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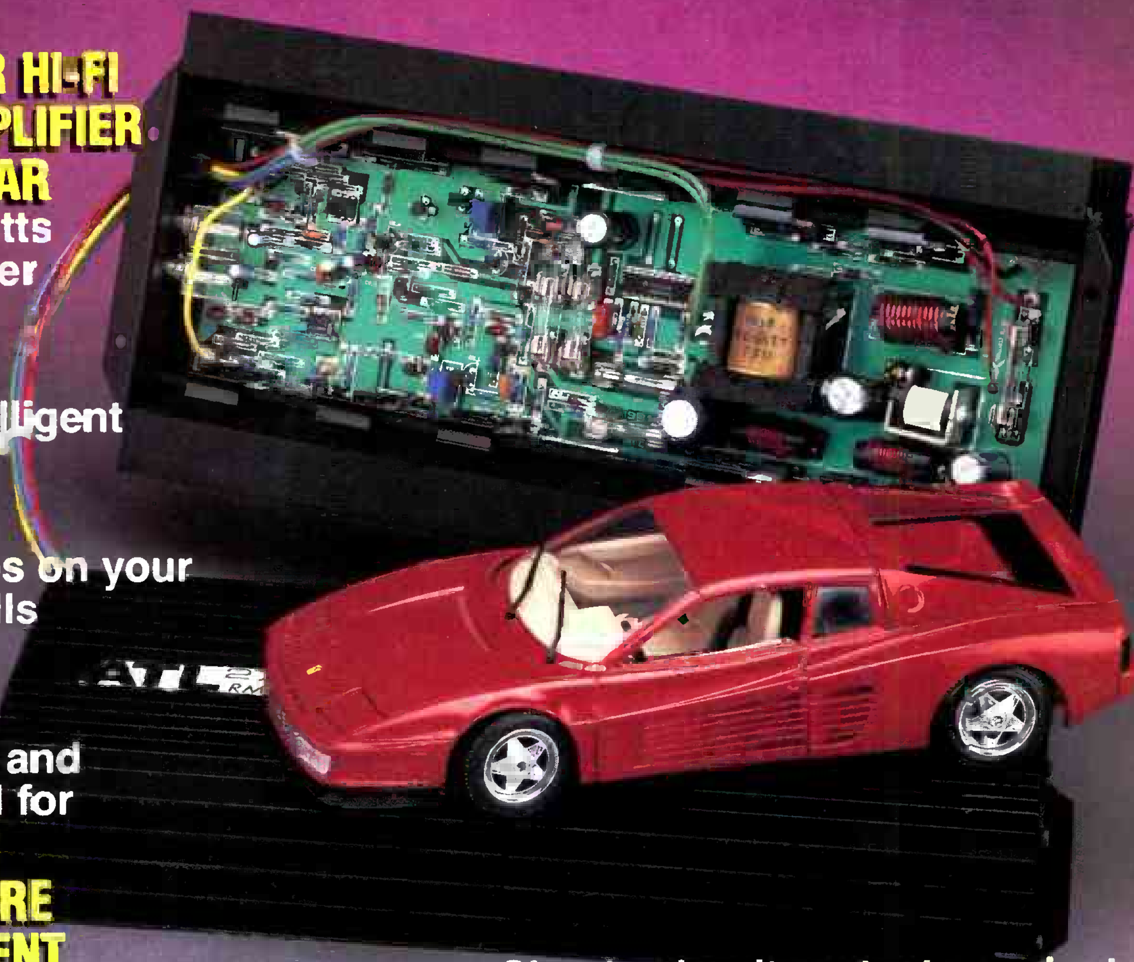
Radio Electronics

APRIL 1992

TECHNOLOGY - VIDEO - STEREO - COMPUTERS - SERVICE



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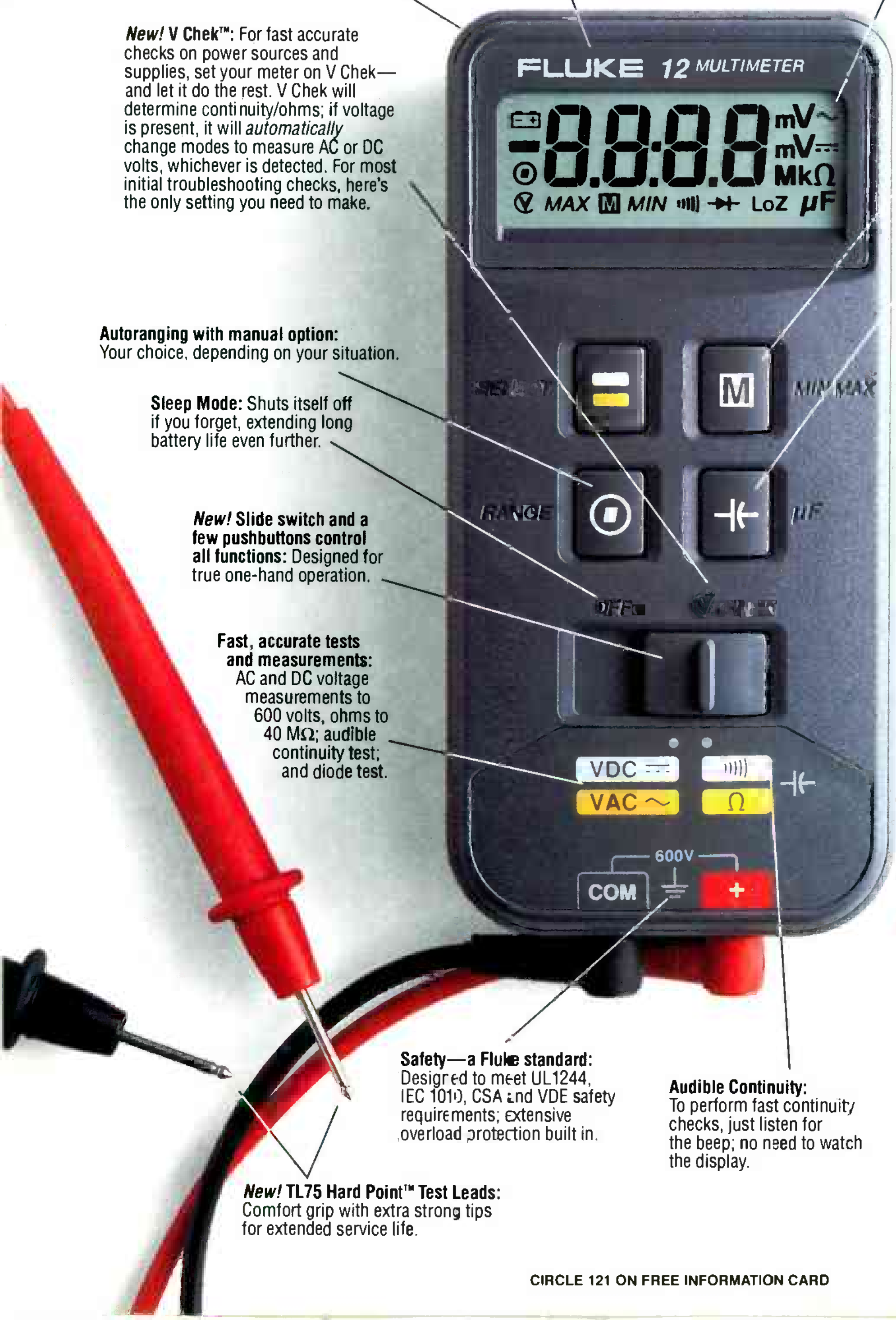

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April 1992

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Vol. 63 No. 4

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ON THE COVER

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WHAT'S NEWS

A review of the latest happenings in electronics.

World's smallest infrared antennas

Scientists at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD have produced antennas the size of a single grain of sand. The scientists believe they might have industrial importance and might also help explain how insects communicate. The antenna development paves the way for unique infrared detectors that rely on antennas to "see" images of heat radiating from all warm objects such as people, animals, and buildings.

The microantenna is unlike conventional communications antennas for operating at the longer wavelengths that require larger antennas that might range in size from 1 meter in diameter (for radio and TV broadcast) to 100-meters (for deep-space communciations and radio astronomy). The NIST "microantenna" is only 60 micrometers wide, about the diameter of human hair. Yet it can effectively capture the extremely short wavelengths of infrared radiation. Made of gold, the microantenna can pick up infrared wavelengths at one sixth the range of previous antennas.

TINY INFRARED ANTENNA developed by NIST scientists is shown next to a human hair.

About half of the infrared energy that falls on the antenna is delivered to the detector at the device's center. Superconductive material was used in the development of those detectors which are so small that they cannot effectively capture infrared radiation unless they are coupled to antennas. The goal is to build an array of the microantennas to provide an infrared image of objects within its field of view.

Scientists have long suspected that tiny structures on certain insects were actually "organic infrared microantennas," used by the insects to "see" in the dark.

Energy storage breakthrough

Quadri Electronics Corporation (Chandler, AZ) has been granted a patent on a new energy-storage device, called "Hypercap." It provides far more storage than similar-sized capacitors and, when used in combination with CMOS RAM to provide nonvolatile memory, overcomes many of the problems inherent in lithium and nickel-cadmium batteries. Quadri plans to sell the product in an energy module that will mount directly on a CMOS RAM memory PC board to provide power for nonvolatile storage.

Neither a battery nor a conventional capacitor, Hypercap has some properties of both. According to Quadri, the solid-electrolyte, radiation-hard device can be deep discharged and recharged tens of thousands of times. It contains no lithium or toxic chemicals and the company says it will not outgas, explode, or ignite. The Hypercap operates over a temperature range of −55°C to +125°C and is said to provide about 100 times the energy storage density of a wet-slug tantalum capacitor. Hypercap discharges at less than 3% per year.

QUADRI ELECTRONICS researchers have developed a new technology for high-density, radiation-hardened energy storage.

Promoting amateur radio

A new educational program created by Kenwood U.S.A. Corporation (Long Beach, CA) is designed to encourage young people to learn more about amateur radio. More than 2000 amateur radio clubs in the United States are being invited, in a special mailing, to join Kenwood in sponsoring a local junior or senior high school class, scout troop, or youth club in the Kenwood KIDS program." Each club that responds to the mailing will receive a package of educational materials. The package includes ten copies of the ARRL publication *Now You're Talking* and the companion instructor's guide, as well as a certificate for the Kenwood HamWindows computer program. According Tom Wineland, Vice President Communications and Test Equipment Division, "The heart of the program is education, but we have built-in incentives for both the kids and the co-sponsoring clubs. Every youngster who succeeds in obtaining a license will receive a $25 Kenwood gift certificate, while the sponsoring club will receive ten $25 certificates for each successful class. The participating schools and clubs can also win complete HF stations. **R-E**

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VIDEO NEWS

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

DAVID LACHENBRUCH

• **Widescreen TV age.** Widescreen TV is here, with expensive sets ready to go, but very little specially formatted programming to show on them. JVC promises to be the first brand to offer sets on the American market—although only in token quantities—to be followed by Thomson Consumer Electronics, which will field larger numbers under its RCA and ProScan labels. Both brands will offer these widescreen (16:9 ratio) sets with direct-view tubes measuring 34 inches in viewable diagonal, the equivalent of a stretched-out 27-inch tube.

At our deadline, prices for the United States hadn't been revealed, but similar widescreen sets on the Japanese and European markets were fetching the equivalent of $5,500 to $7,000 in list prices. Neither Thomson nor JVC was talking about low prices, so it's a good guess that the tags here will be in line with those other countries. Thomson, which is making widescreen tubes at its plant in Italy, has indicated that its imported widescreen tubes in the United States currently cost five to six times as much as a 4:3 ratio counterpart.

• **Widescreen VCR's.** JVC has developed a VCR which can accommodate both widescreen and standard-ratio pictures, telling the TV set what type of picture is on the tape. The widescreen pictures are compressed horizontally, as compared with letterbox pictures, which leave a blank horizontal band at the top and bottom of standard-ratio screens. The recorders are in the Super VHS format, and are already on sale in Europe and Japan. Thomson will offer widescreen camcorders in VHS, VHS-C, and 8mm formats, but they will just have horizontal strips masked off at the top and bottom of the picture to provide a letterbox format (they'll also be able to record a standard picture).

At first, widescreen TV's will depend on letterbox material for prerecorded programming (although they can also display standard-format material), and Thomson says some 400 movies are available in that format on Laserdisc. Because letterbox movies occupy only a portion of the picture vertically, vertical resolution is reduced. The Thomson widescreen TV's will use the "double-scan," or IDTV approach, doubling the number of horizontal lines, and also adding motion compensation, while JVC's set will have standard interlace and the normal 525 lines.

• **HDTV worries.** Although the United States is only now involved in testing proposed high-definition TV systems, all of the systems which are serious contenders are digital. As a result, the US has moved from last place to first place in the HDTV sweepstakes. Even before any digital system has been proven viable, America's digital approach has struck fear into the hearts of Europe and Japan. The European community had developed a gradual approach to HDTV; the D2-MAC system was supposed to evolve into something called HD-MAC in direct-to-home satellite broadcasts. They decided, however, to make the transition optional, so the new system will never be effected because of the reluctance of satellite broadcasters to convert to a system that nobody is equipped to receive.

In Japan there is similar discontent, although the Japanese Hi-Vision system is now being broadcast by satellite by the Japan Broadcasting Company (NHK). The analog system, however, is based on 20-year-old technology, and requires extremely complex receivers. Recently the Hi-Vision partisans hailed a major breakthrough, and receiver prices came down from the equivalent of $70,000 to $30,000!

Increasingly, Japanese manufacturers and broadcasters are beginning to realize that Hi-Vision is a system whose day has come and gone. How ironic it would be to find the United States emerge as the leader in this technology because it had to find a fresh approach.

• **Rethinking HDTV.** Increasingly, we are hearing rumbles that maybe HDTV—digital or analog—isn't what it's cracked up to be. In Japan, enthusiasm is growing over widescreen 16:9 TV without improved resolution, which many observers are saying goes more than halfway to HDTV in consumers eyes. Even at Sony, which has been among the staunchest advocates of Hi-Vision, Deputy President Ken Iwaki recently called its gamble on HDTV a "miscalculation."

In the US, some doubts are arising about the value of HDTV. The MIT Media Lab, in the past, has noted that the quality difference between a broadcast station's NTSC monitor and the received TV signal in the home is greater than the difference between NTSC and HDTV. Consumer tests show that the greatest perceived value of the HDTV picture is the wide screen.

• **Ghostbusting.** One of televisions major drawbacks, ever since the first broadcasts, has been ghosting. The average consumer in an area plagued by ghosts might find elimination of ghosts in a conventional picture a greater achievement than HDTV. The National Association of Broadcasters has tested five different ghost-cancellation systems, using three Washington area TV stations, and should announce the results soon. All of the systems require the transmission of an invisible pilot signal by the TV station, and special receivers to make use of that signal. After more than 40 years of TV, it now appears that the system's biggest technical problem is about to be licked! **R-E**

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SKIP THE ZERO

I'm building some electronic dice for my children who are visually impaired. For that reason I'm using a large seven-segment display and I've run across a problem I can't seem to solve. I'm using a 555 to drive a 7490 decade counter which is connected to a 9368 decoder driver latch. Two AND gates reset the circuit after the six count and the problem is that the count includes a zero. The blanking input on the 9368 will just turn off the LED's so my choices seem to be limited to having either a zero or a blank in the display—neither of which you want with dice. Is there some trick I can use to have the 7490 skip the zero count?—J. Mullane, Dunn Loring, VA

When digital electronics filtered down to the hobby market some twenty years or so ago, electronic dice were among the most common projects you could find. Of course, they were all made with discreet LED's instead of seven-segment displays so your particular problem never really presented itself.

First of all, there's no way—short of microsurgery—to alter the count of the 7490. That isn't to say that you can't solve the problem but the idea is to do it with a minimum of brain damage. Given that criterion, you can throw out all the schemes (most of which you've undoubtedly thought of) that use the reset pulse to force feed two counts to the clock or the 7490. It's possible to do that but the gating problems, while solvable, are a pain in the neck and always lead to the addition of lots of silicon to what should really be a simple, straightforward circuit.

Although there are several different approaches that can be taken to come up with a solution to your problem, if I were building a circuit like yours, I would rethink the entire circuit.

The most direct way to eliminate the zero count altogether is to recognize that the problem is being caused by the 9368, not the 7490 as you indicated in your letter. If you think about the circuit for a minute, you'll realize that you're resetting the 7490 after it's gone through seven counts—zero through six. All the solutions that try to gate in two counts at reset still let the 7490 go through seven counts, not six (which is really what you want for dice). Keeping that in mind, it's clear that you want the 7490 to be reset after six counts, not seven.

The problem you're left with is that the 9368 causes the display to show the numbers zero through five when the 7490 puts out its first six counts. What you want to happen is to force the 9368 to put out a one when it has a zero at its inputs, a two when it sees a one, a three when it sees a two, and so on. Unfortunately, making it do that is what the engineering journals refer to as a "major problem."

The way around the problem is to get rid of the 9368 altogether and find a decoder driver latch that does it automatically. I'll save you a lot of research time and tell you that there's no such animal around. The way to do it is to use an EPROM and make one of your own. It's a simple thing to do and the truth table for the EPROM you are going to need is shown in Table 1.

There's a lot of wasted space in the EPROM since you're only using the first six out of a total of 2048 storage locations (assuming you use a 2716). But EPROM's are cheap and as long as they do the job, who cares how efficiently they're being used?

Burning an EPROM used to be an exotic activity but EPROM burners (particularly those that can do 2716's) are cheap and available from just about every supplier in the world. If you don't have one you can probably find someone locally who does but, if you're interested in

TABLE 1—EPROM CHARACTER GENERATOR CHART

Input	Programmed Output Data									LED's
EPROM Address	D 7	D 6	D 5	D 4	D 3	D 2	D 1	D 0	Hex Data Byte	Segment Display
Common—Cathode Display										
000	0	0	0	0	0	1	1	0	06	1
001	0	1	0	1	1	0	1	1	5B	2
002	0	1	0	0	1	1	1	1	4F	3
003	0	1	1	0	0	1	1	0	66	4
004	0	1	1	0	1	1	0	1	6D	5
005	0	1	1	1	1	1	0	1	7D	6
Common—Anode Display										
400	1	1	1	1	1	0	0	1	F9	1
401	1	0	1	0	0	1	0	0	A4	2
402	1	0	1	1	0	0	0	0	B0	3
403	1	0	0	1	1	0	0	1	99	4
404	1	0	0	1	0	0	1	0	92	5
405	1	0	0	0	0	0	1	0	82	6

Note 1. Be sure to connect all unused EPROM address lines to either ground or power.

Note 2. The EPROM output pins are assigned as follows:

D0 – A Segment
D1 – B Segment
D2 – C Segment
D3 – D Segment
D4 – E Segment
D5 – F Segment
D6 – G Segment
D7 – Decimal Point

electronics, you should really have one on the bench.

One of the side benefits of using an EPROM instead of the 9368 is that you won't need the AND gates any longer. You can use the EPROM's eighth bit to directly control the 7490's RESET input while using the first seven bits to drive the LED display. And yes, the outputs of the EPROM have enough muscle to directly drive the display. You can also have the resulting circuit drive either common-anode or common-cathode displays since it's simply a matter of programming a low or high in the EPROM.

Table 1 uses the EPROM's D7 line to control the 7490 counter's RESET input and the A4 address as the toggle to pick between driving either a common-anode display (A4 high) or a common cathode-display (A4 low).

FUSE PLAY

This may seem like a trite question but I haven't seen it discussed before and I'm a bit confused. Since fuses are essentially thermal devices, can I freely substitute fuses of equivalent wattages? In other words, would a fuse rated 2 amps at 250 volts be thermally equivalent to one rated 4 amps at 125 volts?—L. Balla, Chicago, IL

The more time you spend screwing around with electronics, the more you find out what happens when you start bending the rules. Some of them hold together, but some of them are rather "brittle," and they're the ones you must follow to the letter. Fuse ratings are among the most brittle rules around. If a circuit calls for a 2-amp fuse, using one rated at 4 amps is a bit self defeating, and putting a 2-amp fuse in a 4-amp circuit works only if you never turn the thing on.

While it's true that fuses have a voltage and current rating, it's a world class mistake to think of them only in terms of their power rating (amps times volts). A fuse is, as you correctly stated, a thermal device. The element has a certain resistive rating and if more than the specified amount of current flows through it, the heat generated by the current will cause the element to either melt or vaporize.

The voltage rating of a fuse refers to how large a voltage drop can be across the fuse before it starts to pass current. Since a good fuse is really a short circuit, it may not seem to make a lot of sense to talk about voltage, but if you start thinking about what happens when a fuse blows, the picture changes.

The minute the fuse blows, there's a voltage present across the gap created when the fuse element melted or vaporized. Since you don't want the blown fuse to conduct any current, you have to be sure that there's no way the voltage can be high enough to have a spark jump the gap.

You can see now that the important rating for a good fuse is its current rating while the critical number for a blown fuse is its voltage rating. What that means is that a fuse has to protect the circuit before and after it blows—that's why it's there in the first place.

TURN-SIGNAL AMPLIFIER

Like many senior citizens, my hearing isn't that of a teenager's and one problem I have is hearing the sound of my car's turn signals when I'm driving. The weak clicking sound of the indicator is very hard to hear, especially in heavy traffic. I'm looking for a circuit that will emulate the chime sound currently used in cars as a signal that the key has been left in the ignition. I've tried buzzers and sonalert devices but their sound is either too harsh or too high pitched. Can you help me?—W. Baker, Independence, MO

There are lots of available parts that can be turned into a circuit to make bell sounds and, while it doesn't take much effort to put one of these things together, I don't think that's the right way for you to go. Since you've indicated that you've already tried buzzers and other stuff, I'm assuming that you know where the flasher is and also know how to have other devices trigger off the signal. If I were faced with your problem, I would go to the auto dealer and get the part used in cars to generate the chime sound for when the key is left in the ignition, and hook that up. **R-E**

LETTERS

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

DC MOTOR SPEED REGULATION

I believe that I can add a significant comment to a discussion opened in the *Ask R-E* column in the October 1991 issue of **Radio-Electronics**. On the subject of modification of cassette tape machines to run at half speed, there are two basic approaches that I have used with success. There are also some problems that will crop up that weren't discussed in the column.

If a permanent (not switchable) speed change is desired, the most straightforward way to do it is to make a smaller pulley for the capstan motor. Most late-model machines have plastic pulleys that are easily removed. The original pulley could be turned down on a lathe, or a new one could be turned from plastic (delrin works well) rod stock, which is the method I have used. The speed-adjustment range of capstan motors is generally too narrow to obtain half speed, but will allow small errors in pulley size to be compensated. If you use this method, pay a machinist to fabricate your pulley unless you're confident in your own skill and equipment; even minor eccentricity will result in degraded recording quality due to excessive flutter.

The other method I've used is to circumvent the motor's speed-regulation circuitry and replace it with a servo system of my own design. A basic problem with this approach is that of obtaining motor-speed feedback for the controller. I solved that problem by attaching a tiny ferrite magnet chip (taken from a speaker) to the motor-pulley flange, and then I used a tape head positioned nearby to generate one pulse per revolution. (This tachometer head can be almost any tape head taken from older equipment.)

Other approaches to DC motor speed regulation have appeared in the literature. National Semiconductor Application Note AN-292, "Applications of the LM3524 Pulse-Width Modulator," describes a speed servo that does not require separate tachometer sensor, but relies on motor "back EMF" for the speed-related feedback signal. Motorola describes a similar application in the documentation for its MC33030 DC servo motor controller/driver chip. I believe other chips were developed that were more specific for this application, but I don't recall their designations. In any event, the U.S. consumer-electronics business is now so dominated by foreign suppliers that any domestic source for those parts has probably dried up long ago.

After the tape speed has been modified successfully, you will face the second major problem. The audio frequency response will be greatly diminished, and the Dolby noise-reduction system (if any) will be completely out of calibration.

In one system that I developed for background music, I was able to dance around much of this trouble by using an audio equalizer and separate tape decks for recording. The half-speed tape deck was for playback only. I recorded my "master" tape at 75 IPS on two-track open reel, then copied it onto cassette with an unmodified cassette recorder while playing the open-reel deck at 151 IPS. I compensated most frequency response errors by first recording a frequency sweep (at −20 dB), then playing back the final result through an equalizer, which I adjusted for flattest playback response. The equalizer was then patched upstream of the master recording deck for all subsequent program recordings.

In a recorder that must stand alone, you will be forced to learn how to deal with record bias, record and playback equalization, and level calibrations if you want to achieve any semblance of flat frequency response. A service manual for the machine is mandatory. In the end, you will settle for poorer performance at the lower tape speed, due to the laws of physics. But your skill and perseverance will determine the quality of compromise with which you must live. Also bear in mind that media quality becomes a critical parameter at low speed. Wow and flutter, high-frequency roll-off, and dropouts will all become more obvious to the listener.

I hope some other readers can benefit from my experience.

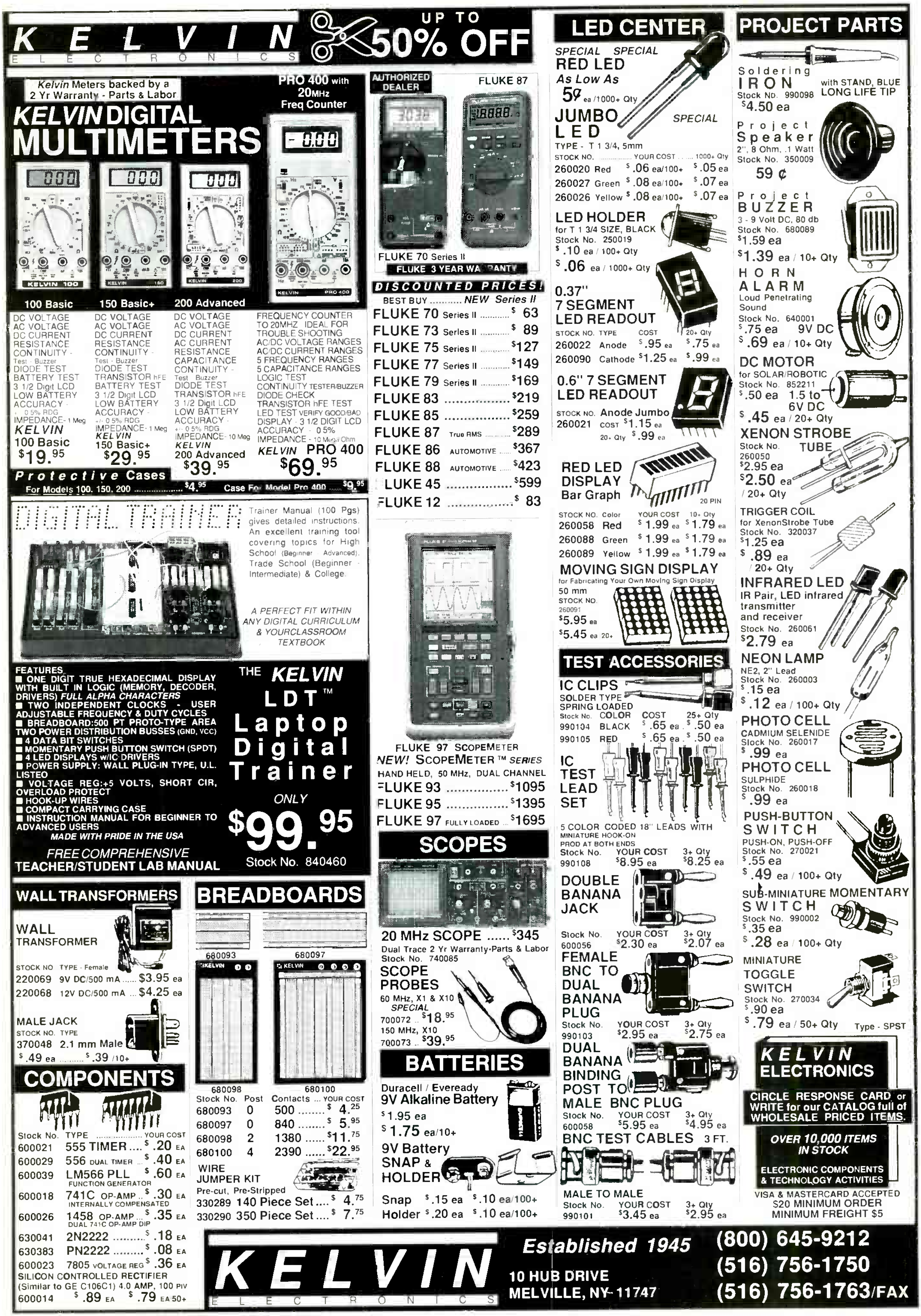
MICHAEL A. HARDWICK
Salem, OR

DIGITAL SCOPE UPDATE

I read with interest the article, "Analog Scopes—They're Far From Dead" (**Radio-Electronics**, November 1991), which compared digital and analog scope technologies. Analog scopes are indeed far from dead, since they fill some basic measurement needs at the low end of the scope market. However, the article contained some misleading information about the advantages and disadvantages of analog and digital scopes.

Concerning jitter, analog scopes are *not* superior for measuring worst-case jitter, as implied by Fig. 1 in the article. The article failed to mention the use of infinite persistence storage on a digital scope, which can capture worst-case excursions of the waveform much better than an analog scope.

In terms of update rate and deadtime, the article correctly points out that the slow update rate of some digital scopes makes them difficult to use in troubleshooting applications (the "rubber screwdriver effect"). However, digital scopes such as the HP 54600A (used as the digital scope example in several of the figures) have custom integrated circuits that greatly reduce the deadtime between acquisitions.



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This makes the scope very responsive when troubleshooting and performing adjustments and its price is comparable to that of an analog scope.

Another misrepresentation occurred in the photos of the HP 54600A display. The HP 54600A displays up to 1 million samples per second, which tends to fill in the waveform when the scope is running. But the photos of the HP 54600A were taken with the oscilloscope in the stop (or stored) condition, which makes the waveform somewhat cleaner. Remember that an analog scope in the stop condition gives you a blank display!

The article does not mention one of the primary weaknesses of an analog scope—viewing low repetition rate signals. However, the article inadvertently exposes the problem in Fig. 6, because the narrow glitch shown there is almost unviewable on the analog display. This occurs when short-lived events don't illuminate the CRT's phosphor screen long enough or often enough. This low light output is what causes analog scope users to reach for their viewing hoods to block out ambient light. Because a digital scope stores the waveform and refreshes the screen from digital memory, this is not a problem. Finally, the article keeps alluding to the extra cost of digital scopes. That used to be true across all bandwidths, but with improving technology, digital scopes are comparable in price with analog scopes for bandwidths of 100 MHz and higher.

Thank you for the attention given to the issues of analog and digital oscilloscopes. In the future, I hope you will supply your readers with a more balanced view.

ROBERT WITTE
R&D Product Manager
Hewlett Packard Company

MYSTERY ANTENNA

I found the article "Scanner Converter" in the February and March issues of **Radio-Electronics** most interesting. The photographs showed the converter in use with an interesting antenna, but there was no mention of it in the article. Can you tell me anything about it?

Yes. We inadvertently left off a mention of the antenna, which is the MAX 800, available from the Cellular Security Group, 4 Gerring Road, Gloucester, MA 01930. It sells for $19.95. A catalog of other VHF and UHF antennas is available on request.—Editor

ALTERED ENERGY CONSUMPTION MONITOR

Here is a picture of my home-built energy monitor, based on the article in the December issue of **Radio-Electronics**. As you can see, the LED power-level indicators were replaced with an analog meter with ranges of 150 and 1500 watts. A clock module was added to keep track of elapsed time.

Two other revisions made it more useful. First, the voltage to pulse converter was made to operate with loads down to 10 watts (not 27 watts), by adding one resistor. Second, the unit was revised to operate and read well with capacitive (lead P.F.) loads. One transistor and two resistors shorten the current sample time to about 5 degrees. Its accuracy appears to be ±5% or so.

Please give us more articles on how to sample whole-house energy.

ROBERT H. MILLER
Garner, NC

THD ANALYZER CORRECTIONS

I found two errors in my "THD Analyzer" article (**Radio-Electronics**, December 1991). First, in Fig. 2, the left side of R10A should connect to ground. Second, in the second column of page 52, the text should read "J5 to J2" instead of "J3 to J2." In addition, I'd like to clarify that the JU1 jumper noted in the first column of page 52 is the same one noted on page 51, *not* an additional one.

JOHN F. KEIDEL

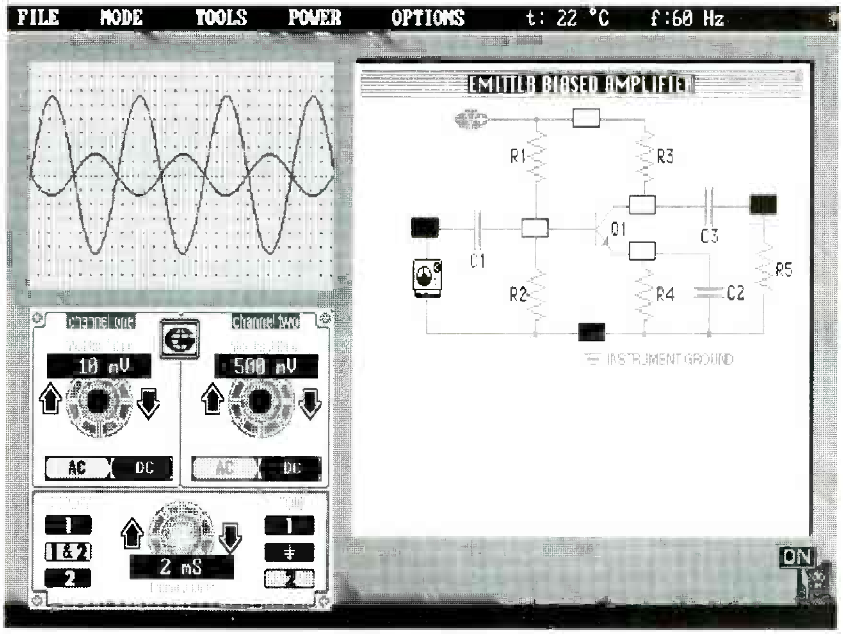
R-E

EQUIPMENT REPORTS

Global Specialties Protolab Release 3.0

Anyone who has studied electronics knows the importance of mixing practical experience with theoretical background. That's why laboratory courses—where real circuits using real components are assembled by students—are required for graduation. In our experience, however, most laboratory classes are too few and far between to reinforce many important lessons. Worse yet, most lab courses don't follow the same syllabus as the theory courses assigned in a given year. Students can supplement their coursework with independent lab experiments, but that requires access to test equipment and components.

We've found a product that will allow students to supplement their coursework without buying a full test lab. *Protolab* Release 3.0 from Global Specialties (70 Fulton Terrace, New Haven, CT 06512.). *Protolab* software turns your PC into a computer-simulated electronics laboratory. You can build circuits on-screen, and use simulated test equipment to examine their behavior. It's not only students who will benefit from *Protolab*. Many schools could use the software as part of their lab courses—at quite a savings over purchasing new equipment.



THE TWO-CHANNEL SCOPE lets you view circuit operation. The common-emitter circuit is shown here.

The basic *Protolab* program lets you build circuits made up of resistors, capacitors, inductors, complex impedances, and AC and DC voltage and current sources. A circuit is built on the *Protolab* breadboard with the help of pull-down menus; a mouse is used to place components. A circuit can consist of as many as 40 components.

Once the circuit is built, you "turn the power on" to start the circuit calculations. Once the computer has finished the calculations, you can use the test equipment to examine the circuit's function. A voltmeter, ammeter, ohmmeter, watt meter, signal generator, and oscilloscope are available.

Of course, once you get the basics of DC and AC circuit theory, you're going to wish for more capability—such as the ability to work with active components. Unlike the original version of *Protolab*, Release 3.0 does support active components and other advanced topics—albeit with some limitations. We looked at three modules that are available from Global Specialties

The Protoware Diode Module covers full-wave and half-wave rectifiers. Only those two circuits are available. Although you can change component and voltage values in the two diode circuits, you cannot alter the circuit configuration or design your own.

The Transistor Amplifier Module contains three circuit configurations, a common-base, common-collector, and common-emitter amplifier. The common-emitter amplifier also allows you to study the circuit either taking only the DC bias into account or the entire AC and DC circuit.

The Protoware Organ Module presents a 4-note electronic organ based on the LM3909 LED flasher. You can "play" the organ by using the mouse to click on one of the four switches. The organ module also

continued on page 71

NEW PRODUCTS

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

CLAMP-ON CURRENT METERS. Measuring current is becoming more complicated. Personal computers, adjustable-speed drives, and other equipment that draws current in short pulses (nonlinear loads) can draw high-peak currents. That causes harmonics to appear in the current, creating such problems as overheated transformers and neutral conductors, and unexplained tripping of circuit breakers. Therefore, for accurate measurements of currents containing harmonics, a true-RMS meter is required.

