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**JULY 1988**

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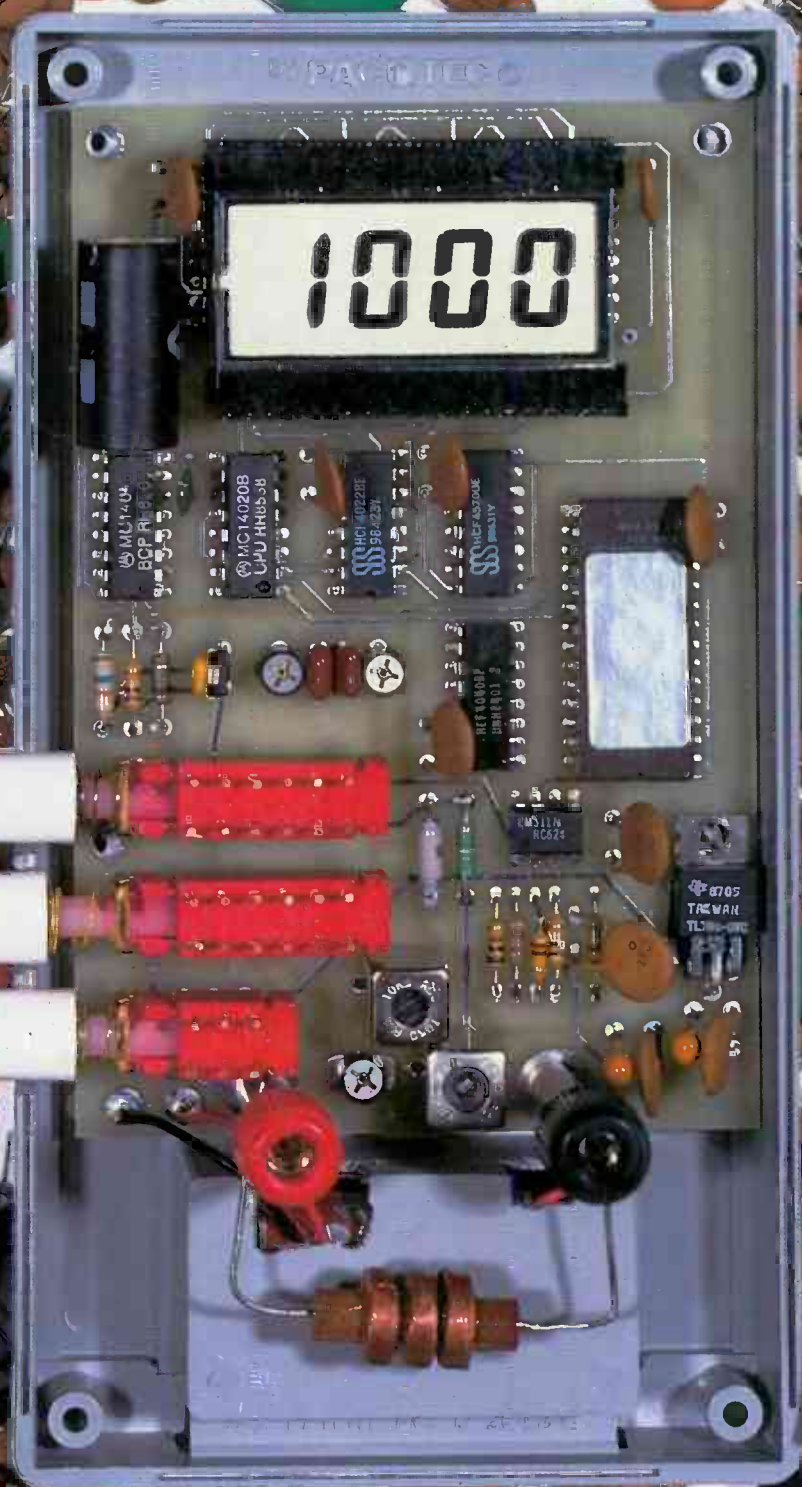
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## COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

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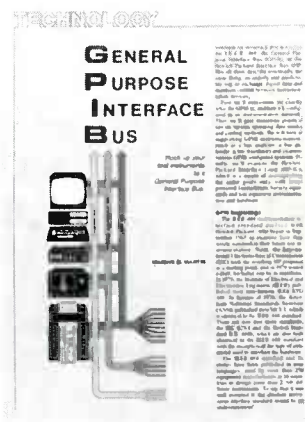
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## ON THE COVER



Just about everyone into electronics—from the hobbyist to the engineer—has a vast collection of unknown parts; or parts whose precise tolerance isn't known. The fact of the matter is that if you need an oddball or precise value of anything it's probably in that collection. Even if the part you need is a precision capacitor or inductor our autoranging digital LC Meter will find the correct part almost as fast as you can snap an unknown value into the meter's binding posts.

