dangerous that the EPA has classified them as "acutely hazardous;" therefore, they require special safety precautions.

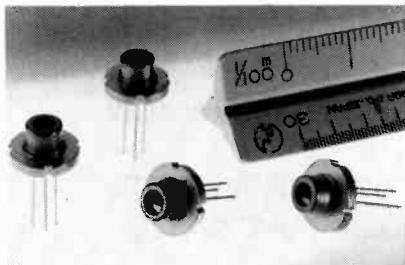
Sandia has applied a gold sulfite solution, which was developed in the 1970's and has been used since then for protective coverings but not for circuitry, to form precise gold patterns for semiconductor devices. The method has been successfully used to plate extremely fine lines on substrates. Sandia researchers have also used the sulfite solution, which contains no cyanide and is not dangerous, to make miniature gold bridges that form crossovers on gallium arsenide substrates. The crossovers allow conductors to cross on the surface of the IC without touching or shorting out adjacent conductors. Tests have shown the plating efficiency to be close to 100% in such applications, and the plated gold's density approached that of pure gold.

## Transmission-line impedance measurement

Beckman Industrial has been awarded a patent for developing a time-domain reflectometry (TDR) technique for the accurate measurement of transmission line impedance. The technique has been incorporated in the company's model TMT-1 transmission media tester, which is used to test and certify LAN and telecom physical layer cabling systems.

TDR could be described as "cable radar"—an electrical pulse is sent along the LAN under test and cable faults (impedance changes) reflect some of the energy back to the TDR where an associated processor plots it in a display or graph as a waveform. Traditional TDR techniques are plagued by "cable dribble-up" or impedance rise, where the fundamental impedance of the cable under test appears to increase along the length of the cable. Beckman's measurement technique correctly measures the impedance along the entire length of cables under test.

**R-E**



**OSCILLATING AT WAVELENGTHS** between 800 and 870 nm, Sanyo's high-power lasers will have applications in optical-disc memories, satellite communications, and blue-laser light generation.

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# VIDEO NEWS

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

**DAVID LACHENBRUCH**

● **Multimedia.** That single word seems to be the hottest topic in both the television and the computer worlds today. With the development of digital video and bandwidth compression, the computer and the TV set are coming increasingly close together, and there are many forecasts that the two will eventually merge. Bets are even being placed as to which will be the survivor.

Of course, that is a ridiculous question, reminiscent of the days when people talked about the computer-controlled home, in which a central computer operated the washing machine, refrigerator, stove, dishwasher, furnace, and everything else. As we all know, that never happened because microprocessors, or mini-computers, became so cheap that they could be incorporated into the appliances themselves.

Since computers and television sets are used in different rooms of the house, the speculation as to which will survive reflects a misunderstanding of the potential of digital technology. We would hope that the computer and the TV set will speak the same language so that their software can be intermixed and combined, but it's ridiculous to think we will attach a keyboard to our TV set of the future to write a nasty letter to the fiber-optic company for overbilling us, while the rest of the family is deprived of watching their favorite sitcom. By the same token, who will want to sit at the 12-inch computer monitor to watch the Olympics? Certainly not anyone who has the option of a 100-inch wall-screen (which, incidentally, has no value in word processing).

● **TV-Computer Compatibility.** Capitalizing on the hope that the TV set and the computer will be able to speak with one another without too much translation is Thomson Consumer Electronics (RCA and GE brands in the United

States). Thomson says that all of its efforts in advanced TV will be focused on standardization with computer multimedia. Thomson recently won the contract to supply the digital-compression system and consumer receiving boxes and antennas for Hughes Communications' 100-channel high-power direct-to-home DirecTV satellite system, due to start in 1994. Thomson is also participating in a proposed digital HDTV system with Philips, NBC, Sarnoff Research Center, and Compression Labs. Their HDTV system and Thomson's satellite transmission signal use a standard based on the Motion Picture Experts Group (MPEG) digital-compression formula for full-motion video on a CD-ROM disc. Thomson calls its system "MPEG + +," because it has much higher resolution than the current MPEG standard. Actually, the MPEG + + system is one of 32 different proposals for a movie-quality digital-compression system being considered for the title of MPEG 2" standard.

Thomson notes that it expects the MPEG + + system DirecTV to be directly compatible with multimedia systems, computers, video recording systems of the future, and all other encoded digital-compression media. They don't say what will happen if MPEG doesn't choose MPEG + + for MPEG 2.

● **How Far Off?** Although we're hearing optimistic forecasts that the multimedia age is upon us, one major Japanese manufacturer doesn't see it that way. Toshiba, which, with C. Itoh and Company, paid \$1 billion for part of Time Warner's TV-related business, says its preparing for the multimedia age, but doesn't agree that it's just around the corner. Rather than go off chasing a non-existent standard, they prefer to wait for the industry to set a standard. Says Kojo Hase, senior manager of Toshiba Media and Commu-

nications Group, "Our dream is a five-inch disc with 120 minutes recording and playback time, erasable and with high-definition quality. A higher density disc and the next MPEG standard for full-motion [movie quality] video will provide this. But the standards negotiations are only beginning, and there are 32 contenders. There cannot be a standard until 1995."

Asked about CD-I, now on the market and hailed by its principle sponsor, Philips, as a success, Hase said, "We do not think that CD-I is fully interactive. The fact that there are only around 50 titles suggests that the tooling is wrong, that the platform is not sufficiently flexible. We are studying very carefully and asking what is the right material. Certainly not encyclopedias. We need something sparkling that makes people say 'I must have it!'"

● **Small Camcorders Dominate.** Last year, 60% of all camcorders sold in the U.S. were "compacts"—that is, 8mm or VHS-C. That is an increase from just over half in 1990 and only 37% in 1989. The figures are supplied by the Electronic Industries Association (EIA), which doesn't break down the compacts by format, but a good estimate is that 8mm won by a large margin, comprising 63% of all compacts and 43% of total camcorder sales, compared to 32% full-size VHS and 25% VHS-C.

● **Ghostbusting Winner.** As we go to press, the National Association of Broadcasters has declared a winner in its field tests of TV ghost-canceling systems (**Radio-Electronics**, April 1992). It is the system developed by Philips. All five of the proposed systems require that the TV station transmit a pilot signal during the vertical blanking interval, and therefore FCC approval is required. Action on a standard system is expected as early as June. **R-E**



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*Ron Bruckman  
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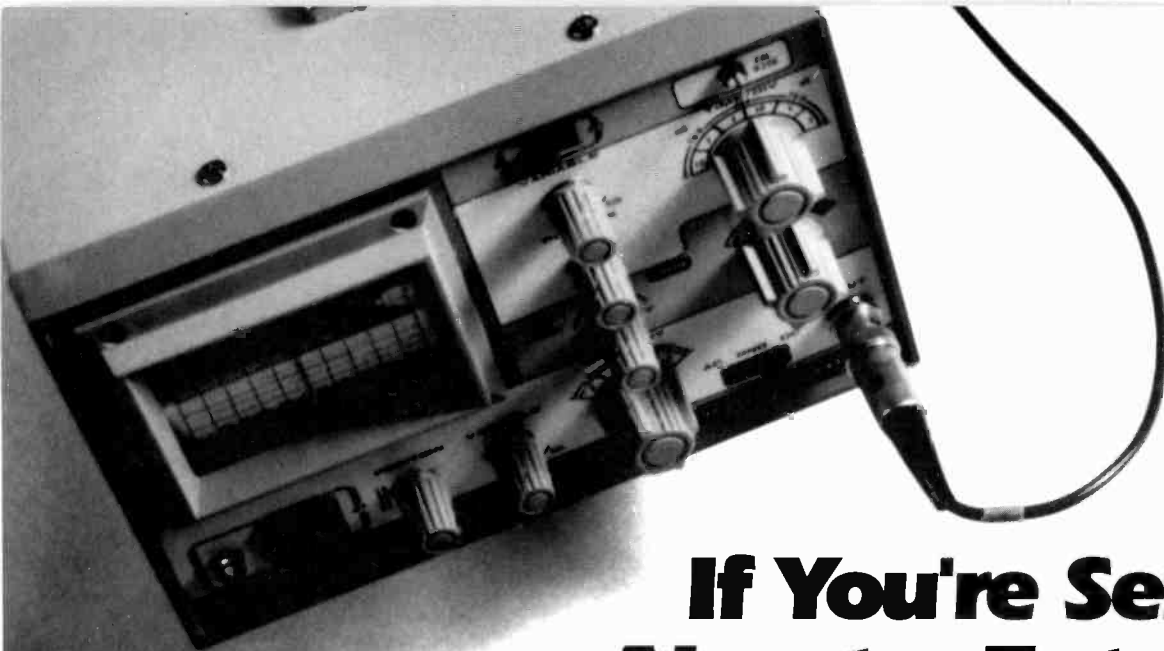
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Display	10 Digit LCD w/Function Annunciators	10 Digit LCD w/Function Annunciators	10 Digit LCD	10 Digit LCD	10 Digit LCD	8 Digit LED	8 Digit LED
RF Signal Strength Indicator	16 Segment Adjustable Bargraph	16 Segment Adjustable Bargraph	16 Segment Adjustable Bargraph	.	.	.	.
Hold Switch	Yes	Yes	Yes	Yes	Yes	No	Yes
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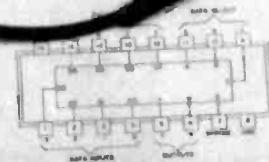
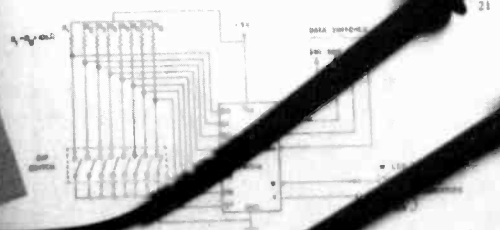
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Procedure

Figure 16 shows the circuit diagram for this experiment. You'll need the pin numbers for the IC aren't included on the diagram. For those, you'll have to refer to Fig. 17, which shows pertinent 74-151A data. For the data input, you'll use an eight-pole DIP switch in conjunction with 10KΩ pull-up resistors. For the Select and Strobe lines, usually, you'll use the standard data switches.

1. With the power off, insert the 7415 A IC and the DIP switch on the breadboard.
2. Connect the eight 10KΩ resistors to the DIP switch as shown in Fig. 16. Connect the opposite end of each of these resistors to the +5V supply. The second terminal of each switch is to be connected to trainer ground.
3. Connect the IC  $V_{CC}$  pin (2) to +5V, connect the GND to trainer ground.
4. Next, connect the trainer data switches to the Select and Strobe inputs on the IC, using Fig. 17 as a guide. Initially, set SW1 through SW4 to 1.
5. Connect the trainer LED to the Y output, and connect the other end to the B output.
6. Set all eight poles of the DIP switch to 0. The logic level will be 0.

7. Turn the power on. The LED on your trainer should be off, and the B LED should be on. If you don't observe these conditions, turn off the power and check your connections.
8. Press the present input conditions on the inputs; you can see that the input will be enabled.
9. Set the appropriate DIP switch HIGH, and verify your prediction. Record your results in terms of the selected input D, (where n is the number of the selected data line) in the appropriate space in the truth table in Fig. 18.

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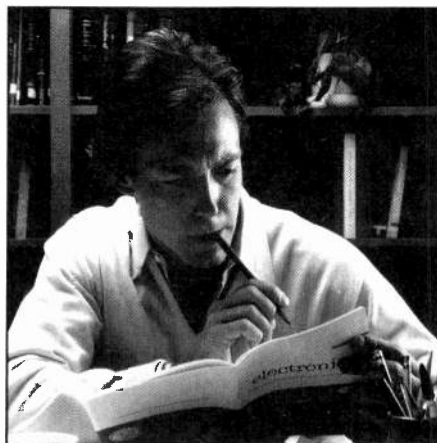
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# ASK R-E

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

## SIMPLE CHARGER

I've been trying to come up with a battery-charger circuit that can maintain an older alarm system. It has two 12-volt 1.2-AH batteries connected in series. I'd like something that charges them in about two hours and then drops the charging current to a trickle charge. I don't need a lot of bells and whistles, but a having a charge/discharge indicator would be nice. Got any tricks up your sleeves that can help me out?—C. Peterson, Van Nuys, CA

It seems that this sort of request shows up every year. Even though rechargeable batteries, of various chemistries are in common use just about everywhere, there's a real shortage of intelligent charging circuits. I ran across the problem a few years ago and designed the circuit in Fig. 1. It has all the features you asked about and can be adapted for use with a wide range of batteries.

The circuit has two basic parts. The first monitors and controls the charging of the batteries and the second monitors the amount of charge left in the batteries when they're being used to power the circuit.

When you're recharging a battery, the most important choice is the value of the current-limiting resistor. Too large a value will result in no charging action, and too small a value will allow so much current to run through the batteries that they'll either be damaged or, if you're not lucky, be destroyed.

The PNP transistor has its base-emitter junction sitting across the current limiter and, when current flows through it, a voltage drop appears across the resistor. That causes current to flow through the collector-emitter junction of the transistor and lights the LED to show that the battery is charging.

As the battery voltage increases, the battery's impedance increases

and the current flow gets less and less. That results in a constantly lowering voltage drop across the resistor, and the LED will get dimmer and dimmer until it finally goes out completely. If the intensity of the LED doesn't change, that's giving you some good information as well. Constant high intensity means the batteries aren't taking a charge, and a low intensity (when you first plug in the charger) means the batteries were already charged.

low a level determined by the potentiometer setting, the transistor turns off and the battery voltage appears at the collector. That triggers the SCR and lights the LED to warn you that the battery has to be recharged. The SCR latches and the LED stays lit until you turn off the power.

The critical element in the monitor circuit is the setting of the potentiometer, so you should use a multiturn unit. The circuit can be cal-

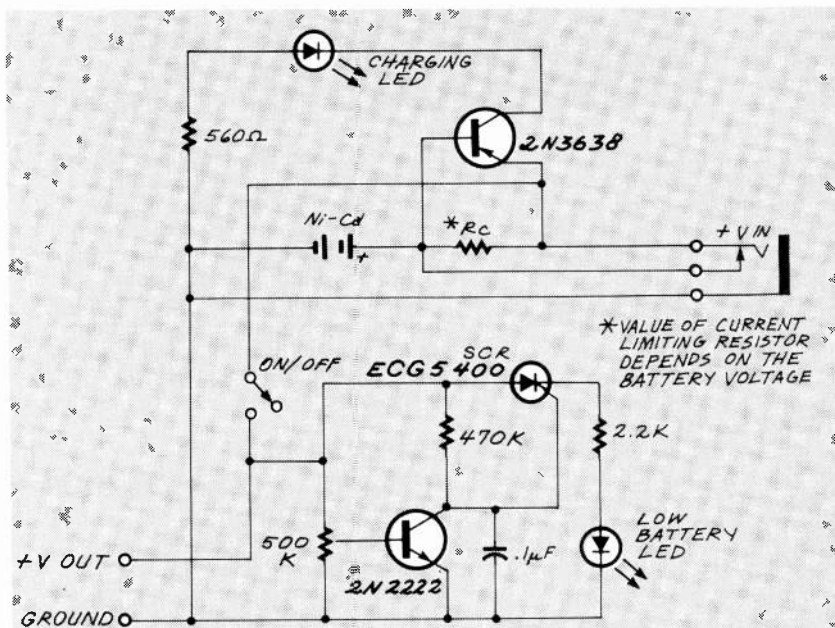


FIG. 1—THIS "INTELLIGENT" CHARGING CIRCUIT can be adapted for use with a wide range of batteries. One section monitors and controls the charging of the batteries and another section monitors the amount of charge left in the batteries when they're being used to power the circuit.

The second part of the circuit monitors the charge on the battery while the batteries are being used. The full battery voltage is put across the potentiometer and a certain value appears at the potentiometer's wiper. The NPN transistor is set up as a switch and, as long as the voltage at its base is high enough to keep it turned on, the collector-base junction conducts and keeps the collector at close to ground level.

When the battery voltage falls be-

ibrated by hooking it up to a variable power supply and setting the voltage to the value you want for the trigger voltage.

The schematic shows the on/off switch for the circuit being powered and uses the single-pole, single-throw switch in the jack to change the power source from the batteries to the charger. If you trace through the connections, you'll see that the charger recharges the batteries and powers the circuit at the same time.

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**DRIVEWAY ALARM**

I have a summer cabin that's located at the end of a long driveway and I'm looking for some way to have an alarm that goes off when a vehicle pulls into the driveway. There are animals around so a photoelectric cell isn't practical. Because there are sensing circuits used on highways all the time, there must be a simple and reliable way to get the job done. I've been toying with the idea of an RF-based circuit that has coils under the road and uses the presence of a vehicle to transfer a signal from one coil to another. If you have any ideas, it would help me a great deal.—D. Ingebright, Seattle WA

I have a house in the country and was faced with the same problem a few years ago. I have to admit though, that the idea of solving it by burying coils in the driveway never occurred to me. Maybe that's because the mere thought of the work involved in digging up part of the driveway just seems like too much effort. The method I used is a lot easier, much more straightforward, and can be done without having to use a shovel.

I contacted the local road maintenance people, and bought a length of the same sort of wire they string across the road when they want to do a traffic count. It's just two lengths of wire, separated by foam, and sealed in a tough rubber overcoat. When a car goes across it, the weight compresses the foam and the two wires inside the cable touch each other—a simple on/off switch. I don't know who makes the stuff, but I'd be willing to bet you can get a length of that wire the same way I did.

Some of the road departments use a different detection method in which the cable they lay across the road is really nothing more than a hollow tube filled with air. When a car crosses over it, the increase in pressure forces an air switch to close. Different method, same idea. It doesn't matter which of the two materials you get since either of them will do the job for you—although an air switch may not be such an easy part to get a hold of.

The signal from the wire across my driveway triggers a simple RF circuit and that, in turn, sounds a bell in the house. The whole system took about an hour to set up and it's been working reliably ever since then.

**CALL-WAITING DILEMMA**

My wife is using a computer and modem on her job, and she's having a problem with call waiting on the line. Whenever an incoming call shows up on the line, the computer locks up and, to make matters worse, the incoming call is lost. Is there anything that can be done about that without doing away with the call-waiting service completely?—T. Edmonson, Birmingham, AL

This is a fairly common problem and, if you can't afford to have a separate data line, it can be a real pain in the neck when you're using a modem. It's bad enough losing the call, but imagine what it's like when call waiting causes the carrier to drop just at the tail end of downloading a huge file. It's practically enough to make you start using the U.S. mail again!

There are ways around the problem without discontinuing call waiting and, believe it or not, the answer is really simple. All that's needed is a bit of software that's so minor you can even write it yourself using BASIC or whatever language you prefer.

The basic approach is to temporarily change the values in a few of the modem's control registers. The exact method is going to vary with different modems, but the basic principle will be the same. Just about all popular modems have one register that controls the amount of time the modem will wait to disconnect, once carrier has been lost. In the Hayes series of modems it's the S10 register and the time can be set in tenth-of-a-second increments. I'm not familiar with the modem you have, but I'm sure that if you go through the manual (or call the manufacturer), you'll be able to get the information you need to make the modification.

I ran across a small public-domain  
*continued on page 22*

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# LETTERS

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## KEEP IT SIMPLE

Regarding the article "Energy Consumption Monitor" (**Radio-Electronics**, December 1991): Sometimes we get so engrossed with today's technology that we lose sight of the simple way to do things. Although certainly not as elegant or convenient, the same thing can be done using a surplus watt-hour meter, which can be purchased at a flea market for a few dollars. (It's the same sort as the electric company uses at your house to bill you.)

The formula for finding power consumed at any given time is:

Watts = rev.  $\times$  kWh  $\times$  360/sec  
(The kWh rating can be found on the name plate.) You can count the number of revolutions by the black

spot on the disk. The meter can be left in the circuit for any length of time—a week, a month, or whatever. You can read the consumption in kWh and use your electric company's rate to arrive at a monetary value.

JOHN L. KURSCHNER  
Toms River, NJ

## MOTOR-SPEED CONTROLLER CORRECTION

I have found the motor-speed controller circuit described in Ask R-E (**Radio-Electronics**, February, 1992) to be very handy. However, there was a schematic error showing the oscillator circuit to be grounded. I've enclosed a drawing

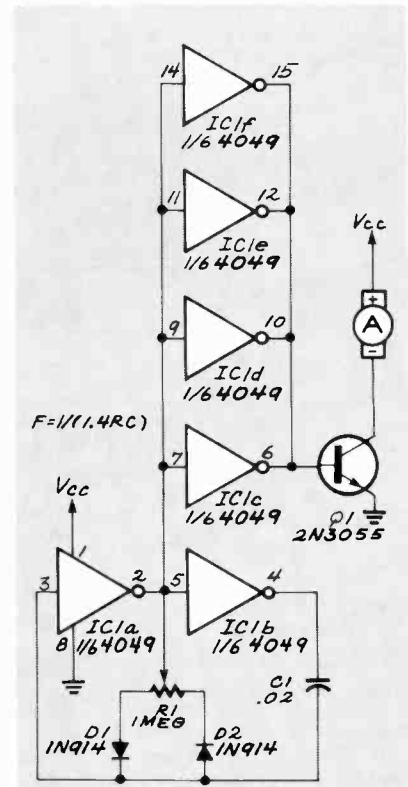


Fig. 1. This is the corrected schematic for the Motor-Speed Controller that appeared in February's Ask R-E.

of the corrected circuit (Fig. 1).  
CALVIN D. KAUFMAN  
Highland, MI

Thanks to you and all the others who pointed out our error.—Editor

## FLIGHTS OF FANCY

For the last few years I have read **Radio-Electronics** without much interest in the "Letters" section, but over the past few issues I've read it. I noted a letter in the February 1992 issue that is very wrong. It concerns the December 1992 *Drawing Board* column, written by Robert Grossblatt.

In the letter, the writer states that "high-speed aircraft all used generators and the electromechanical voltage regulators they required." I have spent the last 20 years as an Air Force airborne radar navigation technician working on KC-135's,

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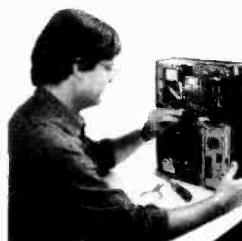


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RICHARD J. GOULET, MSgt,  
USAF

Wright-Patterson AFB, OH

#### ASK R-E ANSWERS

I read about the "Commercial Limiter" in *Ask R-E (Radio-Electronics, January 1992)* with great interest. I have some additional information that I think would be helpful to anyone undertaking such a project.

The article indicates that the audio signal can be obtained at the volume control or the speaker. While the latter is always true, the former might not be.

Many recent model TV's using conventional (potentiometer) volume controls use electronic volume attenuators that are generally incorporated into the sound IC. Those IC's are also used in sets with push-button and remote volume controls. In this type of system, no audio will be found at the volume control.

One reason for adopting this method is that it eliminates hum pick-up, which results from routing the audio signal to and from the volume control.

If a set uses an electronic attenuator and if the concept of the Commercial Limiter is understood, the circuit could be modified to take control of the attenuator line that controls the volume. That would preclude the necessity of using an additional amplifier stage, which could degrade the audio, particularly if the set has a good audio

section like those found in stereo TV's.

In some of these sets, an increase in control voltage causes a decrease in volume, while in others it is just the opposite. Depending on the system, the photo resistor could be placed so that it will shunt the attenuator line to ground, pull it up to some positive value, or it could be placed in series with the line. The LED could be driven by a simple circuit that would cause it to light when the volume exceeds some value. An LM3915 (such as the one shown in the same *Ask R-E* column in the "Audio Light" circuit) would be ideal for that purpose.

If the limiter's input comes from the output of the power amp or any point after the volume control or attenuator, it will have to be readjusted each time the volume setting is changed. If the input comes from some point ahead of the volume control or attenuator, then the limiter's action will be independent of the volume setting.

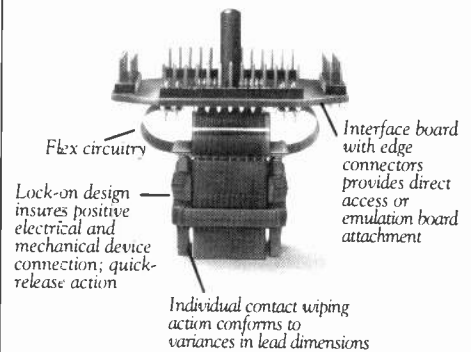
In many of the sound chips that use electronic attenuators, there is a pin that is connected to the output of the FM detector. From there, the audio is sent to the attenuator. That would be a good take-off point. In sets that do have audio at the volume control, audio can be taken from the "hot" side of the control and the photo resistor can be connected between the wiper and ground. All of those points can be easily found if the service literature is available.

By the way, I'd like to point out that there might be a problem with the circuit diagram for the Audio Limiter, shown on page 82. The PNP transistor must have a base voltage of about  $-0.6V$  with respect to the emitter for turn-on. Since the base is tied to  $V+$ , it will always be positive with respect to the emitter. Under these conditions it will never turn on. Perhaps it would if the emitter and the base were reversed.

The writer also indicated that the photo detector is wired in the feedback loop where a change in resistance will change the gain of the amp. Actually, the LM386 is operating in a fixed gain mode. The photo

*continued on page 22*

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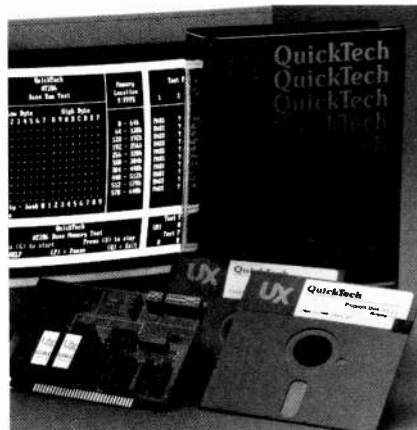
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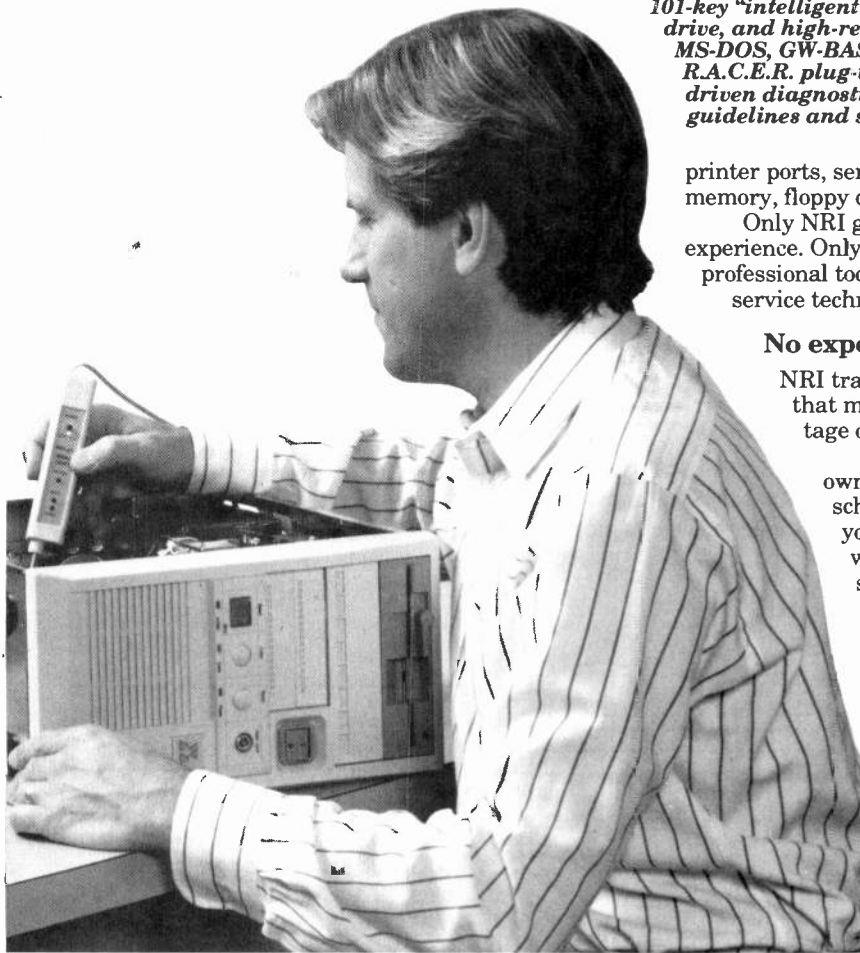


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## LETTERS

continued from page 17

detector is wired across the signal source (the secondary winding of the transformer) and not in a feed-back loop. A change in resistance acts to reduce the audio level by shunting it to ground before application to the "gain adjust," which is actually a level-adjust control. That doesn't involve the same principle as adjusting the gain of a stage.

The "Commercial Limiter" and the "Audio Link" illustrate an important concept. Projects such as these help us to understand how individual building blocks can be assembled to perform a task. I attribute a large portion of my knowledge of electronics to the projects and articles found in **Radio-Electronics**. Keep up the good work.

STEVE BABBERT  
Worthington, OH

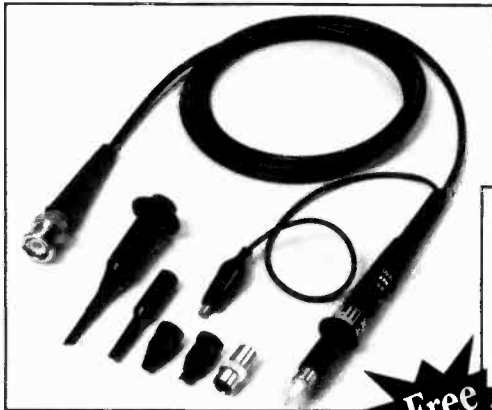
## ASK R-E

continued from page 14

program that addresses this problem and I've put it on the RE BBS (516-293-2283) for you to download. The file is called CALL-WAIT.ZIP. It has a small BASIC program that was designed for a Hayes 1200-baud modem, but it should show you what has to be done and how to do it. The program is well-commented and all you'll really have to do to make it work with your modem is change a few numbers.

It really works. I've tried it with modems from Racal Vadic, US Robotics, and Hayes (after suitable patching), and never had a problem. If you find that it doesn't work, the best advice I can give you is to contact the modem manufacturer and let them come up with an answer. Call waiting is a common service and you can be sure that you're not the only one who's had this problem. If that fails, you'll just have to spring for a second phone line or drop call waiting—whichever method you prefer. Your phone company should have a way to disable call waiting temporarily as well. **R-E**

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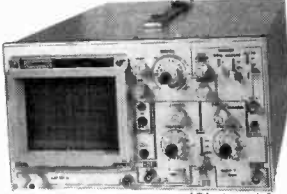
## Hitachi RSO Series

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- VC-6045 - 100MHz, 40MS/s \_\_\_\_\_ \$2,995
- VC-6145 - 100MHz, 100MS/s \_\_\_\_\_ \$4,495

RSO's from Hitachi feature roll mode, averaging, save memory, smoothing, interpolation, pretriggering, cursor measurements. These scopes enable more accurate, simpler observation of complex waveforms, in addition to such functions as hardcopy via a plotter interface and waveform transfer via the RS-232C interface. Enjoy the comfort of analog and the power to digital.

## 25MHz Elenco Oscilloscope



**\$349**  
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- V-1085 - 100MHz, QT, w/cursor \_\_\_\_\_ \$1,995
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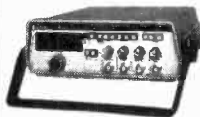
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PageMaker are provided.

The package, which consists of the *Video Frame Grabber* board, a 5¼-inch floppy disk, and a manual, allows you to capture real-time video at up to two frames per second. Pause and freeze modes are available for viewing and modifying the image. The package features scalable printing, user-defined mar-

gins, auto-exposure compensation, and anti-aliasing filtering for lower noise and less snow.

The *Video Frame Grabber*, which carries a one-year warranty, has a suggested retail price of \$149.95.—**MacroHard**, 755 Tatum Street, Woodbury, NJ 08096-3431; Phone: 609-853-4680; Fax: 609-853-0677.

## ANALOG/DIGITAL STORAGE SCOPES.

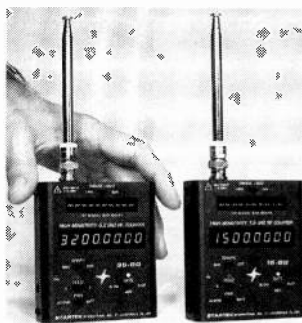
A series of 100- and 200-MHz analog/digital oscilloscopes from Fluke and Philips combines analog familiarity and digital performance. It offers true four-channel operation as well as models with 2+2 input-channel configurations. Additional features include direct-access controls, closed-case calibration, serial interface for printer/plotter, full programmability, automatic pass/fail testing, signal math and analysis, signal averaging, and peak-detect mode for HDTV tri-level sync. A touch-hold-and-measure feature is used for initiating measurements from a probe-mounted button. The units have a wide range of applications in radio/TV, medical electronics, and the new 1100-line resolution video.

The four Fluke/Philips oscilloscopes—*PM 3382*, *PM 3384*, *PM 3392*, and *PM 3394*—can each be considered two scopes in one, with the easy operation and realtime 100- or 200-MHz bandwidth of an analog scope, and digital sampling rates of 200 million samples per second. According to Fluke, the analog portion is not redundant; there continue to be many applications that demand the "live" signal representation and infinite resolution of analog instruments. Switching between analog and digital operation is simple. The units have full digital capture and signal analysis capabilities, providing powerful storage and measurement ca-

## RF DETECTOR/FREQUENCY COUNTERS.

Two new pocket-sized counters from Startek each feature a 2-inch, 10-segment LED signal-strength bar graph that functions independently of the digital frequency counter. The bar graph, which can be used to locate or adjust an RF signal, will indicate the relative strength of an input signal at any frequency from 500 kHz to 3.5 GHz. The user can switch between dot-graph and bar-graph operation, and the sensitivity is adjustable.

The frequency-counter function has a range of 1 MHz to 1.5 GHz on the model 15-BG and 1 MHz to 3.2 GHz on the model 35-

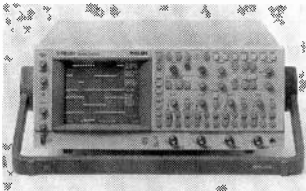


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*BG*. Other than the frequency bandwidth, the only difference between the two models is that the 35-BG is more sensitive above 500 MHz. Both counters have a display-hold switch with indicator and three switch-selectable gate times. Resolution is 1 kHz at 0.25 sec-

ond, 100 Hz at 2.5 seconds, and 10 Hz at 25 seconds, over the entire range. The display consists of eight red LED digits. A 1-PPM TCXO time base is standard, and there are provisions for an optional, ultra-high-stability TCXO. With the Ni-Cd battery pack fully charged, the counter will operate for 3–5 hours. An AC adaptor/charger is standard.

Models 15-BG and 35-BG bar-graph/frequency counters cost \$220 and \$265, respectively.—**Startek International Inc.**, 398 NE 38th Street, Fort Lauderdale, FL 33334; Phone: 305-561-221 or 80-638-8050 for orders only; Fax: 305-561-9133.



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pabilities on demand. Instant results are obtained by selecting the required function and channel from a set of built-in, fully automated voltage and timing measurement functions.

Triggering modes include logic state and pattern triggering, and glitch triggering. In addition to pre- and post-trigger signal display, the scopes have event delay and time-after-event delay.

Models *PM 3384* (100 MHz) and *PM 3394* (200 MHz) offer true four-channel operation, which provides full sensitivity with complete attenuation ranges on each channel. The 100-MHz *PM 3382* and the 200-MHz *PM 3392* offer 2+2 channel operation, a configuration that provides a cost-effective alternative to four fully featured inputs.

Models *PM 3382*, *PM 3384*, *PM 3392*, and *PM 3394* have list prices of \$4490, \$5490, \$5990, and \$6490, respectively.—**John Fluke Mfg. Co., Inc.**, P.O. Box 9090, Everett, WA 98206; Phone: 800-44-FLUKE.

**SELF-TUNING TEST RECEIVER.** For testing the modulation quality of mobile voice transmitters and verifying the accuracy of audio signalling tones such as DTMF and CTCSS, Optoelectronics' *R-10* communications test receiver is a quick, easy, and inexpensive alternative to costly modulation meters. The unit can automatically accommodate

the enormous difference ratio between an unknown carrier of up to 1000 MHz and a modulating frequency as low as 50 Hz, without any manual tuning.

The *R-10* automatically determines and locks onto whatever carrier signal is the strongest within a 100-foot range. Once the signal is locked in, the *R-10* demodulates whatever FM audio is present on the carrier and outputs that audio to an internal power amplifier/speaker and the BNC output jack. For DTMF and CTCSS testing, the audio output is evaluated on a frequency counter or oscilloscope. For counter-surveillance operations, the *R-10's* demodulated audio can be monitored to determine if a surreptitious transmitter is in the area.



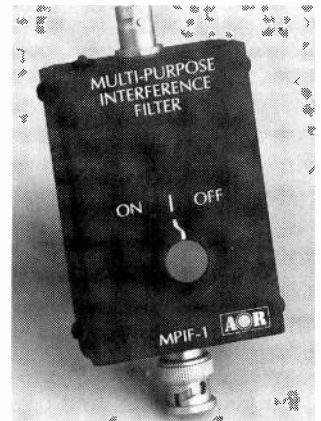
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The test receiver features two operating modes; a squelch capability that serves as a sensitivity control; audio gain, power, and low-battery indicators; and a rear connector that provides output to external frequency counters and other instruments. Power is supplied by an internal 9-volt battery. Options include a rechargeable battery pack and a telescoping whip antenna with swivel base.

The *R-10* test communications receiver costs \$359.—**Optoelectronics Inc.**, 5821 NE 14th Avenue, Fort Lauderdale, FL 33334; Phone: 800-327-5912 or 305-771-2050; Fax: 305-771-2052.

**MULTI-PURPOSE INTERFERENCE FILTER.** Ace Communications' *MPIF-1* receiver filter eliminates a variety of unwanted signals. The compact (3 x 2 x 1½-inch) external filter eliminates most of the sources of interference common in broad-banded receivers. Unwanted signals are filtered from the 54–108 MHz, 174–220 MHz, and 512–806 MHz ranges, as well as the range above 869 MHz. A switchable notch will also eliminate interference on the 150–153 MHz range, which is a common source of interference in many areas. The use of BNC connectors makes the filter quite versatile; the *MPIF-1* can even be used on handheld receivers.

The *MPIF-1* multi-purpose interference filter has



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a suggested retail price of \$59.—**Ace Communications**, Monitor Division, 10707 East 106th Street, Fishers, IN 46038; Phone: 817-842-7115; Fax: 317-849-8794.

**POWER SUPPLIES.** The "smart" front panels on the 15 instruments in Hewlett-Packard's new line of DC

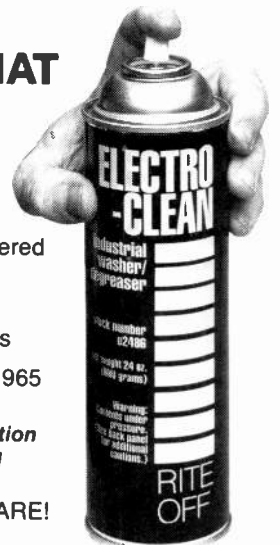
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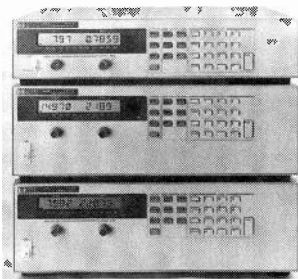


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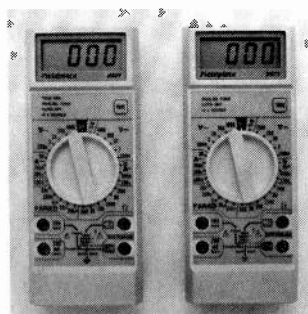
power supplies help provide fast, flexible, and precise output control. With outputs ranging from 200 to 2000 watts, the HP 6000 series power supplies provide a variety of choices for benchtop or system applications that do not require HP-IB control of the power supply. The series consists of five power supplies (which vary by voltage ratings) in each of three power ranges: 200, 500, and 2000 watts.

All models have low output noise, extensive load-protection features, and the "smart" front panel. The peak-to-peak ripple and noise spans from a low of 3 mV p-p on the low-power, low-voltage models to a high of just 16 mV on the 2-kW, 120-volt model. Overcurrent, overvoltage, and over-temperature protection are provided for the device under test and for the power supply. Those features protect the device under test by disabling the output voltage of the power supply when potentially dangerous conditions occur. "Smart" front-panel controls provide three methods for setting the output voltage and current. A numeric-entry keypad allows the user to set the voltage quickly and precisely, while up/down buttons and rotary pulse generators permit the user to quickly and conveniently change the voltage and current settings in small increments. For repetitive

benchtop tests, up to five states or sets of power-supply settings can be stored and recalled for easy sequencing among states. Front-panel controls also allow the user to calibrate the power supply. In addition, the output voltage can be controlled via an external voltage signal, allowing for computer control or analog modulation.

List prices for the HP 6500 series of power supplies range from \$1650 to \$1750 for the 200-watt models, \$2100 to \$2300 for the 500-watt models, and \$3650 to \$3800 for the 2000-watt models.—**Hewlett-Packard Company**, Inquiries, 19210 Pruneridge Avenue, Cupertino, CA 95014; Phone: 800-752-0900.

**HAND-HELD DIGITAL MULTIMETERS.** Aimed squarely the field service technician, Fieldpiece's digital multimeter models HB75 and HB77 are professional-grade instruments that are durable and easy to use in the field. They include a built-in logic probe and a variable-pitch tone. The tone's pitch varies proportionally from high to low with high to low readings. In the field, that feature has two primary uses. First, intermittents can easily be found by listening for discontinuities in the tone while wiggling suspect connections. Second, one "odd" test point in a series



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of test points that are nearly the same can be found without waiting for the meter to display a number; instead, the technician can quickly scan the test points and "hear" the one that is different.

Both models have a built-in logic probe that responds up to 20 MHz. "Hi" and "Lo" are indicated both in the display (with up/down arrows) and by a beeper with two different tones. Both DMM's also have a built-in capacitance meter that measures capacitors up to 200  $\mu$ F in the circuit using the test leads.

Model HB77 measures the true-RMS value of AC voltages and currents. Current ranges go from a low of 200  $\mu$ A to 20 A. Because the meter is manual ranging, the voltage burden (the voltage across the device when current is flowing through it) is low—0.25 volts for the 200- $\mu$ A range.

Both heavy-duty meters feature a drop-resistant housing, O-ring seals to protect against contaminants, MOV's to protect against transients, and full 600-V fusing on all current jacks. They come with a tilt stand and a hanger on the back, test leads, and fuses and batteries installed. Both DMM's have 24 ranges in AC and DC volts, AC and DC amps, and ohms, and both include a high-voltage indicator that warns the user when touching anything over 28 volts. A single rotary dial, with the "menu" of functions printed around it, makes the meters easy to understand and use.

The models HB75 and HB77 digital multimeters have suggested list prices of \$139 and \$179, respectively.—**Fieldpiece Instruments, Inc.**, 8322B Artesia Blvd., Buena Park, CA 90621; Phone:

714-992-1239; Fax: 714-992-1239.

## 2.7-GHZ SYNTHESIZED SIGNAL GENERATOR.

Designed for use in research and development, manufacturing, and servicing electronic products, Leader's model 3221 synthesized signal generator



CIRCLE 23 ON FREE INFORMATION CARD

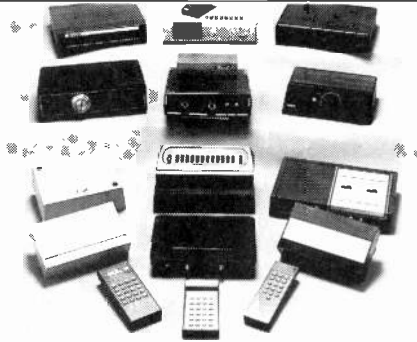
offers high-stability and high-purity outputs to 2.7 GHz. Its extensive modulation capabilities include seven modes with 14 simultaneous combination modulation modes—pulse, logic, DC-FM, and internal or external AM and FM. RF-output level engineering units are selectable between dBm and dB $\mu$  with 0.1-dB resolution. Three convenient presets are included for commonly used RF-output levels. One hundred preset memories allow storage and recall of all front-panel setting conditions. RF output on/of control and 50-watt reverse power-protection reset are accomplished with a single key. A continuous, variable RF-output mode allows  $\pm$ 5-dB variation in 0.1-dB increments for squelch adjustments. Edit functions for frequency, output level, and modulation make it easy to change operating parameters. Other standard features include GPIB and a GaAs FET pulse modulator.

The model 3221 synthesized signal generator costs \$12,300.—**Leader Instruments Corporation**, 380 Oser Avenue, Hauppauge, NY 11788; Phone: 800-645-5104 or 516-231-6900. **R-E**



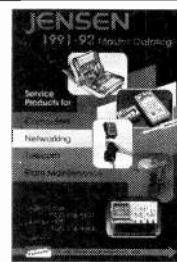


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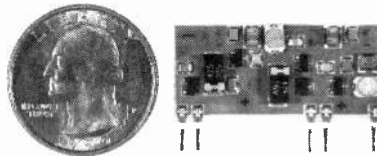
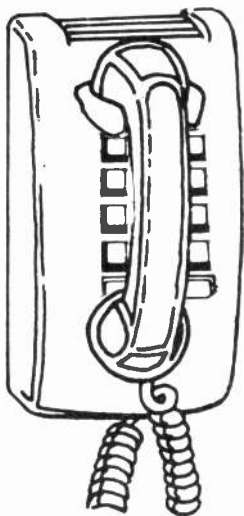
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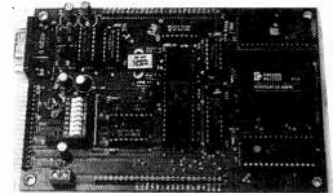
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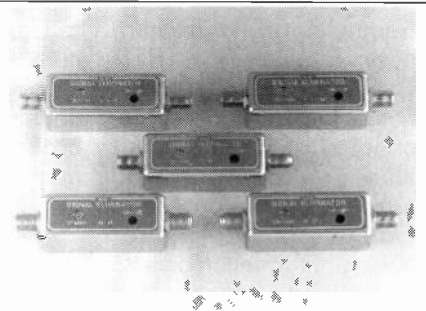
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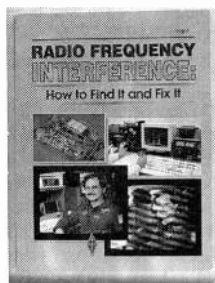
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# NEW LIT

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**RADIO FREQUENCY INTERFERENCE: How to Find it and Fix it; book edited by Ed Hare, KA1CV, and Robert Schetgen, KU7G; The American Radio Relay League; 225 Main Street, Newington, CT 06111; \$15.00 plus \$3.00 shipping and handling (\$4.00 for UPS).**

If you've ever experienced black bars flashing across your TV picture in a rhythmic pattern, a garage door opening or closing by itself, a buzz that drowns out AM stations, a touch-controlled lamp with a mind



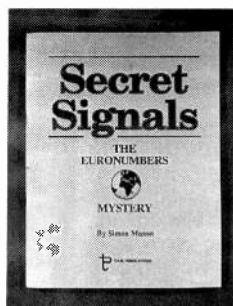
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of its own, or anonymous conversations that interrupt music on your stereo you've experienced radio-frequency or electromagnetic interference (RFI/EMI). This 256-page book not only explains the mechanics of RFI/EMI, but also provides practical cures for the problem. Opening chapters offer general information on how to find the interacting equipment, locate help, and resolve conflicts. Subsequent chapters discuss RFI/EMI problems and provide cures for specific electronic systems, including transmitters, televisions, telephones, amateur-radio equipment, stereos and

other audio gear, power lines and electrical devices, computers, and automobiles. The chapter on filter performance explains how to select a filter and provides test results and performance tables for dozens of low-pass, high-pass, power-line, and miscellaneous filters. In addition, the book also explains RFI/EMI regulations and standards, and provides a copy of the ARRL EMI/RFI report form, which can be used to file official EMI/RFI complaints.

**SECRET SIGNALS: The Euronumbers Mystery; by Simon Mason. Tiare Publications, P.O. Box 493, Lake Geneva, WI 53147; Phone: 414-248-4845; \$9.95 plus \$2.00 shipping and handling (\$3.00 outside the U.S.).**

If you've ever tuned to the frequencies outside the shortwave and ham bands to the regions allotted to "fixed" stations, you might have heard broadcasts consisting of a single voice reading out long lists of numbers in four- or five-digit groups. While explanations for those mysterious broadcasts have ranged from commodity prices to

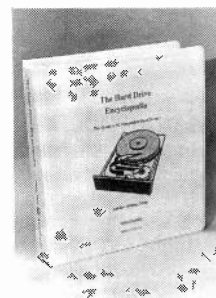


CIRCLE 39 ON FREE INFORMATION CARD

lottery numbers, the most likely explanation is that they are coded messages sent to espionage agents. The end of the Cold War hasn't ended the transmission of coded numbers; they're still being sent, day and night, over all the shortwave-radio bands. This book, written by a man who has studied the European numbers stations for years and has monitored thousands of transmissions in the process, is an indispensable tool for tracking those stations from North America. It includes numerous traffic excerpts, identifiers, schedules, and clues turned up by hearing mistakes in transmissions. Descriptions of transmissions from "Bulgarian Betty," "Papa November," "The Russian Man," "Swedish Rhapsody," and "The Lincolnshire Poacher" are included, as is a complete frequency log with more than 300 entries that are listed by frequency and contain notes on formats and schedules.

**THE HARD DRIVE ENCYCLOPEDIA: The Guide to PC-Compatible Hard Drives; by Adrian Alting-Mees. Annabooks, 12145 Alta Carmel Court, Suite 250-262, San Diego, CA 92128; Phone: 800-462-1042 or 619-271-9526; Fax: 619-592-0061; \$89.00.**

Consisting of more than 600 pages in a three-ring binder and a companion diskette of utilities, this book provides a complete reference on PC-compatible hard-disk drives. The

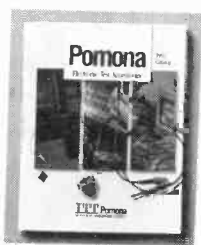


CIRCLE 37 ON FREE INFORMATION CARD

book includes sections on ST-506, ESDI, SCSI, and IDE specifications, as well as a section covering five other interfaces. Other sections cover the physical and electrical characteristics of hard drives, logical encoding schemes, and file formats. Sections covering controller parameters, hard-disk drives, and manufacturers include extensive lists of related information. Another section lists the BIOS hard-drive tables for many popular BIOS's, and explains how to use the utilities on the companion disk to see the drive-type tables in your own BIOS. More than 1600 hard-drive model numbers are listed by manufacturer, so that if you have to install a drive but don't have a spec sheet, you can locate the important parameters in the included tables.

**1992 ELECTRONIC TEST ACCESSORIES CATALOG; from ITT Pomona, 1500 East Ninth Street, P.O. Box 2767, Pomona, CA 91769-2767; Phone: 714-469-2900; Fax: 714-629-3317; free.**

Specially featured in this 140-page catalog are an expanded line of oscilloscope-probe kits and two



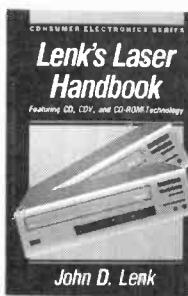
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new lines of test probes and clips for miniature and heavy-duty applications. Also featured are accessories designed to make testing SMT devices and high-density leaded components easier and more reliable. New products include new IC clip kits, coax/BNC universal adapter kits, digital multimeter test-lead kits, cable and patch accessories, and jumper kits. ITT Pomona's popular selection of jumpers and cables, boxes,

plugs and jacks, connectors, adapters, single-point test clips, and static control devices are also described. An easy-to-use index is provided to help readers quickly locate specific products.

**LENK'S LASER HANDBOOK: Featuring CD, CDV, and CD-ROM Technology; by John D. Lenk. McGraw-Hill, Inc., Professional Book Group, 11 West 19th Street, New York, NY 10011; Tel. 1-800-2-MCGRAW; \$39.95.**

This new addition to McGraw-Hill's Consumer Electronics Series is a practical reference book filled with the information needed to troubleshoot today's laser-based products. Aimed at service technicians and field-service engineers who work with laser-based technology,



**CIRCLE 35 ON FREE INFORMATION CARD**

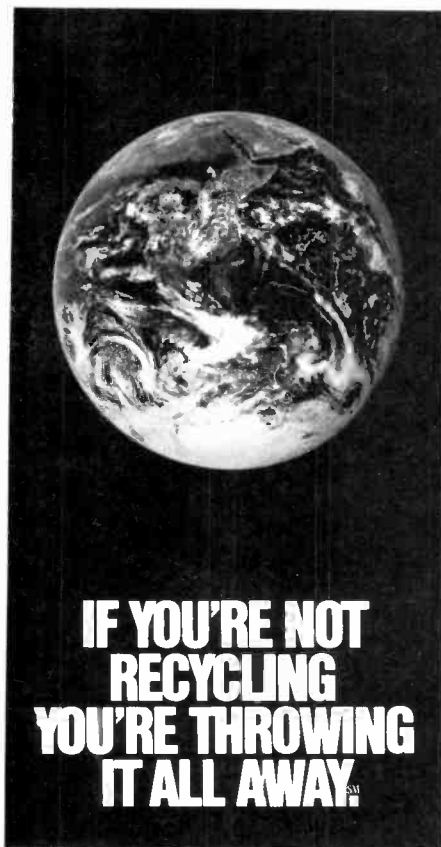
the book focuses on videodisc and compact-disc players, and CD-ROM units, using information that is applicable to all sorts of laser devices, including CD-I (compact-disc interactive) units. The book shows precisely how to repair laser-based equipment and how to pinpoint trouble in a component or module. Step-by-step and circuit-by-circuit examples are used to explain not only how laser equipment

works, but also how to service it.

Opening with a discussion of the basics of CD players, the book goes on to explain various techniques for encoding and decoding as well as the basic principles of optical readout. Proper operation and installation are described, as are the test equipment and tools required for servicing and maintenance.

Typical circuits for compact-disc and videodisc players are explored, accompanied by schematics, block diagrams, and a discussion of the theory of operation. The book also discusses approaches to troubleshooting and adjusting CD and laser disc products based on the type of failure or symptoms of trouble.

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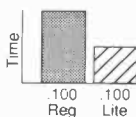
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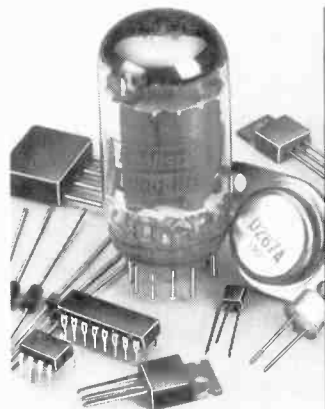


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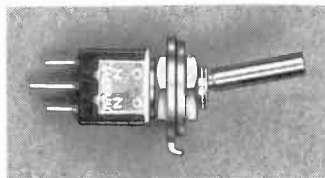
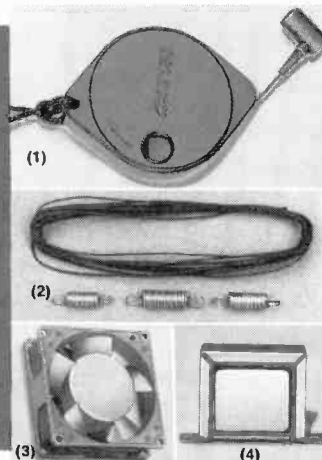
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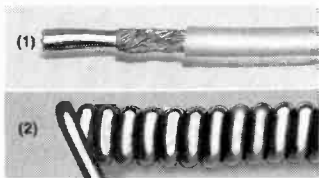
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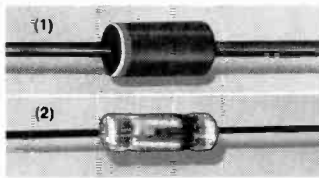


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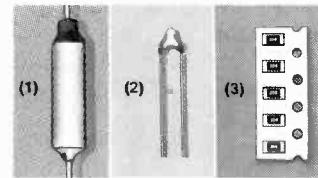
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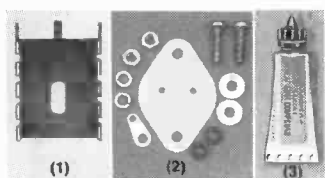
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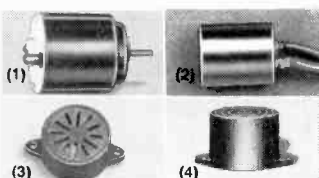
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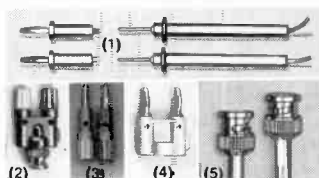
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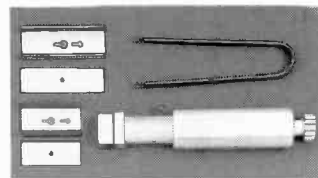
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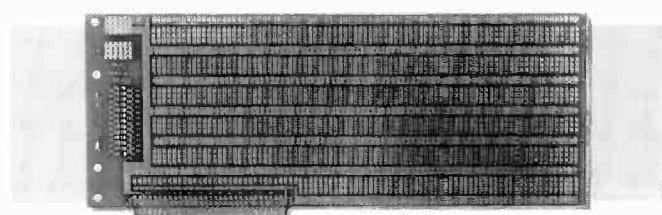
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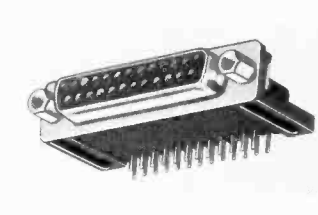
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# BUYER'S GUIDE TO DMM'S

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THE BENCHTOP DIGITAL MULTIMETER (DMM) IS THE workhorse test instrument in today's labs and service shops while the handheld DMM is the favored versatile tester in the field. Bench/portable DMM's have seized the high ground where emphasis is on accuracy, resolution and automated testing. Benchtop DMM's are in use for electronic equipment testing, service, and calibration in both shop and field. They are also filling important roles in design departments, scientific labs, and as components in industrial data acquisition and automated test systems.

To be classed as a DMM, a meter is usually expected to be able to make the five basic electrical measurements: DC and AC volts, DC and AC current, and resistance. However, the term DMM now covers a wide range of instruments from the low-cost handheld, battery-powered units costing less than \$100 to the AC line-powered bench/portable units whose base list prices can range from \$200 to nearly \$2700.

Benchtop DMM's are distinguished from handhelds by their rectangular cases and front-face displays and controls. Their long depth dimensions give them stability on a bench or other flat surface. Most are equipped with tilt bails to raise their front faces for easier user reading. Despite those differences, there is considerable overlap in features between high-end handheld and low-end benchtop DMM's.

In fact, some bench-type meters are little more than repackaged handhelds, and they cannot be distinguished by looking only at specifications. All handheld DMM's are portable, but benchtop DMM's are also portable, and those that are battery powered can be used conveniently in the field.

Many bench DMM's have liquid-crystal displays, typical of today's handhelds, but most of the high-end models have vacuum-fluorescent or LED displays that afford better viewing in subdued light. These displays can be used because the benchtop units have less restricted power budgets than the handhelds.



## How they work

Figure 1 is a simplified functional block diagram of a DMM. In practice, both AC and DC voltage measurements are made by one circuit, and both AC and DC currents are measured by another. Typically there is a separate resistance measuring circuit.

The latest DMM's, both handheld and bench, include either a microcontroller (microcomputer-on-a-chip) or microprocessor for various control and self-check functions. A micro-processing function block has been omitted from the simplified diagram, but it would typically be located between the analog-to-digital (A/D) converter and the display.

The microprocessor or microcontroller provides control signals for the true root-mean-square (RMS) voltage and current converter if the DMM has one. Bench meters are more likely to have this feature than handhelds; thus it is not exclusive to either one. However, provision for interfacing with systems is an exclusive bench DMM feature.

Bench DMM manufacturers have used a number of different schemes to convert analog input signals into a digital readout. Among them are voltage-to-frequency, successive approximation, reciprocating remainder, and dual-slope integration conversion. However, the most popular scheme in use today is some form of dual-slope integration.

Figure 2 is a simplified block diagram of a dual-slope integrating DMM. Instead of converting voltage to frequency as is done in other methods, it is converted to time. The timing sequence for this technique is shown in Fig. 3. Switch S1 connects the unknown input voltage to the integrator consisting of input resistor R1 and an operational amplifier with capacitor C1 in its feedback loop.

Switch S1 remains in that position for the integration period. During this time, C1 is charged at a rate determined by

R1. At the end of the integration period, C1 has a charge that is proportional to the input voltage. The op-amp causes the voltage across C1 to build linearly so the charging rate is governed by the current through resistor R1.