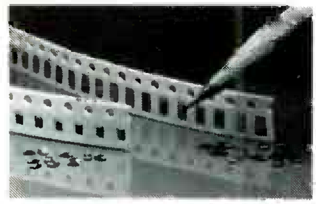
CIRCLE 16 ON FREE INFORMATION CARD

The *30 Series Current Masters* clamp-on meters from *Fluke* measure true-RMS current up to 700 amps at frequencies to 10 kHz, helping technicians track down the hot spots before they become major problems. Their rugged, angular design makes them compact enough to maneuver easily in crowded breaker boxes, yet large enough to surround large-diameter conductors. *Model 31* and *model 33* both offer a host of features for troubleshooting current problems. These include manual and autorange modes, display hold, sleep mode (for battery conservation), and a power-up self test. Each unit comes with a protective holster that can be attached to a work belt.

The *Fluke 33* also includes features that allow the technician to perform more in-depth current tests and to record data for as long as 24 hours. The min/max feature records the maximum and minimum values and calculates the average for both RMS current and frequency. The smoothing feature calculates and displays a three-second running average for both frequency and current. A crest measurement reads or detects the half-cycle peak, and it can be used to determine the crest factor, showing if the waveform is distorted or sinusoidal.

Fluke models 31 and *33* cost $179 and $249, respectively.—**John Fluke Mfg. Co., Inc.**, P.O. Box 9090, Everett, WA 98206; Phone: 800-44-FLUKE.

LOW-NOISE CERAMIC CAPACITORS. According to *Rohm Corporation*, its *MCH Series' NPO/C0G "A"* chip capacitors have the industry's best equivalent series resistance (ESR) characteristics in their price class, and they have been found to perform comparably with much more expensive high-RF/microwave chips. Made with pure palladium electrodes and fired at higher temperatures than competing chips, they deliver better ESR ratings. The *MCH Series* ceramic capacitors are available in 0805 and 1206 sizes, with a capacitance range of 0.5 to 2700 pF for NPO dielectrics, and 680 pF to 0.22 µF for X7R dielectrics. The popular tolerances of 5% for NPO and +10% for X7R are both available. Series operating temperatures can range from −55°C to +25°C. The chips are designed for both wave and IR reflow soldering methods. Designed for automatic placement, they are available in 8mm tape-and-reel format. Both 7-inch (4,000 pieces) and 13-inch (16,000 pieces) reels are available.



CIRCLE 17 ON FREE INFORMATION CARD

Prices for the *MCH Series* ceramic capacitors range from $15.80 to $45.10 per 1000 pieces.—**Rohm Corporation**, 3034 Owen Drive, Antioch, TN 37013; Phone: 615-641-2020, ext. 117; Fax: 615-641-2022.

LAB INTERFACE KIT. Designed to meet the needs of engineers and technicians, *Probe Master's Lab Interface Kit* contains a

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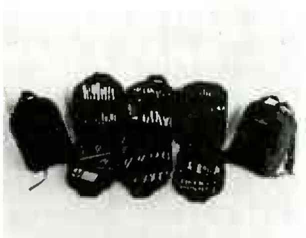
combination of the most often used adapters, terminations, and attenuators, as well as two precision

BNC RG58/U cables that can be used for calibration lab standards. The adapters provide peak performance and are designed to minimize reflective losses. The kit comes in a moisture-resistant, high-impact case that protects each adapter.

The *Lab Interface Kit* costs $199.—**Probe Master Inc.**, 4898 Ronson Court, San Diego, CA 92111-1807; Phone: 800-772-1519.

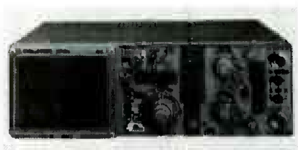
BACKPACK TOOL ORGANIZER. Particularly helpful in situations that require the engineer or technician to keep two hands free for carrying heavy equipment or gripping handrails, the *Toolpak* from *Paktek* allows him to carry more than 100 tools, charts, and meters on his back. The pack makes it easy to carry all the right tools to the work and to find them quickly. Three zippered compartments contain six fold-out tool panels with more than 100 pockets for holding tools securely in place, and a large pocket for maps and schematics. In addition, two outer pockets provide quick access to frequently used tools or supplies. The *Toolpak*, which is made from durable puncture and abrasion-resistant nylon, has heavily padded straps for comfortable wear, and attache-style handles for hanging or carrying the pack while it's unzipped.



CIRCLE 19 ON FREE INFORMATION CARD

The *Toolpak* tool organizer costs $99.97 (plus $4 shipping).—**Paktek Inc.**, 7307 82nd St. Ct. SW, Tacoma, WA 98498; Phone: 1-800-258-8458; Fax: 206-851-2365.

PORTABLE 100-MHz OSCILLOSCOPE. Measuring just 3¼ inches high by 9½ inches wide by 13¾ inches deep, and weighing just nine pounds, *Leader's model 326* 100-MHz oscilloscope fits easily into an attache case for portable use by field-service engineers and technicians. The two-channel, dual-time-base scope has a 12-kV CRT with an illuminated graticule. An alternate sweep with a calibrated-delay time base permits simultaneous display of the

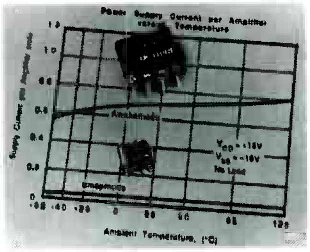


CIRCLE 20 ON FREE INFORMATION CARD

observed waveforms and the time-expanded sections. Two asynchronous signals are displayed at the same time by the *326*, thanks to an alternate triggering mode and complete triggering facilities.

The *model 326* oscilloscope has a suggested list price of $2795.—**Leader Instruments Corporation**, 380 Oser Avenue, Hauppauge, NY 11788; Phone: 1-800-645-5104 (in NY, 516-231-6900).

DUAL SLEEP-MODE OP AMP. With two separate modes of operation, *Motorola's MC33102 dual Sleep-Mode op amp* has very low standby power operation. In the sleep-mode state, it operates with a very low current drain. Each amplifier automatically changes to the awake-mode state when an input signal is applied to the amplifier, causing it to sink or source sufficient load current. The



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op amp uses industry-standard pin-outs and has independent sleep-mode capability with no extra pins or external components required. Key applications are those that require improved energy efficiency. For example, the amplifier can operate in a mode that consumes just enough power to detect incoming signals and then shift to a higher performance mode upon demand. That makes it ideal for use in cordless phones, portable computers, tape recorders, baby monitors, sensors, automobiles, hand-held equipment, cordless appliances, and battery-operated test equipment.

The *MC33102* changes from sleep mode to awake mode in 4.0 microseconds when the output current exceeds 160 microamps, and automatically returns to the sleep mode when the output current drops below the threshold. It can be used as a fully functional micropower amplifier in the low-current sleep-mode state. Crossover distortion is as low as 12.0 Hz in the awake mode. ESD clamps protect the inputs, increasing stability without affecting amplifier performance. The device is available for commercial applications in both an 8-pin plastic DIP (*MC33102P*) and an 8-pin plastic SO-8 surface-mount package (*MC33102D*).

In quantities of 10,000, the *MC33102* costs $1.60.—**Motorola Inc.**, Bipolar Analog IC Division Marketing, EL340, 2100 East Elliot Road, Tempe, AZ 85284; Phone: 602-897-3615; Fax: 602-897-4193.

AUDIO MEMORY/VOICE KEYER. If you want to transmit two letters over and over, or repeat a contest CQ thousands of times in a two-day period, the *Ventriloquist* voice keyer and audio memory device can help. Based on the ISD1020 nonvolatile analog memory chip, j·COM's device stores sampled analog speech signals for up to ten years, even if the power is shut off.

The *Ventriloquist* can hold four variable length messages for a total of 20 seconds of high-fidelity audio storage. Each message can be played at any time by pressing one of the four message keys. A built-in microphone for recording and a speaker for playback are included. A PTT keying circuit is provided to operate the transmitter automatically when a message is played. The *Ventriloquist* can be set up to endlessly record your DX QSO's with an endless-loop record and playback feature. The unit interfaces with most modern transceivers. It also has a built-in computer interface that can be connected directly to the printer port of any PC-compatible computer, and it is compatible with the popular CT contest-logging program.

Although the *Ventriloquist* was designed to be used as a voice keyer, it has many other uses. For language training, you can record the instructor's voice in one message and try to match it in another. A sample program code in BASIC and C programs is provided to illustrate how easily you can add speech output to any computer application. The remote interface can be used to trigger speech output from alarm systems, motion detectors, or other sensors. Connected to your doorbell, it can announce "Someone is at the door!" The voice keyer

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can be used as an audio notebook when driving or when it's too dark to see what you're writing.

The *Ventriloquist* voice keyer/audio memory device is available as an assembled and tested board for $124.95, or packaged in a high-impact ABS enclosure for $149.95. —**j·COM**, P.O. Box 194, Ben Lomand, CA 95005; Phone: 408-335-9120; Fax: 408-335-9121.

SOLID-STATE RELAY. Offering high current in a small package, the *GSAC-01 Mini-SP* solid-state relay from *Gordos* permits a large number of output circuits to be placed on a small amount of PC board space. The relay is housed in a single in-line package that measures 0.7×1.0×0.18 inches. It offers a 12- to 240-VAC output rated at 2 amps RMS at a 25°C ambient temperature. The solid-state relay features zero-voltage turn-on, 3750 VAC optical isolation, and 10-mA DC input sensitivity. UL, CSA, and VDE ap-

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provals are pending.

The *GSAC-01* mini solid-state relay costs $3.65 each in quantities of 1000.—**Gordos**, 1000 North Second Street, P.O. Box 824, Rogers, AR 72757; Phone: 800-726-5000 or 501-636-5000; Fax: 501-636-2305.

FET DYNALOAD. *Transistor Devices Inc. (TDI) Dynaloads* are power-sinking devices used to simulate a variety of complex electrical loading conditions in

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the design and testing of power-conversion systems.

According to TDI, the *DLF-4000*, with its 4000-watt power dissipation rating, is the most powerful stand-alone electronic load on the market. The instrument can be used for easy creation of complicated load profiles that allow power-supply engineers to verify the integrity and stability of their designs. It can also be used in production environments for system burn-in and for incoming inspection and test of power supplies, batteries, and other power sources. Its low compliance voltage means that the *DLF-4000* can be used for special applications including things like testing 1.5-volt battery cells or other similar applications.

The instrument uses FET's to achieve an ultra-fast response time of less than 15 microseconds and a low compliance voltage of under 0.15 volts. With an operating range of 0–400 volts, and load currents from 0 to 600 amps, the *DLF-4000* can dissipate up to 4000 watts. Multiple instruments can be paralleled to increase current ratings and total wattage dissipation for the testing of larger power sources if necessary.

The *DLF-4000* costs about $8000.—**Transistor Devices Inc.**, 274 Salem Street, Randolph, NJ 07869-1697; Phone: 201-361-6622; Fax: 201-361-7665.

SURFACE-MOUNT CRYSTALS AND OSCILLATORS. *Ralton's* family of four crystals and oscillators for surface mounting offer output frequencies ranging from 624 kHz to 300 MHz. Three of the four are fundamental quartz resonators, two of which are produced from ultra-small "AT strip" crystals. Those two are the newly packaged *HC-49* and *TT-SMD* products are available for use over the 3 MHz to 50 MHz band. The *HC-49* is in a metal SMT can; the *TT-SMD* is in a plastic SMT package. The third quartz resonator, the *HC-45*, is available with any frequency rating from 3.579545 MHz (for TV color-burst frequency) to 300 MHz (for high-speed logic).

The *HC-45's* have a unique package design with a special clip that allows them to very easily be mounted and soldered flat on a surface-mount circuit board.

The *CO-99100* is a complete, integrated SMT clock-oscillator circuit with an internal "AT-cut" crystal. The clock oscillator circuit operates from 625 kHz to 24 MHz, is mounted in a 28-pin plastic leaded-chip carrier (PLCC), and pro-

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vides a square-wave output with a TTL fanout of 10, or 50 pF of high-speed CMOS loading.

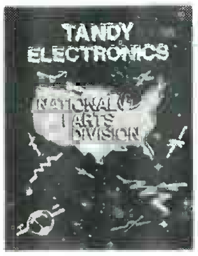
In lots of 1000, the *HC-49* costs 70 cents each, the *TT-SMD* costs 90 cents each, the *HC-45* costs between 75 and 95 cents (depending on frequency and tolerance requirements), and the CO-99100 costs $2.50 each.—**Ralton Electronics Corporation**, 2315 NW 107th Avenue, Miami, FL 33182; Phone: 305-593-6033; Fax: 305-594-3973. **R-E**

NEW LIT

Use The Free Information Card for fast response.

NATIONAL PARTS DIVISION CATALOG; from Tandy Electronics, National Parts Division, 900 East Northside Drive, Fort Worth, TX 76102; Phone: 800-322-3690; $7.00.

Tandy's newest 232-page catalog of electronic and electro/mechanical parts now contains listings of products from 29 well known manufacturers.



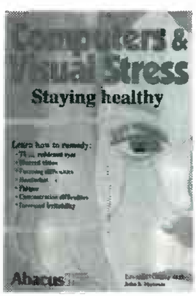
CIRCLE 40 ON FREE INFORMATION CARD

Product information is presented alphabetically by category—from "antennas" through "wires"—and complete pricing information is printed on the same page as the part listing. Product and manufacturers' indexes are included for cross-referencing, and many photographs and specification drawings are provided. The National Parts Division requires only a $5 minimum purchase.

COMPUTERS & VISUAL STRESS: STAYING HEALTHY; by Edward C. Godnig, O.D. and John S. Hacunda. Abacus, 5370 52nd Street, S.E., Grand Rapids, MI 49512; Phone: 616-698-0330; Fax: 616-698-0325; $12.95.

With more than 100 million people now using computers on a daily basis, several common complaints have arisen. Classed as "computer-induced stress" are such symptoms as tired eyes, blurred or double vision, irritated or reddened eyes, and difficulties focusing the eyes. Also included are excessive fatigue, headaches and irritability, and difficulty in concentrating.

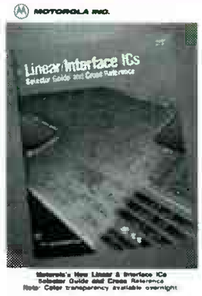
This book explains how your computer work environment contributes to visual stress, and how it can be corrected by altering that environment and improving your visual fitness. It explains the basic functioning of your eyes and your computer, and describes the symptoms and causes of visual stress. Proper contrast settings, eye-to-screen distance from the VDT, overhead and source lighting, and glare reduction are discussed. Other topics are the need for good posture, eye examinations, corrective lenses, and rest periods. The book views vision as a complex process that can be altered and improved by visual training procedures, proper diet, work organization, and education. Special eyeglasses, designed for computer work, are described, and visual training exercises are presented. The book also describes stretching exercises to reduce stress and promote relaxation. A glossary of terms lists information sources for vision-related services, general health services, and industry- and labor-related data.



CIRCLE 39 ON FREE INFORMATION CARD

LINEAR/INTERFACE IC's: Selector Guide and Cross Reference (SG96/D Rev 4); from Motorola Inc., Literature Distribution Center, P.O. Box 20924, Phoenix, AZ 85063; Phone: 800-441-2447; free.

Significant new entries have been added to this updated catalog. It presents the latest linear circuit design techniques and processes needed to meet the needs of diversified markets. The selector guide includes new switching regulator control circuits, RF communication circuits, and surface-mount devices, in addition to a wide variety of standard devices covered earlier. **R-E**



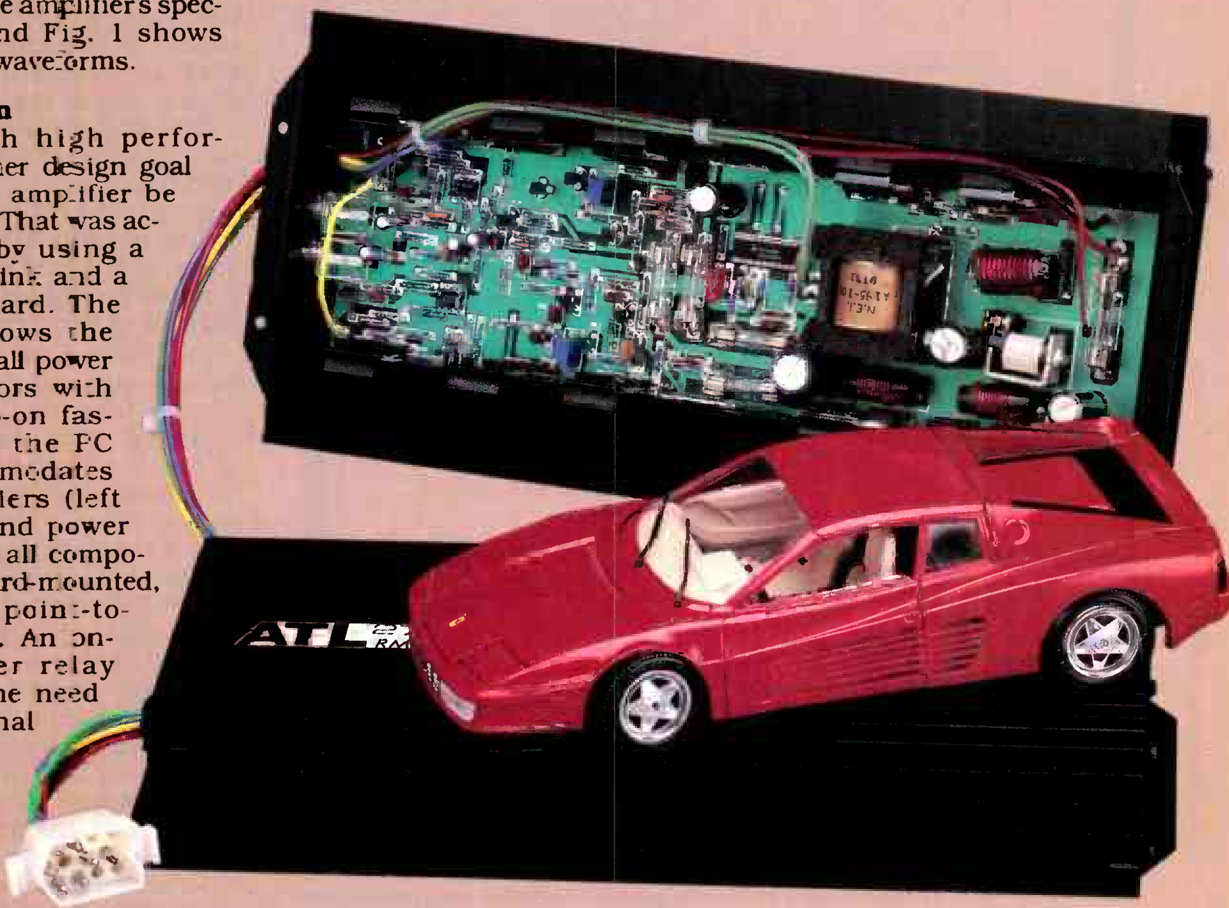
CIRCLE 38 ON FREE INFORMATION CARD

BUILD THIS HIGH POWER HI-FI AUDIO AMP FOR YOUR CAR

Our build-it-yourself car amplifier has so much power that it ought to be illegal!

REINHARD METZ and MYZIL BOYCE

CAR STEREO AMPLIFIERS ABOUND, but most are compromises in performance, or are expensive. Our build-it-yourself car amplifier is a real goose-bump generator, offering performance in the high-end home-stereo range, yet is cost-effective and easy to build. Performance highlights include 270 watts output power (135 watts per channel, RMS, into 8 ohms), low distortion, and exceptional output current capabilities. The power supply itself is capable of delivering over 600 watts, giving the amplifier plenty of reserve power. Note also that the power rating is for real, continuous watts, into 8 ohms (not the way most car amps are rated), allowing the use of home-system speaker components, which are generally less expensive than 4-ohm versions, and offer a much broader selection of quality elements. If 4-ohm speakers are desired, the amplifier will deliver a whopping 200 watts per channel! Table 1 shows the amplifier's specifications, and Fig. 1 shows some output waveforms.



Overall design

Along with high performance, another design goal was that the amplifier be easy to build. That was accomplished by using a custom heatsink and a single PC board. The heatsink allows the mounting of all power semiconductors with simple snap-on fasteners, and the PC board accommodates both amplifiers (left and right) and power supply. Also, all components are board-mounted, minimizing point-to-point wiring. An on-board power relay eliminates the need for an external high-current switch, and allows the amp to be slaved to an auto radio's power-antenna lead. Both the power

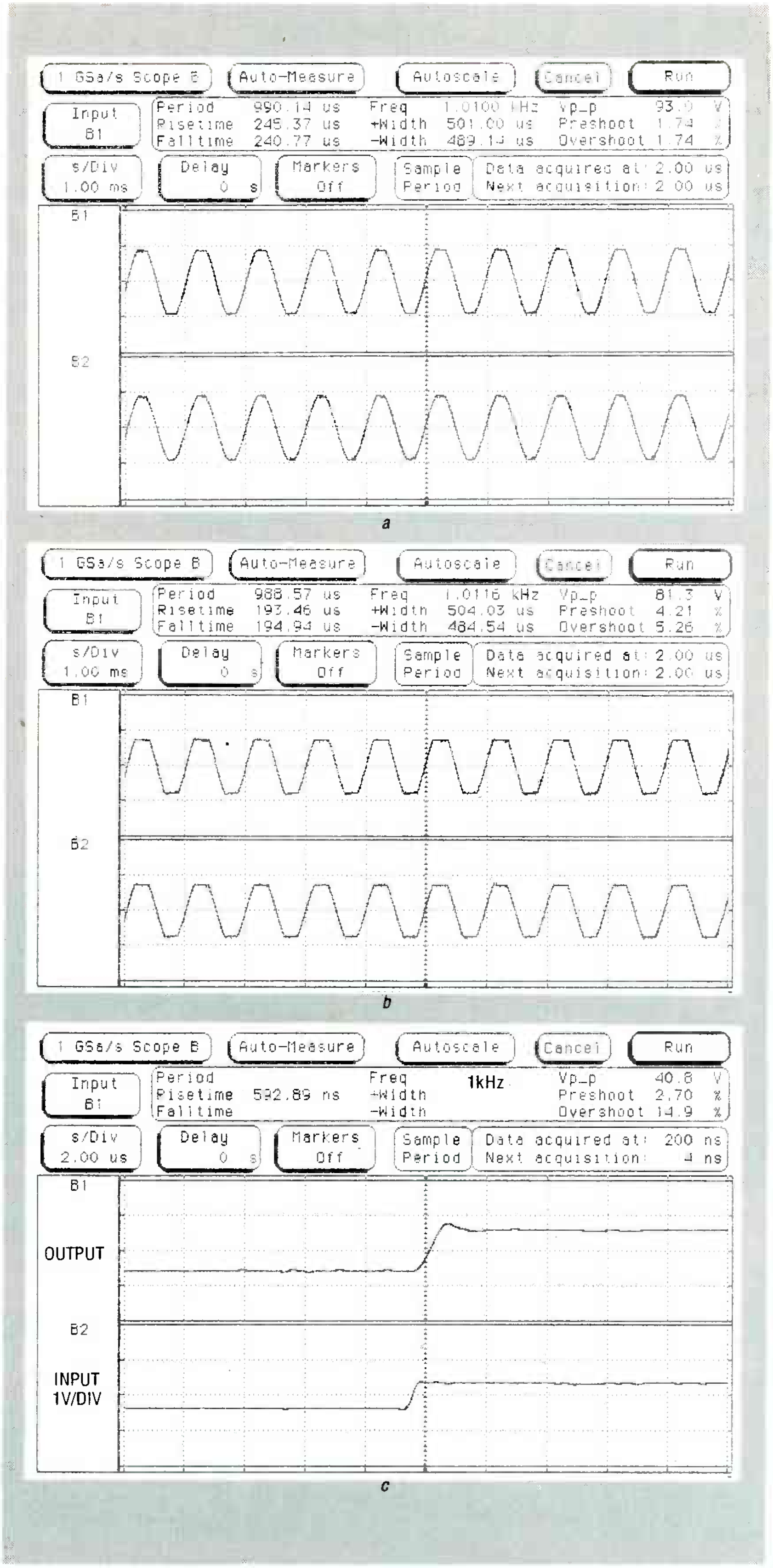


FIG. 1—OUTPUT WAVEFORMS. In *a*, the amplifier is driving an 8-ohm load on both channels at 1 kHz; the signal clips at 93 volts p-p with 135 watts per channel. Both channels are driving a 4-ohm load at 1 kHz in *b*; it clips at 81 volts p-p with 200 watts per channel. Using an 8-ohm load with the input filter removed, a rise time of 600 ns and a slew rate of 54 volts/μs can be seen in *c*.

supply and the amplifiers use state-of-the-art field-effect power transistors (FET's). A custom copper-tape-wound inverter transformer gives the power supply its punch. A CAD-supported printed-circuit board with ground plane, plated-through holes, silkscreened parts placement, and solder mask completes the picture. Let's take a more detailed look at how the unit works.

The power supply

Figure 2 shows the power-supply schematic. The basic design is a push-pull forward inverter with pulse-width modulation voltage regulation. Relay RY101 is energized via the 12-volt control lead, applying power to the pulse-width-modulator chip IC101 and the power transformer center tap. Alternating pulses generated by IC101 drive the output transistors at pins 16 and 13, turning on Q101 and Q102, and Q103 and Q104, one pair at a time. The transistors are paralleled for increased power handling capacity. Resistors R107–R110 eliminate the possibility of local transistor oscillation. As the transistors alternately conduct, an alternating current flows in the primary of transformer T101, in turn inducing an alternating current in the secondary.

The output of T101 is full-wave bridge rectified and then filtered by L101, L102, C106, and C107. With a winding ratio of 4 to 1, a maximum of about 58 volts can be generated at the output. That is regulated down to ± 47 volts by sending a sample back to resistor divider R112 + R113 and R105. The divided voltage is applied to pin 2 of IC101, where it is compared to a 2.5-volt reference, generated in turn by dividing the chip-provided 5-volt reference at pin 10 by R101 and R102. When the supply output drops below 47 volts, IC101 drives the transistors with longer pulses, and with shorter pulses when the output goes above 47 volts, thus achieving voltage regulation. Components C102, C103, and

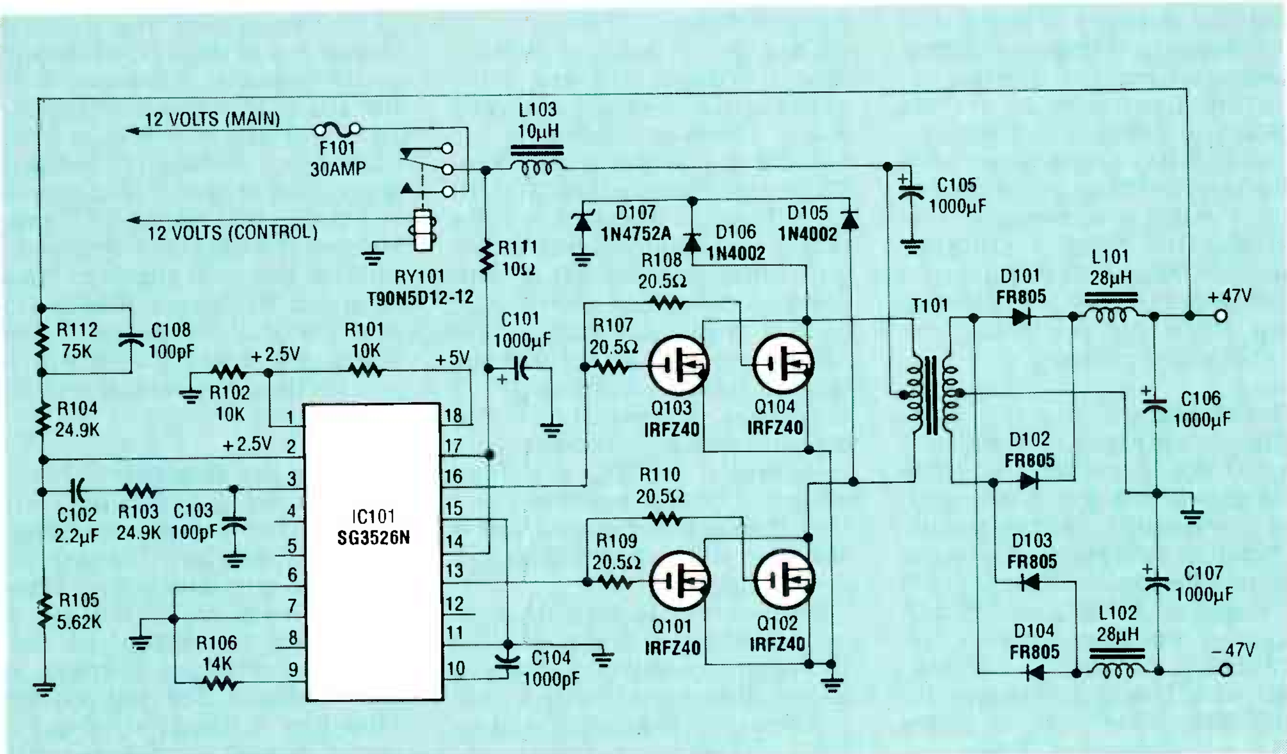


FIG. 2—POWER-SUPPLY SCHEMATIC. It's a push-pull forward inverter with pulse-width modulation voltage regulation. Relay RY101 is energized via the 12-volt control lead, applying power to the pulse-width-modulator chip IC101 and the power transformer center tap.

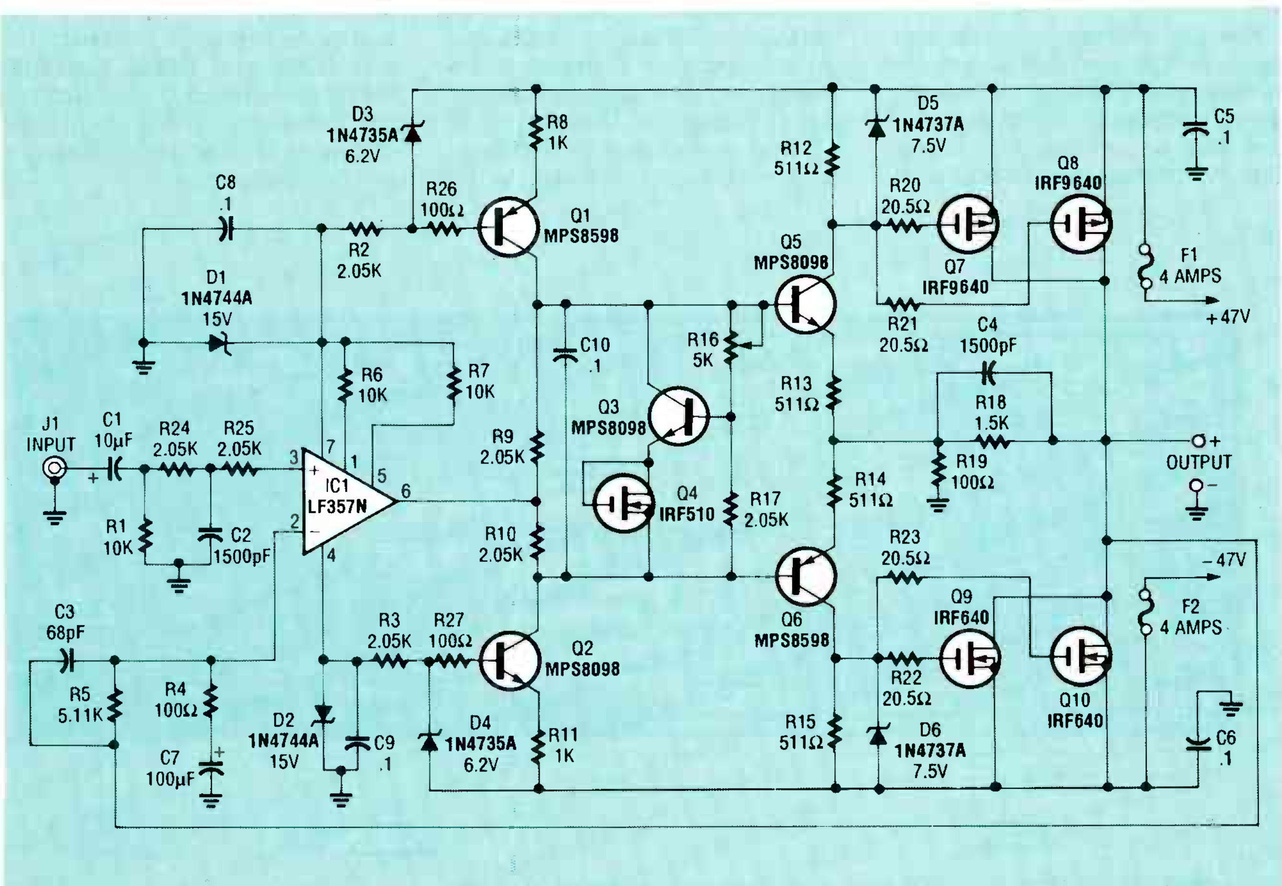


FIG. 3—THE LEFT AND RIGHT AMPLIFIERS are identical and the parts numbered the same except for an L or R suffix; here's one of the amplifiers.

R103 form a filter network that stabilizes the voltage-regulation feedback loop. The inverter operating frequency is set via C104 and R106 to about 50 kHz. Finally, L103 keeps noise from the inverter from getting back into the car power system, and D105–D107 form a snubber network that limits ringing voltages generated by the alternating high currents in the transformer primary.

The amplifiers

Both amplifiers (left and right) are identical, and parts are numbered the same, with an L or R suffix, as appropriate. Therefore we'll show only one of them—see Fig. 3. Input signals are applied to IC1, an LF357A op-amp, via filter network R1, R24, R25, C1, and C2. The output of IC1 drives resistors R9 and R10, which are in series with current source Q1 and current sink Q2. The result is that voltage swings at the output of IC1 (at pin 6) are translated and applied to the bases of Q5 and Q6.

The DC voltage between the bases of Q5 and Q6 is set by voltage multiplier Q3. The voltage is nominally about 8 volts, and can be set as desired by R16. It appears across R13 and R14 by emitter-follower action of Q5 an Q6. In turn, a current flows through R12 and R15, generating a voltage across them, which is applied as the bias for the output transistors. FET output transistors Q7–Q10 each require about 3.5 volts bias from gate-to-source to begin conduction, which is supplied as described above. The output transistor bias is adjusted to provide an optimal idle current in the output stage. To keep that current stable, the output transistor temperature is sampled by Q4, which is mounted on the heatsink, and the Q3 bias generator voltage is varied to track the temperature accordingly.

Transistor Q4 has its gate connected to its drain, causing the drain-to-source voltage to be roughly equal to the gate turn-on threshold, which varies with temperature and tracks the output transistors. Transistor Q3 multiplies that voltage by a factor of two, to provide the bias required by both the positive and negative output transistors. Transistors Q5 and Q6 also provide a phase-inversion function, taking the AC signal voltage at the output of IC1 and applying it to the gates of the output transistors. As the gates are driven, the drains, connected to the output, swing in the opposite direction, driving the load. Components C4, R18, and R19 form a local feedback loop, setting the output stage gain at about 15. Components C3, R5, R4, and C7 provide overall amplifier feedback, and set the total amplifier gain at about 51. Zener diodes D5 and D6 limit the output transistor gate drive voltages, which in turn limit the maximum output current.

Building the amplifier

If you are fabricating your own circuit board, remember that you will have to provide feed-throughs and solder component leads on both sides of the board in several places. We've provided foil patterns if you want to do that, but you can also buy a ready-to-use PC board, as well as various other parts, from the source mentioned in the parts list. Figure 4 is the parts placement diagram. Begin assembly by installing all parts except the TO-220 power components and potentiometers R16L and R16R. Carefully verify resistor and capacitor values before installing them, and check diode and electrolytic capacitor polarities.