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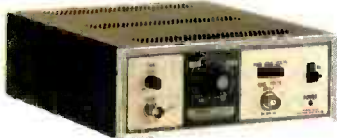
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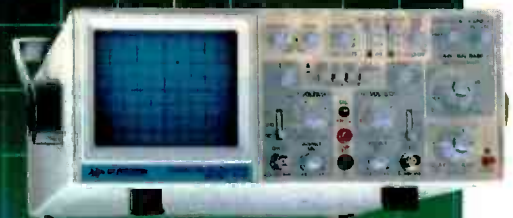
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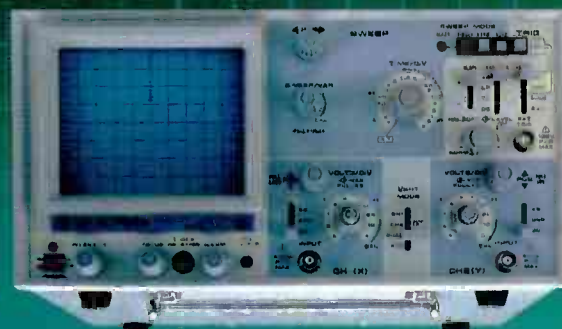
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# WHAT'S NEWS

## Superconducting chips are now on the way

General Electric scientists, Dr. Antonio Mogro-Campero and Larry G. Turner, report successful operation of a "high-temperature" superconducting film applied to a silicon substrate at liquid-nitrogen temperatures. There is great interest in depositing superconductors on silicon, because silicon is the substrate for practically all the world's microchips. It is advantageous to be able to deposit the

new superconducting material on the same familiar substrate.

The new yttrium-barium-copper superconductors lose all resistance at temperatures as high as  $-310^{\circ}$  Fahrenheit. Those high-temperature superconductors can be cooled in relatively cheap nitrogen. Low-temperature superconductors have to be cooled in liquid helium—a hundred times more expensive to produce.

Silicon presented problems. The components of the supercon-

ductor tended to mix with those of the substrate, contaminating the superconductor material and destroying the superconductivity.

GE scientists evaporated a zirconia buffer layer on the substrate and then evaporated the superconducting film on top of it, effectively isolating the superconducting material from the substrate. To deposit the active materials, a layer of copper was deposited first, then barium, and then yttrium. The sequence was repeated six times to build up an 18-layer "stack" with a total thickness of 0.6 to 0.7 micron.

No practical applications for the new chips have yet been demonstrated, but the developers see a wide range of possibilities. The use of superconductors on chips might greatly reduce the time delays in electronic circuits.

## Databank access proposal abandoned by FCC

The FCC's decision to drop its proposal to impose charges for access to on-line data banks was applauded by the Consumer Electronics Group of the Electronic Industries Association's (EIA/CEG) in a recent news release.

The FCC had, in June 1987, issued a notice of proposed rule-making that would have treated modem-accessible database providers (for example, CompuServe) as if they were common carriers. This would have increased costs for both database providers and database users, and would have, in the words of the EIA/CEG, "dramatically increased the cost of using a home computer."

Bowing to strong industry and Congressional opposition, the FCC stated on March 16, 1988 that it would withdraw its proposal for the database access charge. R-E



**ELECTRON-BEAM EVAPORATION SYSTEM** is being prepared to deposit a zirconia buffer and superconducting film on silicon chips by co-developers Larry G. Turner and Dr. Antonio Mogro-Campero.



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# VIDEO NEWS



**DAVID LACHENBRUCH,**  
CONTRIBUTING EDITOR

• **Enforcing Macrovision.** The VHS video-recorder group has recognized Macrovision—in a way.

Macrovision is the process designed to keep VCR's from making copies of copyrighted prerecorded movie cassettes. A recording made using the Macrovision process can fool the AGC circuit of most VCR's into thinking it's a non-standard signal, while not generally affecting the AGC of most TV sets. It's estimated, however, that Macrovision foils only about 75 percent of the VCR's, and often causes distortion during playback of even legitimate tapes. Also, the system is relatively easy to defeat by using reasonably inexpensive picture clarifying black boxes, which have been widely available.

Now Macrovision Corp., with the cooperation of the Motion Picture Association of America and the Japanese VCR interests, has embarked on a campaign to eliminate the capability of defeating the system.

A little-known "recommendation" was sent out last year by JVC, which holds the patents on the VHS system, urging its licensees to adopt standards on the response of the luminance-signal AGC so that their products are unable to copy Macrovision-treated tapes. It's understood that all licensees except one have agreed to the change.

At the same time, Macrovision began a legal crackdown on the so-called "defeat boxes," filing suit against manufacturers and threatening distributors and retailers who carry them. They are basing their suit on the grounds that its patents cover methods of defeating the system as well as the system itself. That aspect of Macrovision's patents has not been tested in court, but the company has achieved some success in causing the "defeat boxes" to be removed from the market.

Behind the campaign is the Motion Picture Association of America, which has endorsed Macrovision and given up its quest for anti-copy legislation, presumably in exchange for eliminating the existing technical loopholes in Macrovision's coverage.

• **Digital VTR age.** Digital recording has come into the television industry with the deliveries of digital videotape recorders to TV stations being made by three broadcast-equipment manufacturers—Ampex, Hitachi and Sony. Although Sony has been delivering component signal digital recorders (the so-called D-1 type) to teleproduction companies for some time, their price has been close to \$200,000 each, generally beyond the reach of most TV stations.