In the second phase of dual-slope operation, control logic switches S1 to connect a reference voltage to R1 and the input of the integrator. The reference polarity is always opposite to that of the unknown input voltage. Two references are used—one negative and the other

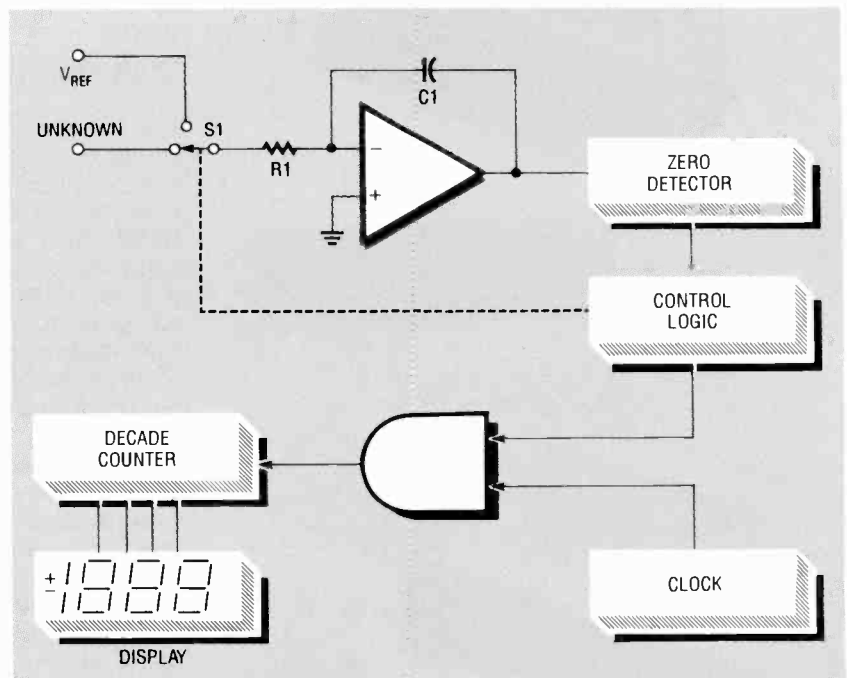


FIG. 2—SIMPLIFIED BLOCK DIAGRAM of a dual-slope integrating DMM. Switch S1 connects the unknown voltage to the integrator for the first half of the cycle, and the reference voltage for the second half. The time to discharge capacitor C1 is converted to a digital readout.

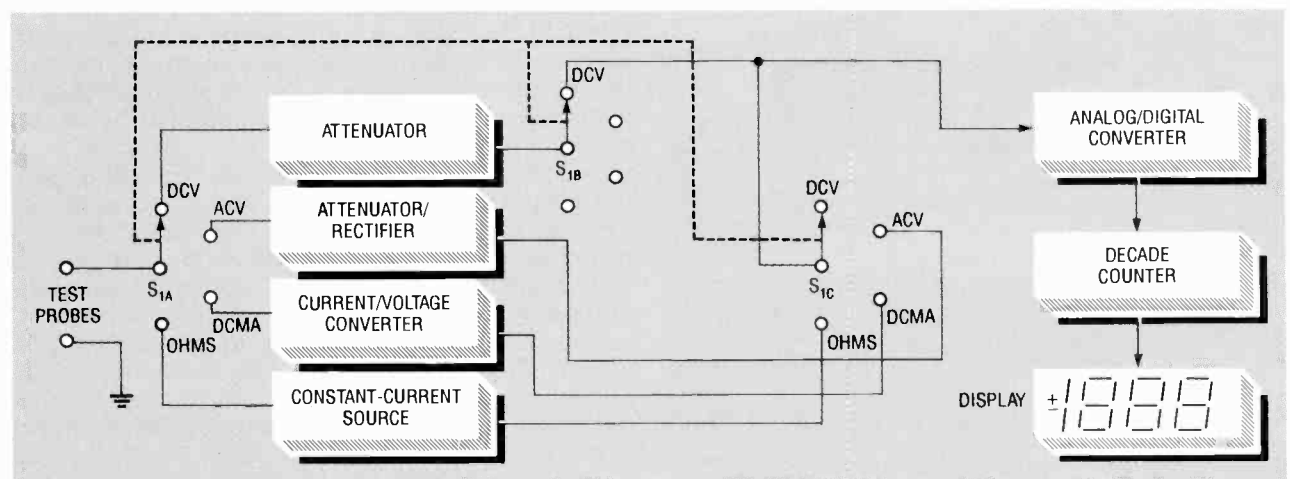
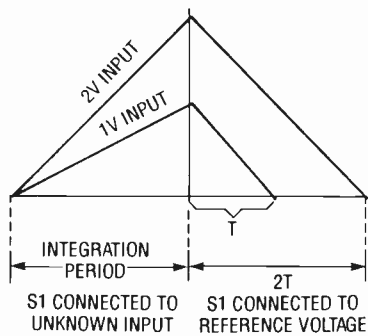


FIG. 1—BLOCK DIAGRAM of a basic digital multimeter.



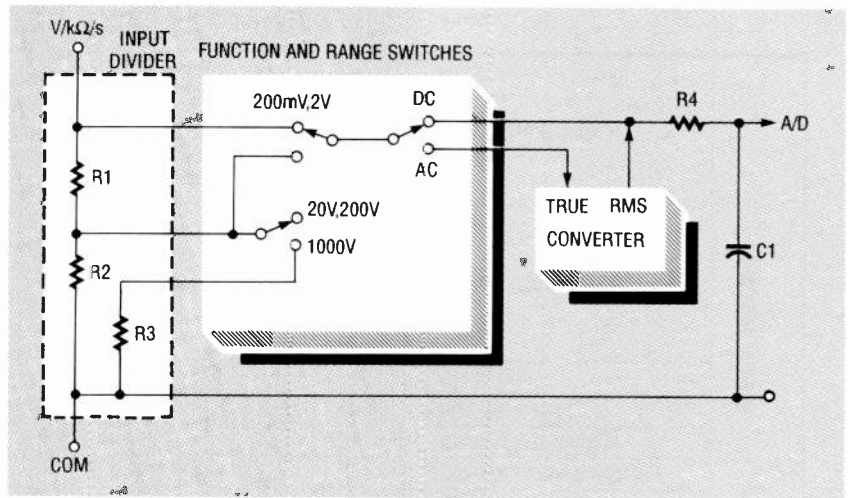
**FIG. 3—DUAL-SLOPE INTEGRATION measuring sequence.** The slope angle depends on the magnitude of the unknown input voltage and the time to discharge to zero is a function of that value.

positive. At the beginning of the second phase, the output from the clock is gated. Capacitor C1 is then discharged linearly by the reference voltage, and the clock is stopped when C1 is discharged through zero.

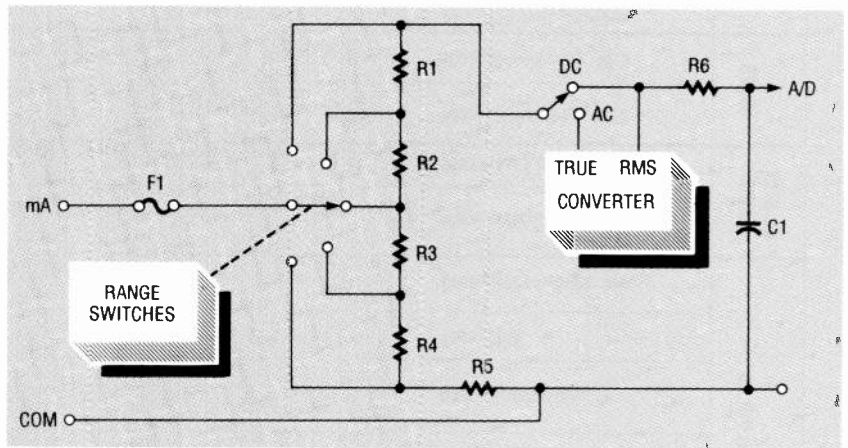
If the unknown input voltage is doubled, C1 charges up twice as fast. Since a constant reference voltage is applied to discharge the capacitor, the discharge rate will be constant. This means that the time to discharge C1 is doubled if the unknown input is doubled, as shown in Fig. 3. The accuracy of the dual-slope technique depends primarily on its reference voltages. This method is favored because errors introduced during charging are canceled during discharge. Some benchtop DMM A/D converters can now take 1000 readings per second. Hewlett-Packard's HP 34401A DMM can, for example, make up to 50 range/function changes per second.

Figure 4 is a simplified diagram of a typical DMM circuit for measuring both AC and DC voltage. Many different proprietary circuits are used for true RMS AC and DC voltage conversion. As can be seen, the output of the true RMS converter goes to the A/D converter.

Both AC and DC current can be measured with the circuit shown in simplified form in Fig. 5. Again, the range switch block represents either manual or automatic range functions. Fuse F1 can represent two fuses in series, one rated for low current values, and the other for



**FIG. 4—SIMPLIFIED DIAGRAM of a typical voltage-measurement circuit.**



**FIG. 5—SIMPLIFIED DIAGRAM of a typical current-measurement circuit.**

high current values. Those protect the meter against accidental damage and the user from shock. The true RMS converter functions in both the voltage and current measurement circuits and, as in the voltage circuit, the output goes to the A/D converter.

Several different resistance measuring circuits can be found in today's crop of bench DMM's. The most popular are the constant-current source and voltage-ratio techniques. The constant-current source supplies current to the unknown resistance value. The DMM then measures the voltage drop across the unknown. In the voltage ratio-method, shown in simplified form in Fig. 6, there is a voltage source and an internal divider consisting of a reference resistor ( $R_{REF}$ ) and the unknown value ( $R_X$ ). The value of  $V_{RX}$  is obtained from the lower op-amp.

Figure 7 illustrates a conventional 2-wire ohms converter found in most bench DMM's. It is based on a DC constant-current source. Figure 8 is a simplified schematic of a four-wire ohms converter that will eliminate measurement errors introduced by lead resistance in precision DMM's.

Alternate or optional battery power enhances the bench/portable meter's portability and improves its isolation from the AC line for certain critical measurements. It also ensures the safety of the user when making certain kinds of high-voltage and current measurements. Most low-cost, battery-powered bench DMM's use multiple "C" or "D" cells, or 9-volt transistor batteries, typically disposable alkaline. However, the battery power sources of the higher performance meters are typically multiple rechargeable nickel-cadmium (Ni-Cd) cells or sealed

TABLE 1—BENCHTOP DIGITAL MULTIMETER CHARACTERISTICS

Manufacturer	Model No.	BASIC FEATURES		DC VOLTS		AC VOLTS				AC & DC AMPS		OHMS		SPECIAL FEATURES							Price			
		Number of Digits	Display Counts	Basic Accuracy, %	Max. DC Voltage w/o Probe	Max. Resolution, $\mu$ V	Basic Accuracy, %	Max. AC Voltage w/o Probe	Max. Resolution, $\mu$ V	True RMS	Frequency Range, kHz	Max. Resolution, $\mu$ A	Max. Resistance, $M\Omega$	Max. Resistance, $M\Omega$	Auto/Manual Ranging	Frequency Measurement	dB, dbm Readout	Offset/Relative Reference	Continuity & Audible	Min./Max. Hold		Diode Test	System Interface	Other (See Notes)
Analogic B & K	DP100	5½	200,000 LCD	0.0035	450	0.1	450	1.0	•	50	1.0	2.0	1.0	20	•	•	•	•	•	•	•	232(ST)	(B/AC)(DM)(TM)	595
	2831A	3½	2000 LED	0.1	1200	100	1000	100	—	40	0.1	20	100	20	•	•	•	•	•	•	•	—	—	295
	2832	3½	2000 LCD	0.5	1000	100	1000	100	—	500	0.1	20	100	20	•	•	•	•	•	•	•	—	(B/AC)(CA)	195
	2833	4½	20,000 LCD	0.05	1000	10	1000	10	•	50	0.01	20	10	20	•	•	•	•	•	•	•	—	(B/AC)(DH)	356
Beckman	350	3½	2000 LCD	0.1	1500	100	1000	100	—	10	0.1	10	100	20	•	•	•	•	•	•	•	—	—	259
	360B	3½	2000 LCD	0.1	1500	100	1000	100	•	40	0.1	10	100	20	•	•	•	•	•	•	•	—	(TM)	329
Daeltron	MM300A	4½	20,000 LCD	0.2	500	10	500	1000	—	0.06	1000	2	1.0	20	•	•	•	•	•	•	•	232(OP)	(BG)(M)(PH)	450
	37	3½	3200 LCD	0.1	1000	100	1000	100	—	30	0.1	10	100	32	•	•	•	•	•	•	•	—	(BG)(CO)(DH)	269
Fluke	45	5	100,000 FL	0.02	1000	1.0	750	1.0	•	100	0.1	10	1	300	•	•	•	•	•	•	•	232(ST), 488(OP)	(DH)	635
	8010A	3½	2000 LCD	0.1	1000	100	1000	100	•	50	0.1	10	100	20	•	•	•	•	•	•	•	—	(CO)	379
8012B	3½	2000 LCD	0.1	1000	100	1000	100	•	50	0.1	2	1	20	•	•	•	•	•	•	•	—	(CO)	389	
	8050A	4½	20,000 LCD	0.03	1000	10	750	10	•	50	0.01	2	10	20	•	•	•	•	•	•	•	—	(CO)	479
8840	5½	200,000 FL	0.005	1000	1.0	1000	1.0	(OP)	100	10	2	1	10	•	•	•	•	•	•	•	•	488(OP)	—	875
	8842A	5½	200,000 FL	0.003	1000	0.1	1000	0.1	(OP)	100	1.0	2	0.1	20	•	•	•	•	•	•	•	488(OP)	—	1095
Goldstar	DM7241	4½	20,000 LCD	0.05	1000	10	750	10	•	50	0.1	10	10	20	•	•	•	•	•	•	•	—	(DH)	229
	34401A	6½	1,200,000 FL	0.0035	1000	0.1	750	0.1	•	300	0.01	3	0.1	120	•	•	•	•	•	•	•	232, 488(ST)	(M)(DM)(PH)	995
Hewlett-Packard	3468A/B	5½	300,000 LCD	0.018	300	1.0	300	1.0	•	300	1.0	3	1.0	30	•	•	•	•	•	•	•	—	(B/AC)	1095
	3478A	5½	300,000 LCD	0.006	300	1.0	300	1.0	•	300	1.0	3	0.1	30	•	•	•	•	•	•	•	488(ST)	—	1295
Keithley	175A	4½	20,000 LCD	0.03	1000	10	750	10	•	100	0.01	10	100	200	•	•	•	•	•	•	•	488(OP)	(B/AC)(OP)	495
	196	6½	3,029,999 LED	0.003	300	0.01	300	1.0	•	100	0.001	3	0.1	300	•	•	•	•	•	•	•	488(ST)	—	1495
197A	5½	219,999 LCD	0.01	1000	1.0	350	750	1.0	•	100	0.001	10	1.0	220	•	•	•	•	•	•	•	488(OP)	(B/AC)(OP)	659
	199	5½	302,999 LED	0.006	1000	1.0	300	1.0	•	100	0.01	3	1.0	300	•	•	•	•	•	•	•	488(ST)	—	1045
20001	7½	21,000,000 FL	0.0007	1100	0.01	0.03	750	0.1	•	2000	0.0001	2	0.001	1000	•	•	•	•	•	•	•	488(ST)	(CF)(TM)	2695
	DL712	3½	2000 LCD	0.1	1100	100	850	1000	•	0.5	0.1	10	100	20	•	•	•	•	•	•	•	—	(B/AC)	249
Leader	856	4½	20,000 LED	0.05	1000	10	750	100	•	100	10	3	10	30	•	•	•	•	•	•	•	232 or 488(OP)	(BG)	800
	HC-797	4½	32,000 LCD	0.04	1000	10	4750	10	•	30	0.1	10	10	30	•	•	•	•	•	•	•	232(ST)	(BG)(CF)(M)	350
Simpson	460-6	4½	20,000 LCD	0.07	1000	10	750	10	•	100	0.1	10	10	20	•	•	•	•	•	•	•	—	(BG)(B/AC)	500
	461-2R	3½	2,000 LED	0.10	1000	100	750	100	•	50	0.1	2	100	20	•	•	•	•	•	•	•	—	(B)	300
464-4	3½	2,000 LED	0.10	1000	100	750	100	•	100	0.1	10	100	20	•	•	•	•	•	•	•	•	—	—	360
	467-2	3½	2,000 LCD	0.10	1000	100	750	100	•	5	0.1	2	100	20	•	•	•	•	•	•	•	—	(BG)(PH)	420



Triplet	4800	4%	25,000	LCD	0.04	1000	10	0.5	1000	10	0.01	2	10	25	(M)(PN)(TM)	600
Yokagawa	7551	5%	200,000	LED	0.005	1000	1.0	0.2	700	1.0	0.01	2	1.0	200	(M)	895
	7552	5%	200,000	LED	0.005	1000	1.0	0.2	700	1.0	100	20	1.0	200	232 or 488	995
	7561	6%	2,000,000	LED	0.003	1000	1.0	0.15	700	1.0	—	2	0.1	200	232 or 488	1195
	7562	6%	2,000,000	LED	0.003	1000	1.0	0.15	700	1.0	0.01	2	0.1	200	232 or 488	1295

Peak hold  
Temperature measurement  
RS-232 compatible  
IEEE-488 (GP1B) compatible

(PH)  
(TM)  
232  
488

Standard

(ST)

Crest factor  
Conductance measurement  
Display hold  
Memory

(CF)  
(CO)  
(DH)  
(M)

Optional

(OP)

Bar graph  
Battery operation  
Battery & AC line powered  
Capacitance measurement

(BG)  
(B)  
(B/AC)  
(CA)

NOTES:

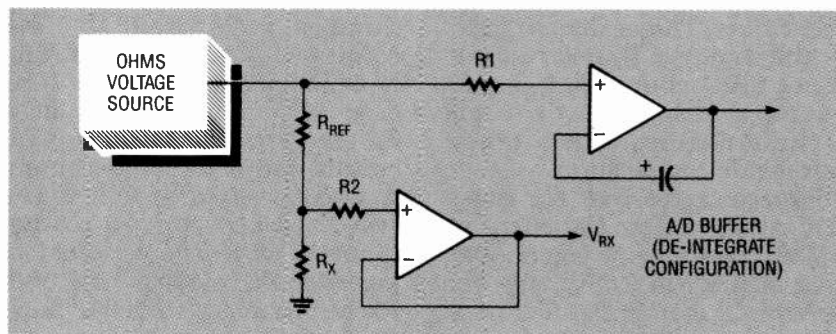


FIG. 6—SIMPLIFIED DIAGRAM of a typical DMM voltage ratio resistance-measurement circuit.

lead-acid batteries. Manufacturers offer power options: 117 or 220 volts, 50 to 60-Hz line, and/or batteries.

Some bench DMM's have been designed for dual use as portable or rack-mounted instruments. Rack mounting is used in systems applications. The purchaser can specify the case style desired.

### Available bench DMM's

If you examine Table 1, Digital Multimeter Characteristics, included here you will see 3-1/2-digit bench/portable DMM's list priced below \$200, and higher performance instruments priced for more than \$2600—a price spread of better than an order of magnitude. Those prices include only the bare necessities such as basic test leads, power cord, and manuals. Most DMM accessories such as probes and carrying cases are extra expense items.

The basic electrical measurement functions in bench DMM's are usually supplemented with special features, many of which are can also found in the handhelds. The most common examples are diode test and audible continuity. As stated earlier, bench models are more likely to include true RMS AC voltage and current measurement than handhelds, and system compatibility is an exclusive feature with the bench models. Many bench DMM's can also display such math functions as min/max hold, and provide readouts in dB and dBm.

With their focus on accurate measurement, many DMM's have only a few of the special features found in handhelds.

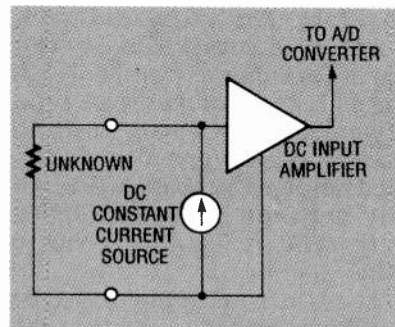


Fig. 7—SIMPLE 2-WIRE ohms converter.

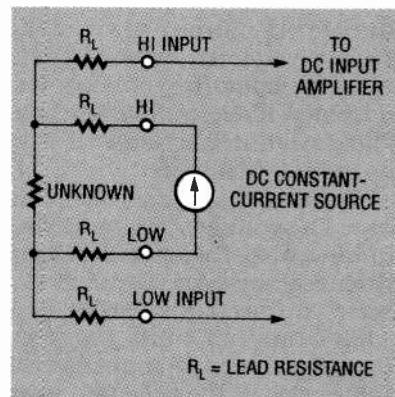


FIG. 8—SIMPLIFIED 4-WIRE ohms converter for eliminating lead resistance errors. Current is supplied by a separate current source.

The line separating the features of handhelds from those of benchtop DMM's is fuzzy, at least in the \$200 to \$300 price range. Features such as peak hold, sleep mode, and capacitance measurement are more likely to be found on the handhelds.

But it's worth keeping in mind that, generally speaking, you get what you pay for in bench/portable DMM's. Prices have been raised on many of the models that have been on the market for ten years or more. However, there is general agreement that you can get more for

your DMM dollar today than ever before. This is due, in part, to the ongoing transfer of advanced A/D converter IC's and microprocessor devices to instrumentation, and intense worldwide competition.

Experts agree that the most critical parameter in benchtop DMM's (and the one you should look at first) is DC voltage accuracy. It can be stated in a number of ways:  $\pm$  (% of reading + number of least significant digits),  $\pm$  (% of reading + % of range),  $\pm$  (% of reading + number of counts), and even parts per million (ppm) of reading as  $\pm$  (ppm of reading + ppm of range). Regardless of the form used, it will be given at a specified ambient temperature, usually between 18°C and 28°C, with relative humidity up to 90%.

Accuracy ratings might be given for periods of one year, six months, 90 days, or even 24 hours. To cut through all this complexity, most manufacturers give short forms of their accuracy specification known as basic DC-voltage accuracy. That is what we used in our characteristics table.

After you have checked out basic DC-voltage accuracy, you should study the specifications and literature to be sure that the meter you are considering is a quality product built ruggedly enough to meet your needs and includes all of the accepted user safety and instrument protection features for that class of product. Next you might want to examine the basic AC-voltage accuracy rating.

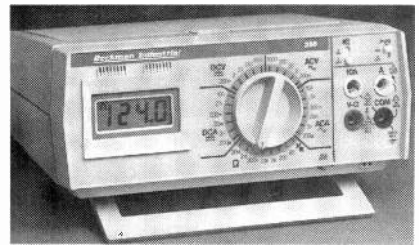
A 5-1/2- or 4-1/2-digit DMM can be expected to offer higher accuracy and resolution than a 3-1/2-digit DMM, and this should be kept in mind during your search. The 1/2 in the specification of the DMM display refers to the use of the digit 1 in the most significant digit (MSD) position. The full scale on a 4-1/2 digit display, for example, is 9999, but the additional digit 1 permits the display to show a value that is 100% higher (19999) in what is known as the 100% overrange condition.

There is a close but not abso-

lute correlation between the number of display digits and counts. For example a 3-1/2-digit DMM might have 2000 or even 3200 counts, a 4-1/2-digit meter typically has 20,000 counts, but it could have more. A 5-digit DMM will have 100,000 counts, but a 5-1/2-digit meter would be expected to have a count of at least 200,000. Rather than try to define such confusing designations as a 4-3/4 -digit DMM, it is a lot easier to look for the display count that we have listed in our selection table.

As you move upscale in bench DMM's, prices rise accordingly. Therefore, it becomes even more important to pay attention to the reputation of the manufacturer, and inquire about any guarantees or warranties being offered. Not surprisingly, even some reputable manufacturers who are willing to offer 3-year warranties on their handheld and low-cost bench DMM's are reluctant to offer more than a one-year warranty on their most sophisticated bench models. However, one-year warranties can usually be extended for a fee. We suggest that you carefully read and compare specifications, literature, and any available evaluations of products before you buy any bench DMM.

In searching for the bench DMM best suited to your needs, you should consider the value of such features as autoranging vs. manual ranging. Autoranging automatically determines the proper range and polarity for the DMM to display a measurement with the best resolution. Manual ranging allows you to override the autoranging function and make manual se-



BECKMAN INDUSTRIAL'S MODEL 360

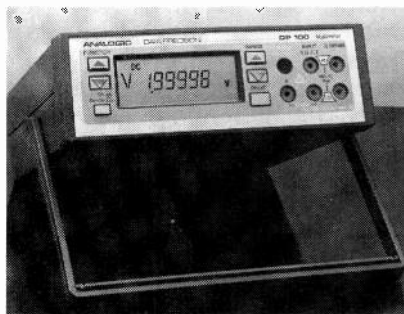
lections. While some DMM's have both, many high-performance DMM's do not include autoranging. This is acceptable because those instruments will be used in controlled environments where the ranges of unknown signals are generally known.

### Measurement capabilities

In addition to basic DC-voltage accuracy, you will want to know the maximum DC voltage that can be measured without a plug-in probe, and maximum DC-voltage resolution. Basic DC-voltage accuracy will range from 0.1% in 3-1/2-digit (2000 count) meters to 0.003 % in 5-1/2-digit (200,000 count) meters. A rating of 1000 volts maximum DC voltage is commonplace in modern bench DMM's; it will be obtained at the high end of as many as five ranges, typically 200 mV, 2 V, 20 V, 200 V, and 1000V. Maximum DC-voltage resolution should typically be a value of 100 microvolts or less.

The AC-voltage specifications also include basic accuracy, maximum resolution, and maximum (RMS) value without the use of a probe. Frequency range in hertz over which AC measurements are valid is another variable included under AC volts. Basic AC-voltage accuracy is typically a fraction of the DMM's DC-voltage accuracy; in some cases it is as much as an order of magnitude less.

Maximum AC resolution, also measured in microvolts, typically matches the values for DC volts. Maximum voltages for bench DMM's are typically between 750 and 1000 volts AC RMS. Expect five AC voltage ranges comparable to the DC voltage ranges. The ability to measure true RMS voltage is a popular feature for bench

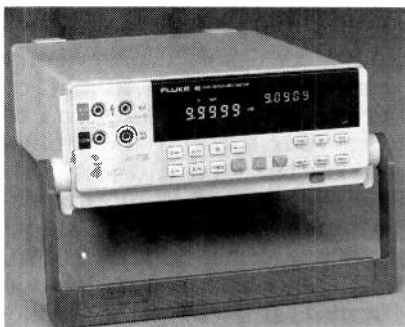


ANALOGIC'S DP 100.

DMM's; most bench DMM's either offer this feature or make provision for it as an option.

Maximum ratings for AC and DC current in amperes that can be measured without a probe are also important for the bench DMM user. Don't be surprised to find that handhelds have higher maximum current ratings than high-performance bench meters to protect against the unknown conditions encountered in making current measurements in the field. They could be only 2 amperes. However, you can expect the bench meter to have better current resolution—0.1 microampere or better.

Maximum resistance values that can be read on a bench DMM are typically 20 megohms or better, but they could be as



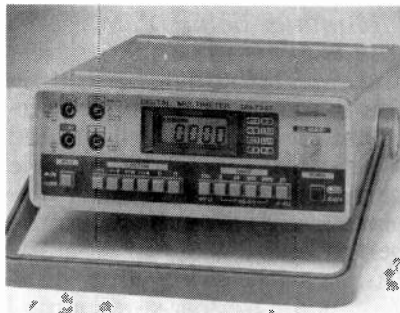
FLUKE'S DUAL-DISPLAY MODEL 45

high as 300 megohms. However, maximum resistance resolution could be 1 milliohm or less in the high-end models. The diode tests and conductance measurement functions are less popular in high-performance DMM's.

### Special features

Beyond the capability for measuring the five basic electrical parameters and doing diode tests, many DMM functions are considered to be special. In general, with the exception of system compatibility, none are exclusive to bench DMM's.

Because of their normally controlled working environments, accuracy and resolution outrank versatility in the selection of a bench DMM. It has been found that specialized temperature, frequency, and even capacitance measuring instruments are preferred over



GOLDSTAR'S MODEL DM-7241

those functions in DMM's used in labs or shops. Manufacturers will, however, include these functions if they find a demand for them. But if you don't need them you could be paying a lot for a feature with lower performance than is obtainable in a specialized instrument.

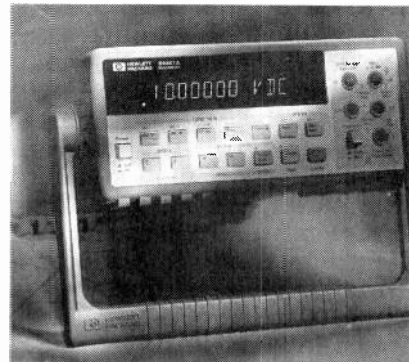
By contrast, the handhelds follow the Swiss Army knife philosophy of stuffing as many "tools" as is practical in a single package. Battery conservation and protection against personal shock and destruction of the DMM are, as you might expect, more important characteristics in handhelds.

**True RMS voltage and current:** This feature provides accurate measurement of non-sinusoidal waveforms such as square waves, pulses, or the outputs of silicon-controlled rectifiers. This function, either standard or optional, is widely found in bench DMM's, but less often found in handhelds. You can be sure that any DMM with the true RMS measurement feature will cost more than a comparable meter without that feature.

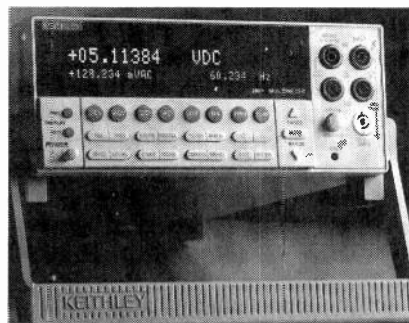
**System compatibility:** Some bench DMM's offer an EIA RS-232C and/or IEEE-488 interface as either standard or optional features. The RS-232C interface allows data to be interfaced to any serial printer or computer. The data can be filed, manipulated, printed, or transmitted by modem. Internal DMM circuits format the measurement data transmission. Host computer software permits remote operation of all instrument functions.

IEEE-488 (also known as the general purpose information bus or GPIB), is a parallel inter-

face bus that consists of eight bidirectional data lines and eight signal grounds (three wires for handshakes between equipment, and five wires for management). Some DMM's permit both RS-232C and GPIB interfaces. Although RS-232C interfaces are becoming more popular because of the proliferation of personal computers in laboratories, the IEEE-488



HEWLETT-PACKARD'S MODEL 34401A



KEITHLEY'S MODEL 2001

bus is still widely used in industrial data acquisition systems.

**Decibel (dB) and dBm readout:** DMM's with this function measure and display the dB gain or loss of amplifiers, filters or attenuators. The dBm readout is referenced to 1 milliwatt and 600 ohms.

**Offset/relative reference:** This function stores the input in memory as a zero "reference". Any subsequent input is automatically compared to the reference in memory, and the display shows the difference ( $\pm$ ) between these two values. It is also a handy feature for nulling out test lead resistance or measuring the dB gain for the stages of an audio amplifier. Relative reference works in all functions and ranges, and is a feature found on high-end handhelds and low-end benchtops.

**Frequency or period:** Some DMM's can also measure frequency or its reciprocal period. Bench-type DMM's are likely to have frequency responses in the megahertz range, especially if they have six or more readout digits. Some DMM's now have AC voltage input ranges as high as 15 MHz and AC current input to 1 MHz. These can be translated into period. You will want to know accuracy, sensitivity, maximum input, and trigger level for these measurements.

**Temperature measurement:** Some bench DMM's have the capability for measuring temperatures with one or more standard thermocouples or a resistance temperature detector (RTD). Here again, the specified accuracy and resolution will be important in your decision if you want this feature in your multimeter.

**Continuity beeper and diode test:** Continuity, diode and transistor checks can be made quickly on DMM's with this feature without looking at the display. A continuous tone indicates continuity, while a beep signals a forward-biased diode or transistor. The beeper is easily heard in a noisy industrial environment.

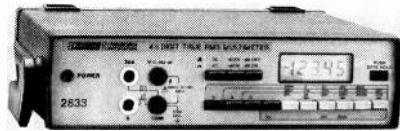
**Min/max hold:** DMM's with this feature store the highest and lowest readings, permitting you to monitor a signal for seconds, or even days. Collected average values during the period are calculated and displayed, and when the recording period ends, you can examine the readings at your convenience. Overloads or manual stop/starts won't erase memory until you give the command. Min/max recording is possible when measuring AC and DC voltage or current, and resis-

herent in a needle's movement. This feature is not widely available in bench DMM's.

**Sleep mode:** This feature automatically shuts off power if you forget or if no measurements are taken for a specified length of time, say 60 minutes. This conserves battery life. It is found in some battery-powered bench meters.

**Peak hold:** This feature is useful for recording transients as low as 1 millisecond, especially from intermittent power lines or connections. This mode can also be used to measure the plus and minus peak values of sine waves up to about 450 Hz. It permits easy measurement of both peak line voltage and line current in power supplies and electrical equipment. However, it is rarely found on bench DMM's.

**Data hold:** This feature is known by different proprietary names such as "touch hold" or "probe hold." It allows you to keep your eyes on the probes and on the circuit under test. The DMM's microcomputer determines when the input signal is steady, alerts you with a beep, and then captures and holds the measurement on the display until you are ready to view it. It



**B&K PRECISION'S MODEL 2833**

tance. This feature is also found on some handheld meters.

**Analog Bar Graph:** The analog bar graph is a segmented analog needle simulator. It performs the same role as a VOM needle, while eliminating the mechanical/inertial distortion

#### BENCHTOP DMM SOURCES

Analogic Corp.  
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automatically updates with each new measurement.

### Reading spec sheets

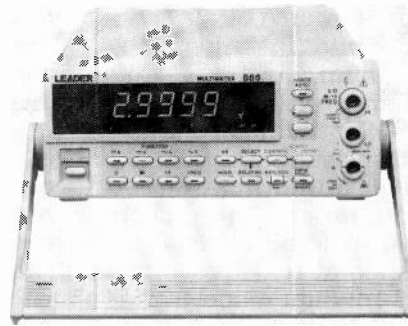
Manufacturers' specification sheets can be quite confusing because they do not follow a uniform format. They can be especially intimidating for the first time DMM buyer trying to decipher the baffling terminology. The wise buyer should understand such terms as CMR, NMR, and RMS, average, and peak AC readout.

Definitions of some of the commonly used terms in DMM specifications sheets will be helpful to you. Remember that the manufacturers are trying to attract your attention to their instrument's more glamorous features which may or may not be something you need. So brochures do not necessarily rank the qualities that are of most importance to you in any logical order. The burden for interpreting these specifications falls on you, the prospective buyer and user. But this also holds for a lot of other purchases such as appliances, automobiles or home-entertainment products.

Noise is an especially severe problem in DMMs due to their high accuracy, resolution, and sensitivity. DMMs used in systems are more susceptible to noise than those used just in isolated measurement applications. Long signal leads and coupling between adjacent signal leads compound the problem in systems.

Noise can be defined by its origin relative to signal input lines on the DMM. Normal-mode noise enters with the signal and is superimposed on it. Common-mode noise is common to both the high and low signal inputs. Common mode noise becomes normal-mode noise when it flows into the DMM's signal inputs.

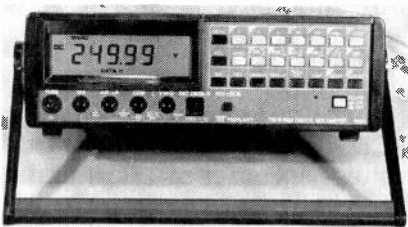
Normal-mode noise originates from power-line pickup, electromagnetic fields or even from within the device being measured. Noise can be sinusoidal, spikes or white noise. There are two techniques used to reduce normal-mode noise: integration and filtering. Inte-



LEADER'S MODEL 856



SIMPSON'S MODEL 460-6



TRIPLET'S MODEL 4800

gration stretches the measurement out over a fixed period of time during which amplitude variations are averaged out. If the integration period includes a sufficient number of periodic noise cycles, the noise will be averaged out.

Filtering slows down the conversion process or measurement speed so it is used judiciously. Integration does a better job of rejecting line-related noise, and filtering is better for broadband noise.

Common-mode rejection (CMR) is a measure of the change in output voltage when both inputs are changed by equal amounts of AC and/or DC voltage. It is the measure of an instrument's ability to cancel undesirable signals entering the measurement circuit between the input and ground. A reasonable value for CMR in a bench DMM is 100 volts DC or peak AC from any earth input.

*Normal-mode rejection* (NMR) is a logarithmic measure of at-

tenuation of normal-mode noise components at specified frequencies in dB. For an amplifier used in instrumentation, the normal-mode signal is the actual difference signal being measured. This signal often has noise associated with it.

*DC voltage uncertainty* = [(ppm of reading) × (measured value) + (ppm of range) × (range used)]/1,000,000.

*Percent uncertainty* = (ppm uncertainty)/10,000.

*AC voltage uncertainty* = [% of reading) × measured value) + (% of range) × (range used)]/100.

*Crest factor* (CF) expresses the waveform's peak value ratio to that of its RMS value. Crest factors in true RMS meters actually specify their dynamic ranges.

*Self-test*: DMMs with a microprocessor-controlled self-test feature usually run through this routine when they are turned on and the results show up on the display as segments that appear as rapidly as four times per second.

Self-check capability is extremely important for the assurance of accuracy and continued calibration to laboratory or international standards. Nevertheless, all DMMs, even those with this feature should be recalibrated at least once a year for maximum accuracy and reliability.

Input impedance is the combined AC and DC resistance at the input of the DMM. An input impedance of 10 megohms or better virtually eliminates measurement errors caused by loading in most circuits.

The outstanding characteristics of bench-type DMMs have been highlighted primarily on a basis of published specifications and unusual features. In an evaluation section that follows we have selected a cross-section of available benchtop DMMs and discussed some of their outstanding features. All of the bench multimeters discussed in this article are capable of making the five basic electrical measurements: AC and DC voltage, AC and DC current and current.

## Selected reviews

Analogic offers the DP100, with a 5-1/2-digit LCD display capable of measuring voltage current and resistance. It is also a frequency counter capable of measuring up to 25 MHz as well as an RTD temperature meter. The portable DP100 is powered from both built-in rechargeable batteries and the AC line. It offers  $\pm 0.003\%$  basic DC-voltage accuracy, 0.1-microvolt sensitivity and the ability to measure true RMS AC voltage and current, and 2- or 4-wire resistance. The DPM includes RS-232C compatibility or optional IEEE-488.2 converter.

B&K Precision offers three bench DMM's all capable of making the five basic measurements—AC and DC voltage and current, and resistance. The model 2831A is a 3-1/2-digit meter with a LED display that also offers continuity checking and diode test. It has a 0.1% basic DC-voltage accuracy rating. The model 2833 with a 4-1/2-digit LCD display, features true RMS voltage and current measurement. It has basic 0.05% DC-voltage accuracy. Other features include audible continuity check, diode test, data hold, dBm readout, and frequency measuring.

The B&K model 2832, with a 3-1/2 digit LCD display, measures capacitance. Its basic DC-voltage accuracy is stated at 0.5%. Other features include audible continuity check and diode test. This DMM can be powered from the AC line or six "C" cells.

Beckman Industrial Corp. offers two 3-1/2-digit bench/portable DMMs with LCD displays, the models 350 and 360 B. Both are packaged in similar cases with a front-panel rotary function switch, and both have basic 0.1% basic DC-voltage accuracy and 22-megohm input impedance. In addition to the five measurement functions, the meters provide audible continuity checking and diode testing. The model 360 offers true RMS AC voltage and current measurement as well as temperature measurement with a type K thermocouple. Both meters

are powered by six "D" cells and are built for field use.

John Fluke Mfg. Co. offers a family of seven bench/portable DMM's with 3-1/2 to 5-1/2-digit displays. Some also offer diode test and others measure conductance. There is, however, considerable variation in the special features offered. The 3-1/2-digit model 37 has a basic DC-voltage accuracy of 0.1% and the 5-digit model 45 has a basic DC-voltage accuracy of 0.02%. The model 45 has a dual vacuum-fluorescent display and it can measure frequency and display dB and dBm. It also has the min/max hold feature.

Fluke is also offering two 5-1/2-digit models in the 8800 series, the 8840A and 8842A. The 8840A offers 0.005% basic DC-voltage accuracy, while the 8842A has 0.003%. Both feature optional true RMS AC voltage and the ability to measure frequency to 100 kHz.

Goldstar Electronics offers the DM-7241 with a 4-1/2-digit LCD display. It has a basic DC-voltage accuracy of 0.05% and a resistance range to 20 megohms.

Hewlett-Packard offers four benchtop DMM's. The HP34401A has a 6-1/2-digit vacuum-fluorescent display and features true RMS AC voltage and current measurement. Resistance is measured in ohms with 2- and 4-wire circuits. In addition, the model 34401A measures frequency, period, and continuity, and can do diode tests and DC:DC ratios. DC-voltage accuracy is given as 0.0035% while AC-voltage accuracy is 0.06%. The meter's bandwidth is 3 Hz to 300 kHz. Its math functions include null, min/max average, dB and dBm readout, and limit test. Both the IEEE-488.2 and RS-232C interfaces are standard.

Keithley Instruments offers five bench/portable DMMs. The model 2001 has a 7-1/2-digit display and a rated basic DC-voltage accuracy of 0.0007%. Basic AC-voltage accuracy is given as 0.03%, and bandwidth is 1 Hz to 2 MHz. The 2001 can measure resistance values from 1 micro-ohm to 1 gohm. It takes

2000 readings per second with 4-1/2-digit resolution, 300-500 with 5-1/2-digit resolution, and between 45 and 200 with 6-1/2-digit resolution.

The 2001's standard measurement functions include AC crest factor, frequency from 1 Hz to 15 MHz, true RMS, and peak and average AC. It also makes DC in-circuit current measurements, and offers simultaneous displays. Options include a ten-channel scanner. GPIB (IEEE-488.2) output is standard.

Kenwood USA Corp. offers the model DL-712 that has both manual and autoranging. Other standard features of the DMM include diode test, data hold, and continuity checking.

Leader Instruments' model 856 has a 4-1/2-digit LED display which includes a bar graph. Equipped with autoranging, it measures true RMS and frequency. The 856 also does diode test and continuity checks, displays dB and dBm, and makes data comparisons. Its basic DC-voltage accuracy is 0.05%.

Simpson Electric offers four 4-1/2- and 3-1/2-digit benchtop DMM's. They all feature true RMS AC measurement. The 4-1/2-digit 460-6 offers Ni-Cd battery/AC-line operation and 0.07% DC volts accuracy. The 467-2, a 3-1/2-digit DMM, has peak hold.

Triplet Corp. offers the model 4800, a 4-1/2-digit benchtop DMM with true RMS readout. Its features include data memory, peak hold, dBm readout, autoranging, temperature measurement, and diode test.

Yokogawa offers the 5-1/2-digit models 7551/7552 and the 6-1/2-digit models 7561/7562. They are rated for basic DC-voltage accuracies of 0.005% and 0.003%, respectively. These DMM's can be calibrated with external signals. The 7552 and 7562 offer RMS AC measurement, while the 7551 offers AC mean measurement. The 7552, however, offers both frequency measurement and a 20-ampere range. The RS-232C or IEEE-488 interfaces are standard on all these models. R-E



# MIDI LIGHT CONTROLLER

EDWARD J. KEEFE JR.

MOST SMALL BANDS USUALLY HAVE such a hard time paying for travel and instruments that their shows must forgo any type of sophisticated lighting. The lights provided by the clubs and bars where they play do little to showcase a band's talent. With the MIDI (Musical Instrument Digital Interface) light controller presented here, that can all end. A simple microprocessor with a handful of components can transform their act into a full fledged "concert." Everything that is needed to synchronize lights and music already comes out of the MIDI port of MIDI keyboards. This circuit will make use of that information and enhance the show.

MIDI is a communications protocol originally created for interfacing synthesizers and other electronic devices. It has evolved into a communications standard that is used in all phases of audio and video pro-

duction. MIDI allows devices to talk to each other with different types of control and data values. The values can be either CHANNEL, SYSTEM, REAL-TIME, or SYSTEM EXCLUSIVE messages. MIDI communication is achieved through multi-byte messages, each consisting of one STATUS byte followed by one or two DATA bytes. Real-time and exclusive messages are exceptions to that rule.

Two types of data bytes are sent over the MIDI cable, STATUS and DATA. Status bytes are eight-bit binary numbers in which the most-significant bit is set to "1." A status byte sets the func-

tion of the data bytes that follow it, and a new status byte is required for each new action. The MIDI specification also outlines RUNNING STATUS. That defines the action for all data bytes that follow a status byte, until a new status byte is sent. That way more information can flow down the cable. Data bytes are eight-bit binary numbers in which the most-significant bit is set to "0."

The MIDI light controller presented here reacts to NOTE ON, NOTE OFF, START, STOP, and CONTINUE status bytes. The data bytes are used to determine which light to control and how

***Our MIDI light controller can  
turn an ordinary musical performance  
into a concert!***

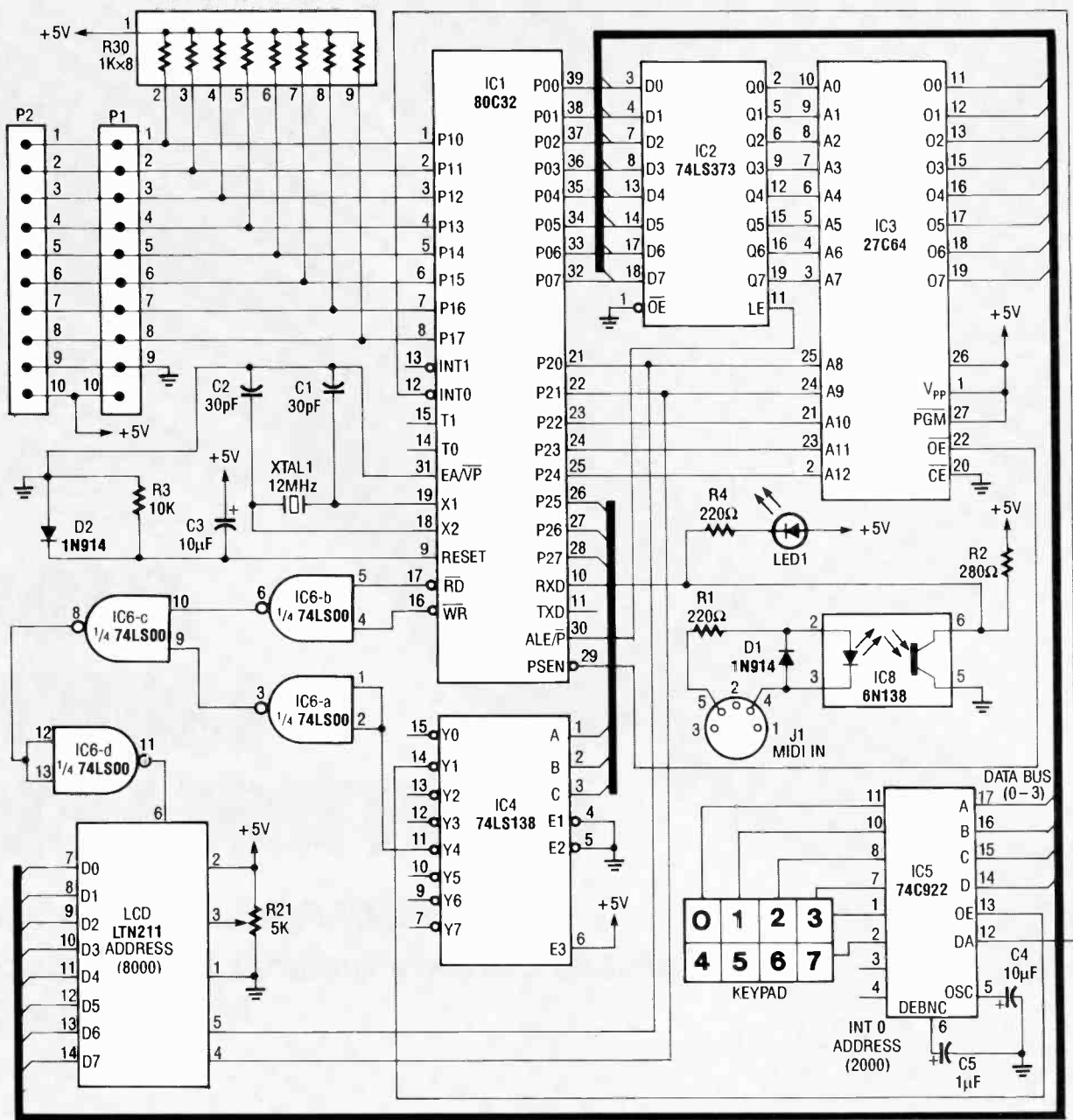


FIG. 1—SCHEMATIC OF THE MAIN PROCESSOR BOARD. The MIDI signal is fed in through an optocoupler (IC8) to the microcontroller (IC1).

to respond to different conditions on the MIDI. It can operate on any of the 16 MIDI channels, and will respond to note information from octaves 1–8. The MIDI light controller is user-configured. You have control over whether the lights will latch, toggle, or stay off in reaction to note information on the MIDI by setting the OUTPUT TYPE keyboard selection.

When a STOP command is received (STOP, START, and CONTINUE commands syn-

chronize all elements of a MIDI system), the lights can either all go off, all go on, or light selectively, depending on the user's STOP DEFINE parameters. That is useful for creating a "scene" between songs and during breaks on stage. The CONTROL OCTAVE determines which range of notes will be used to control the lights. The operating channel is set by selecting CHANNEL DEFINE. The message CHANGE CHANNEL # will be displayed on line 1. Line 2 will toggle between "1" (chan-

nels 1–8) and "2" (channels 9–16). You must select "1" or "2" for the desired range of channels (1–8 or 9–16) and select the desired channel.

The lights are controlled by note information on the MIDI. They can respond to actual notes of a song or notes that are placed in the sequence specifically for the light controller. To use existing notes, you would select the channel and octave from the sequence, and enter them on the keyboard. If the lights are to be controlled by a separate track, you would enter



the note information for each light, keeping all notes in one octave. Timing and synchronization is provided by a sequencer. (A sequencer is any instrument that can store and read back MIDI data.)

The light controller will also work directly from a keyboard without the aid of a sequencer by connecting a keyboard's MIDI output to the jack on the light controller. As you play the keyboard, the appropriate lights will illuminate.

### The circuit

Figure 1 shows a schematic of the main processor board. The MIDI signal is fed in through IC8, an HP 6N138 optocoupler. Any optocoupler can be used as long as it has a rise time of less than 2 microseconds, and can turn on with less than 5 mA. The MIDI signal has the following operating specifications:

31.25-kHz baud rate, asynchronous, 1 start bit, 8 data bits, and 1 stop bit, with a period of 320 microseconds per serial byte. The signal is well suited to the serial portion of the Intel 80C32 microcontroller (IC1) that has built-in transmit and receive serial ports, 128 bytes of internal RAM, two interrupt lines (each with programmable priority), and external memory addressing capability up to 64K. The CMOS version of the 8032 was used because of its higher speed and lower power consumption.

The output of optocoupler IC8 enters the serial receive port (pin 10) of microcontroller IC1. Software in the 27C64 EPROM (IC3) controls port setup and baud-rate selection. At power up, a small reset circuit (R3, D2, and C3) initializes the microcontroller. An oscillator is made up of a 12-MHz crystal (XTAL1)

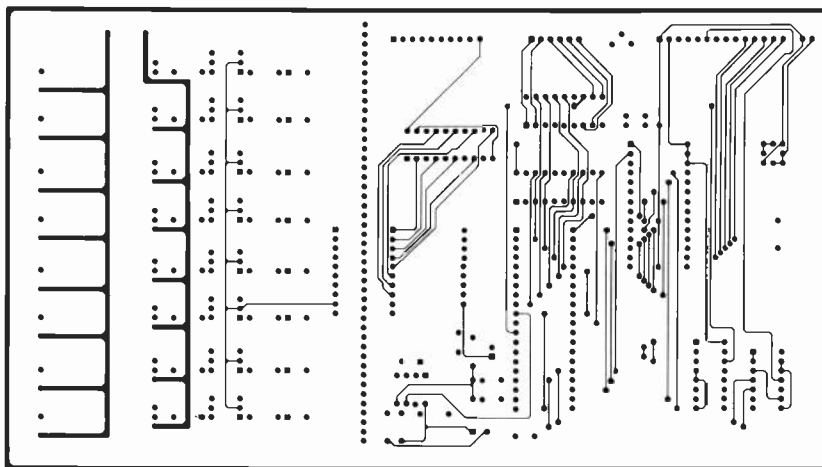
and two 30 pF capacitors (C1 and C2).

The address and data buses of the microcontroller are multiplexed. To remove the low-order address information, a 74LS373 8-bit latch is used. The 74LS373 is strobed with the ALE (ADDRESS LATCH ENABLE) signal from the microcontroller, and address data is removed. The 27C64 EPROM (IC3) is used to store program data. The EPROM is enabled by the microcontroller's PSEN (PROGRAM STORE ENABLE) line.

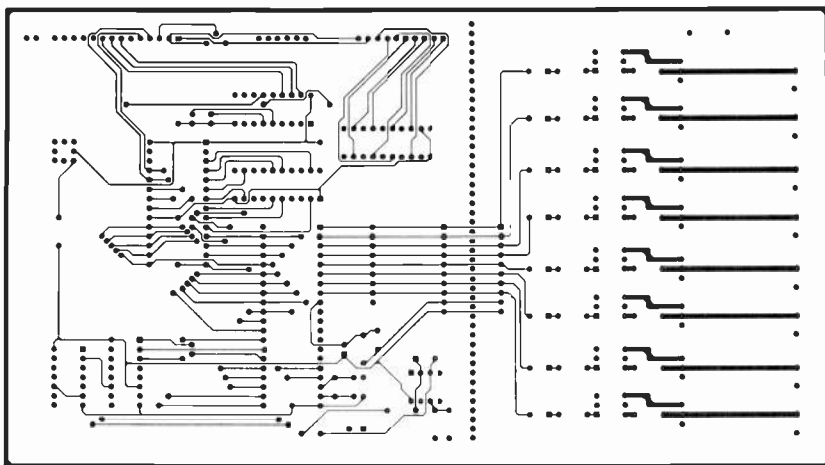
The keyboard and LCD circuits both require an address signal to interact with the data bus. A 74LS138 (IC4) is used to generate a signal when certain addresses are reached (1000h, 2000h, 4000h, 6000h...). The keyboard is mapped at external address 2000h. The keys are scanned by the 74C922 keyboard controller chip, IC5. All keyboard action, including debouncing, is handled by IC5. The scan rate is controlled by C4, and debouncing by C5.

The LCD is mapped at external address 8000h. An Optrex LTN211 two-line LCD module is used to display current channel and mode information. Also, user-definable selections are displayed there. Function data is written to the module at address 8000h, and display data is written at 8200h. Address selection and read/write functions are established by IC6, a 74LS00. Contrast of the LCD is altered by R21. Output from the microcontroller is on port 1, pins 1-8. A resistor network, R30, is used to pull-up output lines. The lines drive the Triac and LED sections.

Figure 2 shows the high-power output section of the light controller. Eight identical drivers are used to control the output channels. An output from IC1 is passed through a 1N914 diode and a 120-ohm resistor that drives an MOC3010 Triac-driver optocoupler. Output from the optocoupler is sent to a high-power Triac. The circuit is designed with 6-amp Triacs, which are fused at 5 amps for added protection. The 120-volt AC input to the Triacs must



COMPONENT SIDE FOIL PATTERN for the light controller.



SOLDER-SIDE FOIL PATTERN for the light controller.

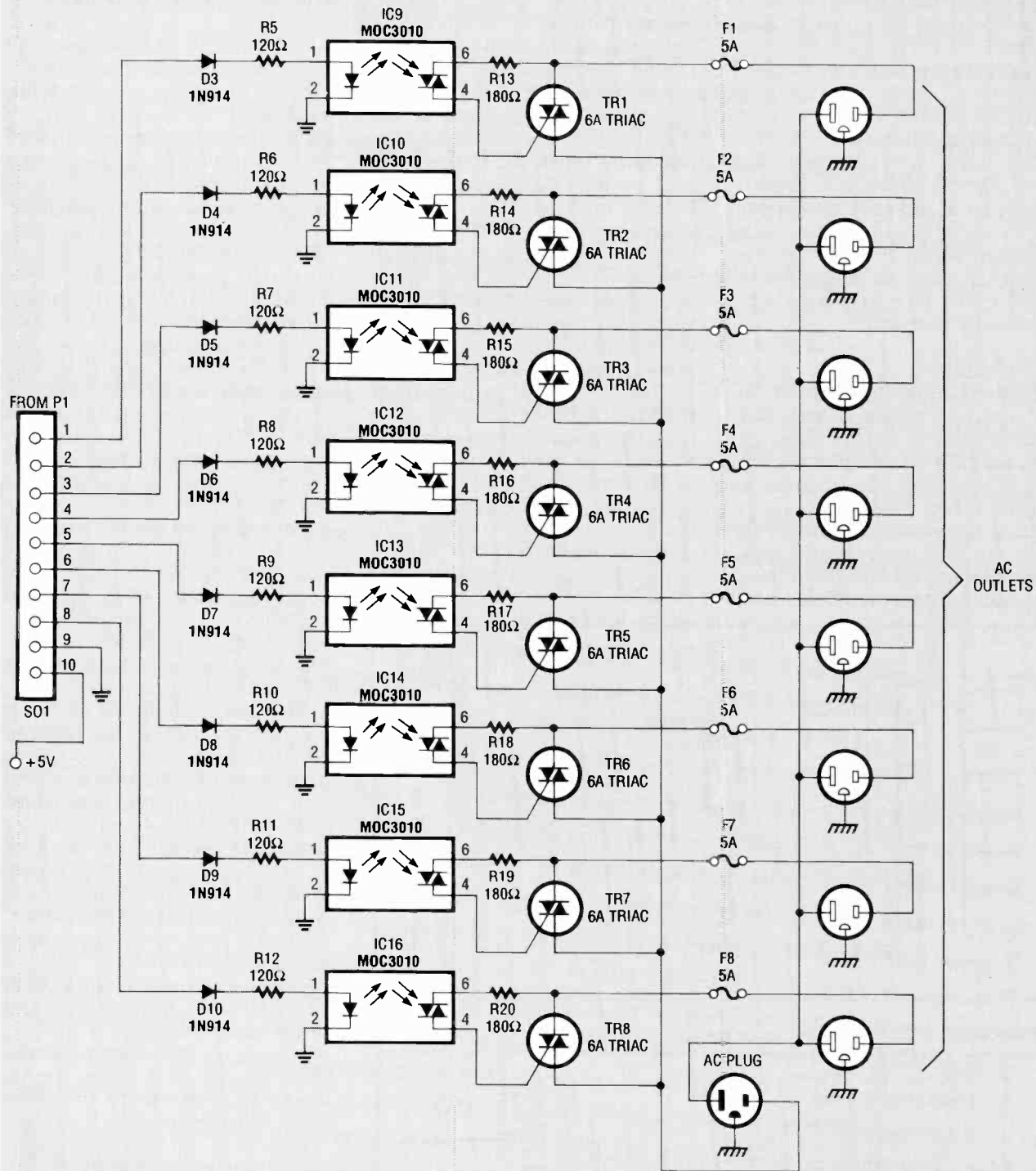


FIG. 2—HIGH-POWER OUTPUT SECTION. An output from the microcontroller is passed through a 1N914 diode, a 120-ohm resistor, an MOC3010 Triac-driver optocoupler, and finally to a high-power Triac.

be connected to a circuit that can handle the current. Power consumed by the light controller at 120 volts AC with all eight channels operating at full power is 4400 watts—that's almost 40 amps! Most household wiring is 15 or 20 amps per circuit break-

er, so the AC input should be separated into multiple circuits to control that much power.

Figure 3 is the LED display section. It's used to indicate which output channel is active. It also helps you set up MIDI sequences without having to

hook up any external lights.

A clean 5-volt DC power source is required for the light controller. The author used a self-contained 5-volt supply that includes a built-in transformer, rectifier, and regulator. The supply accepts a 120-volt AC input and outputs 5-volts DC. You can use a similar supply if you like, although they are

more expensive. Otherwise any 5-volt supply will do.

## Software

Software for the light controller is interrupt-driven. Upon reception of MIDI data, an interrupt is generated. The software jumps to the interrupt routine for the serial port. First the interrupt is cleared, then the byte is placed in the receive buffer. As more data comes in, it is buffered. The keyboard also generates an interrupt any time

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

R1, R4—220 ohms

R2—280 ohms

R3—10,000 ohms

R5, R6, R8, R10, R12, R15, R17, R19, R22—R29—120 ohms

R7, R9, R11, R13, R14, R16, R18, R20—180 ohms

R21—5000 ohms, potentiometer

R30—1K × 8 SIP resistor

### Capacitors

C1, C2—30 pF, mica

C3—10 μF, 16 volts, electrolytic

C4—10 μF, tantalum

C5—1 μF, tantalum

### Semiconductors

IC1—80C32 microcontroller

IC2—74LS373 8-bit latch

IC3—27C64 EPROM

IC4—74LS138 3-to-8 demultiplexer

IC5—74C922 16-key keypad encoder

IC6—74LS00 quad NAND gate

IC7—74LS244 octal buffer/line driver

IC8—6N138 optocoupler

IC9—IC16—MOC3010 optoisolator

D1—D10—1N914 diode

TR1—TR8—any 6-amp Triac in a T0-220 case

LED1—LED9—Chassis-mount light-emitting diode, any color

### Other components

XTAL1—12-MHz crystal

F1—F8—5-amp fast-blo fuse

P1, P2—10-pin header strip

SO1, SO2—10-pin header socket

J1—5-pin DIN socket

**Miscellaneous:** inverter (for use with LCD backplane, see text), 5-volt power supply (see text), project case, grounded AC linecord, 8 grounded AC outlets, wire, solder, etc.