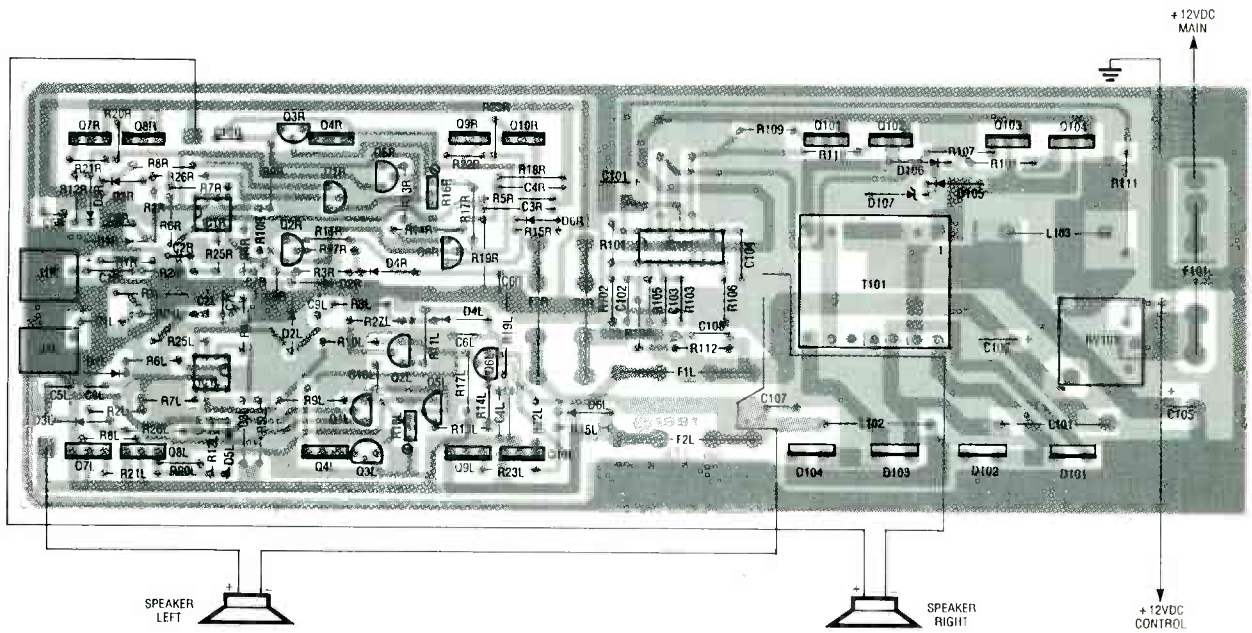


FIG. 4—PARTS PLACEMENT DIAGRAM. First install all parts except the TO-220 power components and potentiometers R16L and R16R. Before installing the output FET's, they must be matched in pairs within each particular type (see text and Fig. 5).

Before installing the output FET's, they must be matched in pairs within each particular type to ensure proper current sharing and power dissipation. As an example, Q7L and Q8L must be matched to each other, but they don't have to match the right-channel components. (Q7R and Q8R must, of course, match each other.) The same goes for Q9 and Q10. A simple circuit for matching them is shown in Fig. 5. The parts should be matched to be within 100 millivolts of gate voltage at 50 mA of drain current, and 200 millivolts of gate voltage at 2 amps of drain current. Make the 2-amp measurement quickly—otherwise you must heatsink the transistor. Note that P-channel devices (the IRF9640's) must be supplied with −5-volts DC and N-channel devices (the IRF640's) must be supplied with +5-volts DC.

Once you have matched the transistors, insert them in the PC board. Make sure they are straight up with their leads protruding uniformly about 1/16-inch from the *bottom* of the board. Check to see that the transistors are centered on the heatsink rail, and then solder. Next, prepare potentiometers R16L and R16R by adjusting them for a resistance of 1000 ohms between pins 1 and 2 (see Fig. 6), and then install them.

Finally, install the three power and ground lead-in wires, as well as the speaker outputs and grounds. Check that all parts are the correct type and value, and in the correct orientation.

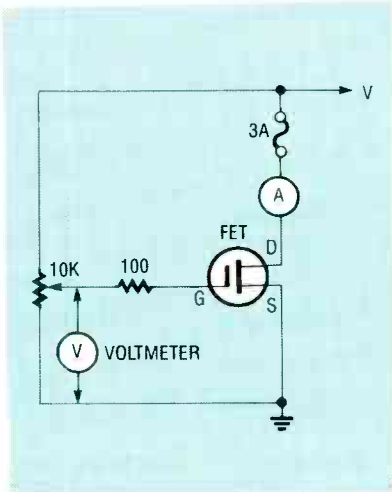


FIG. 5—PAIRS OF FET'S MUST BE MATCHED using this circuit (see text). First set the potentiometer's wiper voltage to zero, turn it up to the desired drain current, and measure the voltage as shown. Match the parts to within 100 millivolts of gate voltage at 50 mA of drain current, and 200 millivolts of gate voltage at 2 amps of drain current. N-channel devices (the IRF640's) require a +5-volt supply, and P-channel devices (the IRF9640's) require −5 volts.

Chassis assembly

Prepare the heatsink by checking to see that the mounting surfaces for the power components are clean and smooth. Temporarily slide the circuit board assembly into the heat-

PARTS LIST

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

R1, R6, R7 (two of each, L&R), R101, R102—10,000 ohms
R2, R3, (two of each, L&R) 2050 ohms, ½-watt
R4, R19, R26, R27 (two of each, L&R)—100 ohms
R5 (two, L&R)—5110 ohms
R8, R11 (two of each, L&R)—1000 ohms
R9, R10, R17, R24, R25 (two of each, L&R)—2050 ohms
R12–R15 (two of each, L&R)—511 ohms
R16 (two, L&R)—5000 ohms, potentiometer
R18 (two, L&R)—1500 ohms
R20–R23 (two of each, L&R), R107–R110—20.5 ohms
R103, R104—24,900 ohms
R105—5620 ohms
R106—14,000 ohms
R111—10 ohms, 1/2-watt
R112—75,000 ohms

Capacitors

C1 (two, L&R)—10 µF, 35 volts, electrolytic
C2, C4 (two of each, L&R)—0.0015 µF, ceramic
C3 (two, L&R)—68 pF, ceramic
C5, C6, C8–C10 (two of each, L&R), C104—0.1 µF, Mylar
C7 (two, L&R)—100 µF, 10 volts, electrolytic
C101, C105—1000 µF, 15 volts, electrolytic
C106, C107—1000 µF, 50 volts, electrolytic
C102—2.2 µF, 15 volts, electrolytic
C103, C108—100 pF, ceramic
C104—0.001 µF, ceramic

Semiconductors

IC1 (two, L&R)—LF357A op-amp
IC101—SG3526N pulse-width-modulator
D1, D2 (two of each, L&R)—1N4744A diode
D3–D6 (two of each, L&R)—1N4737A diode
D101–D104—FR805 diode
D105, D106—1N4002 diode
D107—1N4752A 33-volt Zener diode
Q1, Q6 (two of each, L&R)—MPS8598 PNP transistor
Q2, Q3, Q5 (two of each, L&R)—MPS8098 NPN transistor
Q4 (two, L&R)—IRF510 N-channel MOSFET
Q7, Q8 (two of each, L&R)—IRF9640 P-channel MOSFET
Q9, Q10 (two of each, L&R)—IRF640 N-channel MOSFET
Q101–Q104—IRFZ40 N-channel MOSFET

Other components

L1, L2—28 µH coil
L3—10 µH coil
RY101—T90N5D12-12 relay (Potter and Brumfield)
T101—transformer, 4 turns, center-tapped primary, 16 turns, center-tapped secondary; 5-mil copper-foil wounded on a Ferroxcube ETD-34 core.
F101—30-amp fuse
F1, F2 (two of each, L&R) 4-amp fuse
J1, J2—RCA-type input jack

Miscellaneous: PC board, 16 "Q" clips, 16 insulators, 10 fuse clips, heatsink/case strain relief, 4 "L" brackets, wire, solder, etc.

Note: The following items are available from A&T Labs, Box 4884, Wheaton, IL 60187:

- **Complete kit of parts including heatsink and covers, PC board, and transformer—$245**
- **Fully assembled and tested unit—$315**
- **PC board (Mil-spec glass, double-sided, silkscreened, with solder mask)—$29**
- **Transformer T1—$40**
- **Custom heatsink with covers—$44**

Please add 5% of total order for shipping and handling, 12% in Canada. IL residents must add 7% sales tax. Check, money order, or C.O.D. in cont. U.S. All inquiries must include a SASE.

sink. Install the endplate with the input connector holes, and slide the board up against it. Take a look at Fig. 7, the inside of the author's completed prototype, to get a feel for the overall assembly and close-up details. Lightly mark each power component site on the case. Remove the amplifier and prepare each site with a thin coat of thermal heatsink grease. Apply a mica insulator at each site.

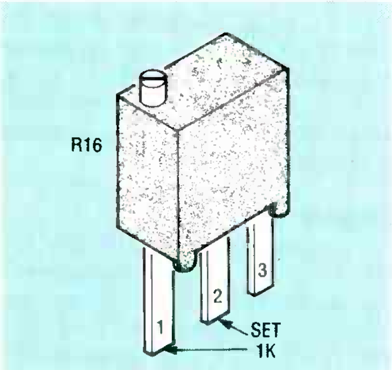


FIG. 6—PREPARE POTENTIOMETERS R16L AND R16R by adjusting them for a resistance of 1000 ohms between pins 1 and 2.

TABLE 1—SPECIFICATIONS

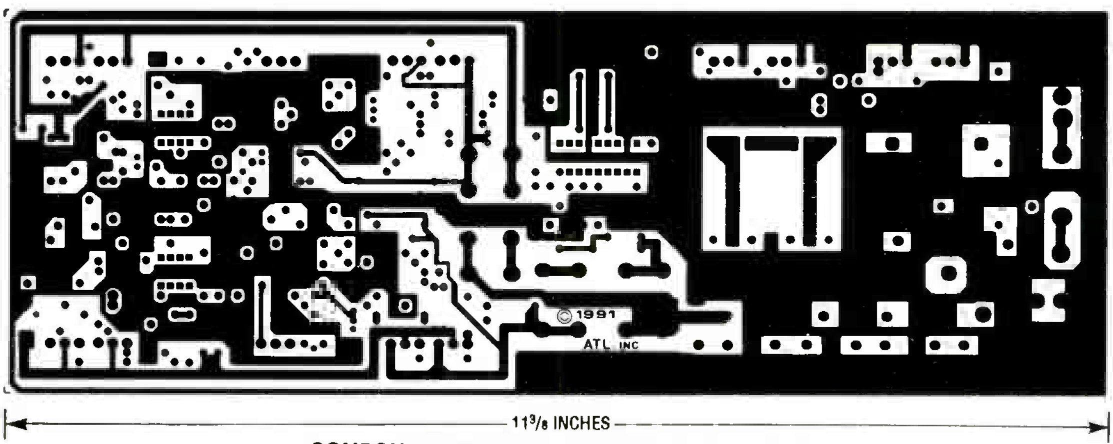
Power Output	135 watts/channel RMS into 8 ohms with both channels driven 200 watts/channel RMS into 4 ohms with both channels driven
Frequency Response	12 Hz–45 kHz (+0, −3 dB) 12 Hz–400 kHz with input filter removed
Distortion	<0.03% THD at 1 kHz, <0.1% 20 Hz–20 kHz
Rise Time	<0.6 µs
Slew Rate	>100V/µs
Power Input	12–14.5 volts, 0.5 to 50 amps maximum

Re-install the amplifier board with each of the power parts bent slightly away from the heatsink surface. Apply a thin layer of thermal grease to each part. Then bend the part back against the heatsink, and hold it in place with a spring clip as shown in Fig. 8. Use a piece of cardboard or plastic as an insulator between the part and the clip. After each clip is in place, remove the two wire bales from the clips. Make a final check with an ohmmeter to see that none of the power parts are shorted to the heatsink. We are now ready to make a few safety checks on the circuitry.

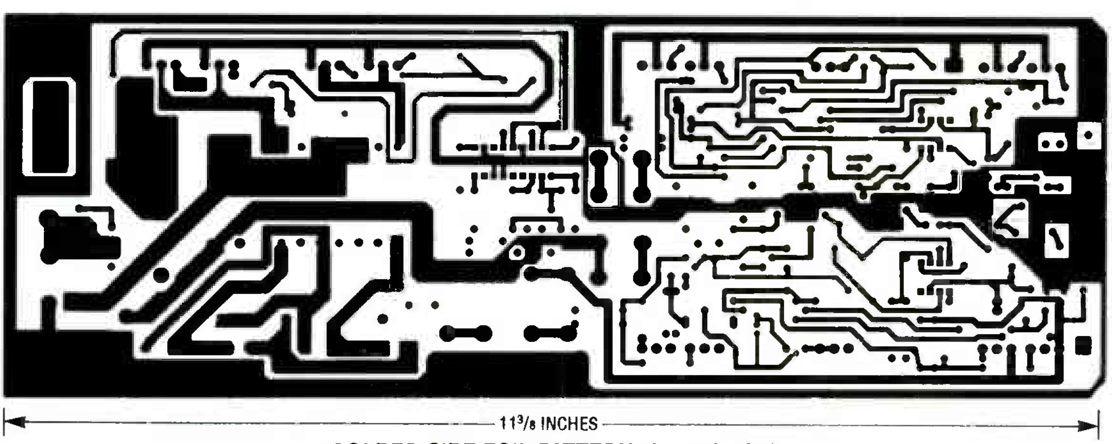
Testing

Install a 5-amp fuse for F101, and apply power. The inverter should now generate plus and minus 47 volts, as measured at the fuse clips for F1 and F2. Now install a 1-amp fuse for F1L and a milliammeter for F2L. Apply power and adjust R16L for a cur-

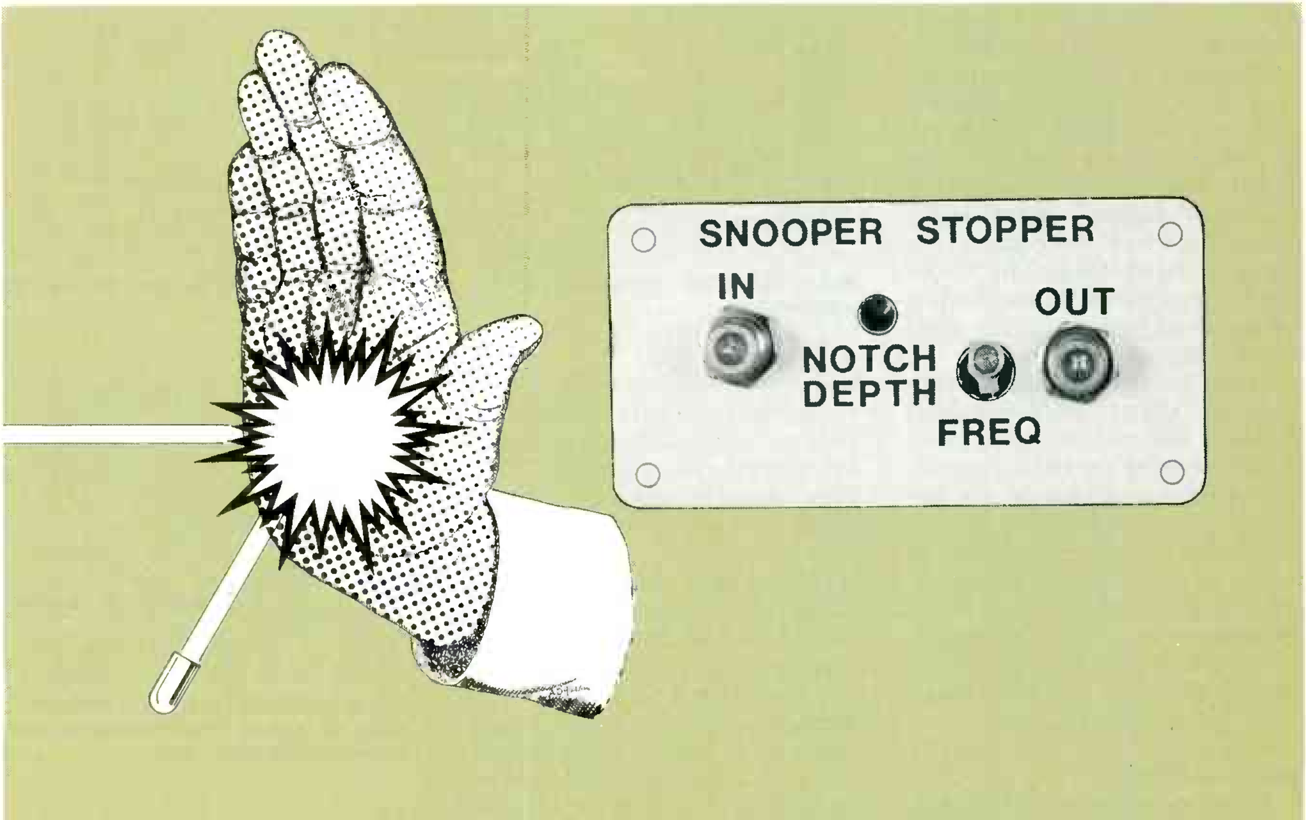
continued on page 74



COMPONENT-SIDE FOIL PATTERN shown half-size.



SOLDER-SIDE FOIL PATTERN shown half-size.



BUILD THE SNOOPER STOPPER

An easy-to-build filter rejects cable TV signals that interfere with your FM—and stops the infamous "bullet."

EDGAR WOLF

CABLE TV SERVICES HAVE COME A long way since they put antennas on hilltops to relay programs to customers hidden in radio "shadows." People subscribed to what used to be called community TV because they had to, not because they wanted to. But now this has all changed: Cable TV offers scores of channels and special programs not available from commercial channels for a monthly fee. The latest estimates place the number of homes in the U.S. with cable TV at 52 to 53 million, an astounding 61% of all homes.

However, CATV has become a victim of its own success. Many people want the programming but are unable or unwilling to foot the monthly bill. So many have turned to "pirating" the programs with unauthorized converters. Not surprisingly, the cable TV companies are striking back at unauthorized (nonpaying) users by charging them with "theft of service." According to the National Cable Television Association (NCTA), U.S. cable companies lost $3 billion in revenues because of pirating in 1991.

The cable companies have developed countermeasures to root out offenders. These include the infamous "bullet" (see **Radio-Electronics** January 1992.) and distinctive give-away identification signals. Both are sent out to customers over their cables.

The selective "bullet" will zap

only unauthorized TV converters or descramblers hooked up to the cable, and the identification signal, which sounds like a cuckoo at about 108 megahertz on the FM band, presents no threat to paying customers. The bleeping "cuckoo" signal leaks from unauthorized converters and can be detected by cable company personnel monitoring a suspected pirate's house with handheld receivers.

Unfortunately, both the "cuckoo" identification signal (if used) and routine command signals sent by the cable company over their cables to set up converters in customers' homes can cause interference with FM reception in those homes. To prevent the signals from interfering with your FM reception—and to ward off a "bullet"— you can build this passive filter called a Snooper Stopper.

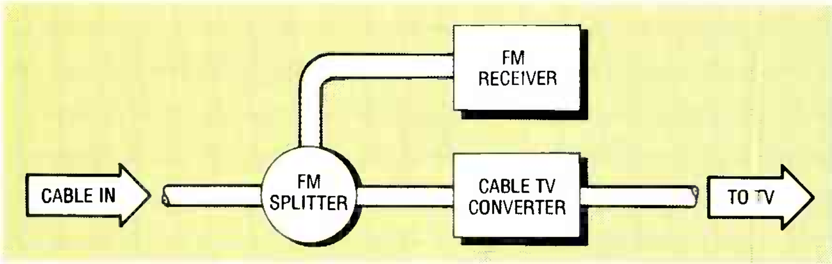


FIG. 1—TYPICAL INSTALLATION of a cable TV converter, FM receiver and an FM splitter.

Addressability

Cable operators have the ability to control individual subscriber service from the head end in fully addressable systems. This permits prompt service changes and reduces tampering problems with converter computer control by identifying and "tagging" each channel so that specific programming can go to the authorized subscriber.

Each cable TV converter has its own unique identification code. When you change from one pay service to another, or request a pay-per-view program, that unique code identifies your converter. The code is first sent to access your converter to prepare it for data that is to follow. The data includes instructions that set up your converter for the programs you are authorized to receive.

Data channel

With fully addressable systems, cable TV companies send setup data to your converter over the cable with an FM signal called a *data channel*. This is done by frequency modulating the data at 106.5 MHz. Cable companies use addressable converters because they are cost effective and convenient. When a customer calls for a change, or orders a pay-per-view movie, these instructions can be carried out automatically by the cable company's computer. However, not all homes with cable TV have addressable converters yet.

Some cable companies have added the chirping cuckoo-like sound at 108 megahertz. The "cuckoo" signal rides along with the command signal at 106.5 MHz. Therefore, noise might show up at several spots on your FM dial. This is caused by what has been referred to as "channel splash" due to the high energy level of the signals being sent.

If you want to find out if your cable system is addressable and thus the source of superfluous noise, you can hook up your FM receiver to the cable TV system as shown in Fig. 1 (if it is not already connected). Next scan the FM band to pick up any beeping noise and record the dial setting at which it is strongest—most likely around 106.5 megahertz. However, noise could also occur around channels 59 and 60 on your cable converter. If you detect the beeping signal at any of those points, the Snooper Stopper will eliminate the noise and prevent you from being a target for surveillance. In addition, the Snooper Stopper is an electronic shield that will block the "bullet."

Circuit description

The schematic of our Snooper Stopper is shown in Fig. 2. It is a low-cost passive band-rejection (notch) filter known as a bridge-T trap. The filter, offering a notch depth of 40 to 60 dB, has only one resonant circuit—C1, C2, L1, and L2—making it easy to tune. This bridge-T trap uses a tapped inductor. Trimmer potentiometer R1 permits critical adjustment of notch depth. Although a bridge-T trap provides sufficient signal attenuation, its band (notch) width is not very precise.

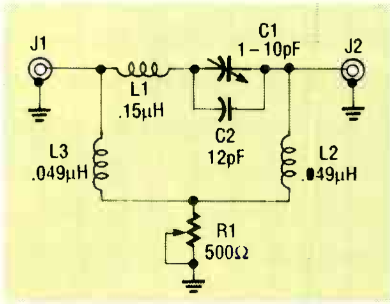


FIG. 2—SCHEMATIC OF THE SNOOPER stopper, actually a band-rejection filter known as a bridge-T trap.

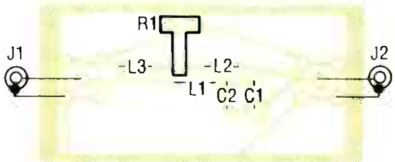


FIG. 3—PARTS-PLACEMENT DIAGRAM for the Snooper Stopper. Install all components as shown here.

Snooper Stopper's performance on systems with single interfering carriers is good, but with dual carriers, calibrating the notch frequency is critical. For this reason, trimmer capacitor C2 is included for tuning throughout the entire band, while R1 is used to adjust the notch depth.

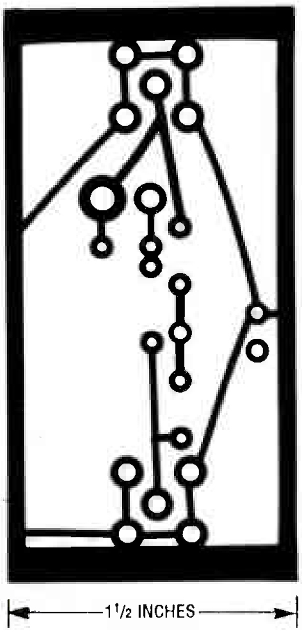
Building and adjusting

If you wish to make your own PC board, use the actual size foil pattern. Refer to the PC board layout shown in Fig. 3, and mount all components as shown. Be sure to install the F-

PARTS LIST

Resistors
R1—500-ohm potentiometer
Capacitors
C1—1 to 10 pF, adjustable, Johanson type #8052 or equivalent.
C2—12 pF NPO
Inductors
L1—0.15 µH, fixed coil
L2, L3—0.049 µH, fixed coil
Other components
J1, J2—F-type RF jack connectors for circuit-board mounting with ring nuts
Miscellaneous: case (Radio Shack Cat. No. 270-231 or equivalent).
Note: The following items are available from Northeast Electronics Inc., P.O. Box 3310, N. Attleboro, MA 02761, (1-800-886-8699). Check, money order, Visa and Mastercard accepted. Massachusetts residents must add 5% sales tax.
- **A kit of parts including an etched and drilled PC board, all components, and a plastic case with aluminum cover—$19.95.**
- **An etched and drilled PC board—$7.95.**
- **A kit of just the parts (no board or case)—$15.95.**

Please add $4.50 S&H to any order.



SOLDER SIDE foil pattern for PC board shown actual size.

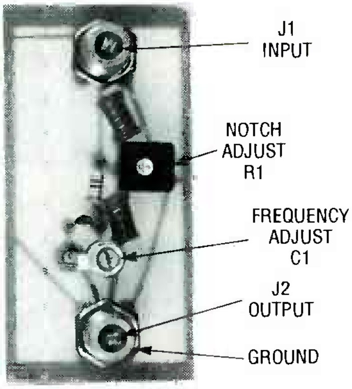


FIG. 4—THE AUTHOR'S PROTOTYPE removed from the case and without the cover plate.

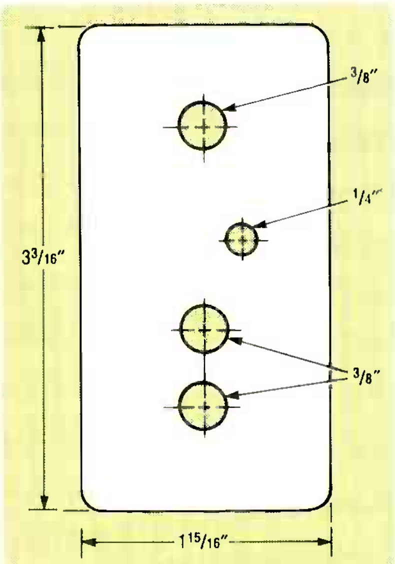


FIG. 5—HOLE-DRILLING TEMPLATE for aluminum cover of recommended plastic case.

type RF coaxial jack connectors and trimmer potentiometer R1 so they face up on the PC board as shown in Fig. 4. When the components have been positioned and soldered, check your work carefully, looking for solder bridges and open traces. Next, use the template (Fig. 5) as a guide for drilling the four holes in the aluminum cover of the recommended case. The same template can be used for drilling the holes in an alternate case cover by centering it on the cover. Be sure that the alternate case has sufficient volume to contain all of the circuitry without interference.

Install the completed Snooper Stopper as shown in Fig. 6 and tune it for the nuisance noise. Adjust C2 (frequency) and R1 (notch depth) until the interfering noise is blocked from your FM receiver.

Do not use the Snooper Stopper to circumvent the cable company's right to de-authorize your converter. Along with blocking a destructive "bullet," the filter will also prevent all programming instructions from reaching your cable box. If you install the Snooper Stopper ahead of the cable company's converter and change services, you will have to remove it so the converter can receive new instructions. Some new converters shut down if data is missing for long periods of time. **R-E**

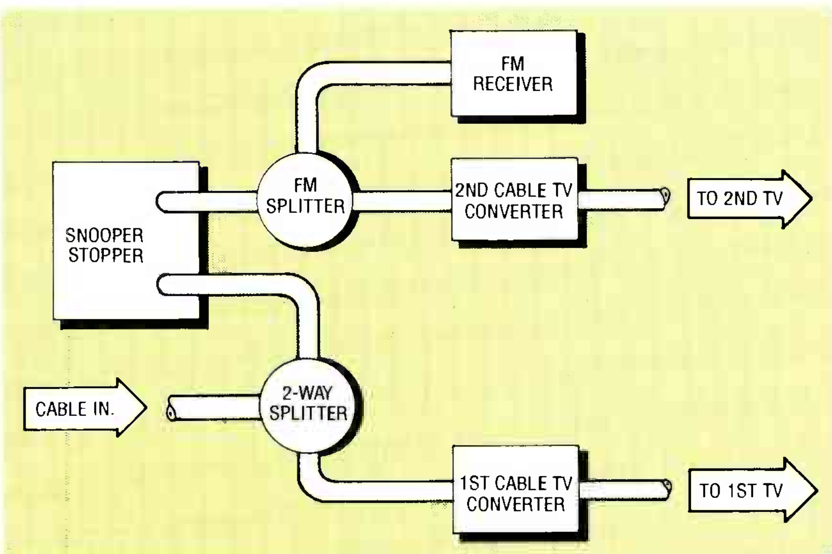


FIG. 6—INSTALLATION OF THE SNOOPER STOPPER ahead of the FM receiver and a second cable TV converter.

Electronic Temperature Measurement

No study of electronic temperature measurement would be complete without showing some actual circuits.

HARRY L. TRIETLEY

LAST MONTH WE CLOSED WITH A look at thermistors. Let's continue with some basic circuits—some thermistor application circuits to start off with. In the Wheatstone bridge of Fig. 1, the thermistor resistance decreases as temperature goes up, raising V_{OUT}. If R1 = R3, V_{OUT} will be zero at the temperature where the thermistor's resistance equals R2.

The output can be made linear if R1 is chosen correctly. As it turns out, the NTC (negative temperature coefficient) thermistor's nonlinearity is largely compensated for by the nonlinearity of the bridge's own voltage-versus-resistance curve. Figure 2 shows the voltage versus temperature curve fairly linear in the middle of its range, dropping in sensitivity at both ends. We won't take the time to prove that here, but the best possible linearization occurs if R1 is equal to:

$$\frac{R_{T1}R_{T2} + R_{T2}R_{T3} - 2R_{T1}R_{T3}}{R_{T1} + R_{T3} - 2R_{T2}}$$

where R_{T1}, R_{T2}, and R_{T3} are the thermistor's resistance at the low end, midpoint, and high end of the temperature range respectively. (Remember, R_{T1} is higher than R_{T3}.)

You can see by looking at Fig. 2 that the deviation from perfect linearity gets worse as the temperature range widens. The table in Fig. 1 includes calculated values for three typical ranges, and Table 1 gives R versus T data for the thermistor. Ranges of equal width centered at different temperatures will have similar nonlinearities. For example, a properly designed 50 to 100°C range will be about as nonlinear as 0 to 50°C.

A thermistor's sensitivity changes greatly with temperature, making it difficult to linearize one over its entire range. Even digital techniques are difficult, requiring a large number of bits in the A/D converter. One trick is to use two thermistors, one with low resistance for optimum low-temperature response, and the other with higher resistance for high temperatures.

Figure 3 shows such a circuit. At very low temperatures R_{T2} is so large that R_{T1} and R2 dominate. At higher temperatures the opposite is true: R_{T1} becomes small in comparison with R2, and R_{T2} shunts the R2-R_{T1} combination. If the component values are properly chosen, R_{T2} begins to make a noticeable contribution just as R_{T1} begins to fall off. The values in Fig. 3 yield better than ±0.22°C linearity from 0 to 100°C if the proper thermistor pair is used.

Two-thermistor composites containing two precision discs encapsulated in one epoxy case are available from YSI in Yellow Springs, OH and Fenwal in Milford, MA. Figure 3 uses the most common, available in YSI's family of 700-Series probes. Table 2 shows its R versus T values. Resistor selection is not easy, and is usually done using a computer. The manufacturers offer precalculated values for several temperature ranges. The concept also has been extended to three-thermistor networks.

RTD's

A resistance thermometer, or RTD (Resistance Temperature Device), is simply a wirewound coil or metal film whose resistance increases with temperature. As we saw last month, platinum is the most widely used material, offering the best stability and widest temperature range, while nickel is sometimes used for moderate industrial temperature measurements. Platinum thermometers are sometimes known as PRT's (Platinum Resistance Thermometers).

Table 3 gives R versus T tables and typical accuracies for platinum and nickel RTD's per the German DIN (Deutsche Industrie Normenausschuss) standard. Other curves exist, but those in Table 3 have achieved world-wide recognition. Most manufacturers offer platinum matching the DIN R versus T table, but often with tighter or looser accuracies. Not all platinum thermometers cover the entire −200 to 850°C range, and a 500 or 600°C upper limit is common.

Sensors of 100 ohms (at 0°C) are most common, but others exist. At 100 ohms, platinum's sensitivity is 0.385 ohms/°C between 0 and 100°C, decreasing slightly as temperature rises. Nickel's sensitivity is 0.618 ohms/°C, increasing with temperature. Higher resistance sensors provide proportionally higher ohms per degree.

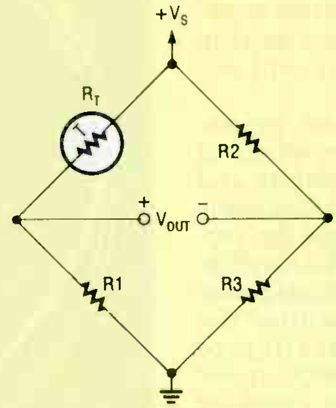
Platinum is expensive, but very little metal is used in making RTD's. Typical 100-ohm elements use about 22 inches of 0.001-inch diameter wire wound on a small ceramic bobbin.

Manufacturing details vary, but the wire must be constrained well enough to avoid shorts between turns, yet free enough to minimize strain-gage effects due to thermal expansion. The finished element is usually encased within an outer ceramic or glass housing. Most elements are under 0.1-inch diameter and a fraction of an inch long. Figure 4 shows some typical elements.

The biggest challenge for manufacturers is accuracy, and 0.25°C accuracy corresponds to 0.1% resistance, or about 0.022 inch of wire. Some manufacturers carefully control the wire length while others have developed methods to trim at a known temperature. The wire composition itself must be carefully controlled; very slight amounts of impurities are alloyed with the platinum to achieve the correct temperature coefficient. Pure platinum sensors having slightly higher sensitivity are also available.

Platinum-film elements are a more recent development. Most are made by vacuum-depositing platinum onto ceramic substrates, although silk-screened thick-film pastes have also been used. Film elements are not as stable as wire at high temperatures, but they cost less. Deposited film uses less platinum and can be bulk manufactured and laser trimmed. The elements can be made smaller—as small as thermistors—and can be supplied in resistances to 2 kilohms for higher sensitivity.

Copper, in general, is a poor choice for temperature measurement due to its limited temperature range and very low resistance. Its most common application is monitoring the



EXAMPLES OF BRIDGE DESIGNS			
Temperature range	10 to 30°C	0 to 50°C	0 to 70°C
Temperature for zero output	10°C	0°C	0°C
Sensitivity	10 mV/°C	10mV/°C	10mV/°C
Bridge supply (V_s)	916.2 mV	1017.3 mV	1147.0 mV
R1	2,168 ohms	1,763 ohms	1,164 ohms
R2	4,482 ohms	7,355 ohms	7,355 ohms
R3	2,168 ohms	1,763 ohms	1,164 ohms
Maximum nonlinearity	+0.07 −0.06°C	+0.85 −0.95°C	+2.0 −2.3°C

Note: Thermistor is a YSI 44004, 400 series probe or equivalent, 2,252 ohms at 25°C.

FIG. 1—A WHEATSTONE BRIDGE with a thermistor arm will produce an output that increases with temperature. The table shows three practical ranges.

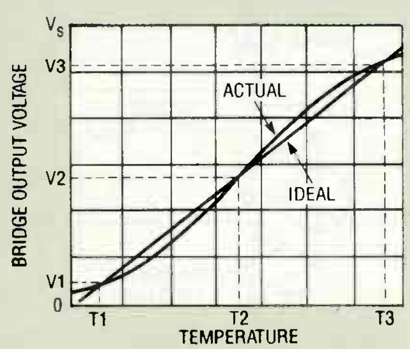


FIG. 2—THE WHEATSTONE BRIDGE OUTPUT is fairly linear near the middle of its range.

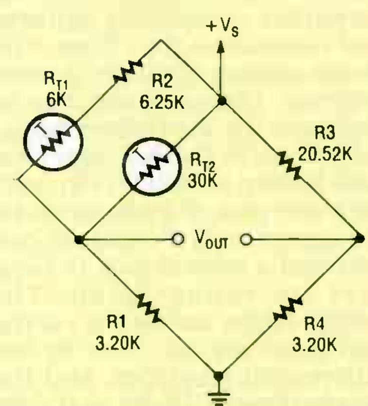


FIG. 3—A THERMISTOR-PAIR can be used in a Wheatstone bridge to improve the output linearity. This circuit is linear to within ±0.216°C from 0–100°C.

temperature rise of motors, generators, and transformers. Other alloys have been used to create RTD's, but we will not cover them here.

RTD elements can be assembled into a wide variety of probes, as can thermistors and thermocouples, including some with threaded fittings for permanent installation into industrial processes. A pointed probe could be used to monitor the cooking or refrigeration of foods, while a flat probe (made from a film element) could be used to measure surface temperatures. Other styles are available, including laboratory types and probes with bends.