Now the three companies have adopted the Ampex-developed D-2 system which makes a composite recording and sells for less than half the price of the D-1. The D-2 system is expected to replace the current "Type-C" analog VTR's as the standard for broadcasting. The advantages of the new D-2 machines are picture quality far beyond that of any comparably priced unit to date and the ability to make at least 20 generations of copies with no noticeable deterioration.

• **A "Foreign" Industry.** The call for a "new" American TV industry comes at a time when the existing so-called "American" TV industry has passed largely into foreign hands. Although more than 20 manufacturers have television-assembly plants in the United States, almost all of them are Japanese, Korean, or European owned. With the sale of RCA/GE Consumer Electronics to Thomson of France, there is only one major TV manufacturer still American owned—Zenith.

The picture-tube industry is also rapidly becoming foreign-owned. Ten years ago, all picture-tube manufacturers were American. Today, as in TV-receiver manufacturing, Zenith is the only American-owned picture-tube manufacturer left in North America. The others are RCA (Thomas of France), Philips (Netherlands), Sony (Japan), Toshiba-Westinghouse (50% Japanese), Mitsubishi in Canada (Japan), and Japan's Matsushita ready to build new tube plant. Even the picture-tube glass industry seems to be slipping into foreign hands. One of the two major companies in that industry, Owens-Illinois' TV glass operation, has sold half of themselves to Nippon Electric Glass. **R-E**

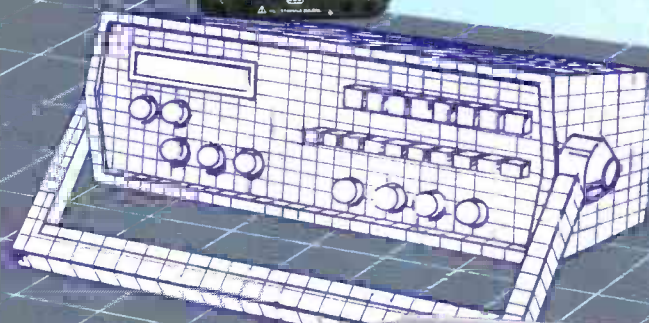


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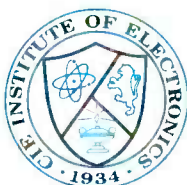
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Farmingdale, NY 11735

## IBM VIDEO

I'm confused about the different video cards and monitors that are available for the IBM PC and compatibles. Could you explain what the standard is for IBM video and tell me which monitors go with which cards. I've also heard that a color TV can be used as a monitor; is that so?—H.C.Y, Charleston, SC

The reason you're confused is that you're using the word "standard" when referring to IBM video. It's not that there isn't a standard, the problem is that there are several of them. When IBM entered the home-computer market, there were established standards for video, serial interfaces, disk drives and formats, and other computer peripherals. IBM, for reasons only they understood, decided to ignore all of them—including the ones for video.

The technical data that you need to understand the differences between the various types of IBM video is summarized in Table 1. Most video standards keep the vertical frequency at 60 Hz to avoid trouble from the powerline frequency. If you paint frames on the tube at a different rate, you stand a good chance of having your TV

beat against the line frequency and having interference show up on the screen. Given a fixed vertical rate, the only way to get more horizontal lines on the screen is to draw them faster—and more lines per frame means more resolution in the displayed image. It's simply a matter of arithmetic.

IBM started out with a TTL monochrome display that uses a horizontal-scan rate of 18.432 kHz. The display is denser and more attractive than that of computers that put out video at the NTSC standard of 15.75 kHz, but you need a monitor that could lock at that frequency. IBM introduced the Color Graphics Adapter (CGA) in response to the demand for color and graphics. It uses the NTSC video standard of 15.75 kHz, but requires a monitor that can accept TTL-level signals for the red, green, and blue video signals and the resolution when working with text is terrible. The 21.8-kHz scan rate of the Extended Graphics Adapter (EGA) delivers much better resolution for that type of application; it, too, delivers TTL signals. The new VGA standard uses the higher rate of 31.5 kHz (twice the NTSC color standard),

and generates 16 colors—you can get a deep red, a pale pink, and several shades in between.

Keeping all of that in mind, you have to make sure that the monitor you buy can lock to the horizontal scan frequency of the card you own—if you drive a monitor with a higher scan frequency than it can handle you'll damage the monitor. And there's no compatibility at all between digital TTL and composite (color TV) video. You can't easily feed a regular TV with computer video unless the output is really close to the NTSC standard of 15.75 kHz. Some CGA cards have composite video outputs that can be fed to an RF modulator. That's fine for graphics work, but trying to do 80-column word processing on that type of setup is only beneficial to your eye doctor.

## DIRECTION-FINDER ANTENNA

I am trying to develop a transmitter-locator system that does not require an antenna array and the calculations that must be made when determining the vector of a transmitter. Perhaps you can suggest a system similar to those used in wildlife tracking.—G.P.R., Salt Lake City, UT

The type of antenna system most suitable for your transmitter-locating project will depend largely on the frequency and power output of the transmitter, and on the distance from the locator at the start of the search.