**Note:** The following items are available from Audio Visual Imagery, P.O. BOX 332, Randolph, MA 02368:

• PC board—\$35.00

• Programmed 27C64 EPROM—\$10.00

A diskette with the sample files will be included with any order. Please add \$1.50 S&H to any order. MA residents must add 5% sales tax.

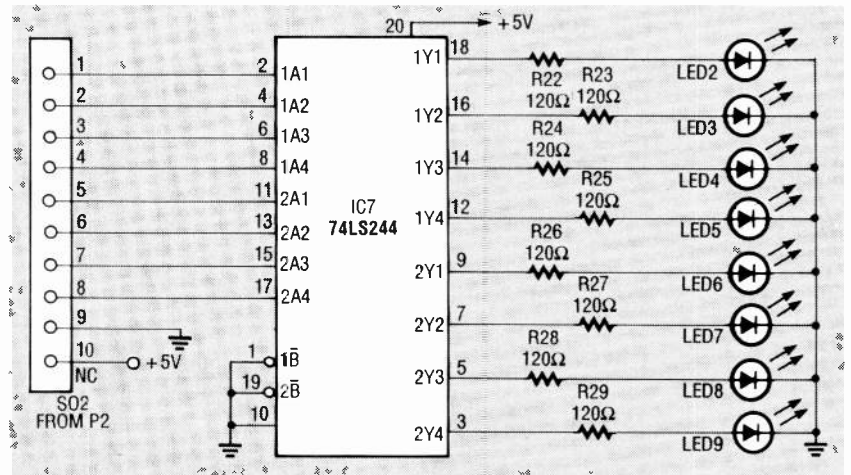


FIG. 3—LED DISPLAY SECTION. These LED's will indicate which output channel is active without having to set up the full-power lights.

a key is pressed. As in the serial section, first the interrupt is cleared.

The main monitor loop of the program simply tests to see if data is in the receive buffer or the keyboard flag is high. If data is in the buffer, the byte is checked for a high MSB indicating a status byte. If it is a status byte, the status register is updated. The status will then remain until a new status byte is received. The program then continues the main monitor loop. If the byte is data, it is examined to determine the action to be taken. Depending on the current user-set mode of the controller, a light will be turned on, a light will pulse, or nothing will happen. If the data turns out to be bad, it is flushed.

After examining the data and acting upon it, the main monitor loop is resumed. When the key flag is high, the data in the temporary buffer is examined. The action desired is stored in the appropriate register. The main monitor loop is then resumed. All user-defined actions are entered on the keyboard. As options are entered, the LCD displays the choices available. The option being defined is displayed on the top line, and the selections are cycled through. Press the key for the desired action. If more information is needed for the chosen item, it will be presented on the LCD. The source code for the EPROM and some sample files to run on a sequencer are avail-

able on the RE-BBS as a self-unarchiving zip file called MLC1.EXE. A programmed EPROM is available from the source mentioned in the Parts List.

## Construction

The PC board for the light controller can be made using the foil patterns we've provided, or it can be purchased from the source mentioned in the Parts List. A parts-placement diagram is shown in Fig. 4. Notice the row of pads to the left of the P1 header that divides the board down the center; the board can be cut there if you want to remotely locate the power section of the board and then run low-voltage wiring between the two sections.

If you are going to cut the board in two, do it before stuffing it, as it will be easier. Install the components according to Fig. 4, and check your work as you go. The pads marked "INV" on the board are for a voltage inverter (see parts list), if used. It that generates the proper voltages for the backlight on the LCD if the LCD you use has one. If it does have a backlight, and you wish to use it, install the inverter and connect the LCD's backlight terminals to the pads marked "BL" on the board.

Any kind of case will do for this project, as long as everything fits inside—keep in mind the power supply you will use and be sure to leave room for it. If you use a metal enclosure be

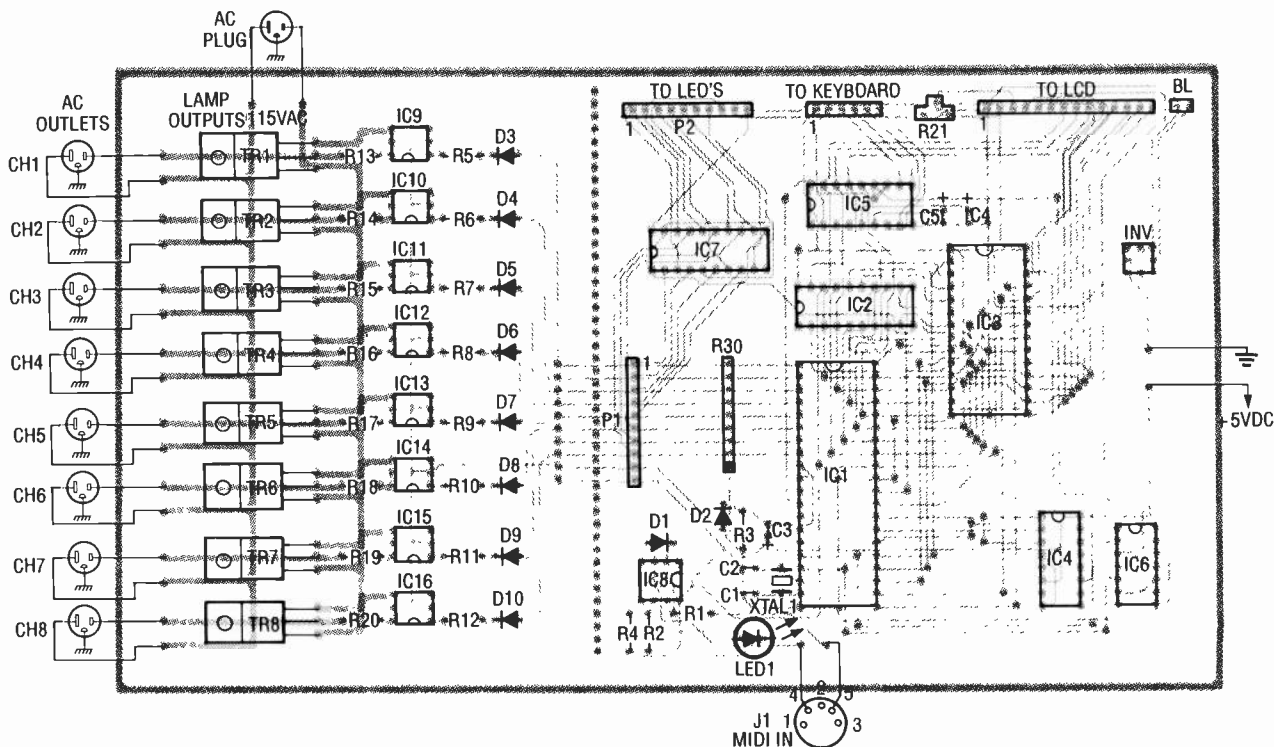


FIG. 4—PARTS-PLACEMENT DIAGRAM. The PC board can be cut down the row of pads to the left of the P1 header if you want to run low-voltage wiring between the two sections.

sure to ground it to the AC safety ground as shown in Fig. 2, and also properly ground all eight AC outlets.

As a reminder, the light controller can output about 5 amps per channel, and any wire common to all eight outputs must carry about 40 amps. The controller's internal AC wiring must therefore be chosen accordingly. Also, if your house wiring is rated 15 or 20 amps per circuit breaker, the AC input to the controller should be separated into at least two circuits. Figure 5 shows the current version of the PC board.

### Testing

To test the light controller, simply adjust R21 to the middle of its range, and apply a clean 5-volt DC power source to the circuit. A message will appear on the LCD. Adjust R21 for the best-looking display. Plug a MIDI cable into the MIDI IN jack (J1) on the light controller. The other end should be placed in the OUTPUT jack of a sequencer or the THRU jack of a synthesizer. (If you're not using a sequencer, connect it to the OUTPUT jack of

the keyboard.) At power up, the light controller is on MIDI channel 1. Make sure your MIDI equipment is sending notes out on channel 1. As notes are sent, LED1 will light, indicating that data is being sent over the MIDI. As notes are received and examined, the appropriate LED(s) will light (as long as the notes are in the CONTROL OCTAVE of the light controller).

If the circuit does not work, check the supply voltage. Make sure XTAL1 is oscillating. Check for a 1-microsecond reset pulse on pin 9 of IC1 at power up. If the reset circuit does not produce a pulse, the circuit will not start up. At power up, the eight LED's should light and then extinguish. If that does not happen and the clock and reset circuits are working, check the wiring of the LED's and the Triac section. If nothing happens still, the problem is with the microcontroller. Check the wiring of the ADDRESS and DATA bus. The circuit will function without the keyboard and LCD sections. If the circuit seems to be working (responding to MIDI notes, turning on LED's) but

the keyboard and/or LCD do not respond, check the wiring of IC4 and IC6. Check for READ and WRITE (RD and WR) signals from IC1, pins 17 and 18 respectively.

Along with source code and HEX data for the EPROM, sample songs are provided in the zip file on the RE-BBS. (The sample files are also included with any order from the source men-

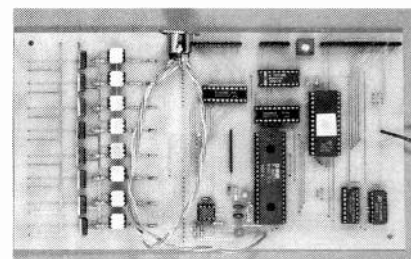
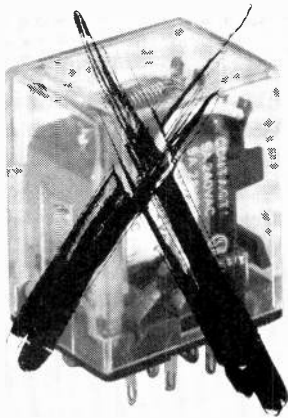


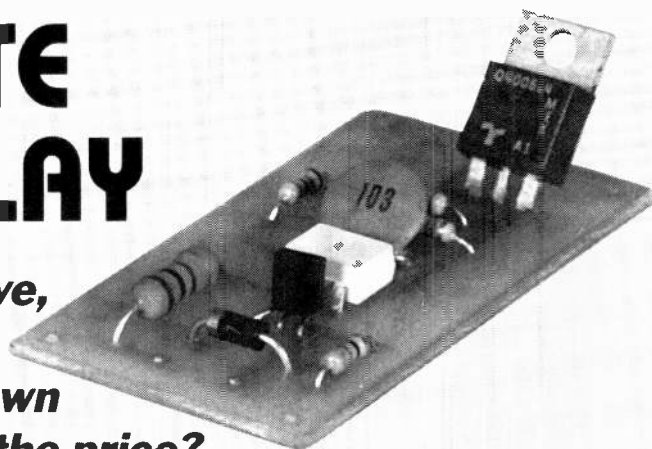
FIG. 5—THE CURRENT VERSION of the PC board, shown here with all parts installed.

tioned in the Parts List.) Three samples are provided in both \*.WRK and \*.MID formats that will help you get started. The songs were set up using a Roland MT-32, Cakewalk 3.0, and our MIDI Light Controller. The MIDI Light Controller and knowledge of your sequencer's operation will provide you—and your audience—with a great looking show. **RE**



# SOLID STATE RELAY

**Why buy expensive, commercially made solid-state relays when you can make your own solid-state relays at a fraction of the price?**



RODNEY A. KREUTER

SOLID-STATE RELAYS MAKE IT A cinch to connect digital logic to the nasty world of 115 volts (or more). These handy little devices make it possible for a battery-operated supply to turn on 100-watt light bulbs, 10-horsepower motors, a lawn sprinkling system, or almost anything else you can imagine.

Solid-state relays, or SSR's, usually consist of an optoisolator and a Triac, which is used as an AC switch. There are many SSR variations such as those using reed relays in place of the optoisolator, and those using SCR's instead of Triacs, but most consist of less than a dozen parts.

Solid-state relays can provide isolation from 2 to 7.5 kilovolts and can drive tens of amps. They're usually offered in a plastic-filled cube with a heat sink on the bottom and screws for attaching the four wires—nothing could be simpler.

There are three common complaints with SSR's: First is the cost—twenty dollars apiece is about average. Second is the fact that they can't be repaired. When SSR's go bad, the fix could usually be a two-dollar Triac, but you can't get inside the plastic potting compound to repair it. Third is the fact that most SSR's made in large quantities are usually rated at about 10 amps. Who wants to pay for a ten-amp relay when all he needs

is a two-amp relay? Besides, the larger the Triac, the larger the leakage currents.

There is hope for readers of **Radio-Electronics**, however. Using all new parts, the solid-state relay presented in this article can be built for less than eight dollars. An added bonus is that it can be repaired if anything goes wrong.

## Operation

The basic operation of a solid-state relay is much like a switch that is controlled by an input voltage or current. That is illustrated in Fig. 1. Keep in mind that this switch can only be used for AC voltages because it will "latch up" on DC. (A Triac will turn off only when the current drops to zero.)

Our SSR circuit is shown in Fig. 2. Diode D1 provides protection in case you connect the input backward. Resistor R1 limits the input current. If you would like to use an SSR that requires a large input voltage (to increase the noise immunity) you can make R1 a large value. If you make R1 470 ohms, the relay will need about 12 volts to turn on. The power rating of R1 is a function of the maximum input voltage. For inputs up to 10 volts, a 1-watt resistor is needed.

The voltage across Q1's collector-emitter junction is almost constant (with a minimum in-

put of three volts) at 1.75 volts (typical LED voltage) plus 0.7 volts (typical  $V_{BE}$ ), or 2.45 volts. The voltage across R1 will therefore be the input voltage minus about 2.5 volts.

The minimum input voltage needed to turn on the SSR is a function of the minimum LED current (the LED inside IC1) and R1. The minimum for the MOC3010 is 15 milliamps. That works out to an input voltage of about 4 volts using the components shown. You can reduce the minimum voltage needed by decreasing R1 or by using an optoisolator that requires less LED current. Since the LED needs about 1.75 volts across it before it begins to emit light, operation below three volts isn't practical. The maximum current through the LED is set by resistor R2.

When the voltage across R2 reaches about 0.65 volts, Q1 begins to conduct, shunting current from the LED. The result is that, although the current through R1 rises as the input voltage rises, the current through the LED stops increasing at about 15 milliamps. The minimum LED current, therefore, is not the minimum current you can pass through the LED; rather it is the minimum LED current that will operate the Triac.

Probably the most misunderstood aspect of solid-state re-

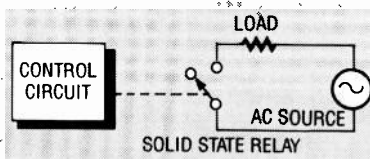


FIG. 1—A SOLID-STATE RELAY is much like a switch that is controlled by an input voltage or current.

you can use a transistor to provide a current sink as shown in Fig. 5.

### Zero-voltage switching

Some of the newer SSR's provide zero-voltage or zero-crossing switching. In normal opera-

tion, a large current will flow into the load almost instantly. That creates a lot of RFI (radio frequency interference) and also is very hard on the filament of ordinary light bulbs. In order to prevent that, zero-crossing SSR's accept the trigger at any time but delay turning on the AC load until the next time the AC voltage passes through zero volts.

### Safety

Building an SSR requires putting 110 volts on a printed circuit board. From an electrical point of view, that can be perfectly safe. However, it's probably a good idea to cover all printed circuit runs on the 110-volt side of the PC board with silicone sealer. Also, try to use only isolated Triacs (where the case is electrically isolated from the Triac), and ground the heat sink to the AC safety wire (green, or earth ground).

### Choosing a Triac

There are three basic requirements when choosing the output Triac. First is to make sure that it will handle the voltage required. The minimum for a 115-volt AC line requires a 200-volt Triac. A 220-volt line requires a 400-volt Triac. Remember that those are the minimum so, for a few cents more, it pays to use the next highest voltage rating.

The next requirement is current. A 6-amp Triac will handle 6 amps only if it is properly heat

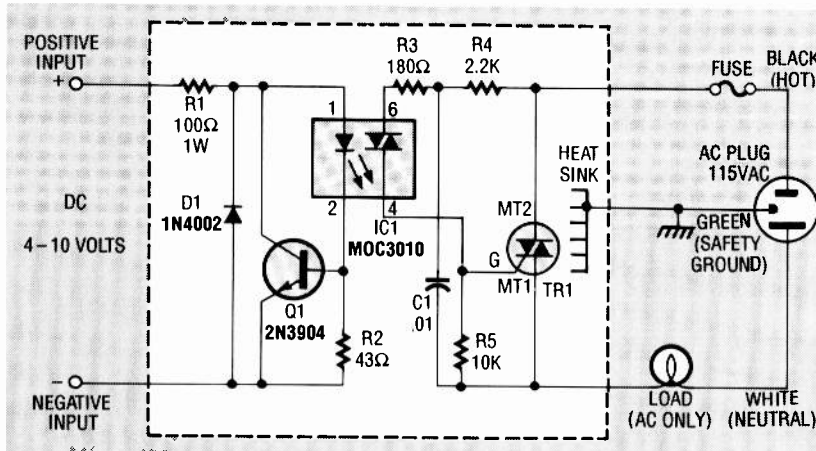


FIG. 2—SSR CIRCUIT. Diode D1 protects the unit if you connect the input backward, and R1 limits the input current.

lays is that the input requirement is really current, not voltage. That means that the driving circuit must be able to supply the current necessary to operate the LED in the SSR. In the example shown, the current is about 15 milliamps. The current can come from a current source as in Fig. 3 or a current sink as in Fig. 4. Most circuits can sink more current than they can source. For example, TTL can source only one milliamp or so, but it can sink 10 to 15 milliamps. If you must use a logic family that can't source or sink much current, such as the output of most computer ports,

tion the trigger side of the relay is totally asynchronous to the AC side. That means that a trigger could occur during any part of the AC sine wave. If the trig-

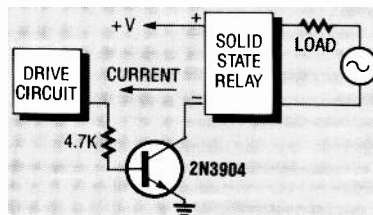


FIG. 5—IF YOUR CIRCUIT can't source or sink much current, use a transistor as a current sink.

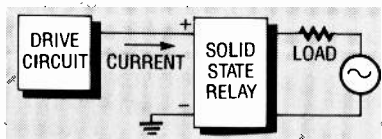


FIG. 3—THE INPUT REQUIREMENT of an SSR is current. Here the driving circuit is shown as a current source.

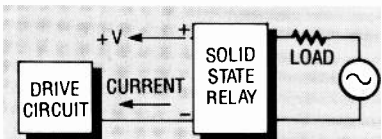


FIG. 4—THE DRIVING CIRCUIT is shown here as a current sink.

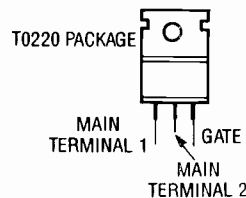
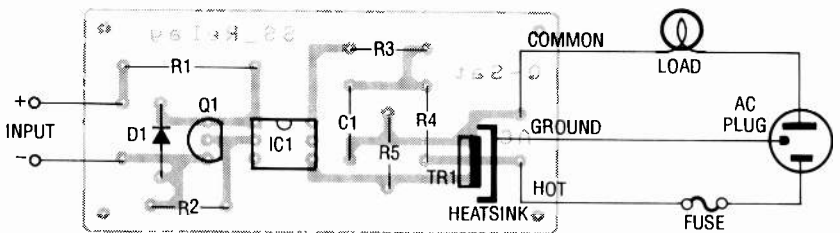


FIG. 6—PARTS-PLACEMENT DIAGRAM. You must heatsink the Triac and connect the heatsink to earth ground, even if you're using an isolated Triac.

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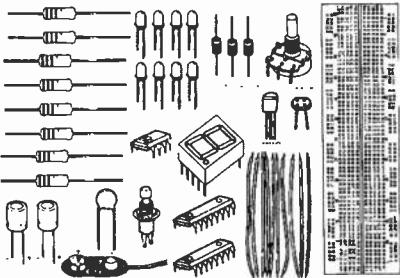
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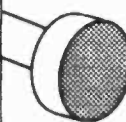
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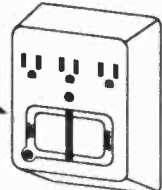


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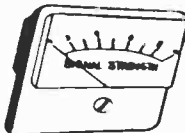
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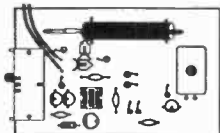
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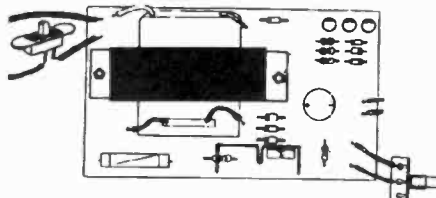
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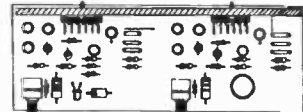


This is one of the most useful kits to have around! Features  
variable output from 0 - 12VDC filtered at up to 1 amp. Uses  
IC voltage regulator and heavy duty transformer. Also features  
red, yellow and green LEDs that glow at different output  
voltages to show approximate output voltage - no need for  
meters. Operates from standard 120VAC, and is great for  
powering projects, calculators, radios, tape players, etc. Size  
of board: 5" x 2.75".  
**C5177 \$18<sup>95</sup>**

**Kits are complete with all parts,  
PC board and instructions.**

**SEND FOR OUR FREE CATALOG  
FEATURING OUR COMPLETE LINE OF KITS.**

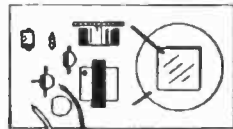
**20W + 20W  
STEREO AMP KIT**



Two separate high power amps on one PC board  
put out an incredible 20 watts RMS each. Features  
low distortion circuitry. Great stereo booster amp  
for your car sound system. Use with any speakers  
capable of handling at least 20 watts. Operates on  
12VDC. Size of board: 6" x 2.25"  
**C6442 \$19<sup>95</sup>**

**INFRARED DETECTOR KIT**

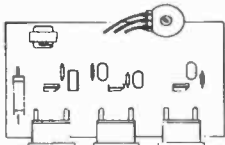
Great for testing and verification of infrared output.  
Uses sensitive sensor and electronic circuitry to  
respond to all types of infrared TV, VCR, etc. remote  
controllers and LEDs producing sound and lighting  
a bright red LED. 9V battery (not included). Size of  
board: 2.5" x 1.4".  
Complete with all  
parts, PC board  
and instructions.  
**C6441  
\$5<sup>95</sup>**



**120VAC 3 CHANNEL  
COLOR ORGAN KIT**

Very popular 3 channel color organ causes lights  
of your choice (up to 200 watts per channel) to  
flash to the beat and frequency of your music.  
Connects to stereo speaker and operates from  
standard 120  
VAC. Board  
size: 3" x 5".

**C4530  
\$12<sup>98</sup>**



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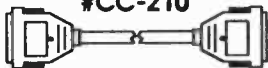
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## DATA TRANSFER CABLES

use with Laplink, Brooklyn Bridge, etc.

**NEW**

#CC-210



DB25 male to male  
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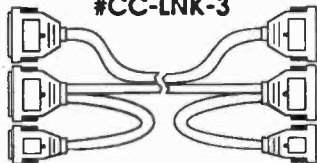
#CC-LNK



DB 25 female to female  
DB9 female to female  
For serial use only

6 Ft \$10 set

#CC-LNK-3



DB25 male to male  
DB 25 female to female  
DB9 female to female  
For serial and parallel use

6 Ft \$24 set

## #VA-154 COPYGUARD CORRECTOR

Enjoy videotapes without flashing and tearing

Macrovision methods often make it impossible to enjoy a clear, stable picture from prerecorded video cassettes. Picture roll, jitter, snow, tearing and flashing are the annoying side effects cured by the Copyguard Corrector.

Sophisticated digital circuitry inside this compact unit (no larger than two 8mm tapes!), descrambles any copy-protection scheme and delivers a stable, whistle-clean signal. Connects easily between two VCR's, or your VCR and a video monitor, with its single video in and video out jacks. Recently, copy protection developers have successfully sued to keep descramblers such as the Copyguard Corrector off the market. We cannot predict for how long this unit will be available, and suggest you order early to be safe!

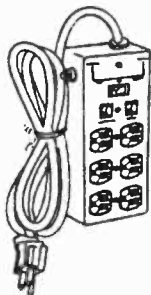


Reg. \$69.00 Now \$49 each or 2/ \$90 Special!

#TM-200

## SURGE PROTECTOR

6 Outlet  
Power/Modem  
EMI/RFI protector  
with indicator.



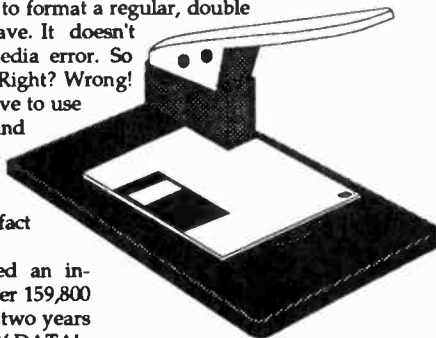
\$19.95

20 up \$18 each

#TM-319 DOUBLE DISK™ The original patented disk converter.

HOW IS THIS POSSIBLE? Have you ever tried to format a regular, double density 3.5" disk to 1.44 MB? Of course you have. It doesn't work. The computer gives you an invalid media error. So there must be a difference in the disk media. Right? Wrong! Surprisingly, manufacturers find it less expensive to use THE SAME MAGNETIC MEDIA for both HD and DD disks. THE ONLY DIFFERENCE IS THE EXTRA SENSE HOLE IN THE HD CASE. That hole tells the drive to operate in high density mode. So, how can you take advantage of the fact that the media is the same?

TWO YEARS OF TESTING. We've conducted an intensive testing program. We have converted over 159,800 disks and tested each one for data Integrity. In two years NOT ONE CONVERTED DISK HAS LOST ANY DATA! SUCCESS! "The Double Disk Converter" is a true product success story. From the moment we put it on the market the order lines have been ringing non stop! Nearly every major corporation, school, university and government agency is now using the device. In fact, over one hundred thousand satisfied purchasers are converting millions of disks and SAVING SERIOUS MONEY with the Double Disk Converter™.



STILL THE BEST  
Made of heavy gauge, deep drawn steel! For all IBM/clones and Macintosh systems! Don't trust your data with anything less than The Original Double Disk Converter™!

\$26.95 4 up \$25 each

## #VC-3VG DUBBING CABLE

3 foot triple RCA gold stereo audio/video 75 ohm high shield coax cable.  
"For Dubbing"  
VCR to VCR or to video component.



\$5 set 4 sets \$18

#CA-930

For compatible "IBM" serial port testing



\$4 each

## LOOPBACK TESTERS

20 up \$3.80 each

#CA-185

For compatible "IBM" parallel port testing



#SPL-29

"AT" Mouse  
DB25/female to DB9/male

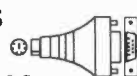


\$2 each 50/\$80

## ADAPTERS

#SPL-31

PS/2 Serial  
Mini 6/male to DB9/male



#CC-PWXC

Coiled Power Extension  
6 ft Belden, Great for movable CPU's / Monitors / Printers



\$2.50 each 20/\$2.25

#VC-6FF

TV CABLE  
6 ft "F" to "F" male connectors



\$1 Ea 10/\$5

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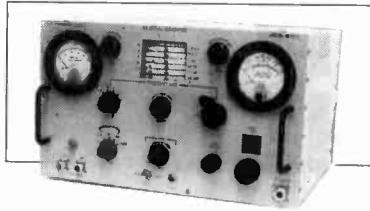
CIRCLE 261 ON FREE INFORMATION CARD

# Davilyn CORP.

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North Hollywood, CA 91605-3475



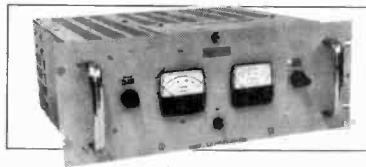
(Call for free catalog)



### AN/USM 44C

Signal Generator: General purpose, solid state, high frequency generator which provides radio frequency (rf) signals used to test, evaluate and align radio receivers, rf equipment and amplifier. Direct replacement for HP 608 series. Frequency: 10 MHz to 480 MHz  $\pm$  0.5% in 6 bands. Modulation: Internal AM: 400 and 1000 Hz + 10%, 0 to 95% with 0.5 volt RF output. External AM: 0 to 95%, 0.5 volt output, 1.0 volt RMS input @ 20 to 200 KHz. Pulse Modulation: 40 to 200

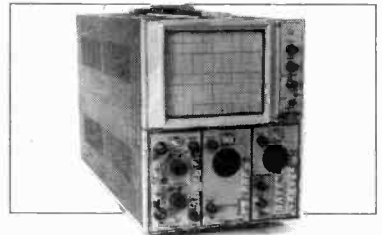
Price: \$200.00



### HYPERION POWER SUPPLY MODEL HY T1-36-30C

Solid state output 0-36 VDC, 0-30 amps. Input 115 vac 55 to 60 cps. Current limit adjustable. Dual meters to monitor voltage and current strapped connections in back to allow remote control.

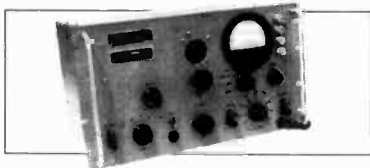
Price: \$250.00



### TEKTRONIX MODEL 5110N (also known as 5103N/D10)

General purpose, 2 MHz plug-in oscilloscope. Includes 5B13 Time-Base, 5A18 Dual-Trace vertical amplifier and 5A23 Horizontal amplifier. 6 1/2 inch rectangular display. Sweep rates from 5 microseconds to .5 second per division. Vertical sensitivity from 1 mV to 5 V per division. Add, alternate or chopped operating modes. X-Y mode, within 1 degree from dc to 100 kHz.

Price: \$225.00



### TS-723A/U

Spectrum Analyzer: Frequency range 20 Hz to 20 KHz. Fundamental frequency rejection, -80 dB. Inherent distortion <math>\leq 0.1\%</math>, sensitivity 0.3% full-scale. Useable to 0.1%. Input impedance 200Kohms 40 pf. Meter frame 0.3 to 300 volts fullscale. VTVM frequency range 10 Hz to 100 kHz + 3% flatness. VTVM input impedance 1M ohm, 3M ohm, 2.4M ohm, 37 pfs dependent on range selected. Noise measurement—full scale 300 microvolts, minimum—75 dBm, frequency—10 Hz to 20 KHz. Power Supply—115V/230V, 50 to 100 Hz, 90 watts.

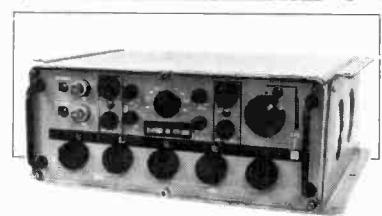
Price: \$100.00



### MODEL HP 180A

Oscilloscope: Mil Spec AN/USM-281A, 8 x 10 CM display, 100 MHz response which accepts standard 1800 series Plug-Ins. Includes Vertical Plug In: 1801A (PL-1186), frequency BW 50 MHz, maximum sensitivity 5mV/DIV. Horizontal Plug-In: 1821A (PL-1187), triggering to 100 MHz, minimum sweep time 100 NS/DIV, has delayed sweep capacity.

Price: \$250.00



### R-1051B/URR SYNTHESIZED HF RECEIVER

2-30 MHz LSB-USB-ISB-AM-CW-FSK radios. Tunes in 0.1 KHz increments plus vernier for virtual continuous tuning: 500 KHz IF. 50 ohm antenna input: 600 ohm audio out: Highly stable frequency control: rugged shipboard design. 7x17.4x18.9. 84 lbs sh. Used—checked.

Price: \$450.00



### I.R. TANK PERISCOPE

Type M-24. Rugged military construction. Contains two independent infrared image converter tubes plus correction lenses, prisms, and eyepieces. The binocular viewing system is directly connected to a prism-type periscope. The image tubes have dynamic focus provided by a built-in adjustable voltage divider. This unit requires 10 to 15 KV at low current for operation. Unable to supply power supply. (Dimensions: 18" high x 9" wide x 4 1/2" thick. Weight 17 lbs.) Stock #OP 9001

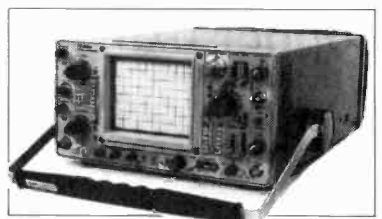
Price: \$200.00



### A.C. POWER SUPPLY STACO MODEL E1010VA

This unit has been designed and constructed for rigorous industrial, classroom or laboratory applications. These power supplies are brand new. Current list price \$750.00. Specifications: Input: 120 VAC 50/60 HZ. Output: 0-120 VAC 10 amps. Includes manual with schematics. Features: Ammeter, voltmeter, convenience outlet, power indicator and circuit breaker. Dimension: 10" x 15" x 6". Weight: 22 lbs.

Price: \$165.00



### TEKTRONIX 465 PORTABLE OSCILLOSCOPE

This popular unit has been the standard of the industry for many years. Features dual trace input, DC to 100 MHz response, and 5mV/div sensitivity. Sweep rates of 0.05  $\mu$ sec/div to 0.5 sec/div (Timebase A) and 0.05  $\mu$ sec/div to 50 msec/div (Timebase B). X10 magnifier extends maximum sweep rate to 5 nsec/div. Versatile triggering capabilities. 8 x 10 cm CRT display. Weighs only 22 1/4 lbs. Price: \$800.00 With option DM40 or DM44 \$950.00

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CIRCLE 271 ON FREE INFORMATION CARD

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Cool-Amp is a proven product that silver-plates high amp connections (any connections) *on the job*. It is very simple to use. Simply clean the contact and apply with a damp rag. Cool-Amp adheres permanently. It is equal to electroplating in performance.



Use Cool-Amp to reduce maintenance time. Use it on all current carrying connections. Prevent power losses and overheating from copper oxide. Time-tested for over 35 years.

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## COOL-AMP

**Cool-Amp Conducto-Lube Company**

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- Immediate delivery



**AR-170NL**  
TRUE RMS 3-1/2 DIGIT DMM + NOISE AND LEVEL MEASUREMENT

- 0.1% DCV accuracy
- True RMS AC measurement
- Level measurement in range -70dBm to +60dBm
- Noise measurement with 3KHz flat weighting filter
- Audible continuity check
- Up to 10A AC/DC capability
- Resistance measurement up to 20MΩ
- Range extended to: 20mV, 20μA & 20Ω
- Diode check

Reg. \$149.95  
Our price \$99.95



**AR-470D**  
WIDE-RANGE LCR METER WITH DISSIPATION FACTOR

- Drop-proof, Heavy Duty
- Inductance: 200uH to 200H
- Capacitance: 200pF to 20mF
- Resistance: 2 ohms to 20M ohms (max. resolution: 1 milliohm)
- Dissipation factor (D=1/Q) measurement
- 120Hz and 1KHz test frequencies
- +/- offset indication
- SMD or Chip component test probes available

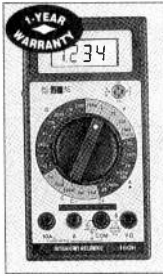
Reg. \$249.95  
Our price \$179.95



**112CF  
112J  
112K**  
TEMPERATURE MEASUREMENT ADAPTERS

Reg. \$99.00/\$69.00/\$69.00  
Our price \$34.95/\$34.95/\$34.95

MODEL	MEASUREMENT RANGE	ACCURACY
112CF	-50°C to 150°C (-58°F to 302°F)	±0.5°C (±1°F)
112J	-50°C to 750°C (-58°F to 1382°F)	0°C to 700°C: ±2°C OVER ENTIRE RANGE: ±4°C
112K	-50°C to 1000°C (-58°F to 1832°F)	-20°C to 1000°C: ±2°C OVER ENTIRE RANGE: ±4°C



**AR-160H**  
3-1/2 DIGIT DMM + hFE MEASUREMENT + CAPACITANCE

- 0.5% DCV accuracy
- Audible continuity check
- Up to 10A AC/DC capability
- Diode test
- Resistance measurement up to 20MΩ
- Capacitance measurement
- Transistor hFE measurement
- "LOBAT" indicator

Reg. \$89.95  
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**3000 SERIES**  
3-3/4 DIGIT AUTORANGING DMM

- 0.25% Accuracy (3010)
- 40 Segment Analog Bargraph
- 0.65" LCD Display
- Range-Alert (programmable levels)
- MIN/MAX Memory
- 20/sec Display Updates (Fast Mode)
- Auto Data Hold
- Relative Measurements
- TTL/CMOS Logic Probe
- dBm Measurements
- Fused 20 Amp AC/DC Range
- 2 Year Warranty

Four models to please everyone:

	Reg.	Our Price
3000 0.5% accuracy	\$129.00	\$69.00
3010 0.25% accuracy & range-alert	\$149.00	\$79.00
3100 drop-proof to 10'. Same ranges as 3010 plus 400μA & 4mA	\$199.00	\$89.00
3200 contamination & water resistant version of 3100	\$229.00	\$99.00



**PS-2330**  
DC Power Supply

Reg. \$249.00  
Our price \$195.00

OUTPUT VOLTAGE	0 to 30 VDC
OUTPUT CURRENT	0 to 3 ADC
OUTPUT RIPPLE & NOISE	0.5mV RMS or 4mV p-p Maximum
LINE REGULATION	CONSTANT E MODE: 0.02%+2mV CONSTANT I MODE: 0.02%+250μA
LOAD REGULATION	CONSTANT E MODE: 0.02%+2mV CONSTANT I MODE: 0.02%+500μA
OUTPUT IMPEDANCE	5mΩ+2H
DVM ACCURACY	0.2% Reading + 2LSB



**AR-700T**  
TRUE RMS 4-1/2 DIGIT DMM + FREQUENCY COUNTER

- 0.05% DCV accuracy
- True RMS AC measurement
- Frequency counter up to 200KHz
- Data Hold
- AC / DC up to 20A
- Audible continuity check
- Diode check
- Drop proof to 4 feet

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Our price \$129.95

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If you buy any of the equipment above, within ten days, you may buy any of our "BONUS BUYS" listed below, at below our costs. Sorry, only three "BONUS BUYS" per customer.  
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**Tektronix**  
**20MHZ TWO CHANNEL SCOPE**

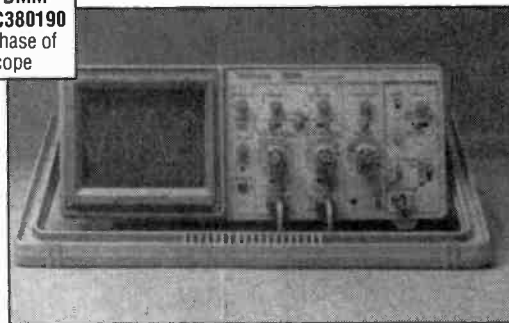
**\$695.<sup>00</sup>**

**Model R2205**

**1 Year Warranty**

Engineered for ease of use with enhanced performance. Features include: 5mV/div vertical sensitivity, 10ns/div horizontal display, and flexible triggering system. Peak-to-peak Auto makes triggering virtually hands free. Also featured are: Front panel access to the z-axis input; risetime of 17.5ns; single timebase with .05µs-5s range; single sweep, normal, auto, TV field and line trigger modes; DC trigger coupling and Ch1, 2, ext. line and vertical trigger source. Comes complete with manual and two 1X test leads.

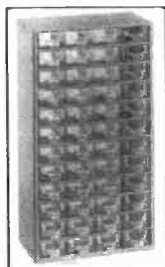
**FREE DMM**  
**Model RC380190**  
 with purchase of  
 R2205 Scope



**SPECIAL**  
**\$40.<sup>00</sup> each**

Reg. \$49.<sup>20</sup>

Specify Model R48A or  
 Model R60W



**SPACE-SAVING  
 SMALL PARTS  
 CABINETS**

Steel frame construction with blue-lacquer finish. Cabinets can be stacked or wall mounted. Both models are 22" h x 12" w x 5.75" d. Clear polystyrene drawers have large handles and adjustable dividers. **Model R48A** has 48 drawers that measure 1-3/8" x 2-1/2" x 5-5/16". **Model R60W** has 60 drawers that measure 1-3/8" x 2-3/64" x 5-5/16".

**SPECIAL**  
**\$25.<sup>95</sup>**

Reg. \$36.<sup>60</sup>

**Model R17420**



**LOCTITE  
 ADHESIVE KIT**

**For bonding virtually any materials**  
 This handy "first-aid" kit for adhesives has five different types of "high-tech" bonding compounds for plastic, glass, metal, ceramic, and rubber. Threadlocking adhesive vibration-proofs nuts, bolts and screws. Wire-tacking adhesive permits wire adds to PCB surfaces. Compact case is 7" x 3.5" x 1".

**SPECIAL**  
**\$29.<sup>00</sup>**

**Model RC380190**

**3-1/2 DIGIT  
 MINI DMM**

• 0.8% accuracy  
 • 1-year warranty  
 This pocket-sized DMM measures AC/DC voltage, current and resistance, plus features a diode test and signal injection. (It measures



DC voltage: 200mV to 1000V; AC voltage: 200V to 750V; DC current 200 µA to 2A; Resistance 200Ω to 2000KΩ; Resolution down to 100 µV, 100nA, 0.1Ω. Signal injector 50Hz square wave, 5V peak to peak.) Comes complete with test leads, battery and instruction manual.

**SPECIAL**  
**\$90.<sup>00</sup>**

Reg. \$110.<sup>00</sup>

**Model R3950**



**42-PIECE VARIABLE-SPEED  
 DREMEL MOTO-TOOL KIT**

Used for cutting, grinding, carving, sanding, polishing, drilling, sharpening and slotting. Works on wood, metal, plastic and more. Five speed motor develops 5,000 to 30,000 rpm and features ball-bearing construction for smooth, quiet power. Operates at 115 VAC and comes complete with a 2-wire flexible coiled chord, fitted carrying case, 40 accessories and a 1-year warranty.

**SPECIAL**  
**\$385.<sup>00</sup>**

**Model RPP4**

**LOGICAL  
 EPROM  
 PROGRAMMER**

- Stand-alone mode
- Copies and verifiers
- Upload/download in six file formats

With its 512K-bits of internal RAM, you can program all popular single voltage EPROMs from 2716 through 27512, including CMOS and "A" versions. Can be connected to a dumb terminal, computer, or modem, to perform transfer in six different formats. When operating in the stand-alone mode, you can directly copy and verify EPROMs via the three control switches and LED status indicators. RS-232 port operates at 110, 300, 1200 and 2400 baud. Operates on 110VAC.



**SPECIAL**  
**\$59.<sup>95</sup>**

**Model RT8/1**

**\$189.<sup>00</sup>**

**Model RLUV1**



**LOGICAL  
 ULTRAVIOLET  
 EPROM ERASERS**

You can now erase your UV EPROMs, MICROS and UVE Logic safely and efficiently. Model ZT8/1 has a EPROM capacity of 8, and an erasing time of 20 minutes. Also available is model ZLUV1 with an EPROM capacity of 50, and an erase time of 15 minutes.

Contact East, Inc. 335 Willow Street  
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**SPECIAL**  
**\$139.00**

Model RRMS225

**Beckman Industrial**

**4 DIGIT  
 TRUE RMS DMM**

- 0.25 % accuracy
- 41 segment analog bargraph
- 3-year warranty

Full-function, auto-ranging DMM with 4 digit, 10,000 count resolution measures DC voltage and current, resistance and true RMS AC voltage and current. (It measures DC voltage: 1V to 1000V; AC RMS Voltage 10V to 750V; DC/AC current: 10mA to 10A; Resistance: 1K $\Omega$  to 40M $\Omega$ ; Resolution down to: 0.1mV, 0.001mA, 0.1 $\Omega$ .) It features a continuity beeper, diode test, an Auto Min-Max mode, a relative mode and a probe hold mode. Comes complete with manual, test leads, battery(9V), protective holster with tilt stand and adjustable strap.



**SPECIAL**  
**\$59.95**

Reg. \$80.00  
 Model RIM5 Tool Case

**SPECIAL**  
**\$299.00**

Regular \$365.00  
 R22-IM5 117 Pc. Tool Kit



**THE  
 PROFESSIONAL'S  
 TOOL CASE**

- Case top has built-in document holder
- Case bottom is partitioned into 3 areas
- Two removable pallets hold over 60 tools

A handsome black case to organize and transport your valuable tools and instruments. This is the same quality case used by thousands of professional field engineers. Case is made of high impact polypropylene, and has snap-action key locks and a padded handle.

**Size:** 17 1/2" x 12 1/2" x 5"

**117-PC. PROFESSIONAL FIELD SERVICE KIT**

The complete kit comes with the tool case described above and a complete selection of quality, brand-name tools including Diamond, Xcelite and Weller. The kit includes screwdrivers, pliers, tweezers, cutters, wrenches, alignment tools, hex driver blades and a crimping tool, wire stripper, soldering iron & supplies, socket set, penlight, inspection mirror, hammer and more.

**Lifetime Guarantee:** Any tool that fails under normal use will be replaced free of charge.

**SPECIAL**  
**\$109.00**

Reg. 139.00  
 Model R380912

**\$129.00**

Reg. 159.00  
 Model R38091F

**DCA/ACA CLAMP METER**

Functions as 3 1/2 Digit DMM

Transformer jaws measure up to 400A AC/DC and a peak-hold function provides recall of AC or DC current surges. As a DMM it measures AC voltage, DC voltage, AC/DC current and resistance. The meter has the following ranges:ACV: 750V; DCV: 200mV,200V; DCA/ACA; 200A,400A; Resistance; 2000 ohms; Resolution down to 0.1mV, 0.1A and 1ohm. Comes complete with test leads, battery, carrying case and 1-year warranty. Model R38091F also has a built-in temperature function, 0-1400°F.



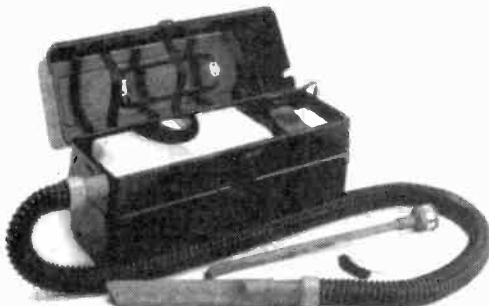
**SPECIAL**  
**\$188.00**

Reg. 208.00  
 Model R497AJM

**SERVICE VACUUM  
 CLEANER**

This vacuum cleaner is both portable and powerful. Originally designed by 3M for their own field service technicians. A special filter/collector cartridge holds more than conventional vacuum bags.

The cartridge is spill-proof and pops out for quick disposal. A cartridge with a filter that collects 2.0 - 20 micron-sized particles is included. Stretch hose (extends 32" to 7 ft.), crevice, wand and needle nozzles, brush and 9 foot 15VAC 3-wire cord are all stored inside cover. A 1-H.P. RFI-filtered 5A motor is thermally protected with auto-reset. ESD-safe. Measures 18" x 7.75" x 9.75" and weighs 9 lbs., 3-year warranty.



**SPECIAL**  
**\$99.00**

Reg. 128.65  
 Model RWTGPS

**Weller**

**PROFESSIONAL  
 TEMPERATURE CONTROLLED  
 SOLDERING SYSTEM**

Widely used in industry. It maintains a constant tip temperature of 700°F. Grounded tip protects components from voltage spikes. Comes with power unit, iron, stand, sponge and 700°F tip.

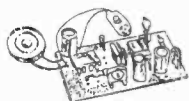


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# RAINBOW KITS



## RADAR SIGNAL DETECTOR

If you think that a sensitive radar detector is a complicated piece of equipment, take a look at this new kit. This simple, yet effective, detector circuit can be built in less than an hour and can be tuned to respond to signals between 50MHz to 500GHz. It's a fun kit to build and play with. A cigarette lighter plug is included. Size 1"x3/4" operates on 9 to 15v DC.

**KIT RSD-1 \$12.95**

## STROBE LIGHT

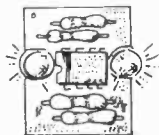
If you need an attention getter, or warning light, you need the strobe light kit. Use it for emergency light for autos, for model planes or radio towers. Even use it on your bicycle. Operates on 6 or 12v DC and has a variable strobe rate.

**KIT ST-1 \$8.95**

## DIGITAL THERMOMETER

Have you ever wanted to tell temperature changes fast & accurately? The DT-1 kit will turn your digital volt meter into an accurate digital thermometer with .1 degree resolution. It gives you a 250 degree window with a range from -40F to 300F degrees. It has a remote sensor .25" sq. that can be mounted many feet from the meter if need be.

**KIT DT-1 \$8.95**



## BLINKY LIGHTS

Want to attract attention? These kits are perfect for decorating name tags, lighting up your hat, or flashing lights for your model trains. Some people use them to simulate a burglar alarm for autos. Put it in a box, set it on your dash and it looks like the real thing. Each kit contains two LEDs that alternates flashing. Operates on a 9v battery. Size .5"x.5"

**KIT RB-2 \$3.45**

## CAPACITANCE METER

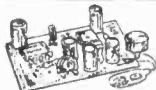
This easy to build kit will turn your digital volt meter into a CAPACITOR METER. Turn that junk box of unmarked capacitors into a fortune. Measures capacitors from (2pF to 2.2uF. Operates on a 9v battery. Size 1.75"x2"

**KIT CA-2 \$12.95**

## WIRELESS FM MIKE

Small but mighty .8"x1" PCB, will really stomp out a signal well over 400 yds. This is a buffered wireless mike that operates on 80 to 120 MHz FM. Comes complete with a microphone, and 9V battery connector. Operates on 6 to 12v DC.

**KIT WM-1 \$12.95**



## SUPER SNOOPER-BIG EAR

Use this BIG EAR amplifier to listen through walls, hear conversations across the room. Beef up the sensitivity with a parabolic reflector and hear blocks away. Due to the size, the BIG EAR can be hidden about anywhere. Use the earphones from a pocket transistor radio to listen. Makes an ultra-sensitive intercom. Can also be used as a general purpose 1.5W amp. We supply a mini-microphone in the kit. You can also use any 8 to 45 ohm speaker. Operates on 6 to 12v DC. Size 1"x1.75"

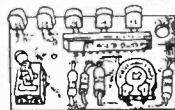
**KIT AA-1 \$10.95**



## AC LINE MONITOR

This is something every computer user, photographer, or anyone that must maintain a safe usable AC line voltage should have handy. Monitor the voltage of your motor home's 110v AC generator inside the motor home. Every technician's bench needs this item. The AC line monitor will indicate, with multi-color LEDs, what voltage is being distributed to your equipment at that particular outlet.

**KIT LM-110 \$10.95**



## 12V BATTERY MONITOR

Have you ever been in your car, boat, or camper — you try to start your motor but the battery is dead? The BATTERY MONITOR kit uses the cigarette lighter plug outlet to monitor the true battery voltage. Multi-color LEDs indicate the voltage in 1v steps from 11v to 15v, green means great, yellow is good, and red — call the tow truck or get out the oars. Size 1.2"x1.75"

**KIT LM-12 \$5.95**



## PHONE BUG

Small but mighty, so small it fits anywhere. Telephone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances away. Variable tunes 70MHz to 130MHz. It can also be used to make any phone a speaker phone. Size .55"x1"

**KIT TEL-B1 \$10.95**



## PHONE RECORDING SWITCH

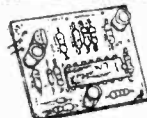
This telephone line powered switch is small enough to install anywhere only 9"x6". Every time someone picks up the phone the tape recorder will record both sides of the conversation automatically. Use it in your office to record all phone conversations so you don't lose that important address you wrote on the back of an envelope.

**KIT TEL-SW 1 \$10.95**

## BUSY PHONE LIGHT

Add this little kit to any or all of your phones. When any extensions are in use the LED will light. Uses a 9v battery. P.C. Board 1"x1/2". Complete with etched & drilled PCB, all parts and schematics.

**KIT TEL-LIT-1 \$9.95**



## VOICE ACTIVATED SWITCH

This vox can be used to operate a tape recorder, ham radio, CB radio. Use it to turn on an alarm. The output can operate a load up to 100ma. It will operate a relay, lights, motor, or LEDs. What could you do with a sound activated switch? Size 1.5"x1.25"

**KIT VOX-1 \$6.95**

## LIE DETECTOR

This kit can be great fun at parties. Lie and an audible tone will change, the more you lie the more the tone changes. When you lie your palms & forehead sweat. This kit allows you to measure these changes. Only a very slight amount of change will cause the tone to increase in frequency. Operates on 6 to 12v DC. Size

**KIT LD-1 \$9.95**

# LASER KITS

Laser Switching Power Supply Kit, input 12V DC .75-1.25A. Output 2 to 3 KV at 3-4.5 MA, trigger voltage of approx. 8-10 KV. Complete with 6.25" x 2.25" printed circuit board, schematic and all the parts.

**LPS-1.....\$59.95**

1MW Laser Tube, NEW Mini He-Ne 1.125" dia. x 5.75" long, perfect for experimenters and laser projects. Works great with above power supply LPS-1.

**L1MW-1.....\$39.95**

Mirror and Motor Kit—This unique kit allows you to project Lissajous patterns on walls and ceiling. Change the pattern by changing the speed of the motors. Comes complete with 2 motors, front surface mirrors, motor brackets, rheostat control to control #1 motor, and high power resistors to use on #2 motor.

**MM-2.....\$19.95**

★ SPECIAL ★  
Laser Power Supply Kit LPS-1  
1MW Laser Tube L1MW-1  
Mirror and Motor Kit MM-2  
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9V 100MA rechargeable Ni-cad batteries. This 9V Ni-cad is truly a 9V not the standard 7.2V you're accustomed to. Use over and over.

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9V battery charger kit. This kit is a must when you buy 9V Ni-cads, charges 2 batteries at once. Use on 110V AC or with a 12V DC cigarette lighter plug which is included. Comes complete with parts, P.C. board, housing and schematic.

**CH-9V.....\$19.95**



THIS MANUAL CONTAINS ALL SCHEMATICS, PARTS & P.C. BOARD LAYOUTS FOR ALL OF THE RAINBOW KITS. USE YOUR OWN PARTS TO CONSTRUCT ANY OF OUR KITS.

**KIT BOOK \$14.95**

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# Put Real World Control In Your Grasp

**Micro-440 Combines the Features  
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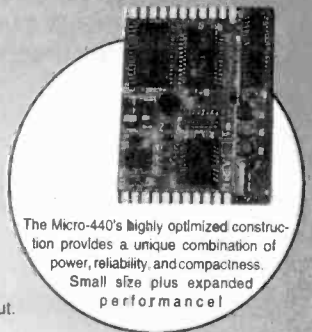
**Everything You Need  
in One Compact Package!**

The Blue Earth Micro-440 is a versatile programmable controller designed for the demands of today's fast-paced development environment. The standard features of the Micro-440 provide you with everything needed for a quick, cost-effective solution to your project design requirements. In applications from automation to data logging, embedded control to hobby projects, see what the Micro-440 can do for you!



## Standard Features:

- **83C51FB CPU** - High integration member of the popular 8051 family includes a PCA (Programmable Counter Array) with 5 high speed I/O channels and a watchdog timer.
- **Built-In BASIC and MONITOR-51** - The CPU ROM contains a floating point BASIC interpreter and an assembly language debug monitor for fast and easy program development.
- **32K RAM** - On-board memory can be used for program or data storage and includes a 10+ year lithium backup battery. A write protectable block is available for permanent program storage (no EPROM needed).
- **Dual RS-232C Ports** - Includes a primary communication channel plus a printer port and features a hardware or software selectable low power shutdown mode.
- **14 Digital I/O** - All I/O lines are TTL/CMOS compatible for easy interfacing to application circuitry.
- **Clock/Calendar Module** - Includes year, month, day, and time registers plus a programmable interrupt output.
- **Precision 5 Volt Regulator** - Allows operation from almost any filtered 6-16 volt D.C. source.
- **A/D Converter** - An 8-bit 8 channel analog-to-digital converter features single-ended and differential inputs and 40µS conversion time.
- **Expansion Connector** - Contains all CPU bus signals plus power - enabling user to add Blue Earth or custom expansion modules.
- **Sturdy ABS Plastic Case** - Provides protection for electronic components and looks good, too!
- **6 Layer Board Uses SMT** - High tech manufacturing enhances performance and reliability while reducing overall size.



The Micro-440's highly optimized construction provides a unique combination of power, reliability, and compactness. Small size plus expanded performance!

## Expansion Modules

For fast implementation of expanded hardware requirements, Blue Earth Research has developed several ready to use add-on modules, all in their own attractive plastic case.

- Application Module** - For testing and demonstration. Includes 7-segment LED, beeper, potentiometer, and power MOSFETS.
- 12-Bit A/D Module** - Four channels of high speed (15 µS) precision analog inputs.
- I/O Expander** - Adds 24 configurable I/O channels for LCD and keypad, general purpose I/O, or high current outputs.
- Memory Expander** - Plug in 8K to 128K bytes of RAM, EPROM, or EEPROM.



APPLICATION MODULE

## Software

The Micro-440 can be purchased with a wide range of program development and support software. All software packages run on any PC or compatible and include complete documentation.

- Macro Assembler** - Full featured 8051 assembler with powerful macro capabilities and comprehensive error processing.
- C51 Compiler** - Optimizing C Compiler for the 8051 family by Franklin Software, Inc. Supports re-entrant functions and implements the ANSI standard for the C language.
- PL/M-51 Compiler** - Powerful yet easy to learn language. Genuine Intel Compiler.
- TASM** - Table driven cross assembler. Supports 10 different processor families. Includes "C" source code on disk.

## Our Programming Power is Affordable!!

Blue Earth Research is breaking traditional cost barriers by including all the necessary features that are either expensive options or not available with other controllers. To realize even more power and potential from your Micro-440, we offer packages that combine the Micro-440 with powerful development software and applicable hardware - all at reasonable prices.

Micro-440 Programmable Controller Only - Stand Alone Unit .....	\$199.00
Hardware Package - Micro-440 with Power Supply, Application Module, RS-232 Cable, User's Manual, and Pocket Reference .....	\$299.00
As above, with MCS@-51 Reference Manual .....	\$319.00
Assembler Package - Includes complete hardware package, with professional grade Macro Assembler, Symbolic Debugger, and Hex File Converter .....	\$399.00

Prices and specifications subject to change without notice. Prices do not include shipping or MN sales tax.



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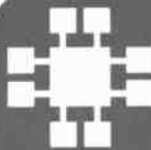
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MMC

## RS-232 BREAKOUT BOX

WITH 24 SWITCHES AND 12 LINE MONITOR LEDS. THIS BREAKOUT BOX SIMPLIFIES CABLING TASKS.



- TEN BI-POLAR LEDS MONITOR TF, RD, RTS, CTS, DSR, CD, TC, RC, DTR AND TC SIGNALS (2 SPARES)
- 24 SWITCHES FOR BREAKOUT AND PATCHING
- INCLUDES JUMPER WIRES • REQUIRES NO BATTERY

BRBOX-BO ..... \$34.95

## RS-232 TESTER

\$149.95

DISPLAYS ALL 25 LINES ON BOTH THE DTE AND DCE SIDE WITH TWO SETS OF LEDS. DIP SWITCHES ENABLE ALL 25 LINES, PLUS ALLOW SWITCHING LINES 2 AND 3.



- 100 LEDS DISPLAY ALL DTE AND DCE SIGNALS
- 29 DIP SWITCHES OPEN & CLOSE ALL CONNECTIONS & SWAP COMMON LINES SUCH AS PINS 2-3
- EASY LOOPBACK AND NULL MODEM TESTS

BRBOX-702 ..... \$149.95

## LOW COST POWER SUPPLIES

### 40 WATT POWER SUPPLY \$19.95

- 5V @ 4.8A, 12V @ 1.1A, -5V @ 0.12A
- OPEN-FRAMED SWITCHING SUPPLY
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PS-TC24 ..... \$19.95

### 112 WATT POWER SUPPLY \$24.95

- +5V @ 10A, +12V @ 3.5A, +12V @ 1.5A, -12 @ 200MA
- 5" X 8.5" X 1.97"
- OPEN FRAMED POWER SUPPLY

PS-DPS-110AP ..... \$24.95

## EPROMS

PART#	SIZE	SPEED	Vpp	PINS	PRICE
2716-1	2048x8	350ns	25V	24	4.95
2732A	4096x8	250ns	21V	24	3.95
2764	8192x8	450ns	12.5V	28	3.95
2764-250	8192x8	250ns	12.5V	28	3.95
2764-200	8192x8	200ns	12.5V	28	4.49
27128A-200	16384x8	200ns	12.5V	28	4.95
27256	32768x8	250ns	12.5V	28	4.95
27C256	32768x8	250ns	12.5V	28	5.95
27512	65536x8	250ns	12.5V	28	5.95
27C101-20	131072x8	200ns	12.5V	32	12.95

## STATIC RAM

PART#	SIZE	SPEED	PINSCMOS	LP	PRICE
HM6116-2	2048x8	120ns	24	Y	2.95
HM6116LP-4	2048x8	200ns	24	Y	2.95
HM6116LP-3	2048x8	150ns	24	Y	3.25
HM6116LP-2	2048x8	120ns	24	Y	3.95
HM6264LP-15	8192x8	150ns	28	Y	3.95
HM6264LP-12	8192x8	120ns	28	Y	4.95
HM6264LP-10	8192x8	100ns	28	Y	5.95
HM43256LP-15	32768x8	150ns	28	Y	4.95
HM43256LP-12	32768x8	120ns	28	Y	5.95
HM43256LP-10	32768x8	100ns	28	Y	6.95

## PALS

PART#	SPEED	PINS	IN	OUT	I/O'S	FUNCTIONS	PRICE
16L8	35ns	20	10	2	6	AND-OR INV	2.95
16R4	35ns	20	8	4	4	AND-OR INV	2.95
16R6	35ns	20	8	6	2	AND-OR INV	2.95
20L8	40ns	24	14	2	6	AND-OR INV	2.95
20R4A	25ns	24	12	4	2	AND-OR INV	3.49
20R6	40ns	24	12	8	2	AND-OR INV	2.95
20R8	40ns	24	12	8	2	AND-OR INV	2.95
20X8	50ns	24	10	8	2	AND-OR-XOR INV	2.95

## GALS

PART#	SPEED	PINS	REPLACES	IN	OUT	PRICE
16V8	35ns	20	10L8 TO 16RP8	8	8	2.49
16V8-15	15ns	20	10L8 TO 16RP8	8	8	2.95
20V8	35ns	24	14L8 TO 16RP8	20	8	3.49
20V8-15	15ns	24	14L8 TO 16RP8	20	8	4.95
22V10	35ns	24	PGM OUTPUTS	22	10	6.95
22V10-15	15ns	24	PGM OUTPUTS	22	10	19.95

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## 3.5 DIGIT DMM PROBE \$49.95

CUSTOM 80 PIN LSI CHIP FOR ACCURACY AND RELIABILITY IN A COMPACT SIZE. AUTORANGING, AUDIBLE CONTINUITY AND DATA HOLD FEATURES. CASE AND BATTERIES INCLUDED.