RTD circuits

RTD readout circuits are basically ohmmeters, specialized to ignore lead-wire resistance and (sometimes) to compensate for R versus T nonlinearity. Since typical RTD sensitivities are 0.4 or 0.6 ohms per degree, each ohm of lead resistance contributes about 2°C measurement error. Therefore, compensation circuitry must be used.

Four-wire resistance measurement completely ignores lead resistances, but three-wire compensation circuitry is more common. (An extra wire can be expensive in an industrial installation!) In Fig. 5-*a*, four-wire (also known as Kelvin) circuitry uses one pair of leads to excite the sensor with a constant current and a second pair to measure its voltage drop. The voltage drops across the excitation leads are not seen by the differential amplifier, and the measurement leads carry essentially no current, so their voltage drop is zero. Therefore, the amplifier's input sees only the voltage drop across the RTD itself. The circuit also performs linearization, but we'll come back to that in a moment.

The three-wire circuit in Fig. 5-*b* uses an identical controlled current source but different readout circuitry. The main amplifier's "+" input sees the combined voltage drop of the RTD and the two excitation leads. The second (×2) amplifier sees

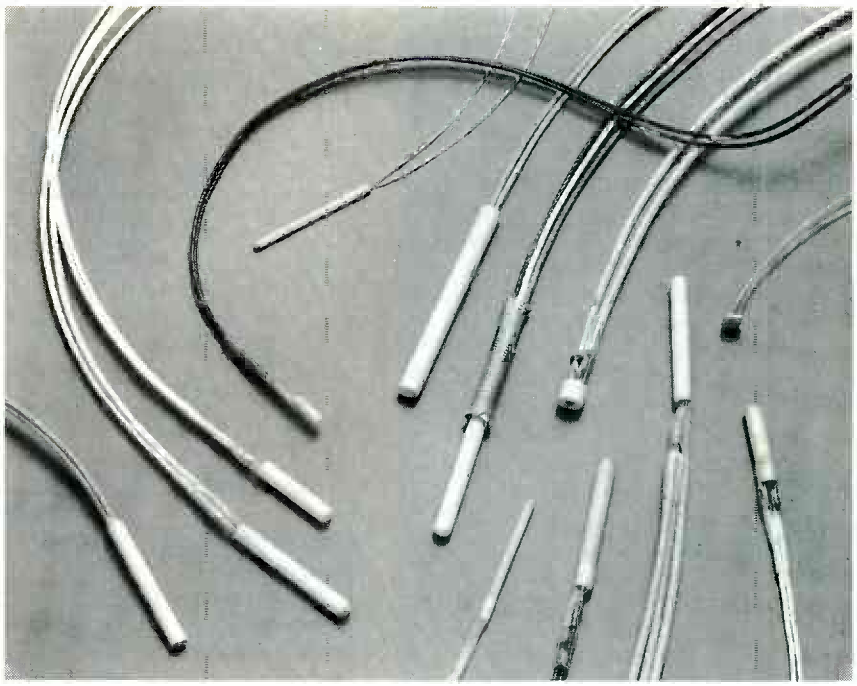


FIG. 4—TYPICAL RTD ELEMENTS, with leads attached. The small square element toward the right of the picture is a platinum-film element. (Courtesy of Sensing Devices Inc.)

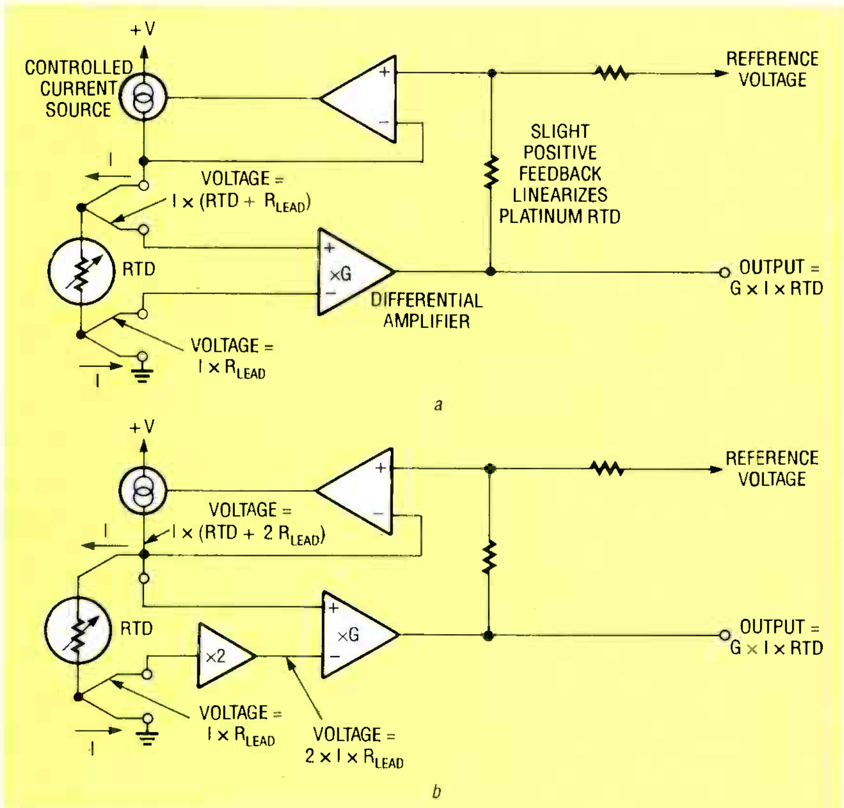


FIG. 5—FOUR-WIRE MEASUREMENT (*a*) measures the RTD's resistance and ignores lead wire resistances completely; it also includes linearization for platinum RTD's. Three-wire circuitry (*b*) compensates for voltage drops in the lead wires.

TABLE 1—CHARACTERISTICS 2252-OHM PRECISION THERMISTOR

Temperature °C	°F	Resistance Ohms
−80	(−112)	1660K
−70	(−94)	702.3K
−60	(−76)	316.5K
−50	(−58)	151.0K
−40	(−40)	75.79K
−30	(−22)	39.86K
−20	(−4)	21.87K
−10	(14)	12.46K
0	(32)	7.355K
10	(50)	4.482K
20	(68)	2.814K
25	(77)	2.252K
30	(86)	1.815K
40	(104)	1.200K
50	(122)	811.3
60	(140)	560.3
70	(158)	394.5
80	(176)	282.7
90	(194)	206.1
100	(212)	152.8
110	(230)	115.0
120	(248)	87.7
130	(266)	67.8
140	(283)	53.0
150	(302)	41.9

TABLE 2—700-SERIES THERMISTOR PAIR

Temperature °C	°F	T1 (Ohms) (6K at 25°C)	T2 (Ohms) (30K at 25°C)
−30	(−22)	106.2K	481.0K
−20	(−4)	58.26K	271.2K
−10	(14)	33.20K	158.0K
0	(32)	19.59K	94.98K
10	(50)	11.94K	58.75K
20	(68)	7496	37.30K
30	(86)	4834	24.27K
40	(104)	3196	16.15K
50	(122)	2162	10.97K
60	(140)	1493	7599
70	(158)	1051	5359
80	(176)	753.8	3843
90	(194)	549.8	2799
100	(212)	407.6	2069

TABLE 3—PLATINUM AND NICKEL RTD'S (DIN STANDARD 43760)

Temperature (°C)	Platinum (Ohms)	Tolerance (°C)	Nickel (Ohms)	Tolerance (°C)
−200	18.49	1.3		
−100	60.25	0.8		
−60	76.33	0.6	69.5	2.1
−50	80.31	0.55	74.3	1.8
0	100.00	0.3	100.0	0.4
50	119.40	0.55	129.1	0.75
100	138.50	0.8	161.8	1.1
150	157.31	1.05	198.7	1.45
180	168.46	1.2	223.2	1.7
200	175.84	1.3		
400	247.90	2.3		
600	313.59	3.3		
800	375.51	4.3		
850	380.26	4.55		

only the IR drop of the lower excitation lead. The ×2 amplifier doubles that voltage and presents it to the main amplifier, which subtracts it from the total. Thus, the signal seen by the main amplifier is $(I \times (RTD + 2R_{LEAD})) - (2 \times I \times R_{LEAD})$, which equals $I \times RTD$. Compensation will be perfect as long as the resistances of the leads and their connections are equal.

Now back to linearization. Platinum RTD's decrease in sensitivity (ohms per degree) as temperature rises. That can be compensated for by causing the current source to increase slightly with temperature. In Fig. 5-*a*, a slight amount of positive DC feedback (much too small to cause oscillation) increases the controlled current source as the output rises.

Figure 6 shows a practical circuit. The controlled current source consists of IC1-b and Q1; IC1-b compares the voltage drop across R2 to the voltage on R7's wiper and controls Q1 to keep the two equal. Resistors R3 and R4 "pad" the value of R2; when properly adjusted, the net resistance of R2, R3, and R4 is 100 ohms. Filter R5-C2 removes 60 Hz or other noise picked up by the RTD leads. The main amplifier, IC2, is a differential amplifier with a gain of 1. The positive feedback from R16 increases the RTD current with output, linearizing the platinum curve to better than ±0.5°C between 0 and 500°C. Linearization degrades somewhat at higher and lower temperatures.

Components IC1-a, R10, and R11 form the ×2 amplifier, with R1 and C1 providing filtering. Notice that IC1-a amplifies the voltage drop across R2 as well as that of the current-carrying lead. Its output is:

$$2 \times I \times (R_{LEAD} + 100\Omega)$$

Now notice that the main amplifier's input is:

$$I \times (RTD + 2R_{LEAD} + 100\Omega)$$

IC2's output is the difference: $I \times (RTD - 100\Omega)$. Since the RTD is 100 ohms at 0°C, the output at zero degrees is zero millivolts. With the circuit values shown, sensitivity is 1 mV/°C, which is handy for measuring temperature with a DVM.

Zero is set by providing a 100-ohm input and setting R4 for a 0-mV output. The gain is adjusted via R7 for 500 mV output at 280.90 ohms (500°C). Because RTD's are interchangeable, you do not need known temperatures or a reference thermometer for calibration.

Thermocouples

A thermocouple is simply two unlike metals joined together. The junction produces a voltage that increases with tempera-

TABLE 4—STANDARD THERMOCOUPLES

Thermocouple Type	Specified Temperature Range	Specified Error (Above 0°C)	Applications
Base Metal Thermocouples:			
J: Iron vs. Constantan	−210 to 760°C	Std: 2.2°C or .75% Special: 1.1°C or .375%	Reducing and inert atmospheres. Avoid oxidation and moisture.
K: Chromel vs. Alumel	−270 to 1372°C	(Same as type J)	Oxidizing and inert atmospheres.
T: Copper vs. Constantan	−270 to 400°C	Std: 0.83°C or .75% Special: 42°C or .375%	Most atmospheres. Best choice below 0°C. Moisture ok.
E: Chromel vs. Constantan	−270 to 1000°C	Std. 2.2°C or .5% Special: 1.1°C or .375%	Oxidizing and inert atmospheres. Highest sensitivity.
N: Nicrosil vs. Nisil	−270 to 1300°C	Std: 2.2°C or .75% Special: 1.1°C or .4%	Hi temp and oxidizing. More stable than type K.
Platinum Alloy Thermocouples:			
R: Pt/13% rhodium vs. pure pt.	−50 to 1768°C	1.4°C or 0.25%	Oxidizing & inert atmospheres. Avoid reducing atmospheres, metallic vapors.
S: Pt/10% rhodium vs. pure pt.	(Same as type R)	(Same as type R)	(Same as type R)
B: Pt/30% rhodium vs. pt/6% rhodium.	0 to 1820°C	0.5%	(Same as type R)

ture. Almost any pair of dissimilar metals can be used to make a thermocouple, but some will be more stable and accurate than others. Eight types are documented by NIST (formerly NBS) as standards, but specialized nonstandard thermocouples are available as well.

Table 4 lists the eight standard types, which are identified by letter codes. The first five (types J, K, T, E, and N) are pairs of base-metal alloys. Type K covers the widest range and is most popular. (Handheld DVM-like thermocouple thermometers most often use type K.) Type N, the newest, is similar to K but is more stable at high temperatures and in oxidizing atmospheres. Type T is best below freezing and in moist atmospheres, but is very limited at the upper end because one lead is copper. Type J includes iron and should not be used in moist or oxidizing environments. It is the best choice for inert or reducing atmospheres. Type E is the most sensitive of the standard thermocouples.

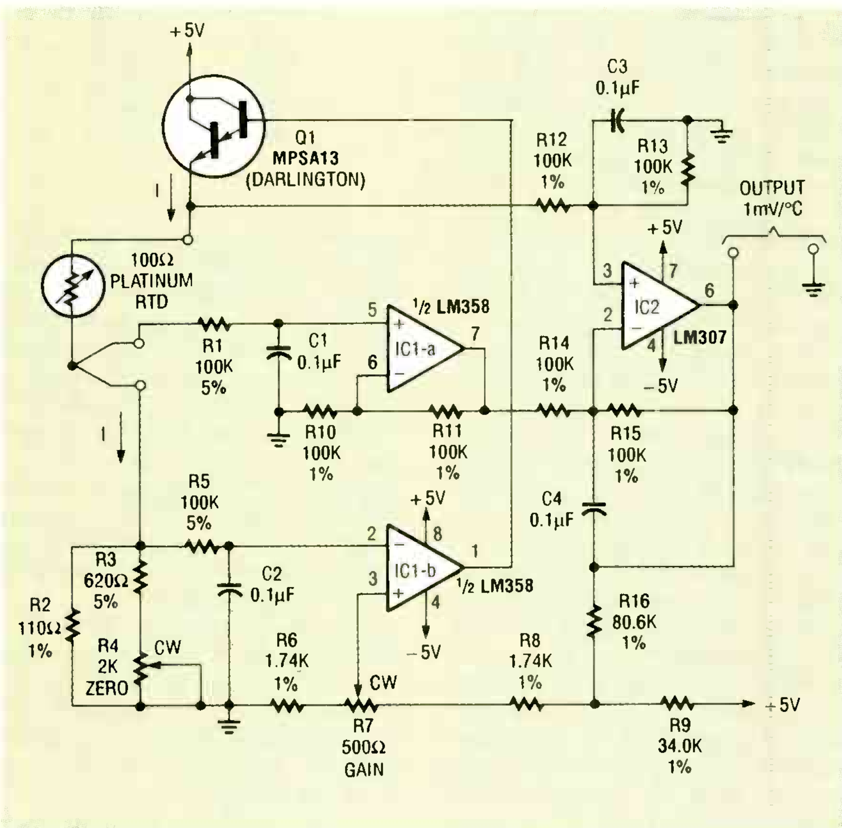


FIG. 6—THIS CIRCUIT INCLUDES 3-WIRE lead compensation, linearizes a platinum RTD, and produces a 1 mV/°C output.

Types R, S and B consist of various platinum-rhodium alloys. They are more stable and accurate, and operate to higher temperatures. They also are less sensitive and, of course, more expensive. Types R and S are very similar to each other. Type B goes a bit higher in temperature, but falls off drastically in sensitivity below several hundred degrees. All three lose sensitivity near room temperature.

We do not have room here for data on all thermocouples, but Table 5 gives abbreviated millivolt versus temperature tables for types K, R, and a nonstandard high-temperature tungsten alloy thermocouple. (The catalog from Omega Engineering, Stamford, CT, mentioned last month, contains complete thermocouple reference data.)

Thermocouples offer more variety in size, shape, and configuration than any other sensors. Preassembled probes are available in many styles, and wire is available bare or insulated with such material as PVC, Teflon and ceramics. Various diameters are available from 14 AWG to 0.0005 inch, and ribbon thermocouples serve for surface temperature measurement.

The junction is usually formed by welding the two wires together, although twisting works for temporary purposes. One-shot measurement of molten steel can be made by simply plunging the two wires into the steel. Wires may be welded to metal surfaces or epoxied in place. One precaution when making surface measurements: place some of the connecting wire along the surface to make sure it does not conduct heat away from the junction.

Two final notes on wire: First, it can be expensive. Less-expensive extension-grade wire is sometimes used in industrial installations to connect remote measurement points to the readout instruments. Measurement-grade wire is used to make the measurement and runs out to locations at ambient temperature, where it is spliced to extension wire. The extension wire runs the rest of the distance to the readout or control devices. Extension wire matches measurement wire at ambient temperatures, but is not suitable for high- or low-temperature use.

Second, thermocouple cable is often coded by insulation color. Type K, for example, is identified by yellow on the positive wire and red on the negative. An outer brown jacket identifies measurement-grade wire: type K extension wire is yellow. Note that all color-coded thermocouples use red to identify the negative wire, which seems backwards to most of us in electronics.

TABLE 5—VOLTAGE VS. TEMPERATURE

Temperature (°C)	Type K Chromel vs. Alumel (mV)	Type R Pt-13% Rhodium vs. Platinum (mV)	Tungsten vs. Tungsten-26% Rhenium (mV)
−270	−6.548		
−200	−5.891		
−100	−3.553		
0	0	0	0
100	4.095	0.647	0.334
200	8.137	1.468	1.037
400	16.395	3.407	3.339
600	24.902	5.582	6.529
800	33.277	7.949	10.296
1000	41.269	10.503	14.389
1200	48.828	13.224	18.607
1372	54.875	15.639	22.213
1400		16.035	22.792
1600		18.842	26.820
1768		21.108	30.009
1800			30.592
2000			34.022
2200			36.884
2315			38.556

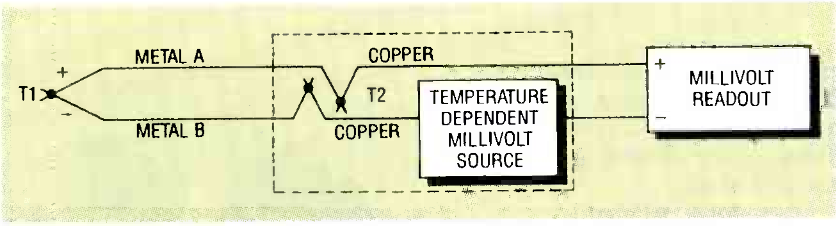


FIG. 7—COLD-JUNCTION COMPENSATION is necessary to offset EMF's generated by the unwanted thermocouples at the readout connections.

Thermocouple circuit

A thermocouple circuit must do three things: amplify millivolt-level signals, correct for nonlinearities in the millivolt-versus-temperature table, and provide cold-junction compensation. Accurate amplification of millivolt-level signals requires stable, low-drift op-amps.

Thermocouples are not as easily linearized as RTD's, but we will not show specific circuits here. A wide variety of analog techniques have been used, the most common being diode breakpoint circuits. Those circuits use op-amps, diodes, precision resistors, and trimmer potentiometers to create an output versus input function consisting of a series of straight-line segments which approximate the required curve. Other approaches use one or several computational IC's (exponential, logarithmic, etc.) as part of the linearization circuitry.

Today it is common to digitize the amplified signal and lin-

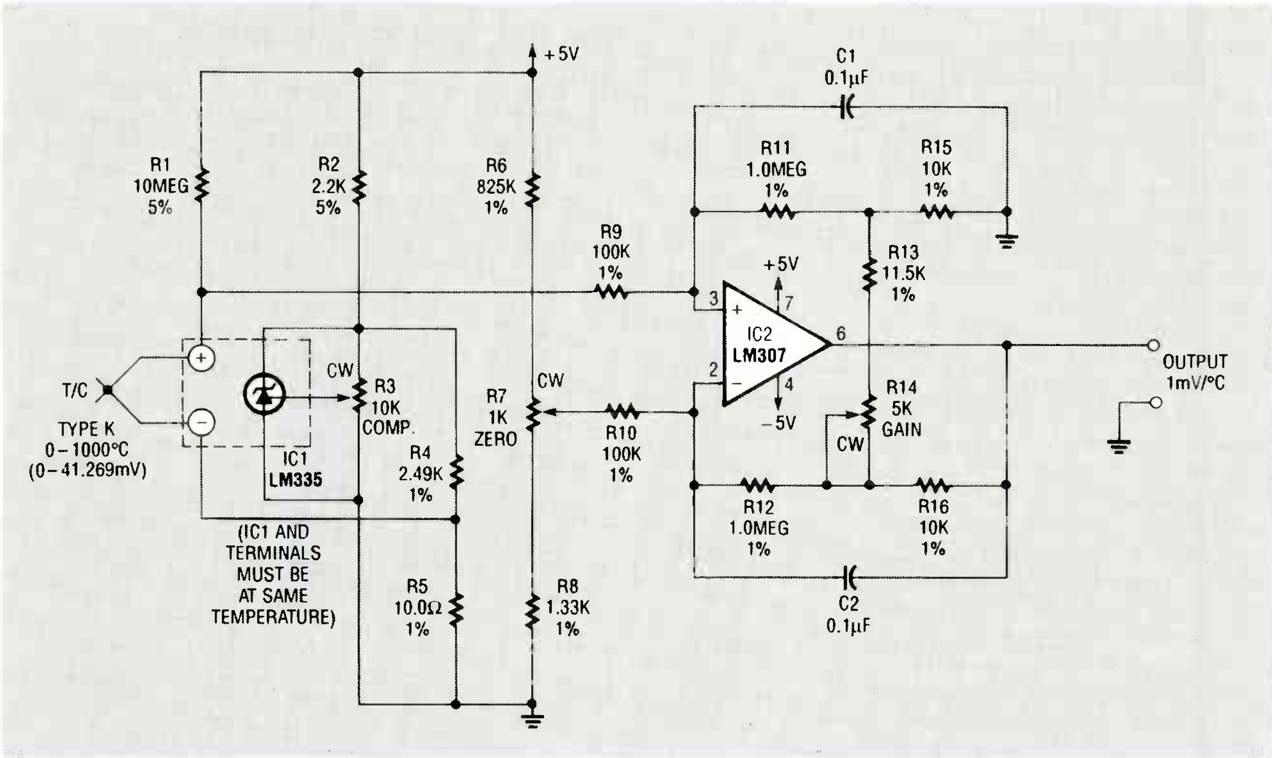


FIG. 8—THIS CIRCUIT PROVIDES cold-junction compensation and amplifies a type-K thermocouple to 1 mV/°C.

earize it with a microprocessor. On the other hand, since thermocouples are approximately linear they might not be linearized at all.

Let's look at cold-junction compensation. Remember that any connection between two unlike metals generates thermocouple voltage. Figure 7 shows that two unwanted thermocouples (cold junctions) are formed where the wires are connected to the readout's copper circuitry (T2). As the T2 temperature changes, the reading will be affected, even if T1 remains constant.

The cold-junction voltage is predictable, however, in fact, its temperature coefficient is equal and opposite to that of the thermocouple itself. (If T1 and T2 are equal, the net voltage will be zero.) It is a fairly simple matter to use a semiconductor or thermistor temperature sensor with circuitry creating an offsetting millivolt signal.

Figure 8 shows a complete circuit capable of producing a 1mV/°C output from a type-K thermocouple. It includes cold-junction compensation, but

FIG. 9—THIS HANDHELD DEVICE measures temperature using noncontact infrared, radiation thermometry.

does not linearize the thermocouple curve. It would make an ideal circuit to turn your DMM into a thermometer.

Let's start with the cold junction compensation. An LM335 temperature sensor IC (discussed last month) generates 10 mV/K (273.15 mV at 0°C). Potentiometer R3 adjusts the precise sensitivity of the IC—you can omit it if you use a tight-tolerance grade LM335. R4 and R5 divide the signal down to 40 μV/K, equivalent to type K's sensitivity at room temperatures.

Without R13 and R14, the gain of IC2, a modified differential amplifier, would be 1 megohm/100K, or 10. Resistors R13 and R14 work with R15 and R16 to divide the feedback signal by 2.42:1, which multiplies the closed-loop gain by the same factor. The resulting 24.2 gain produces a 1000-mV output from the 41.269-mV (1000°C) input signal. The zero offset provided by R6, R7, and R8 is needed because the cold-junction compensation voltage is not zero at 0°C.

Note that IC1 must be at the same temperature as the thermocouple connections. One construction technique is to epoxy the IC to the terminal block. To calibrate, measure the ambient temperature, then set R3 for the proper voltage across IC1 (10 mV/K, which is 2.732 volts plus 0.01V/°C).

Zero and gain calibration is tricky because disconnecting

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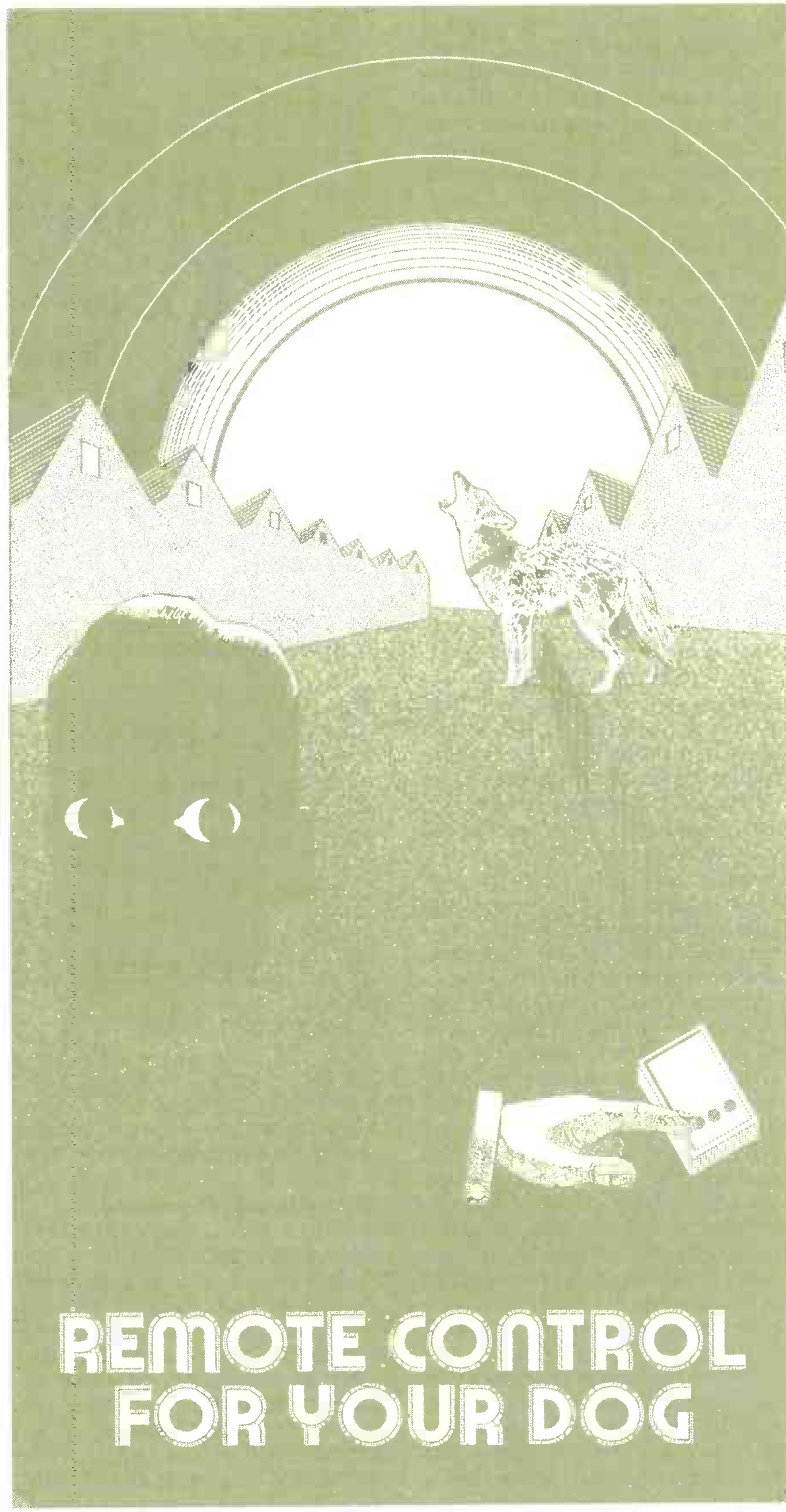


Silence nuisance dog barking safely and humanely with a wireless remote trainer.

FIDEL CANINO

DOES YOUR DOG KEEP YOU AWAKE nights yelping at the moon or just about anything real or imagined that moves? Has that fluffy, cuddly pup that you brought home just weeks ago become a four-legged 100-dB loudspeaker that's endangering neighborhood tranquility? Has Spot frightened the mailman, the paper boy, or the Girl Scout on her cookie route? If your answer to one or more of those questions is yes, you should consider building this safe, humane, and efficient radio-frequency dog trainer that controls nuisance barking without affecting the dog's ability to bark when it's desirable in cases of alarm or intrusion.

Developed in cooperation with a major research laboratory and tested and approved by veterinarians and animal behaviorists, the Dog Trainer combines advanced BICMOS (bipolar combined with CMOS technology on the same chip) electronic control circuitry with high frequency-vibration generation to teach most dogs to modify their barking behavior within a few weeks.

Basic concept

Your handheld RF transmitter sends a coded signal that's picked up by a subcutaneous receiver implanted in the fleshy part of your dog's neck as shown in Fig. 1. The coded signal triggers a microresonator that causes a painless but annoying tickling vibration in your dog's neck, not unlike a flea biting. The tiny resonator grabs your dog's attention and reminds him or her that it's time to quit nuisance barking. Figure 2 is a simplified block diagram of the complete Dog Trainer. It is not intended to turn a good watchdog into a passive puppy. For example, you wouldn't want to inhibit your pet's alarm barking when your smoke alarm goes off, your dog is being attacked by the local pit bull, or you forget to put out his bowl of Alpo.

Stimulus-response

The Dog Trainer demonstrates the beneficial effects of the stimulus-response concept first set forth by the famous Russian physiologist, Ivan Pavlov (1887—1935). He stimulated a dog with the sound of a bell for a brief period, and then gave it food and measured the resulting flow of saliva. After a considerable number of pairings of bell with food, the sound of the bell alone would call forth salivation in somewhat the same manner as had the food: that is to say, the bell had taken the place of the food as stimulus to salivation. Pavlov called this a conditioned reflex, but because later work has shown that many other responses than reflexes alone can be conditioned in a similar manner, the phenomenon has come to be known as the conditioned response.

Prolonged yelping by your dog alerts you to the need for silencing your pet so you press the button on your handheld unit. The irritant provided by the remotely operated resonator first startles your dog who soon learns to relate the onset of the irritating sensation to his or her nuisance barking. Pretty soon, anticipation of the sensation will take over and your dog learns that, except for a few short alarm barks, silence will avoid the irritant. In this case the resonator is the stimulus and cessation of nuisance barking is the conditioned response.

This trainer is an alternative to shock collars, acoustic collars, or even vocal-cord surgery as ways to control nuisance barking. It has obvious humane advantages over shock collars and surgery, and not so obvious advantages over high-frequency sound collars. As an alternative to the sound collar, you don't need the special collar that is vulnerable to water and you don't have to replace a 9-volt battery in the dog's collar.

Because there is no collar, you don't have to worry about ruining the electronics in the collar if Rex runs out in the rain. Moreover, you can give Rex a bath at any time because the self-contained receiver-actuator is under your dog's skin. Your dog can run through sprinklers or plunge into rivers, lakes or oceans to his heart's content.

FIG. 1—ACTUATOR CAPSULE IS LOCATED in loose fold of dog's skin in a fast, painless implant operation by a licensed veterinarian.

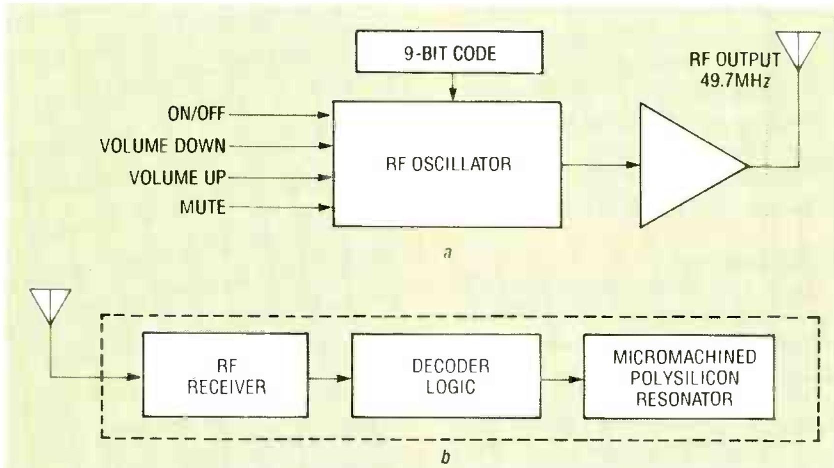
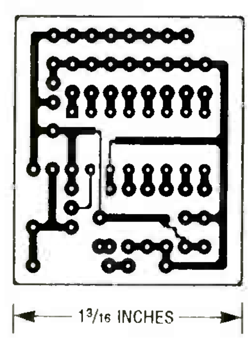


FIG. 2—BLOCK DIAGRAM OF ELECTRONIC DOG TRAINER SYSTEM showing hand-held RF transmitter and an implanted actuator.

Microminiature resonator

The trainer includes the first consumer application for a micromachined silicon resonator shown in Fig. 3. Fabricated with manufacturing techniques similar to those used for integrated electronics, this "solid-state" linear resonator features a pair of folded-beam suspensions. The vibrating microstructure is a transducer that sends signals directly to your dog's nerve endings through an impedance-matching silicone dome in the miniature implant. In effect, the device is a tiny sonar emitter.



FOIL PATTERN for the Dog Trainer transmitter single-sided PC board

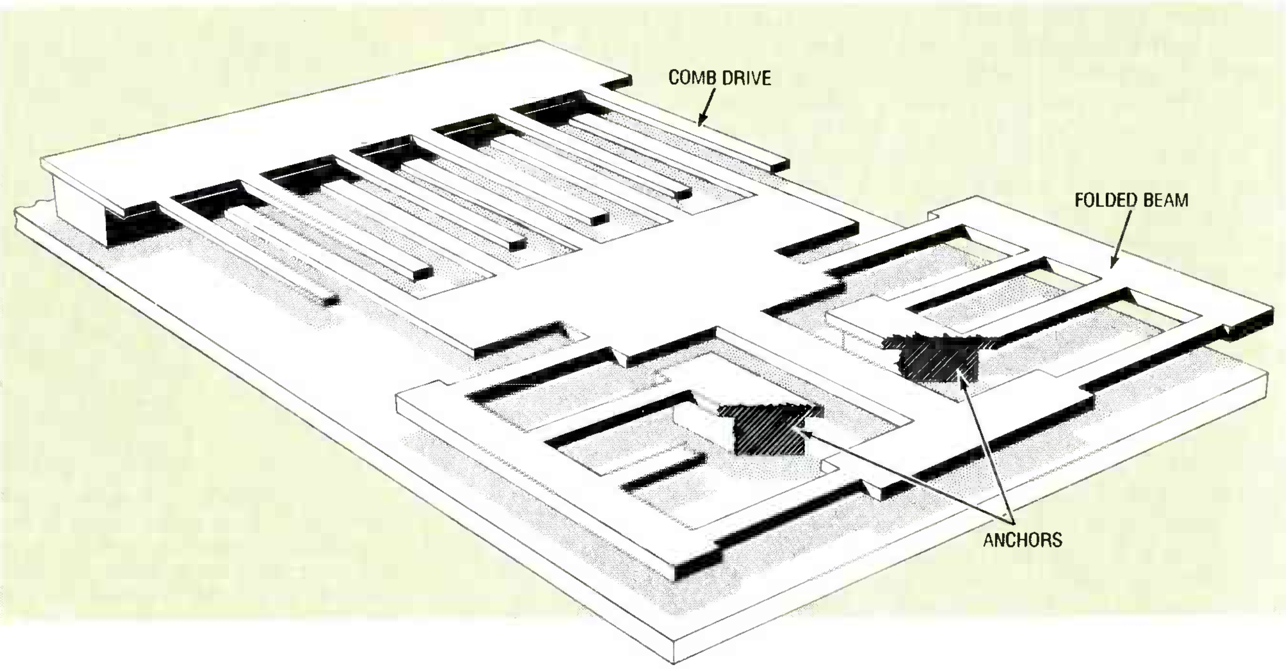


FIG. 3—MICROMACHINED SILICON RESONATOR provides stimulus to inhibit dog from nuisance barking. Supporting anchors for folded beam are cutaway. The resonator is integrated on a chip with receiver-decoder circuitry.

The linear resonator in the Dog Trainer actuator is suspended by a pair of folded beams and driven electrostatically with a comb structure. Vibrational motion is in the *x* direction, while sideways motion in the *y* direction is damped by the folded beam. The use of electrostatic forces for actuating microstructures is especially attractive because the magnitude of the induced force scales favorably with the small size of the actuator, approximately 35 microns wide.