I have seen several "nature" specials on TV where a wild animal or a bird, such as the bald eagle, is tracked as it roams its natural habitat. In all the cases I've seen, the tracker or trackers, used hand-held Yagi antennas of four or five

TABLE 1  
IBM VIDEO STANDARDS

VIDEO TYPE	ACRONYM	COLOR	SCAN RATE
MONOCHROME DISPLAY ADAPTER	MDA	MONOCHROME	18432 kHz
HERCULES GRAPHICS ADAPTER	HGA	MONOCHROME	18432 kHz
COLOR GRAPHICS ADAPTER	CGA	8	15750 kHz
ENHANCED GRAPHICS ADAPTER	EGA	16	21800 kHz
PROF. GRAPHICS ADAPTER	PGC	256	30480 kHz
VIDEO GRAPHICS ARRAY	VGA	256	31500 kHz



with incoming signal (transmitter on the bird being tracked) being fed to a meter as a signal.

Recently, area Boy Scout and Civil Air Patrol cadets participated in a training exercise simulating the location of a downed aircraft. In that case, the equipment used by the scouts and cadets to locate the "scene of the crash" was similar to that used by wildlife researchers.

Ferrite-rod and loop antennas can be used in direction-finding. Ham operators often use them for close-in work on hidden-transmitter hunts—often called "Fox" or "Bunny Hunts". Consult back issues of *QST*, 73, and other amateur-radio magazines for articles on equipment for direction finding and hidden-transmitter hunts.

#### PA SPEAKER PLACEMENT

The new PA system in our church has only two speakers. Each is about 18 inches wide and about six feet tall. The enclosures are mounted

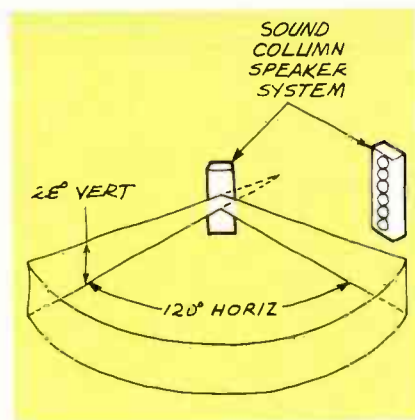


FIG. 1

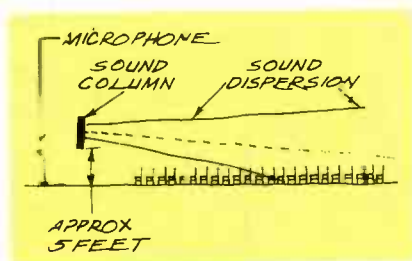


FIG. 2

vertically high on the front wall, close to the side walls. I questioned the installer and suggested that we

could get better results with the longest dimension running horizontally. The "sound expert" insisted that he was right and that the speakers—he called them "sound columns"—are always mounted with the long dimension vertical. Is he correct?—E.B., Greenville, NC

Yes, he is! Sound columns are designed for theaters, churches, arenas, and auditoriums where there is a need to cover a large area with a minimum number of speakers. A sound column usually consists of several cone speakers in a rectangular enclosure, as shown in Fig. 1.

Most of the energy from a sound column is radiated in a highly directional beam pattern. Typically, the radiation pattern from a sound column covers about 120° horizontally and 25° vertically. The enclosures are mounted so that any microphones are below the high-energy portions of the fan-shaped sound distribution pattern, while delivering equal loudness to all listeners in the room. That is illustrated in Fig. 2.

R-E

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# LETTERS



## ADDRESS CORRECTION

In "Hardware Hacker" in the April 1988 issue of *Radio-Electronics*, we inadvertently printed the wrong address for Melles Griot. The correct address is Melles Griot, 2251 Rutherford Road, Carlsbad, CA 92008; phone (619) 438-2131.—Editor

## GOOD KNIGHT

Concerning the article "Electronic Knighthood" in the April 1988 issue, we have since learned that our prototype knight does not match the circuit that was shown.

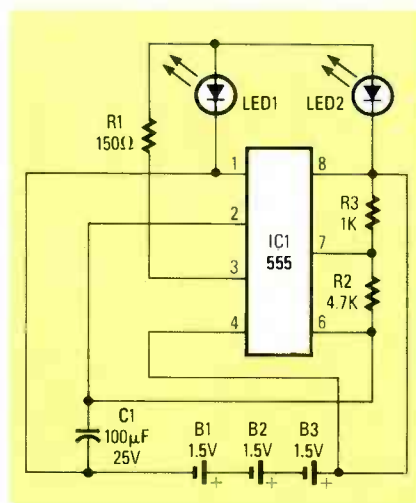


FIG. 1

The correct circuit is shown in Fig. 1, and we apologize to anyone who may have had trouble guarding their castle.—Editor

## MORE ON THE MACRO SCRUBBER

When I built the Macro Scrubber (*Radio-Electronics*, December 1987), it would not work, due to the 14-μs window that permitted some of the Macro Vision pulses to pass. The circuit shown in Fig. 3 is a quick, simple solution I devised to