- 16 RANGES • AUTORANGING • BASIC DC ACCURACY: ±1.0%
- MEASURES:

DC VOLTAGE: .1MV - 500V  
AC VOLTAGE: .1MV - 500V  
RESISTANCE: .1Ω - 2MΩ



INPUT IMPEDANCE: 10MΩ  
DPM-1500 ..... \$49.95

## 3.5 DIGIT DMM MULTITESTER

THIS FULL FUNCTION 3.5 DIGIT DMM OFFERS HIGHLY ACCURATE PERFORMANCE TO HELP YOU DO THE JOB! TEMPERATURE PROBE, TEST LEADS AND BATTERY INCLUDED.

- 34 RANGES • BASIC DC ACCURACY: ±0.25%
- MEASURES:

DC VOLTAGE: .1MV - 1000V  
AC VOLTAGE: .1MV - 750V  
RESISTANCE: .1Ω - 2MΩ  
CAPACITANCE: .1PF - 20 μF  
CONDUCTANCE: .1NS - 200NS  
TRANSISTOR HFE GAIN: 0 - 100  
AC/DC CURRENT: .1μA - 10A



INPUT IMPEDANCE: 10MΩ  
DMM-300 ..... \$79.95

## POCKET-SIZE DMM

CONVENIENT POCKET-SIZE DOESN'T COMPROMISE FEATURES OR ACCURACY. EASY TO READ 1 1/2" LCD DISPLAY. 200-HOUR BATTERY LIFE WITH 9-VOLT BATTERY. PROBES & BATTERY INCLUDED.

- 19 RANGES • BASIC DC ACCURACY: ±0.5%
- MEASURES:

DC VOLTAGE: .1MV - 1000V  
AC VOLTAGE: .1MV - 750V  
RESISTANCE: .1Ω - 2MΩ  
DC CURRENT: .1μA - 10A



DIODE TESTER • INPUT IMPEDANCE: 10MΩ  
DMM-150 ..... \$29.95

DMM-200 3.5 DIGIT DMM 22 RANGES ..... \$29.95

## PULSER PROBES

DETECT SIGNAL TRANSITIONS WITHIN YOUR CIRCUITS.

- RED/GREEN LED INDICATES HIGH/LOW
- YELLOW LED INDICATES PULSE
- MINIMUM PULSE WIDTH: 30NS
- MAXIMUM INPUT FREQUENCY: 17 MHZ
- LOGIC 1: TTL 2.3V ± 0.2V CMOS 70% VCC
- LOGIC 0: TTL 0.8V ± 0.2V CMOS 30% VCC
- OVERLOAD PROTECTION: ±220V DC/AC



LP-100 ..... \$17.95

LP-200 PULSER PROBE ..... \$19.95

## DATASE II EPROM ERASER

CONVENIENT POCKET-SIZE!

- ERASES ALL SIZES OF EPROM UP TO 4 AT A TIME
- WALL PLUG POWER SUPPLY



DATASE II ..... \$39.95

## PORTABLE IC TESTER

EASY-TO-OPERATE AND COST EFFECTIVE UNIT. SUPPORTS THE

FOLLOWING COMMON FAMILIES OF IC'S: 74 SERIES TTL, 40 AND 45 SERIES CMOS AND 41/44 SERIES DRAM UP TO 1MB, AND RECOGNIZES 411000 DEVICES (11MBX1). CAN ALSO IDENTIFY UNKNOWN PART NUMBERS.



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JDR'S NEWEST ADDITION TO THE PROJECT DESIGN SERIES INCLUDES A SELF-POWERED SOLDERLESS BREADBOARD WITH INTERFACE FOR YOUR PC. A TUTORIAL PROVIDED TEACHES HOW TO MAKE YOUR PC INTERFACE WITH DIGITAL AND ANALOG DEVICES.

PDS-1000 ..... \$399.95

## BENCH TYPE DMM \$199.95

EXTREMELY ACCURATE BENCH-TYPE MULTIMETER HAS A CONTINUITY ANNUNCIATOR THAT SOUNDS WHENEVER A SHORT IS DETECTED.

- 4-1/2 DIGIT LCD DISPLAY
- BASIC DC ACCURACY: ±0.05%
- MEASURES:

DC VOLTAGE: 10μV - 1000V  
AC VOLTAGE: 10μV - 750V  
RESISTANCE: .01Ω - 20MΩ  
AC/DC CURRENT: 10NA-10A



DIODE/CONTINUITY TESTER  
DBM-500 ..... \$199.95

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PROVIDES FREQUENCY, PERIOD AND TOTALIZE MEASUREMENTS OVER A WIDE RANGE OF APPLICATIONS.

- RANGE: 10HZ TO 10MHZ DIRECT, 0MHZ TO 100MHZ PRESCALED BY 10
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DFC-100 ..... \$179.95

DFC-1000 1GHZ VERSION ..... \$199.95

DFG-600 SWEEP FUNCTION GENERATOR ..... \$189.95

## 35MHZ OSCILLOSCOPE

- EXCEPTIONALLY BRIGHT CRT • TV SYNCH FILTER
- DELAYED & SINGLE SWEEP MODES
- FAST 10NS RISE TIME

MODEL-3500 ..... \$499.95

MODEL-2000 20MHZ VERSION ..... \$389.95

## THE JDR FRONTPANEL \$99.95

A BUS EXTENDER AND

INSTRUCTION EXECUTION

DETECTOR IN ONE! YOU

SIMPLY SET THE ADDRESS

AND OPERATION TO BE

DETECTED ON THE SWITCHES

AND WHEN THE PROCESSOR

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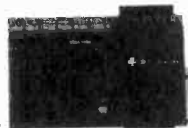
AND AN INTERRUPT OCCURS.

• NMI VIA /OCHECK LINE, OR IRQ 2, 5, 7 CAN BE ASSERTED

WHEN MATCH OCCURS

• ENABLE/DISABLE MATCH ON READ/WRITE, I/O MEM, DATA

DMA, OR EXTERNAL EVENT



FRONTPANEL ..... \$99.95

## PC PROTOTYPE CARDS

8-BIT SOLDERLESS 8088

BREADBOARD WITH DECODE

• 8-BIT CARD • GOLD-PLATED EDGE-CARD FINGERS

• BUFFERING & DECODE LAYOUT • FR-4 EPOXY LAMINATE

JDR-PR2 ..... \$29.95

JDR-PR2-PK OPTIONAL PARTS KIT ..... \$8.95

JDR-PR10 16-BIT WITH I/O DECODING LAYOUT ..... \$34.95

JDR-PR10-PK OPTIONAL PARTS KIT ..... \$12.95

EXT-80286 286-COMPATIBLE EXTENDER CARD ..... \$39.95

EXT-8088 8088-COMPATIBLE EXTENDER CARD ..... \$29.95

PC PROTOTYPING CARDS

• ADDRESS DECODING LOGIC, DATA BUFFERING, 2 LSI CIR-

CUITS FOR PROGRAMMABLE DIGITAL I/O & COUNTER-TIMER

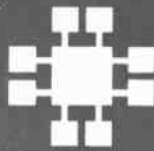
FUNCTIONS

PDS-601 ..... \$79.95

PDS-600 ABOVE CARD WITHOUT DECODE ..... \$49.95

PDS-611 16-BIT BUS BREADBOARD WITH DECODE ..... \$69.95

PDS-610 ABOVE CARD WITHOUT DECODE ..... \$59.95



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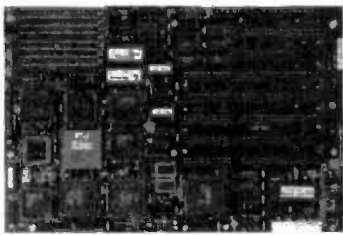
• 30-DAY MONEY BACK GUARANTEE

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## MOTHERBOARDS



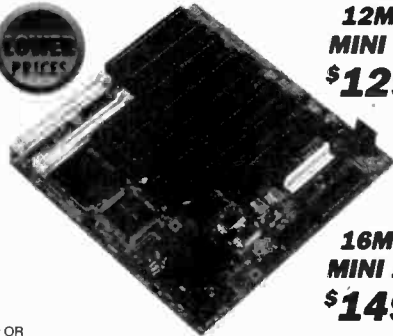
### 16MHz MINI 386-SX \$249<sup>95</sup>

• NORTON SI 18.3 • LANDMARK AT SPEED 20.8

• EXPANDABLE TO 8MB ON-BOARD • AMI BIOS • CHOOSE 0 OR 1 WAIT STATE FOR USE WITH SLOWER RAM • FIVE 16-BIT AND THREE 8-BIT SLOTS • CHIPS & TECHNOLOGY "NEAT" CHIPSET • SOCKET FOR 80387 CO-PROCESSOR • 8.5" X 13" SIZE FITS MINI-286 & FULL-SIZE CASES

MCT-386SX 16 MHz 386SX	\$249.95
MCT-386SX-20 20 MHz VERSION	\$299.95
MCT-M386-25 25 MHz MINI 386	\$399.95
MCT-C386-33 MINI 33MHz CACHE 386	\$599.00
MCT-C386-40 40 MHz CACHE 386	\$699.00
MCT-M486-33 33 MHz MINI 486	\$995.00

## MODULAR CIRCUIT TECHNOLOGY



### 12MHz MINI 286 \$129<sup>95</sup>

### 16MHz MINI 286 \$149<sup>95</sup>

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• 6/12MHz KEYBOARD SELECTABLE SPEEDS • EXPANDABLE TO 4MB ON-BOARD USING 80NS 256K OR 1MB SIMMS(OK INSTALLED) • FIVE 16-BIT AND THREE 8-BIT SLOTS • AMI BIOS • SOCKETED FOR 80287 CO-PROCESSOR • 8.5" X 8.75" SIZE FITS MINI-286 AND FULL-SIZE 286 CASES

MCT-M286-12	\$129.95
MCT-M286-16 16MHz VERSION	\$149.95
MCT-TURBO-10 10 MHz 8088	\$69.95

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- 60 WATTS, THERMOSTATICALLY CONTROLLED HEAT FROM 200-900° F
- °F AND °C GAUGE
- SOLDER GUN, GUN-REST & COOLING TRAY
- LEADS • REPLACEABLE TIP



168-3C ..... \$59.95

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- OIL-FREE VACUUM PUMP
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XY999SD ..... \$399.95

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60% TIN / 40% LEAD IN 1 LB. REELS.

SLDR-025 0.025" DIA	\$9.95
SLDR-031 0.031" DIA	\$9.95
SLDR-050 0.050" DIA	\$9.95

## CONDUCTIVE PEN

• LINK COMPONENTS, REPAIR DEFECTIVE TRACES, MAKE SMOOTH JUMPERS • TRACES DRY IN MINUTES, CAN BE SOLDERED AT LOW TEMPS • HOLDS APPROX. 100 FT.

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PEN-3300 CONFORMAL COATING PEN	\$9.95

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• PROGRAMS EPROMS, EEPROMS, CMOS EPROMS, GALs, BI-POLAR PROMS, 8748 AND 8751 SERIES DEVICES • TESTS TTL AND CMOS ICs, DYNAMIC AND STATIC RAM • TEXTBOOK SOCKET ACCEPTS 3-6" ICs FROM 8-40 PINS • LOAD FILE, SAVE FILE, EDIT, BLANK CHECK, PROGRAM, AUTO, ROAD MASTER, VERIFY AND COMPARE • COMPATIBLE WITH PAL SOFTWARE



MOD-MUP ..... \$499.95

### ADAPTOR PROGRAMS 4 EPROMS AT ONCE

MOD-MUP-EA ..... \$99.95

### HOST ADAPTOR CARD AND CABLE

MOD-MAC (REQUIRED FOR OPERATION) ..... \$29.95

## EPROM PROGRAMMER

• QUICKLY, EASILY PROGRAMS 24 TO 32-PIN EPROMS, CMOS EPROMS, EEPROMS FROM 16K TO 1 MB • HEX TO OBU CONVERTER • AUTO BLANK CHECK, PROGRAM AND VERIFY

MOD-MEP 1-EPROM PROGRAMMER ..... \$119.95

MOD-MEP-4 4-EPROM PROGRAMMER ..... \$169.95

MOD-MEP-8 8-EPROM PROGRAMMER ..... \$259.95

MOD-MAC HOST ADAPTOR CARD & CABLE ..... \$29.95

\*NOTE: REQUIRES MOD-MAC HOST ADAPTOR CARD

## PAL DEVELOPMENT SOFTWARE

• SUPPORTS 16L8, 16R4, 16R6, 16R8, 20L8, 20R4, 20R6, 20R8 AND 20X8-CUPL SIMULATOR TESTS FUNCTIONALITY OF DESIGNS-PTOC (PALASM TO CUPL TRANSLATOR)

MOD-MPL-SOFT ..... \$99.95

## UNIVERSAL PROGRAMMER



• SUPPORTS DEVICES FROM ALTERA, AMD/AMI, AMI, ATMEL, CATALYST, CYPRESS, EXEL, FUJITSU, GOULD, HARRIS, HITACHI, HYUNDAI, ICT, INTEL, LATTICE, MATSU-SHITA, MICRORCHIP/IGI, MITSUBISHI, MOTOROLA, NEC, NATIONAL SEMICONDUCTOR, OKI, RICOH, ROCKWELL, SAMSUNG, SEEG, SGS-THOMSON, SINGNETICS, TI, TOSHIBA, VLI, XICOR, XILINX AND ZILONG

MOD-EMUP ..... \$699.00

## SYSTEM DIAGNOSTICS CARD

\$49<sup>95</sup>

- WORKS WHEN SOFTWARE CANNOT
- 286/386/486 COMPATIBLE
- PLUG INTO SLOT, READ LED DISPLAY AND CHECK YOUR BIOS MANUAL FOR ERROR CODE
- DUAL GAL CHIP DESIGN INSURES ULTRA-LOW CURRENT OPERATION AND LOW NOISE
- VIEW LEADS ON-BOARD OR ON BACK-PANEL



PCODE	\$49.95
GATEKEEPER 8-BIT PASSWORD SECURITY CARD	\$49.95

### MEMORY CARDS

SIMPLY-RAM MEMORY EXPANSION CARD	\$199.95
MCT-EEMS 16-BIT EEMS CARD	\$149.95
MCT-EMS 8-BIT EMS CARD 2MB CAPACITY	\$129.95
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MCT-VGA-1024+ 1024 X 768 IN 256 COLORS	\$149.95
MCT-MGP MONOGRAPHS/PRINTER CARD	\$49.95

## IDE FLOPPY/HARD CONTROLLER \$29<sup>95</sup>

- SUPPORTS 2 IDE HARD & 2 FLOPPY (360K, 720K, 1.2MB & 1.44MB) DRIVES
- HARD DISK ACTIVITY LED SUPPORTED

MCT-IDEFH ..... \$29.95

## 1.44MB FLOPPY CONTROLLER \$49<sup>95</sup>

- SUPPORTS 2 FLOPPY (360K, 720K, 1.2MB & 1.44MB) DRIVES
- SELECTABLE AS PRIMARY OR SECONDARY DRIVE CONTROLLER

MCT-FDC-HD	\$49.95
MCT-FDC-HD4 4 FLOPPY VERSION	\$59.95
MCT-HDC HARD DRIVE CONTROLLER	\$79.95
MCT-RLL RLL HARD DRIVE CONTROLLER	\$89.95
MCT-FAFH 16-BIT 1:1 F/H CONTROLLER	\$99.95
MCT-AFH-RLL 16-BIT F/H RLL CONTROLLER	\$149.95

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MCT-AIO 8-BIT 286/386 MULTI I/O CARD	\$49.95
AIO-SERIAL OPTIONAL 2ND SERIAL PORT	\$24.95

## Seagate HARD DRIVES 131MB \$399

FORMAT	FORM	MODEL #	STORAGE	AVG. SPEED	PRICE
IDE	3-1/2"	ST-351A	42.0MB	28MS	\$209
IDE	3-1/2"	ST-3096A	89.1MB	16MS	\$319
IDE	3-1/2"	ST-3144A	131MB	16MS	\$399
IDE	3-1/2"	ST-1201A	177MB	15MS	\$559
IDE	5-1/4"	ST-2383A	338MB	16MS	\$1159
IDE	3-1/2"	ST-1480A	426MB	14MS	\$1239
MFM	5-1/4"	ST-225	21.4MB	65MS	\$199
MFM	5-1/4"	ST-251-1	42.8MB	28MS	\$249
MFM	5-1/4"	ST-4096	80.2MB	28MS	\$569
RLL	5-1/4"	ST-238	32.7MB	65MS	\$219
RLL	5-1/4"	ST-277-1	65.5MB	28MS	\$289
SCSI	5-1/4"	ST-296N	84.9MB	28MS	\$369

5-1/4" MOUNTING KIT FOR MOST 3-1/2" DRIVES HD-MHW ..... \$9.95

## FLOPPY DRIVES

FDD-1.44X 1.44MB HD BLACK FACEPLATE	\$79.95
FDD-1.44A 1.44MB HD BEIGE FACEPLATE	\$79.95
FDD-360 5-1/4" DOUBLE-SIDED DD 360K	\$69.95
FDD-1.2 5-1/4" DOUBLE-SIDED HD 1.2M	\$89.95
FD-55GFV TEAC 5-1/4" DOUBLE-SIDED HD 1.2M	\$89.95

## 1024 x 768 VGA PACKAGE \$469<sup>95</sup>

- 8088 & 286/386/486 COMPATIBLE CARD & 1024 X 768 INTERLACED MONITOR
- 1:1 ASPECT RATIO
- 0.28 DOT PITCH
- 256 COLORS FROM 262,000
- 8/16-BIT CARD HAS 512K VIDEO RAM EXPANDABLE TO 1MB



VGA-PKG-1024+	\$469.95
VGA-PKG 640 X 480 VGA PACKAGE	\$349.95

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NEC-3FGX	NEC MULTISYNC 3FGX	\$749.00
VGA-MONITOR	VGA MONITOR	\$299.95
MONO-VGA	PAPERWHITE VGA MONITOR	\$149.95
JDR-AMBER	12" MONO-AMBER SCREEN	\$89.95

## 2400 BAUD MODEM \$49<sup>95</sup>

• 2400/1200/300 BPS INTERNAL DATA MODEM • FULL HAYES AT COMPATIBILITY • INCLUDES PROCOMM SOFTWARE

MCT-241	\$49.95
PCEM7296 INTEL 9600 BPS EXTERNAL	\$499.00
PCCB6201 INTEL SATISFACTION FAX/MODEM	\$399.95
VIVA-24MNP 2400 BPS EXT MODEM W/MNP	\$149.95

TERMS For shipping & handling include \$5.00 for ground and \$1.50 for air. Orders over 1 lb. and long distances may require additional shipping charges - contact our Sales Dept for the amount. CA residents must include applicable sales tax. Prices subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturers. All merchandise subject to prior sale. A full copy of our terms and conditions of sale is available upon request from our office by registered mail. JDR Microdevices, JDR, the JDR logo and the MCT logo are registered trademarks of JDR MICRODEVICES, INC. Modular Circuit Technology is a trademark of JDR MICRODEVICES, INC. Copyright 1992 JDR MICRODEVICES.



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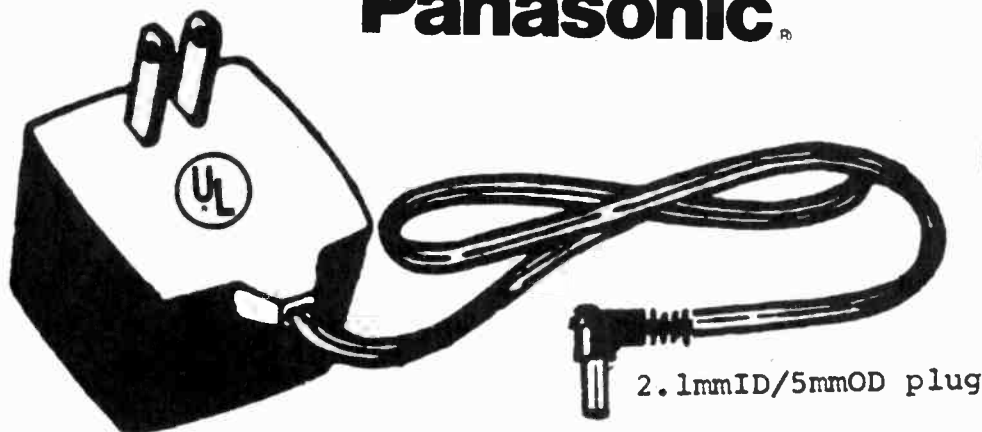
WE HAVE AVAILABLE OVER 125,000 SURPLUS PLUG-IN WALL ADAPTERS. THESE ARE ALL BRAND NEW IN A WIDE RANGE OF VOLTAGES AND CURRENTS IN BOTH AC AND DC OUTPUTS. WE ALSO HAVE 220/240VAC ADAPTERS AND DUAL OUTPUT VOLTAGE POWER SUPPLIES. PHONE OR FAX US FOR OUR LATEST ADAPTER CATALOG OR CALL FOR AVAILABILITY AND PRICE QUOTE ON YOUR NEEDS. WE ARE ALSO INTERESTED IN PURCHASING YOUR EXCESS ADAPTER INVENTORY. CONTACT US TODAY!

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HOME CONTROL CONCEPTS HAS COME DOWN WITH A SEVERE CASE OF  
**STANLEY MANIA**

**SYMPTOMS:** Shortness of breath, extreme excitement about Stanley LightMaker home controls, and an uncontrollable craving to sell top quality Stanley LightMaker products at extreme low prices.

**CURE:** Home Control Concepts has been ordered by our doctor to hold the most unbelievable Stanley LightMaker sale ever seen in the history of home automation.

**Mobile Control & Base**

8-button handheld remote done in sleek 1990's styling. Transmits RF signal up to 100 ft. to plug-in base transceiver. Off-white color. HCC-2553 **ONLY \$37.99**



**Lamp Module**

Plug-in lamp module controls incandescent lights up to 500 Watt max. Off-white color. Only 672 modules reserved for this promo, so order soon! Limit 16. HCC-2474 **ONLY \$8.99**



**3-Prong Appliance Module**

Plug-in appliance module rated 15A resistive, 500W lamps, 1/3HP motors. Off-white. 672 reserved. Limit 16. HCC-2550 **ONLY \$9.99**

**Motion Detector with Floods**



Detects motion, turns on floodlights, and sends up to four X10 on signals to modules located inside or outside the house. OFF delay (10 sec. to 35 min.), dusk/dawn and sensitivity adjustments. Detects 40 ft. at 110° arc. Weatherproof. Bulbs not included, 450 units reserved for promo. Limit 8 HCC-2651 **ONLY \$39.99**

**Power Timer / Radio**

Programmable timer can schedule 4 lights and appliances up to twice a day. Manual control of 8 devices. Security feature for random on/off times. Delay feature turns off selected device at a later time... great for late night TV viewing! AM/FM clock radio with alarm and snooze feature. Illuminated ALL LIGHTS ON button. Attractive simulated woodgrain design. Battery backup. 180 units reserved for promo. Limit 6. HCC-2649 **ONLY \$34.95**

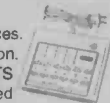


**HOME CONTROL CONCEPTS**

**STANLEY LightMaker**  
 X-10 Compatible Home Controls

**Home Control**

Turns on/off up to 8 lights and appliances. Has illuminated ALL LIGHTS ON button. Also has DIM/BRIGHTEN and ALL UNITS OFF buttons. Off-white color. 261 reserved for promo. Limit 12. HCC-2551 **ONLY \$8.99**



**Premier Home Control**



Same features as Home Control (above); controls 16 devices. Handsome simulated woodgrain design with smoked flip-up keyboard dust cover. HCC-2549. **ONLY \$16.49**

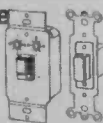
**Motion Detector & Base**

Indoor/outdoor wireless motion detector mounts virtually anywhere. Transmits ON signal to base transceiver up to 66 ft. away. Operates 24 hrs. or only after dusk. Sensitivity adjustment and variable OFF delay. Detects 40 ft. at 110° arc. HCC-2653 **ONLY \$44.95**



**Wall Switch Module**

Replaces existing wall switch. Controls incandescent lights up to 500 Watt max. Ivory color button. Only 672 modules reserved for this promo, so order now! Limit 12. HCC-2475 **ONLY \$9.99**



**3-Way Wall Switch Set**

Replaces existing switches controlling incandescent light from 2 locations. Ivory color buttons. HCC-2476 **ONLY \$12.99**

Same features as Power Timer/Radio (above left) without AM/FM radio. Limit 8. HCC-2552 **ONLY \$24.95**



**Free Home Automation Coffee Mug**

Get this exclusive gift with every order! This mug is great for drinking freshly brewed coffee from your module-controlled coffee maker.

**Guaranteed Lowest Prices**

Our incredible sales volume allows us to offer you the lowest prices... guaranteed! We can beat anyone's price! Call for details.

**Order Requirements**

\$100 minimum per order. We accept Mastercard, Visa, Discover, check & MO. Overseas orders payable in US funds. Call for warranty & return info.

**Immediate Shipment**

Most orders are shipped same day. Federal Express or UPS overnight air or second day air available upon request at additional charge.

**TOLL-FREE ORDER LINE (ORDERS ONLY)**

**INFO, PRICING & CUSTOMER SERVICE**



**1-800-CONTROL**



**1-619-693-8887**



**Wireless RF Link**

Manufactured by Linear, this low cost RF link is ideal for wireless control of your own projects, your home & car alarm, and even X10 modules (with addition of HCC-2841) Set security code on transmitter & receiver, apply power to receiver, & you're ready for wireless control! 100' range.

**TRANSMITTER:** Tiny keychain transmitter is approx. half the height of a matchbox! Transmitter has two buttons corresponding to channels 1 and 2. Includes two Lithium batteries.

**RECEIVER:** Board level receiver measures approx 3" square! Requires power supply of 8 to 24 VDC or 12 to 18 VAC. Two outputs (channels 1 and 2) can each switch up to 300 mA @ 18 VDC maximum to ground. Directly activate relays, drive bulbs, more.

HCC-RF1 Set includes transmitter, receiver, and complete documentation. **ONLY \$39!**  
 HCC-284 X-10 Powerflash interface **ONLY \$19!**

**New! Leviton 6381-U**

X-10 compatible. Switch controls motor speed (e.g. ceiling fan) and dims low voltage lighting! Rated 500W incandescent; motors & transformers 2/3 HP or 500VA. White or ivory. HCC-6381U **ONLY \$48.64**  
 HCC-6291 Switch for fluorescents & appliances **\$48.98**

**Enerlogic ES-1400e**

Intelligent X10 scheduler with 2-way interface. Monitors powerline and allows IF-THEN control. PC may be shut off once system is programmed. Use with HCC-2653 Stanley motion detectors! Powerful New Model. **ONLY \$359**  
 New Software. HCC-1400

**X-10 Development Kit**

Use to develop your own PC-based "smart" home automation system! Monitor status of home's lights & appliances and make intelligent decisions based on their on/off status. Develop a home control system with IF-THEN logic, even 1-button macros! Add Stanley motion detectors to give system input of room presence. Development software is interrupt based and includes compiled library routines & sample C-language source code.

Use with PC to Infrared Interface to develop a system which combines home automation and IR control; any X-10 controller can control infrared! Add Voice Master Key, for voice control of the home! Use X-10's Sundowner to give dusk/dawn input to your system. Add PC voice mail for X-10 control of your home from any phone in the world! Requires IBM or compatible computer with parallel port. Includes TW523 module, adapter, interface cable, development software, demo program & technical info/data. HCC-523K **ONLY \$69!**

**Thermostat Setback**

X-10 energy saver! Pays for itself! Works with your existing thermostat! Installs quickly and easily. Use in summer and winter! Below dealer cost! HCC-2807 **ONLY \$9.99**

**We have GE Homeminders!**

We believe we have the last 200 units in the universe! Originally sold for over \$500! X10 compatible; schedule your home on your TV! Pictorial display of rooms & devices (coffee maker in kitchen, etc.) with on/off status. Remote phone interface, memo pad, security mode, message system, password protection, more. Complete with infrared remote control, cables, & warranty. Limited supply & going fast! **ONLY \$149**  
 so order now! HCC-GE1  
 HCC-GE2 With 2 Modules \$159

**Motion Switch**

Heath Zenith switch senses motion & turns on light. Adjustable delay shut off. Great for hallways, basements, garages, laundry rooms, bathrooms, more. Photocell adjusts for night-only operation. HCC-6105 **ONLY \$14.95**

**PC to IR Interface Kit**

This kit is great for development of your own infrared home control system! Allows your PC to "push buttons" on remote control! Combine PC based home automation with infrared control of your TV (volume, channel, etc), stereo, VCR, and more! Add whole-house IR repeater such as X-10's Powermid. Use with Covox Voice Master Key for voice control of your entertainment system! Combine with X-10 Development Kit to allow any X-10 controller to control your infrared devices! Use with voice mail system for remote control of IR from any telephone in the world! Possibilities are limitless!

Remote control links to PC's serial port. Use the SendIR program to transmit infrared signals (e.g. The dos command SendIR TV MUTE will mute the tv). Write your software around SendIR or develop from scratch using sample source code. Complete with interface, cable, development software, sample C-language source code, technical info/data and documentation. Requires remote control (One-For-All or 1-Control) and IBM or compatible computer with serial port. HCC-PCIR **ONLY \$69!**

**One-For-All Universal Remote**

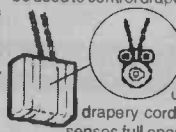
Replaces 12 remotes! TV, cable, VCR, Hi-Fi, satellite converter, more! Macros, sleep timers, more. X10 compatible when used with HCC-3000. Lowest price ever! **ONLY \$79.95**  
 HCC-RC5  
 HCC-3000 IR Command Center \$29.95!

**Automation Book**

New Edition! "How to Automate Your Home" by David Gaddis. Excellent! Reviews in Popular Science, Radio Electronics, Circuit Cellar INK, & Electronic House. 150 pages and over 125 illustrations. Reg. \$29.95 **ONLY \$26.95**

**Drapery Controller**

This X-10 compatible quiet motor can be used to control draperies and vertical blinds. Installs in minutes. Mounts on the wall and takes up the loop of the drapery cord. Automatically senses full open/full close. Can be stopped at any point in open/close cycle. Motor has two AC cords; one powers motor's "brains," the other plugs into an X-10 module or receptacle for control. Provides convenience, energy savings & security. Pre-schedule open/close times and/or use with an X-10 Sundowner. In summer have drapes close following the sun to keep home cool. In winter have drapes open following the sun to warm house. When away, open/close to give home "lived-in" appearance. Remotely close drapes while watching TV to reduce glare. Schedule a midnight "sweep" command to shut off all appliances, lights, & close all drapes. Stick for custom installer demos, or end-user home automation "showing off!" Manufactured for Kirsch, the famous name in draperies & blinds. Over 40% off retail! **ONLY \$269**  
 HCC-DRP1



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May 1992, Radio-Electronics

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## LIGHT EMITTING DIODES

	color / description	cat#	100	1000
<b>STANDARD JUMBO</b> T 1 3/4 (5 mm)	RED / diffused	LED-1	10 for \$1.50	.13 .11
	GREEN / diffused	LED-2	10 for \$2.00	.17 .15
	YELLOW / diffused	LED-3	10 for \$2.00	.17 .15
	YELLOW point source	LED-3P	10 for \$1.20	.10 .07
	CLEAR / lights RED point source stubby	LED-7	10 for \$1.00	.08 .07
<b>FLASHERS</b> Built in flashing unit. T 1 3/4 (5 mm)	RED / diffused	LED-4	\$1.00 each	.90 .80
	GREEN / diffused	LED-4G	\$1.00 each	.90 .80
	YELLOW / diffused	LED-4Y	\$1.00 each	.90 .80
<b>JUMBO LED HOLDER</b> Fits all T 1 3/4 (5 mm) LED's	BLACK	HLED	10 for 65¢	.05 .045
<b>MINIATURE</b> T - 1 SIZE (3 mm)	RED / diffused	MLED-1	10 for \$1.50	.13 .11
	GREEN / diffused	MLED-2	10 for \$2.00	.17 .15
	YELLOW / diffused	MLED-3	10 for \$2.00	.17 .15
<b>SUB-MINIATURE</b> axial (.079" X .098)	RED / diffused	LED-5	10 for \$1.50	.13 .11
	GREEN / diffused	LED-5G	10 for \$1.50	.13 .11
	YELLOW / diffused	LED-5Y	10 for \$1.50	.13 .11
<b>RECTANGULAR</b> 3.18 X 5.58 X 6.73" high	RED / diffused	RLED-1	5 for \$1.00	.18 .15
	GREEN / diffused	RLED-2	5 for \$1.50	.27 .24
	YELLOW / diffused	RLED-3	5 for \$1.50	.27 .24

## CABLE TIES

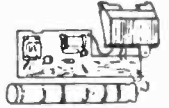
CAT#	APPROX. LENGTH	MIN. TENSIL STRENGTH	COLOR	MAX. BUNDLE DIA.	10	100	1000
TR-400	4"	18 lbs	neutral	15/16"	.30	\$2.50	\$15.00
TR-400B	4"	18 lbs	black	15/16"	.35	\$3.00	\$17.50
TR-600	6"	30 lbs	neutral	1 1/2"	.50	\$4.00	\$30.00
TR-600B	6"	30 lbs	black	1 1/2"	.50	\$4.00	\$30.00
TR-800	8"	50 lbs	neutral	1 3/4"	.60	\$5.00	\$40.00
TR-800B	8"	50 lbs	black	1 3/4"	.70	\$6.00	\$50.00
TR-1100	11"	50 lbs	neutral	3"	.70	\$6.00	\$50.00
TR-1100B	11"	50 lbs	black	3"	.80	\$7.00	\$60.00
TR-1500	15"	50 lbs	neutral	4"	\$1.00	\$8.00	\$70.00
Heavy-duty 15" cable tie.							
TR-1500HD	15"	120 lbs	neutral	4 1/4"	\$1.50	\$12.00	\$100.00

## RECHARGEABLE BATTERIES (nickel-cadmium)

SIZE	VOLT	AMPERAGE	CAT#	1 - 9	10 +
AAA	1.20	180 mAh	NCB-AAA	\$1.50	\$13.50
AA	1.20	500 mAh	NCB-AA	\$2.00	\$18.50
AA w/ Solder Tabs	1.20	500 mAh	NCB-SAA	\$2.20	\$20.00
Sub C w/ Solder Tabs	1.20	1200 mAh	NCB-SC	\$4.25	\$40.00
C	1.20	1200 mAh	NCB-C	\$4.25	\$40.00
C Heavy Duty	1.25	1800 mAh	HDNCB-C	\$5.25	\$42.50
D	1.20	1200 mAh	NCB-D	\$4.50	\$42.50
D Heavy Duty	1.25	4000 mAh	HDNCB-D	\$7.00	\$65.00

## FLASH UNIT

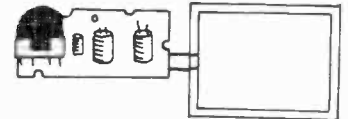
New compact flash assembly from a U.S. manufacturer of cameras. Operates on 3 Vdc and measures 2 1/2" x 1 1/4". Ideal for use as a strobe, warning light or attention getter. Includes hook-up diagram. **CAT# FSH-1**



10 for \$35.00  
100 for \$325.00

**\$375 each**

## Electroluminescent BACKLIGHTS



At last! A low cost electroluminescent glow strip and inverter. These brand-new units were designed to backlight small LCD TVs made by the Citizen Watch company. The inverter circuit changes 3 or 6 Vdc to approximately 100 Vac, the voltage required to light the glowstrip. Luminescent surface area is 1.7" X 2.25". The strip is a salmon color in its off state, and glows white when energized. The circuit board is 2.2" X 1". Glow strip and circuitry can be removed easily from plastic housing. Ideal for special lighting effects and backlighting. Two models available:

Citizen# 91TA operates on 3 Vdc  
**CAT# BLU-91**

Citizen# 92TA operates on 3-6 Vdc  
**CAT# BLU-92**

**\$350 each**

**LARGE QUANTITY AVAILABLE**

10 for \$32.00 • 100 for \$275.00

## 200 ASSORTED PARTS



Strips of assorted parts. Each strip contains an assortment of resistors, capacitors and diodes. Each strip contains at least 200 parts.

**CAT# GRABTR \$2.00 per assortment**

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# ITEMS of SPECIAL INTEREST

## THIRD TAIL LIGHT OR SPECIAL EFFECTS LIGHT

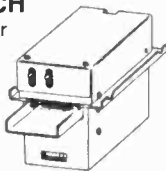
Sleek, high-tech lamp assembly. Could be used as a third auto tail light, emergency warning light, or special effect lamp. Red reflective lens is 2 3/4" X 5 1/2" mounted on a 4" high pedestal with up-down swivel adjustment. Includes 12 volt replaceable bulb.



**CAT# TLB-S** \$3.00 each • 10 for \$25.00

## DOLLAR BILL SWITCH

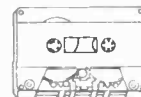
We sold out of these popular dollar bill switches last year, but now they're back! Insert bill into chute. Magnetic head and infrared sensors analyze bill for authenticity and position, if anything is wrong it kicks the bill back. If good, bill passes through the chute and a 5 volt current is switched. Will pass any size U.S. bill. It cannot differentiate between \$1, \$5, \$10 etc. Operates on 12vdc. Solid metal housing 5.32" x 4.1" x 5.21" high. Chrome dollar chute extends 1.34" in front. Removed from new equipment. Guaranteed.



**CAT# DS-2** \$25.00 each

## HIGHEST QUALITY METAL CASSETTES (Erased)

Premium quality metal tape in C-60 cassettes (30 or more per side). One of the finest "brand-name" tapes on the market, in durable, clear plastic transport mechanisms. Recorded and bulk erased, the record-protect tabs have been removed and therefore, need to be taped over to re-record. Audiophiles will appreciate the wide dynamic range of this tape. If your cassette deck has a "metal" setting you will hear the difference. A real bargain!



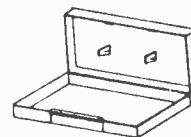
**CAT# C-600M**

10 for \$10.00

**\$1.25 each**

## CASSETTE STORAGE CASE

Black, unbreakable plastic audio cassette storage case.

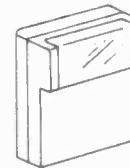


**CAT# CBOX** 5 for \$1.00 • 100 for \$15.00

## WIRELESS REMOTE CONTROL For Nintendo™ Video System

CAMERICA "Freedom Connection"™

Turns your wired Nintendo™ control paddle into a remote control unit. Infrared remote like those used on TV's and VCR's eliminates messy wires. Allows players more mobility. Two



players can use one remote unit except on games where they play simultaneously. In those games two "Freedom Connections" units are required. A well-known national discount toy chain sells these for more than twice our price. Operates on 4 AAA batteries (not included).

**CAT# IR-1**

**\$9.95 each**

Set of 4 AAA batteries **CAT# BAT-4AAA** \$2.40 / set

## D.C. Wall Transformers (all are 120Vac)



Style A



Style B



Style C

VOLTS	AMPS	PLUG STYLE	CENTER	CAT#	PRICE	STYLE
4 Vdc	70 ma.	2.5mm co-ax	negative	DCTX-470	\$2.00	C
6 Vdc	200 ma.	2.1mm co-ax	positive	DCTX-620	\$2.25	C
6 Vdc	200 ma.	1.3 mm co-ax	negative	DCTX-621	\$2.25	C
6 Vdc	300 ma.	2.1 mm co-ax	positive	DCTX-632	\$2.75	C
7.5 Vdc	400 ma.	1.3 mm co-ax	negative	DCTX-754	\$3.25	C
9 Vdc	10 ma.	battery snap		DCTX-8310	\$1.50	C
9 Vdc	200 ma.	2.1mm co-ax	positive	DCTX-920	\$2.75	C
9 Vdc	300 ma.	2.1mm co-ax	negative	DCTX-930	\$3.00	C
9 Vdc	300 ma.	2.1 mm co-ax	positive	DCTX-932	\$3.00	C
9 Vdc	300 ma.	2.5mm co-ax	negative	DCTX-931	\$3.00	C
9 Vdc	500 ma.	2.5mm co-ax	positive	DCTX-950	\$3.50	C
9 Vdc	1 Amp	2.1 mm co-ax	negative	DCTX-910	\$5.00	C
10 Vdc	500 ma.	2.5mm co-ax	positive	DCTX-1050	\$3.50	C
12 Vdc	100 ma.	2.1mm co-ax	negative	DCTX-1210	\$2.50	C
12 Vdc	200 ma.	2.1mm co-ax	negative	DCTX-122	\$3.00	C
12 Vdc	200 ma.	2.1mm co-ax	positive	DCTX-1220	\$3.00	C
12 Vdc	300 ma.	2.5 mm co-ax	positive	DCTX-123	\$3.50	C
12 Vdc	500 ma	2.1mm co-ax	negative	DCTX-125	\$4.50	C
12 Vdc	1 Amp	none		DCTX-121	\$6.50	A
14 Vdc	700 ma.	1.3mm co-ax	negative	DCTX-1470	\$5.25	C
15 Vdc	400 ma.	2.5mm co-ax	positive	DCTX-1540	\$4.50	A
17 Vdc	210 ma	none		DCTX-1721	\$3.75	C

## MAGNETS

### FLEXIBLE SELF-ADHESIVE MAGNET STRIP



Flexible barium ferrite magnet strip with adhesive back. Peel off backing to expose adhesive. 8.1" long X 0.5" wide X 0.125" thick.

Can easily be cut into smaller pieces.  
**CAT# MAG-8** \$1.00 per 8.1" strip  
10 for \$8.50 • 100 for \$75.00



### POWERFUL MAGNET

Powerful neodymium rare-earth magnet. Originally for use in permanent magnet d.c. motors. Irregular in shape. Approximate dimension: 1 1/4" x 3/4" x 1/2" thick.

**WARNING - Don't put your hand between magnet and metal objects.**

**CAT# MAG-2** \$7.50 each

### MINI MAGNETS



Small, powerful-for-their-size magnets. Rectangular - 0.48" X 0.25" X 0.08".

**CAT# MAG-4** 3 for \$1.00

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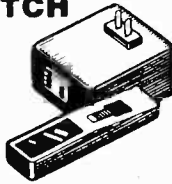
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# HOSFELT ELECTRONICS, INC.

## INFRARED WIRELESS REMOTE SWITCH

Mfg - Polenex



This two piece device (transmitter/receiver) lets you turn on/off lamps, appliances or other 120 VAC units (15 amp max), using 2 prong non-polarized plugs. The hand held control requires a 9V battery (not included). Operates in line of sight up to 25 ft. away.

No. 25-131 **\$8.95**

## SURFACE MOUNT LED CHIP

.115" x .055" x .05" Thick  
Lens Dia - 1mm (.04")  
Off - Clear / Lit - Green  
Has gold plated mounting surfaces for super conductivity.



No. 25-130 **pk of 10/\$1.00**

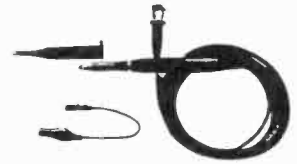
## SELF-ADHESIVE RUBBER FEET

Round  
Color - Black  
1.19" Dia x .25" Tall



No. 85-108 **pk of 12/\$1.00**

## OSCILLOSCOPE PROBES



DC to 60 MHz, 1:1 switchable 10:1 max. input 600 Vp-p.

No. PP-80 **\$15.95**

DC to 100 MHz, 10:1. 9M ohm/14 pF, max. input 600 Vp-p.

No. PP-150 **\$29.95**

## 3 CONDUCTOR LINE CORD



6 ft. 7 in. - Black  
18 AWG/3 Cond - SJT  
O.D. - .315"

No. 60-171 **\$2.59**

## TWIN BIT



1-7/8" long x 1/4" dia  
#2 Phillips on one end  
#6 (1/4") slot on the other end

No. 54-107 **pk of 4/\$1.00**

## ROSIN CORE SOLDER



Meets Fed Spec QQ-S-571E  
.031 - 21 Gauge  
60% tin - 40% lead  
One Pound

No. 46-127 **\$6.95**

## 4 PIECE MICROPROBE SET



Set includes 4 couple ended probes about 6" long

No. MPS **\$5.00**

## CLEANING BRUSH



4" L x approx 1/4" Dia  
This tapered cleaning brush has nylon bristles. Comes in a pack of 3.

No. 80-213 **\$.29**

## 10 AMP SOLID STATE RELAY

Mfg - Douglas Randall  
Mfg # - JD10BNZ  
2-1/4" x 1-3/4" x 7/8"  
Control Voltage: 3-32 VDC  
Load: 10 amp @ 20-300 VRMS



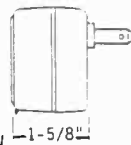
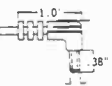
Non-zero crossing for lamp dimming or heater control applications.

No. 45-258 **\$9.95**

## 12 VDC @ 500 mA ADAPTER



coaxial plug



Mfg - Panasonic  
Mfg # - KX-A11  
2" x 2-3/8"

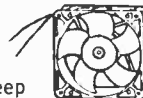
Input: 120 VAC @ 60 Hz 12 W  
Output: 12 VDC @ 500 mA

6 ft wire has a gray tracer. The center is negative for polarity. Right angle coaxial plug: OD - .215", ID - .077".

No. E-1760-W White **\$1.99**

## 12 VDC BRUSHLESS FAN

Mfg - Motor-One  
Mfg # - D06T12LWS  
Size: 2-3/8" Sq x 1" Deep  
12 VDC, 90mA, 1 watt  
12 CFM, 3500 RPM  
5 Blades  
Two 14" color coded leads



No. 26-167 **\$3.95**

## UNIVERSAL ADAPTER

POSITIVE POLARITY



D - 2"  
W - 1-7/8"  
H - 2-3/4"

Converts 110 VAC to 6, 7.5 and 9 VDC. Current is rated at 300 mA. Features a polarity reverse plug and 5 universal plugs on a 6 ft. tracer cord.

No. 56-166 **\$2.95**



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1 800 524 6464  
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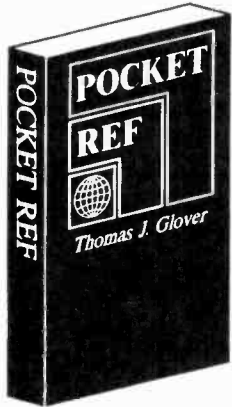
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## Grill Guides

Ball and socket type grill guides for attaching speaker grill to cabinet. To use, simply drill the appropriate size holes in cabinet and grill frame. Package of 12 pair.



#RD-260-367

\$1<sup>80</sup> Per Pkg

## Subwoofer Chokes

Super duty professional P.A. type chokes. Capable of handling 500 watts of continuous power. Air core construction reduces saturation potential. Made with a special "hard drawn" copper with high temperature, triple thick polypropylene-nylon coating. Each audiophile grade unit is specially wound and trimmed to 1% of the rated value.



Part #	Inductance	Crossover Point (Hz)		Price
		4 ohm	8 ohm	
#RD-260-754	2 mH	318	636	10.40
#RD-260-755	4 mH	159	318	13.95
#RD-260-756	6 mH	106	212	19.25
#RD-260-757	8 mH	80	160	23.20
#RD-260-758	10 mH	64	128	25.60

## Pyle 15" Poly Woofer

15" poly woofer with a 60 oz. magnet and 2" voice coil. Power handling: 100 watts RMS, 145 watts max.

VAS= 10.9 cu ft., QTS=.53, fs = 30 Hz. Frequency response: 20-3,000 Hz. SPL= 98 dB 1W/1M. Impedance: 4 ohm. Net weight: 9-1/2 lbs.

#RD-292-070

\$64<sup>80</sup> Each



## Pickering Headphones

We made a special buyout directly from the manufacturer on these super quality personal headphones. 1" dynamic high velocity element with strontium ferrite magnet. Adjustable headband with foam ear cushions. 5 ft. cord to 3.5 mm and 1/4" adaptor included.



#RD-249-100

\$2<sup>49</sup> Pair

## Honeycomb Tweeter

Unique tweeter with a square diaphragm of honeycomb material. Diaphragm is 1" square. Excellent dispersion. 13/16" voice coil.

Frequency response: 2,000-20,000 Hz. Impedance: 8 ohm. Power handling: 25 watts RMS, 40 watts maximum. 4" x 3-1/4". Limited availability. Net weight: 1 lb.

#RD-279-110

\$8<sup>70</sup> Each



## Onkyo Dome Tweeter



Original Onkyo 1" dome tweeter. Onkyo #TW-388A used in Onkyo's Monitor-5 speaker system. Aluminum voice coil former for heat dissipation. Soft textile dome. Power handling capability: 40 watts RMS, 60 watts maximum. Impedance: 4.5 ohms. Frequency response: 2,000-20,000 Hz. Dimensions: 4-3/4" (L) x 3-5/8" (H). Net weight: 1-1/2 lbs. Limited quantities.

#RD-279-100

\$12<sup>50</sup> Each

## Headphone Extension

Original Teac display packaged 25' coiled headphone extension. Limited availability.

#RD-240-051

\$2<sup>50</sup> Each



## 3" x 5" Speaker

Standard radio and TV speaker. 16 ohm impedance. 3 watts maximum power handling. Limited availability.

#RD-299-115

\$1<sup>95</sup> Each



## Large Input Terminal

Large input cup with push spring terminals and 4 lug terminal strip on rear. Flush mounted housing measures: 4" x 5-1/2" outside diameter. 4-5/8" x 3-1/16" mounting hole required. Limited availability.

#RD-269-220

95¢ Each



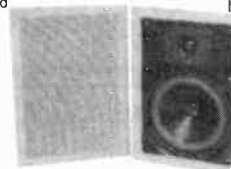
## 6-1/2" Two-Way In-Wall Speaker System

6-1/2" poly woofer with a 10 oz. magnet combined with a 1" soft dome tweeter. Integral 2-way crossover with pushbutton terminals. 8 ohm impedance. Frequency response: 40-20,000 Hz. 40 watts RMS, 80 watts maximum power handling capability. Sensitivity: 90 dB 1W/5M. Dimensions: 8-1/2" (W) x 12" (L) x 3-1/2" (D). Hole dimensions: 7-1/2" (W) x 11" (L). Net weight: 9 lbs. per pair.

#RD-300-036

List \$299<sup>95</sup>

\$99<sup>95</sup> Pair



## Philips Tweeters



These tweeters incorporate a 3/4" polycarbonate dome with a 1/2" high temp ferro fluid cooled voice coil. 15 watts RMS, 22 watts maximum power handling capability. 2 oz. magnet, 1,550 Hz. Frequency response: 5,000-20,000 Hz. 1-5/8" round and 2" square.

#RD-279-150 (Round)

\$6<sup>95</sup> Each

#RD-279-155 (Square)

## 5-1/4", 2-Way Pioneer

5-1/4" paper cone woofer with a 1" post mounted polymer tweeter. 4 ohm impedance. Response: 100-20,000 Hz. Power handling: 35 watts RMS, 50 watts maximum. 2-3/4" mounting depth. Limited availability.

#RD-269-065

\$12<sup>80</sup> Each



## Mini Super Tweeter

Super paper cone tweeter with silver mylar dust cap. Impedance: 8 ohm. Power handling capability: 2 watts RMS. 9-1/16" voice coil. 1-1/2" diameter cone with mounting tabs. Mounting holes: 1-7/8" on center. Limited availability.

#RD-279-120

95¢ Each



## Universal "L" Pad Housing

Universal "L" pad housing for high or midrange applications. Dimension: 2-1/2" square recessed knob.

#RD-260-263

50¢ Each

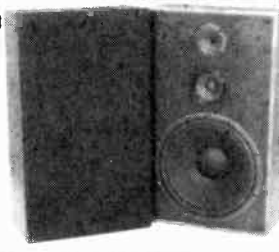


## 12", 3-Way Speaker System

3-way acoustic suspension loudspeaker system. Attractive simulated light oak veneer. System features a 12" woofer, 4" midrange, and a 3" cone type piezo tweeter. Removeable brown cloth grill. Excellent for use as a surround speaker system. Screw type input terminals. Capable of handling 30 watts RMS, 50 watts maximum. 24" (H) x 14" (W) x 7" (D). Sold in pairs. Limited availability.

#RD-310-060

\$79<sup>95</sup> Pair



## Pyle 10" Poly Woofer

Long throw poly woofer with poly foam surround for superb low bass. 2" voice coil, power handling: 85 watts RMS, 130 watts max. fs= 43 Hz. Frequency response: 25-3,000 Hz.

SPL= 95 dB 1W/1M. Impedance: 4 ohm. 40 oz. magnet. VAS=1.8 cu ft., QTS=.34, QMS=.10, QES=.35. Net weight: 8 lbs.

#RD-292-030

\$45<sup>80</sup> Each



## The Loudspeaker Design Cookbook IV

This book describes the "science" of loudspeaker design, however applying it is an "art". Using the information in this book will yield hundreds of possible variations in speaker design, with some subtle and not-so-subtle differences. 1991 copyright, fourth edition. Author: Vance Dickason. 154 pages paperback.

#RD-500-035

\$29<sup>95</sup> Each



## Ferro Fluid

Pro-Tech ferro fluid is commonly used on voice coils to improve frequency response, increase transient and continuous power handling capabilities and reduce second and third order harmonic distortion. It reduces the Q and lowers the impedance peak at resonance without a significant reduction in SPL. General purpose fluid for tweeters and midranges only. 5cc bottle.

#RD-340-435

\$9<sup>95</sup> Each



## Cabinet Carpet

High quality cabinet carpet with no backing so it easily conforms to sharp corners on custom car and stage cabinets. Easily cut and glued using spray adhesive or latex contact cement. Provides protection and good looks. 54" wide, and sold by the linear yard.

#RD-260-765 (Dark Charcoal)

#RD-260-767 (Med Gray)

#RD-260-768 (Jet Black)

\$3<sup>95</sup> (Per Linear Yard 36" x 54")



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### Power Cord

Super duty power cord. 14 ga., 3 conductor. 4 ft. length. Limited availability.



#RD-119-010 \$1<sup>50</sup> Each

### 12VDC, 800mA Adaptor

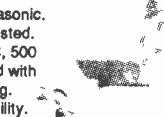
Fisher Price battery charger. 120VAC input. 12VDC, 9.6W (800mA) output. 6 ft. cord with special connector. Limited availability.



#RD-120-361 \$3<sup>50</sup> Each

### 12VDC, 500 mA Adaptor

Manufactured by Panasonic. Model #KX-A11. UL listed. 120VAC input, 12VDC, 500 mA output. 6 foot cord with 2.1mm DC coaxial plug. White. Limited availability.



#RD-120-360 \$2<sup>90</sup> Min

### Molykote 557 Lube

A wax-like silicon product in a chlorinated solvent. The solvent evaporates rapidly leaving a color-free, almost transparent lubricating film. Solvent may affect certain plastics. Made in the U.S.A. by Dow Corning. 13.6 oz. aerosol can. Limited availability.



#RD-340-420 \$1<sup>50</sup> Each

### Replacement Antenna

Hinged 7 section antenna. 19" extended, 5-1/4" collapsed. 3/16" threaded base. Excellent antenna for portable radios, TVs, and more.

#RD-210-200 50<sup>¢</sup> Each

### 30 Watt Iron

Economical 30 watt iron with replaceable tip. Blue plastic handle. 120VAC. A quality iron at a reasonable price. Display packaged.



#RD-370-010 \$4<sup>90</sup> Each

### Soldering Stand

Convenient weighted soldering iron stand with cleaning sponge. Display boxed.



#RD-370-020 \$4<sup>95</sup> Each

### Kester Pocket Pack

Perfect tool box solder supply. The wire feeds conveniently from the handy dispenser tube. Pocket clip attached. .031" diameter solder. .5 ounce (approximately 15 feet).

#RD-370-050 \$1<sup>00</sup> Each

### Isotip Butane Soldering Iron

The ideal soldering iron for field repairs where no AC power is present. Operates for up to 100 minutes of continuous soldering per refill. Uses standard butane (not included) available at most stores. Tip temperature is adjustable up to 1067° F. Iron also comes with a torch attachment which easily screws on in place of the soldering tip. As a torch, one refill will provide up to 1 hour of continuous flame. Temperature is adjustable up to 2372° F. A protective cap with a built-in striker is included. Limited one year warranty.



#RD-370-235 \$24<sup>95</sup> Each

### Test Clip

72" shielded cable. 3.5mm mono to two clip leads. Limited availability.



#RD-240-200 50<sup>¢</sup> Each

### Monitor Power Jack

Standard computer type monitor jack. Limited quantity.



#RD-090-446 50<sup>¢</sup> Each

### Spray Handle

Fits most paint and cleaner cans. Limited availability.



#RD-340-371 75<sup>¢</sup> Each

### Green Rectangular LED

.2" x .075". Green rectangular LED.



#RD-070-040 15<sup>¢</sup> Min 10

### Chassis Mount RCA Jack

#RD-090-281 19<sup>¢</sup> Min 10



### F-59 Connector

Popular connector for cable TV systems. Full ferrule for hex crimp. Securely holds RG-59 cable.



#RD-090-355 22<sup>¢</sup> Each

### Matching Transformer

Adapts 75 ohm coax to 300 ohm twin lead (or visa-versa) at antenna or television. 5-90 MHz UHF/VHF. 3 capacitor PC board type.

#RD-180-010 49<sup>¢</sup> Each



### TNC Male Crimp-On

(For RG-59 and RG-62)



#RD-090-1000 75<sup>¢</sup> Each

### Panasonic Type Antenna

Very popular dual antenna. Replaces many name brand sets manufactured by Matsushita. Five section dual, 38 extended with 20" twin lead hook up wire.

#RD-210-050 \$1<sup>95</sup> Each

### Alligator Clip

Heavy duty alligator clip. Manufactured by Mueller, part #27.



#RD-090-872 19<sup>¢</sup> Each

### Outdoor Phone Jack

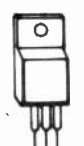
Heavy duty, diecast aluminum housing withstands the harsh conditions associated with outdoor use. Form gasket under snap shut lid prevents water leakage. Complete with mounting screws. Limited availability.



#RD-150-030 \$2<sup>95</sup> Each

### TA78005

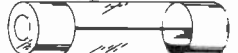
Popular TO-220 5 volt positive voltage regulator. Current handling: 1 amp. Manufactured by Toshiba. Replaces LM340T-5, MC7805, ECG 960, and 7805. Limited availability.



#RD-TA78005 50<sup>¢</sup> Each

### AGC Fuses

Limited availability.



#RD-070-421 (.5A)  
#RD-070-423 (.75A)  
#RD-070-429 (2.5A) \$3<sup>95</sup> Per 100

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Add 6 feet to your mini headphones. Gives the user added mobility when listening to personal cassette players.



#RD-240-090 95<sup>¢</sup> Each

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Converts any Nintendo compatible joystick into a wireless infrared joystick. Simply plug joysticks into the infrared transmitter and plug the infrared receiver into your Nintendo control deck. You now have a cordless joystick with a range of up to 18 ft. with no noticeable degradation of playing speed.

#RD-130-357 \$6<sup>95</sup> Each

### 8 Position Dip Switch

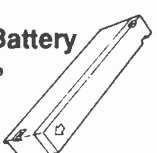
Switch type (IE: rocker, slide, toggle) may vary, call.



#RD-060-134 60<sup>¢</sup> Each

### 12V, 2.3Ah Camcorder Battery

Popular battery for use with Canon, Chinon, Curtis Mathes, G.E., Magnavox, Minolta, Olympus, Panasonic, J.C. Penny, Pentax, Philco, Quasar, Sears, Sylvania, Teknika and other miscellaneous manufacturers. Dimensions: 7.17" (L) x .94" (W) x 2.42" (H).



#RD-140-541 \$39<sup>95</sup> Each

### 8-Way Splitter

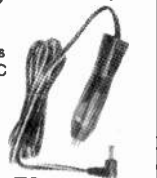
Zinc diecast indoor/outdoor splitter. "F" type input and outputs. 5-900 MHz UHF/VHF. 20 dB (min.) port to port isolation.