The resonator is made by surface machining deposited thin films. Both anisotropic reactive ion etching (RIE) and wet chemical etching are used to define deposited films such as polysilicon (SiO_2), silicon nitride (Si_3N_4), and phosphosilicate glass (PSG). To create this free-standing structure, the underlying superficial layer of SiO_2 or PSG is removed by highly selective hydrofluoric acid (HF) etching, after the polysilicon layer is deposited and patterned. The resonator is approximately 10 microns thick.

The resonator is an integral part of the microminiature actuator assembly, combining a BICMOS RF receiver and de-

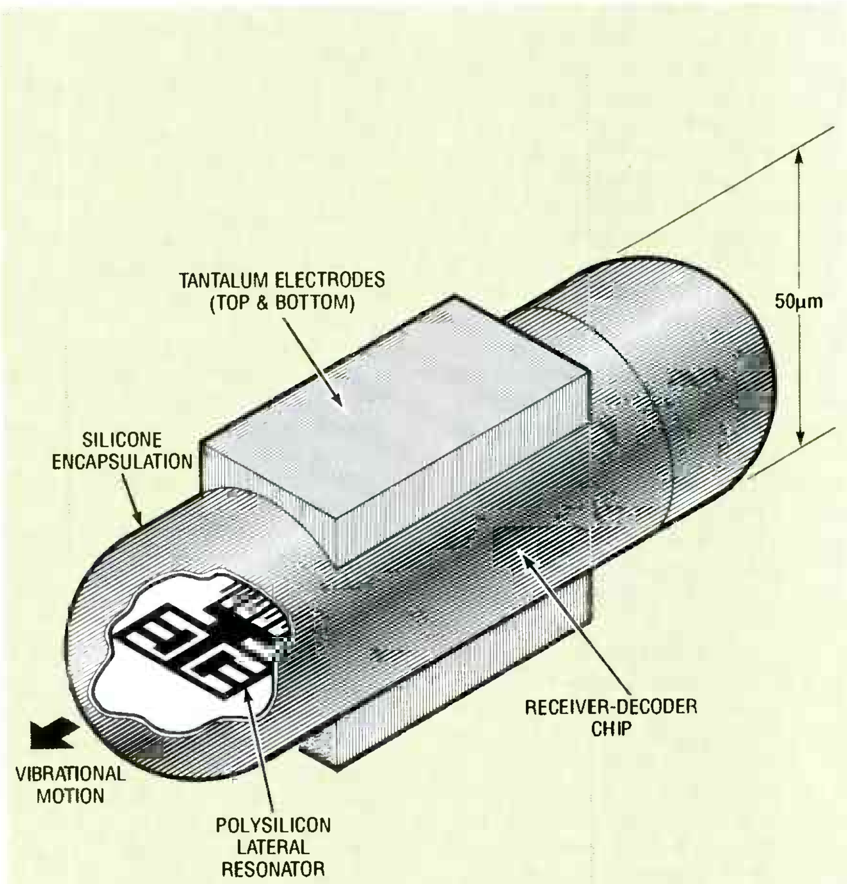


FIG. 4—ACTUATOR PACKAGE SHOWING the location of the lateral resonator, receiver-decoder chip and top and bottom electrodes that act as antenna terminals within the dog.

coder on a chip. This circuitry is furnished prepackaged in a miniscule capsule as shown in Fig. 4. The capsule, which measures approximately 50 microns in diameter by 200 microns long, is implanted with a hypodermic needle. The capsule is located in the hollow needle of a syringe furnished as part of the kit obtainable from the author. It is recommended that the implantation be performed by a licensed veterinarian.

The kit contains the syringe with the receiver capsule assembly, the PC board, semiconductors, resistors, capacitors, and other parts. The actuator implant in a syringe is available only from the author. Insertion of the actuator is virtually painless and should take any qualified vet only about 10 seconds. You give your vet the directions as to recommended location.

How does it work?

The actuator assembly is encapsulated with a non-toxic, non-allergenic material and can remain under your dog's skin indefinitely. The tantalum electrodes form a conductive bond between your dog's tissue and the internal electronics. The dog's body, acting as an antenna, relays the control signals to the tantalum electrodes. The signal is amplified and sent on to the decoder. The decoded signal is then fed to the actuator. Each implanted actuator has its own identification code to prevent interference from say, passing airplanes, garage-door openers, or microwave ovens. Training time can vary depending on your dog's breed and his personality.

If a valid data command is present at the implanted receiver within the dog, the resonator is triggered. The choices of switch function available to the operator on the handheld transmitter are: volume up, volume down, on/off, and mute. The use of these is arbitrary, depending on how you want to train your dog. You might want to press mute when company comes over and Rex persists in barking even after you have exiled him to the basement. This feature also permits you to carry on a phone conversation when the door bell or chimes sound or the buzzer goes off on your clothes dryer.

Figure 5 is the schematic for the transmitter capable of triggering the Dog Trainer at distances up to 50 feet. By tying the actuator's nine inputs pins to a high, low, or open, the signal may encode or allocate 3×10^9 or 19,683 different codes. This signal is then transmitted serially. The on-chip re-

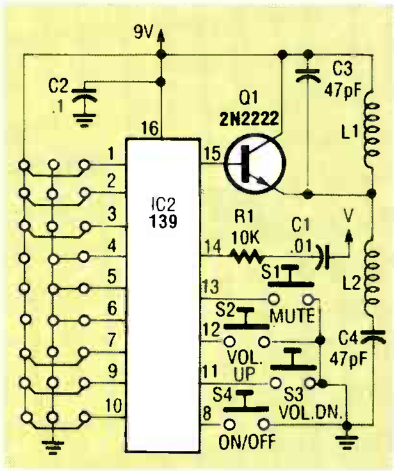


FIG. 5—SCHEMATIC OF REMOTE RF transmitter sends coded signal to implanted actuator package in dog up to 50 feet away. Jumpers to power bus indicate high; those to ground bus indicate low. Coding shown is 111000111.

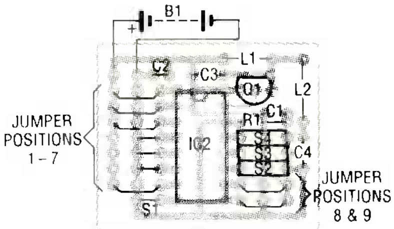


FIG. 6—PARTS PLACEMENT. Mount and solder all components as shown here. Note that jumper locations set code.

sistance-capacitance oscillator eliminates the need for crystals to control frequency. The transmitter circuit can be built in one evening and put to use within hours after that.

If you don't purchase the full kit, start construction by etching and then drilling your PC board. The full size foil pattern is shown. Use the parts placement illustration, Fig. 6. Solder the DIP socket in place first, followed by IC2, noting pin arrangement. L2 is a hand-wound antenna. Wrap a 22-gauge insulated solid copper wire tightly around a 1/8" drill bit nine times, strip its ends and solder it flush to the PC board. The remaining components can now be soldered in place. Resistor R1 and connector C1 connect to IC2's oscillator output pin 14. The resistor-capacitor network precisely controls the frequency transmitted.

PARTS LIST

All resistors are 1/4-watt, 5%.
R1—10,000 ohms
Capacitors. All are 50 volts DC, 10% tolerance , mono or ceramic disk unless otherwise indicated.
C1—0.01µF 5%
C2—0.1µF
C3,C4—47pF ceramic disc
Semiconductors
IC1—AF311992 receiver-decoder-resonator
IC2—AP139F encoder-transmitter chipEP Q1—2N2222 NPN transistor
Other components
L1—0.05 uH fixed inductor (Inductrix no.319-02 or equivalent)
L2—antenna (hand wound, see text)
SW1-4—miniature SPST-NO momentary pushbutton switch
B1—9-volt alkaline battery
Miscellaneous: PC board, project case (builder's choice), DIP socket, battery holder, hardware as required.
Note: the following items are available from Jack's Electronics Emporium, P.O. Box 4079, Farmingdale, NY 11735
- **PC board only—13.50 + 3.50 S&H.**
- **A complete kit of parts including receiver-decoder- resonator, PC board, all components, machined plastic case —$1992.00 + 3.00 S&H.**
- **An assembled and tested transmitter—$992.00 + $3.00 S&H.**

Send check or money order. New York residents add 8% sales tax. Allow 6-8 weeks for delivery.

The identification code must be set to match the transmitter to the receiver. IC2's pins, 1 through 7 and 8 and 9 are the input bits controlling your ID code. The number on the label of the shipping bag for the syringe is the data ID code for your specific unit. 111000111 is a sample ID code. This means the first three pins, 1-3, are tied high, with the middle three tied low, and the last three tied high. Don't lose this code. You will need it if you want to build additional transmitters, or order more receiver chips with the same ID.

Once you have assembled the transmitter, take your dog, and the actuator assembly with directions for implanting it to your vet. Wait at least two hours after the implant operation before you test your circuit. You must allow enough time for the tissue to bond to the electrodes.

If the transmitter circuit that you built from a kit does not seem to be working, recheck your work. As with any construction project, check for solder bridges, swapped wires, and poorly soldered connections. The most likely mistake will be improperly placed jumpers determining the code.

In the unlikely instance that your silencer transmitter interferes with your neighbor's TV sets or opens their garage doors and they start to complain, respond by asking them if they would rather have these minor inconveniences or put up with a noisy dog. You could, of course, demand that they change their garage door codes. Most neighbors will understand.

You wouldn't want the transmitter to fail just as you get an important phone call or an unexpected visitor. You'd be reduced to having to scream at your poor dog. So keep a spare 9-volt battery within the enclosure just in case.

Squelching the unwanted barks of man's best friend has now become safe, humane and easy. With a 50-foot range and the user-friendly handheld remote control, we can all sleep better. At least we could if it wasn't April 1st. **APR-1**

Let's build Digi-Call and put it in operation.

THOMAS E. BLACK

LAST TIME WE DISCUSSED CIRCUIT theory behind Digi-Call, the automatic digital telephone call logger. Digi-Call gives you an automated way of tracking all incoming and outgoing calls. This time, let's build the unit, and get it up and running.

Construction

The circuit should be assembled using a printed-circuit board; foil patterns are provided here to make your own, or you can buy the double-sided, etched, drilled, and silk-screened board from the author (see the parts list). Use care in handling the IC's, and socket all of them, especially the EPROM (IC4).

If it becomes necessary to substitute parts, use only ones that you know are exact replacements of those listed. In particular, the realtime clock (IC11, an MC146818A) must be an "A" revision device. Also, when selecting parts for the telephone interface, note that low-leakage components are necessary. The AC supply must be a wall-transformer type that does *not* include a ground connection.

As we mentioned last month, two different DTMF decoders can be used for IC2, and the PC board supports both. If you look at Fig. 6, you can see that IC2 is shown twice in a dashed outline with an asterisk, along with C7, R15, and XTAL1. One location is for a 16-pin 75T202 and the other is for a 14-pin 75T204. Both decoders perform equivalently, so use only one, of whichever is available, and install C7, R15, and XTAL1 inside the corresponding dashed outline.

Mount all components as shown in Fig. 6, and check your work carefully, looking for solder bridges and open traces.

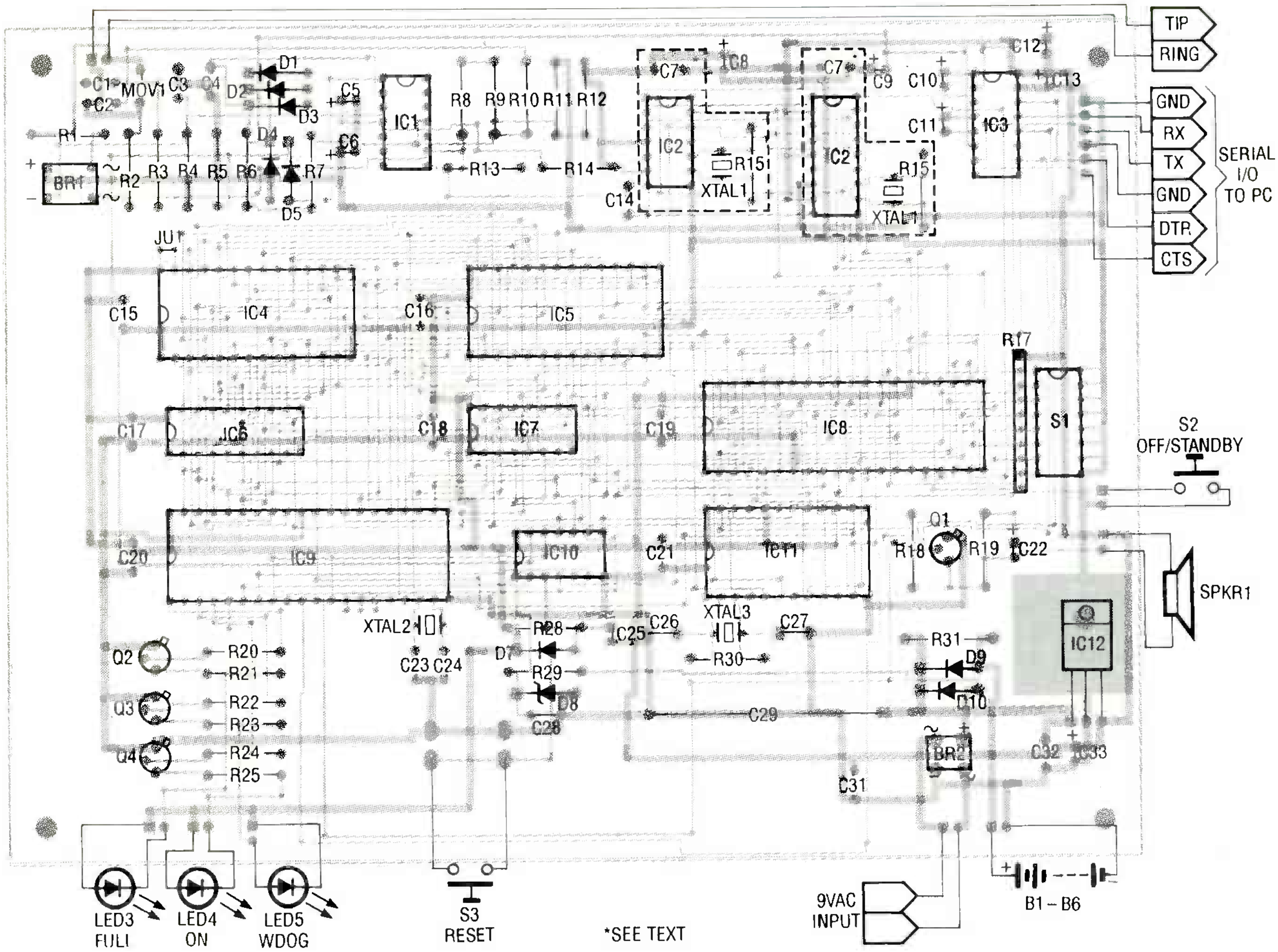


FIG. 6—MOUNT ALL COMPONENTS as shown here. Note that the PC board has two locations for IC2: one for a 16-pin 75T202 and one for a 14-pin 75T204. Use either the 14- or 16-pin IC2 position, depending on which chip you use, and install C7, R15, and XTAL1 inside the corresponding dashed outline.

Mount and label LED3 (FULL), LED4 (ON) and S2 (ON/STANDBY) on the front panel of your enclosure, and mount the speaker behind a vented grill.

Cable connections can be hard-wired or made using header connectors (recommended). The "tip" input (T) of the line interface goes to the red wire of the telephone line cord, and the "ring" input (R) goes to the green wire. Connect the "+" and "−" leads of the battery connector to a six-cell AA Ni-Cd battery holder. Wire the wall transformer to the "AC" inputs. Last, connect the DB25 connector to P1 as shown in Table 4. Figure 7 shows the completed prototype.

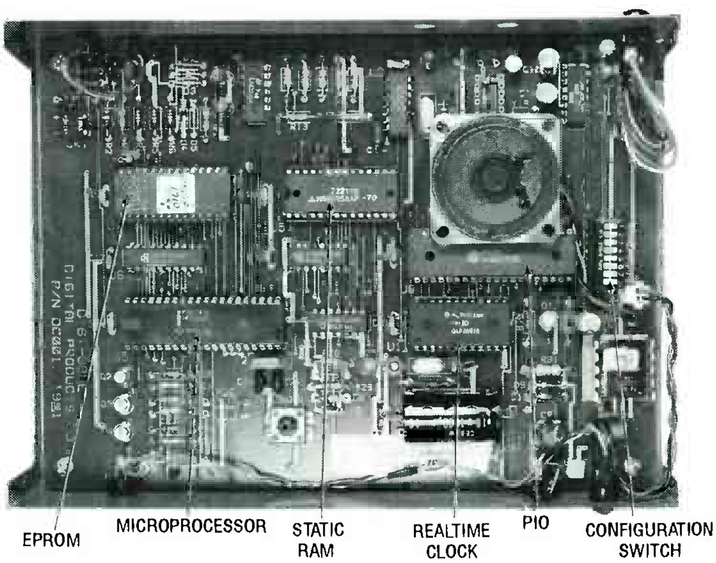


FIG. 7—CABLE CONNECTIONS can be hard-wired or made using header connectors. Here's the completed prototype.

Check-out and power-up

Note: If troubleshooting is necessary, you must use AC-iso-

lated test equipment. Line-powered oscilloscopes, DVM's, etc., must be ungrounded. The author recommends use of an isolation transformer for safety. Failure to do so will cause incorrect operation of the line interface circuit.

Check all solder connections for shorts and opens, and all polarized components for correct orientation before powering up the unit. If any of the following tests do not perform as specified, then you must correct the problem before continuing.

Disconnect the phone cord if Digi-Call is plugged in. Apply AC power, and push and hold S3 (RESET). Verify that LED3, LED4, and LED5 light up. Release S3 and observe the following actions during power-up:

- LED5 (W-DOG) is off (interrupts off).
- LED3 (FULL) and LED4 (ON) blink for 1–2 seconds (CPU initialization complete).
- Four sharp beeps sound (peripheral initialization complete).
- LED3 (FULL) on for 2–3 seconds (POST self-test running).
- LED3 (FULL) off, LED4 (ON) on for 1 second (RTC RAM OK).
- LED5 (W-DOG) blinks, LED3 (FULL) and LED4 (ON) off (interrupts on, unit ready).

Remove AC power and install the six Ni-Cd batteries. Repeat the power-up reset test. The LED's should behave as before except that LED5 (W-DOG) will blink at a faster rate. Leave the batteries in place, restore AC power, and reset. W-DOG will again blink slowly.

Push S2 (ON/STANDBY) several times and verify that LED4 (ON) goes on and off and that Digi-Call beeps. Leave Digi-Call in Standby mode (LED4 not illuminated). The power-up tests are now complete.

Operation

The first thing to do is to set the configuration options, shown in Table 5. For testing, set all options "on." If you are using Digi-Call with a slow PC, you may have to set S1-a to the 2400-baud setting (off). Be aware that configuration switch settings are read only at power up and reset.

The host software consists of three files: the main program (DC.EXE); the help support file (DC.HLP); and the configuration file (DC.CFG). The files are available from the author, as mentioned in the parts list, as well as from the RE-BBS (516-293-2283, 1200/2400, 8N1), compressed and combined into a single self-extracting archive file called DIGICALL.EXE. That file also contains a binary image of the EPROM software, in case you want to program your own.

Create a directory on your hard disk and copy to it the files from the distribution disk. If you downloaded the software, copy DIGICALL.EXE to that directory, and run the program. It will extract the files from the archive and decompress them. Then you can delete DIGICALL.EXE, although you may want to maintain a backup copy of it.

Change to the directory with the Digi-Call files, and execute the host program as follows:

```
DC /option1 /option2 /option3 . . .
```

Options are shown in Table 6, but normally they are not required. Some options will override configuration settings, discussed below.

With the host program running, activate the menu bar by pressing Esc; the screen should appear as shown in Fig. 8. Use the left and right cursor keys to select a menu, then press Enter.

TABLE 4—SERIAL I/O CONNECTIONS

Function	J1 Pin No.	DB-25 Pin No.
RXD	2	2
TXD	3	3
GND	4	7
DTR	5	5/6
CTS	6	20

TABLE 5—CONFIGURATION SWITCH SETTINGS

Position	Function	On	Off
1	Baud rate	9600	2400
2	Not used		
3	Not used		
4	Not used		
5	Record	Incoming and outgoing calls	Outgoing calls only
6	Record	Rotary and DTMF digits	DTMF only
7	Bell	On	Off
8	Reminder chime	On Off	

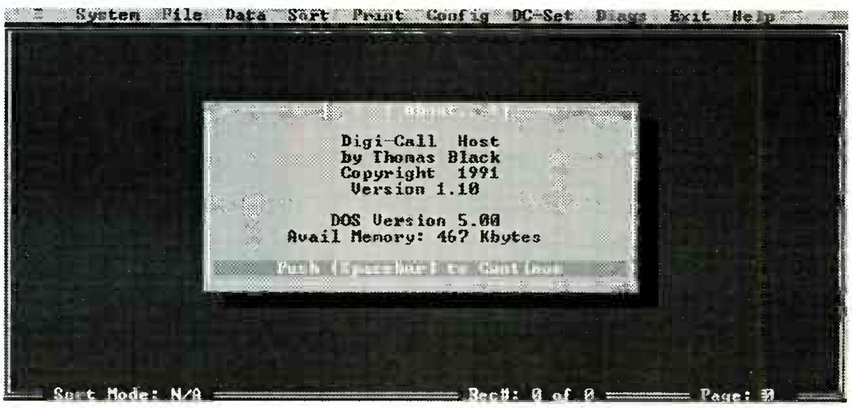


FIG. 8—DIGI-CALL'S PC-BASED HOST SOFTWARE is shown here. Activate the menu bar by pressing Esc, use the cursor keys to highlight the desired function, then press Enter to execute it. On-line help is available for all functions.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted
R1, R2—100,000 ohms
R3, R10, R13—470,000 ohms
R4–R6—22,000 ohms
R7, R14—470 ohms
R8—56,000 ohms
R9, R11, R12, R28—47,000 ohms
R15—1 megohm
R21, R23, R25—220 ohms
R16, R26, R27—not used
R17—10,000 ohms
R18, R29—1000 ohms
R19—100 ohms
R20, R22, R24—10,000 ohms
R30—10 megohms
R31—470 ohms, ½ watt

Capacitors
C1, C2—0.001 µF, 100 volts, polyester, radial lead
C3, C14—0.01 µF, 100 volts, polyester, radial lead
C4, C7, C15–C21, C28, C31, C32—0.1 µF, 50 volts, monolithic, radial lead
C5, C6, C8–C13, C22, C25, C33—10 µF, 16 volts, electrolytic, radial lead
C23, C24, C27—27 pF, 100 volts, ceramic
C26—5–35 pF, variable, top adjust, 5 mm, PCB mount
C29—1000 µF, 16 volts, electrolytic, axial lead
C30—not used

Semiconductors
BR1—DB103, 200 volts, 1 amp, bridge rectifier, DIP package
BR2—W005M, 50 volts, 1 amp, bridge rectifier
LED1, LED2—Not used
LED3, LED5—LED, red, T-1¾
LED4—LED, green, T-1¾
D1–D7—1N4148 or 1N914 diode
D6—not used
D8—1N4732A, 4.7 volts, 1 watt, Zener diode
D9, D10—1N4001 diode
Q1–Q4—2N2222 transistor
IC1—LM324, low-power op-amp
IC2—75T204 (SSI204) or 75T202 (SSI202) DTMF decoder (see text)
IC3—MAX232 or ICL232, 5-volt RS-232 driver
IC4—27C64-2, 8K CMOS EPROM
IC5—M5M5256A or HM62256LP-15, 32K × 8 static RAM
IC6—74HCT373, CMOS 8-bit latch
IC7—74HCT138, CMOS 3-to-8 line decoder
IC8—82C55A, CMOS peripheral interface
IC9—80C31 or 80C32, CMOS microprocessor
IC10—74HCT14, CMOS hex inverter
IC11—MC146818A, realtime clock with RAM (see text)
IC12—LM2940T, 5 volts, 1 amp, low-power regulator

Other Components
B1—6 NI-Cd AA Cells, 400–600 mAH
P1—6-pin, 0.1" header connector
SPKR1—8-ohms, 1½"
S1—8-position DIP switch
S2—SPST, normally open, momentary, PC board mount
S3—SPST, normally open, momentary, panel mount
XTAL1—3.58 MHz, HC-18
XTAL2—11.0592 MHz, HC-18
XTAL3—4.194 MHz, HC-18
MOV1—ERZ-C07DK201U, 130 volts, 400 amps, ZNR surge suppressor
Miscellaneous: 6-cell AA battery holder, TO-220 heatsink, wall transformer (8–9 VAC, 300–1000 mA), PC board, IC sockets, enclosure (8.25 × 6.25 × 2), modular telephone line cord, assembly hardware, software.
Note: The following parts are available from Digital Products Company, Attn: Thomas E. Black, 134 Windstar Circle, Folsom, CA 95630: Complete kit of PC-board and parts without enclosure, $169.95; printed circuit board #DC001, $42.50; 75T204 DTMF decoder $14.50, programmed EPROM, $16.50, software on disk (5.25" only), $7.50. All orders add $3.75 S&H. CA residents add CA tax. U.S. funds only, no foreign shipments. Personal and business checks allow 3–4 weeks. No COD's or bank cards accepted. Prices subject to change.

Use the up and down cursor keys to select an item, and press Enter to execute it. If you need help on any function, highlight it and press F1.

To customize DC.EXE to your environment, enter the Config menu and execute each menu item. Be sure to save the changes when you are done: DC.CFG will be updated. You must select the correct COM port and match the baud rate in the configuration program to that set on S1.

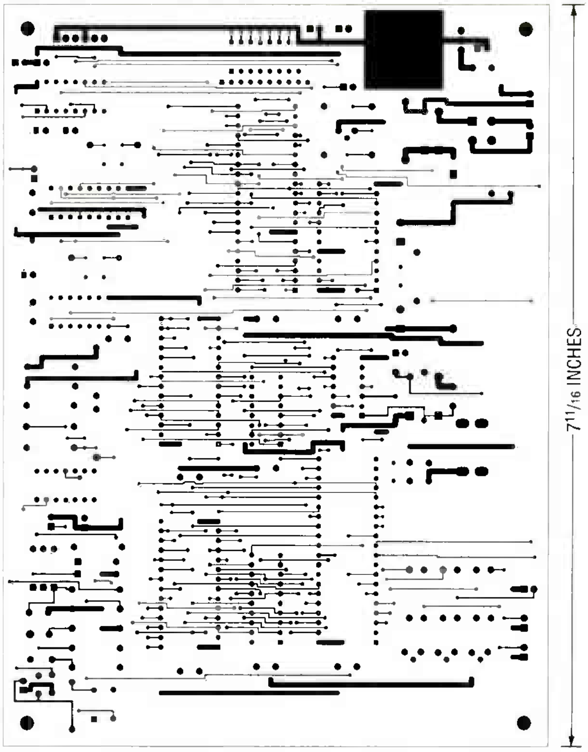
Now connect your PC to Digi-Call, enter the Diags menu and select Test. The Digi-Call hardware will be tested, and any errors will be reported. The expected response is as follows:
- Digi-Call 32K Ram : Checks Ok
- Digi-Call Clock : Not Set
- Digi-Call RTC Ram : Checks Ok
- Digi-Call Power is : AC Power

Return to the main menu bar. Enter the DC-Set menu and select Time Entry. Use the Set or Auto Time feature to update Digi-Call's on-board clock. Repeat the Diags Test feature and verify that the "Not Set" message disappears.

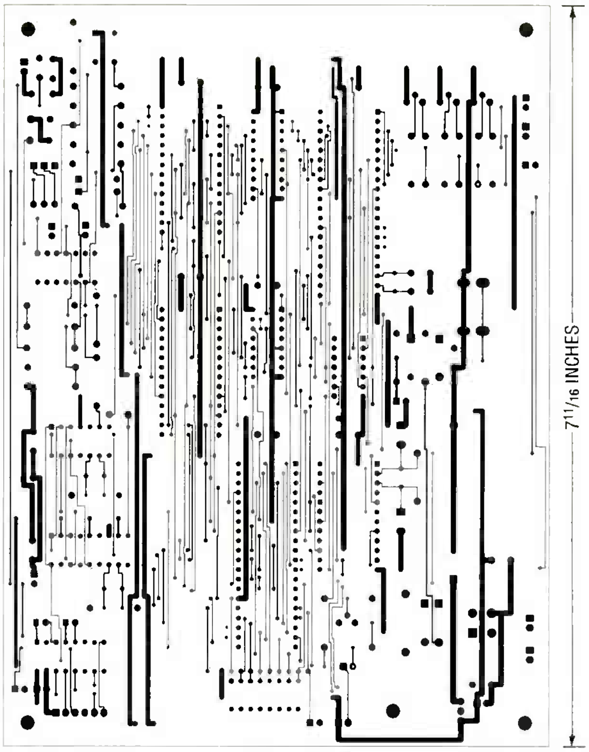
Select the Debug Entry in the Diags menu and verify that the displayed time is incrementing and that the date is correct. Variable capacitor C26 allows you to improve the accuracy of the on-board clock. Adjustment should be performed in small increments over a number of days. Monitor the effects of an adjustment by waiting at least 48 hours and checking the reported time; readjust the capacitor if necessary.

While still viewing the Debug menu, verify that the current status values are as follows (ignore the other data entries):
- Total Call Count : 0000
- Outgoing Calls : 0000
- Incoming Calls : 0000
- Incoming Hangups : 0000
- Next Rec to Write: 0001
- Last Read Record#: 0000
- Records Remaining: 1557
- Max Record Count : 1557

With the phone line still disconnected, push Digi-Call's "On" button and verify that LED4 (ON) illuminates. Temporarily short resistor R4 with a jumper to force the line interface circuit into the active state. (Remember, Digi-Call does not fully operate when directly connected to your PC.) Now plug Digi-Call's modular phone cord into a spare telephone jack.



COMPONENT SIDE FOIL PATTERN SHOWN HALF-SIZE.



SOLDER SIDE FOIL PATTERN SHOWN HALF-SIZE.

Note: Digi-Call will operate only when connected to standard telephone lines; some systems (electronic keysets and PBX's) are not compatible with Digi-Call.

Using a Touch-Tone phone, dial some phone digits and verify that they are echoed in the Dialed Digit entry area of the screen. Rotary (pulse) digits can not be tested in this mode. Remove the jumper lead when the test is complete, and exit the Debug menu.

Disconnect the cable to the host PC and remove all test equipment. Verify that the LED4 blinks when the phone is in use, and lights steadily when it is not.

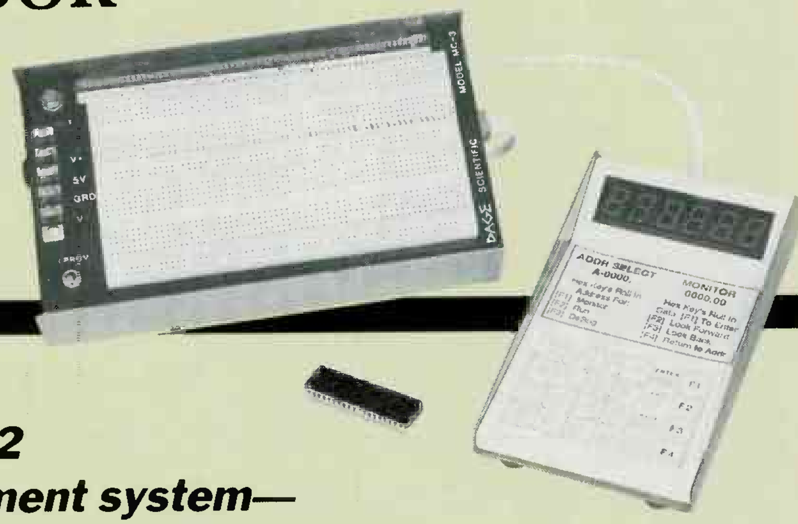
Record several test calls. Digi-Call qualifies phone transactions, so be sure that your test calls use actual phone numbers and that the call lasts at least 15 seconds. Also, record some dummy Account Codes after placing or receiving a call. Press asterisk twice, followed by a four-digit code; be sure to enter the code within five seconds.

Set Digi-Call to Standby and connect it to your PC's serial port. Transfer the logged phone data to the PC by selecting Data from the menu bar, and then selecting Download. After the download completes, you may print the data, save it to a file, or sort it. To clear the current data set execute the Erase function from the Data menu. Digi-Call is now ready to be placed into service. **R-E**

TABLE 6—COMMAND LINE OPTIONS	
/?	Display option summary
/43	43-line EGA, 50-line VGA mode
/B80	Black and white operation (CGA/EGA)
/C80	Color operation (CGA/EGA)
/COMx	Communication port, where x = 1–4
/CMPx	Printer Compress CMD defined by x, a decimal number
/DTOFF	DOS error traps off
/DTON	DOS error trap on
/HLPON	Help mode on
/HLPOFF	Help mode off
/LPTx	Printer port, where x = 1–4
/M80	Monochrome mode (MDA or Hercules)
/PGSZx	Printer page length, x = decimal number
/R80	80-column printed reports
/R132	132-column printed reports
/SOFF	PC sound off
/VB	Use video BIOS (non-compatible PC's only)

Built it yourself . . . I'll plug it in later

BUILD THIS MICROPROCESSOR DEVELOPMENT SYSTEM



DAVE DAGE

Build this intelligent 1802 microprocessor development system—for a lot less than the cost of a new Porsche!

SURE, HARDWARE IS FUN, BUT IT'S software that makes hardware dance—literally, if it happens to be a robot.

But designing with microprocessors is difficult. Typically, the first thing you need for a custom design is an operating system, but you can't write an operating system without already having one. Of course, microprocessor vendors are more than willing to help; they'll be more than happy to set you up with a development system for a little less than the cost of a new Porsche. If for some reason that's not satisfactory, read on.

Features

This project is a stand-alone microprocessor-based controller that is suitable for both training and development. It consists of two units. The main unit contains an 1802 microprocessor, sockets for as much as 64K of RAM and EPROM, an EPROM burner, serial and parallel I/O, and a solderless breadboard area. A separate keypad/display unit, which connects to the main unit via a six-conductor telephone cable, allows you to enter and view programs and data. When your design is complete, you can disconnect the keypad/display unit, leaving the computer to perform a dedicated function.

The EPROM-based operating system contains a monitor program to view and alter memory, load and run programs, and insert breakpoints for debugging. (When an executing program hits a breakpoint, it stops and returns control to the monitor, at which point you can view and alter the microprocessor's internal registers and external memory, and then continue running.)

Programs under development can be stored in an EPROM using a software "move" utility and the built-in EPROM programing capabilities. You activate the EPROM programmer simply by flipping a front-panel switch.

Together, the main and keypad/display units require about 700 mA of 5-volt DC power. EPROM programming requires a higher voltage (12.5 or 21), depending on the type of EPROM used.

Partial and complete kits of parts are available; a complete system using all new parts can be assembled for less than $200.

How it works

Figure 1 shows a block diagram of the circuit, which consists of three main sections: the main board, the EPROM board, and the keypad/display board. The main board holds the microprocessor, decoding logic, RAM and EPROM memory, and the serial and parallel I/O ports. Decoder IC23 divides the 1802's 64K address space into four 16K blocks (IC19–IC22). Another set of decoders (not shown) decode 48 bits of latched inputs (IC2–IC7) and 48 bits of latched outputs (IC8–IC13).

An 8-bit shift register (IC17) provides a clocked serial interface to the keypad/display unit, which itself uses latched shift registers to read key presses and display data on the six seven-segment LED's.

The EPROM board works by inserting a 50-ms delay any time the microprocessor attempts to write to IC20. If the proper programming voltage (V_{PP}) appears at pin 1 of IC20, the corresponding value will be written to the selected address in the EPROM. Switch S2 determines whether V_{CC} or V_{PP} is applied to the EPROM. The value of V_{PP} will depend on the type of EPROM used, generally either 12.5- or 21-volts DC.

Now let's discuss each section in detail.