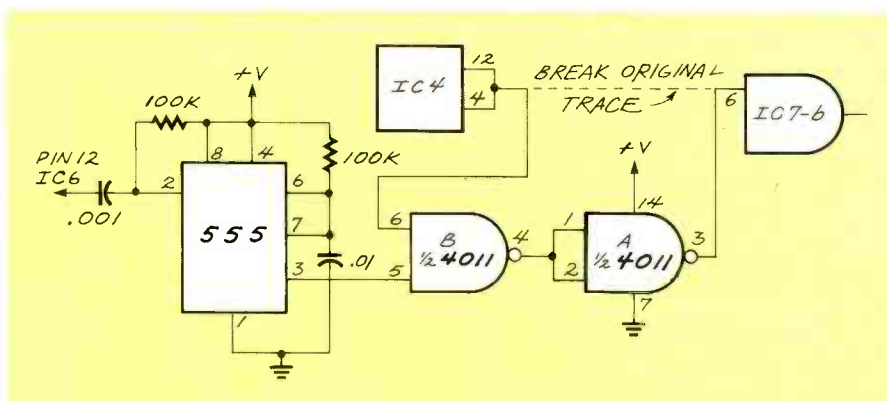


FIG. 2

prevent a total redesign and rebuild of the already-constructed project.

First I increased the oscillator frequency to 5.9 MHz. That narrowed the window to prevent any Macro Vision pulses from passing. The unfortunate result was slight, unwanted pulses on each line into the video coming from IC4. To prevent those pulses from showing up in video, I built the circuit in Fig. 2 to gate out IC4's output during the normal video lines.

I used a 555 one-shot triggered from IC6, pin 12 to "gate in" the output from IC4, pins 12 and 4, to allow IC4 to be active only from the start of serration pulses to the start of picture video. One more gate was used as an inverter in order to restore the proper logic level to IC7-b, pin 6.

The circuit uses easy-to-find parts that I already had, and was built on a small board that was simply wired in. The intent of the modification was a quick and easy answer to a problem. The result of the modification turns out to be acceptable—but not absolutely perfect—video.

ROBERT MASLAK  
Johnstown, PA

## MACRO SCRUBBER UPDATE

I purchased the kit and built the "Macro Scrubber" that appeared in the December 1987 issue of *Radio-Electronics*. The project is very good, and I'd like to share some changes I made to the circuit with other readers.

The input is shown as not terminated and the input and output levels shown in the article are measured with both input and output unterminated. That is not normal video practice. The input should be terminated in a 75-ohm resistor added across J1. That will then maintain the usual 1-volt level when the unit is inserted into a video system.

Resistor R24 is necessary and the adjustment is somewhat critical. With the supplied resistors and a 1-volt video level monitored on a

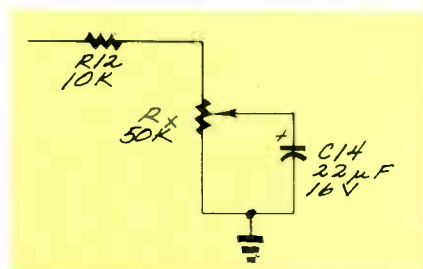


FIG. 3



television-waveform monitor, a quick dark-to-light scene transition would certainly cause lines in the picture.

The DC level of the reinserted lines 12 to 19 was about 40 IRE in my unit. The components all checked OK and the input clamp was right at 0.2 volts, as specified in the article. Adding a 50k potentiometer after R12, as shown in Fig. 3, lets me trim the level to match the video signal.

W. BLAKE HAWKINS  
Atlanta, GA

#### MORE ON FREQUENCY STANDARDS

It's disappointing when a usually up-to-date magazine like **Radio-Electronics** presents readers with out-dated information.

In your April issue, the author of "TV-Derived Frequency Standard" asserts that there is a difference in time-base accuracy between network-originated and locally-originated programming. That is no longer true at any television station with which I am acquainted.

The difference has disappeared due to the emergence of a box called a frame synchronizer. As you know, a television signal is basically a serial-analog medium, where pictures are sent a line at a time. In order to do any kind of video special effects—such as a dissolving between two pictures or superimposing letters over a picture—all the video sources involved must be exactly synchronized to one another. Within a station, that is accomplished by feeding a reference signal developed in a master synchronizing generator to all equipment. The problem comes in dealing with out-of-house sources—such as when you need to superimpose your station's call-sign over a network sports program for a station identification. There is no way that all the synchronizing information from the network is going to be timed to within a couple of nanoseconds of your house sources by pure coincidence.

In the old days, timing was dealt with by slaving the station's master

sync generator to the incoming network video—a process known as "genlock." There are problems with that. One obvious impossibility is presented if you want to switch between network, local sources, and a remote truck. The sync generator can't be slaved to both the network and the remote truck at the same time.

Enter digital electronics: A frame synchronizer digitizes an incoming video signal—often at the rate of 14 million analog-to-digital conversions per second—and stores a full frame's worth of video information in RAM memory. The input clock is derived from incoming video. The picture in RAM is then clocked out and reconverted to analog video by an output clock that is derived from the station's master sync generator. Thus, instead of slaving the station to the remote, we have a way of converting a remote source into a local signal that can be manipulated like any other local signal.

That, incidentally, is why pictures sometimes start to lose lip

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sync even on a live broadcast—each synchronizer in the signal path introduces at least a one-thirtieth-of-a second delay. (Some synchronizers store the full four fields required for an NTSC color frame, and introduce a total delay of one-fifteenth of a second.) To compensate for that small delay, audio-delay devices are available that can be controlled by frame synchronizers.

Frame synchronizers are quite prevalent in the broadcast indus-

try. The NBC Ku-band earth-station package, by means of which affiliates receive network programming, comes complete with synchronizers.