#RD-180-055 \$2<sup>95</sup> Each

### Cigarette Lighter Cord

Popular power cord used on radar detectors, portable TVs and many other 12VDC powered units. Heavy SPT-1 cord (18 ga.). 2.5mm DC coaxial plug. 4-1/2 ft. length. Limited availability.



#RD-090-918 70<sup>¢</sup> Each

### 3.5 Amp DC Power Supply

A quality, compact 12VDC power supply. Perfect for testing car stereos, CB equipment, radar detectors and other 12VDC items. Regulated 13.8VDC, 3.5 amp continuous, 6 amp surge. LED power indicator. Binding post outputs. Net weight: 4 lbs.



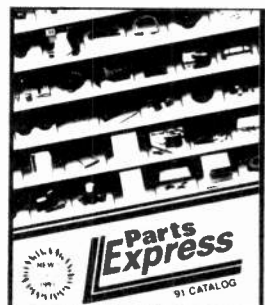
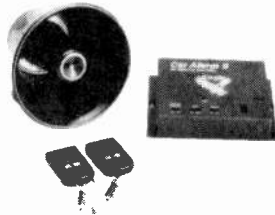
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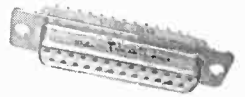
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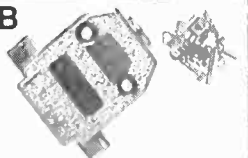
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9	Male	240-1101F	45c	30c
15	Male	240-1093F	65c	45c
25	Male	240-1311F	65c	50c
25	Female	244-1206F	65c	50c
37	Male	240-1096F	85c	65c
37	Female	244-7300F	85c	65c
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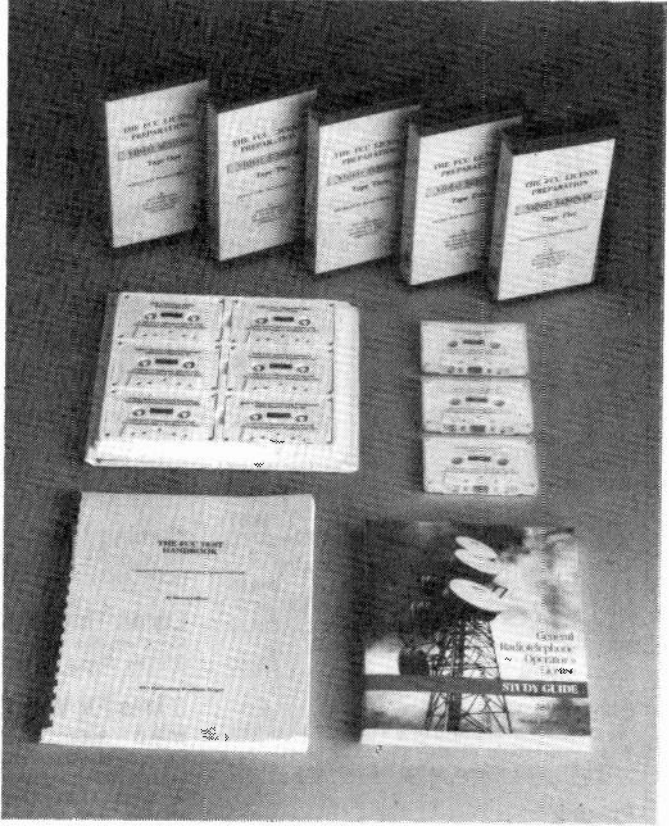
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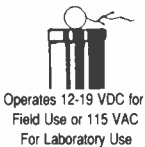
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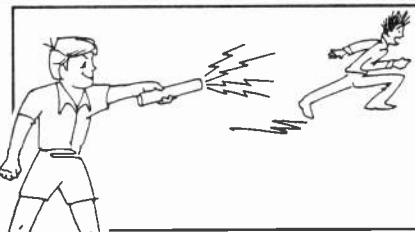
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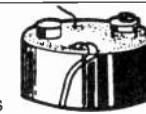
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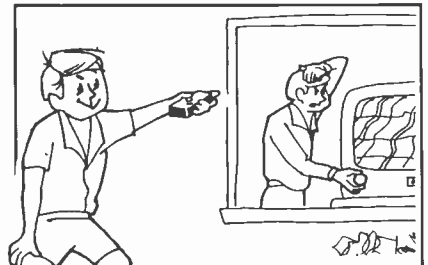
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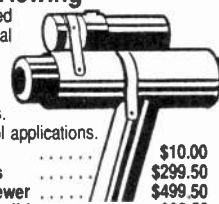
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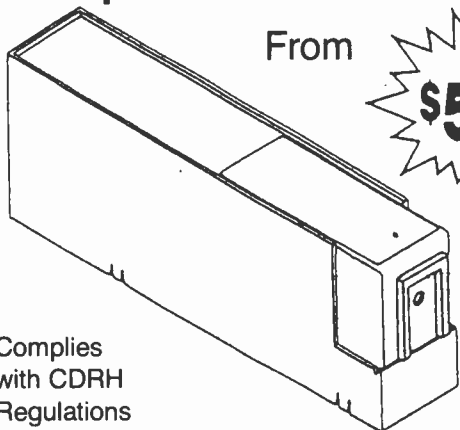
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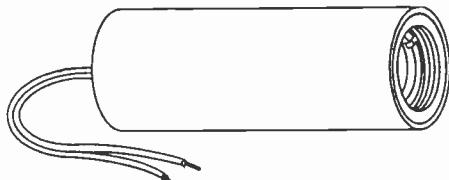
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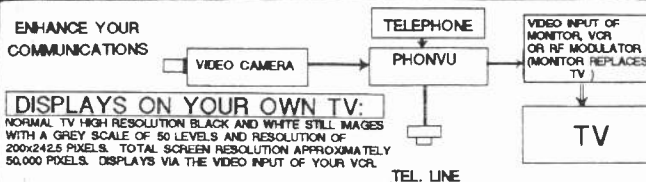
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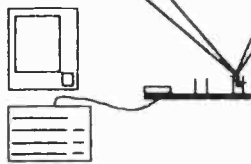
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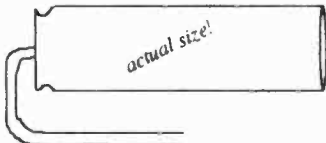
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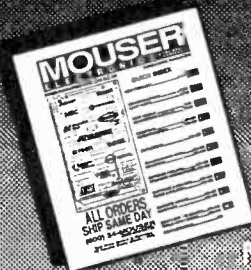
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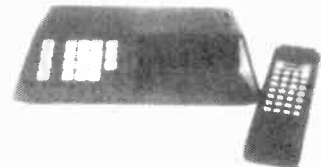
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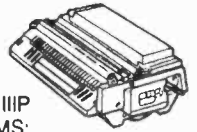
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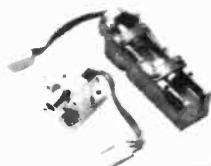
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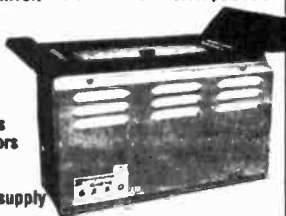
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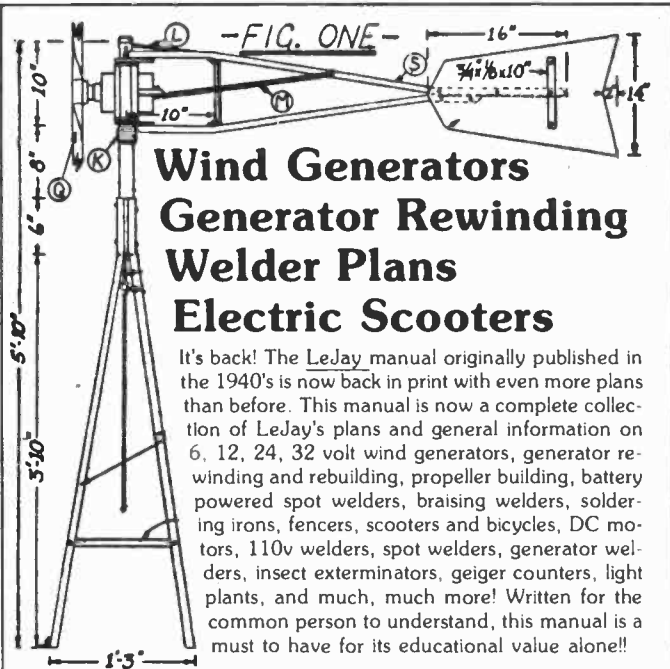
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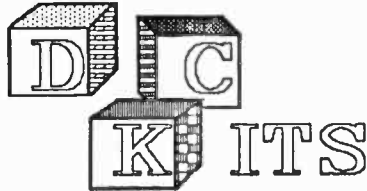
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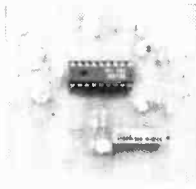
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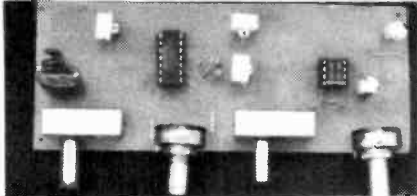
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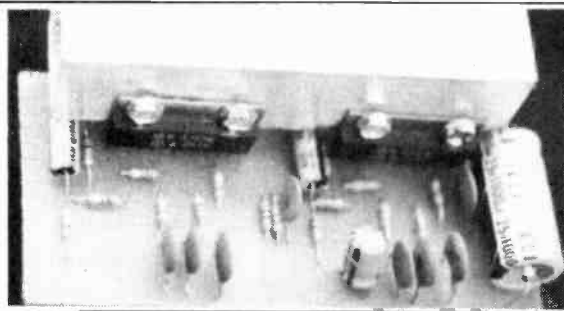
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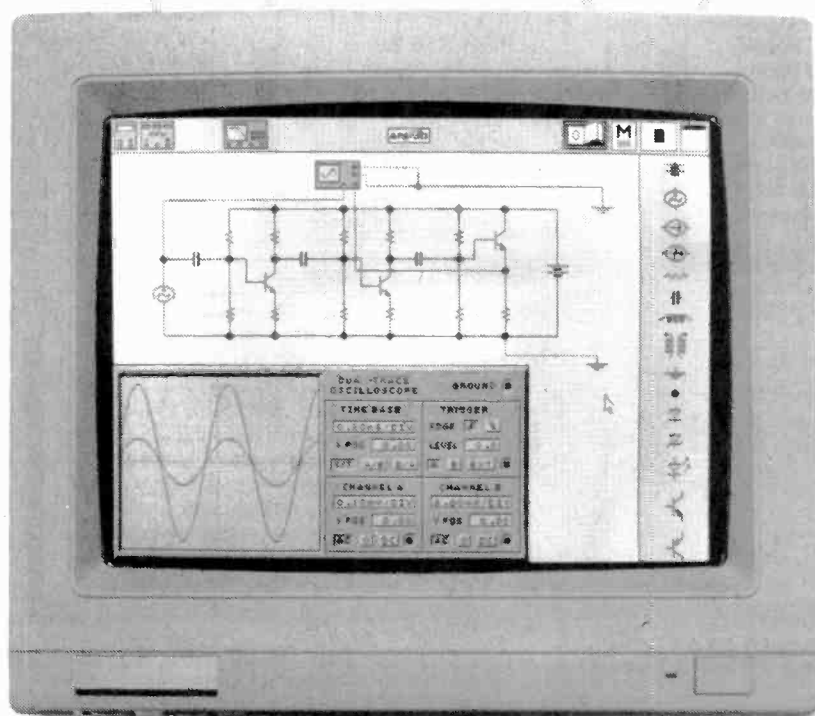
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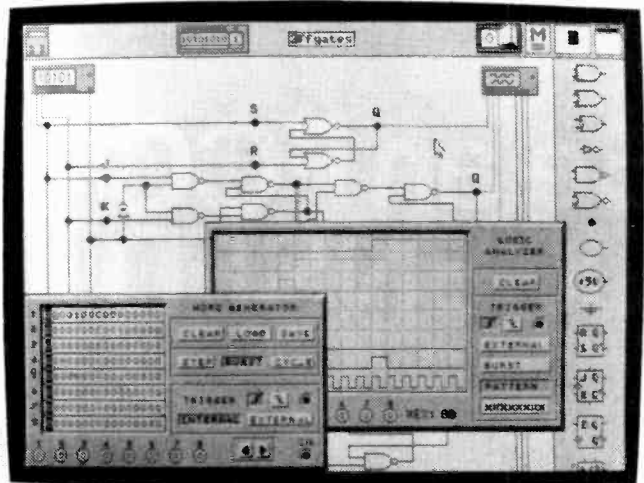
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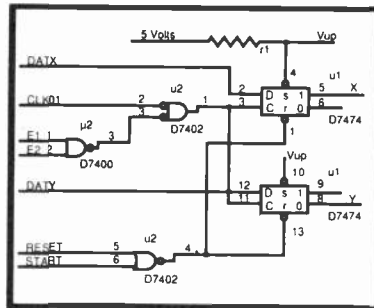
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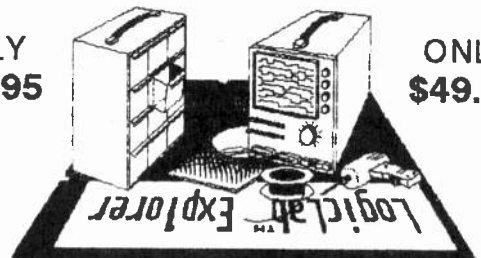


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7441	2.95	74289	2.95	74HC414	92	4110	34	LM393	99	CA3163	2.19	7865	1.50	82633	3.50	27C256-1548	25	NEC0258	1.00
7442	2.95	74290	2.95	74HC415	92	4111	34	LM393	99	CA3163	2.19	7866	1.50	82634	3.50	27C256-1549	25	NEC0259	1.00
7443	2.95	74291	2.95	74HC416	92	4112	34	LM393	99	CA3163	2.19	7867	1.50	82635	3.50	27C256-1550	25	NEC0260	1.00
7444	2.95	74292	2.95	74HC417	92	4113	34	LM393	99	CA3163	2.19	7868	1.50	82636	3.50	27C256-1551	25	NEC0261	1.00
7445	2.95	74293	2.95	74HC418	92	4114	34	LM393	99	CA3163	2.19	7869	1.50	82637	3.50	27C256-1552	25	NEC0262	1.00
7446	2.95	74294	2.95	74HC419	92	4115	34	LM393	99	CA3163	2.19	7870	1.50	82638	3.50	27C256-1553	25	NEC0263	1.00
7447	2.95	74295	2.95	74HC420	92	4116	34	LM393	99	CA3163	2.19	7871	1.50	82639	3.50	27C256-1554	25	NEC0264	1.00
7448	2.95	74296	2.95	74HC421	92	4117	34	LM393	99	CA3163	2.19	7872	1.50	82640	3.50	27C256-1555	25	NEC0265	1.00
7449	2.95	74297	2.95	74HC422	92	4118	34	LM393	99	CA3163	2.19	7873	1.50	82641	3.50	27C256-1556	25	NEC0266	1.00
7450	2.95	74298	2.95	74HC423	92	4119	34	LM393	99	CA3163	2.19	7874	1.50	82642	3.50	27C256-1557	25	NEC0267	1.00
7451	2.95	74299	2.95	74HC424	92	4120	34	LM393	99	CA3163	2.19	7875	1.50	82643	3.50	27C256-1558	25	NEC0268	1.00
7452	2.95	74300	2.95	74HC425	92	4121	34	LM393	99	CA3163	2.19	7876	1.50	82644	3.50	27C256-1559	25	NEC0269	1.00
7453	2.95	74301	2.95	74HC426	92	4122	34	LM393	99	CA3163	2.19	7877	1.50	82645	3.50	27C256-1560	25	NEC0270	1.00
7454	2.95	74302	2.95	74HC427	92	4123	34	LM393	99	CA3163	2.19	7878	1.50	82646	3.50	27C256-1561	25	NEC0271	1.00
7455	2.95	74303	2.95	74HC428	92	4124	34	LM393	99	CA3163	2.19	7879	1.50	82647	3.50	27C256-1562	25	NEC0272	1.00
7456	2.95	74304	2.95	74HC429	92	4125	34	LM393	99	CA3163	2.19	7880	1.50	82648	3.50	27C256-1563	25	NEC0273	1.00
7457	2.95	74305	2.95	74HC430	92	4126	34	LM393	99	CA3163	2.19	7881	1.50	82649	3.50	27C256-1564	25	NEC0274	1.00
7458	2.95	74306	2.95	74HC431	92	4127	34	LM393	99	CA3163	2.19	7882	1.50	82650	3.50	27C256-1565	25	NEC0275	1.00
7459	2.95	74307	2.95	74HC432	92	4128	34	LM393	99	CA3163	2.19	7883	1.50	82651	3.50	27C256-1566	25	NEC0276	1.00
7460	2.95	74308	2.95	74HC433	92	4129	34	LM393	99	CA3163	2.19	7884	1.50	82652	3.50	27C256-1567	25	NEC0277	1.00
7461	2.95	74309	2.95	74HC434	92	4130	34	LM393	99	CA3163	2.19	7885	1.50	82653	3.50	27C256-1568	25	NEC0278	1.00
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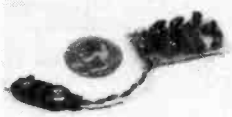
The XTR100 Tracking Transmitter transmits a continuously beeping tone that can be received by any FM receiver. Can be used for games, contests, or as an anti-theft device.

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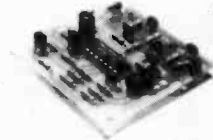
The XFM100 FM transmitter has a range of up to 1 mile. It works with any standard FM receiver. It contains a built-in high gain two stage audio amplifier for maximum sensitivity.

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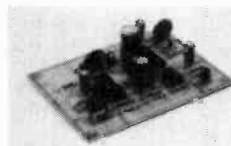
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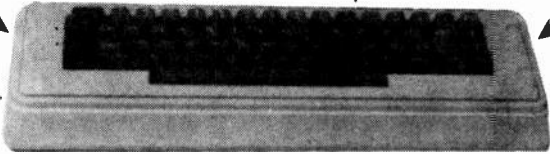
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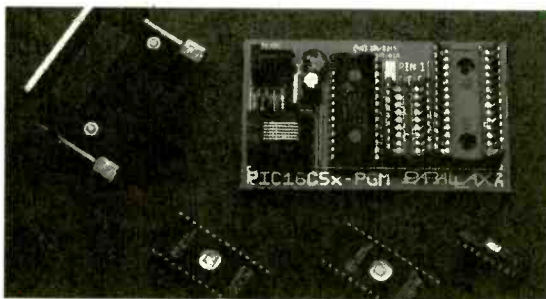
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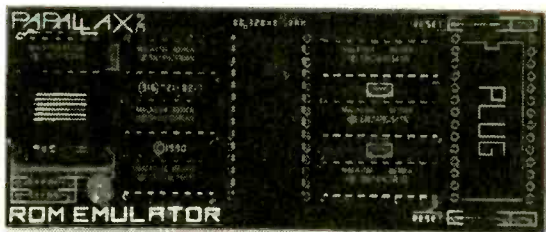


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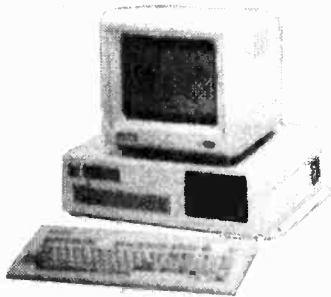
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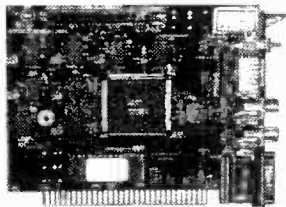
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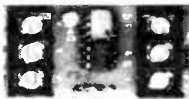
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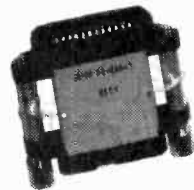


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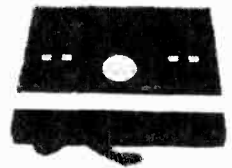
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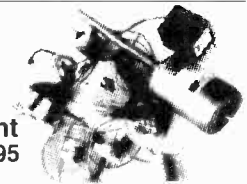
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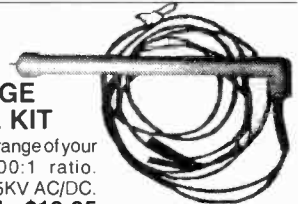
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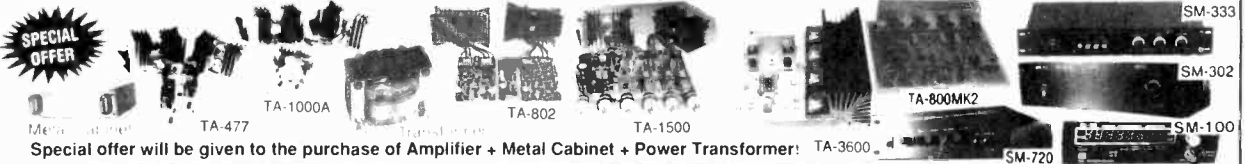
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TA-50A / B	Multi-Purpose Melody Generator ▲	12.84	17.20
TA-50C	Multi-Purpose Melody (Happy Birthday, Wedding March, etc.) Generator ▲	13.65	18.71
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TA-300	30W Multi-Purpose Single Channel Amp ▲	20.00	29.00
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TA-323A	30W X 2 Stereo Pre-main Amp ▲	31.50	42.80
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TA-477	120W Mosfet Power Mono Amp ▲▲	68.00	85.00
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TA-802	80W + 80W Pure DC Stereo Main Power Amp ▲▲	45.94	59.72
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TA-1500	100W X 2 Class "A" DC Stereo Pre-Main Amp ▲▲▲	73.70	95.81
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TA-2500	HQ Pre-Amp w/10 band graphic equalizer ★		78.00
TA-2900	BI-FET IC Pre-Amp w/3 way tone control ▲▲	48.90	63.57
TA-3000	Stereo Simulator (For Mono TV or Any Mono Source) ▲▲	27.00	38.50
TA-3600	300W HG Hi-Fi Power Mono Amp ▲▲▲	85.00	110.00
SM-222	7 Band Hi-Fi Graphic Equalizer ▲▲▲	26.80	38.80
SM-333	Audio/Video Surround Sound Processor ▲▲▲▲	65.00	75.00
SM-666	Dynamic Noise Reduction ▲	26.00	34.00
SM-888	Universal Audio/Video KARAOKE Mixer, Pre-Amp ★		155.00

MISCELLANEOUS		KIT	ASSEMB.
MODEL	DESCRIPTION		
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TY-35	FIM Wireless Microphone ▲	11.25	
TY-36	AC/DC Quartz Digital Clock ▲	19.00	26.20
TY-38	Sound / Touch Control Switch ▲	12.00	
TY-41MK V	Infrared Remote Control Unit (w/Case) ▲▲▲	22.00	35.00
TY-42	Bar / Dot Level Meter ▲	24.15	33.81
TY-43	3 1/2" Digital Panel Meter ▲	29.00	38.00
TY-45	20 Steps Bar / Dot Audio Level Display ▲▲	38.45	46.14
TY-47	Superior Electronic Roulette ▲▲	19.46	27.24
016	10,000 µf 80V DC Capacitor (TA-3600, TA-477, TA-1000A, TA-802)		23.00
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021	Nobel Resistor-Single Vol. Control (TA-3600, TA-477, TA-1000A, TA-120MK2)		12.00
022	Alps Resistor - Dual Vol. Control (TA-377A, TA-802, TA-2200)		22.00

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TR-355B	0-30V 3A Regulated DC Power Supply (no case & x'former) ▲	15.65	21.76
TR-503	0-50V 3A Regulated DC Power Supply (no case & x'former) ▲	16.75	23.65

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MODEL	H" x W" x D"	MATCHING	PRICE
LG-1273	3' 12" 7"	TA-2800 TA-377A TA-2200	\$23.85
LG-1884	4' 16" 8"	TA-323A TA-377A TA-2200	28.50
LG-1924	4' 19" 11 1/2"	TA-802 TA-1500 TA-120MK2 TA-800 MK2 TA-1000A TA-1000A	34.50
LG-1925	5' 19" 11 1/2"	TA-477 TA-2800 MK2 TA-1500 TA-1000A TA-3600	38.00
LG-1983	2 3/4' 19" 8"	TA-377A TA-2200 TA-120MK2	30.50

POWER TRANSFORMERS			
MODEL	DESCRIPTION	MATCHING	PRICE
001	28V x 2 6A to 30V x 2 6A	TA-800 MK2, TA-802, TA-1000A, TA-1500	\$28.00
002	36V x 2 3A	TR-503, TA-323A, TA-400, TA-300, TA-377A	23.00
003	40V x 2 6A	TA-477	30.00
004	24V x 2 6A	TA-120 MK 2	23.00
005	25V x 2 3A	TR-355B	17.00
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007	53V x 2 8A	TA-3600	45.00

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<p><b>KESTER SOLDER</b> SN60/40 .031DIA <b>\$7.50ea</b> 1 Lb ROLL</p>	<p><b>24 PIN MACHINE</b> \$0.30ea / 10pcs \$0.20ea / 100+</p>	<p><b>PUSH-BUTTON</b> <b>MINI - N.O.</b> \$0.30ea / 10pcs \$0.25ea / 100+</p>	<p><b>DIODES</b></p> <table border="1"> <tr> <td></td> <td>10</td> <td>100</td> <td>500+</td> </tr> <tr> <td>1N4148</td> <td>0.05</td> <td>0.03</td> <td>0.02</td> </tr> <tr> <td>1N4001</td> <td>0.05</td> <td>0.04</td> <td>0.03</td> </tr> <tr> <td>1N4004</td> <td>0.07</td> <td>0.06</td> <td>0.05</td> </tr> <tr> <td>1N4007</td> <td>0.09</td> <td>0.08</td> <td>0.07</td> </tr> </table>		10	100	500+	1N4148	0.05	0.03	0.02	1N4001	0.05	0.04	0.03	1N4004	0.07	0.06	0.05	1N4007	0.09	0.08	0.07
	10	100	500+																				
1N4148	0.05	0.03	0.02																				
1N4001	0.05	0.04	0.03																				
1N4004	0.07	0.06	0.05																				
1N4007	0.09	0.08	0.07																				



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HSC#12846

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## Power Supply Special for Spring!



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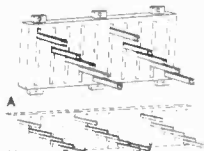
We still have some of our two most popular open-frame power supplies, and we just got a third type that deserves mention. First, at left is a tiny switching supply, perfect for powering a single 3.5" hard disk drive. Its small (2" x 6.25" x 1.25") outline will fit in many types of external drive enclosures. It features a selectable 110/220VAC input and is rated at 5VDC @ 2A and 12VDC @ 1.5A output. Made by Computer Products, used, tested good. We also have some made by Skyenet with equivalent ratings that are .75" shorter in length. Either one, use HSC #12758, price \$17.50. The model shown at right is a 110/220VAC input, 24VDC @ 2.4A output linear supply on aluminum chassis by Condor Electronics. These are new, and quantities are available! HSC #8611, at the low, unheard-of price of \$7.95! And the new addition is a Condor 24VDC @ .225A linear supply that measures only 3" x 3.75" x 1.75". Truly the smallest linear we have seen! Linears are great because they are not sensitive to light load ratings. Similar to illustration at right. New in box, HSC #12941, price \$6.95



\$7.95, \$6.95

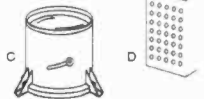
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B. Deluxe Electrical Tester uses two AAA batteries (not included) to test for continuity. Useful for unpowered circuits, fuses and diodes. HSC #99002 \$2.95



C. Hi-Lc Voltage Tester for automotive use...tests for presence of 6-12 VDC and 20KV for ignition. Light indicates presence of voltage. HSC #12819 \$3.49



D. Macro-Hook by E-Z-Hook is a large (5.5" long) test probe with insulation-piercing tip, ready to put on your custom or favorite test lead. Red only. HSC #12157 \$2.95



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## 14GHz Satellite Antenna Bits



A. Avantek Microwave Power Amplifier Mfr. Part #AMP-14504M402 Ku band (14.0 to 14.5 GHz) .25 Watt SMA Conns. with monitor and detector outputs, Operates on 12 to 15 VDC New! 4" x 8" x 1" Sorry, no other info. HSC #12938 \$24.95



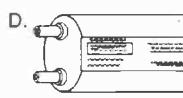
B. Feed-horn Assembly, Ku Band 3.5" dia. x 3.5" long plus 2.75" plastic shield Circular flange bolts to Waveguide Adaptor below, or to LNB below for receive - only applications. New! HSC #12939 \$9.95



C. Ku Band Waveguide adaptor bolts to Feed-horn above and LNB below for transmit/receive applications. The SMA Connector is was connected to the output of the 14 GHz RF Amplifier above. New! HSC #12937 \$12.95



D. General Instrument Low-Noise Block Converter Model LNB-125C bolts to above Feed-horn adaptor assembly, and converts 14 GHz down to lower frequency RF that may be carried over regular 75-ohm coax. (equipped with "F" connectors) New! HSC #12940 \$14.95



Special! Some used units consisting of B, C, and D above, as used with 1.2 meter dish antennas. HSC #12942 \$27.95

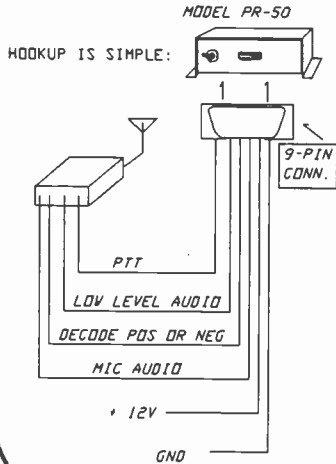
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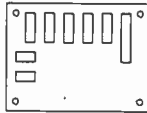
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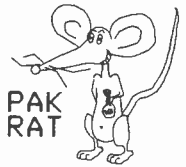
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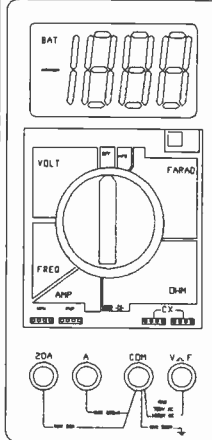
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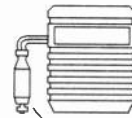


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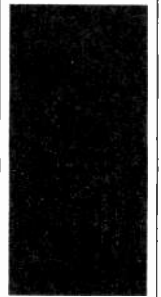
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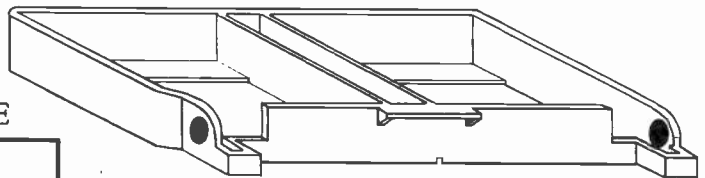
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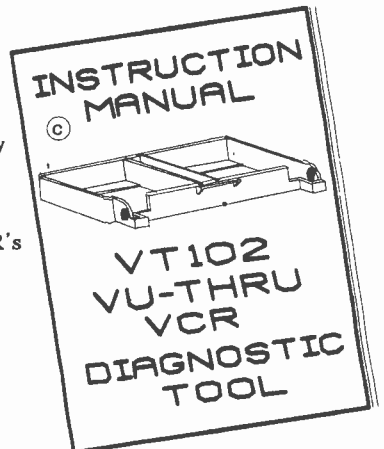
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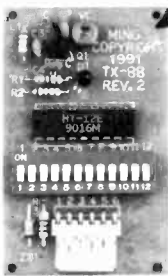
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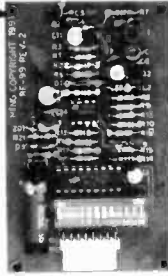
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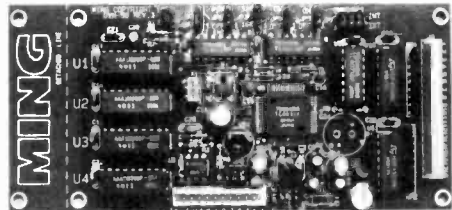
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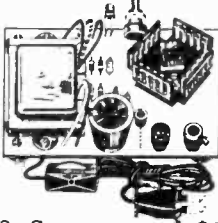
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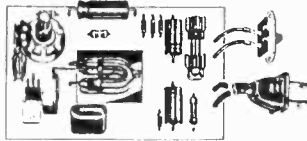
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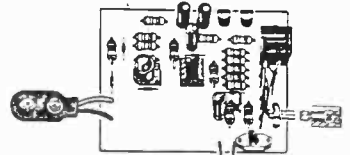
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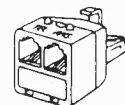
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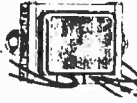
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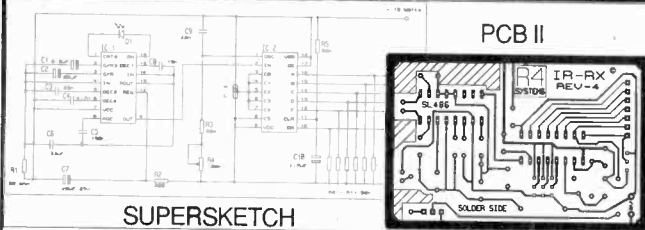
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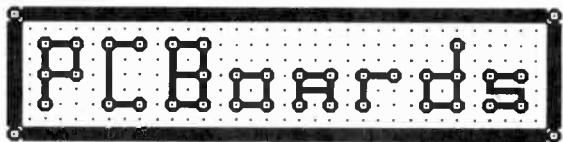
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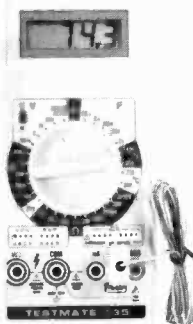


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QUALITY TEST EQUIPMENT  
AFFORDABLE PRICE



**DMM 2360**  
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**DMM + LCR Meter**  
**Most Versatile DMM**  
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Capacitance: 1pF-40 $\mu$ F  
Frequency: 1Hz - 4MHz  
Temperature: -40 - 302°F  
Logic Test: 20MHz  
Diode, Continuity  
Volt, Amp, Ohm  
3999 count display  
Peak Hold  
Auto power off



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**DMM measures Temperature**  
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Volt, Current, Continuity  
Diode, hFE tests  
Type K thermocouple included



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Comes with leads, hard carrying  
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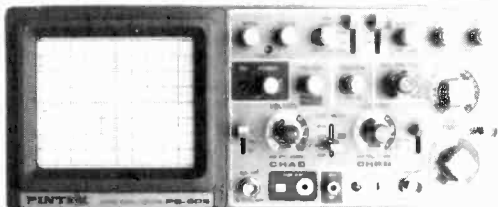
**LCR Meter 814**  
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**The Best Handheld LCR**  
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Zero adjustment to reduce  
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Very good for high frequency RF  
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Resistance: 0.01 $\Omega$ -20M $\Omega$   
Basic accuracy: R:1%, C:2%,  
L:3%  
Test frequency 1 kHz

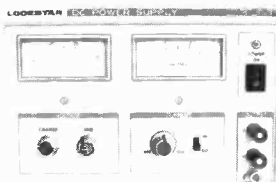


**Capacitance Meter 7705**  
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0.1 pF-20,000 $\mu$ F in 9 ranges  
0.5% basic accuracy  
Zero adjustment  $\pm$  20pF to  
compensate parasitics from test  
fixture

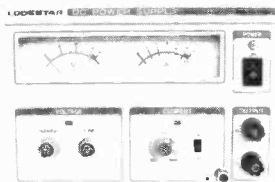


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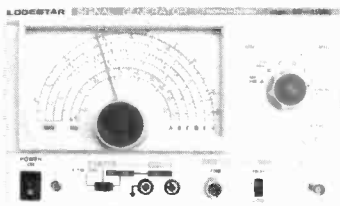
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Short circuit and overload protected



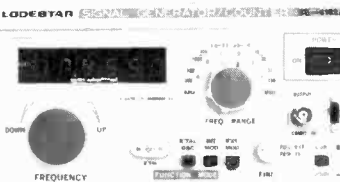
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100 kHz-150MHz sinewave in 6 ranges  
Output 100mVrms to 35 MHz  
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Audio output 1 kHz at 1 Vrms

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\$124.95  
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Output: 8Vrms sine, 10Vp-p squarewave  
Synchronization:  $\pm$ 3% of oscillation  
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0.5% 50Hz - 500kHz  
Output impedance: 600 ohm

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Sine, square, triangle, pulse and ramp  
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Generates RF signal same as SG-4160B  
Frequency counter 1Hz - 150MHz  
Sensitivity <50mV  
For internal and external sources

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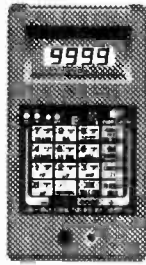
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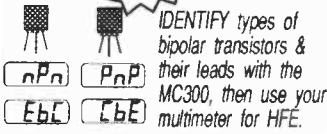
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MULTI CAPACITANCE METER

**MC400 "EVEN MORE POWERFUL"**  
COMPONENT ANALYSER/CAPACITANCE METER

**DAETRON**  
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What your multi functioned Multimeter **CAN'T** do the MC300 will do.  
Your multi-functioned multimeter can measure HFE on transistors but you still have to identify the type and the leads.



- "IN ADDITION"** to its incredibly large auto ranging capability (0.1 pF to 1 FARAD, which your multimeter can't do) the MC300 also does the following:
- 10 range manual capability
  - reads dielectric absorption
  - 3 ways of zeroing including power-on auto zero
  - ability to zero large values up to 99.99 uF
  - ability to read leakage of capacitors
  - sorts capacitors in 2 different modes
  - Hold function freezes display in most modes

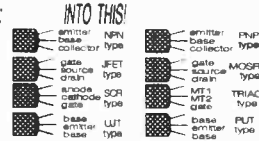


Besides appearance what do the following components have in common?



ANSWER: Nothing! They're all completely different components. Some have generic part numbers (have your catalog ready to identify which is which) others have OEM numbers (bet you don't have that catalog) while still others have no markings!

ONLY the MC400 can sort this:



THE MC400 CAN ALSO DO:

- all the functions of the MC300
- identifies type of component - PETS, BIPOLARS, SCRs, TRIACS, UJTs, PUTs
- identifies polarity of Component - NPN, PNP, P or N channel, enhancement or depletion for above
- identifies pinout of component
- bases, collectors, emitters, gates, drains, sources, cathodes, for all above components
- tests 3 pinned low powered voltage regulators
- Zener diodes to 23 V and rectifiers

Both units have - 4 full digit 0.5 inch LCD display, diode clamped and fuse protected input, powered by 9 volt battery or optional AC adaptor (recommended for MC400), impact resilient plastic case

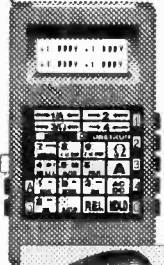
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- MC300 @\$189.95
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  - PAIR OF 36" LONG TEST LEADS @\$12.95
- MM200A has 2 amp range. All units have standard pair of test leads
- MM200A @\$259.95
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  - MM300A @\$469.95

- (benchtop version)
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  - TL230 6 COLOR CODED ALLIGATOR TEST LEADS @\$39.95
  - AC adaptor for MM200 @\$10.95
- SHIPPING AND HANDLING @ 7.50 UNIT
- check  VISA  TOTAL
- money order  mastercard
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- EX. DATE \_\_\_\_\_
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- SIGNATURE \_\_\_\_\_
- Credit card order must be shipped to the address the credit card is registered in
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- ADDRESS \_\_\_\_\_
- CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_

**FREQUENCY COUNTER with PROGRAMMABLE MULTIMETER**

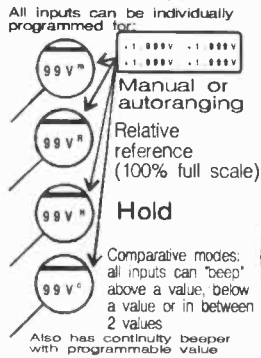
MM200A Multimeter that reads not only Frequency and Voltage at the same time but also 4 Voltages at the same time (2 freq., 4 voltage, 1 current & 1 resistance input)



Color coded inputs and optional color test leads to avoid confusion

- QUAD DISPLAY
- DUAL DISPLAY
- SINGLE DISPLAY (any function including frequency)
- SIMULTANEOUS VIEWING OF MIN/MAX MODES
- FREQUENCY and VOLTAGE

- 1 VOLTAGE & 2 FREQUENCIES
- 10 MHz Frequency on top 5 Khz Frequency on bottom
- 2 VOLTAGES & 1 CURRENT & 1 RESISTANCE (many other combos available)
- SETUP MENU
- EVEN READS IT OWN BATTERY VOLTAGE



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Plugs into your lighter and runs

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1N5401	3 AMP 100 PRV	.20
1N5402	3 AMP 200 PRV	.20
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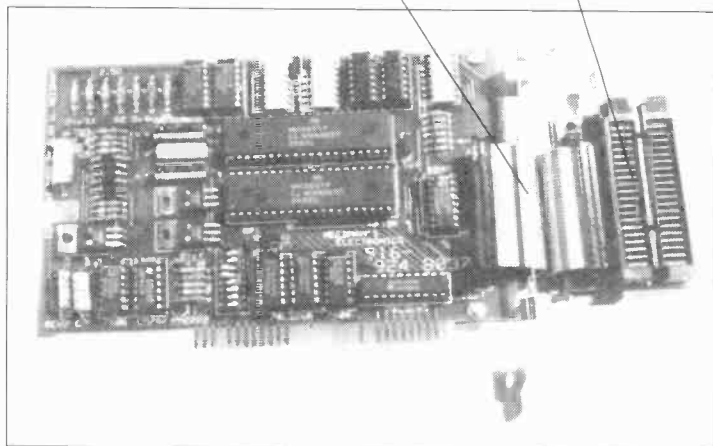
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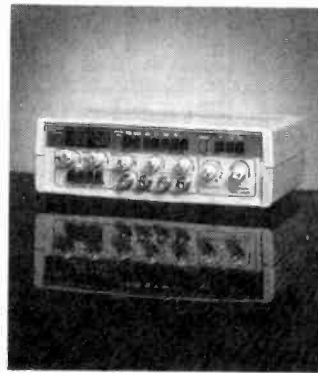
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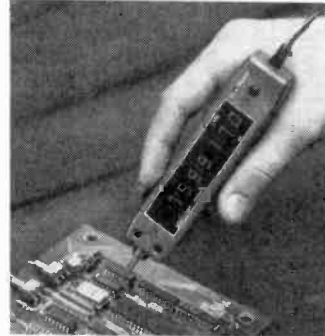
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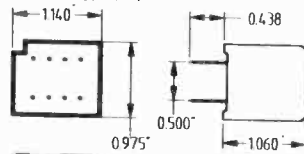
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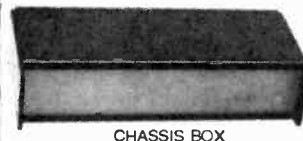
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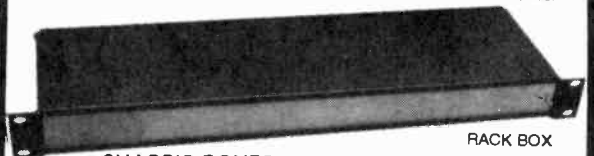


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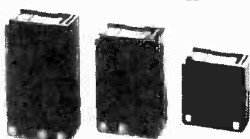
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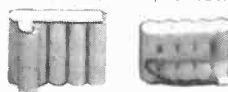
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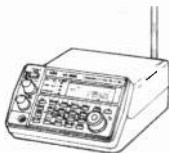
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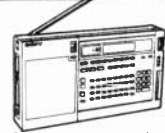
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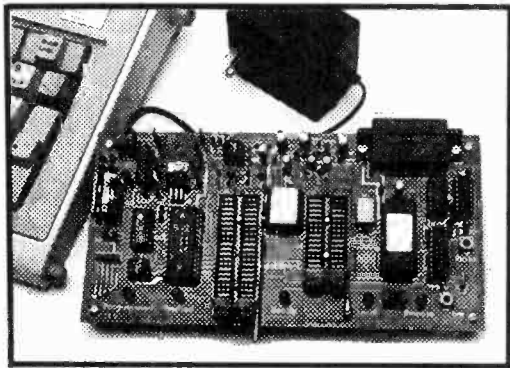
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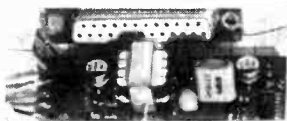
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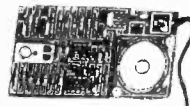


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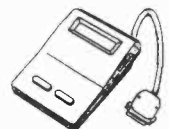


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- Telescopic whip antenna—BNC plug, WA-10 ..... \$11.95
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MODEL	FREQ. RANGE	SENSITIVITY	DIGITS	RESOLUTION	PRICE
CT-50	20 Hz–600 MHz	< 25 mV to 500 MHz	8	1 Hz, 10 Hz	\$189.95
CT-70	20 Hz–550 MHz	< 50 mV to 150 MHz	7	1 Hz, 10 Hz, 100 Hz	\$139.95
CT-90	10 Hz–800 MHz	< 10 mV to 150 MHz < 150 mV to 800 MHz	9	0.1 Hz, 10 Hz, 100 Hz	\$189.95
CT-125	10 Hz–1.25 GHz	< 25 mV to 50 MHz < 15 mV to 500 MHz < 100 mV to 1 GHz	9	0.1 Hz, 1 Hz, 10 Hz	\$189.95
CT-250	10 Hz–2.5 GHz typically 3.0 GHz	< 25 mV to 50 MHz < 10 mV to 1 GHz < 50 mV to 2.5 GHz	9	0.1 Hz, 1 Hz, 10 Hz	\$249.95
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**SPEED RADAR**  
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**complete kit**  
**SG-7**



New low-cost microwave Doppler radar kit "clocks" cars, planes, boats, horses, bikes or anything else moving close. Operates on 2.4 GHz with up to 1/4 mile range. Digital readout meters display speed in mph. 30-second/minute per hour speed set. Second! Earphone output allows for listening to actual doppler shift. Uses two 1.5 cell coin cells for antenna (not included) and runs on 12 VDC. Easy to build—all microwave circuitry is PC strip-line. ABS plastic case with speedy graphics for a professional look. A very useful and full-of-fun kit.

**BROADBAND PREAMP**



Boost those weak signals to your advantage. V. shortwave radio or frequency counter. 25 dB gain, 1 to 1000 MHz, 300 nF. BNC connectors. Runs on 12 VDC or 110 VAC. FR-2, wired, includes AC adapter. \$59.95

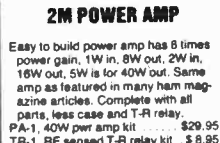
**FM WIRELESS MIKE KITS**



Pick the unit that's right for you. All units transmit stable signal in 88–108 MHz FM band up to 300' except for hi-power FM-4 that goes up to 1/2 mile.


- FM-1, basic unit ..... \$5.95
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- FM-4, long range, high power with very sensitive audio section, picks up voices 10' away ..... \$14.95
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- SMC, miniature sensitive mike cartridge for FM-1, 2, 4 ..... \$2.95

**2M POWER AMP**



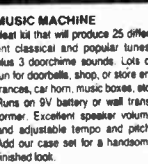
Easy to build power amp has 8 times power gain. 1W in, 8W out, 2W in, 18W out, 5W in for 40W out. Same amp as featured in many ham magazine articles. Complete with all parts, less case and T-R relay. PA-1, 40W power amp kit ..... \$29.95  
TR-1, RF sensed T-R relay kit ..... \$8.95

**MICROWAVE INTRUSION ALARM**



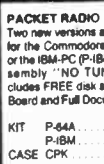
A real microwave Doppler sensor that will detect a human as far as 10 feet away. Operates on 1.3 GHz, and is not affected by heat, light, or vibrations. Drives up to 100 mA output, normally open or closed, runs on 12 VDC. Complete kit MD-3 ..... \$19.95

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Heart kit that will produce 25 different classical and popular tunes, plus 3 doorchime sounds. Lots of fun for doorbells, shop, or store entrances, car horn, music boxes, etc. Runs on 9V battery or wall transformer. Excellent speaker volume and adjustable tempo and pitch. Add our case set for a handsome finished look. Complete kit, MM-5 ..... \$24.95  
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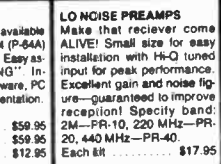
**PACKET RADIO**



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**TICKLE STIK**



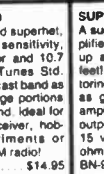
A shocking kit! Blinking LED attracts victims to pick up innocent-looking can—you watch the fun! Ideal for office desks, parties, nosey know-it-alls! TS-4 kit ..... \$9.95

**VOICE ACTIVATED SWITCH**



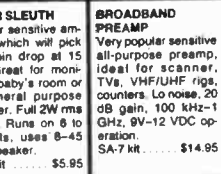
Voice activated switch kit provides switched output with current capability up to 100 mA. Can drive relays, lights, LED, or even a tape recorder motor. Runs on 9 VDC. VS-1 kit ..... \$8.95

**TELEPHONE TRANSMITTER**



Mini-sized with professional performance. Self-powered, from phone line, transmits in FM broadcast band up to 1/4 mile. Installs easily anywhere on phone line or inside phone. PB-1 kit ..... \$14.95

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Talk on the phone hands-free, great to put in shop or shack, press the button to answer—no actual phone needed. Works same as commercial units. Talk from anywhere in room, phone line powered—no battery needed. Super for family and conference calls or buy two for hands-free intercom! Add our case set for a pro look. SP-1 ..... \$29.95 Case-CSP ..... \$12.95

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Here's a great booster for any 2 meter or 220 MHz hand-held unit. These power boosters deliver over 30 watts of output, allowing you to hit the repeater's full quieting while the low noise preamp remarkably improves reception. Ramsey Electronics has sold thousands of 2 meter amp kits, but now we offer completely wired and tested 2 meter, as well as 220 MHz, units. Both have all the features of the high-priced boosters at a fraction of the cost.

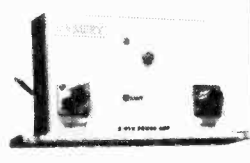
- PA-10 2 MTR POWER BOOSTER (10 X power gain) Fully wired & tested ..... \$79.95
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### 20, 30, 40, 80M CW TRANSMITTERS

Join the fun on QRP! Thousands of these mini-rigs have been sold and tons of DX contacts have been made. Imagine working Eastern Europe with a 530' transmitter—that's ham radio at its best! These CW rigs are ideal mates to the receivers at right. They have two-position variable crystal control (one popular QRP XTAL included), one watt output and built-in antenna switch. Runs on 12VDC. Add our matching case and knob set (only handsomely finished look) ..... \$29.95  
Your choice of bands: QRP-20, 30, 40 or 80) ..... \$8.95  
Matching case & knob set, QCRP ..... \$12.95

### 20, 30, 40, 80M All Mode RECEIVERS

Build your own mini ham station. Sensitive all-mode AM, SW, SSB receivers use direct conversion design with NE602 IC as featured in QST and ARRL handbooks. Very sensitive varactor tuned over entire band. Plenty of speaker volume. Runs on 9V battery. Very EASY to build, lots of fun and educational—ideal for beginner or old pro. New 30-page manual. Add the case set for well-fitted professional look. Your choice of bands ..... \$29.95  
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### E-Z KEY CMOS KEYSER

Send perfect CW within an hour of receiving this kit! Easy-to-build kit has sidetone oscillator, speed control and keys most any transmitter. Runs for months on a 9V battery. 28-page manual gives ideas on making your own key for extra savings. Add our matching case set for complete station look. CW-7 kit ..... \$24.95  
Matching case knob set, CQW ..... \$12.95

### 2, 6, 10 MTR, 220 FM RECEIVERS



Keep an ear on the local repeater gang, monitor the cops, check out the weather or just plain listen around. These sensitive superhet receivers are just the ticket. They tune any 5 MHz portion of the band and have smooth varactor tuning, dual conversion with ceramic IF filters, AFC, adjustable squelch and plenty of speaker volume. Runs on 9V battery and performance that rivals the big rigs! For a complete finished pro look, add our matching case and knob set with screened graphics. FM communications receiver kit ..... \$29.95  
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Matching case & knob set, CAA ..... \$12.95

### FM STEREO TRANSMITTER

Run your own stereo FM station! Transmit a stable signal in the standard FM broadcast band throughout the house, dorm or neighborhood. Connects easily to line outputs on CD player, tape decks, etc. Runs on 9V battery, has internal whip antenna and external antenna jack. Add our case set for a "station" look! FM-10 kit ..... \$29.95  
Matching case set, CFM ..... \$12.95

### SPEECH SCRAMBLER

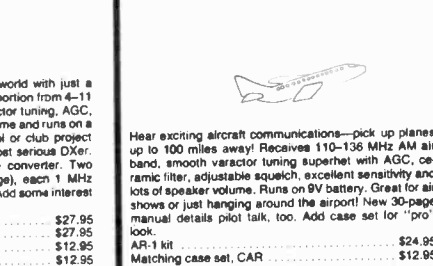
Communicate in total privacy over phone or radio. Kit features full duplex operation using frequency inversion. Both mike and speaker or line in/out connections. Easy hookup to any radio, and telephone use requires no direct connection! Easy to build 2 IC circuit. Can also be used to descramble many 2-way radio signals. Fin-SS-7 kit ..... \$29.95  
Matching case & knob set, CSS ..... \$12.95

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Hear exciting aircraft communications—pick up planes up to 100 miles away! Receives 110–135 MHz AM air band, smooth varactor tuning superhet with AGC, ceramic filter, adjustable squelch, excellent sensitivity and lots of speaker volume. Runs on 9V battery. Great for air shows or just hanging around the airport! New 30-page manual details pilot talk, too. Add case set for "pro" look. AIR-1 kit ..... \$24.95  
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Shortwave case set for SRI, SCR ..... \$12.95  
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Looks and functions like a common outlet; uses power line for power and antenna (no batteries needed ever!)  
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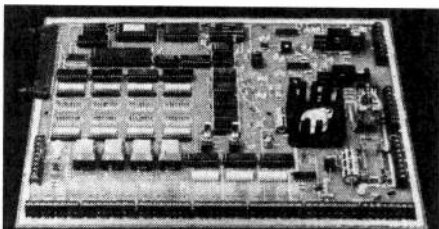
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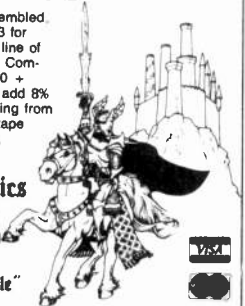
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MC68020RC25E	189.95	32-Bit Virtual Memory MPU, 25MHz	PGA 114
MC68030RC16B	229.95	Second Generation 32-Bit Enhanced Virtual Memory MPU, 16MHz	PGA 128
MC68030RC25B	319.95	Second Generation 32-Bit Enhanced Virtual Memory MPU, 25MHz	PGA 128
MC68230P10	8.95	Parallel Interface/Timer	48
MC68450L10	59.95	Direct Memory Access Controller	64
MC68488P	22.95	General Purpose Interface Adapter (1MHz)	40
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MC68681P	7.95	Dual Universal Asynchronous Receiver/Transmitter	40
MC68881RC25B	114.95	HC MOS Floating-Point Coprocessor, 25MHz	PGA 68
MC68882RC25A	149.95	HC MOS Enhanced Floating-Point Coprocessor, 25MHz	PGA 68
MC68701	16.75	8-Bit MCU, 2048 Bytes EPROM, 128 Bytes RAM, I/O	40
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MC68HC000P12	17.95	Low Power HC MOS 16-/32-Bit MPU, 12MHz	64
MC68HC11A1P	18.95	8-Bit HC MOS MCU with SPI, SCI, 8-Bit A/D Conv., 512 Bytes EEPROM, 256 Bytes SRAM	48
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2817A25	6.75	2048x8 250ns, 5V Read/Write (Pin 1 - Ready/Busy)	28
2864A25	8.95	8192x8 250ns, 5V Read/Write (Pin 1 - N/C)	28
28C256-25	26.95	32,768x8 250ns, 5V Read/Write CMOS	28

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ADC0809CCN	3.75	8-Bit A/D Converter with 8-Channel Multiplexer	28
ADC0817CCN	12.95	8-Bit A/D Converter with 16-Channel Multiplexer	40
ADC0820CCN	8.95	8-Bit High Speed A/D Conv. with Track/Hold Function	20
DAC0800LCN	1.95	8-Bit D/A Converter ( $\pm 1$ LSB)	16
DAC0806LCN	1.49	8-Bit D/A Converter (MC1408-6)	16
DAC0807LCN	1.49	8-Bit D/A Converter (MC1408-7)	16
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Z80A	1.25	CPU (MK3880-4) (780C-1) 4MHz	40
Z80A-CTC	1.55	Counter Timer Circuit (MK3882-4) 4MHz	28
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Z80A-SIO/0	3.95	Serial I/O (Tx/CB & Rx/CB Bonded) (MK3884-4) 4MHz	40
Z80A-SIO/2	3.95	Serial I/O (Lacks SYNCB) (MK3887-4) 4MHz	40
Z80B	2.45	CPU (MK3880-6) 6MHz	40
Z84C0008	5.95	CPU 8MHz (CMOS)	40
Z84C1008	10.95	DMA (Direct Memory Access) 8MHz (CMOS)	40
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Z84C4008	8.95	SIO/0 8MHz (CMOS)	40
Z84C4108	8.95	SIO/1 8MHz (CMOS)	40
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MRF221	16.35	15	3.5	136-174	6.3/175	211-07
MRF224	17.75	40	14.3	136-174	4.5/175	211-07
MRF237	3.69	4	0.25	136-174	12/175	79-05
MRF238	15.95	30	3.7	136-174	9/175	145A-09
MRF239	16.95	30	3	136-174	10/175	145A-09
MRF240	17.49	40	5	136-174	9/175	145A-09
MRF240A	17.49	40	5	136-174	9/175	211-07
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MRF260	11.95	5	0.5	136-174	10/175	221A-04
MRF262	12.95	15	3.5	136-174	6.3/175	221A-04
MRF264	13.95	30	9.1	136-174	5.2/175	221A-04
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MRF555	3.49	1.5	0.15	400-512	10/470	317D-02
MRF557	5.49	1.5	0.23	806-960	8/870	317D-02
MRF559	2.25	0.5	0.08	806-960	8/870	317-01
MRF607	2.49	1.75	0.12	136-174	11.5/175	79-04
MRF627	9.95	0.5	0.05	400-512	10/470	305A-01
MRF629	4.49	2	0.32	400-512	8/470	79-05
MRF630	3.95	3	0.33	400-512	9.5/470	79-05
MRF641	20.49	15	2.5	400-512	7.8/470	316-01
MRF644	23.95	25	5.9	400-512	6.2/470	316-01
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MRF648	30.95	60	22	400-512	4.4/470	316-01
MRF650	29.95	50	11.7	100-500	6.3/470	316-01
MRF652	11.49	5	0.5	400-512	10/512	244-04
MRF654	19.95	15	2.5	400-512	7.8/470	244-04
MRF660	13.95	7	2	400-512	5.4/470	221A-04
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2N3866	1.25	1	0.1	100-400	10/400	79-04
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2N5641	16.95	7	1	30-200	8.4/175	144B-05
2N5642	18.49	20	3	30-200	8.2/175	145A-09
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2N5945	11.95	4	0.64	400-512	8/470	244-04
2N5946	14.95	10	2.5	400-512	6/470	244-04
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2N6082	14.95	25	6	136-174	5.2/175	145A-09
2N6083	14.95	30	8.1	136-174	5.7/175	145A-09
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MRF426	19.49	25	0.16	22	211-07
MRF427	16.95	25	0.4	18	211-11
MRF428	59.95	150	7.5	13	211-11
MRF429	44.95	150	7.5	13	211-11
MRF433	12.49	12.5	0.125	20	211-07
MRF448	72.95	250	15.7	12	211-11
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MRF466	34.95	40	1.25	15	211-07
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MRF476	3.95	3	0.1	15	221A-04
MRF477	13.75	40	1.25	15	221A-04
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MPF102	.45	.39	JFET (N Channel) RF, VHF, UHF, Amp	TO-92
MPSA05	.25	.19	NPN Medium Power Amp and Switch	TO-92
MPSA06	.19	.15	NPN Medium Power Amp and Switch	TO-92
MPSA13	.25	.19	NPN Power Darlington	TO-92
PN2222	.12	.10	NPN General Purpose	TO-92
PN2907	.12	.10	PNP General Purpose	TO-92
TIP29A	.49	.39	NPN Power Transistor	TO-220
TIP30A	.49	.39	PNP Power Transistor	TO-220
TIP31A	.49	.39	NPN Power Transistor	TO-220
TIP32A	.49	.39	PNP Power Transistor	TO-220
TIP41A	.55	.49	NPN Power Transistor	TO-220
TIP42A	.55	.49	PNP Power Transistor	TO-220
TIP102	.65	.59	NPN Power Darlington	TO-220
TIP120	.55	.45	NPN Power Darlington	TO-220
TIP125	.55	.45	PNP Power Darlington	TO-220
2N2219A	.49	.39	NPN General Purpose	TO-39
2N2222A	.25	.23	NPN General Purpose	TO-18
2N2907A	.25	.23	PNP General Purpose	TO-18
2N3055	.69	.65	NPN Power Transistor	TO-3
2N3772	1.29	1.19	NPN Power Transistor	TO-3
2N3903	.23	.19	NPN General Purpose	TO-92
2N3904	.12	.10	NPN General Purpose	TO-92
2N3906	.12	.10	PNP General Purpose	TO-92
2N4123	.23	.19	NPN General Purpose	TO-92
2N4401	.15	.13	NPN General Purpose	TO-92
2N4403	.15	.13	PNP General Purpose	TO-92
2N5087	.25	.22	PNP Low Level, High Gain, 50-100mA	TO-92
2N5089	.25	.22	NPN Low Level, High Gain, to 100mA	TO-92
2N5951	.69	.59	JFET (N Channel) RF, VHF, UHF, Amp	TO-92

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BC547	.20	NPN	45	100	0.5	300	TO-92
BC549	.20	NPN	30	100	0.5	300	TO-92
BC549C	.30	NPN	30	100	0.5	300	TO-92
BC557	.20	PNP	45	100	0.3	150	TO-92
BC558	.20	PNP	25	100	0.3	150	TO-92
BC639	.45	NPN	80	1000	1	130	TO-92
BC640	.45	PNP	80	1000	1	50	TO-92
BD139	.55	NPN	60	1000	8	250	TO-126
BD140	.55	PNP	80	1000	8	75	TO-126
BD681	1.05	NPN	100	4000	40	1	TO-126
BD682	1.05	PNP	100	4000	40	1	TO-126
BF199	.95	NPN	25	25	0.23	550	TO-92
BF469	.95	NPN	250	50	1.8	60	TO-126
BF470	.95	PNP	250	50	1.8	60	TO-126

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### Flexinol Muscle Wire Specifications

Wire Diameter	50 $\mu\text{m}$	100 $\mu\text{m}$	150 $\mu\text{m}$
Resistance	510 $\Omega/\text{m}$	150 $\Omega/\text{m}$	50 $\Omega/\text{m}$
Contract Force	35 grams	150 grams	330 grams
Typical Current	50 mA	180 mA	400 mA

### How much power do Muscle Wires need?

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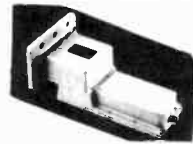
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CIRCLE 263 ON FREE INFORMATION CARD

## PARTS LIST

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

R1—100 ohms, 1-watt (see text)

R2—43 ohms (see text)

R3—180 ohms

R4—2200 ohms

R5—10,000 ohms

### Capacitors

C1—0.01 µF, 500 volts, ceramic

### Semiconductors

IC1—Motorola MOC3010 Triac-output optoisolator (or MOC3011 for zero-crossing switching, see text)

D1—1N4002 diode (or any 1-amp, 100-volt or greater diode)

Q1—2N3904 NPN transistor

TR1—Teccor Q4006L4 Triac (or equivalent, see text)

**Note: The following items are available from Q-Sat, PO Box 110, Boalsburg, PA 16827:**

• A printed circuit board for two solid-state relays, can be cut in two or left together (part number SSR-PCB)—\$8.00 postpaid

• A complete kit minus heat sinks for two solid-state relays (sorry, sold in multiples of two only, part number SSR-KIT)—\$18.00 postpaid

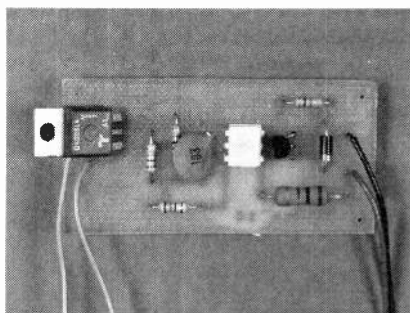
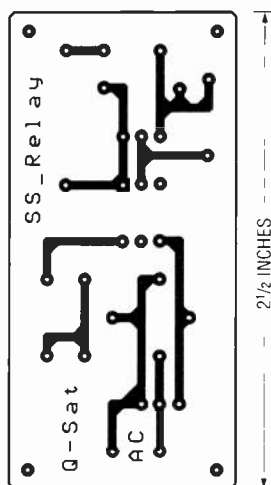


FIG. 7—THE AUTHOR'S PROTOTYPE. The board is shown here without a heat-sink on the Triac, although one should definitely be used.

sinked. As a word of warning, motors draw a lot more current on start-up than they do during normal operation, sometimes as much as ten times more.