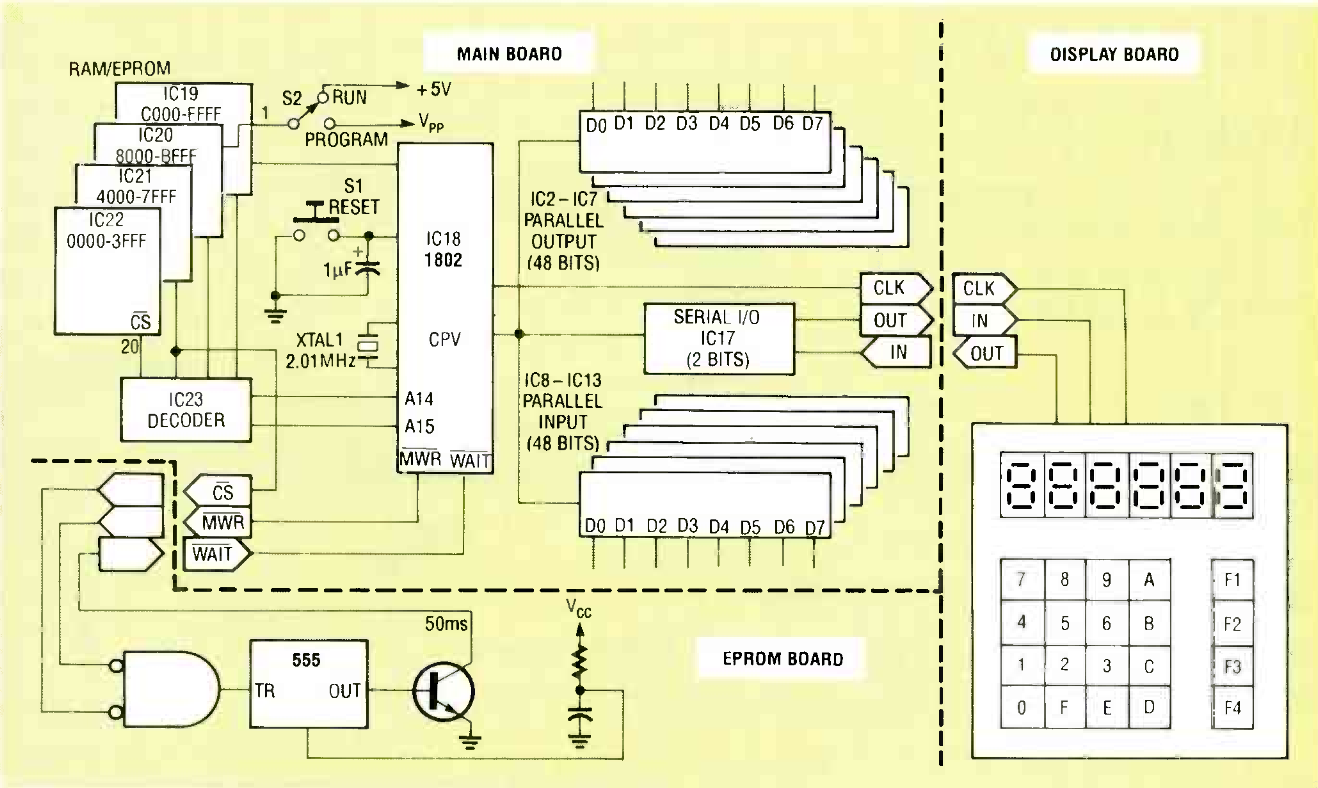


FIG. 1—BLOCK DIAGRAM shows the three major sections of the circuit: the main board, the keypad/display board, and the EPROM board.

Main board

Due to the size of the schematic, the main-board circuit diagram is shown in two parts, Fig. 2, and Fig. 3. The CPU, memory, and associated decoding circuitry is shown in Fig. 2, and the serial and parallel I/O and associated decoding circuitry is shown in Fig. 3. Refer to the appropriate diagram as necessary in the descriptions that follow.

Although the 1802 has a 16-bit address bus, it multiplexes them onto eight lines. First the 1802 places the high-order address lines (A8–A15) on the bus.

PARTS LIST—MAIN BOARD

All resistors are ¼-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, ⅛ watt

Capacitors

C1—1 µF, 35 volts, tantalum
C2, C3—20 pF, ceramic
C4—10 µF, 25 volts, tantalum
C5, C6—0.1 µF, 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 × 0.75"
J1—6-conductor telephone jack

PARTS LIST—KEYPAD/DISPLAY BOARD

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

R1–R20—51,000 ohms, ⅛-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, pushbutton, PC mount

PARTS LIST—EPROM BOARD

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

R1, R4—22 megohms
R2—47,000 ohms
R3—100,000 ohms

Capacitors

C1—0.001 µF, Mylar
C2—100 pF, ceramic
C3—0.001 µF, Mylar
C4—0.02 µF, 5%, Mylar
C5—0.1 µF, 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.

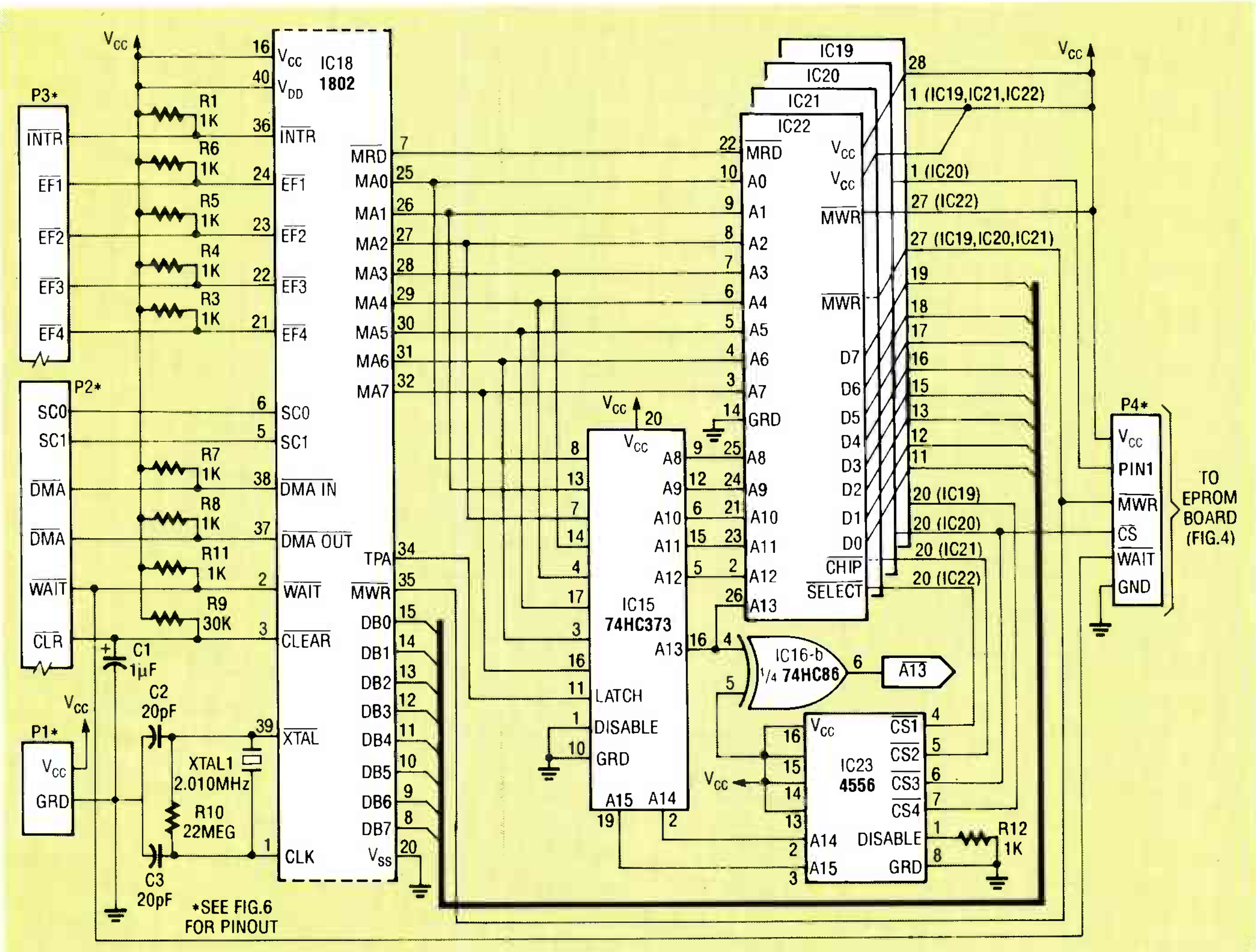


FIG. 2—THE MEMORY DECODING PORTION OF THE CIRCUIT: Note the different connections to pins 1 and pins 27 of IC19–IC22. Pins 1 of IC19, IC21, and IC22 are tied to V_{CC}. Pin 1 of IC20 (the EPROM programming socket) goes to P4, which routes it to the EPROM board (Fig. 4) and then to programming-voltage selector switch S2. Figure 6 details the wiring.

Then, on the trailing edge of TIMING PULSE A (TPA), IC15 latches those values, and the 1802 places the low-order bits (A0–A7) on the bus. After a short settling time, the full 16-bit address bus remains stable for address decoding.

As mentioned earlier, IC23 divides the 64K address space into four equal chunks. After power-up or reset, the CPU begins execution at address 0000, so the lowest address must be filled by EPROM. The other three memory blocks accept either RAM or EPROM.

With an arrangement of 16K × 8, the 27128 is ideal for a boot EPROM; the 2764 (8K × 8) will also work. However, if you use a 2764, the upper half of the 16K address space will mirror the lower half.

Static RAM IC's are somewhat unusual in that they are available in 8K × 8 and 32K × 8, but not 16K × 8. Address line A13 of the 1802 selects between the lower and upper 8K slots; A13 drives pin 26 of IC19–IC22. However, pin 26 of a 6264 static RAM (8K) functions as a chip select (CS). Hence a 6264 appears only in the upper half of a 16K slot. To achieve a full 16K of RAM at each position, two 8K devices could be piggybacked, except that pin 26 of one should be connected to A13, which is available at pin 6 of IC16.

The 1802 selects inputs and outputs through 3 lines, N0, N1, and N2. For inputs, IC14 decodes a negative-going pulse at pin 13 (SEL2); for outputs IC1 decodes a positive-going pulse at pin 13 (SEL2). Because N0–N2 are low under normal circumstances (i.e., even when no I/O activity is occurring), the SEL0 outputs of IC1 and IC14 are not used.

Each of the SEL2–SEL7 outputs of IC1 drives a separate LATCH input on IC2–IC7, respectively. IC14's SEL outputs drive IC8–IC13 in like manner.

The software for writing to an I/O port works as follows. For example, to output parallel data through IC2, the CPU executes the software instruction "OUT 2." The CPU places a binary 2 (010) on the I/O select lines N0–N2. The decoder decodes these lines; then TIMING PULSE B (TPB) from the CPU generates a pulse on pin 13 of the decoder, which in turn latches data sitting on the data bus into IC2. (TPB is also available through ex-

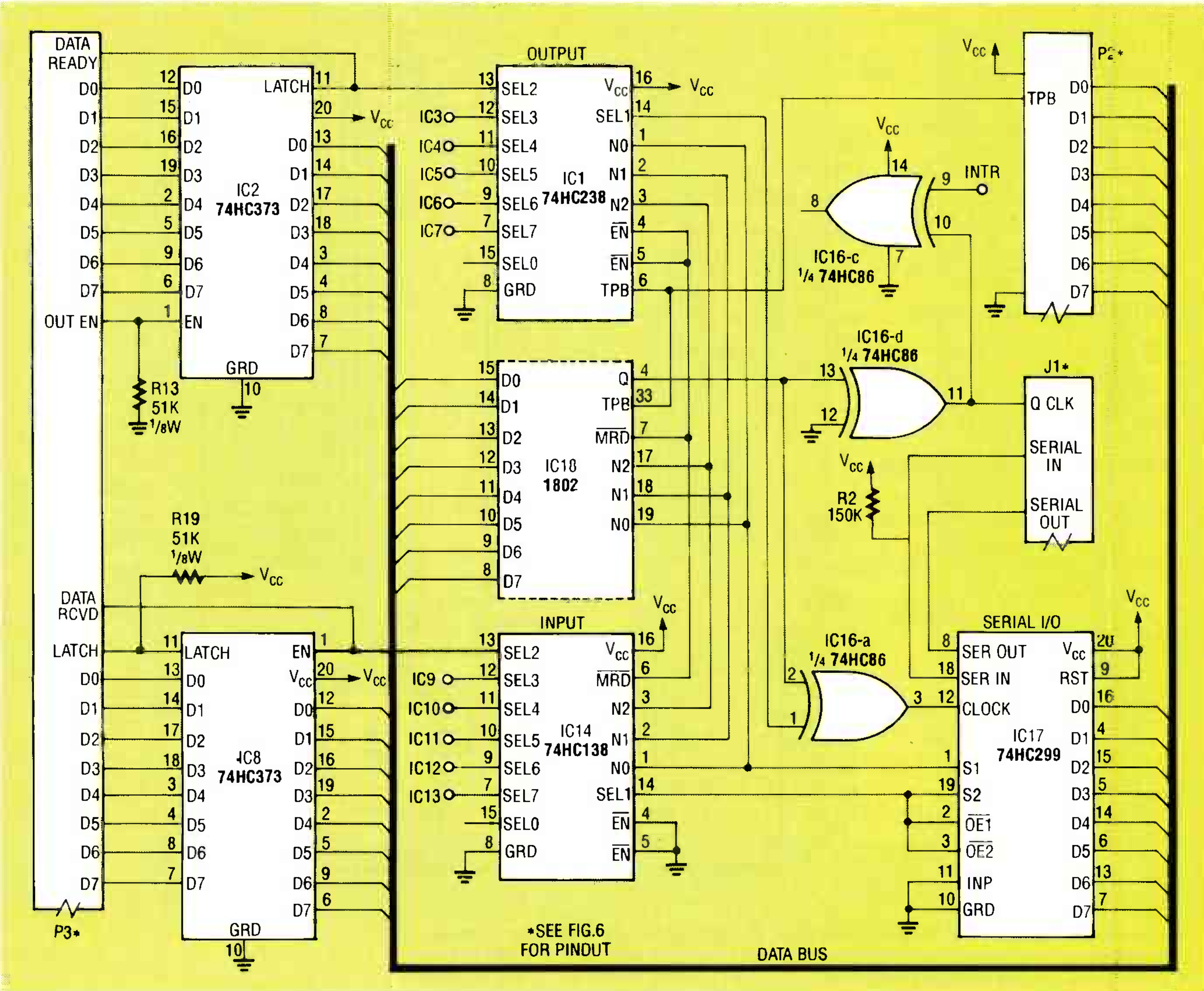


FIG. 3—THE I/O PORTION OF THE CIRCUIT: Note that only one 8-bit output port is shown (IC2 and R13). Each additional port requires another 74HC373 (IC3–IC7) and pull-down resistor (R14–R18). Similarly, only one input port is shown (IC8 and R19); each additional port requires complementary components. The PC board accommodates all IC's and resistors.

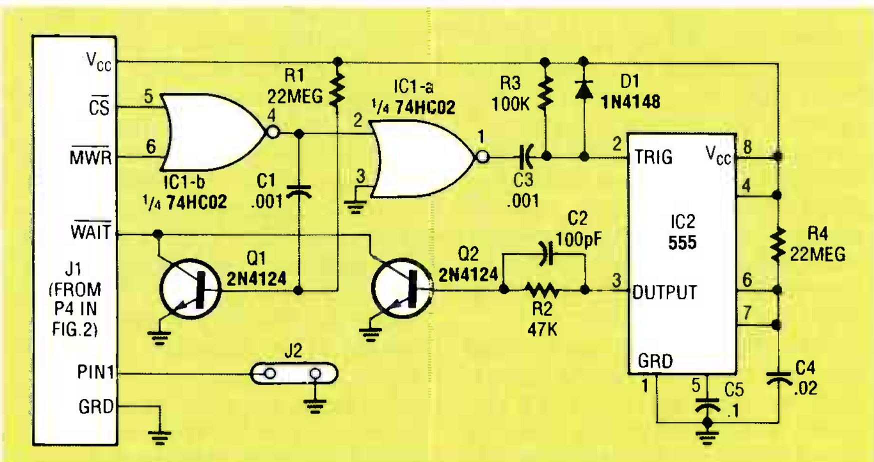


FIG. 4—THE EPROM BOARD serves to increase memory write time by the delay specified by the 555, in this case 50 ms, just right for burning standard EPROM's.

ternal bus connector J3.) IC2 has three-state outputs; they are normally held *on* by pulling $\overline{\text{EN}}$ high through R13.

Reading an I/O port works similarly. For example, to read parallel data through IC8, the CPU executes the software instruction "IN A." Again, a binary 2 (010) appears on the I/O select lines, but this time the CPU's MEMORY READ ($\overline{\text{MRD}}$) line generates a negative-going pulse on pin 13, which in turn enables the input latch, and allows data to appear on the data bus, where the CPU can read it. Both $\overline{\text{MRD}}$ and the latch-enable pulse are available at J3. The latch-

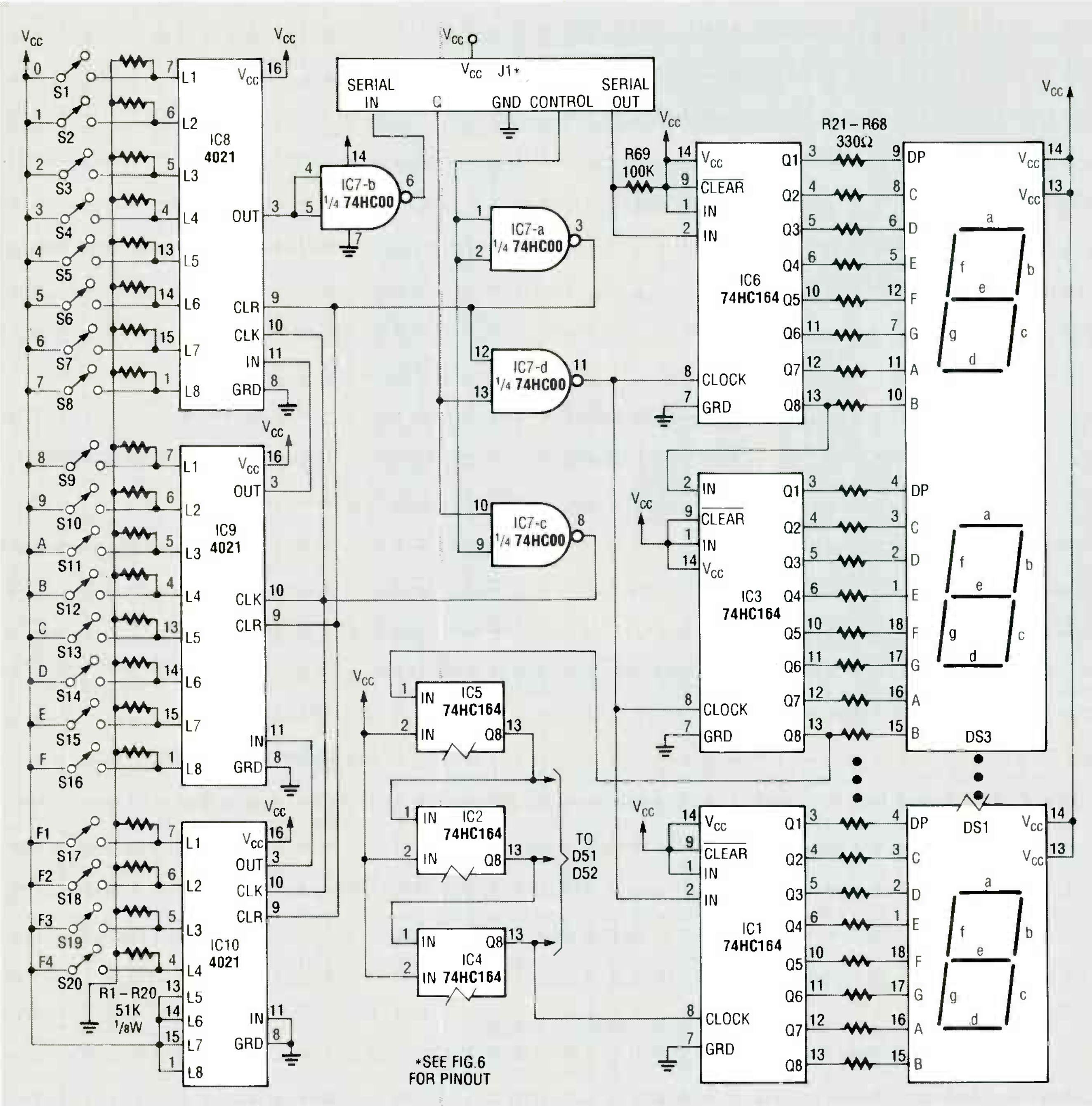


FIG. 5—THE KEYPAD/DISPLAY BOARD consists of an input section (IC8–IC10) and an output section (IC1–IC6). The input section reads the status of 20 SPST momentary switches (S1–S20); the output section drives six seven-segment LED's. For reasons of space, we do not show the output lines of IC2, IC4, and IC5, associated current-limiting resistors, or connections to the LED's for DS2 and half of DS1. However, the hookups parallel those for the other digits.

enable pulse can also be used to signal the external device that data has been received. In addition, R19 normally holds the latch signal (pin 11 of IC8) high, but that signal is also available at J3, should the external circuit require data to be latched at a precise moment.

The serial I/O circuit consists of IC17, an 8-bit three-state universal shift register, and associated gates. The shift register accepts eight bits of parallel data from the CPU and shifts them out one by one, synchronous with the signal that appears at its CLK input. Conversely, IC17 also accepts serial data and deliver them to the CPU in parallel, eight bits at a time.

The CPU drives the CLK input via a special signal called the Q output. (After buffering by IC14-d, that signal also appears on J3.) Bit 1 of parallel port two (pin 14 of IC1) works in conjunction with CLK to control serial I/O. That software-controlled I/O allows serial data to be fed in and out of the computer at about 50,000 bits per second.

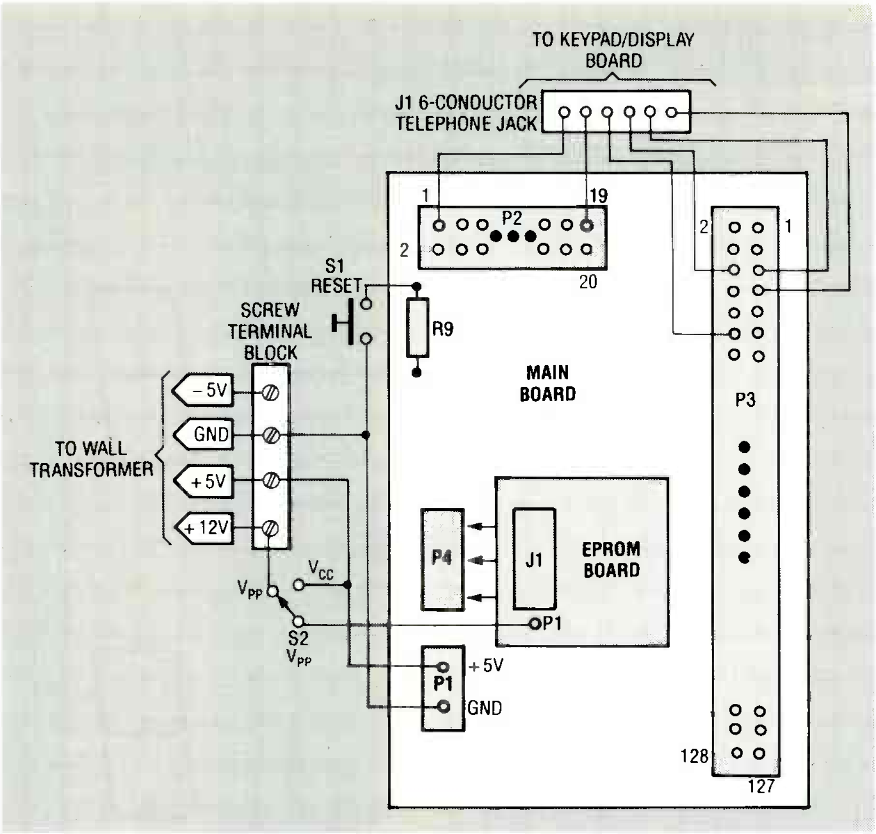


FIG. 6—MAKE SUBASSEMBLY INTERCONNECTIONS as shown here. Next time we'll provide details on pinouts of all connectors.

To output serial data, first bring the control line (DO from output 2) low, and set Q high. Then parallel load the data into IC17 in the same manner as a parallel output to the other latches, this time using the software instruction "OUT 1." Then toggle Q eight times, which causes the shift register to clock the data out.

To read serial data into the CPU, bring the control line (DO from output 2) low then high, thereby latching the data into the external shift registers. This time Q cycles the data from the external shift registers into IC17. The input instruction "IN 9" gates whatever's on the data bus into the CPU.

EPROM board

The circuit for the EPROM board appears in Fig. 4. When the $\overline{CS}$ and $\overline{MWR}$ signals go low, the 555's trigger input drops to ground, followed by the output (pin 3). The output remains low for a time period determined by R4 and C4, in this case, 50 ms. That signal pulls the 1802's $\overline{WAIT}$ line low, which effectively halts all bus activity for 50 ms. Thus programming an EPROM is really nothing more than writing bytes of data to the correct memory locations in IC20. (The author's monitor program provides help in burning EPROM's, which is discussed in "Circuit Operation" below.)

Keypad/display board

The main board outputs serial data to six serial-in/parallel-out shift registers (IC1–IC6), one for each digit in the display (see Fig. 5). Each 7-segment LED display segment illuminates with a low from a shift-register output. This arrangement allows the CPU to control each segment independently, thus allowing formation of both numbers and alpha characters. You can even form words, for example, HELLO, On-OFF, Error, CHOOSE, HELP, Addr. Another advantage of the latched shift registers is that once the display is loaded, it remains in a static condition, hence requires no CPU time.

The keypad circuit consists of three parallel-in/serial-out shift registers (IC8–IC10) and 20 independent SPST momentary-contact switches. All 20 key inputs are tied low through the resistors in the resistor networks; the four extra IC10 inputs are tied to V_{CC}.

When the user presses a key, a shift-register input goes high. When the software reads the serial port, it shifts all three bytes across the data link and into the CPU. The software then eliminates contact bounce and multiple key entries.

The gates in IC7 steer the Q clock to either the keypad or the display circuit, depending on the state of the control input (pin 1 of J1).

Software can sense whether or not the keypad is connected. Referring back to Fig. 3, note that R2 holds the serial input high. If the keypad is connected, one or more of the keypad bytes will have a low bit, due to the presence of the pull-down resistors.

Interconnections

Figure 6 shows how the various subassemblies, connectors, and switches interconnect. Switch S2 applies either +5- or $+V_{PP}$ to the pad labeled P1 on the EPROM board, which in turn routes that voltage through to pin 1 of IC20 on the main board.

The main PC board has four connection areas labeled P1–P4. The +5-volt DC power connects to P1; P2 is an auxiliary connector that provides access to several useful signals. P3 is the I/O connector; it contains 128 pins. P3 brings numerous control signals outside of the chassis for access by breadboard circuitry. Last, P4 is a six-pin 0.1" header that mates with a six pin socket on the EPROM board.

That's all we have space for this time; next time we'll provide construction details and show how to operate this 1802 development system. In the meantime, if you are interested in building our microprocessor development system, you can begin to gather all the parts. R-E

HARDWARE HACKER

Laser printer repairs, sync-separator circuit, GPS navigation update, video interface module, and hacking Super Nintendo!

DON LANCASTER

We will start out with our usual reminder that this is your column and you can get lots of technical help, off-the-wall networking, plus consultant referrals per the box below. Your best calling times are from 8–5 weekdays, mountain standard time.

But please, before you call, make sure that the answer isn't already in the text or in the *Names and Numbers* or in our occasional special resource sidebars. And please have a pencil or pen handy. I just cannot believe the number of calls I get from readers that either refuse to look at or can't find the sidebars.

I am also greatly expanding our informal PostScript *Hardware Hacking Consultants Network*. Send me a letter or give me a call if you wish to participate.

We also have special *Hardware Hacker* and *Midnight Engineering* topics up on *GEnie* PSRT. You could reach me via [SYNERGETICS] e-mail here to get the preprints, reprints, tutorials, and other great downloads in our ongoing experiment in electronic on-demand publishing—and receive late breaking news (especially on PostScript, solar energy, and caller ID) literally as it happens.

We do have lots of information this month on the *Super Nintendo* interface. But first...

A GPS update

We sure had strong reader interest in our GPS navigation story from two columns back, so here is a quickie update:

That GPS, or *Global Positioning Satellite* system includes a flock of roving satellites that broadcast spread spectrum codes on 1227.6 and 1575.2 megahertz. By receiving those signals and digitally processing them, you can obtain your exact position and speed anywhere in the world to an absolute accuracy of a hundred feet or so, and a potential relative accuracy of an inch or less. Thus GPS can be used for long-distance navigation *and* for accurate surveying.

The horse's mouth key paper you need is known as the ICD-GPS-200 document and is obtainable at no charge to U.S. citizens through *Space Systems Division/MZEE*. You must send them a letter stating your name and purpose.

A great $12 Dan Doberstein reprint titled *A GPS Data Receiver* is newly available through *DKD Instruments*. It includes an excellent tutorial on GPS, full construction details on his ham radio-style GPS receiver, and an extensive bibliography. The receiver is both data-only and an older analog design. While specifically designed with hardware hacking in mind, this receiver is definitely not a "shake the box" project. You'll need microwave, digital logic, RF design, and software skills to successfully complete it. Your costs are also likely to be very much higher than by using a modern digital chip set as well.

Good navigation technical papers often appear in the *Journal of the Institute of Navigation*. Those folks also have a new three-volume *GPS Resource File* available for $50.

The prices of the commercial GPS receivers are literally in free fall, and I'd expect a $35 chip set and a $79.95 system within five years. Today's best offer in a high-quality receiver useful for trucking companies and such appears to be the GPS-1 from *Loyola Enterprises*. The current list price is $795 plus software.

Note that all the GPS signals are right on top of each other and deeply buried in background noise, so any old surplus microwave receiver tuned to the GPS frequencies will show you nothing useful at all. Special digital *despreading* circuits *must* get built into your receiver.

I'll try to work up a tutorial on GPS in a future column. But I think I'd better first do some background stuff on the very fundamentals of digital correlation and spread spectrum communications. Whenever.

Video sync separation

Another popular helpline topic is video interface. And the number-one ongoing request is for a simple and effective sync separator. The *sync separation* process lets you take the normal composite video signal and extract those horizontal and vertical synchronizing pulses from it.

The most obvious use for a sync separation is to let you clearly view video signals on your oscilloscope. Without a field or frame reference, all you will see is a blur. Other uses for sync separation involve stripping closed captioning or other data off specific horizontal lines present during vertical retrace, grabbing stock quotes, inserting windows, pattern generators, title overlays, wiping and fades, color keying, and other special effects. Or simply adding a pair of crosshairs.

Figure 1 shows you a simple and low-cost circuit I've worked up that

NEED HELP?

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

can combine both an effective sync separator and a low-cost universal video interface card. The key chip is the *National* LM1881 sync separator mini-dip. You take your usual one to two-volt positive-going *sync = ground* video signal and capacitor couple it to pin 2. The chip extracts the composite video and produces the active-low TTL/CMOS-compatible composite sync output on pin 1.

Several other pins on the LM1881 provide other functions that you may find handy. Pin 3 gives you a vertical sync reference as one single pulse without the usual teeth or serrations. This is the one you will usually want to lock your scope to. Pin 5 is a burst gate that gives you a slightly delayed horizontal sync pulse that can be used to extract any NTSC chroma burst information from the signal.

An RC network found on pin 6 is intended to create a default vertical sync in the absence of a true NTSC video input. This is handy for the "almost" NTSC common to the computers and video games. The time constant can be shortened for higher scan rates; see National's data sheet for details.

Finally, pin 7 lets you pick out the odd and even fields of an interlaced NTSC frame. The output is active only when the input composite video has a full interlace. Advanced color editing is one possible use.

An external source of the usual five-volts DC is needed. Since the current is only seven milliamperes, just about any old supply will do. As usual, keep the power bypass capacitors real close to your chips.

Several other features on the circuit are handy for special video interface cables. The three large capacitors let you couple red, blue, or green video off emitter-follower outputs and then connect them to RGB monitors. A 75-ohm resistor is handy for terminating cables. And a logical high signal is useful for such things as enabling the sound on certain receiver/monitors.

By itself, the inverter is handy for converting active-low sync into active-high and vice versa. While most of the video systems use active-low sync, *Commodore* and one or two of the others might not.

The printed circuit layout is shown in Fig. 2. Empty boards, kits, tested circuits, and both stock and custom interface cables are available from *Redmond Cable*. You can call or write them for a current price list. I'll also post this layout on *GEnie* PSRT so you can easily create your own accurate version without the need for any photographic work. See HACKFG51.PS.

You might want to keep some empty or partially populated boards on hand to solve special cabling and interface uses. The large runaround

LASER RESOURCES

Black Lightning
RR 1-87 Depot Road
Hartland, VT 05048
(800) BLACK99
CIRCLE 301 ON FREE INFORMATION CARD

GEnie
401 North Washington Street
Rockville, MD 20850
(800) 638-9636
CIRCLE 302 ON FREE INFORMATION CARD

Hewlett-Packard
PO Box 10301
Palo Alto, CA 94303
(415) 857-1501
CIRCLE 303 ON FREE INFORMATION CARD

Lazer Products
12741 East Caley Ave #130
Englewood, CO 80155
(303) 792-5277
CIRCLE 304 ON FREE INFORMATION CARD

Recharger
101 Granite St Suite F
Corona, CA 91719
(714) 359-8570
CIRCLE 305 ON FREE INFORMATION CARD

Don Thompson
23072 Lake Center Dr #100
El Toro, CA 92630
(800) 457-5776
CIRCLE 306 ON FREE INFORMATION CARD

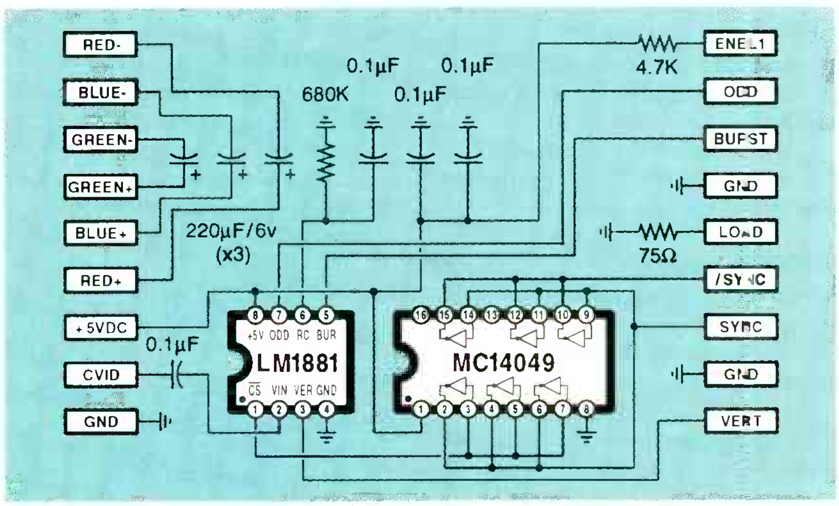


FIG. 1—THIS COMBINATION SYNC STRIPPER and universal video interface can solve a lot of problems for you, including Super-Nintendo-to-anything interfacing, video overlay, and scope TV frame locking. Kits, fully tested units, and custom cable assemblies are available through Redmond Cable.

ground on the outside of the board is especially handy for shielded-cable terminations.

For this month's contest, just tell me about an unusual or off-the-wall use for a sync-stripper circuit. There will be all of those usual *Incredible Secret Money Machine II* book prizes, along with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all. As usual, send your written entries directly to me at *Synergetics*, rather than over to **Radio-Electronics** editorial.

Let's hear from you.

Nintendo interface

As Fig. 3 shows us, there's a *very* interesting *Multi-Out* connector on the back of those *Super Nintendo* game machines. That gives you lots of alternate video and sound output formats that you might find handy.

For instance, you can go to a RGB monitor for sharper images and better colors. Or add total stereo sound or Super VHS improved resolution.

Or you may want to hang any old TV-compatible color monitor plus a pair of headphones on the machine to silence kids and keep them off your main prime-time television set.

Let us see exactly what is on the connector and how to use it. By a special arrangement with *Redmond Cable*, all the connectors, that interface kit, and special and stock cable solutions for most *any* Super Nintendo interface are now available.

The Multi-out connector is really six-over-six edge traces on a double sided circuit board. Looking at the rear, the traces are odd numbered 1,3,5,7,9,11 on the top, going right to left. And the similar pins are even numbered 2,4,6,8,10,12 on the bottom, again going from right to left.

Both pins 7 and 8 are grounds. The pair make terminating several shielded wires much easier.

A +5-volt DC output is provided on pin 10. It appears to be capable of driving at least 50 milliamperes. But you shouldn't suck the poor machine dry, and you should very carefully bypass and filter any use of the supply.