Since synchronizers are driven by the station's sync generator, there is no longer a timing difference between local and network programming. The networks' rubidium standard is not put directly on the air. FCC regulations require that our 3.58-MHz oscillator be within 10-Hz accuracy,

and in practice we try to maintain much closer tolerance than that.

Hope this helps put to rest what has now become an old wives' tale.

JAMES BRODSKY  
KBSY-TV  
San Luis Obispo, CA

#### COMPUTER VARIETY

I don't know whether to be mad or disappointed but I'm not going to let it slide anymore! For over a year I have owned an Atari 520ST personal computer and I still can't believe I got all that machine for the price. For \$750.00 I got a 16-bit computer with a number of standard features (512K RAM, DMA, serial, parallel, and midi in and out ports, cartridge slot, and 2 joystick/mouse ports). The price also includes a RGB monitor, 3½" disk drive, and a mouse.

It's a Macintosh, but with a bigger color screen and with quite few more standard features—at a fraction of the cost. There is a cartridge available for the 520ST that will let you run quite a bit of Macintosh software. The disk drive uses the same format as IBM, so you can access IBM data files from current ST programs such as *Word Perfect*, *dbMan* (a *dBase* copy), and *VIP* (an exact *Lotus* clone) without any modifications. Attach a currently available 5¼" drive and a program called *PC Ditto*—you now have an IBM clone.

A large number of quality programs are now available for the ST, and that number is growing daily. When you combine that with all the Mac and IBM software you can run on it, one question comes to mind: Why are people flocking to buy IBM clones? They must pay seven or eight hundred dollars and up, and still have to spend more more more for adding things that are all standard on the ST.

My conclusion is not that people are narrow-minded or brain-washed with IBM—they just don't know about the alternatives.

What finally blew my fuse was Jeff Holtzman's article on desktop publishing (*ComputerDigest*, February 1988) which failed to mention the new Mega ST's (2 or 4 meg standard) which, combined with Atari's own laser printer (under \$3700.00 retail for both), makes an



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excellent and quite professional desktop publisher. The article didn't mention any of the current desktop publishing programs for the 520ST and a dot matrix or laser printer.

There was the same lack of information when I read of the CD-ROM player for the IBM. I believe it was around \$1200.00—compared to the \$599.00 price tag of Atari's, which has comparable features.

There is a lot more information about the ST, but nobody seems to know about it and they are losing out. Does your magazine purposely not review Atari equipment for a particular reason, or due to lack of knowledge about it? If a review is what you need, I would be glad to do it.

CARL KONA  
Birmingham, MI

*Mr. Kona has a legitimate concern, but there are several problems with covering Atari (and other) systems. First is that the editors grew up on CP/M systems and later moved to MS-DOS systems.*

*Does that mean we've been brainwashed by IBM? No, it doesn't. It means that, even though there are many systems—including the Atari—that on technical merit alone deserve coverage, in a world of limited resources (i.e., time), one simply can't learn about every system on the market.*

*Another problem is that our surveys indicate that the vast majority of readers (80%) use MS-DOS systems. It would not be fair to them, even if we had the expertise, to devote large amounts of space to other systems.*

*On the other hand, we do try to broaden our readers' horizons; Peter Stark's series on the PT-68K system is a case in point. It has proved popular with a small but vocal and dedicated group of readers, who want to build the computer; with other readers, who want to understand, by comparative means, their own non-68000 systems better; and with yet other readers, who simply want to learn about other system designs. Based on past experience, obtaining*

*from Atari the kind of technical detail that Mr. Stark presents would be impossible.*

*Mr. Kona's description of the 520ST's "compatibility" with both the Macintosh and the IBM PC family sounds fascinating, but again based on past experience, we're skeptical. Over the years we have seen many products that claim magically to transform product X into product Y, but seldom have we seen a truly seamless, bug-free hybrid that imposed no performance or convenience penalties. Adding a simulated Rolls Royce front end to a Volkswagen Beetle simply does not make the Beetle a Rolls.*

*As for desktop publishing, it may be true that Atari offers a better hardware platform, but that's not the point. Can the Atari run PageMaker or Ventura Publisher? If not, do truly comparable programs exist for the Atari? It's possible, but unlikely. It's a fact that Atari has never penetrated the U.S. business market (Europe is*  
*continued on page 31*