The third requirement is the gate current. The Motorola MOC3010 optoisolator will provide about 100 milliamps of drive current for the output Triac. That should be adequate



SSR FOIL PATTERN shown actual size.

for any Triac you can find in a TO-220 package.

Although not a strict requirement, an isolated Triac is a good safety precaution. Isolated Triacs provide electrical isolation from the electrical connections

to the case. Early Triacs were not normally isolated. That meant that you had to use mica washers and thermal grease. Thermal grease is still a good idea, but the mica washer isn't required for isolated Triacs. If you don't know whether or not your Triac is isolated, simply measure the resistance from each lead to the case. An isolated Triac will measure open on all three leads.

**Warning:** The Radio Shack 400-volt, 6-amp Triac (part number 276-1000) will work well in this circuit, but it is *not* isolated. You *must* use a TO-220 mica washer and thermal grease if you plan to use that device.

### Construction

For a simple SSR, an optoisolator such as the Motorola MOC3010 will be sufficient. For a zero-crossing SSR, an MOC3031 will do. Many companies make optoisolators. Make sure yours has a Triac output and that the pinouts are compatible with your design. Table 1 shows some typical Triac-output optoisolator specifications.

Although the SSR can certainly be built without a printed circuit board, using the foil pattern we've provided will make building it a simple task. You can also buy a pre-made PC board from the source mentioned in the parts list. Figure 6 shows the parts-placement diagram. The only precaution, other than the one about working with 110 volts, is to heatsink the Triac. If you leave the leads on the Triac long, it should be a simple matter to find some heat sink to attach to the Triac. Just remember to connect the heat-sink to an earth ground. Even if you're using an isolated Triac, the earth ground is still necessary. Otherwise you should buy your solid-state relays from a reliable company—don't build them yourself. Figure 7 shows the author's completed prototype.

Remember that SSR's can switch only an AC line. Trying to switch a DC line will result in a relay that closes but never opens.

TABLE 1—TYPICAL TRIAC-OUTPUT OPTOISOLATORS

Motorola Type	Blocking Voltage	LED Current (mA)	Maximum R2 (ohms)	Zero Crossing Switching	AC Line Voltage
MOC3009	250	30	22	No	115
MOC3010	250	15	43	No	115
MOC3011	250	10	68	No	115
MOC3012	250	5	130	No	115
MOC3020	400	30	22	No	220
MOC3021	400	15	43	No	220
MOC3022	400	10	68	No	220
MOC3023	400	5	130	No	220
MOC3030	250	30	22	Yes	115
MOC3031	250	15	43	Yes	115
MOC3032	250	10	68	Yes	115
MOC3040	400	30	22	Yes	220
MOC3041	400	15	43	Yes	220

## ANTHONY J. CARISTI

IF YOU ENJOY HIKEING OR DRIVING through mountainous country—but without knowing how far above sea level you are—this project will be of interest. It's a simple, easy-to-build, compact electronic altimeter that provides altitude readings from zero to 1999 feet with a resolution of 1 foot. The device has a 3½-digit LCD readout and is powered by a common 9-volt battery.

The altimeter's small size and light weight allows it to be easily carried wherever you travel. The modest power drain of the circuit ensures many hours of operation on a single 9-volt battery. If desired, the instrument can also be powered by the 12-volt electrical system of any vehicle.

The electronic altimeter is a pneumatically operated device that responds to absolute atmospheric air pressure. It operates on the same principle as the aneroid altimeters found in every aircraft.

Absolute atmospheric pressure is a mathematically definable parameter that varies inversely with altitude. At sea level the pressure is 14.7 pounds per square inch, and decreases as altitude increases.

The heart of the altimeter is a high-quality solid-state absolute-pressure sensor that is sensitive enough to detect changes in altitude as small as one foot. The surrounding circuitry amplifies the analog voltage output of the sensor, and converts it to digital form to drive the display.

### The sensor

The pressure sensor was developed by Motorola Semiconductor Products, Inc., Phoenix, AZ. It's designed to respond to absolute atmospheric pressure, which is defined as pressure measured with respect to a perfect vacuum (zero pounds per square inch absolute, or 0 PSIA). Over the altimeter's range of interest, 0 to 1999 feet, the absolute atmospheric pressure varies from 14.696 PSIA to 13.67 PSIA (which corresponds

to 29.92 to 27.82 inches of mercury, respectively).

Inside the sensor is a monolithic silicon piezoresistor that is ion-implanted on a thin silicon diaphragm. The pressure sensor contains two chambers separated by the silicon diaphragm. One of the sensor's chambers is exposed to atmospheric pressure by means of an external port. The other chamber is evacuated to as perfect a vacuum as possible, and sealed. That way the diaphragm of the sensor is under constant stress in accordance with the difference between atmospheric pressure on one side, and an essentially "perfect" vacuum on the other. The mechanical stress placed on the diaphragm (and the piezoelectric resistor) causes the sensor to generate an output voltage that is proportional to the applied pressure as seen by the open port of the solid-state sensor.

to 1999 feet), the sensor's output voltage will change only about 1.4 millivolts.

A differential amplifier, composed of three sections of an LM324N quad op-amp (IC1), provides voltage amplification of the sensor output. The gain of the amplifier can be adjusted by potentiometer R3 to allow for the normal tolerance difference between different sensors. The DC voltage level at pin 8 of IC1 is set to 2.5 volts when the altimeter is at zero altitude (sea level). At 1999 feet, the amplifier output falls to about 2.4 volts.

The DC voltage from the differential amplifier (IC1) drives an ICL7106CPL analog-to-digital (A/D) converter (IC3). That chip, which is used in many commercial DMM's, converts the differential voltage from IC1 to digital form and drives the 3½-digit liquid crystal display (DSP1). An external reference voltage, generated by R14–R17,

# ALTIMETER

**Add new dimensions to your next trip to the mountains with our pocket-sized electronic altimeter.**

Refer to the schematic of the altimeter circuit shown in Fig. 1. The piezoresistor within the sensor (IC4) is connected between pins 1 and 3, and is driven by the 5-volt power supply in the circuit. The taps on the resistor, connected transversely across the element, are brought out to pins 2 and 4 of the sensor.

Under normal conditions in which atmospheric pressure causes a stress on the piezoelectric resistor, the sensor differential output voltage is a finite but very small value—about 20 millivolts. Over the range of interest for climbers (0

provides the proper conversion factor between the analog input voltage and the desired digital display in feet.

As described earlier, the output voltage of the amplifier section is set to 2.5 volts by R3 when the altimeter is at sea level. That voltage is fed to the negative analog input of IC3 (pin 30). Since the altimeter must read zero at sea level, the positive input of IC3 (pin 31) must see a constant 2.5-volts. That way the differential input voltage between the positive and negative inputs will be zero, and the display will read 000 as



desired. As the elevation of the altimeter increases, the voltage fed to pin 30 decreases while the voltage at pin 31 remains constant. As a result, the net difference in voltage is detected by IC3 and converted into an increasing digital display readout of altitude.

There is one other factor that must be taken into consideration in a pneumatically sensing altimeter of this type. Changing weather conditions cause changes in barometric pressure from the standard value of 14.7 PSI (or 29.92 inches of mercury at sea level). As with any altimeter that reacts to absolute air pressure, the effect of changing barometric pressure must be canceled out.

In this project the effect of barometric pressure is canceled out by means of BARO SET potentiometer R11 which can be adjusted for about 2.4 to 2.6 volts at its wiper. Therefore, R11

must be set so that the voltage at pin 14 of IC1-d causes the display to indicate the correct known altitude at any reference location. Once that is done, the altimeter is calibrated for the current barometric reading—but changing weather conditions can change the readings significantly. You will probably have to recalibrate the altimeter before each use, or simply set it to zero and use it to measure a relative altitude.

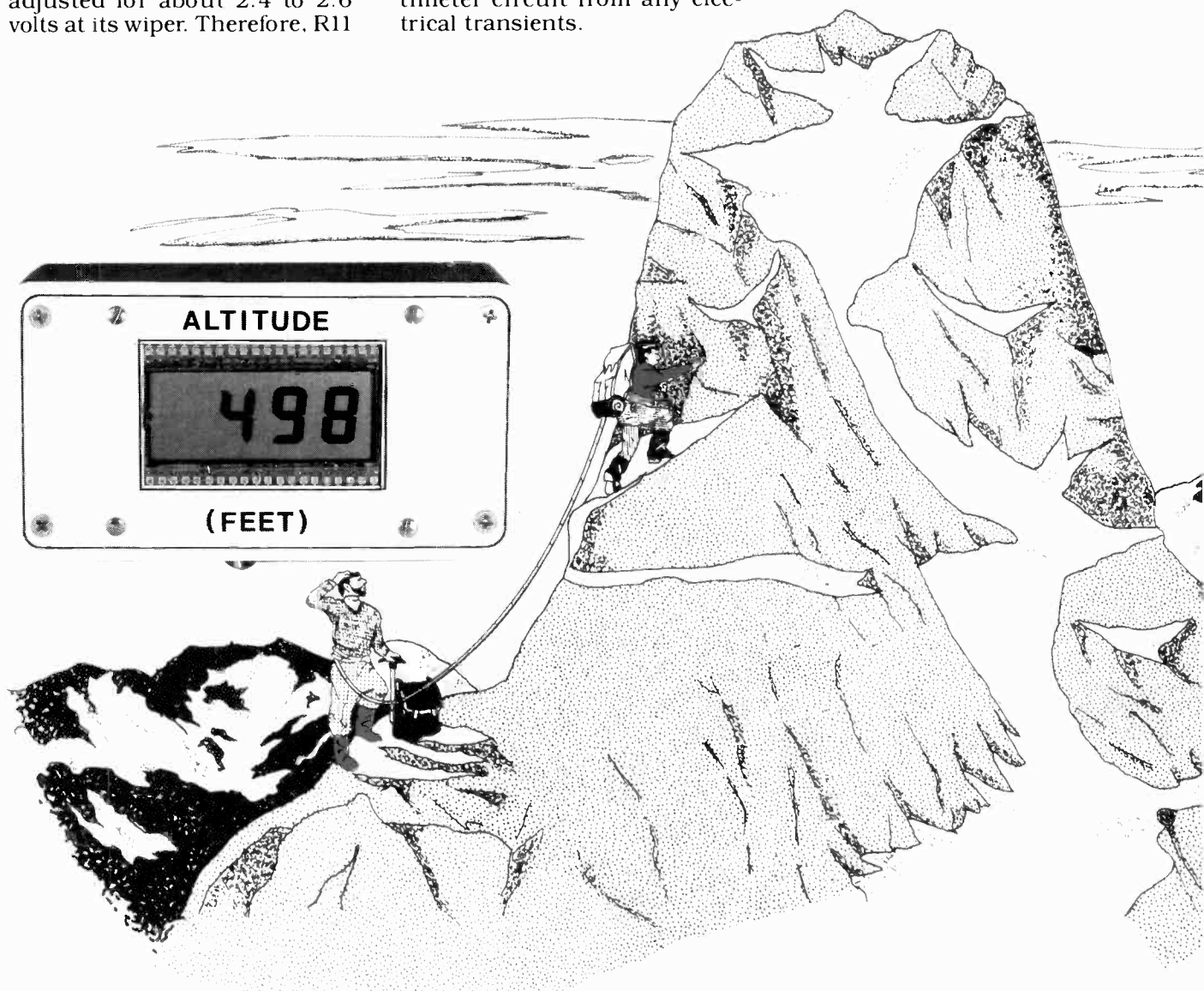
Power for the altimeter comes from a 9-volt battery or from a vehicle's 12-volt electrical system. Either source is fed to an AN78L05 fixed 5-volt regulator (IC2). The altimeter's modest current drain of about 6½ millamperes allows many hours of operation from a 9-volt battery. When 12 volts is used as the power source, a resistor and diode are used to isolate the altimeter circuit from any electrical transients.

## Construction

The altimeter is built using two single-sided PC boards—one analog and one digital.

The two PC boards can be made using the foil patterns we've provided, or they can be purchased from the source mentioned in the Parts List. Point-to-point wiring can also be used. Parts-placement diagrams for the analog and digital boards are shown in Figs. 2 and 3, respectively.

You should use sockets for the two DIP IC's, but because of the limited space in the prototype's enclosure, only low-profile sockets would fit. Do not install the IC's in the sockets until instructed to do so. Note that the altimeter's accuracy will suffer if metal-film resistors, where specified, are not used. Also



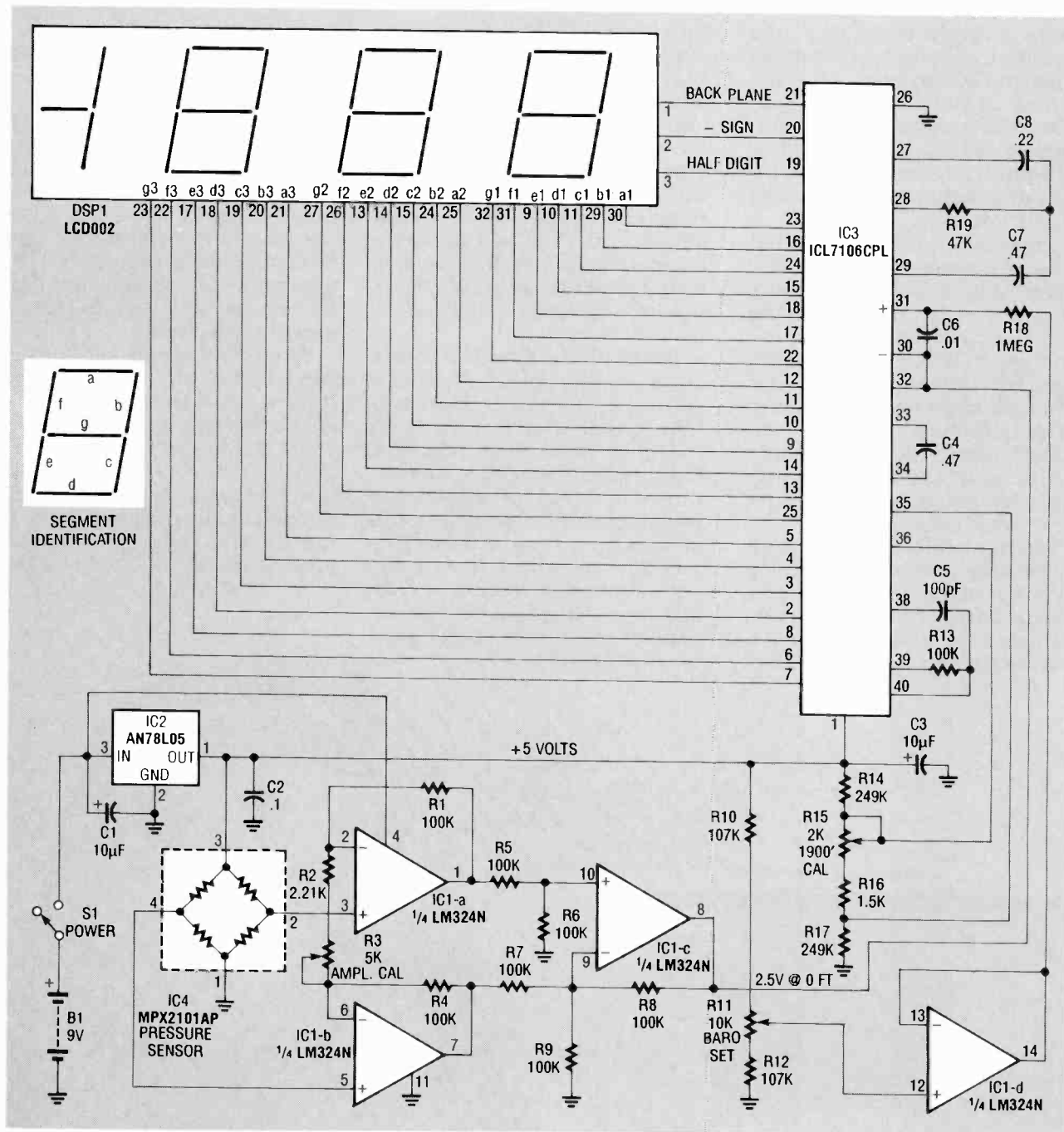


FIG. 1—THE PRESSURE SENSOR (IC4) has an analog output that is converted to digital form by IC3 and then displayed on the LCD.

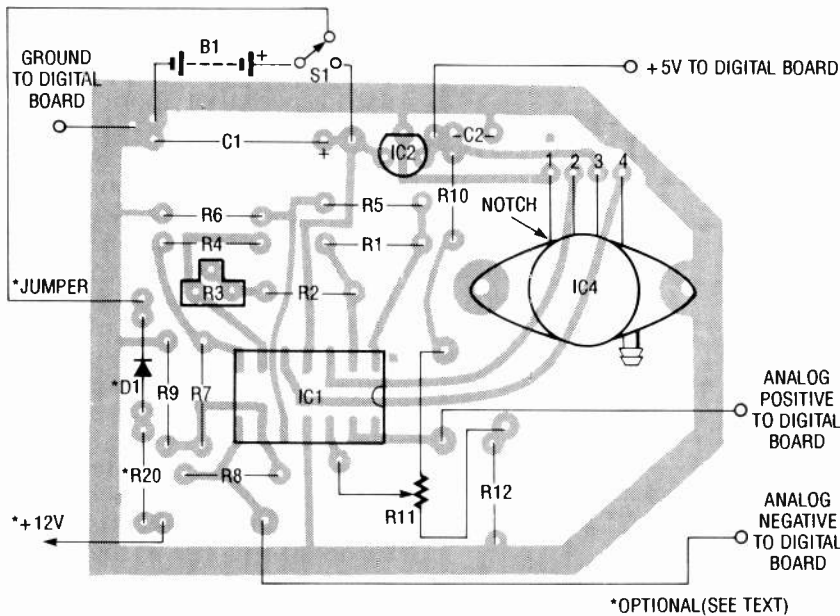
note that R20 and D1 (shown on the analog board in Fig. 2) are to be installed only if you wish to power the unit from a vehicle's 12-volt source.

The pressure sensor should be handled with care. Its leads must be bent at right angles so that the sensor lies flat on the analog board. Use two long-nose pliers when bending the leads—one to prevent stress on the lead where it enters the plastic body and the other to bend

it. Before forming the leads, locate pin 1 of the sensor; it's identified by a notch cut into the lead. Then you'll be able to form the leads in the correct direction. Mounting hardware for the sensor is optional because the leads will hold it in place. No pneumatic connection to the sensor's pressure port is required, except calibration.

The LCD module can also be mounted in a socket if you like; you can make one for it by cut-

ting a 40-pin DIP socket in half lengthwise. To keep the altimeter as compact as possible, the LCD module is mounted on the copper side of the digital board, *after* all of the components are installed on the component side. (You can install a socket for the LCD now, but don't install the LCD just yet.) Mounting the LCD on the copper side allows the digital board to be mounted on the cover of the enclosure.



**FIG. 2—PARTS-PLACEMENT DIAGRAM** for the analog board. Note the components that are optional for 12-volt use. Also note the four connections that must be made to the digital board (see Fig. 3).

Obtain a clip for the 9-volt battery, or salvage a connector taken from an exhausted battery. Be sure to observe proper polarity on the battery connector. Power switch S1 and potentiometer R11 should be installed on the side of the enclosure, easily accessible to the user. If you are dealing with limited space (a small enclosure), use a miniature toggle or slide switch for S1. Once R11 is set, it's best if it can not be accidentally changed during the use of the altimeter. Therefore, R11 should be a screwdriver-adjusted part. If mounting R11 is a problem, the resistor can be epoxied in place next to the power switch. A multiturn potentiometer will make it easier to calibrate the unit.

A number of jumper wires, labelled JU1—JU20, are required on the component side of the digital board to complete the circuit. You must solder a jumper wire between each pair of pads—JU1 to JU1, JU2 to JU2, and so on. Use #24 or #26 insulated stranded wire. Examine both boards carefully for bad solder joints, shorts, and improperly installed components before continuing.

### Final assembly

When both boards are com-

pleted, power, ground, and the two differential output wires from IC1-c and IC1-d must be connected between the analog and digital boards, as indicated in Figs. 2 and 3. Use insulated stranded wire for those connections and be sure to allow sufficient length to permit proper mounting in the enclosure. In the prototype, the boards are placed one above the other.

### 12-volt power

If you want the option of powering the altimeter from a vehicle's 12-volt source, R20 and D1 must be installed on the analog board. To allow operation from either the 9-volt battery or 12-volt source, a miniature jack can be installed in the enclosure to allow connection to the vehicle's electrical system and still allow portable use. Be sure to observe proper polarity when wiring the altimeter for 12-volt operation. You can make a power cable by putting a mini plug on one end and, most likely, an automotive cigarette lighter plug on the other. Just be sure to plug the cable into the altimeter first, to avoid having a live male connector completely exposed.

The altimeter can be wired for 12-volt power exclusively, or as a combination 9- and 12-volt

unit. Follow the wiring diagrams in Figs. 4 and 5 for the selected power-source option. Give the project one final visual inspection before continuing with the checkout. Figure 6 shows the author's prototype.

### Electrical checkout

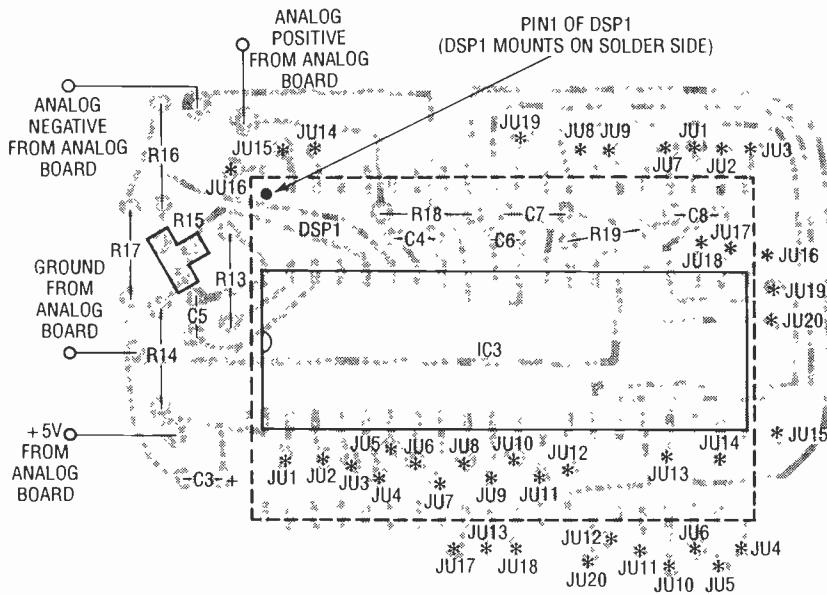
Before proceeding, make sure the IC's are not in the sockets. You'll need an accurate DC voltmeter with an input resistance of at least 1 megohm to perform the checkout.

Use a fresh 9-volt alkaline battery or a well-regulated DC power supply to power the circuit. If the power supply has current-limiting capability, set the limit to 10 milliamps to protect the project in the event of a malfunction. (The normal current drawn by the circuit is about 6½ milliamperes.) Set the supply for 9- or 12-volts output, as applicable.

First, check voltage regulator IC2. Apply power to the circuit and measure its output voltage. Anything between 4.75 and 5.25 volts is good. In case of trouble here, check the orientation of C1 and IC2, and the polarity of the power supply. Measure the terminal voltage of the battery or supply while it is powering the circuit to be sure it is delivering at least 7 volts to the regulator. Disconnect power and measure the resistance between the 5-volt line and ground to be sure there is no short circuit. As a last resort, try a new regulator.

Check the analog circuit next. Insert IC1 into its socket, and apply power to the circuit. Measure the voltage at pin 8 of IC1; adjust R3 for a reading of 2.5 volts. Measure the voltage at pin 14 of IC1 while rotating potentiometer R11 over its range. Make sure the range of adjustment is about 2.4 to 2.6 volts. If you don't see the correct voltages, check the wiring and components associated with IC1. Check the pressure sensor for correct orientation. Try changing IC1 as a last resort.

Disconnect power from the circuit and insert IC3 into its socket. Place the readout in its socket on the solder side of the

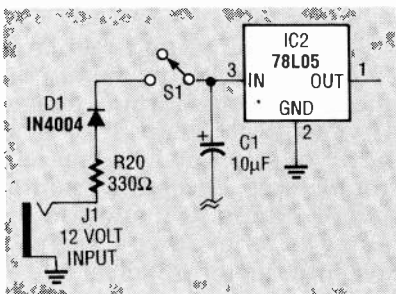


**FIG. 3—PARTS-PLACEMENT DIAGRAM** for the digital board. Note that the LCD module mounts on the solder side of the board after all other components are installed and the board is tested (see text for details). Also note the twenty pairs of pads labelled JU1–JU20. You must solder a jumper wire between each pair of pads; for example, JU1 to JU1, JU2 to JU2, and so on.

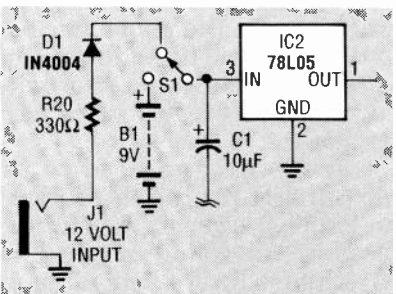
by IC3 at pin 1 of the readout. A normal indication at pin 1 is a 5-volt peak-to-peak square wave with a period of about 140 microseconds.

If the readout displays digits but the numbers do not ascend and descend with adjustment of R11, the fault is most likely with the components or wiring of IC3. Check all parts to be sure they have the correct value. The reference network composed of R14–R17 can be checked by removing IC3 from its socket and measuring the voltage between pins 35 and 36 of the socket while adjusting R15 over its range. Normal indication is 15 to 35 millivolts with pin 36 positive with respect to pin 35.

Operation of IC3 can be checked by removing IC1 from its socket and temporarily shorting pins 8 and 14 of IC1



**FIG. 4—WIRE THE ALTIMETER** as shown here for 12-volt power exclusively.



**FIG. 5—THE ALTIMETER IS SHOWN** wired for both 9- and 12-volt operation.

digital board in accordance with Figs. 3 and 7. If you didn't use a socket for the display, position it so that its terminals are flush with the component side of the board and solder.

With the LCD installed, set R15 to mid position, apply power, and adjust R11 over its range. The display should indicate some number that can be varied via R11 between approxi-



**FIG. 6—HERE'S THE AUTHOR'S PROTOTYPE.** Notice the four wires that connect the analog and digital boards together.

mately -1000 and +1000.

If the display is completely blank, check the orientation of the LCD module and IC3 to be sure that they have not been placed backwards in the circuit. If available, an oscilloscope can be used to verify the presence of the backplane signal generated

socket. That causes the differential input voltage fed to the A/D chip to be zero, and the display should read 000.

Once the display is operating properly, operation of the altimeter can be verified before final calibration. Set R15 to mid position and adjust R11 for a

display of about 20 or 30 feet.

Physically move the altimeter higher and lower to observe the change in altitude reading. Hold the project horizontally or vertically as you make this test; a change from one orientation to the other can cause the read-out to vary 3 or 4 feet, due to gravitational force on the extremely sensitive solid-state pressure sensor.

You should be able to detect and resolve 1 or 2 feet of vertical displacement. It is normal for the display to fluctuate 1 or 2 digits. Additionally, it should be noted that the altimeter is a pressure-sensitive device and will respond to any variation in barometric pressure, in which a change in pressure of only 0.001 inch of mercury at sea level will

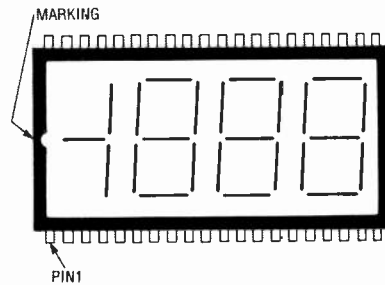


FIG. 7—THE LCD MODULE has a marking similar to that on an IC, indicating where pin 1 is. Note that the module mounts on the solder side of the digital board, so be careful where pin 1 goes.

cause a change of 1 foot in the altitude reading.

Even though the resolution of the instrument is 1 foot, the altimeter will not have either the accuracy or stability to indicate altitude that accurately.

## PARTS LIST

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

- R1, R4–R9—100,000 ohms, 1% metal film
- R2—2210 ohms, 1% metal film
- R3—5000 ohms, cermet PC-mount potentiometer
- R10, R12—107,000 ohms, 1% metal film
- R11—10,000 ohms, PC-mount potentiometer, screwdriver adjust
- R13—100,000 ohms
- R14, R17—249,000, 1% metal film
- R15—2000 ohms, cermet PC-mount potentiometer
- R16—1500 ohms, 1% metal film
- R18—1 megohm
- R19—47,000 ohms
- R20—330 ohms (optional for 12-volt operation)

### Capacitors

- C1—10  $\mu$ F, 25 volts, axial electrolytic
- C2—0.1  $\mu$ F, 50 volts, ceramic disc
- C3—10  $\mu$ F, 25 volts, radial electrolytic
- C4, C7—0.47  $\mu$ F, 50 volts, metal film
- C5—100 pF, 50 volts, ceramic disc
- C6—0.01  $\mu$ F, 50 volts, ceramic disc
- C8—0.22  $\mu$ F, 50 volts, metal film

### Semiconductors

- IC1—LM324N quad op-amp
- IC2—AN78L05 5-volt regulator
- IC3—ICL7106CPL A/D converter (Intersil)
- IC4—MPX2101AP semiconductor

pressure sensor, 15 PSI absolute (Motorola)

- D1—1N4004 silicon diode (optional for 12-volt operation)
- DSP1—3 1/2-digit LCD module (DigKey LCD002)

### Other components

- J1—Miniature jack (optional for 12-volt operation—also requires matching plug)
- S1—SPDT miniature slide or toggle switch
- B1—9-volt transistor battery, alkaline or heavy duty

**Miscellaneous:** 9-volt battery clip, IC sockets, #24 gauge stranded hookup wire, enclosure, hardware, plastic tubing, tee fitting, clamp, soda or wine bottle, food coloring, solder, etc.

**Note:** The following parts are available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463:

- Set of 2 etched and drilled PC boards (analog and digital)—\$19.95
  - LM324N op-amp (IC1)—\$2.00
  - AN78L05 regulator (IC2)—\$1.50
  - ICL7106CPL A/D converter (IC3)—\$17.50
  - MPX2101AP pressure sensor (IC4)—\$39.50
  - Set of 13 metal-film resistors—\$4.95
- Please add \$2.75 postage/handling.

## Final calibration

To perform the final circuit adjustment, you will need a tape measure, three lengths of 1/4-inch outside diameter clear plastic tubing, a tee for a three-way connection, and a clear plastic or glass bottle of clean drinking water. A soda or wine bottle is a good choice. Be sure that the inner diameter of the plastic tubing allows it to be stretched over the pressure port of the sensor for an airtight seal. The suggested test setup is shown in Fig. 8.

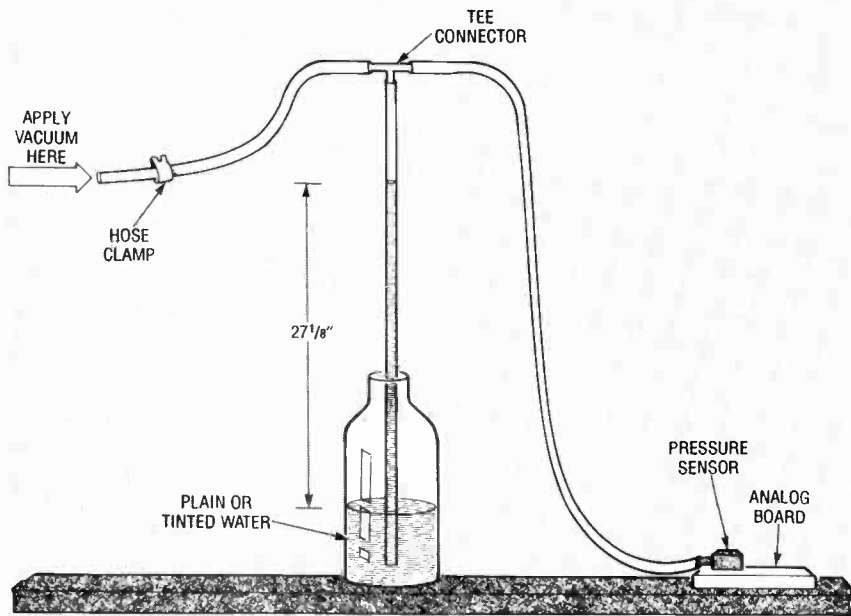
In this procedure, the absolute pressure that represents 1900 feet of altitude will be simulated by drawing a partial vacuum to cause a column of water to rise in the straight, clear tube. This procedure uses basic laws of physics to set a desired pressure differential.

As noted earlier, absolute air pressure, under standard conditions, is 14.696 PSI at zero altitude (sea level). At 1900 feet, the pressure falls to 13.716 PSI. The pressure levels can also be specified in other units such as inches of mercury or inches of water. In this case, the desired pressure differential between zero altitude and 1900 feet, 0.98 PSI, is equivalent to 27.13 inches of water, rounded out to 27 1/8 inches. Thus, to simulate the change in pressure from zero to 1900 feet, a column of water 27 1/8 inches high can be used.

Set up the altimeter and apparatus as shown in Fig. 8. In this test, the water in the vertical tube is drawn up to the required height of 27 1/8 inches by drawing a vacuum at the open end of the tubing.

With no vacuum applied to the open end of the plastic tube and the pressure sensor connected as shown in Fig. 8, turn on the altimeter and allow a minute for the circuit to stabilize. Adjust R11 for an altitude reading of some small positive number, such as 50 feet or so. The number selected is not significant.

Now, gently draw vacuum at the open end of the tubing so that the column of water rises 27 1/8 inches above the level of



**FIG. 8—CALIBRATION SETUP.** You will need a tape measure, clear plastic tubing, a tee connector, and a clear bottle with water in it. Food coloring will make the water easier to see. See text for details.

water in the bottle. You can clamp the hose to maintain the required vacuum. Make sure you have a solid column of water with no air bubbles in it. Allow the display to reach a stable level and note the reading. Adjust

### Using the altimeter

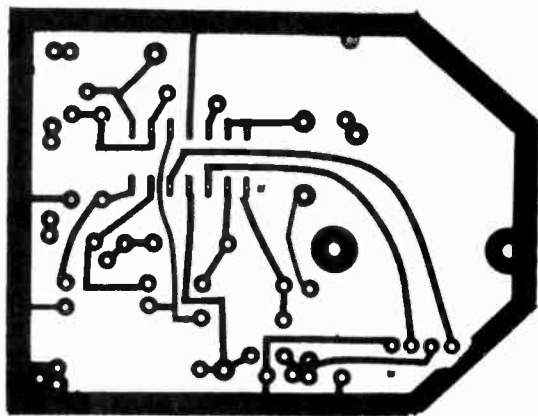
Since the altimeter is subject to the variations of barometric readings, the instrument must always be corrected for the current barometric pressure before starting out on an excursion.

such as an airport where the altitude is documented, setting the altimeter to reflect the correct altitude, and then returning home immediately. The reading of the altimeter at your home will then be your reference altitude. For best accuracy, do this during a period of steady barometric pressure conditions.

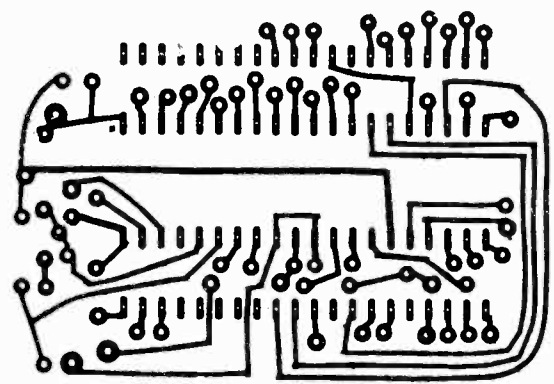
For future use, before leaving home with the altimeter, simply turn it on and allow a minute or so for the display to stabilize. Then set R11 so that the reading is equal to the reference altitude at your home.

Once set, do not readjust R11 since you will have no reference against which to adjust it. At a later time, if you travel to another location with a known altitude, R11 can be readjusted to reflect a more accurate altitude if the barometric reading has changed since the original setting of R11.

When taking an altitude reading, turn the unit on and allow about a minute for the circuit to stabilize. Remember, if there is a sudden change in air pressure such as might occur with a changing weather, the reading



**FOIL PATTERN** for the analog board.



**FOIL PATTERN** for the digital board.

R15 so that the display indicates 1900 feet more than the original reading (50 feet) set previously.

Repeat the above test as necessary until you are satisfied that the change in altimeter reading is as close to 1900 feet as possible when the water column is drawn up 27 1/8 inches. This completes calibration.

You do not have to know the actual barometric reading to do this. Simply turn the unit on, allow a minute for the circuit to stabilize, and set R11 to obtain a display that represents the known existing altitude at your location.

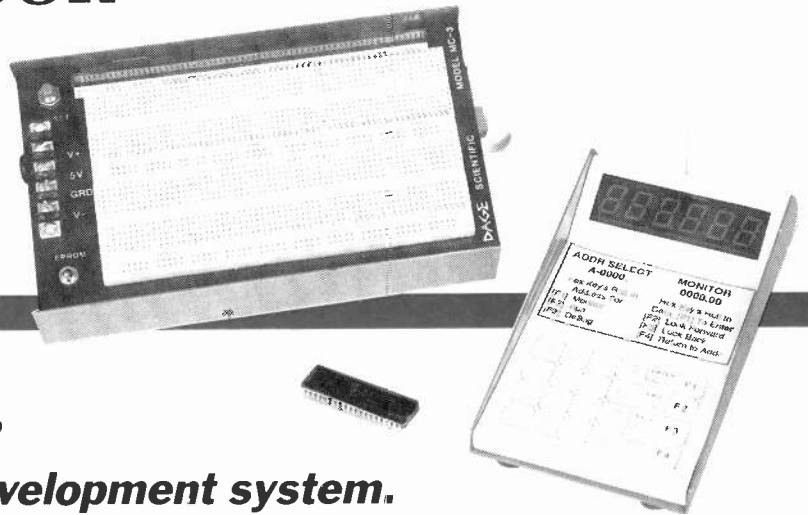
Learning the true altitude of your home can be done by taking the altimeter to a location

can fluctuate. Wait for the display to settle down.

Be sure to turn off your battery-powered altimeter when not taking altitude readings. That will conserve power and provide extremely long battery life, which should be about 10 or 15 hours of altimeter operating time when using an alkaline battery.

R-E

# BUILD THIS MICROPROCESSOR DEVELOPMENT SYSTEM



## Construction details for our inexpensive 1802 microprocessor development system.

LAST TIME WE DISCUSSED THE CIRCUITRY for our 1802 development system and described how the software functions. This time we'll talk about construction and operation.

### Construction

The complete unit uses three PC boards, corresponding to the sections of the circuit (main, keypad/display, EPROM). Foil patterns are provided if you want to make your own boards; boards and kits are also available commercially (see the parts list).

The main chassis measures 8" × 4.6" × 1.5". As shown in Fig. 7, S1 (reset) and S2 (EPROM power) mount on top of the chassis, as does a four-conductor terminal block that brings several voltage sources out of the chassis for use by experimental circuits (developed on the breadboard). In addition, there is space for two 63-row solderless breadboards, and two 63-row power buses. Further, the rear edge of the case is slotted to allow the pins of P3 to protrude.

The power supply enters one

side of the chassis through a grommet; the 6-wire telephone jack for the keypad/display unit fits in a slot on the other side.

### Main board

Mount all parts on the main PC board, as shown in Fig. 8. Resistors R13–R24 must be 1/8-watt units in order to mount on 0.3" centers. All other resistors mount on 0.4" centers. Sockets should be used in all IC positions, and are required for IC20 (the EPROM burner slot) and IC22 (the EPROM that contains the operating system). You can buy a pre-programmed EPROM (see the ordering information in the parts list for details) or burn your own using the hex dump shown in Listing 1.

The operating system requires the first output port, IC2. The other output ports can be installed during assembly, or as the need arises. In addition, you can eliminate IC3–IC13 if you don't need parallel inputs. The author recommends that you install at least two output ports (IC2 and IC3) and two input ports (IC8 and IC9).

You must install the operating-system EPROM at IC22 (0000h), and 8K of RAM at IC19 (E000h). You needn't install additional components at IC20 and IC21 unless you need additional memory.

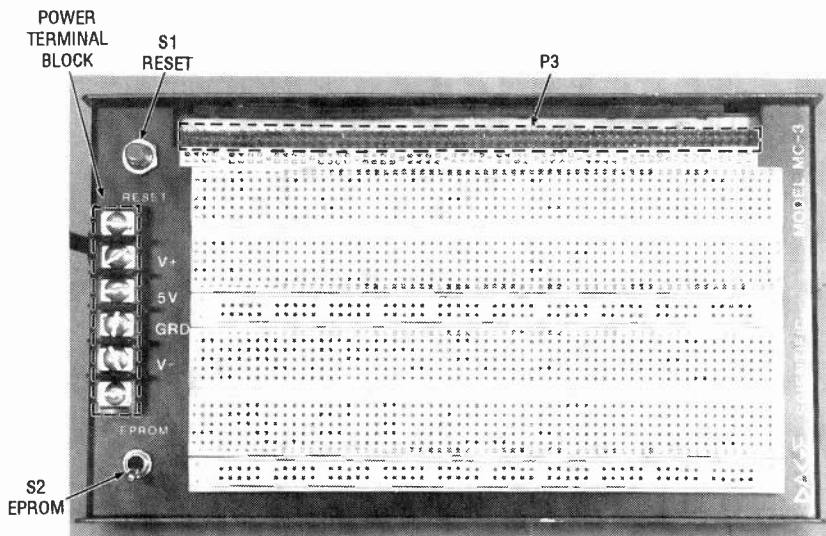


FIG. 7—MAIN CHASSIS ASSEMBLY. The terminal block on the left delivers power to breadboard circuits. Note that P3 consists of separate wire-wrap pins that protrude through a slot in the case.

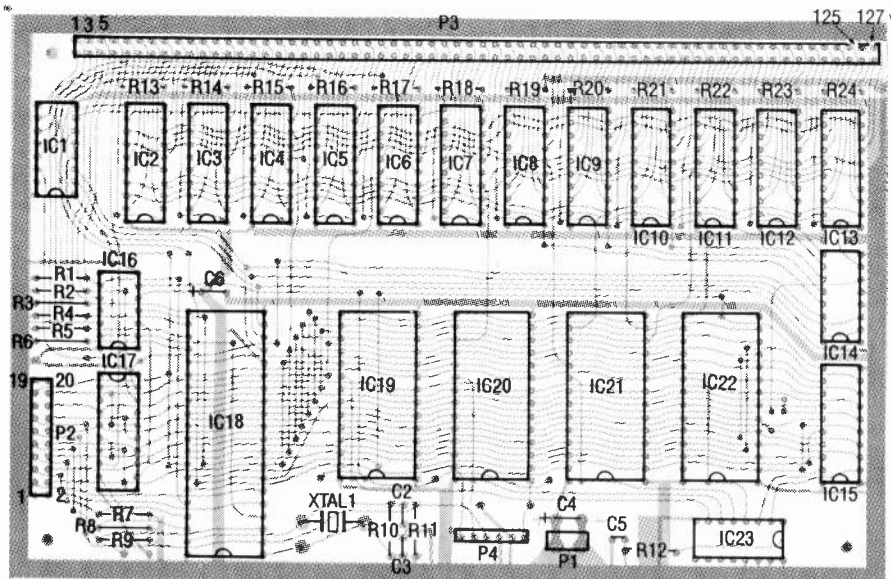


FIG. 8—MAIN PC BOARD. Note that R13–R24 must be 1/8-watt units to fit in the available space. Sockets are required for IC20 and IC22, and optional but recommended elsewhere.

The bus connector (P3) consists of 128 individual wire-wrap pins, each measuring 0.075". The best way to install them is to insert them through the board and into a female header to hold them perpendicular while soldering. Figure 9 details the function of each pin.

Connect one wire from ground to the reset switch, and another to the pad marked *reset* on the main board. Figure 10 shows the completed main board.

### Keypad/display assembly

Assemble the keypad/display unit as shown in Fig. 11. Mount the IC's without sockets, as there is not enough clearance to use them. However, mount each display using half a socket under the rear row of pins only. Doing so angles the display about 20 degrees for better viewing. The pull-down resistors for the key switches must be 1/8-watt units to fit the 0.3-inch mounting centers.

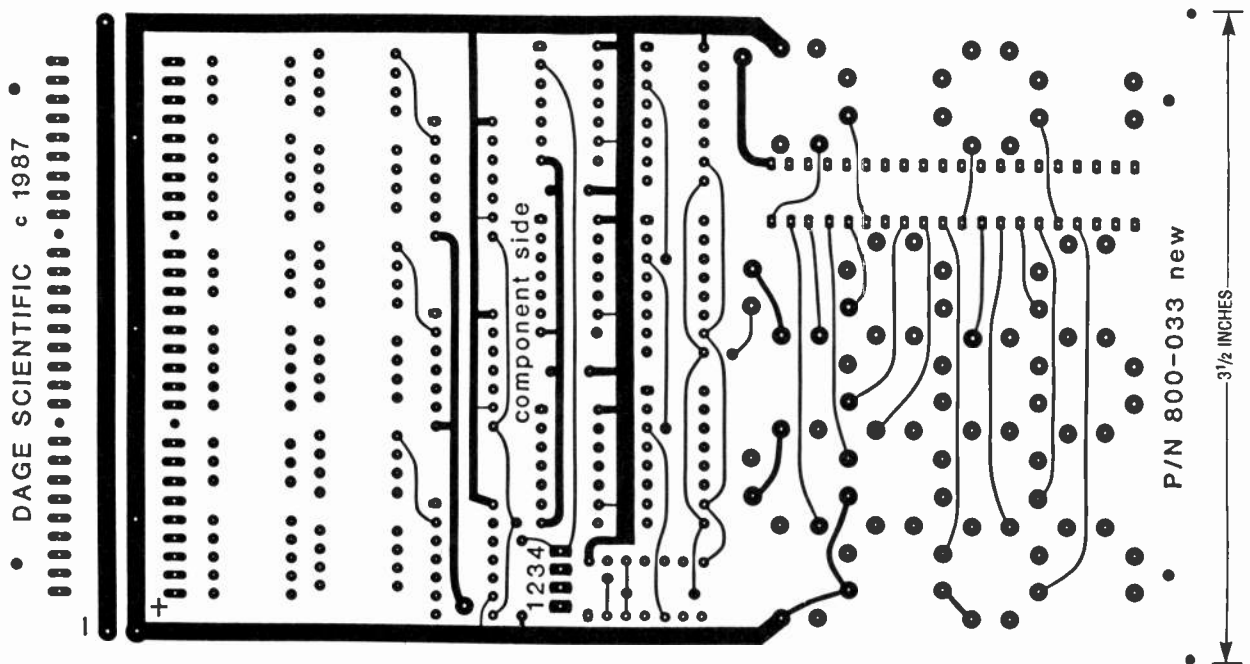
The six-conductor telephone cord connects directly to the foil

side of the board, as shown in Fig. 12; secure the cord with a nylon wire wrap. The other end of the cord has a modular plug that fits into J1 on the main board. The color codes in phone cords and connectors seem to vary, so we haven't provided specific details. It doesn't matter which color you use for which signal; just make sure that you're consistent at both ends of the cable. Figure 13 shows the completed keypad/display board.

### EPROM board assembly

Assemble the EPROM board as shown in Fig. 14. Mount a six-pin female connector (J1) on the solder side of the board; it will mate with P4 on the main board, and serves to hold the EPROM board in place. The completed EPROM board is shown in Fig. 15. When mounted properly, the EPROM board rides about 1/2" above the EPROM that is being programmed (see Fig. 16). In front of this connector are two solder pads used to connect the EPROM programming voltage. Connect the ground side (gnd) only if the programming voltage doesn't have a common ground with the main board.

In case you want to install RAM in IC20, remove the EPROM circuit; otherwise every



COMPONENT SIDE OF THE KEYPAD/DISPLAY BOARD.