There are a pair of sound outputs. Pin 11 is your choice of monophonic sound or L+R matrixed stereo. Note that "left" plus "right" equals "both." Pin 12 is L−R matrixed stereo. These signals are capacitor-coupled and are the proper size for your usual audio inputs on a hi-fi receiver or computer monitor.

Note that some computer monitors have a sound capability and some do not. The easiest way to tell is to find an obvious *volume* control located somewhere on the set. No volume control, no sound. Other monitors may need a special pin activated to turn the sound on or off. We'll see an example of this shortly.

All your sound cables should, of course, be shielded.

Sadly, the power levels are far too low to usefully drive a speaker or a pair of headphones. But *Radio Shack* has an interesting beastie that no Hardware Hacker should be without. It is their #227-1008C mini-amplifier and speaker. The L+R output easily drives the mini-amp via a miniature phone plug.

The mini-amp solves the problem of a monitor that has no sound. You can also plug headphones into your mini-amp for any silent running. The mini-amp is powered by your choice of an internal alkaline 9-volt battery or by a plug-in 9-volt DC supply.

Because of the matrix used, you cannot get stereo directly off pins 11 and 12. Instead, you have to *add* the two signals together to get the left channel, and *subtract* the two signals from each other to pick up the right channel. Like so...

$(L+R)+(L-R) = 2L$

and

$(L+R)-(L-R) = 2R$

A stereo dematrix can be done with a quad op-amp or a transformer and four resistors. In theory, you could make use of a CMOS-biased inverter amplifier, but your common-mode supply noise rejection might suffer on the right channel. More details on biased inverter amplifiers appear in my *CMOS Cookbook*.

Let me know if you need any more information on stereo matrix extraction.

There are three different types of video outputs found on the multi-out connector. Plain old grounded sync composite video appears on pin 9. That can be routed to any standard NTSC video input on a monitor, VCR, or television set. Note that a direct video input will often have sharper images and better colors than does entry by way of some channel 3 or 4 modulator. That's because less electronics get in the way and an RF modulation and demodulation can be eliminated.

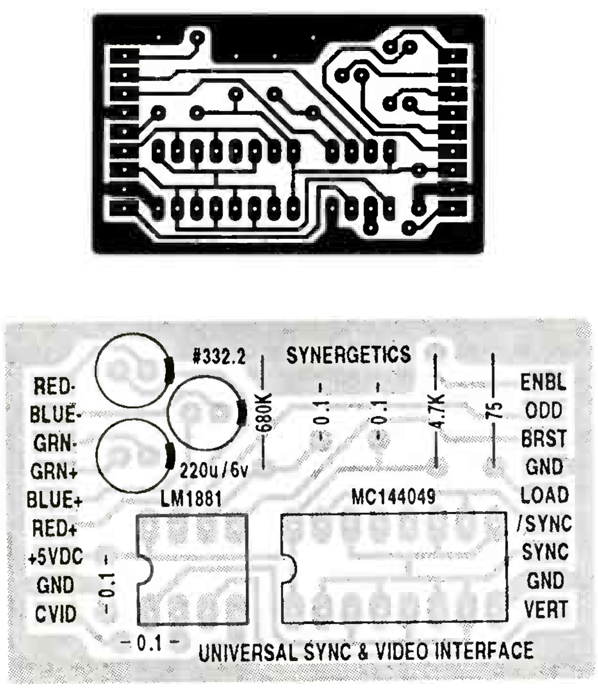


FIG. 2—PRINTED CIRCUIT BOARD LAYOUT and overlay for the universal video interface. Accurate and camera-ready art is also available via GEnie PSRT as file HACKFG51.PS. PostScript downloads can eliminate all darkroom work.

Super VHS, or Y-C video appears on pins 7 and 8 with that luminance "Y" output on pin 7 and the chrominance or "C" output on pin 8. They can be routed to any system which accepts Y-C video. Because of the separation of the color information and the higher bandwidths, these outputs should look far better than regular composite video.

The best video of all, though, is available as a separate red (on pin 1), green (pin 2), and blue (pin 4) video. The red, blue, and green outputs come from emitter followers and have a strong DC bias. They *must* be capacitor coupled to your ultimate destination using a 220-microfarad or higher series capacitor on each line. Be certain to put the (+) side of the capacitor on the Nintendo end.

The needed RGB sync appears on a fourth active-low line on pin 3. The active-low sync is correct for Apple IIGS, Sony, and most "standard" RGB uses. It is the complement of what is needed for *Commodore* and certain others. The line swings rail-to-rail or ground to +5 and thus is both CMOS and TTL-compatible.

Note that some connector plugs do not have all of their pins available, especially for the RGB sync and VHS chroma. The Redmond plugs include all of the pins.

Several interface circuits appear in Fig. 4. In each case, a partially populated Fig. 1 circuit can be used to greatly simplify your cables and interface.

In Fig. 4-*a*, you can connect RGB video to any Apple IIGS monitor by using the three serial video capacitors and the right connector on each end of your cable. Since the IIGS monitor has no speaker, you have to use a hi-fi or the *Radio Shack* mini-amp.

Figure 4-*b* shows an interface to the older *Sony* KV1311-CR receiver/monitor. Again, we have those three serial video capacitors. This time we use an enabling resistor to turn on the internal sound and eliminate any need for a companion amplifier.

The interface to the *Commodore* 1084 color monitor is shown in Fig. 4-*c*. As usual, the red, blue, and green video have to be capacitor coupled to the appropriate pins on the *LinRGB* connector. This time, an active-high sync is needed rather than active-low, so the inverter must get added as shown. While the sound is internal, it has to be routed via a separate audio cable and phono plug that goes into the *Audio* input. The size and position adjustments on the back might also need a slight readjustment.

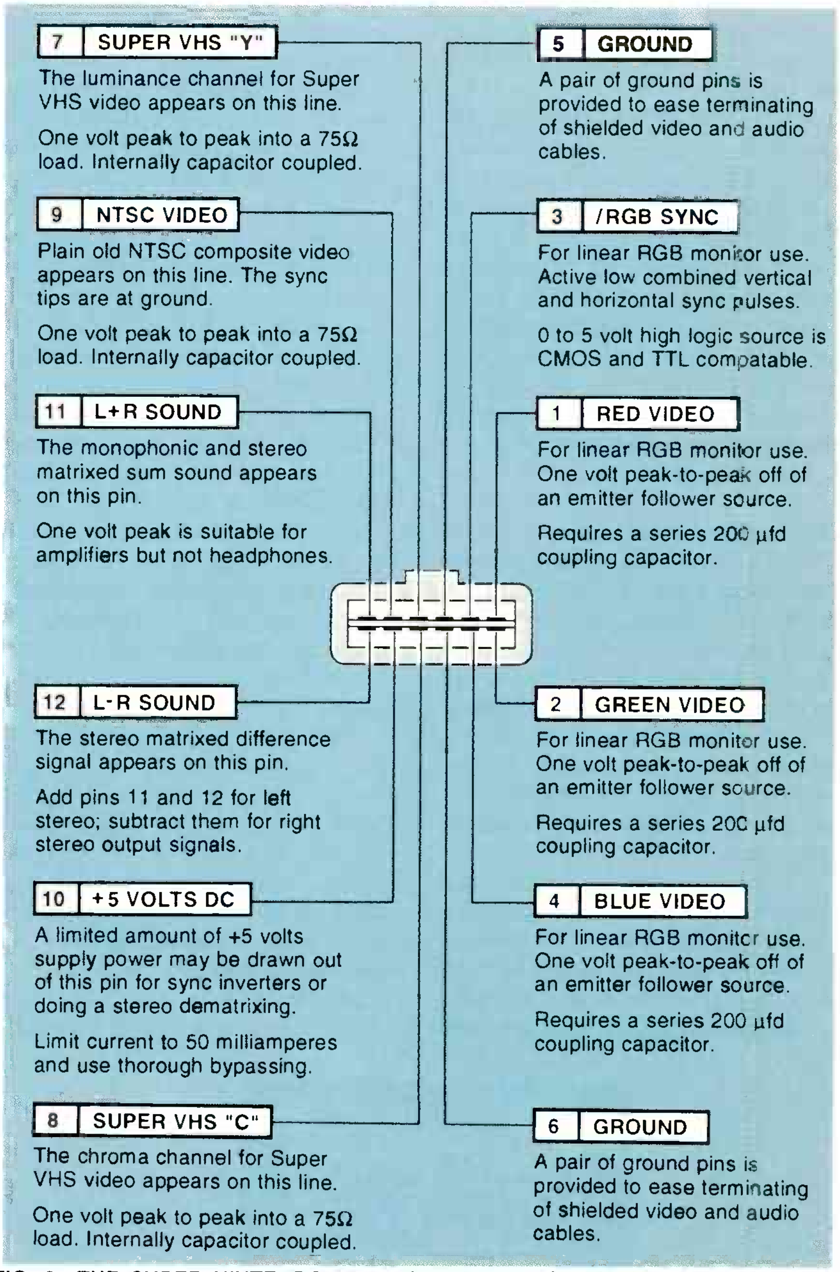


FIG. 3—THE SUPER NINTENDO MULTI-OUT REAR CONNECTOR has all sorts of useful video and audio options available. Here are the key details.

Yes, we are working on VGA and multi-sync solutions. Stay tuned or check *GEnie* PSRT for availability.

Once again, some mix-and-match kits, all-pin connectors, parts, and cables are available from *Redmond Cable*. Do let me know which other interface circuits you would like to see worked out.

Laser printer repair

Where can you go to get training, parts, and information on today's laser printers? Many of the printer manufacturers are super secretive and go far out of their way to prevent you from getting the parts and materials you need to make best use your printer and to keep it alive cheaply. So, for this month's resource sidebar, I thought we'd gather together some of the best of the laser repair resources.

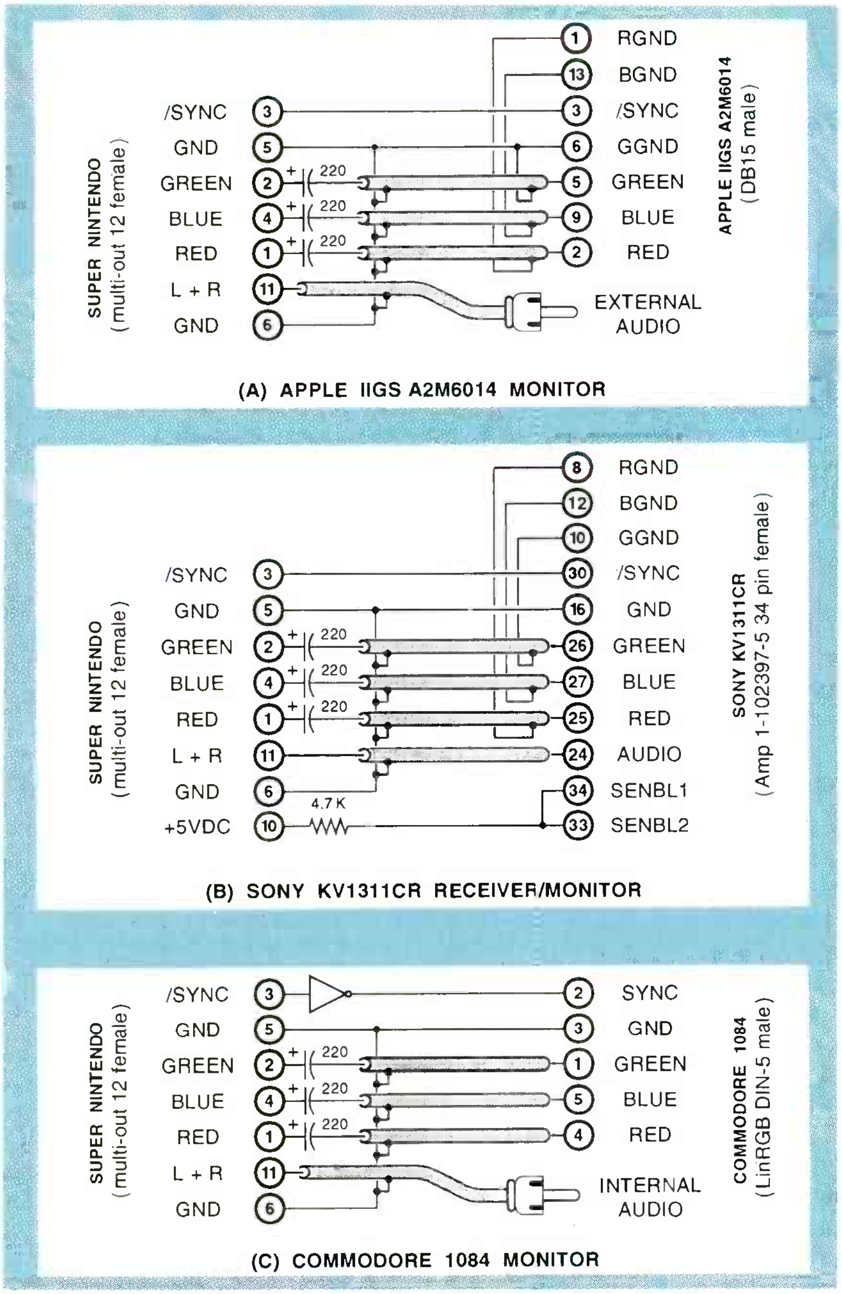


FIG. 4—TYPICAL SUPER NINTENDO TO LINEAR RGB video monitor interface connections can give you sharper resolution and better colors.

The overwhelming majority of all laser printers use *Canon* engines, so that is usually where you'll want to start. *Hewlett Packard* has by far the best and the most available Canon manuals in the industry. And since an SX engine is an SX engine, those HP manuals are most useful on similar *Apple*, *QMS*, and lesser machines.

Figure 5 summarizes the key HP service manuals, along with some of the competing machines they cover. HP recently has sharply raised all of their service manual prices. Many of these HP service manuals are in the $100 range. Even at that price, they pay for themselves on their first use. They are essential gottahaves.

HP also sells parts to anybody overnight via VISA and an 800 order line. Again, sadly, individual parts are hard to get. They prefer to sell you an entire $50 fan instead of the 50-cent grommet which is the only thing that ever goes wrong with the fan.

The best place to go if you want to buy individual laser-printer parts is

NAMES AND NUMBERS

Aham Tor
27901 Front Street
Temecula, CA 92390
(714) 676-4151
CIRCLE 307 ON FREE INFORMATION CARD

AIS Satellite
106 North 7th Street
Perkasie, PA 18944
(215) 453-1400
CIRCLE 308 ON FREE INFORMATION CARD

Benchmarq
2611 Westgrove Dr, Ste 101
Carrollton, TX 75006
(214) 407-0011
CIRCLE 309 ON FREE INFORMATION CARD

CADalyst
859 Willamette Street
Eugene, OR 97440
(503) 343-1200
CIRCLE 310 ON FREE INFORMATION CARD

Caplugs
2150 Elmwood Avenue
Buffalo, NY 14207
(716) 876-9855
CIRCLE 311 ON FREE INFORMATION CARD

DKD Instruments
1406 Parkhurst
Sima Valley, CA 93065
(805) 581-5771
CIRCLE 312 ON FREE INFORMATION CARD

Electronic Product Review
411 Eagleview Blvd
Exton, PA 19341
(215) 458-6440
CIRCLE 313 ON FREE INFORMATION CARD

GEnie
401 North Washington Street
Rockville, MD 20850
(800) 638-9636
CIRCLE 314 ON FREE INFORMATION CARD

Institute of Navigation
1026 16th St NW, Ste 104
Washington, DC 10036
(202) 783-4121
CIRCLE 315 ON FREE INFORMATION CARD

Loyola Enterprises
904 Meadowburm Court
Virginia Beach, VA 23452
(804) 459-2972
CIRCLE 316 ON FREE INFORMATION CARD

Redmond Cable
17371-A1 NE 67th Court
Redmond, WA 98052
(206) 882-2009
CIRCLE 317 ON FREE INFORMATION CARD

Rutland
16700 E Gale Avenue
City of Industry, CA 91745
(818) 961-7111
CIRCLE 318 ON FREE INFORMATION CARD

Serigraph
760 Indiana Avenue
West Bend, WI 53095
(414) 335-7200
CIRCLE 319 ON FREE INFORMATION CARD

SGS/Thompson
1000 East Bell Road
Phoenix, AZ 85022
(602) 867-6259
CIRCLE 320 ON FREE INFORMATION CARD

Skyvision
1010 N Frontier Drive
Fergus Falls, MN 56537
(800) 543-3025
CIRCLE 321 ON FREE INFORMATION CARD

Small Parts
PO Box 4650
Miami Lakes, FL 33014
(305) 557-8222
CIRCLE 322 ON FREE INFORMATION CARD

Space Systems Division/MZEE
LA AirForce Base, PO Box 92960
Los Angeles, CA 90009
(310) 363-0215
CIRCLE 323 ON FREE INFORMATION CARD

Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073
CIRCLE 324 ON FREE INFORMATION CARD

HP MANUAL	HP PRINTER	APPLE PRINTER	QMS PRINTER
02686-90920 (CX Engine)	LaserJet I	LaserWriter LaserWriter Plus	PS800
33449-90906 (SX Engine)	LaserJet II LaserJet III	LaserWriter NT LaserWriter NTX LaserWriter F LaserWriter G	PS810 & Turbo PS820 & Turbo PS815-MR PS825-MR
33459-90906 (SX Engine)	LaserJet IID LaserJet IIID	----	----
33471-90904 (LX Engine)	LaserJet IIP	Personal LW NT	PS410
33491-90929 (SI Engine)	LaserJet IIIsi	----	----

FIG. 5—THESE HEWLETT-PACKARD LASER SERVICE MANUALS can be used for mechanical repairs on most of the printers shown here. While expensive, they are the best information sources available, and far easier to get than the others. Many different laser printers use Canon engines, so these HP manuals are very useful on similar machines. HP also sells parts to anybody overnight via VISA and an 800 order line, although individual parts are hard to get.

Don Thompson, who also now offers by far the finest multi-level training and repair seminars in the entire industry.

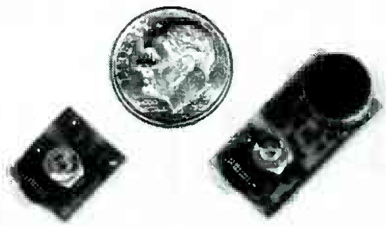
My two favorite places for toner refilling supplies and materials are Arlin Shepard of *Lazer Products*, and Walt Jeffries and his crew at *Black Lightning*. The latter are also into special toners for fabric printing and printed circuits as well, should you have such a need.

Black Lightning also publishes *The Flash*, a free and friendly newsletter crammed full of useful desktop information.

There are several laser-printing and toner-recharging trade journals, but the only one of any consequence is *Recharger*. They are already up to several hundred pages per issue, and list dozens of suppliers for just about any laser-printing repair need.

I try to carry a lot of toner and laser printer repair stuff on our

continued on page 75



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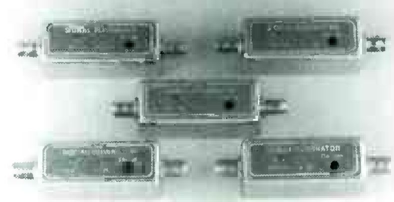
CIRCLE 181 ON FREE INFORMATION CARD



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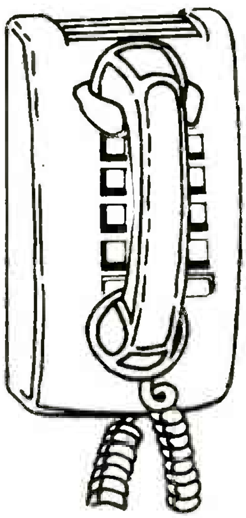

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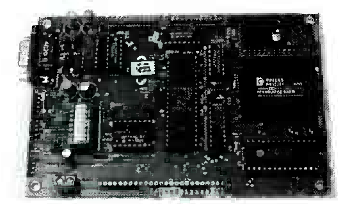

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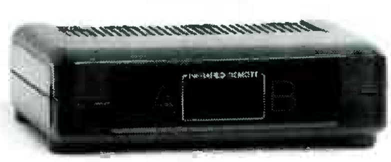

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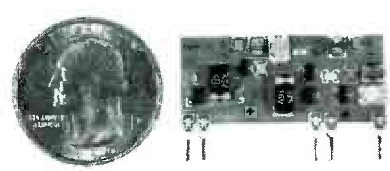

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AUDIO UPDATE

Hear today, gone tomorrow.

LARRY KLEIN

No new prescription drug reaches the market without extensive double-blind test studies designed specifically to eliminate the influence of the "placebo effect." In a nutshell, the testing works something like this: a group of, say, 50 sufferers from some specific malady are chosen to participate in the study. They are divided into two groups, each matched as closely as possible in terms of relevant characteristics such as overall health, severity of the malady under study, mental attitude, etc. An important part of the design of any research study is the isolation and elimination of irrelevant random factors that may skew the results in one direction or another. Unfortunately, the history of science is littered with studies that were invalidated by methodological flaws.

Every person in the two matched groups is given the same treatment, be it injections, pills, diathermy, or whatever, *except* that those in group B get a phony treatment. They are unaware that the "therapeutic" injection is a saline solution, the pills are sugar tablets, and so forth. Group A is given the real drug being tested *under identical conditions*. To prevent unwitting clues being given by the doctors involved, those administering the drugs do not know which drug is which. This is the essence of the "double-blind" technique.

One might imagine that from that point on all that is needed is a checkup to see who gets better and who doesn't. However, things are not that simple. Let's suppose that 30% of those getting the real drug improve. Would that be considered a reasonably successful outcome? Not if 30% percent of those getting the placebo (phony drug) also get better. And that is exactly what happens repeatedly in medical research. In many cases, the administration of *any* treatment whatsoever—including a chanting witch doctor—will produce a certain number of cures or at least some alleviation of symptoms.

In less sophisticated times than ours it was a common belief that faith could work miracles; now most people prefer to refer knowingly to mind/body interactions for an explanation. There are those who believe that if a belief system—however irrational—can effect a cure, then why not go along with it? (More on this later in respect to the alleged special sound qualities of super-expensive audio equipment).

Trustworthy ears

All of the above is a preface to my discussion of a paper given by Tom Nousaine at the Audio Engineering Society convention last October. Tom's paper, *Can You Trust Your Ears* (preprint 3177 L3), deals with a matter that I've pondered for many years. In past columns I've discussed the various problems of subjective testing, and I've touched on the question of why those listeners obsessed with high-end audio equipment tend to hear things that objectively don't exist.

Audiophiles frequently complain that critics such as myself are too insensitive to respond to the sonic nuances in question, or that we have vested interests in *not* hearing the virtues of very expensive equipment. But aside from anyone's alleged hearing deficits or personal perversity, it is very easy to demonstrate that audiophiles—and others—do indeed tend to hear things that have no objective existence. All that needs to be done is to establish a listening panel of audiophiles and general listeners, as Tom Nousaine did. He set up a placebo comparison between an amplifier fed directly from a CD player (A) and the same amp with a supposed "signal processor" in the signal path (B). Despite the fact that the listening panel was exposed to exactly the same material in both A and B, a preference was expressed for A or B 76% of the time! Of course, the audiophiles in the group strongly preferred A because they had been told that there was an experimental signal processor in channel B.

As I've remarked before, many audiophiles feel that their credibility is on the line during every listening experience. Because of the implicit audiophile belief that every component inherently sounds different, you can see how detecting such differences is *very* important. But there's more to the story than audiophile ego trips. In further testing without the "signal processor," when preference between identical amplifiers was still 76%, there was *no difference in the scores between audiophiles and general man-on-the-street consumers!*

It appears that under certain conditions, even unbiased ears tend to hear differences when none exist. Perhaps—and this is sheer speculation—any interruption in the input signal causes a shift in the listener's auditory zero-reference level, which is then interpreted as a change in musical quality.

It's been known for years (I first wrote about it in the early 70's) that the ear hears minor differences in level (less than 0.5 dB) as differences in clarity. In his paper Tom attempted to quantify the effect. When slight loudness differences were introduced, listeners much preferred the louder alternative. For unknown reasons, the effect was even more pronounced when the louder choice was presented to the listener second.

Critics' recommendations

I've detected the appearance of a pernicious philosophy among a few audio writers. Although they may acknowledge that there is no objective evidence supporting their preference for a given product, the fact that they have a preference is sufficient justification for a recommendation. The problem with that sort of approach is its ultimate unreliability.

I've had friends who compulsively traded in fine top-of-the-line equipment for newer, more recently touted products in the hope of coming one step closer to audio nirvana. And in truth they did bask in "unsurpassed sonics with superb imaging," as one reviewer put it, until the same reviewer(s) soon discovered an even juicier cherry-of-the-month to extol.

In the same way that double-blind placebo testing is needed to differentiate drugs that work from those that don't, equivalent techniques are needed to separate the genuine advances in the audio art from those that are merely commercially inspired or delusional. Tom's data indicate that those audio critics who evaluate equipment primarily by uncontrolled listening tests (supported or unsupported by measurements) are likely to be fooling themselves and their readers. Double-blind testing is the only way to ensure audio objectivity.

Tom concludes his paper with a plea for further research in listening test techniques. I couldn't agree more. For most of audio history, comparative listening tests were mostly what audiophiles did for fun on Saturday afternoons. To my knowledge, the first serious industry listening tests were undertaken by the FCC in deciding on a stereo FM broadcasting system. Today, with the proliferation of signal-compression techniques used in broadcasting and data compression used in digital home formats, refining the methodology of listening-test evaluations becomes a high-priority concern in professional audio. **R-E**

EQUIPMENT REPORTS

continued from page 71

gives you the option of showing a suggested layout on a breadboard, instead of the schematic view.

This latest version of Global Specialties *Protolab* has several improvements over earlier versions, namely improved graphics (EGA is required) and the additional modules that present transistor and diode circuits. The manuals that are supplied cover only the operation of the software, without providing any circuit theory—an unfortunate change from previous versions. Our suggestions for improvements? We would like to see a little more consistency in the menus from module to module. And we'd like to see the removal of copy protection.

Protolab system software costs $129.95. Additional modules cost $19.95. We'd recommend it to anyone trying to learn the basics of circuits. **R-E**

DRAWING BOARD

Let's work on the vertical section of our scope.

ROBERT GROSSBLATT

I've been doing this column for a long time and, after writing more words than I can count (even with my shoes off), I can tell you that the most important ingredient is the feedback I get from those of you who take the time to drop me a note. The reason that I'm mentioning this is that I seem to have recently overstepped the lines of electronic propriety.

When we were recently talking about automotive charging systems I made the comment that generators were a "really stupid charging system," and the amount of output power you could get from them was solely a function of how fast the engine was turning. A lot of you took me to task on this and I'm therefore formally apologizing for what, in retrospect, was somewhat of an overstatement. Generators were used for a lot of years in a lot of cars, and it wasn't really fair for me to condemn the whole thing out of hand.

Generator-based charging systems had their faults (especially at low engine speeds and during heavy current demands), but alternators have their quirks as well. Since we were talking about a regulator for alternators, I spent most of the time discussing alternators and summed up generators in a few (unfortunate) words. And while the theory of operation behind mechanical voltage regulators is really similar to the electronic ones, it's still true that they had to deal with large amounts of current. The modern alternator/regulator arrangement has the advantage of low-current control of the output of the alternator.

I got a lot of thoughtful letters on the subject and, while I don't have the space to thank everyone who wrote, I want to give a special tip of the hat to David Parrish, Lucius Day, and William Newell. Even though they beat me up as well, their letters were great to read and forced me to review stuff I hadn't thought about since college. I screw up as often as anybody, and I'm grateful for people like those three guys who can catch the goofs and call me on it in an intelligently written letter that's a real pleasure for me to read. Once again, my sincere thanks to all of you.

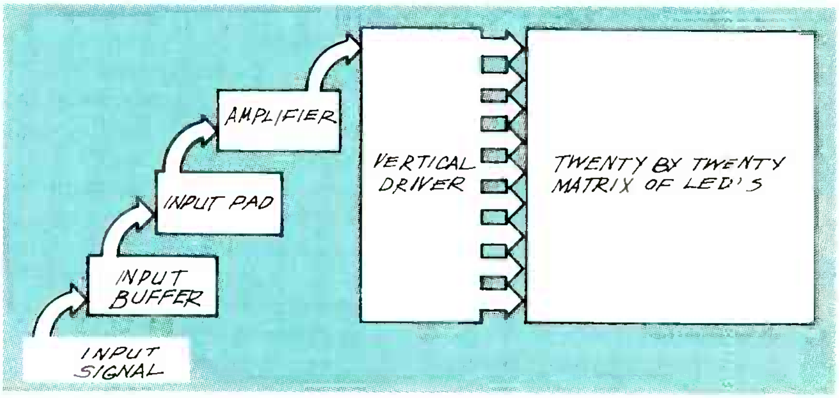

FIG. 1—HERE ARE THE DIFFERENT SECTIONS of the scope that we have to design.

But back to the subject at hand. We've got the horizontal section of our scope up and running, and it's time to turn to the vertical circuitry. As with the horizontal section we just finished, the vertical section is really made up of several different sections, each of which does a different job. Figure 1 gives you an idea of the pieces we have to design to get the scope working.

Even though we're designing a scope that can look at both digital and analog input signals, the fact that we have an LED display means that any signal we measure has to be "digitized" ultimately before it can be seen on the scope. That isn't to say that we're building a digital scope—we're not. I just want to point out that having a display made up of discrete points means that all the input signals have to be reduced to discrete values. With a CRT-based scope, you can display any analog value—with a digital display like ours, we have to quantify the input signal to match the restrictions of the display.

The work of digitizing the input signal is done in the "Vertical Driver" section in Fig. 1. The standard way of doing that is to stack up a bunch of comparators and configure them so that each successive comparator goes high as the input voltage increases. Even though the basic idea is really simple, from a practical point of view it's always been a real pain in the neck to translate it into reality. Because you want the voltage steps to be as accurate as possible, you have to spend a lot of time working out the values of the resistors used in the voltage-divider chain that makes up the analog-to-digital conversion circuit.

The way around the problem is to use the LM3914 dot/bar display driver from National Semiconductor; the pinout diagram is shown in Fig. 2. The 3914 is basically an ana-

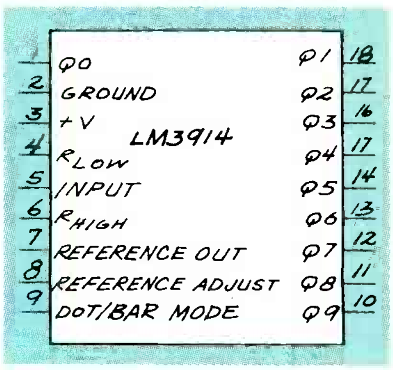

FIG. 2—THE LM3914 DOT/BAR DISPLAY driver will be used to drive our scope display.

log IC, and that means you have to do some work to calculate the values of the components needed to make the chip do its thing. There's an internal ten-step voltage divider to drive the chip's comparators, but external components have to be used to set the overall voltage range for the whole chip. That's important for us to talk about since we want to be able to switch ranges when we're using the scope.

National Semiconductor has made the job of determining the 3914's voltage range as easy as possible by making the two ends of the IC's comparator chain available on pin 4 (the low end) and pin 6 (the high end). The ten comparators in the 3914 each have one leg chained to a resistive ladder so that the comparators respond linearly to the input voltage. If the external components are set to have the 3914 cover a one-volt range, each tenth-of-a-volt increase in the input voltage will cause the next 3914 output, in turn, to become active.

Just as with any comparator circuit, getting the component values worked out to have the 3914 respond to a particular voltage range is a tricky business. The details are spelled out in the data sheet for the chip but, for our application it's better, faster, and much easier to handle the problem by padding the level of the input signal before it gets to the 3914 input. Even though we'll do that, it's still necessary to know exactly what the 3914 is telling us when it turns on a particular output. In other words, while we don't have to configure the 3914 to cover different voltage ranges, we still have to know what range it is covering so we know how to pad the input.

The absolute voltage generated by the 3914's internal voltage regulator is 1.2 volts and, if you set the 3914 up as shown in Fig. 2, each increase of 0.12 volts at the input will cause the next 3914 output, in turn, to become active. You should notice that the lower end of the divider chain, pin 4, is connected to ground so that the 3914 will cover the range of 0–1.2 volts full-scale. Once you have it wired up, you can fool around with the reference-adjust terminals and the internal resistor chain to change the full-scale

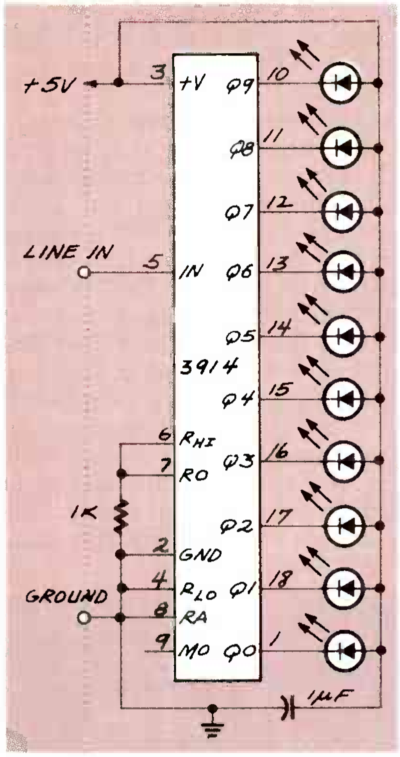

FIG. 3—CONNECT LED'S to the 3914 as shown here to serve as temporary indicators.

response of the chip. I don't want to go into it here since we'll be prescaling the input voltage, but you can get the details for doing it from the data sheet.

The 3914 can be set to output either a bar-type (all LED's on) or a moving-dot (only one LED on) display. For our purposes, a single dot is preferable so we'll be leaving pin 9 unconnected. When we expand the display to twenty LED's, we'll be using two 3914's and the mode-control pins will have to be handled differently—but we'll get to that later.

It may seem to be somewhat wimpy to operate the 3914 in such a minimal mode by not taking advantage of some of the obviously slick things it can do. Using the internal voltage reference in its most basic fashion, and only sticking with a moving dot is configuring the 3914 in a really bare-bones way. But don't forget that the reason we're using this chip in the first place is because it's a one-chip answer to driving the LED's in our display. And even though we have it set up for a 0–1.2 volt range, we'll be putting circuitry in front of the 3914's input to pad the input voltage to have switch-selec-

continued on page 82

AMPLIFIER
continued from page 36

rent of about 60 mA. Repeat the same procedure for the right channel, adjusting R16R. Check the voltage at the two speaker output terminals. The DC value should be less than 50 mV. If all is well so far, replace F1 and F2 with 2-amp fuses, connect a pair of test speakers to the output leads, and apply an input signal.

If everything still checks out, feed the wires through the end plate using a plastic strain relief to secure the wires. Now install the final fuse values, slide the cover in place, and attach the other end plate.

Installation and use

The first thing you must do is decide on an appropriate location for the amplifier. Good choices include under a seat or in the trunk. Once the unit is mounted, wire the power, ground, and speakers. Ground can be picked up from the chassis of the vehicle, if desired, making sure it is a solid ground. Use appropriately heavy wires for the main power and ground, as they will have to conduct as much as 40 or 50 amps. You may wish to pick up the main power close to the battery, in which case you should use a fuseable link as the very first piece of the connection. Fuseable links are readily available from most automotive parts stores. You may also wish to install an engine noise filter in series with the main supply.

The 12-volt control lead is ideally connected to the radio's electric antenna output, if it is so equipped. If not available, a separate switch can be used. Finally, wire the inputs with shielded cable. It's best if the car radio you're using has a volume-controlled line-level output, which most of the better radios have. In any case, do not drive the amplifier from the speaker output of the radio—the signal levels could damage the amplifier inputs, and the signal would include the inherent distortion of the radio's amplifier. One last word of caution: the heatsink is designed for the peak-to-average power ratio of music. Therefore, for applications which require continuous output at the rated power levels, forced cooling or a bigger heatsink are recommended. Happy listening! **R-E**

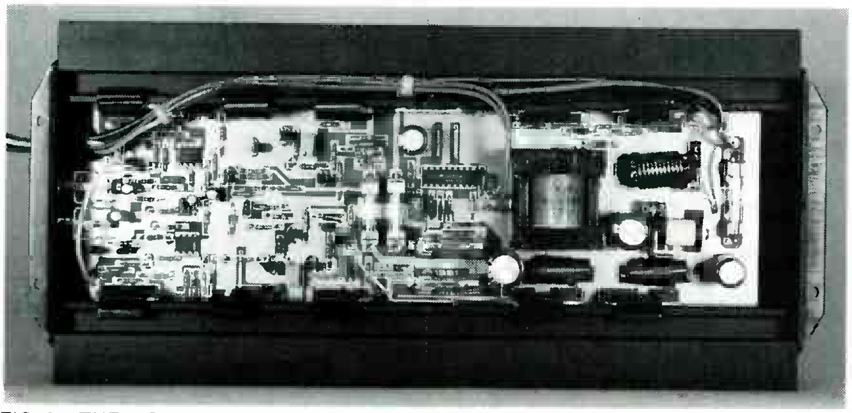

FIG. 7—THE MOUNTING SURFACES of the heatsink and power components must be clean and smooth. Mark each power component site on the case, remove the amplifier board, and prepare each site with a thin coat of thermal heatsink grease and a mica insulator. Then re-install the amplifier board with each of the power parts bent slightly away from the heatsink surface. Apply a thin layer of thermal grease to each part and then bend the part back against the heatsink. Now take a look at Fig. 8.