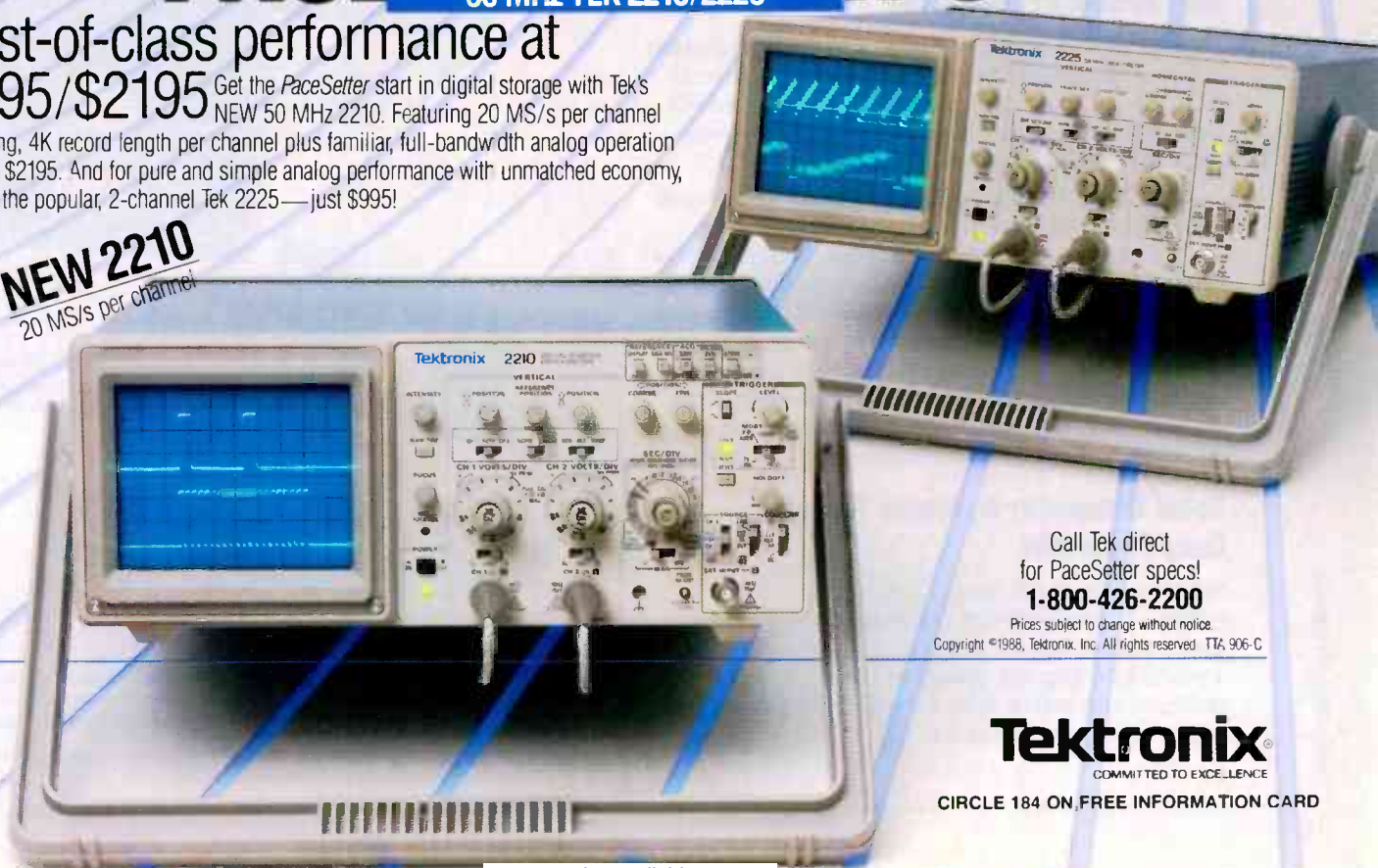
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# EQUIPMENT REPORTS

## Philips ECG RCT7501 Remote Control Tester

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EVEN IF YOU AREN'T A TV SERVICE TECHNICIAN, we're sure that there have been times when you wished for some way to test a remote-control transmitter. Since humans can't see the infrared light, and can't hear the ultrasonic signals emitted from such transmitters, troubleshooting remote controls systems has been a guessing game. The odds of winning, of course, are not in your favor.

We recently found a way to increase your odds at winning the remote-control guessing game: a new remote-control transmitter tester, the model RCT7501 from Philips ECG, Inc. (1025 Westminster Drive, P.O. Box 3277, Williamsport, PA 17701). The RCT7501 can be used to test both ultrasonic and infrared remote controls.

We tested the RCT7501 with a good assortment of transmitters, including TV, cable, compact-disc, stereo, VCR, satellite TV, and even computer-keyboard remotes. The tester had no problems detecting signals from any of those transmitters, and no false triggering was noted.

### The simpler the better

The RCT7501 is one of the simplest of test instruments. Its circuitry consists of an infrared detector, an ultrasonic transducer, amplifying transistors, and a pulse stretcher. The only control is a power switch. When the detectors sense infrared or ultrasonic signals, a green TEST LED lights, and remains lighted for about 1 second after the signals cease.

No test instrument could be easier to use for go/no-go tests. Simply turn the tester on, and aim the suspected transmitter at it. When you press a key on the transmitter, you should see the green LED light. If all the other transmitter keys also give positive results, you should assume that the receiver is at fault. If you need to do further testing of the remote, a SCOPE/COUNTER test jack is provided on the side of the tester. (A cable is included.) That lets you view the received signals on an oscilloscope or measure the frequencies on a meter. If you know what signals you should expect, that feature can be an invaluable troubleshooting aid. A sample I-R

test signal is shown in Fig. 1.

The tester is a perfect example of what a shirt-pocket tester should be. It's about 4½ inches long, a little more than an inch wide, and about ¾ inch thick. The power switch is located on one side, opposite the SCOPE/COUNTER jack. The red POWER and green TEST LED's are on the front panel, and the infrared and ultrasonic detectors are on the top end.