LISTING 1—HEX DUMP OF OPERATING SYSTEM (0000—04FF)

```

0000 71 00 F8 00 B3 F8 09 A3 D3 F8 FE B2 F8 FF A2 E2
0010 F8 00 B4 F8 60 A4 F8 00 B5 F8 70 A5 F8 00 B8 F8
0020 91 A8 34 3A E3 62 00 62 01 E2 D8 69 FB FF 3A 3D
0030 D8 D8 69 FA F0 C2 02 24 30 52 C0 04 A1 F8 00 52
0040 62 22 F8 06 A7 F8 00 52 7B 61 D8 22 27 87 3A 45
0050 30 22 FF FF FF FF FF FF FF FF C0 E0 00 D3
0060 E2 96 73 86 73 93 B6 83 A6 46 B3 46 A3 30 5F D3
0070 96 B3 86 A3 E2 12 72 A6 F0 B6 30 6F FF FF FF FF
0080 21 7D 13 19 4D 89 81 3D 01 0D 05 C1 A3 51 83 87
0090 D3 7B 7A 7B 7A 7B 7A 7B 7A 7B 7A 7B 7A 7B 7A
00A0 7A 30 90 99 B6 89 A6 D5 FF D4 00 CE 46 B8 46 A8
00B0 46 B9 46 A9 46 A7 46 32 C3 E9 08 28 73 27 87 3A
00C0 BA 30 CA 48 59 19 27 87 3A C3 D4 00 EE D5 87 73
00D0 97 52 60 60 60 02 A7 22 02 B7 22 22 22 89 73 99
00E0 73 8A 73 9A 73 88 73 98 73 87 73 97 73 D5 60 42
00F0 B7 42 A7 42 B8 42 A8 42 BA 42 AA 42 B9 42 A9 60

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0100 60 60 87 73 97 73 22 42 B7 02 A7 D5 87 73 97 73
0110 88 73 98 73 F8 00 B8 F8 91 A8 F8 02 B7 A7 27 97
0120 3A IE F8 00 52 62 22 F8 01 52 62 22 D8 69 FB FF
0130 3A 22 D8 69 FB FF 3A 22 D8 69 FB FF FA OF 3A 22
0140 F8 10 B7 27 97 3A 43 F8 00 AA F8 00 52 62 22 F8
0150 01 52 62 22 D8 69 FB FF 3A 78 F8 08 AA D8 69 FB
0160 FF 3A 78 D8 69 FB FF FA OF 32 47 F9 80 AA 60 72
0170 B8 72 A8 72 B7 F0 A7 D5 F6 33 6E 1A 30 78 FF FF
0180 88 73 98 52 F8 FF B8 F8 F0 A8 F8 05 58 18 F8 DF
0190 58 18 99 F6 F6 F6 F6 BA D4 02 09 9A 58 18 99 BA
01A0 D4 02 09 9A 58 18 99 F6 F6 F6 BA D4 02 09 9A
01B0 58 18 89 BA D4 02 09 9A FF 01 58 18 09 F6 F6 F6
01C0 F6 BA D4 02 09 9A 58 18 09 BA D4 02 09 9A 58 09
01D0 BA 72 B8 F0 A8 D5 87 73 88 73 98 73 89 73 99 73
01E0 E6 72 B9 72 A9 E2 F8 00 B8 F8 91 A8 F8 00 52 62
01F0 22 F8 06 A7 E9 7B 61 D8 27 87 3A F5 E2 60 72 B9

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0200 72 A9 72 B8 72 A8 F0 A7 D5 88 73 98 52 F8 00 B8
0210 F8 80 A8 9A FA OF 32 1D FF 01 18 30 16 08 BA 72
0220 B8 F0 A8 D5 F8 00 B9 A9 D4 01 80 D4 01 D6 FF F0
0230 D4 01 0C 8A 52 FE 33 A4 F8 04 A7 89 FE A9 99 7E
0240 B9 27 87 3A 3B 89 F1 A9 30 28 8A F6 33 5C F6 33
0250 56 F6 33 A0 30 24 D4 00 A3 D4 01 80 09 73 D4 01
0260 D6 FF F2 D4 01 0C 60 8A FE 33 88 F8 FF B8 F8 F7
0270 A8 02 FE FE FE FE 52 8A F1 52 08 28 58 18 02 22
0280 BA D4 02 09 9A 58 30 5E 8A F6 33 94 F6 33 9A F6
0290 33 9C 30 24 02 59 09 F3 3A 59 19 38 29 30 59 FF
02A0 F8 02 B1 F8 C8 A1 F8 FF B8 F8 FA A8 E8 49 73 49
02B0 73 09 73 E9 F8 D1 73 F8 79 73 F8 22 73 30 24 FF
02C0 42 70 22 78 22 52 30 D8 52 F8 FF B0 F8 F9 A0 F0
02D0 73 40 73 40 73 40 73 60 E2 92 B0 82 A0 22 F8 00
02E0 7E 73 F6 C5 F8 01 73 10 10 80 73 90 73 20 83 73
02F0 93 73 84 73 94 73 85 73 95 73 86 73 96 73 78 73

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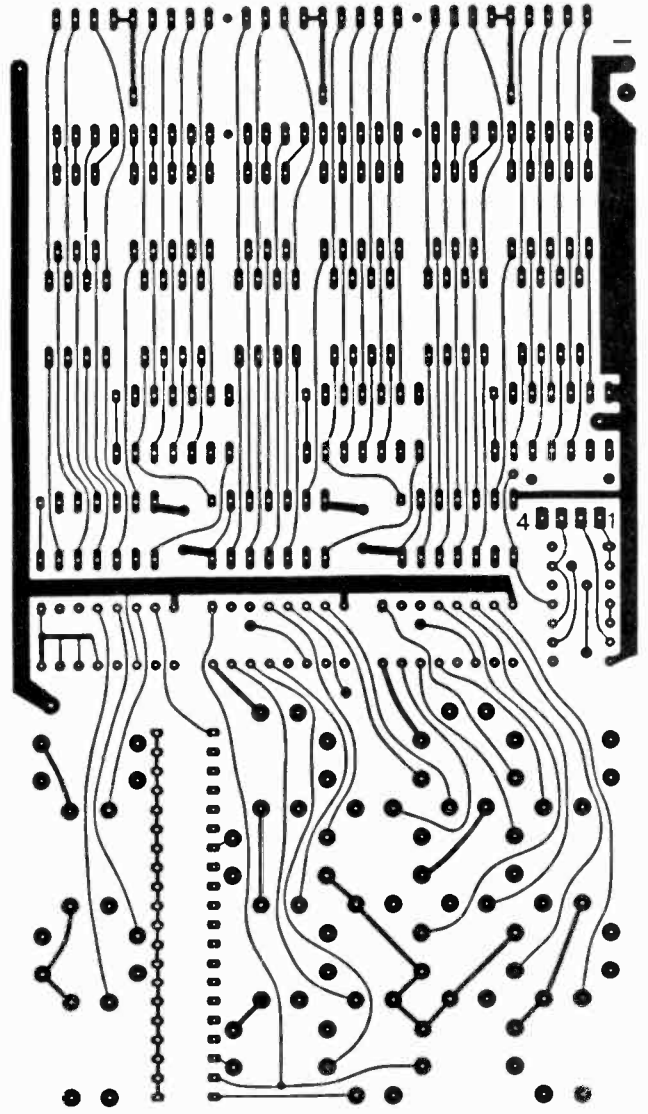
0300 97 73 88 73 98 73 89 73 99 73 8A 73 9A 73 8B 73
0310 9B 73 8C 73 9C 73 8D 73 9D 73 8E 73 9E 73 8F 73
0320 9F 73 F8 03 B3 F8 29 A3 D3 80 AF 90 BF 0F 8A 0F
0330 AA B7 30 3B D4 01 0C 8A FE 33 59 90 BF 80 AF 8A
0340 B7 32 49 2F 2F 2A 8A 30 41 0F A9 2F 0F B9 1F D4
0350 01 80 D4 01 D6 FF F2 30 34 8A F6 33 98 F6 33 98
0360 F6 33 66 C0 00 09 D4 01 0C 8A FE 33 89 F8 04 A7
0370 89 FE A9 99 7E B9 27 87 3A 70 8A 52 89 F1 A9 D4
0380 01 80 D4 01 D6 FF F2 30 66 8A F6 3B 93 89 5F 2F
0390 99 5F 1F 97 AA 30 3B FF F8 03 B1 F8 9F A1 D1 F8
03A0 1F A7 20 27 87 3A A2 40 BF 40 AF 40 BE 40 AE 40
03B0 BD 40 AD 40 BC 40 AC 40 BB 40 AB 40 BA 40 AA 40
03C0 B9 40 A9 40 B8 40 A8 40 B7 40 A7 40 B6 40 A6 40
03D0 B5 40 A5 40 B4 40 A4 40 B3 40 A3 40 B2 40 A2 40
03E0 7A CE A4 7B 40 F6 22 22 C0 02 C0 FF FF 46 BB
03F0 46 AB 16 E6 F5 A7 26 9B 75 16 B7 17 FR 00 BD

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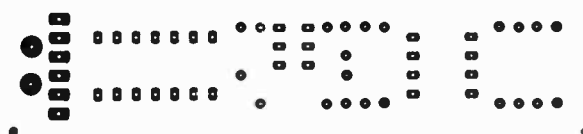
0400 AD AC EB 97 3A 09 87 32 13 8C F4 AC C7 1D C4 27
0410 1B 30 03 8C A9 8D B9 D4 01 80 F8 FF BE F8 F0 AE
0420 9D F6 F6 F6 F6 BA D4 02 09 9A 5E 1E 9D BA D4 02
0430 09 A7 5E D4 01 D6 FF F0 D5 46 BB 46 AB 16 E6 F5
0440 A9 26 9B 75 B9 19 16 16 46 BC 46 AC 99 3A 52 89
0450 32 6A 0B 5C D4 01 80 D4 01 D6 FF F0 EC 0B F3 3A
0460 66 1B 1C 29 30 4C 9C B9 8C A9 D4 01 80 D4 01 D6
0470 FF F0 D5 46 B7 46 A7 27 17 27 87 C4 C4 3A 77 97
0480 27 17 27 C4 C4 3A 77 D5 D4 04 39 04 88 04 A0 FF
0490 00 D4 01 0C C0 02 24 FF D4 03 EE 00 00 00 00 30
04A0 A9 7B F8 40 B7 57 F8 80 B7 07 7A F8 C0 B7 57 34
04B0 A1 F8 FE B2 A2 12 E2 69 22 6A 22 6B 22 6C 22 6D
04C0 22 6E 22 7B 7A 6F 67 66 65 64 63 62 61 22 3D B7
04D0 F8 00 B8 F8 91 A8 E3 7B E2 01 62 00 61 55 D8 E2
04E0 3E D6 F8 00 B8 F8 91 A8 E3 62 00 62 01 E2 D8 69
04F0 22 F8 00 52 62 7B 61 22 D8 3F E8 FF FF FF FF FF

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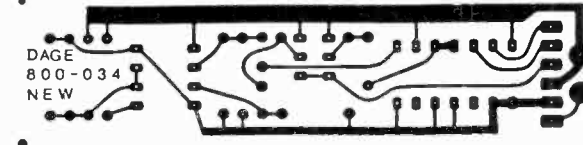
3 1/2 INCHES

SOLDER SIDE OF THE KEYPAD/DISPLAY BOARD.



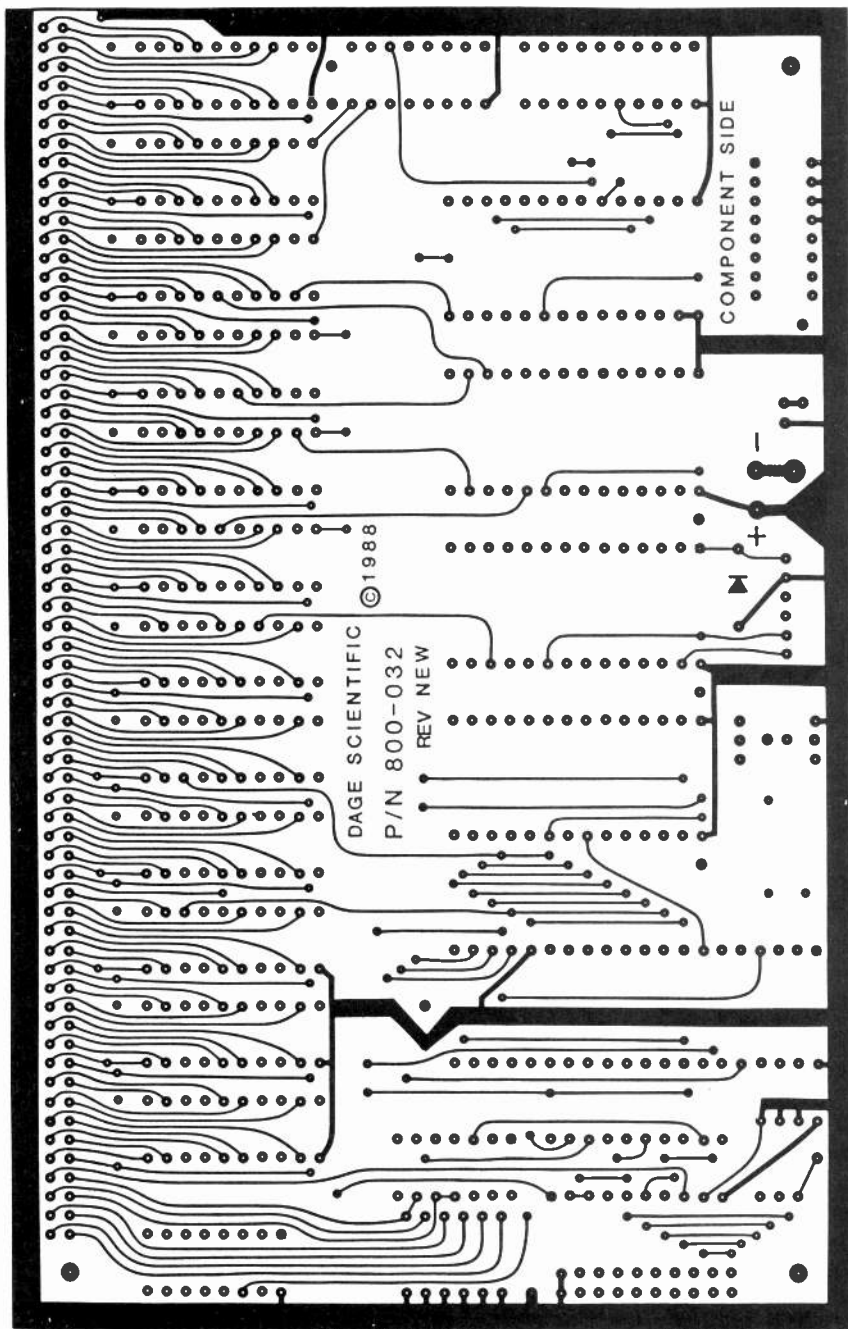
3 INCHES

COMPONENT SIDE OF THE EPROM BOARD.



3 INCHES

SOLDER SIDE OF THE EPROM BOARD.



COMPONENT SIDE OF THE MAIN PC BOARD.

access to that location will incur a 50-ms delay.

After assembling each board, check all work, and correct any mistakes. Then apply power, and hold down the 0 key. If all is well, all segments and decimal points of the display should light up. If they do not, remove power and check all connections again.

Electronic construction is complete; now you can mount

the boards in their proper chassis locations.

### Operation

Boot up normally; the display should read "A-0000." The "A" indicates Address Select mode; the zeros indicate the current address.

Actually, the monitor program has four modes: Address Select, Memory Monitor, Run, and Debug.

### PARTS LIST—MAIN BOARD

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

- R1, R3-R8, R11, R12—1000 ohms
- R2—150,000 ohms
- R9—30,000 ohms
- R10—22 megohms
- R13-R24—51,000 ohms, 1/8 watt

#### Capacitors

- C1—1  $\mu$ F, 35 volts, tantalum
- C2, C3—20 pF, ceramic
- C4—10  $\mu$ F, 25 volts, tantalum
- C5, C6—0.1  $\mu$ F, mini ceramic

#### Semiconductors

- IC1—74HC238 3-to-8 line decoder
- IC2-IC13—74HC373 octal D latch
- IC14—74HC138 3-to-8 line decoder
- IC15—74HC373 octal D latch
- IC16—74HC86 quad 2-input XOR gate
- IC17—74HC299 8-bit shift register
- IC18—1802 microprocessor
- IC19—6264 static RAM
- IC20—see text
- IC21—see text
- IC22—2764 EPROM (with operating system)
- IC23—4556 dual 1-of-4 decoder

#### Other components

- XTAL1—2.010 MHz crystal
- P1-P4—wire-wrap pins, 0.025" square  $\times$  0.75"
- J1—6-conductor telephone jack

### PARTS LIST—KEYPAD/DISPLAY BOARD

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

- R1-R20—51,000 ohms, 1/8-watt
- R21-R68—330 ohms
- R69—100,000 ohms

#### Semiconductors

- IC1-IC6—74HC164 8-bit shift register
- IC7—74HC00 quad 2-input NAND gate
- IC8-IC10—4021 8-bit shift register

#### Other components

- DS1-DS3—dual 7-segment LED display, 0.5", common anode
- S1-S20—SPST, normally open, push-button, PC mount

When the display shows "A-," the monitor is in the Address Select mode. Any time the operating system is in control, pressing F4 returns you to Address Select mode.

To enter a new address, just press the corresponding keys. The digits you enter scroll from right to left; if you make a mistake, simply enter new digits until you see correct address displayed.

After entering the desired address, you have three choices, with corresponding keys:

## PARTS LIST—EPROM BOARD

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

R1, R4—22 megohms

R2—47,000 ohms

R3—100,000 ohms

### Capacitors

C1—0.001  $\mu$ F, Mylar

C2—100 pF, ceramic

C3—0.001  $\mu$ F, Mylar

C4—0.02  $\mu$ F, 5%, Mylar

C5—0.1  $\mu$ F, ceramic

### Semiconductors

IC1—74HC02 quad 2-input NOR gate

IC2—555 timer

D1—1N4148 diode

Q1, Q2—2N4124 NPN transistor

**Miscellaneous:** Chassis & hardware, power supply, telephone cord & connectors, terminal block, toggle switch, push button switch, solderless breadboarding connectors, PC boards.

**Note:** The following items are available from Dage Scientific, 6124 Baldwin St., Valley Springs, CA 95252 (209) 772-2076:

- Kit including everything but power supply (Model MC-2)—\$195

- Surplus power supply (+12, +5, -5)—\$11

- Operating system in EPROM—\$10

- Set of 3 PC boards and manual—\$35

Please add \$5 shipping & handling per order. California residents add applicable sales tax.

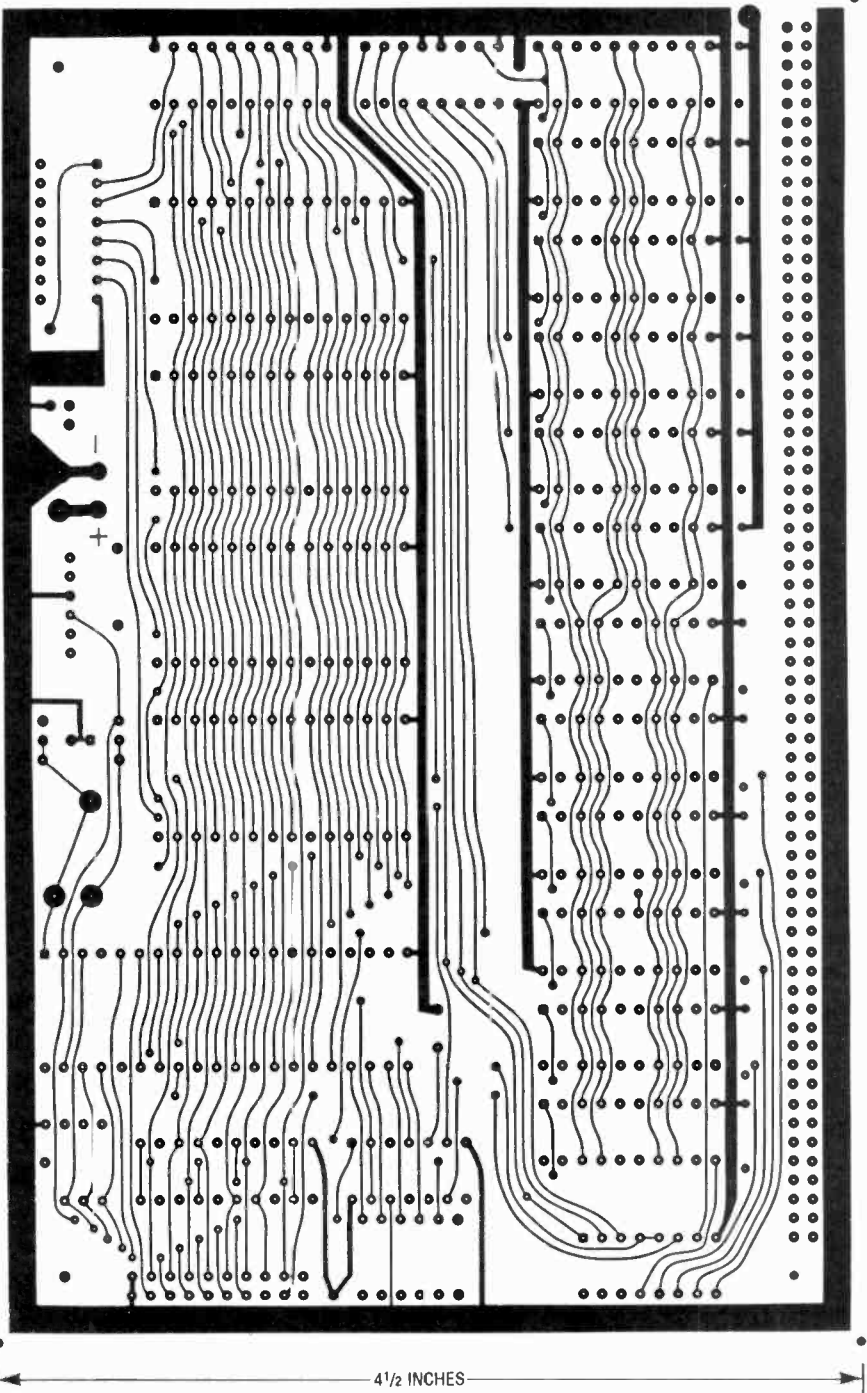
Monitor (F1), Run (F2), and Debug (F3).

Monitor mode allows you to examine and modify memory contents on a byte-by-byte basis. Run mode lets the CPU execute the program at the current address. Debug mode inserts a breakpoint at the current address.

To enter Monitor mode, type the desired address and press F1. That address and its contents will appear. For example, 0000.FF indicates a hexadecimal value of FF at address 0000h.

In this mode, the function keys take on new meanings. F1 stores the currently displayed value into the currently displayed address and moves on to the next address. F2 displays the next address. F3 displays the previous address.

To change the currently displayed value, use the hex keys to roll new digits into positions 5 and 6. If you make a mistake, simply enter new digits until



SOLDER SIDE OF THE MAIN PC BOARD.

the correct value appears. Memory contents will not be altered until you press F1. When you do press F1, the currently displayed value will be stored at the displayed address, and the next address will be displayed. If the value can not be stored into memory, the address counter will not increment. (It's possible to program values one byte at a time into an EPROM using that procedure, but there's a better

way, as discussed below.) And remember: Press F4 at any time to return to Address Select mode.

After storing a program in memory, you can execute it using the Run command. Starting from Address Select mode, enter the desired starting address and press F2. The monitor program then transfers control to your program. If your program hangs, press the

P3 COMPONENT SIDE

TOP PIN#	1-7	9-17	19-27	29-37	39-47	49-57	59-67	69-77	79-87	89-97	99-107	109-17	119-27
J3	SER. FLAG	#2 OUT	#3 OUT	#4 OUT	#5 OUT	#6 OUT	#7 OUT	#A IN	#B IN	#C IN	#D IN	#E IN	#F IN
BOT PIN#	2-8	10-18	20-28	30-38	40-48	50-58	60-68	70-78	80-88	90-98	100-08	110-18	120-28

EF2	EF4	SERIAL IN	SERIAL OUT
EF1	EF3	Q CLK	INTERRUPT

SERIAL I/O AND FLAGS

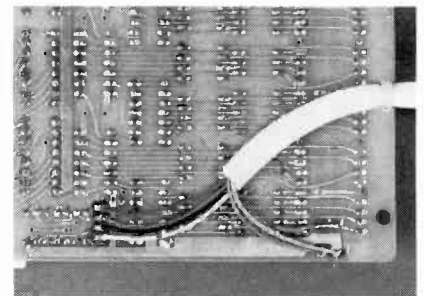
DATA READY	D1	D3	D5	D7
DATA ENABLE	D0	D2	D4	D6

TYPICAL OUTPUT PORT

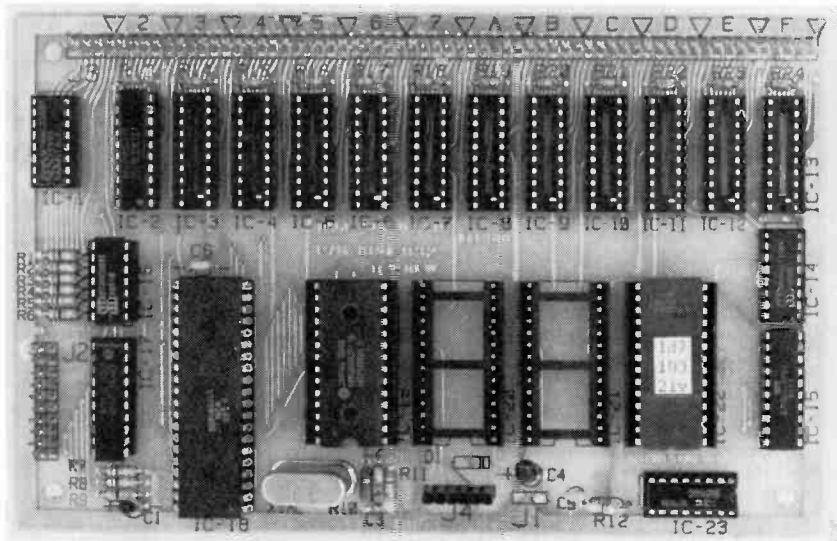
LATCH IN	D1	D3	D5	D7
DATA RCVD	D0	D2	D4	D6

TYPICAL INPUT PORT

**FIG. 9—PLUG P3 CONNECTIONS.** The 128 pins of P3 consist of one group of 8 pins (for serial I/O, EF flags, Q clock, and interrupt) and 12 groups of 10 pins each. Those 12 groups break down into six input ports and six output ports, each with pinouts as shown.



**FIG. 12—PHONE CABLE connections.** Solder the wires directly to the foil side of the board.



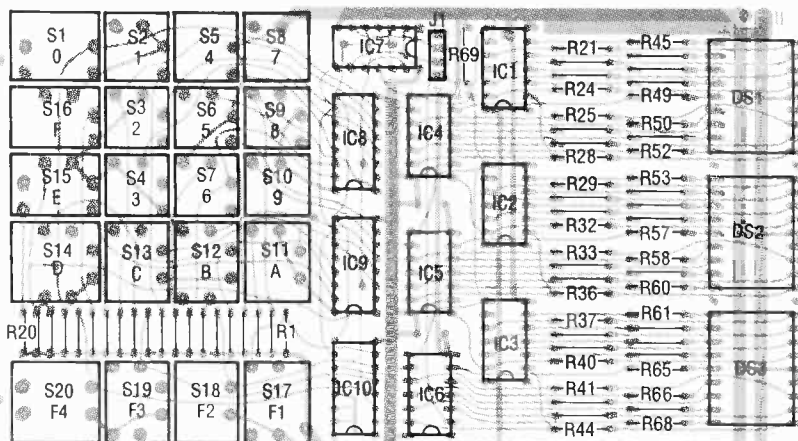
**FIG. 10—THE COMPLETED MAIN BOARD.** Sockets should be used in all IC positions, and are required for IC20 (the EPROM burner slot) and IC22 (the EPROM that contains the operating system).

reset switch to regain monitor control.

In case your program doesn't work the first time, you can use Debug mode to track down problems. Use Address Select mode to select a likely address for troubleshooting and press F3. You'll return to Address Select mode. Now enter the desired starting address and press F2. Later, when the CPU hits the breakpoint address, it will start executing a special debug program that allows you to view the CPU's internal registers, and to verify that what you intended to happen is indeed happening.

You can set only one breakpoint at a time; you cannot breakpoint addresses in ROM. When your program reaches the breakpoint, it will halt and display the current address. You are now in the Debug mode.

In Debug mode, the display appears the same as in Monitor mode. However, as you press the hex keys the display will show the internal register number (in positions 1-4) and the value in



**FIG. 11—KEYPAD/DISPLAY PC BOARD.** Mount all parts as shown here. If you use our case, don't use IC sockets except under the rear row of display pins.

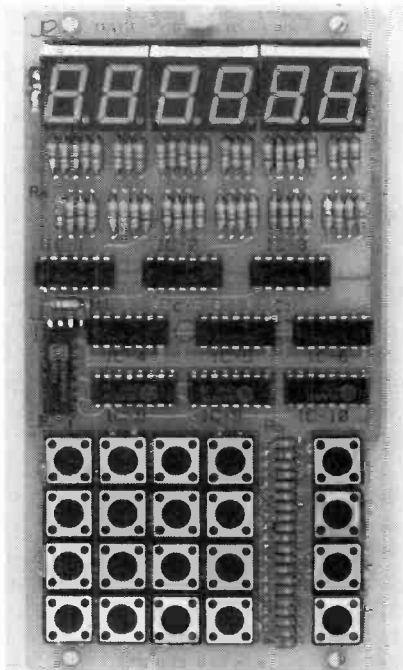


FIG. 13—COMPLETED KEYPAD/DISPLAY board. Mount each display using half a socket under the rear row of pins only, to provide better viewing.



FIG. 14—EPROM PC BOARD. Mount all parts except J1 on the component side of the board; mount J1 on the foil side.



FIG. 15—THE COMPLETED EPROM board. A six-pin female connector (J1) on the solder side mates with P4 on the main board.

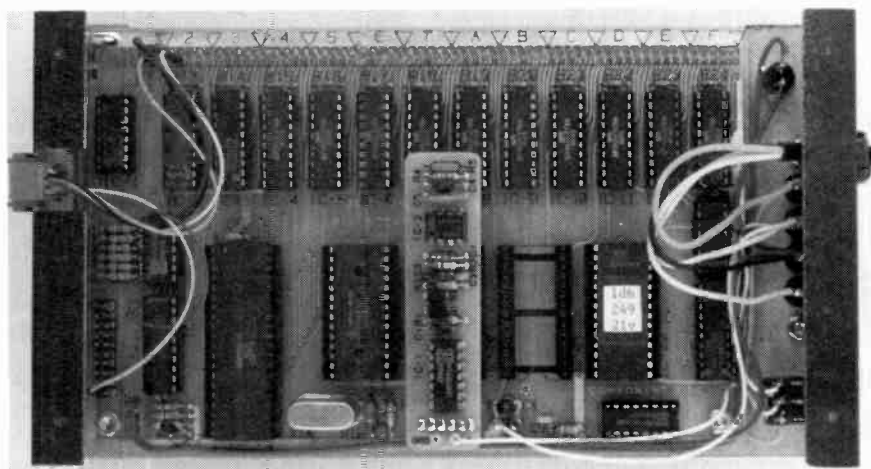


FIG. 16—THE EPROM BOARD mounts on the main board and rides about 1/2" above the EPROM that is being programmed.

that register (in positions 5–6).

The debug program uses registers 0 and 1, which have been reserved for DMA and interrupt. Pressing hex key 0 displays the contents of the D register in positions 1 & 2, the X register in position 3, and the P register in position 4. Pressing hex key 1 displays Q in position 2 (set = 1, reset = 0) and DF in position 4.

While in debug mode, register contents can be altered by first selecting a register pair and then pressing function key F3. Change the value by rolling new digits in from right to left. When the correct value appears, press F1; otherwise press F3 to back out without changing the current register. Registers D, X, P, Q, and DF can also be modified by selecting hex keys 0 and 1 as described above. To exit debug mode and continue execution, press F2. Of course you can press F4 to return to Address Select mode.

The debug breakpoint alters program memory by replacing three bytes at the selected address. When the user program reaches the breakpoint address, the debug program takes over and restores the original three bytes to the proper locations. However, if the user program never reaches the breakpoint, those three bytes will never be restored. In that case you must restore them either by continuing execution at the breakpoint, or by reentering the bytes manually using Monitor mode. If you continue at the break-

TABLE 1—MOVE UTILITY ADDRESSES

Address	Memory Contents
FF03	Start address (hi)
FF04	Start address (lo)
FF05	End address (hi)
FF06	End address (lo)
FF07	Destination address (hi)
FF08	Destination address (lo)

point, the debug program will restore the three bytes and immediately jump into Debug mode. As usual, you can modify registers, continue execution, or return to Address Select mode.

### EPROM programming

With the EPROM programming board connected to J4 and the proper programming voltage available, flip the EPROM switch to on, and you are ready to program the EPROM mounted at IC20. All that is required to program a location is to "write" to it. As mentioned earlier, you can do this byte at a time using the Monitor mode. However, due to the error-prone nature of that procedure, the author recommends a more automated procedure.

The preferred method is to enter your program in RAM and then transfer it to EPROM with the operating system's built-in "move" utility, which in fact will move a block of data anywhere in memory, not just to EPROM. Start the utility by running at 0488. Doing so transfers the move utility itself to RAM starting at FFO0. Now enter the start, end, and destination addresses as shown in Table 1.

Double-check your values to ensure that they are correct, and then run at FFO0. The display will show the remaining number of bytes to be transferred. It will be changing rapidly, but will at least give some idea about how things are progressing. In case data cannot be transferred correctly, the program will terminate and the display will show the address that didn't change.

That about wraps things up. Actually, now that the hardware's built, the real fun is just about to begin.

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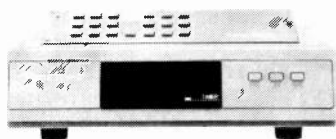
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**Stop throwing away those used Polaroid batteries—use them in your electronic experiments instead!**

MARC SPIWAK

DID YOU EVER NOTICE HOW POLAROID cameras never need batteries? That's because every pack of film you buy contains a brand-new Polaroid Polapulse battery to power the camera's motor and flash. Some people might consider that a modern convenience: Every change of film also replaces the battery. The worry of dead batteries is over, once and for all—or is it? While these flat 6-volt cells certainly make instant-picture taking as convenient as possible, they can be harsh on our environment, or at least our landfills. To add insult to injury, the Polapulse battery that you throw out with your old film pack is still in pretty good shape.

Holding the battery with the contacts nearest to the top, positive is on the right. You can remove the battery from the cardboard mount if you'd like to work with a smaller overall package.

The one problem with using the batteries is that it's hard to make reliable electrical contact with the battery's positive and negative terminals. It's virtually impossible—as well as unsafe—to solder to the terminals. That's where our handy battery jig comes in. It allows you to use a Polapulse battery for whatever the need may be, and pop in a new one when it's dead.

The jig is fashioned from two pieces of perforated construction board, four screws and spacers, and some contact springs from a sacrificed AA-cell holder. Two of the springs make electrical contact with the battery, and a third spring helps to hold the battery in place. Mini-hook leads are soldered to the contact springs, and small nylon screws hold the springs to the fixture.

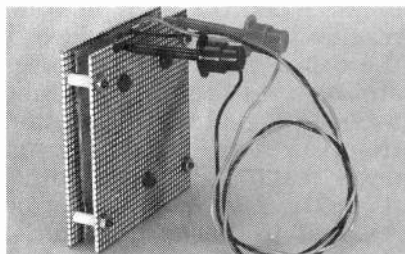


FIG. 1—THE BATTERY JIG lets you recycle "old" Polapulse batteries.

Most people, however, would have no use whatsoever for these used but still perfectly good batteries. The batteries, which can be accessed only by breaking open the film holder, don't fit into any standard battery holder. But readers of this magazine should certainly be able to find hundreds of uses for these "recycled" 6-volt cells.

**Using the Polapulse.**

To get at the battery, all you have to do is crack open the plastic film holder—after the film is finished, of course. Just be careful of the metal leaf-spring's sharp edges. You'll find the battery itself mounted on a piece of cardboard with its two contacts exposed on one side.

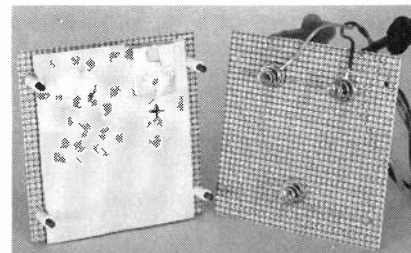


FIG. 2—THE BATTERY JIG uses two pieces of perforated construction board, screws, spacers, and springs from an AA-cell holder. Nylon screws hold the contact springs to the fixture.

You can, of course, use alligator clips or other connectors that better suit your needs. And you may wish to modify the mechanical construction as well. In any case, do try to get the most use possible from these batteries before they are thrown away.

R-E

# WORKING WITH LED DISPLAY DRIVERS

**Learn all about 7-segment display decoder/drivers in our continuing coverage of optoelectronic IC's.**

RAY M. MARSTON

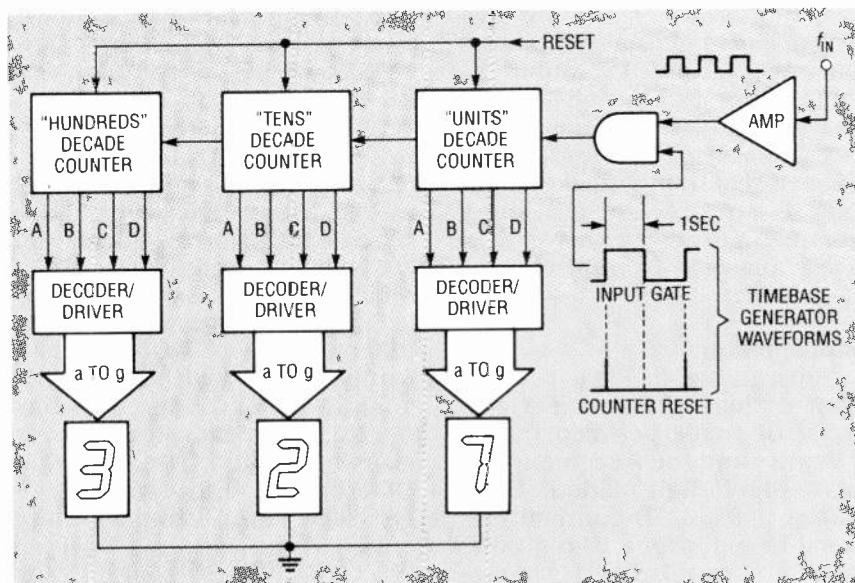


FIG. 1—SIMPLE DIGITAL frequency-meter circuit.

IN OUR LAST INSTALLMENT WE looked closely at theory and practical applications of the LM3914-series of LED bargraph driver IC's and concluded with 7-segment display systems. In this article, we'll examine 7-segment display driving techniques in detail, concentrating on decoder/driver devices and circuitry.

## Display latching

In the last article we introduced 7-segment displays and simple BCD-to-7-segment decoder/driver IC's that can be used to activate those displays. Figure 1 shows how three sets of those IC's can be used with a trio of decade counters to make a simple digital-readout "frequency" meter. In the figure, the amplified external frequency signal is fed to the input of the series-connected counters with one pin of a 2-input AND gate. The other input is derived from a timebase generator.

When the timebase input signal is low, the AND gate is off, and there is no input to the counters. When the timebase gate signal switches high, a brief RESET pulse is fed to all three counters, setting them all to zero. Simultaneously, the input gate turns on and remains on for one second. During that time the input-frequency pulses are summed by the counters. At the end of the one-second period, the gate turns off as the timebase gate signal goes low again. That ends the count and enables the display modules so that they give a steady reading of the total pulse count, and therefore the frequency. The whole process repeats itself again one second later when the timebase gate signal goes high.

The simple system illustrated has one major drawback: The display blurs during the counting period, becoming stable and readable only when each count is complete and the input gate is off. Figure 2 shows a circuit for frequency meters designed to overcome display blurring. In the circuit, a 4-bit data latch is wired between the output of each counter and the input of its decoder/driver IC.

When the timebase gate signal goes high, a reset pulse is fed to all counters, setting them to zero. Simultaneously, the input gate is turned on, and the counters start to sum the input signal pulses. The count continues for one second while the 4-bit latches prevent the counter output from reaching the display drivers. As a result, the display remains stable during that interval. At the end of the period a brief LATCH-ENABLE pulse is fed to all latches.

The instantaneous binary-coded decimal (BCD) outputs of each counter are then latched into memory, and also fed to the display via the decoder/driver IC's. That steadies the reading of the display to give a total pulse count, which corresponds to the input signal frequency. A few moments later, the sequence repeats itself with the counters resetting and then counting the input frequency pulses for one second, and so on.

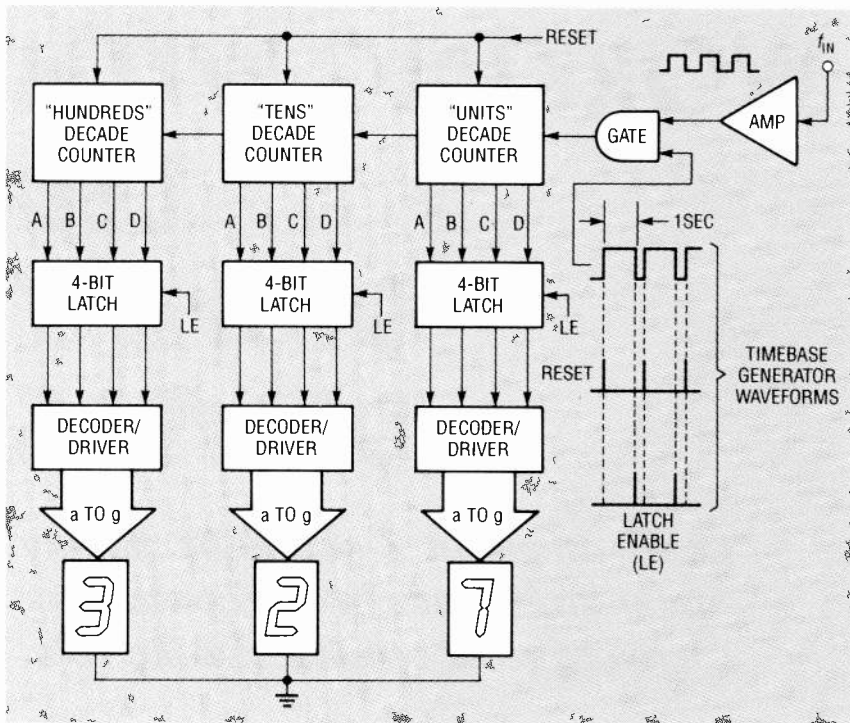


FIG. 2—IMPROVED DIGITAL frequency-meter circuit.

The circuit in Fig. 2 generates a stable display that is updated once per second. In actual circuits, the count periods shown in Figs. 1 and 2 can be set at any decade multiple or submultiple of one second, provided the display is suitably scaled. Many commercial decoder/driver ICs are available with built-in 4-bit data latches.

### Multiplexing

You can see in Figs. 1 and 2 that at least 21 connections must be made between the IC circuitry and the 7-segment displays of a 3-digit readout. Similarly, at least 70 connections must be made for a 10-digit display. The number of IC-to-display connections can be significantly reduced with a technique known as *multiplexing*. Figures 3 and 4 illustrate multiplexing.

Figure 3 shows how each digit of a 3-digit common-cathode LED display is individually activated with only 10 external connections. In the display circuitry, all "a" segments are connected together, as are all other sets of segments ("b" to "g"). Thus only seven external "a" to "g" connections are made to the display, regardless of the number of digits used. However, no 7-segment display is illumi-

nated by signals on the segment wires unless the display is enabled by tying its common terminal to ground. In Fig. 3, enabling is achieved by activating switching transistors Q1, Q2, and Q3 with suitable external signals. However, this scheme calls for an additional connecting wire for each display module.

Figure 3 also shows how three different sets of segment data can be selected with switch S1-a, and each of the three display modules can be selected with switch S1-b and Q1, Q2, or Q3. S1-a and S1-b are ganged together to form a two-pole rotary

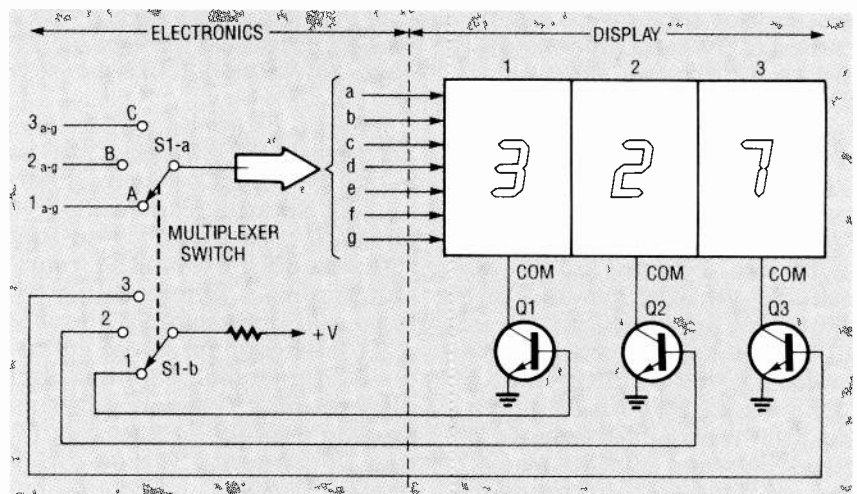


FIG. 3—MULTIPLEXING METHOD for a 3-digit common-cathode LED display.

switch which provides the multiplexing. These switch elements represent a fast-acting electronic switch capable of cycling the contacts through positions 1, 2, and 3 fast enough for flicker-free multiplexing.

The operating sequence of the circuit shown in Fig. 3 will be discussed here. Assume initially that the contacts of S1-a and S1-b are in position 1 so that S1-a selects segment data of display module 1 ( $1_{a-g}$ ), and S1-b activates display module 1 with Q1. Module 1 will then show an illuminated number "3." Moments later the switch contacts move to position 2, selecting segment data 2 ( $2_{a-g}$ ) and illuminating module 2 with Q2. Module 2 will then be illuminated to show the number "2." Moments after that, the switch contacts move to position 3, causing module 3 to show the number "7." Thus only one digit is ever on at any one time.

In practical displays, the sequence is repeated fast enough so that you do not see the display segments being turned on and off. Your eye's persistence of vision makes it look as if the three digits are all lit up together. The multiplexing frequency must be about 1 kHz.

Figure 4 shows a more realistic arrangement for multiplexing a 3-digit frequency meter. The multiplexer (MUX) is located between the outputs of the three BCD data latches and the input of a display-driving BCD-to-7-segment decoder/



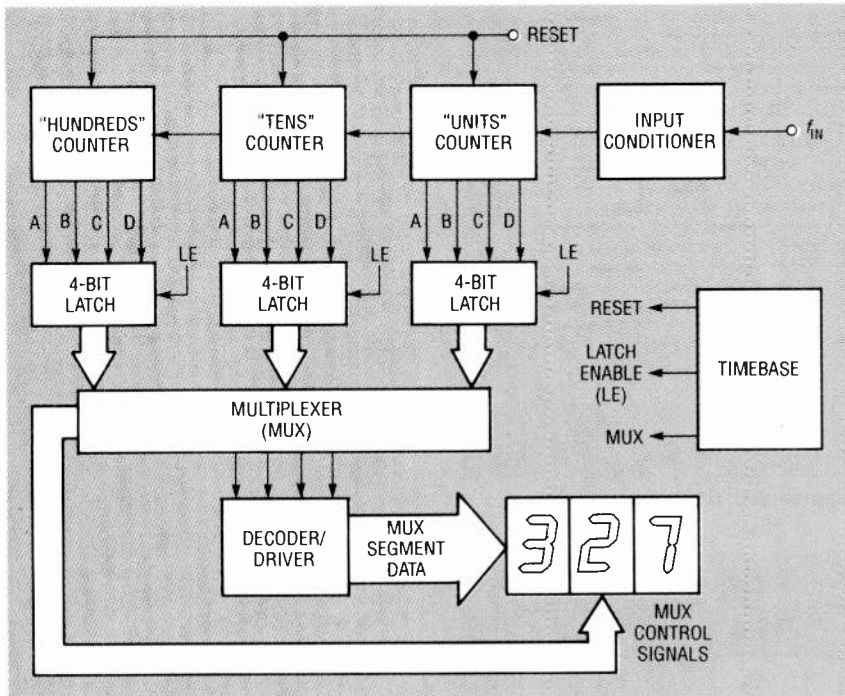


FIG. 4—PRACTICAL MULTIPLEXING of a 3-digit frequency meter.

driver IC. The scheme shown has two major advantages: Only one decoder/driver IC is needed (regardless of the number of readout digits), and its multiplexer includes only five ganged 3-way sequencing switches. One of those switches is for control data, and four are for BCD-segment data. That arrangement saves three ganged 3-way switches, as compared with the eight needed in Fig. 3.

Commercial large-scale integrated (LSI) IC's now available can perform all of the counting, latching, multiplexing, decoding, timing, and display-driving functions in Fig. 4. A device of this complexity is typically packaged in a dual-in-line package (DIP) with only 20 pins. Those pins provide for all necessary connections to the power supply, display modules, and inputs. Therefore, a complete 4-digit counter can be built with a dedicated IC in a circuit such as that shown in Fig. 5. Another example of an LSI IC in a display circuit is the 3½-digit digital voltmeter (DVM) chip shown in Fig. 6.

### Ripple blanking

Unless there is automatic suppression of the two unwanted leading zeros, the 4-digit circuit in Fig. 5 will give an

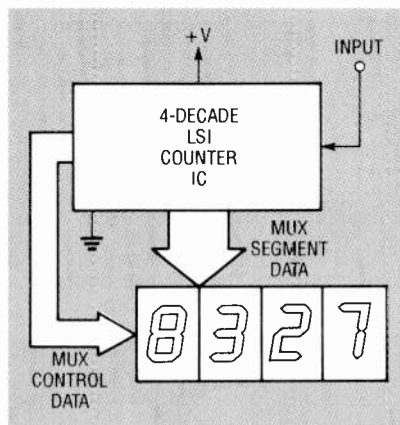


FIG. 5—4-DIGIT COUNTER CIRCUIT based on an LSI chip.

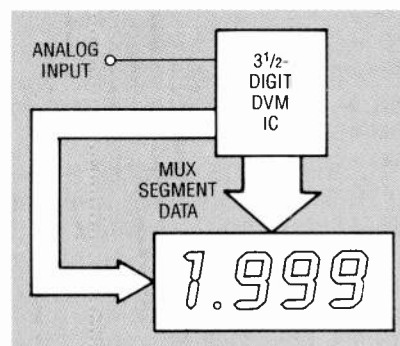


FIG. 6—3-1/2-DIGIT VOLTMETER based on an LSI chip.

actual reading of 0027 if it is used to measure a count of 27. Similarly, if the 3½-digit circuit of Fig. 6 measures 0.1 volt, it will display 0.100 volt unless the

two unwanted trailing zeros are automatically suppressed.

In practical circuits, automatic blanking of leading or trailing zeros can be performed with a *ripple-blanking* technique, as shown in Figs. 7 and 8. Each decoder/driver IC (with a BCD input and 7-segment output) is provided with a ripple-blanking input (RBI) and scribble-blanking output (RBO) pins.

Assuming those pins are active-high, if the RBI terminal is held low (logic 0), the 7-segment outputs of the IC are enabled, but the RBO terminal is disabled (held low). If the RBI terminal is biased high (logic 1), the 7-segment outputs become disabled in the presence of a BCD 0000 input, and the RBO output goes high under the same condition. The RBO terminal, therefore, is normally low and goes high only if a BCD 0000 input is present at the same time the RBI terminal is high.

Figure 7 shows the ripple-blanking technique for leading-zero suppression in a 4-digit display with a reading of 207. The RBI input of the thousands or most significant digit (MSD) decoder/driver is tied high, so the readout is automatically blanked in the presence of a zero when the RBO terminal is high. Consequently, the RBI pin of the hundreds IC is high, the readout shows 2, and the RBO terminal is low. The RBI input of the tens unit is low, so the readout shows 0 and its RBO output is low. The units readout shows the least significant digit (LSD), which does not require zero suppression. Its RBI pin is grounded and the readout shows 7. The display therefore gives a total reading of 207.

In the leading-zero suppression circuit, Fig. 7, the ripple-blanking feedback is applied backwards from the MSD to the LSD. Figure 8 shows how trailing-zero suppression is accomplished by reversing the direction of feedback from the LSD to the MSD. Therefore, when an input of 1.1 volts is fed to that circuit, the LSD is blanked, because its BCD input is 0000 and its RBI input is high. The RBO

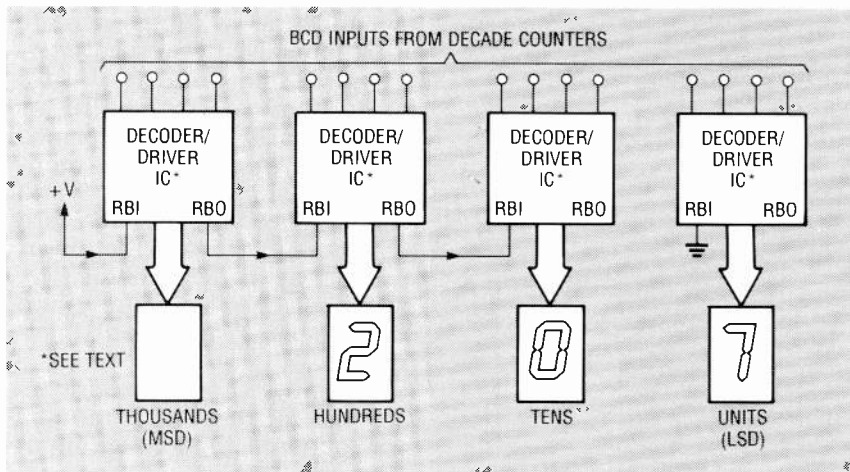


FIG. 7—RIPPLE-BLANKING for leading-zero suppression in a 4-digit counter.

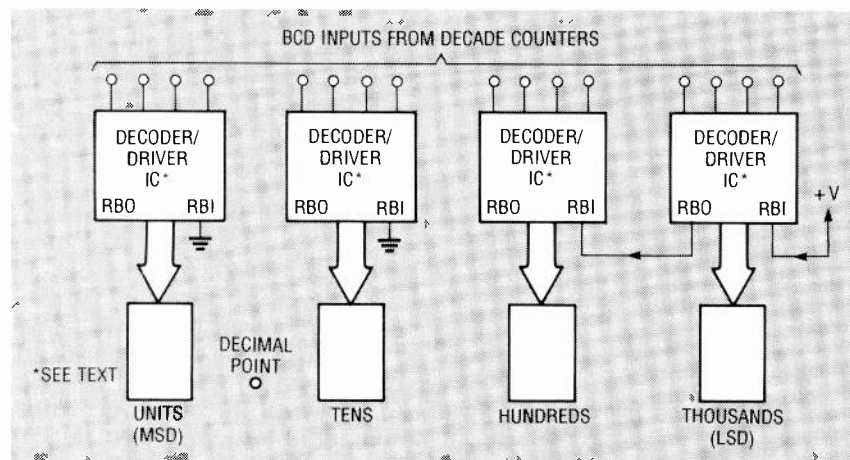


FIG. 8—RIPPLE-BLANKING for trailing-zero suppression of the last two digits of a 3-1/2-digit DVM readout.

terminal is high under that condition, so the hundredth's digit is also blanked in the presence of a 0000 BCD input.

Most decoder/driver IC's have RIPPLE-BLANKING INPUT and RIPPLE-BLANKING OUTPUT pins. Usually these pins are active-low. If a decoder/driver IC does not include integral ripple-blanking logic, it can usually be obtained by adding external logic circuitry similar to that shown in Fig. 9. The RBO pin is connected to the BLANKING INPUT pin of the decoder/driver IC. Figure 9 shows an active-high circuit in which the output of the 4-input NOR gate goes high only with a 0000 BCD input. The RBO output goes high only if the 0.0 input is present when RBI is biased high.

### Decoder/driver IC's

Many decoder/driver IC's are available commercially as both

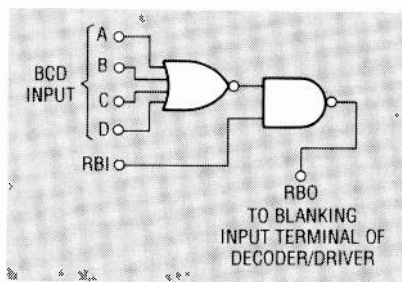


FIG. 9—ACTIVE-HIGH ripple-blanking logic.

TTL and CMOS devices. Some of those devices have integral ripple-blanking capability, and others have built-in data latches. A few of those devices have built-in decade-counter stages. Let's look at some of the most popular of those devices.

The 7447A and 7448 7-segment decoder/driver IC's are in the standard TTL family. They are also available in a low-power Schottky (LS) form designated as 74LS47 and 74LS48, respectively. All of those IC's have inte-

gral ripple-blanking facilities, but do not include data latches. Figure 10 shows the pinout common to those devices, each of which is housed in a 16-pin DIP.

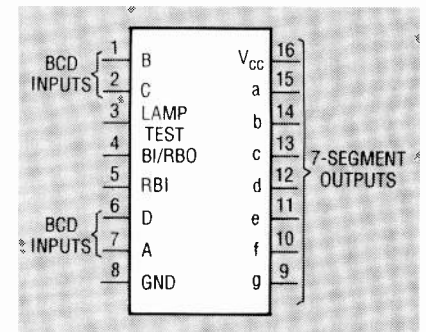


FIG. 10—PINOUT for BCD-to-7-segment decoder/drivers IC's 7447A, 74LS47, 7448, and 74LS48.

The 7447A/74LS47 has an active-low output designed for driving a common-anode LED with external current-limiting resistors ( $R_x$ ), as shown in Fig. 11. The 7448/74LS48 has an active-high output that drives a common-cathode LED in a manner similar to that of the circuit in Fig. 11, but with the common terminal of the display connected to ground. In all cases, the  $R_x$  current-limiting resistors should be chosen to limit the individual segment currents below the following absolute limits:

$$\begin{aligned} 7447A &= 40 \text{ mA} \\ 74LS47 &= 24 \text{ mA} \\ 7448 \text{ and } 74LS48 &= 6 \text{ mA} \end{aligned}$$

Figure 12 shows how a 7448/74LS48 can drive a liquid-crystal display (LCD), using a pair of 7486 or 74LS86 quad 2-input XOR gate IC's. An external 50-Hz square wave applies the necessary phase signals to the display.

As shown in Fig. 10, each of the 7447/7448 IC's has three input control pins: LAMP TEST, BI/RBO, and RBI. The LAMP TEST pin drives all display segments on when the pin goes to logic-low with the RBO pin on or at logic-high. When the BI/RBO pin is pulled low, all outputs are blanked. The BI/RBO pin also functions as a RIPPLE-BLANKING OUTPUT pin. Figure 13 shows how to connect the RIPPLE-BLANKING pins to give leading-

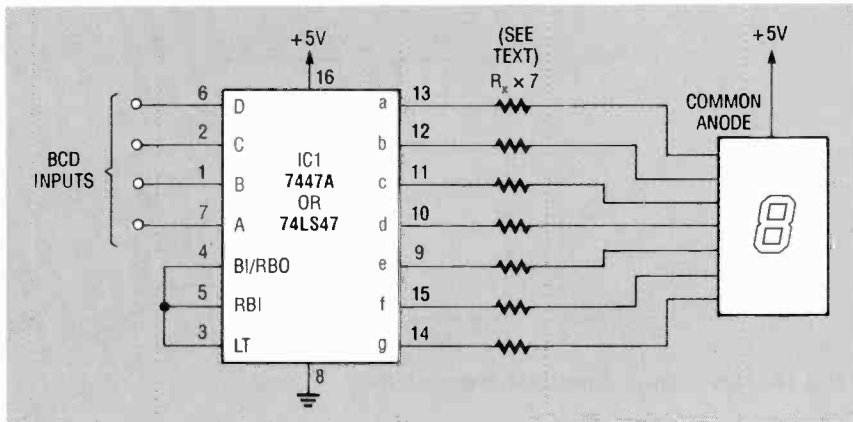


FIG. 11— DRIVING a 7-segment common-anode LED display with a 7447A-type decoder/driver.

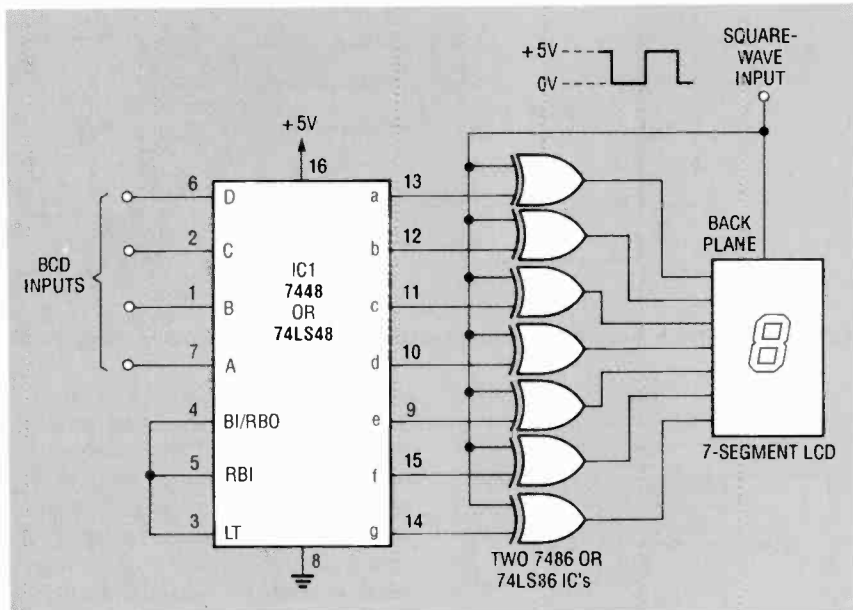


FIG. 12—DRIVING a 7-segment LCD with a 7448-type decoder drivers.

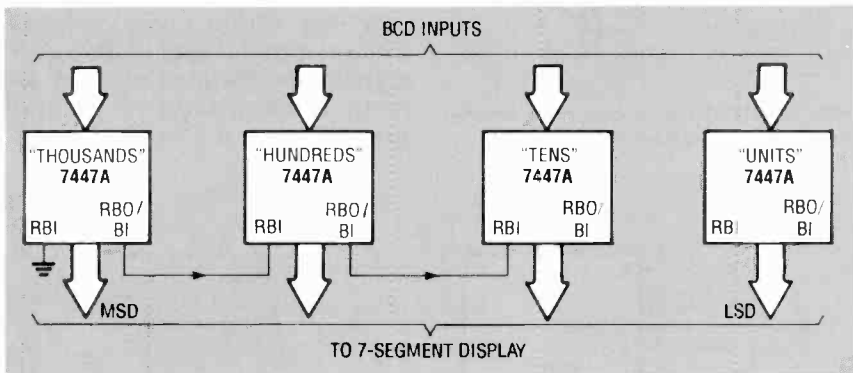


FIG. 13— SUPPRESSION OF FIRST THREE digits of a 4-digit display with 7447A-type decoder/drivers.

zero suppression on the first three digits of a 4-digit display.

The 4511B is a BCD-to-7-seg-mental decoder/driver IC with an integral 4-bit data latch, but it lacks built-in ripple-blanking. That CMOS device features NPN bipolar transistor output stages

capable of handling output currents up to 25 mA. It can drive most popular 7-segment displays. Figure 14 is a functional diagram of the IC. The 4511B will operate from any 5- to 18-volt power supply.

The 4511B has three input-

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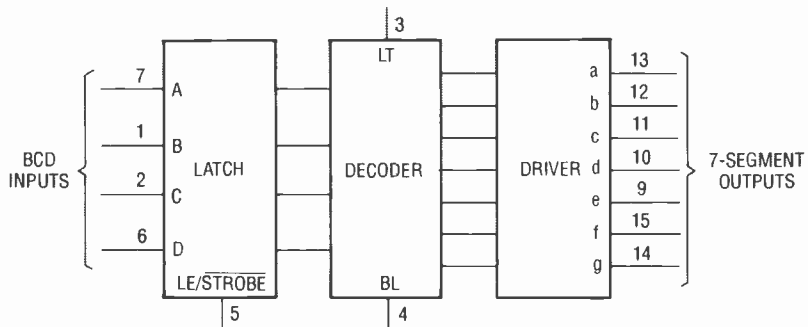


FIG. 14—FUNCTIONAL DIAGRAM of the 4511B IC.

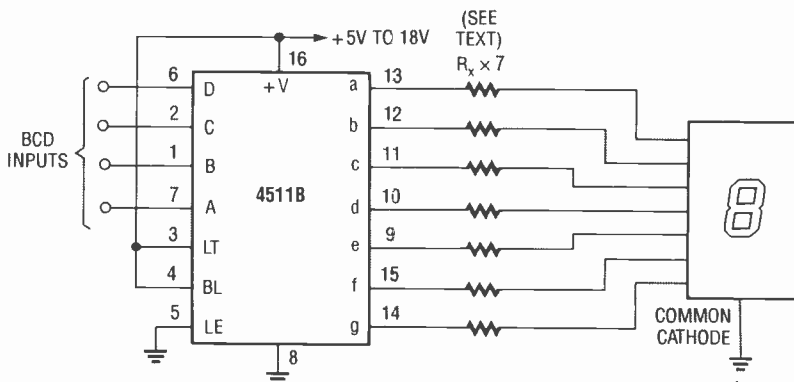


FIG. 15—DRIVING a 7-segment, common-cathode LED display module with a 4511B.

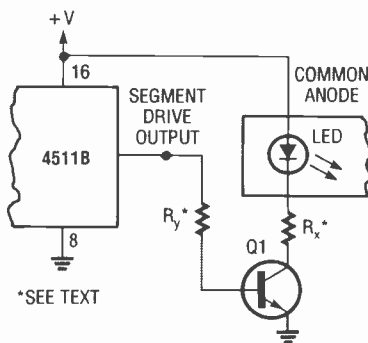


FIG. 16—DRIVING a common-anode LED lamp or segment with a 4511B.

control pins: LAMP TEST (LT), BLANKING (BL), and LATCH ENABLE/STROBE (LE/S). The LAMP TEST and BLANKING inputs are active-low, and the LATCH ENABLE/STROBE input is active-high. In normal operation, LAMP TEST and BLANKING are made high and LATCH ENABLE/STROBE is held low.

When the LATCH ENABLE/STROBE pin is low, BCD input signals are decoded and fed directly to the 7-segment output pins. If LATCH ENABLE/STROBE

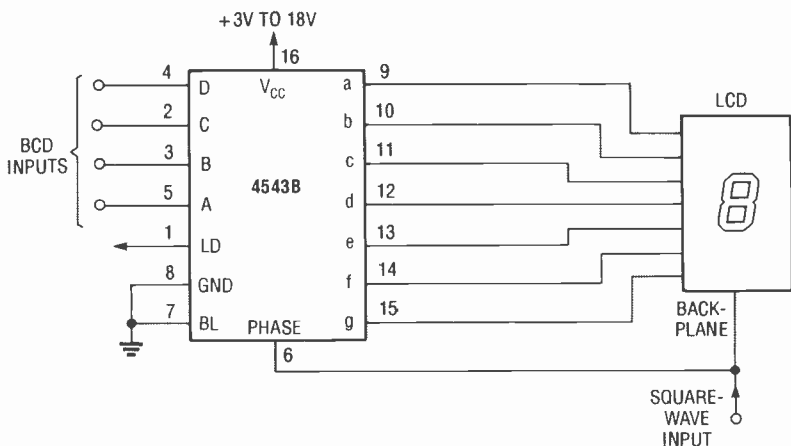


FIG. 17—DRIVING a 7-segment LCD with a 4543B.

goes high, the BCD input signals present at the moment of transition are latched into memory and fed (in decoded form) to the 7-segment outputs, while LATCH ENABLE/STROBE remains high. If the LAMP TEST input is grounded, all output segments are activated, regardless of the BCD inputs. If the BLANKING input is grounded (while LAMP TEST is positive), all output segments are blanked.

Figure 15 shows the basic connections for driving a common-cathode LED. A current-limiting resistor ( $R_x$ ) must be wired in series with each display segment, and it must have a value chosen to hold the segment current below 25 mA. Note that the segment outputs of the 4511B are not internally current-limited. Therefore, the device has no output-overload protection.

Figure 16 shows how to modify the circuit in Fig. 15 to drive an LED common-anode display. In the example shown in Fig. 16, an NPN buffer transistor must be used between each output-drive segment and the input segment of the display. Resistor  $R_x$  sets the operating segment current of the display in those examples, and  $R_y$  sets the base current of the transistor.

The 4511B can also drive 7-segment liquid-crystal displays (LCD) with an external square-wave PHASE signal and a set of XOR gates similar to those of Fig. 12. In practical circuits, however, it is better to use a 4543B IC for that specific application.

The 4543B is a 7-segment CMOS decoder/driver with an integral 4-bit data latch. It was designed for driving LCD's, but it can also drive most other 7-

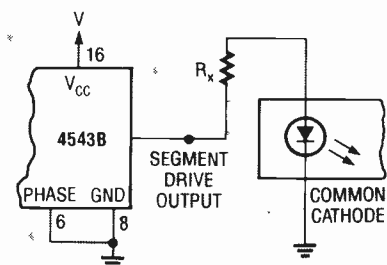


FIG. 18—DRIVING A common-cathode LED lamp or display segment with a 4543B.

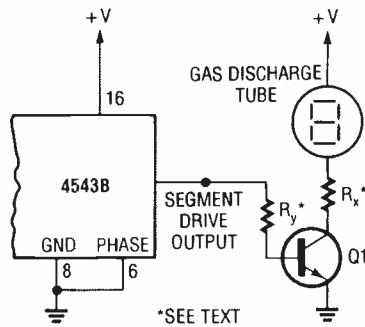


FIG. 19—DRIVING A gas-discharge tube or display segment with a 4543B.

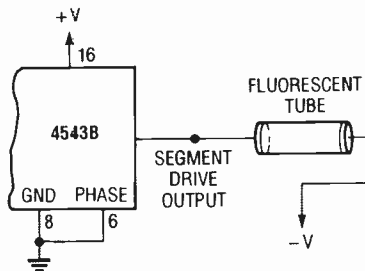


FIG. 20—DRIVING A fluorescent tube or display segment with a 4543B.

segment displays.

The 4543B has three input control pins: LATCH DISABLE (LD), PHASE, and BLANKING (BL). In normal use, the LATCH DISABLE pin

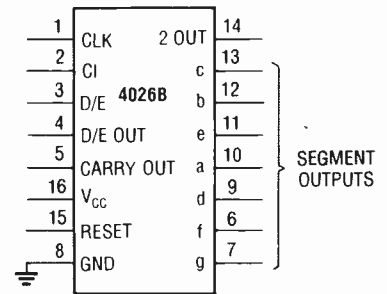


FIG. 21—PINOUT of the 4026B decade counter with 7-segment outputs.

is biased high and the BLANKING pin is tied low. The state of the PHASE pin depends on the display that is being driven. For driving LCD displays, a square wave (approximately 50 Hz, swinging fully between the ground and  $V_{cc}$ ) must be applied to the PHASE pin. The PHASE pin must be grounded for driving common-cathode LED's and it must be tied to logic-high for driving any common-anode displays.

The display can be blanked at any time simply by driving the BLANKING pin to the logic-high state. When the LATCH DISABLE pin is in its normal high state, BCD inputs are decoded and fed

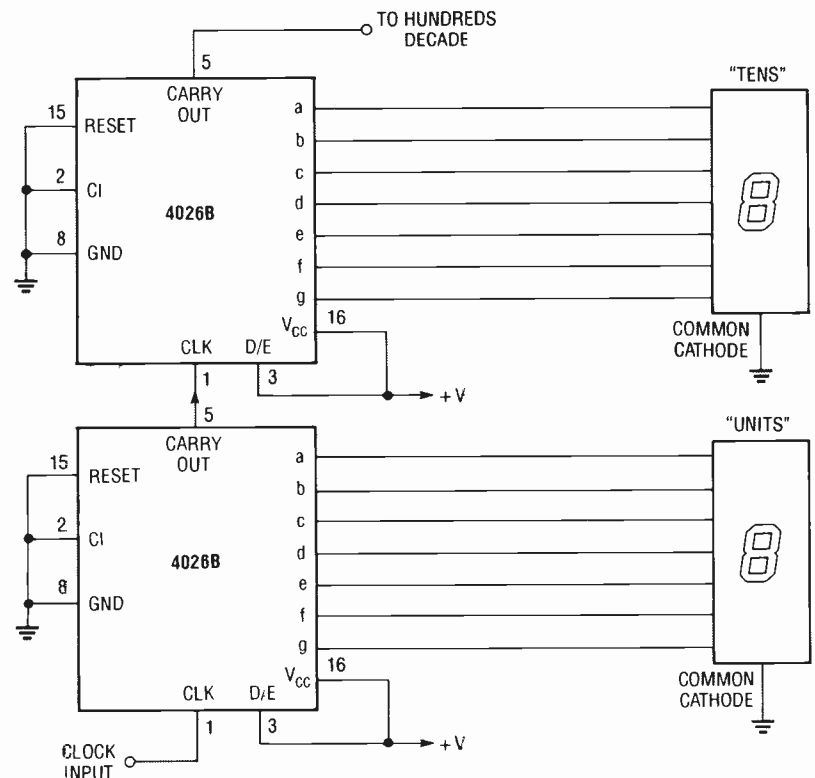


FIG. 22—CASCADED TWO 4026B decade counters.



# AUDIO UPDATE

## Let's Phase the Music: More comments on papers from the 91st AES convention

LARRY KLEIN

**A**coustic phase, and its audibility, has been a subject of controversy ever since Hermann von Helmholtz addressed the subject in the late 1800's. Yet, despite all we've learned about hearing since Helmholtz, and the current availability of sophisticated new research tools, the controversy lingers on. The argument is not, as one might think, simply an abstract, if sometimes heated, debate among philosophical psycho-acousticians. It has real-world consequences for the way audio signals should be recorded and audio equipment should be designed.

I've been aware ever since I built my first Williamson amplifier in the early 1950's that signal phase *shift* was a significant audio parameter—at least in power amplifiers. In its early incarnations, the Williamson suffered from marginal instability because the 20-dB negative feedback loop sometimes shifted positive at the frequency extremes. That frequently resulted in pulsing woofers at one end of the spectrum and RF oscillation at the other. But aside from such obvious instability disturbances, I've never felt that linear phase shift posed a severe threat to fidelity.

In the early 1980's, many speaker manufacturers decided that the conventional two or three drivers installed on the single vertical front panel of a system resulted in acoustic phase shifts caused by the different path lengths to the listener's ears of the woofer and tweeter signals. That was usually "solved" by stepping a cabinet's front panel so that the woofer was several inches forward of the tweeter. Aside from generating new opportunities for advertising copy writers (and some expensive pot-bellied speakers), the arrangement's audible advantages were elusive—at least to my ears. And, in any case, it seems to me that on a purely theoretical basis such "time alignment" would only

hold when a listener's ears were also aligned exactly on axis with the acoustic center of the two (or more) drivers.

I once saw/heard a speaker-phase demonstration using a two-way system with a movable tweeter. A square wave was fed to the system and the speaker's output

### INTERCHANNEL SPEAKER PHASE

Most of us first encountered "phase" as an audio phenomenon when we were told to make sure that the right and left speakers of our stereo system were connected in proper polarity. That meant that when presented with, say, a positive audio pulse from both amplifier channels, the cones of both woofers would move simultaneously in the same direction. If the speakers were wired incorrectly, the cones would move in opposite directions, and bass performance would suffer. In addition, the 180-degree phase differences in the high frequencies would confuse the ear's localization system, disturbing the stereo sound-stage image and imparting a vague "phasiness" to the reproduced sound. In general, speaker polarity/phase, if correct in the original installation, remains so unless the connections are changed. R-E

picked up by microphone and displayed on an oscilloscope. As the tweeter installed on top of the system was slowly shuttled back and forth over a five-inch distance, the square wave would visibly distort and then restore itself as its high- and low-frequency harmonic components shifted in and out of phase. I stood in front of the display for several minutes, really trying to hear the waveform distortion that was clearly evident on the scope screen. Following in the tradition of Herr von Helmholtz, I never did hear any effect. All of this is background for

the latest phase controversy beautifully delineated in the following Audio Engineering Society (AES) preprint.

### Observations on the Audibility of Acoustic Polarity [Greiner and Melton (3170 K-4)].

To understand what is meant by absolute polarity, it helps to use a simple musical example, such as the sound of a kickdrum. The impact on the drum head produces an air compression that moves outward and is picked up by a recording microphone. Ultimately, it is reproduced by a forward-moving speaker cone as an air compression. However, anyone who deals with electronics knows that the original electrical signal from the microphone has had its polarity flipped probably dozens of times by the recording and reproduction electronics before it reaches the speaker. In fact, there's a 50-50 chance that the initial kickdrum impact is being reproduced by a speaker cone that is pulling at the air rather than pushing it. In other words, what reaches our ears is an air rarefaction, although the original was a compression. It follows that our eardrums are also being pulled rather than pushed. Does it make a difference? That's what Greiner and Melton set out to explicate in their paper.

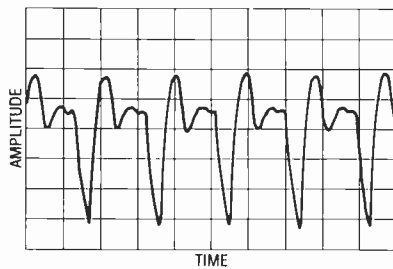