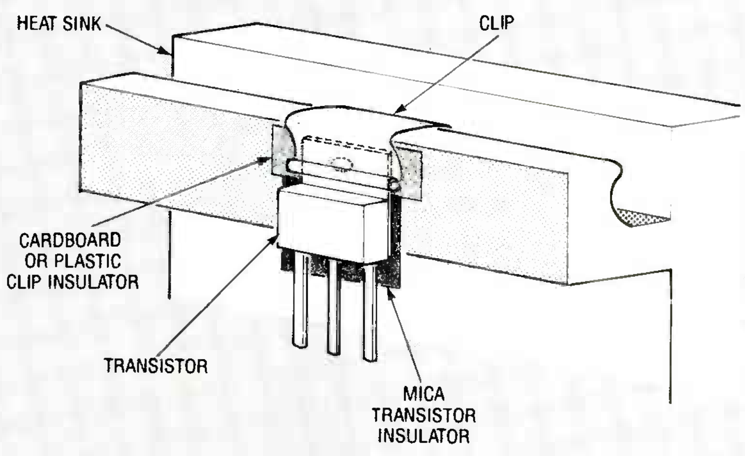

FIG. 8—HOLD EACH POWER COMPONENT IN PLACE with a spring clip, and use a piece of cardboard or plastic as an insulator between the part and the clip. Check with an ohmmeter to see that none of the power parts are shorted to the heatsink.

HARDWARE HACKER

continued from page 68

GEnie PSRT. We also have on-line real-time conferences with the leaders in this field; lists of upcoming conferences and downloadable transcripts of past conference are available. These files usually will start off with an "RTC" prefix.

New tech lit

From *SGS/Thomson* a new *Modem Databook and Applications* manual. From *Benchmarq*, a *1991 Databook* on their energy management (power switching) chips for laptops, real-time clocks, and non-volatile memories.

A new and very thorough *Heatsink Application Handbook* is available from *Aham Tor*. TV satellite products and information are offered by *AIS Satellite* and *Skyvision*. Both provide free catalogs. Skyvision has a very good satellite book selection.

Our two new trade journals for this month include *Electronic Product Review* that covers all kinds of new component parts and *CADalyst* for those users of AutoCad CAD/CAM systems.

The company *Small Parts* has always been a great place to go for all the robotic and mechanical stuff your hardware store never heard of. As well as any precut plastic and metal shapes. They have recently moved to larger quarters, so you might want to note their new address and pick up a free catalog.

A free *School Shop* catalog from *Rutland* offers all the usual machine-shop tools and supplies.

A no-charge sample of backlit fiber-optic displays is available from *Serigraph*, while *Caplugs* offers a free sample *idea kit* of their plastic plugs, caps, and enclosures.

A reminder that I now stock my *Active Filter Cookbook* for all of the fundamentals of quickly building up your own analog low-pass, band-pass, and high-pass filter circuits. I've got autographed copies of the book on hand for you here at *Synergetics* when you call or write. You can get this book by itself or as one portion of my *Lancaster Classics Library*. **R-E**

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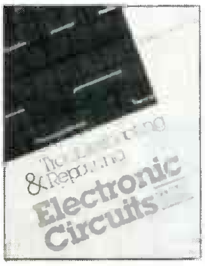

3258 **$28.95**
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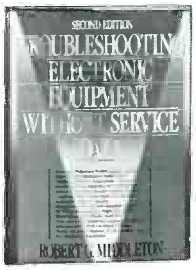
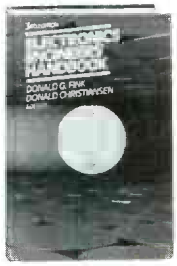


9290 **$48.00**
This guide provides a practical approach to pinpointing symptoms and causes, and effectively troubleshooting malfunctions. Provides many never-before-published techniques and case histories. 315 pp. *Counts as 2*



9255 **$97.50**
"Outstanding, extensive reference to current technology of electronics. Covers everything from principles to applications."
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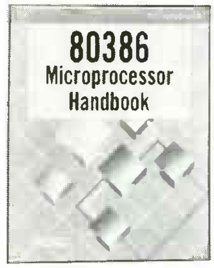

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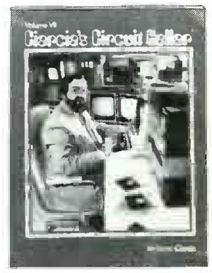

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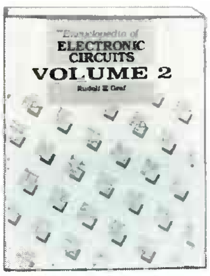

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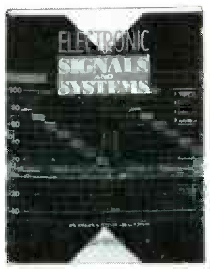

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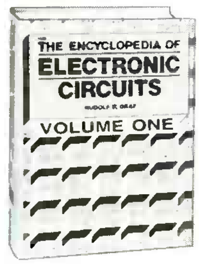

1938 **$60.00**
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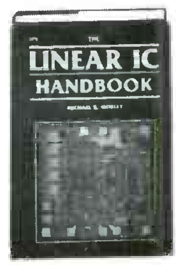
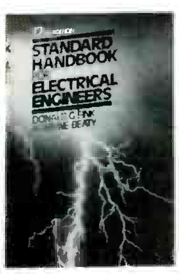
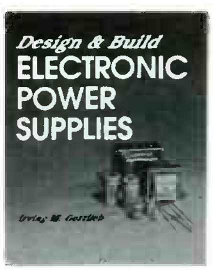


2672 **$49.50**
This one-stop sourcebook bridges the gap between data books and the designer's search for the right component. Covers how linear ICs are fabricated, how they work, what types are available, and techniques for designing. 624 pp.



020975-8 **$99.50**
The essential reference for all electrical engineers. Completely revised and updated, this classic handbook covers the generation, transmission, distribution, control, conservation, and application of electrical power. 2,416 pp., 1,388 illus., 430 tables. *Counts as 3*



3540 **$26.95**
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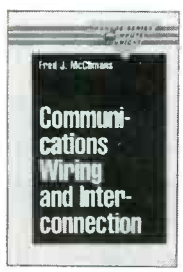

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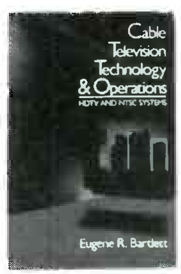

003957-7 **$49.95**
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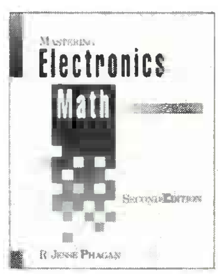

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A practical toolbox reference for anyone in the electronics field. Phagan guides you through the practical calculations needed to design and troubleshoot circuits and components.
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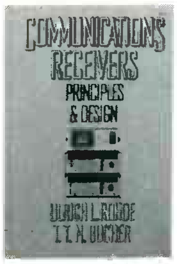

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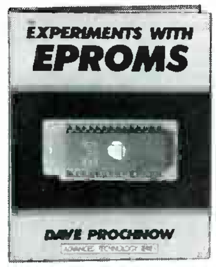

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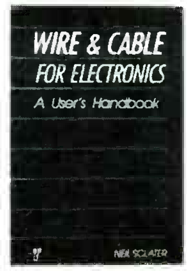

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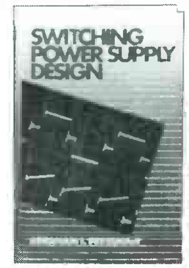

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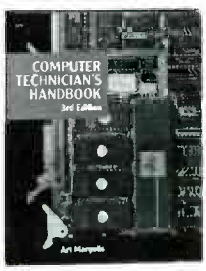

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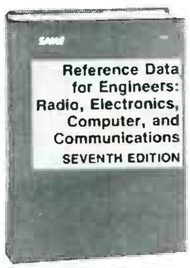

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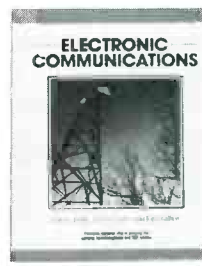
334 pp., 188 illus. *Counts as 2*



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COMPUTER CONNECTIONS

Will you OS/2 it?

JEFF HOLTZMAN

Cut to April, 1987. IBM and Microsoft jointly release a new operating system, the heir apparent to DOS. OS/2 version 1.0 was tuned to the 80286 microprocessor, but it had limited DOS compatibility, and it lacked significant support from applications developers.

Fast forward to June, 1990. After five years and three major versions, Microsoft releases Windows 3.0. It supports all Intel processor modes, has excellent DOS compatibility, and significant applications support. It quickly catalyzes a stagnant industry.

Fast forward to Spring, 1992. After five years and as many versions, IBM will release OS/2 2.0. It's aimed at the 386 and higher, offers excellent DOS (surely) and Windows (maybe) compatibility, but still lacks significant support for native applications. It also introduces a new desktop shell with a whole new paradigm for the user interface. And under the covers, it reportedly makes extensive use of object-oriented technology of the sort that has allowed Borland, for example, to make rapid gains on Lotus and Microsoft in recent years.

Power users and true-blue loyalists may eat it up. But what about the rest of the world? Further, does OS/2 offer significant power that we both need and can't get elsewhere? Does it package this power in an accessible manner? Can IBM overcome the stigma (or just plain indifference) that has haunted OS/2 almost since its inception? Can IBM market this product to a community of users, the vast majority of which, according to recent studies, are still not even running Windows? Can it succeed in an increasingly Windows world? Can it coexist? And what about Windows NT, the only product with which comparison can fairly be made?

What is OS/2 2.0?

Circle one: It's IBM's 32-bit preemptive protected operating system for Intel processors. It's IBM's attempt to apply everything it has learned about building powerful, reliable system software during the past thirty years to desktop PC's. It's IBM's attempt to provide a platform for integrating diverse hardware platforms and operating systems. It's IBM's attempt to wrest control of the PC industry from Bill Gates. It's just another graphical environment for developing and running software. All of the above. Some of the above. None of the above.

However you answer the question, IBM's oft-repeated intent with OS/2 is to provide a better DOS than DOS and a better Windows than Windows. It's safe to say that Big Blue has succeeded with the DOS part of the equation. It's too soon to tell about Windows.

I'm writing this just after the first of the year, based on beta release F6.167 of OS/2; specific features and operations may and probably will change by the time the product is released commercially. Commercial release is presently scheduled around the time you read this, but that may change as well—only time will tell.

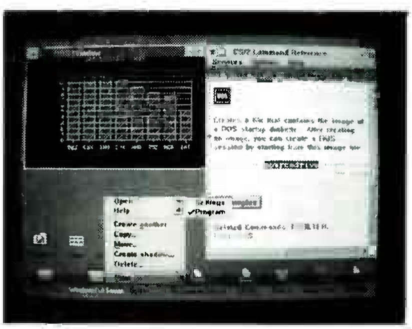

FIG. 1—BETA VERSION OF OS/2 2.0 runs tough DOS applications flawlessly, and has improved compatibility with Windows. More important in the long run is that this is the first widespread object-oriented operating system for desktop PC's.

DOS vs. Windows

DOS programs will run either full screen or in a window (i.e., in a bit-mapped graphic screen that simulates normal text mode); with or without EMS, XMS, and DPMI memory; and with a fine degree of control over how your apps run. Compatibility is extremely good. For example, I ran LapLink 3.00a in its parallel turbo mode to transfer multiple megabytes of files from another machine in a windowed DOS session, while simultaneously running other native-mode (OS/2 specific) software. The mouse had trouble keeping up, but all files transferred flawlessly. All DOS applications I tested worked fine, although some timing-dependent programs acted funny. For example, a Pacman game ran incredibly slow. Lotus 1-2-3 2.01 ran fine in a window, including display of graphs. In general, running on comparable hardware, DOS apps have a snappier feel under OS/2 2.0 than under Windows 3.0. Conclusion: DOS compatibility is not perfect, but it it's probably good enough for most applications.

Windows programs run, but slowly, and not in a window, and not with Windows-OS/2 clipboard support. In other words, you cannot cut and paste between Windows and OS/2 programs, nor can you simultaneously view Windows and OS/2 programs. IBM promises to remedy these problems in the final release of the product.

Select-do

One highly anticipated aspect of OS/2 2.0 is the Workplace Shell (WPS). WPS provides the first widespread object-oriented user interface for personal computers. The overall look of WPS is quite similar to that of Windows, but operation is much different. Everything on the desktop (including the desktop itself) is an object. You manipulate objects with the mouse. Unlike Windows, WPS is a two-button system: You use the left button to select objects and the right button to do something to or with them. (You can customize mouse button usage and many other system features quite easily. For example, you can bring up the color palette editor, select a desired color, drag it over the desktop and drop it. Voila—instant color therapy!)

To move an icon, select it (left button) and then move the mouse with the right button held down. (A shortcut is to just drag with the right button.) To copy an icon, select it and drag as before, but hold down the Ctrl key before releasing the right button. To open an icon (execute a program, open a folder), double click with the left button.

You can also create a shadow (sometimes called a reflection) of any object by holding down Ctrl + Shift when completing a right-button drag. Rumor has it that a shadow will function in an object-oriented way, i.e., a shadow would "inherit" all characteristics of the shadowed object, including any changes made to the original, but changing the shadow would not affect the original. However, the current release appears only to support UNIX-like symbolic links, in which changes to any one instance of an object affect all other instances of it.

Copy, move, open, shadow: Those are direct manipulation operations. Objects in OS/2 also support indirect manipulation; just single-click the right button on the object, so a menu pops up. The content of the menu varies, depending on the type of object, but you'll usually see operations like Help, Open, Copy, Delete, Move, Print, Find, etc. (Direct manipulation operations appear on the menu so that you can, for example, copy a file using a dialog box to specify the destination.) You can drag an object to a Shredder icon to delete it, and to the Printer icon to print it. (The shell in Windows 3.1 reportedly will have similar drag-and-drop features but we'll have to wait and see.)

Under Windows you can double-click an icon repeatedly to launch multiple instances of a program. In OS/2's object-oriented paradigm, that doesn't work. The icon and the running application amount to different views of the same object. To get multiple instances of a program running, you must create copies of the icon and launch each desired program instance from a different icon.

An OS/2 window resembles a Windows' window, but there are differences. The biggest difference is that you cannot minimize a window. When you click the minimize button, a second icon is not created. In Windows, you double click on an icon in the Program Manager to execute a program. When you minimize the program, a new icon is created on the desktop. You use the new icon to restore the program, terminate it, etc. By contrast, in the WPS, no new icon is created. Again, the idea is that the icon and the window are simply different views of the same object. In Windows' PM, it's easy to spot an active program either by its Window or its icon. WPS does it differently. Icons with active programs have special cross-hatching. In both Windows and WPS, you can obtain a list of currently active programs by pressing Ctrl + Esc. You can also get a list of active programs in Windows by double-clicking on the background, and you can get a list of open objects in WPS by clicking both of the mouse buttons on the background.

Menus and scroll bars have a trendy 3D appearance. Text in a window scrolls as you operate the elevator bar. The system includes an extensive hypertext help facility, although the beta lacked much information. In addition, there is a slew of mini applications (calculator, notepad, alarms, charting, telecommunications, icon and text editors, bit map print/view/convert, etc.) and games (including solitaire, tetris clone, etc.).

Advanced features

OS/2 comes with a boot manager that by itself can make it worth purchasing the operating system. In exchange for giving up one megabyte of disk space, you get the ability to boot any operating system from any of four primary partitions. You can also break a primary partition down into an extended partition with one or more logical drives, each of which can have its own bootable operating system. You can boot any partition or drive automatically, or choose from a menu each time you boot. On my test system, I have three bootable partitions (DOS 3.30, DOS 5.0, OS/2 HPFS) and two more for storing data.

From within OS/2, you can boot a DOS session from a floppy disk. It can be any version of DOS, and it can include device drivers. Even more, you can create a boot image of that floppy disk, store it on your hard disk, and boot from the image whenever desired. In the beta, device driver support was limited, and the procedure for creating the boot image was totally buried in the on-line documentation.

IBM also includes a programming language called REXX, which is like a cross between BASIC and a batch programming language. The on-line help facility extensively documents REXX, including examples; another help file lists all OS/2 commands. A special Master Index will index all help files on disk and allow you to access them, complete with hypertext links. Reading a specific help file gives you search and print capabilities, but the Master Index does not.

Then there's the resource requirement. OS/2 requires a 386 or better, runs adequately in 8MB of RAM, and requires 30MB of disk space just for the operating system. Those are significant barriers for many users—but they're no more significant than the resources required by Windows. As of this writing, OS/2 won't work with SCSI devices, and it supports only IBM video standards (i.e., no super VGA or coprocessor cards).

Weighing in

For a new operating-system product to succeed, it needs strong backward compatibility (DOS), compatibility with today's hot ticket (Windows), and a compelling path to the future. OS/2 may be the ultimate platform for running DOS applications, but that is strictly a short-term benefit.

Windows compatibility might turn out to be problematic. "Better Windows than Windows" implies being able to do everything Windows does at least as well as it does it, and some things better. Currently, Windows apps run slowly, not in windows, and the clipboard is not supported. Assuming those basic problems are solved, there's still the matter of dynamic data exchange (DDE), object linking and embedding (OLE), and multimedia extensions. IBM seems doomed to playing a catch-up game with Microsoft as various areas in Windows are enhanced. In any case, total reliability is a must.

As for the future, IBM is potentially in excellent shape. Deals with Next and Apple over the past few years, as well as Borland and other language vendors, potentially give IBM a tremendous edge over Microsoft, whose chief allies (DEC and Compaq) have never been known for strategic software innovation.

Can OS/2 succeed? Yes, if it's very, very good. Would I buy it? I might, if it delivers on its promises or finds a way to make me not care about transgressions. Should you buy it? Depends. Eventually you will own OS/2 or the functional equivalent, regardless who makes or sells it. The fact is that the brave new multimedia world of the future cannot be supported by DOS. Right now multimedia seems like an add-on to an already adequate way of doing things. Some day, though, historians will look back on this era as one of sensory deprivation, akin to the black and white years of commercial TV. OS/2 or something like it is the software engine we need to get there. Regardless who wins, it will certainly be fun getting there. Stay tuned. **R-E**

DRAWING BOARD

continued from page 73

table full-scale readings of any range we want.

Get the chip working and connect LED's as shown in Fig. 3 to serve as temporary indicators. Since the chip will be working over a 1.2-volt range, you can use a signal generator as a source for the chip's input. If you don't have one, any line-level audio output will work just as well.

When we get together next month we'll expand the driver to handle twenty LED's and design the rest of the vertical circuit. That will make the scope operational and we'll be able to talk about all those bells and whistles. And they're the best part. **R-E**

TEMPERATURE

continued from page 46

the thermocouple changes the net cold-junction voltage. With the input shorted (0 mV), set R7 for an output equal to room temperature; for example, 25 mV at 25°C (77°F). Connect 41.269 mV to the input and set R14 for 100 mV plus the room temperature (1025 mV at 25°C).

Resistor R1's small bias current has no effect on normal operation, but causes the output to go high if the thermocouple breaks or burns out.

Noncontact thermometry

We've finished our study of temperature sensors, but let's close with a quick look at noncontact infrared radiation thermometry. Figure 9 shows a handheld device and Fig. 10 illustrates its principle.

Any object warmer than absolute zero radiates energy. Both the intensity and the spectral distribution of that radiation increase with temperature. (We're all familiar with "red hot" and "white hot" temperatures, but even "cold" objects radiate energy.) According to the Stefan-Boltzmann law, the radiated energy density is proportional to T^4, where T is absolute temperature. It is that law which allows scientists to determine the temperature of the sun's surface.

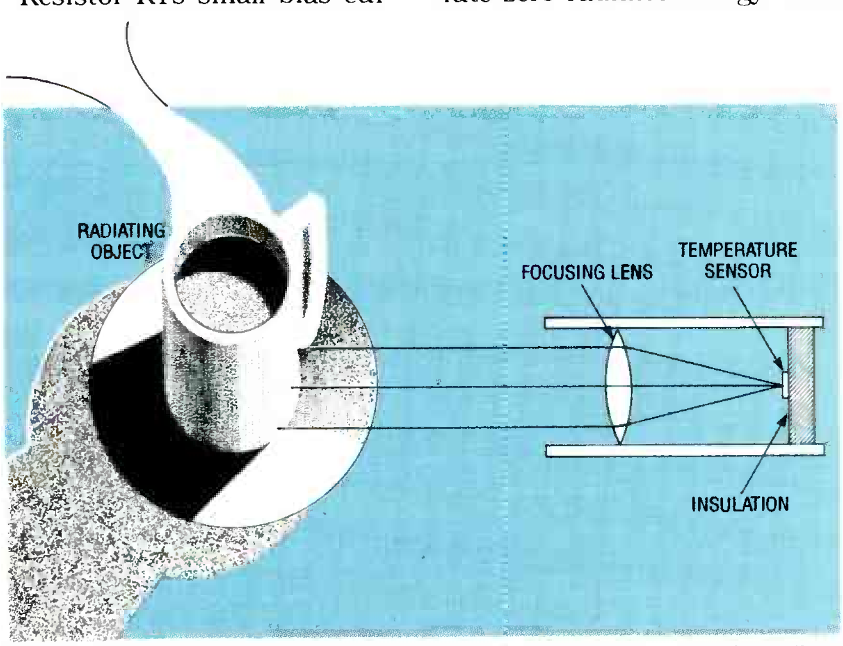

FIG. 10—ANY OBJECT WARMER than absolute zero radiates energy. The radiated energy is focused on a temperature sensor.

In Fig. 10 the radiated energy is focused on a temperature sensor. Designs vary, but in general the sensor should be small and have a low mass for good response time. Some designs insulate the sensor by placing it in a vacuum. The lens material might need to be specially chosen to pass long-wavelength infrared, especially for low-temperature measurement. Some designs might not use a lens at all, substituting a focusing mirror instead. A red or infrared filter might be added to minimize interference from ambient light.

The Stefan-Boltzmann law applies perfectly only to "blackbody" radiators. In reality, the ability of surfaces to radiate energy varies. Every surface has a reflectivity and an emissivity. A perfectly reflective surface has a

continued on page 92

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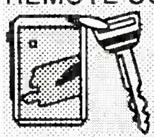

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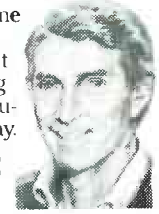

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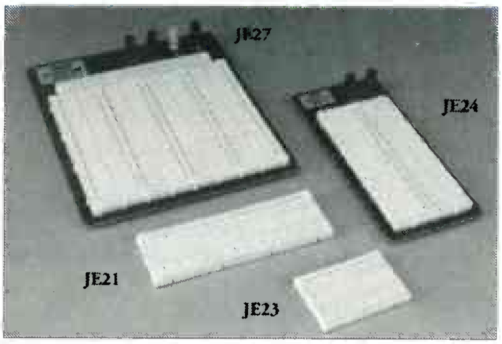

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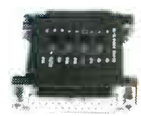

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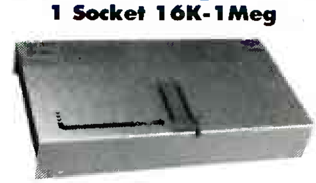

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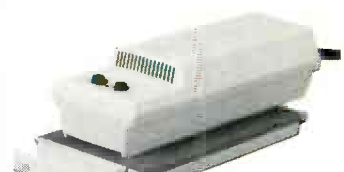

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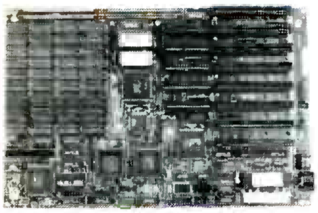

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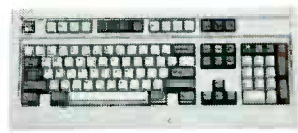

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PN2222	$.12	1N751	$.15
PN2907	.12	C106B1	.65
1N4004	.10	2N4401	.15
2N2222A	.25	1N4148	.07
1N4735	.25	2N3055	.69
2N3904	.12	1N270	.25

Switches

JMT123	SPDT, On-On (Toggle)	$1.15
206-8	SPST, 16-pin (DIP)	1.09
MPC121	SPDT, On-Off-On (Toggle)	1.19
MS102	SPST, Momentary (Push-Button)	.39

**Additional components available*

Connectors

Part No.	Description	Price
DB25P	Male, 25-pin	$.65
DB25S	Female, 25-pin	.75
DB25H	Hood	.39
DB25MH	Metal Hood	1.35

LEDs

XC209R	T1, (Red)	$.14
XC556G	T1 3/4, (Green)	.16
XC556R	T1 3/4, (Red)	.12
XC556Y	T1 3/4, (Yellow)	.16

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8LP	$.10	8WW	$.49
14LP	.11	14WW	.69
16LP	.12	16WW	.79
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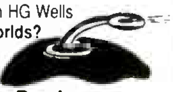

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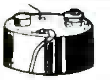

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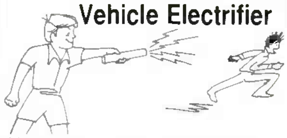

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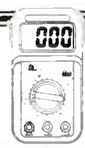

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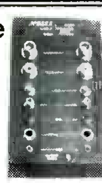

Convenient tester checks cable for center conductor and shield continuity. Tests all BNC, "F", RCA, 3.5mm mini, N, UHF, and 1/4" phone cables. Operates on two AA batteries. Bulit-in battery test function.

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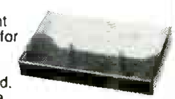

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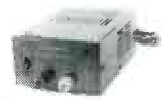

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This very popular woofer is perfect for making bookshelf speakers or for car stereo installations. Response: 70-15 KHz. fs= 70 Hz. 20 watts RMS, 35 watts max. SPL= 90 dB 1W/1M. 10 oz. magnet. 8 ohm impedance. Pioneer #A11EC80-02F. Net weight: 2 lbs.

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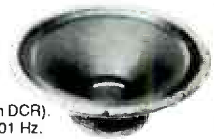
18" Eminence Woofer



Bass reflex woofer with ribbed paper cone and treated cloth accordion surround. Giant 100 oz. magnet. 200 watts RMS, 300 watts max. 3", 2 layer voice coil. 8 ohm impedance (7.5 ohm DCR). Frequency response: 27-3,000 Hz. fs= 28.01 Hz.

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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

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- 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
WIIAP	*Interface Kit For Apple II, IIE, II+*	39.99	37.99	34.19

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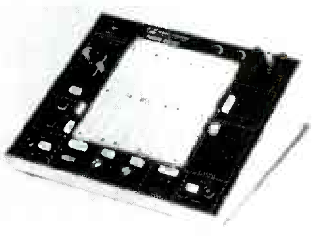

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  +5 VDC @ 1.0 amp, ripple - 5 mV
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  +5 - to +15 VDC @ 0.5 amp, ripple - 5 mV
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  -5 - to -15 VDC @ 0.5 amp, ripple - 5 mV
- **Frequency generator**
  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, triange, TTL
  sine wave: distortion 3% (10 Hz to 100 KHz)
  TTL pulse: rise and fall time 25ns drive 20 TTL loads
  Square wave: rise and fall time ± 1.5 s
- **Logic indicators**
  8 LED's, active high, 1.4 volt (nominal) threshold, inputs protected to ± 20 volts
- **Debounced pushbultons (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
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  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

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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.

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- Additional accessories below
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- 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	170.99	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+
LSLENS	*Collimating Lens Assembly*	24.99	23.74	21.37

DUAL MODE LASER POINTER

New slimline laser pointer is only ½" in diameter x 6¼" 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

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 manufacturers specifications.

STOCK #	DESCRIPTION	1-9	10-24	25+
LT1001	*He-He Laser Tube*	69.99	66.49	59.84

POWER SUPPLY

- Input: 115/230V
- Output: +5v @ 3.75A
  +12v @ 1.5A
  -12v @ 4A
- Size: 7" L x 5¼" W x 2½" H

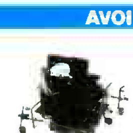
STOCK #	PRICE
PS1003	$19.99

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
YO1	$43.99

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

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CIRCLE 194 ON FREE INFORMATION CARD

TEMPERATURE

continued from page 83

reflectivity of one; a perfect absorber, zero. The sum of reflectivity plus emissivity always equals one.

Most commercial radiation thermometers include a control that allows the user to dial in a value of emissivity, plus a table of typical values. Organic and nonmetallic surfaces generally have emissivities between 0.85 and 0.95 (white paint is around 0.9). Metal surfaces can be as low as 0.1 when highly polished. Stainless steel is 0.3 when polished, 0.5 rough machined, and up to 0.8 or 0.9 when highly oxidized. R-E

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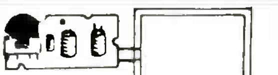
ALL ELECTRONICS CORP.

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.

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

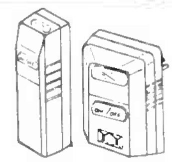
Citizen# 92TA operates on 3-6 Vdc CAT# BLU-92

$3.50 each

LARGE QUANTITY AVAILABLE

10 for $32.00 • 100 for $275.00

INFRARED Remote A.C. SWITCH



This infrared remote control device lets you turn on/off lamps, appliances or other 120 Vac devices using an IR transmitter similar to the one on your TV or VCR. Originally designed for use with a hydromassage unit, these transmitters and receivers will apparently operate most A.C. devices with 2 prong non-polarized plugs. Not recommended for use with heaters. Requires a 9 volt battery (not included).

CAT# RC-1

$9.95 each

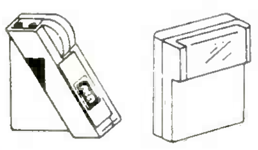
2 for $17.00

UV "Invisable" INK

When the ink dries the writing of these felt tip pens is visible only under a UV "black light". Originally for marking personal belongings in case of theft, these pens might also be used for writing secret messages or marking merchandise for inventory control. Large quantities available.

CAT# UVP 3 for $1.00 - 100 for $25.00

Wireless Remote Control FOR NINTENDO™



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

L.E.D.'s

Surface mount LED chip.

Clear when off, green when lit. Very tiny - whole unit is 0.115" X 0.055" X 0.05" thick. 1mm (0.04") lens diameter. Gold-plated mounting surfaces for superior conductivity.

CAT# SMLED-2 10 for $2.00

100 for $18.00

1000 for $140.00

Standard JUMBO

Diffused T 1-3/4 size (5 mm)

RED CAT# LED-1

10 for $1.50 • 100 for $13.00

GREEN CAT# LED-2

10 for $2.00 • 100 for $17.00

YELLOW CAT# LED-3

10 for $2.00 • 100 for $17.00

FLASHING LED

W/ built in flashing circuit 5 volt operation. T 1-3/4 (5mm)

RED $1.00 each

CAT# LED-4 10 for $9.50

GREEN $1.00 each

CAT# LED-4G 10 for $9.50

YELLOW $1.00 each

CAT# LED-4Y 10 for $9.50

LED HOLDER

Two piece holder.

CAT# HLED

10 for 65¢

D.C. Wall Transformers (120 Vac INPUT)

Volts	Amps	Plug Style	Center	Cat#	Price
4 Vdc	70 ma.	2.5mm co-ax	negative	DCTX-470	$2.00
6 Vdc	300 ma.	2.1 mm co-ax	positive	DCTX-632	$2.75
6 Vdc	750 ma.	2.5mm co-ax	negative	DCTX-675	$4.00
9 Vdc	10 ma.	battery snap		DCTX-8310	$1.50
9 Vdc	300 ma.	2.1 mm co-ax	positive	DCTX-932	$3.00
9 Vdc	500 ma.	2.5mm co-ax	positive	DCTX-950	$3.50
9 Vdc	1 Amp	2.1 mm co-ax	negative	DCTX-910	$5.00
12 Vdc	100 ma.	2.1mm co-ax	negative	DCTX-1210	$2.50
12 Vdc	200 ma.	2.1mm co-ax	negative	DCTX-122	$3.00
12 Vdc	500 ma	2.1mm co-ax	negative	DCTX-125	$4.50

Electret MIKE

High efficientcy, omni-directional, miniature electret condenser microphone element. Low current drain, good signal to noise ratio, operates on 2 to 10 Vdc. Ideal for telephones, tape recorders, noise-activated alarms and other applications. 0.39" dia X 0.31" high.

CAT# MIKE-10 85¢ each

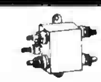
200 pcs $150.00 (75¢ each)

HEAT SINK COMPOUND

G C Electronics # 10-8109 - For effective transfer of heat between components and heat sinks. Z9 silicone heat sink compound.

CAT# HSC-1 $2.00 per 1 oz tube

RFI/EMI LINE FILTER



Corcom# 20B6 20 amp RFI/EMI general purpose common-mode filter. Controls line-to-ground noise. Small size, low leakage. 3.46" X 1.16" X 2.81". UL and CSA listed.

CAT# RFI-201 $8.50 each

PHOTORESISTOR

1K ohms light, 16K ohms dark. 0.182" dia. X .08" high. 0.18" long leads.

CAT# PRE-7

100 for $45.00

1000 for $400.00

2 for $1

DIP RELAYS

Miniature Relays With Pin Configuration To Fit 14 DIP.

5 Vdc - S.P.S.T.

GI Clare # PRMA-1A05B. Normally open reed relay. 500 ohm coil. U.L. listed. Diode protected.

CAT# DRLY-57 $1.50 each

12 Vdc - S.P.S.T.

Gordos# 846A-412 575 ohm coil. Sealed. Internal clamping diode.

CAT# DRLY-12 $1.25 each

24 Vdc - S.P.D.T.

GI Clare # PRMA 1C24 2,150 ohm coil. 10 vA switching power.

CAT# DRLY-1C24 $1.00 ea.

48Vdc - S.P.D.T.

Aromat # DS1E-A-DC48V 5,750 ohm coil. 2 amp contacts.

CAT# RLY-788 $1.00 each

HALL EFFECT SENSORS

Microswitch #SS41 Tiny, solid state switch reacts instantly to proximity of magnetic field. Operates at extremely high speeds, up to 100 khz. Case size: 0.12" X 0.17" X 0.06" thick. 4.5 Vdc to 24 Vdc supply voltage. 10 ma. sink type digital output. Operating gauss - 15 to 40. P.C. leads.

CAT# HESW-2 75¢ each

10 for $6.50 • 100 for $60.00

SURFACE MOUNT STYLE

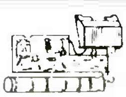
Sprague # UGN3075LT Operates on 4.5 - 24 Volts Can sink 10 ma. With suitable output pull up, can be used directly with bi-polar or CMOS logic circuits. Especially suited for electronic commutation in brushless D.C. motors using multiple ring magnets. Very tiny surface mount package 0.175" X 0.09"X 0.06" thick.

CAT # HESW-5 2 for $1.00

100 for $45.00

LARGE QUANTITIES AVAILABLE

FLASH UNITS



NEW compact flash assemblies from a camera manufacturer. Operates on 3 Vdc. Measures 2 1/2" X 1 1/4". Ideal for use as a strobe, warning light or attention getter. Includes a hook-up diagram.

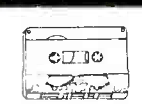
CAT# FSH-1 $3.75 each

10 for $35.00 • 100 for $325.00

RECHARGEABLE BATTERIES (nickel-cadmium)

Size	Volt	Amp	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	-	-	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

Highest Quality METAL CASSETTES



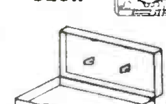
Premium quality metal tape in C-60 style cassettes (30 or more per side). One of the finest "brand-name" tapes on the market, in durable, clear plastic transport mechanisms. Recorded and bulk erased, the record-protect tabs have been removed and therefore, need to be taped over to re-record. Audiophiles 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!

60 min. tape - 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

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