The audibility—or inaudibility—of absolute inversion is a recent element in the ongoing discussion. Unlike other phase shift phenomena discussed earlier, polarity inversion does *not* change the shape of a transient signal nor shift the phase relationship among its component elements. However, as the authors state, it does present to the ear a fundamentally different signal.

A major part of the authors' research effort involved extensive, carefully controlled listening tests to determine the types of signals

most sensitive to polarity inversion. It seems self evident that highly asymmetrical signals were most likely to be audibly changed by inversion. For example, note the trombone waveform shown in Fig. 1.

In general, it could be said that acoustic polarity inversion is clearly audible in some circumstances (particularly with test signals), although most of the time with real-world music it is not. It seems that even when waveforms have clear asymmetries as in Fig. 1—and not all of them do—other effects inherent in the complex nature of most musical tones tend to mask the identifying characteristics of the inversion.

The authors conclude that "while polarity inversion is not easily heard with normal complex musical program material, as our large-scale listening tests showed, it is audible in many select and simplified musical settings. Thus it would seem sensible to keep track of polarity and to play the signal back with the correct polarity to assure the most accurate



**Fig. 1. Trombone waveform. In general, reed instruments show the greatest asymmetry.**

reproduction of the original waveform."

No one can argue with the above as an ideal goal, but exactly how is it likely to be realized? Assuming that (1) we have a recording with all the instruments recorded in phase, that (2) our three-way speaker doesn't have its mid-range connected in inverted polarity to flatten the system's frequency response (a no longer common practice), and that (3) anyone in authority cared enough to manufacture discs and tapes with all their polarity ducks in

a row, how would the consumer know when he had it right?

Next month I'll discuss one more AES paper and then call it quits for the 91st Convention. **R-E**

### PHASE INSENSITIVITY

It is well known that loudspeaker cone travel is seldom equally linear in both its outward and inward excursion. In other words, the speaker cone's push on the air may not be exactly equal to its pull, even when driven by a low-distortion, highly symmetrical sinewave. It seems probable to me that most human ears are also asymmetrical in their responses to the compressions and rarefactions of an impinging acoustic waveform and therefore generate harmonic distortions. Whether any individual listener's degree of hearing asymmetry correlates with their sensitivity to absolute phase is an open question. I noted with interest that Greiner and Melton suggest at one point that a distorting sound system may increase the audibility of polarity inversion.

I know for a fact that I've always been comparatively insensitive to phase. For example, in the early days of quadrophonics I was evaluating a four-channel synthesizer that attempted to generate artificial rear channels by tapping off the front channel, "wobblulating" it at a 25-Hz rate, and feeding it to a pair of rear speakers. The four-channel effect, for better or worse, was barely perceptible to my ears. A friend dropped in unexpectedly while I was doing my listening and greeted me with, "Hi Larry ... (three-second pause) ... your rear speakers are out of phase." I sat alongside him on the couch between the wobblulated rear speakers and for the life of me couldn't hear what he had detected instantly—and claimed was giving him a headache!

I also know that some listeners are incredibly sensitive to very small percentages of tape flutter, a phase-shift phenomenon, but the numbers have to get pretty bad before I hear it. In case you are wondering, my overall acuity and sensitivity were (by test) pretty good in those days, so my phase insensitivity was, in effect, an independent variable. I wonder what the normal distribution of phase sensitivity is, and whether ignoring it may not skew the results of psychoacoustic studies of phase. **R-E**

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# COMPUTER CONNECTIONS

## The personal digital assistant.

JEFF HOLTZMAN

**G**adget lovers take heed: Personal Digital Assistants (PDA's) will be the fastest-growing segment of the computer business within two years—maybe by the end of this year. What is a Personal Digital Assistant? It's a paperback-size computer that bridges the gap between calculator-like organizers on the one hand, and hefty notebooks on the other. In so doing, the PDA hopes to provide both power and ease of use, but without the size, weight, and battery-life and -weight constraints of a notebook PC.

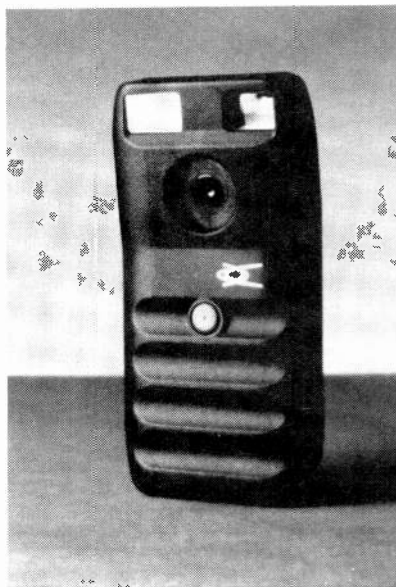
Numerous technologies are coming together to make this category a reality. Low-voltage CPU's, system controllers, video controllers, and DRAM's from Intel, Cyrix, AMD, Western Digital, and others promise to drastically lower power consumption. The chips run at 3.3 volts, and could more than double battery life, from 3.5 to 8.0 full hours. Emerging standards for credit-card sized memory modules seem to be taking hold. Hard-disk drives continue to shrink. Integral Peripherals has introduced 20- and 40-megabyte drives in 3-ounce packages that measure 2" x 3", and that consume 500 mW of power during operation and 15 mW in the "sleep" mode. IBM, Conner, Seagate, and others will ship similar drives later this year.

Look for two basic approaches to the PDA. One, promulgated by PC vendors, amounts to a miniature DOS machine with a QWERTY keyboard that allows touch typing. It has a full 80 x 25 (640 x 200, CGA-level graphics) non-backlit LCD screen. The other, promulgated by consumer electronics companies (e.g., Sony), consists of a proprietary device using a stylus input in place of a keyboard.

The DOS version may well conform to a spec developed by Phoe-

nix Technologies, called the Companion PC (CPC). A CPC will be based on an 8086-level computer-on-a-chip developed by Chips & Technologies (see the January 1992 issue of this column for more information), PCMCIA memory cards, Phoenix BIOS and power management software, and special battery technology developed by Duracell. As for software, Microsoft has delivered a ROMable version of DOS 5.0, and promises to do the same for Windows 3.1. Lotus might supply a suite of applications, including a task switcher, although Microsoft Works could very well provide steep competition.

Tantalizing views of the other category have been revealed by Sony. And there are persistent rumors that Apple and Sony are working together to put a Mac-style interface on this new breed. Sony has released one such device in Japan, but apparently has no plans to mar-



**FIG. 1—DYCAM'S MODEL 1 digital camera stores 32 shots, each with a resolution of 376 x 240 x 256 gray levels. It's a harbinger of the future for PC-based digital imaging.**

ket it here.

Electrical power usage remains a major issue with portable computers of all configurations. In the ROMable versions of DOS 5.0 and Windows 3.1, Microsoft has introduced an Advanced Power Management (APM) Application Programming Interface (API), co-developed with Intel and Phoenix, that provides the system with information about which peripherals are not being used, so it can remove and thereby conserve power. Several battery manufacturers have introduced flat, wide batteries that provide both a better fit with today's sleek designs, and more power. For example, Portable Energy Products has a battery that measures 2.6" x 3.9" x 0.3" and produces two volts at three amps.

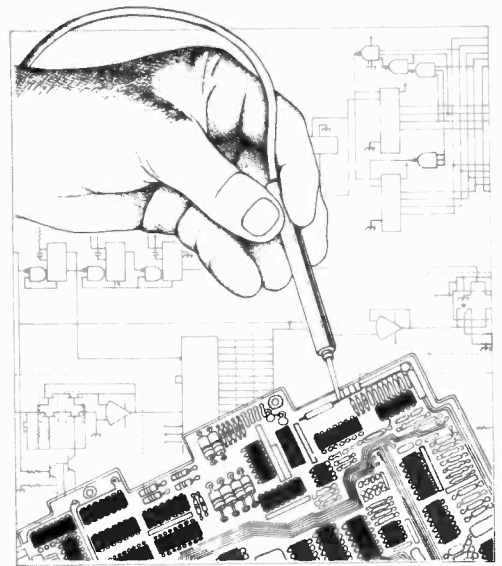
One interesting device is the "Commuter Computer," introduced by Memorex at the January Consumer Electronics Show (CES). The device weighs 1.3 pounds, lists for \$599, and includes a word processor, scheduler, notepad, the DR-DOS 5.0 operating system, carrying case, power adapter, and cables; an external 1.44 megabyte floppy drive is available for \$299.

### Multimedia update

Here's an imaginative use of multimedia: The Virtual Press Conference. Redgate Communications of Vero Beach Florida plans to outfit more than 100 movers and shakers of the computer industry with 1.2-meter satellite dishes, TV's, VCR's, fax machines, and dedicated phone lines, at a cost of about \$2 million. Redgate will then broadcast to them hour-long interactive press conferences, during which they can ask questions, receive printed materials by fax, and record the whole thing on VHS tape. The viewers will pay nothing for the service; Redgate in-

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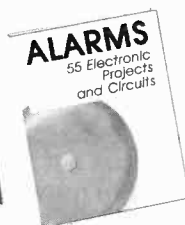
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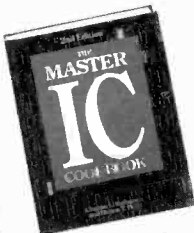
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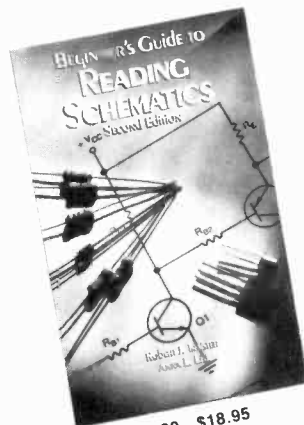
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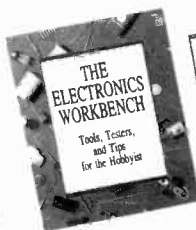
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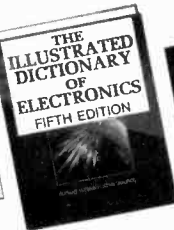
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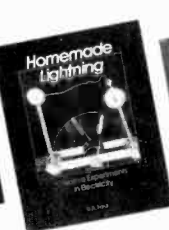
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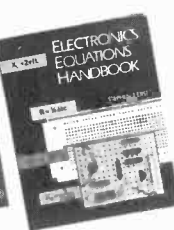
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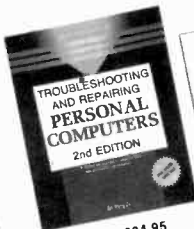
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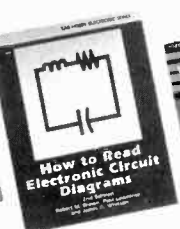
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stead sells the service to large computer companies for \$25,000 per hour. Lotus and DEC have expressed interest.

The Multimedia PC Marketing Council has upgraded the "baseline" spec for a multimedia PC to include a 386SX. The original version specified a 10-MHz 286, which simply didn't provide enough horsepower to run serious applications. In addition, the rapid infusion of 386 technology into general buying habits makes 286 compatibility less of an obstacle than it once was.

Apple has released a multimedia extension to its System 7.0 software. It's called QuickTime, and it provides developers with a standard software architecture for integrating time-variant data (sound, video, animation). In introducing the product, Apple CEO John Sculley said that QuickTime will be the major legacy from his tenure at Apple—more important even than the Macintosh.

The QuickTime architecture includes four components: system software, file formats, compression/decompression technology, and user-interface standards. Apple hopes it will become a cross-platform standard with support for Mac, DOS, Windows, UNIX, Silicon Graphics, DEC, and Cray systems. The video format is 160 × 120 pixels, running at 15 frames per second. That's obviously no competition for broadcast-quality video (BQV); Apple hopes that the standard will evolve to accommodate more powerful hardware that can support BQV.

Apple has announced a QuickTime "player" that will allow PC-based Windows users to experience QuickTime movies. (Corel Systems, of CorelDraw fame, wrote the file-format translator.) In addition, Microsoft has announced support for QuickTime; add-ins for the Mac versions of Excel and Word will allow end-users to build simple movies within the respective applications. You could use this technology to combine a series of spreadsheets into an animated demonstration of how sales are projected to grow.

In response, IBM quickly demonstrated technology with twice the resolution and the same frame rate.

Naturally it runs under OS/2 2.0. One demo showed how advanced features of OS/2 allowed several program processes to control separate halves of a duet in sync.

### Product watch

The Dycam Digital Still Camera Model 1 is the first of a new breed of all-electronic snapshot takers. The Dycam is an easy-to-use, lightweight, hand-held camera that allows you to take as many as 32 pictures, then upload them to your PC or Mac for bit-map editing or desktop publishing. (Logitech markets a nearly identical version under its own name.)

Despite flawed installation instructions, getting the Dycam going is easy. Attach a base mount to the main unit and plug in a wall-mount charger. When the LED starts blinking, the battery is fully charged. Then it's just point, shoot, and upload the images to your PC via an RS-232 port.

The Dycam comes with control software for both PC and Mac; I tested the PC version, which actually comes with both Windows and DOS versions. I found the Windows version unstable, due to frequent UAE's (Unexplainable, unintentional, unwanted Application Errors); consequently I worked mostly with the DOS version.

The DOS-based software works pretty well. The main screen consists of a series of "thumbnails," miniature versions of each image. To view an enlarged version, use the arrow keys to highlight the desired image, press Enter, and the software downloads, decompresses, and displays the complete image; the whole process takes about 10 seconds per shot, depending on system speed.

Documentation is both clear and brief and it includes both Mac and PC instructions in one booklet; the software includes on-line help in the form of brief summaries of key-stroke options.

The camera can operate in two modes, regular and tripod. Unfortunately, to switch modes you must download different software to the camera, a process that takes about 45 seconds. In regular mode, you just point and shoot; the camera

determines shutter speed and whether to use the flash. Tripod mode allows you to set the shutter speed manually, from 1 to 640 milliseconds. Shutter bugs would probably prefer to set shutter speed in familiar inverse time units (1/t, e.g., 1/60, 1/30, etc.). There's no way to attach a standard remote shutter release, but you can take a picture from the keyboard (Alt-T).

The software allows you to save images to disk in a variety of formats, including EPS, TIFF, PCX, a proprietary Dycam format, and others. The software provides some ability to adjust image contrast and brightness, but for optimal results you'll want to use a third-party tool (e.g., PhotoShop). When the camera is full, you will have to clear it out (Alt-C) to make room for more, and you cannot selectively delete pictures from memory. Although the camera maintains a time/date clock, you cannot include a time/date stamp as part of the image.

When I first learned of the Dycam, I thought it would be an ideal way to develop product and screen shots for the magazine. Unfortunately, that will not be feasible. The problem is not limitations with the software, but the optics. The lens system provides image quality comparable to a \$20 instant camera—but the Dycam lists for almost \$1000. The CCD provides a total resolution of 376 × 240 pixels, which is less than found in a TV. It compensates by providing 256 levels of gray, which definitely helps, because the eye responds better to variation in tone and color than to absolute resolution. Even the best shots, however, come out grainy. Shots of people generally fare better than inanimate objects.

Add-on lenses are available, including wide-angle, telephoto, and macro (close-up). Other accessories include an adapter for 12-volt auto operation.

Despite its limitations, the Dycam opens a world of possibilities for users who don't need publication quality. For example, a real estate agent could publish house shots to give prospective clients some idea of layout. Schools could create classroom newsletters.

Dycam is to be commended for being first to market with an all-electronic digital camera. An improved optic system, faster software, and more reliable Windows operation would make it a must-have item for professional desktop publishers. Keep your eye on this one. If you're interested, contact Dycam, Inc., 9588 Topanga Canyon Blvd., Chatsworth, CA 91311 (818) 998-8008.

### News bits

Slate Corporation is a technology leader in the fledgling Pen-computing market. Two officers of the company, **Dan Bricklin and Bob Frankston**, designed the first spreadsheet for personal computers, VisiCalc. The dynamic duo is at it again, with a pen-based spreadsheet called At-Hand. At-Hand reads and writes 1-2-3 and Excel files, and runs under the Pen-Point operating system. It's scheduled to ship in the second quarter.

After several false starts with portable and notebook PC's, the new IBM is trying a new tack. Big Blue just bought a 6% chunk of the French company, Groupe Bull, which owns Zenith Data Systems. The deal provides the rights for **IBM to sell ZDS portables**, and will give Groupe Bull access to IBM's RISC technology. The deal also provides for swapping micro-processor technology; one report indicates that GB will join IBM, Apple, and Motorola in developing the PowerPC, part of last summer's accord between IBM and Apple.

Worried about Japanese encroachment on American markets? Maybe it's time to start learning how to deal with them on their own terms—literally. A company called BayWare (415-949-3190) has introduced a Windows-based program that the company claims can teach the essence of Japanese in four to eight weeks, by studying only an hour per day. **Power Japanese**

was developed using my favorite multimedia authoring system, Tool-Book, and it includes an audio output device that connects to a standard parallel port. The device, which is housed in the connector shell, contains an 8-bit D/A converter and it can drive headphones or an audio amplifier. Software includes 2000 files of native Japanese speech, animated writing sequences, and a set of progressive lessons. The company plans to release versions in French, Spanish, German, and advanced Japanese.

Big-bucks consumer-oriented advertising is becoming the rule in the PC business. You've probably seen Intel's flashy "Vacancy" ads on cable. Now Microsoft is gearing up for a **\$30 million Windows promotion**, including \$8 million for TV spots alone. 1992 is going to be remembered in the PC industry as the year the battle for graphical operating environments became really down and dirty.

R-E

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# DRAWING BOARD

## One step backward to automotive regulators and two steps forward to our oscilloscope.

ROBERT GROSSBLATT

Just when I thought we had driven in the final nail on the whole business of automotive charging systems, I got a letter with some stuff in it that I have to pass on. Even though we spent all our time talking about alternator-based systems, there was a lot of mail from people who had generators. The voltage regulators we designed were specifically aimed at alternators but a regulator is still a regulator and, if you give it some thought, the one we designed can be used with a generator as well.

The most important factor in modifying the design is to realize that regulators for generator have to handle much larger amounts of current and because of that, our existing circuit can't drive the generator directly. The standard way to deal with this is to use relays and that's exactly what was done by Craig Shippee, a reader from Bridgewater, Massachusetts who sent his design to me in the mail.

His circuit, shown in Fig. 1, does several interesting things. First, the basic design is the one we did for an

alternator with a pulled-up field (one side of the alternator's field windings are hard wired to the positive side of the battery) but the generator is set up with a grounded field (one side of the field hard wired to ground). The other interesting part of the design is that it uses only one DPDT relay instead of the two or three relays found in standard generator regulators.

Craig's circuit is a classic example of what happens when need comes up against ingenuity and experimentation. He said that he couldn't give me the exact specifications on the relay he used because he salvaged an old 30-amp light relay from a dead truck. The relay opens when the regulator doesn't want it to charge the battery, and the 40-amp diode makes sure there's no backflow of current from the battery to the generator.

If you're going to use the circuit, make sure the relay is rated high enough to handle the maximum output current of the generator and tweak the 500-ohm potentiometer to get the cut-in point that's best for your system. Craig is using the cir-

cuit on a tractor but there's no reason why it can't be used with any generator-based automotive electrical system.

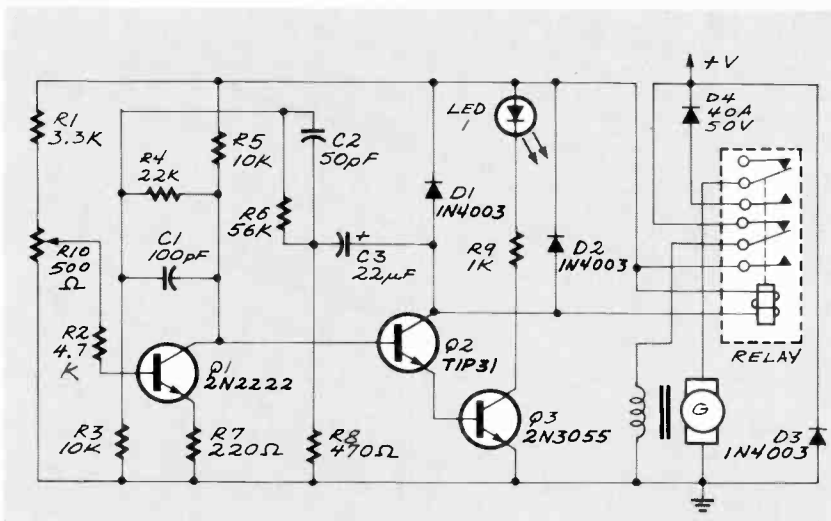


FIG. 1—A REGULATOR FOR A GENERATOR has to handle a lot of current, so a relay must be used.

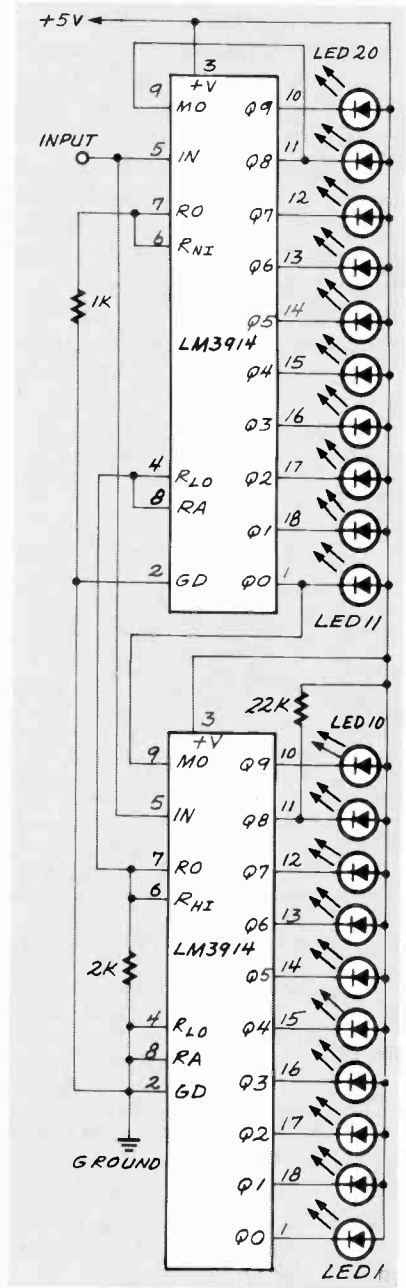


FIG. 2—TO EXPAND THE VERTICAL display to twenty elements we'll have to add a second LM3914 to the circuit. The 3914's were designed to be easily cascaded.

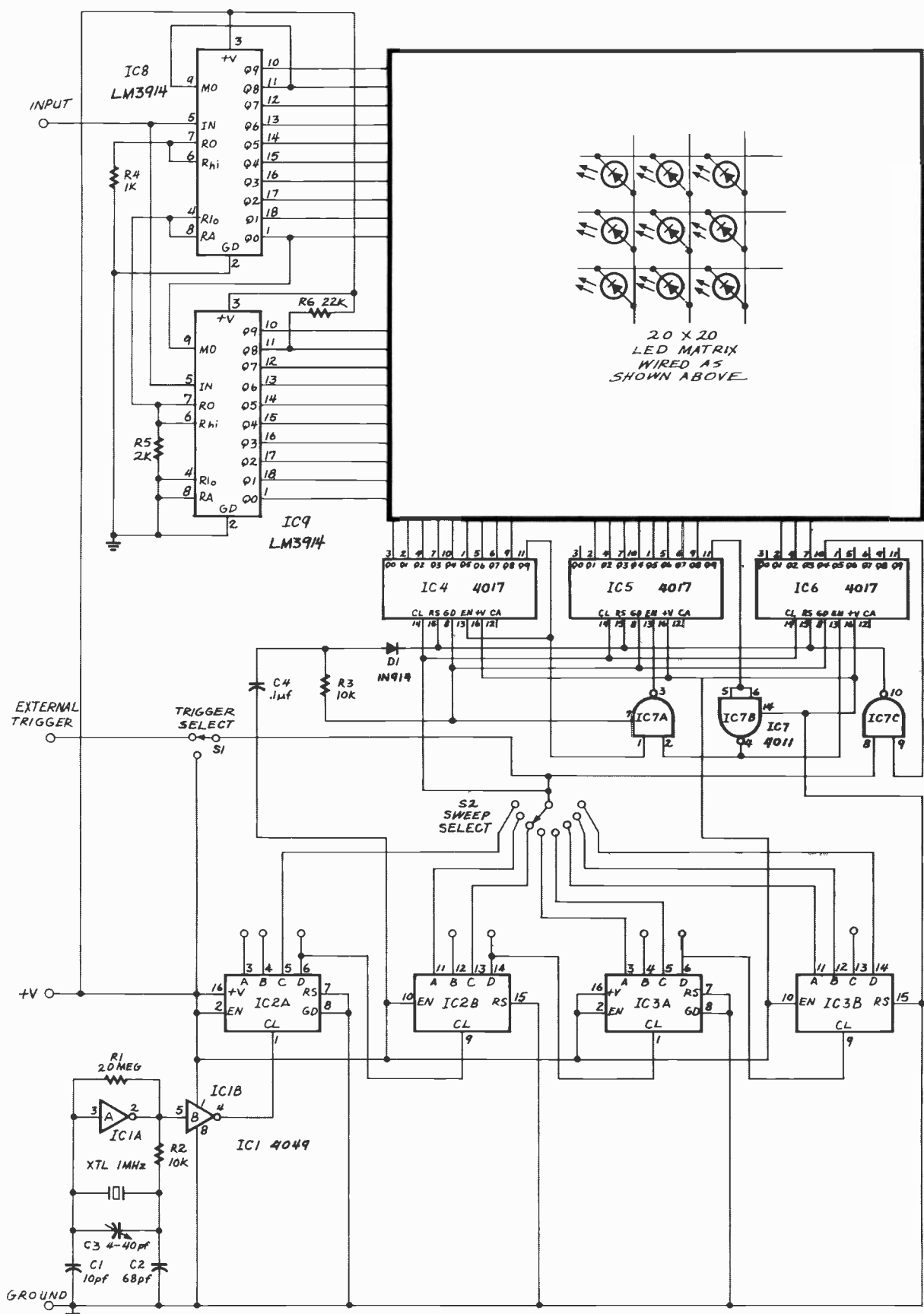


FIG. 3—COMPLETE SCOPE SCHEMATIC SO FAR. All we have to add is an input amp and a pad arrangement to prescale the input voltages.

Some good thinking went into the modification and, in the words of Jimmy Hatlo, a "Tip of the Hat" to Craig Shippee for a good job, a great letter, and taking the time to pass it on. Let me hear some more from you.

But back to the scope.

The next step we have to take is to expand the vertical display to the full twenty elements we specified in the design criteria. Since we're using an LM3914 as the LED driver, we'll have to add a second chip to the circuit. The 3914's were designed with that in mind, so it doesn't take much though to string two (or more) of them together.

The circuit for doing that is shown in Fig. 2. While the actual wiring is simple, there are a few points that should be made a bit clearer. I'll also mention here that all of that information (and a lot more) can be gotten from the 3914's data sheet. One of the most important things when you're designing circuits is to be absolutely familiar with the compo-

nents on the board. It's okay to discover things by accident but only if you then take the time to figure out what happened and why. You can't control what you don't understand.

There are four ways the 3914 can be set to operate: single-chip dot, single-chip bar, cascaded dot, and cascaded bar. In order for the 3914 to reliably know what mode to work in (dot or bar) when two or more chips are cascaded for an expanded display, its internal mode-select amplifier has to watch the state of three pins: MODE SELECT (pin 9), +V (pin 3), and the cathode of LED9 on pin 11.

That last piece of information—the state of pin 11—is critical only when you're doing an expanded dot display. Remember that having a dot display means you want to have only one out of twenty LED's on at any one time. The 3914 controlling LED11—LED20 has to know for sure when one of the earlier LED's is being lit. The circuit in Fig. 2 has the MODE CONTROL pin of the first 3914 connected to the first LED output (pin 1) of the second 3914. That's because when the input signal is driving one of the second bank of LED's (12–20), there will always be some voltage at pin 1. It may not be enough to light the LED but it will be enough to turn off the LED's in the first 3914. As a result of that, the last LED on the first 3914 will always be turned off when any of the LED's on the second 3914 are being lit.

The same sort of reasoning applies to what keeps the second 3914 from lighting an LED when the input voltage to the whole circuit is in the range of the first 3914. In that case, however, the control for the second 3914 is being provided by the voltage on pin 11.

In order for the circuit to be as linear as possible and have each of the LED's indicate equal increments in input voltage, you have to be careful about the reference voltage for each chip. The IC has an internal reference-voltage generator and, even though it can be configured to provide different voltages, we're using it in the plain vanilla mode to generate a 1.2-volt reference. On the second IC in the chain, we have to set the reference voltage a bit higher. Remember that the first 3914 has to respond to input signals

from 0 to 1.2 volts while the second 3914 has to respond to input signals in the range of 1.2 to 2.4 volts.

That sounds more difficult than it really is. All we have to do is use the voltage at the top end of the comparator chain in the first 3914 as the low voltage for the bottom end of the second 3914. By doing that, the absolute working-voltage range for the second 3914 will be 1.2 volts higher than the first one, or 1.2 to 2.4 volts.

This isn't quite the end of the story because we have to give some thought to LED current as well. The drive current for the LED's is determined by the voltage from the +V rail on one side and the IC's reference voltage on the other side. There's a ratio of about ten-to-one between the current for each of the LED's and the current drawn from the reference voltage at pin 7. Since the second 3914 is working with a reference voltage twice as high as the first 3914, we have to adjust the value of the resistor on the second 3914. A simple application of Ohm's law tells us that if we have twice the voltage but want the same amount of current, we have to double the value of the resistor. Since we used about 1K on the first 3914, we have to use a 2K resistor on the second one.

Before we turn away from the 3914, let me repeat that while it's a relatively simple chip to use, there's more going on inside it than you imagine. The only way you'll ever be able to get a good handle on using it is to work your way through the information in the data sheet. The way to do that is to call or write the folks at National Semiconductor (2900 Semiconductor Drive, Santa Clara, CA 95052-8090, 408-721-5000) and ask for the data sheet.

The complete schematic for the scope so far is shown in Fig. 3. Just about the only thing we have to add to it is an input amp and a pad arrangement to prescale the input voltages. The time has also come for us to deal with some of the mechanical problems in the scope—mainly the wiring of the display. While it's certainly not impossible to hand wire four hundred LED's, it's a lot easier to use a commercially available multi-LED module. **R-E**

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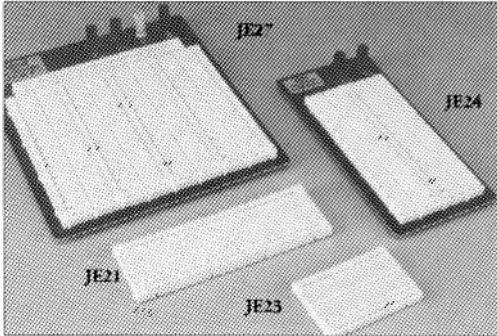
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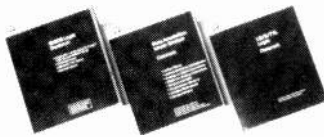
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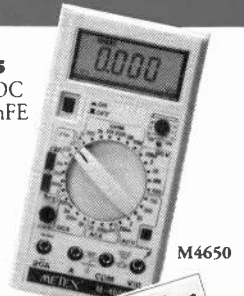
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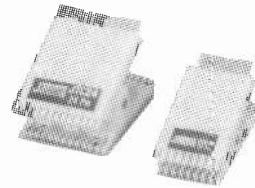
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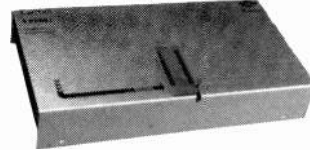
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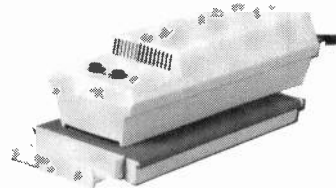
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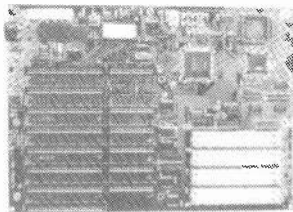
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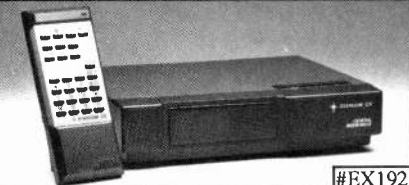
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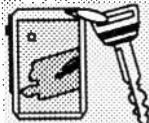
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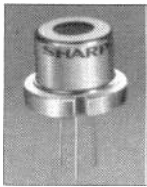
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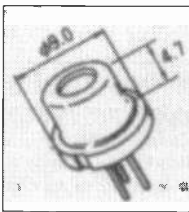


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LT Package Dimensions

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**Due to popular demand in 1991 - EasyTech introduces a comprehensive range of Laser diodes from the industry leader in laser technology.**

**Every Sharp Laser Diode is encased in a high precision hermetic package. A built-in pin photo diode makes it easy to control optical power output.**

**Features:**

- Long life, high reliability and an original VSIS structure, featuring a single transverse mode and negligible waste current.
- Wide variety of models to suit an extensive range of applications in the manufacturing or do-it-yourself environment.
- New B (Buried) - VSIS structure incorporating high resistance GaAlAs crystal buried at both sides of the optical waveguide (V-channel) preventing carriers in the active layer from diffusing from the direction parallel to the active layer, thus dramatically reducing wasted current not contributing to laser oscillation. This achieves a very low threshold current level of only 25mA.
- Compact and lightweight, essential when giving laser-applied equipment-like CD players, VD players and laser printers - a small space saving footprint.

Order #	Price		Wavelength (nm)	Optical Pwr Output (mW)		Typical Applications	Weight
	1-9	10+		Typ.	Max.		
LT020MC	13.90	12.90	780	3	5	Measuring instruments, Bar code readers	3 oz.
LT022MC	13.90	12.90	780	3	5	CD players, CD-ROMs	3 oz.
LT023MC	16.50	15.50	780	3	5	VD players, Analog devices	3 oz.
LT021MC	55.00	50.00	780	10	15	High-speed laser printers, Medical apparatus	3 oz.
LT010MC	49.00	40.00	810	3	5	Short-distance optical fiber communications, Measuring instruments	3 oz.

**RACK MOUNT CABINETS**

•Racks B, C, D, E and H feature extruded aluminum handles



E3120C



E3120E

**MATERIALS**

- Front/Rear and Display Panel: Aluminum
- Top/Bottom, Side Panel and Chassis: 0.9mm Steel

These industry standard 19" rack mount cabinets are made from .9mm steel, with the front and rear panels being made from aluminum for easier, custom fitting. The front panel is 1/8" thick. These cabinets have been finished in gun metal grey and come flat packed, ready for your final construction. The enclosure has die punched venting. Handles are furnished on "B" and larger cabinets. These are sturdy, well made commercial quality cabinets and are sure to make your project look its best. (Please note "Panel" size is the front panel.)

Order #	1-9	10+	Panel	Cabinet (HxWxD)	Weight
E3120A	36.95	34.95	19" x 1.6875"	1.5" x 16.625" x 9.625"	7.0 lbs.
E3120B	44.95	42.95	19" x 3.4375"	3.25" x 16.625" x 9.625"	7.8 lbs.
E3120C	49.95	47.95	19" x 3.4375"	3.25" x 16.625" x 13.1875"	9.0 lbs.
E3120D	54.95	52.95	19" x 5.1875"	5.0" x 16.625" x 13.1875"	12.0 lbs.
E3120E	59.95	57.95	19" x 5.1875"	5.0" x 16.625" x 16.75"	13.2 lbs.
E3120H	79.95	77.95	19" x 8.6875"	8.5" x 16.625" x 16.75"	18 lbs.

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SB830



SB1660



SB3220

**Features**

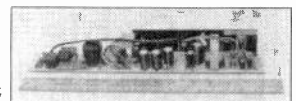
- Color coordinates for easy recognition
- Insertion wire: 20-29 AWG (0.3 – 0.8 mm)
- Over 10,000 insertion cycles
- Accepts all standard components

Order #	Price 1-9	Price 10+	Dimensions (in.) L x W x H	Dist. Strips	Dist. Points	Terminal Strips	Terminal Points	Binding Posts
SB200	2.99	2.49	6.5 x 0.37 x 0.4	2	100	2	0	0
SB400	4.89	4.39	3.3 x 2.2 x 0.4	2	100	1	300	0
SB630	5.45	4.95	6.5 x 1.4 x 0.4	0	0	1	630	0
SB830	6.49	5.99	6.5 x 2.2 x 0.4	2	200	1	630	0
SB1360	12.49	11.99	8.5 x 3.9 x 1.2	1	100	2	1,260	2
SB1660	17.45	16.95	8.5 x 5.1 x 1.2	4	400	2	1,260	3
SB2390	22.49	21.49	9.1 x 6.9 x 1.2	5	500	3	1,890	4
SB3220	31.49	30.49	9.5 x 8.3 x 1.2	7	700	4	2,520	4

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- Automatic over voltage shutdown/fold back protection



Order #	Price	Output Vdc/Amps	Watts	Dimensions (HxDxW in.)	Weight
KCT030FJ1	5.95	+5V@3A/+12V@1A/-12V@400mA...30	14.17 x 1.77 x 1.89	...1 lb.	
KCT040FJ6	6.95	+5V@4A/+12V@1A/-12V@400mA...40	14.17 x 1.77 x 1.89	...1 lb.	



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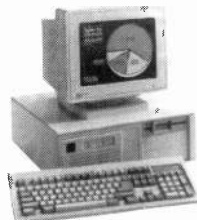
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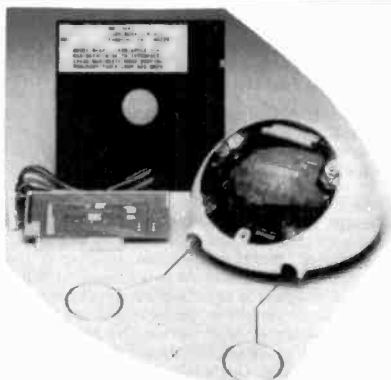
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## LASER DIODES

STOCK #	MFG.	WAVE-LENGTH	OUTPUT POWER	OPER. CURR.	OPER. VOLT.	1-24	25-99	100+
LS9220	TOSHIBA	660nm	3 mW	85 mA	2.5 V	129.99	123.49	111.14
LS9200	TOSHIBA	670nm	3 mW	85 mA	2.3 V	49.99	47.99	43.19
LS9201	TOSHIBA	670nm	5 mW	80 mA	2.4 V	59.99	56.99	51.29
LS9211	TOSHIBA	670nm	5 mW	50 mA	2.3 V	69.99	66.49	59.84
LS9215	TOSHIBA	670nm	10 mW	45 mA	2.4 V	109.99	104.49	94.04
LS3200	NEC	670nm	3 mW	85 mA	2.2 V	59.99	56.99	51.29
LS022	SHARP	780nm	5 mW	65 mA	1.75 V	19.99	18.99	17.09
SB1053	PHILLIPS	820nm	10 mW	90 mA	2.2 V	10.99	10.44	9.40

## WAO II PROGRAMMABLE ROBOTIC KIT

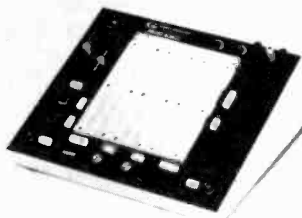


The pen mechanism included with the robot allows it to draw. In addition to drawing straight lines, it can also accurately draw circles, and even draw out words and short phrases. WAO II comes with 128 x 4 bits RAM and 2K ROM, and is programmed directly via the keypad attached to it. With its built-in connector port, WAO II is ready to communicate with your computer. With the optional interface kit, you can connect WAO II to an Apple II, IIe, or II+ computer. Editing and transferring of any movement program, as well as saving and loading a program can be performed by the interface kit. The kit includes software, cable, card, and instructions. The programming language is BASIC.

- Power Source - 3 AA batteries (not included)

STOCK #	DESCRIPTION	1-9	10-24	25+
MV961	WAO II Programmable Robotic Kit	79.99	75.99	68.39
WHAP	Interface Kit For Apple II, IIe, II+	39.99	37.99	34.19

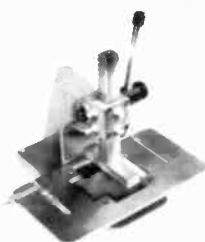
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- **Variable DC output**  
-5 to +15 VDC @ 0.5 amp, ripple - 5 mV
- **Frequency generator**  
frequency range: 0.1 Hz to 100 KHz in 6 ranges  
output voltage: 0 to ±10V (20 Vp-p)  
output impedance: 600 (except TTL)  
output current: 10mA max., short circuit protected  
output waveforms: sine, square, triangle, TTL  
sine wave distortion 3% (10 Hz to 100 KHz)  
TTL pulse: rise and fall time 25ns  
drive 20 TTL loads
- **Logic Indicators**  
8 LED's, active high, 1.4 volt (nominal) threshold, inputs protected to ±20 volts
- **Debounce pushbuttons (pulsers)**  
2 push-button operated, open-collector output pulsers, each with 1 normally-open, 1 normally-closed output. Each output can sink up to 250 mA
- **Potentiometers**  
1 - 1K, 1 10K, all leads available and uncommitted
- **BNC connectors**  
2 BNC connectors pin available and uncommitted shell connected to ground
- **Speaker**  
0.25 W, 8 Ω
- **Breadboarding area**  
2520 uncommitted tie points
- **Dimensions**  
11.5" long x 16" wide x 6.5" high
- **Input**  
3 wire AC line input (117 V, 60 Hz typical)
- **Weight**  
7 lbs.

STOCK #	DESCRIPTION	1-9	10-24	25+
PB503	ProtoBoard Design Station	299.99	284.99	256.49

### IDC BENCH ASSEMBLY PRESS



The Panavise PV505 1/4 ton manual IDC bench assembly press is a rugged, practical installation tool designed for low volume, mass termination of various IDC connectors on flat ribbon cable.

- Assembly base & standard platen included
- Base plate & platen may be rotated 90° for maximum versatility
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- Additional accessories below
- Size - 10" W x 8.75" D x 9" H
- Weight - 5.5 lbs.

STOCK #	DESCRIPTION	1-9	10-24	25+
PV505	Panavise Bench Assembly Press	149.99	142.49	128.24

### COLLIMATING PEN



A low power collimator pen containing a MOVPE grown gain GaAlAs laser. This collimator pen delivers a maximum CW output power of 2.5 mW at 820 nm. The operating voltage of 2.2-2.5V @ 90-150mA is designed for lower power applications such as data retrieval, telemetry, alignment, etc.

The non-hermetic stainless steel case is specifically designed for easy alignment in an optical read or write system, and consists of a lens and a laser diode. The lens system collimates the diverging laser light. 18 mrad. The wavefront quality is diffraction limited.

The housing is circular and precision manufactured measuring 11.0 mm in diameter and 27.0 mm long. Data sheet included.

As with all special buy items, quantity is limited to stock on hand.

STOCK #	DESCRIPTION	1-9	10-24	25+
SB1052	Infra-Red Collimator Pen	49.99	47.49	42.74

### LASER DIODE MODULE



The LDM 135 integrated assembly consisting of a laser diode, collimating optics and drive electronics within a single compact housing. Produces a bright red dot at 660-685 nm. It is supplied complete with leads for connection to a DC power supply from 3 to 5.25 V.

Though pre-set to produce a parallel beam, the focal length can readily be adjusted to focus the beam to a spot.

Sturdy, small and self-contained, the LDM135 is a precision device designed for a wide range of applications. 0.64" diam. x 2" long.

STOCK #	DESCRIPTION	1-9	10-24	25+
LDM135-5	5 mW Laser Diode Module	179.99	170.49	153.89
LDM135-1	1 mW Laser Diode Module	189.99	180.49	162.44
LDM135-2	2 mW Laser Diode Module	199.99	189.99	170.99
LDM135-3	3 mW Laser Diode Module	209.99	199.49	179.54

### COLLIMATING LENS



This economical collimating lens assembly consists of a black anodized aluminum barrel that acts as a heat sink, and a glass lens with a focal point of 7.5 mm. Designed to fit standard 9mm laser diodes, this assembly will fit all the above laser diodes. Simply place diode in the lens assembly, adjust beam to desired focus, then set with adhesive.

STOCK #	DESCRIPTION	1-9	10-24	25+
LLENS	Collimating Lens Assembly	24.99	23.74	21.37

### DUAL MODE LASER POINTER



New slimline laser pointer is only 1/2" in diameter x 6 1/2" long and weighs under 2 oz. 670 nm @ less than 1 mW produces a 6 mm beam. 2 switches, one for continuous mode, and one for pulse mode (red dot flashes rapidly). 2 AAA batteries provide 8+ hours of use. 1 year warranty.

STOCK #	DESCRIPTION	1-9	10-24	25+
LP35	Dual Mode Laser Pointer	199.99	189.99	170.99

### ROBOTIC ARM KIT



Robots were once confined to science fiction movies. Today, whether they're performing dangerous tasks or putting together complex products, robotics are finding their way into more and more industries. The Robotic Arm Kit is an educational kit that teaches basic robotic arm fundamentals as well as testing your own motor skills. Command it to perform simple tasks.

STOCK #	PRICE
Y01	\$43.99

### He-Ne TUBES



New, tested 632nm He-Ne laser tubes ranging from 5mW to 3mW (our choice). Perfect for hobbyists for home projects. Because of the variety we purchase, we cannot guarantee specific outputs will be available at time of order. All units are new, tested, and guaranteed to function at manufacturer's specifications.

STOCK #	DESCRIPTION	1-9	10-24	25+
LT1001	He-He Laser Tube	69.99	66.49	59.84

### AVOIDER ROBOT KIT



An intelligent robot that knows how to avoid hitting walls. This robot emits an infra-red beam which detects an obstacle in front and then automatically turns left and continues on.

STOCK #	PRICE
MV912	\$43.99



• Input: 115/230V  
• Output: +5v @ 3.75A  
+12v @ 1.5A  
-12v @ .4A  
• Size: 7" L x 5 1/2" W x 2 1/2" H

STOCK #	PRICE
PS1003	\$19.99

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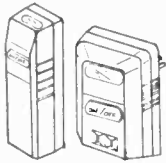
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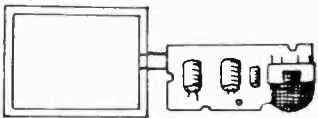


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## DISPLAY DRIVERS

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nals do not have to be pre-shaped. The counter is reset by driving the RESET pin high.

The CLOCK INHIBIT pin must be grounded to allow normal counting. When CLOCK INHIBIT is high, the counters are inhibited. The display is blanked when the display ENABLE pin is grounded.

The three auxiliary output pins of the 4026B are designated DISPLAY/ENABLE OUT (D/E OUT), CARRY OUT (CARRY OUT), and 2 OUT (2 OUT). The DISPLAY/ENABLE OUT signal is a slightly delayed copy of the DISPLAY/ENABLE input signal. The CARRY OUT signal is a symmetrical square wave whose frequency is one-tenth of the clock input frequency, and is used when cascading 4026B counters. The 2 OUT pin goes low only on a count of two. Fig. 22 shows the circuit connections for cascading stages.

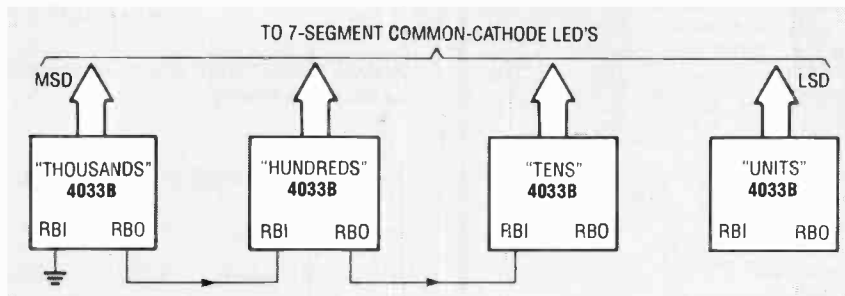


FIG. 25—MODIFICATION of Fig. 24 circuit to obtain automatic leading-zero suppression.

Figure 23 shows the pinout pattern of the 4033B, a modified version of the 4026B. The DISPLAY ENABLE and DISPLAY ENABLE OUT pins of the 4026B have been eliminated and replaced by RIPPLE-BLANKING INPUT (RBI) and RIPPLE-BLANKING OUTPUT (RBO).

Figure 24 shows the wiring scheme for two 4033B's in normal use. The RESET, CLOCK INHIBIT, and LAMP TEST pins are all grounded, and the RIPPLE-BLANKING INPUT pin is positive. That configuration does not blank leading or trailing zeros.

If cascaded 4033B's are to give automatic leading-zero sup-

pression, the circuit in Fig. 24 must be modified as shown in Fig. 25 to provide ripple-blanking. In Fig. 25, the RBI pin of the most significant digit (MSD) is grounded, and its RBO pin is connected to the RBI pin of the next least-significant stage. That pattern is repeated on all except the LSD, which does not require zero suppression. If trailing-zero suppression is required, the direction of ripple-blanking feedback must be reversed. The RBI pin of the LSD is grounded and its RBO pin is wired to the RBI pin of the next least-significant stage. R-E

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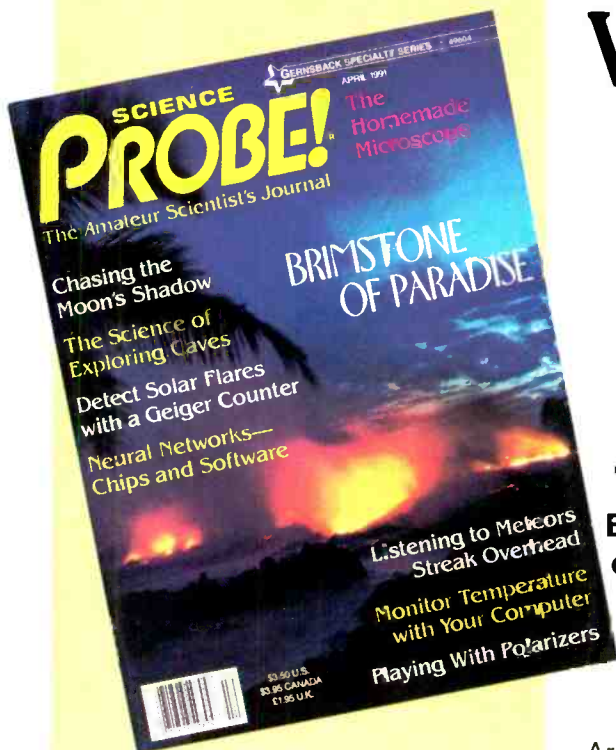
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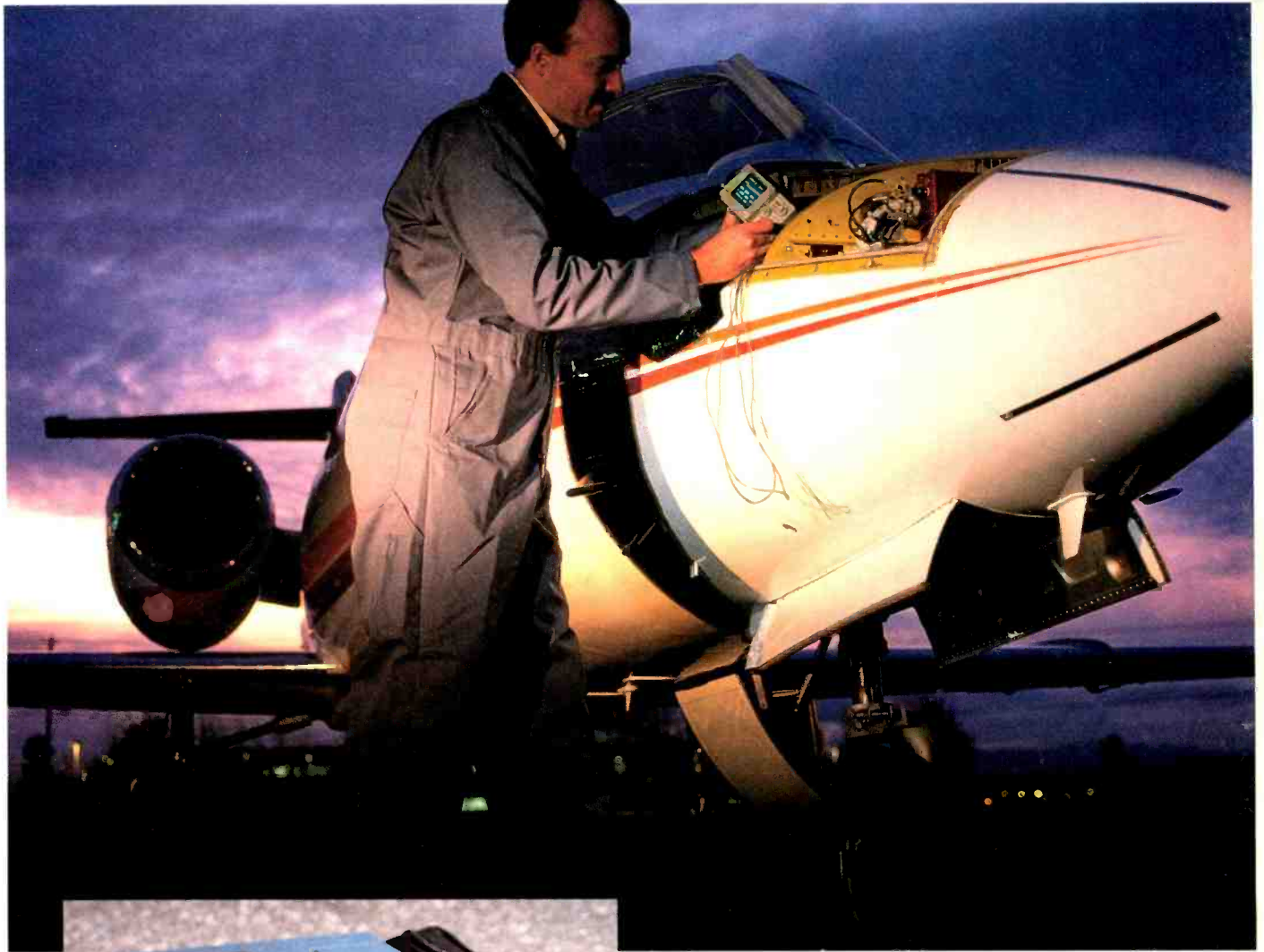
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