The RCT7501 remote-control tester is available from Philips ECG for \$49.95. (Call 1-800-225-8326 for their distributor nearest you.) We were impressed by the sensible, rugged tester and recommend it highly.

### Another tester

As we were finishing our review of the Philips ECG RCT7501 remote-control tester, we got a chance to evaluate a similar tester from Cableserv Electronics (18 Dufflaw Road, Toronto, Ontario, Canada M6A 1C8). Their tester, the Celtron-1, is shown in Fig. 2. It works similarly to the Philips unit: You simply turn it on, and aim a remote transmitter at it. If the transmitter is outputting infrared or ultrasonic signals, a green LED will light. The Celtron-1 includes an output jack for connection to a frequency counter or oscilloscope. No cable, however, is supplied with the tester.

The Celtron-1 offers a couple of

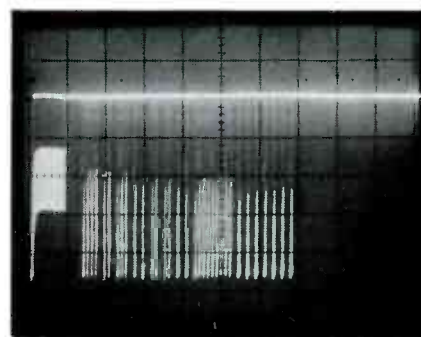


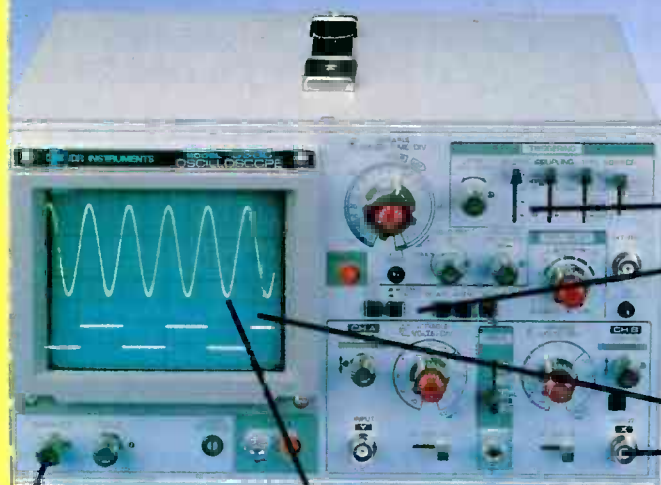
FIG. 1





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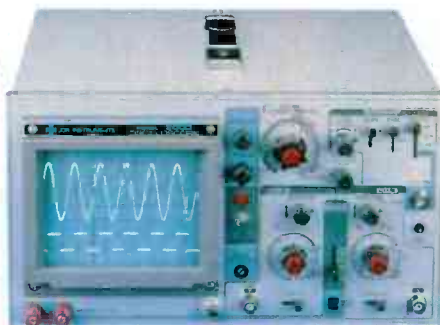
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- Transistor Tester: 0°–2000°F
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Perfect for the field service technician. Shirt pocket size without compromising features or accuracy. Large, easy to read 1/2" LCD display. Fully overload protected for safety. 2000 hour battery life with standard 9v cell. Probes and battery included.

- Basic DC accuracy: plus/minus 0.5%
- DC voltage: 2V–1000V, 4 ranges
- AC voltage: 200V–750V, 2 ranges
- Resistance: 2k ohms–20M ohms, 4 ranges
- DC current: 2mA–2A, 4 ranges
- Input impedance: 10M ohm
- Fully overload protected
- Approx. 5" x 3" x 1". Under 7 ozs.



### DMM-200

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#### 3.5 DIGIT FULL FUNCTION DMM

Get highly accurate performance at a very affordable price. Rugged construction, 20 amp current capability and 22 ranges make it a perfect choice for serious field or bench work. Low battery indicator and 110/220V. Probes and 2000 hour battery included.

- Basic DC accuracy: plus or minus 0.25%
- DC voltage: 200mV–1000V, 5 ranges
- AC voltage: 200mV–750V, 5 ranges
- Resistance: 200 ohms–20M ohms, 6 ranges
- AC/DC current: 200 $\mu$ A–20A, 6 ranges
- Input impedance: 10M ohm
- Fully overload protected
- Approx. 7" x 3 1/2" x 1 1/2". Wt. 11 ozs.

### DPM-1000

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#### 3.5 DIGIT PROBE TYPE DMM

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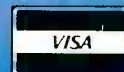
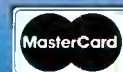
- Basic DC accuracy: plus/minus 1%
- DC voltage: 2V–500V, autoranging
- AC voltage: 2V–500V, autoranging
- Resistance: 2k ohms–2M ohms, auto ranging
- Fully overload protected
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features that the Philips unit does not. First, a piezoelectric transducer beeps to indicate the receipt of a signal, so you don't even have to look at the tester to know that your transmitter is working. Also, you cannot forget to turn the unit off. In fact, there is no off switch—



FIG. 2

the Celtron-1 turns itself off after about 30 seconds.

While we liked the added features and the slightly better sensitivity of the Celtron-1, we did not feel that it was constructed nearly as well as the Philips ECG unit. The Celtron 1 is available for \$89. R-E

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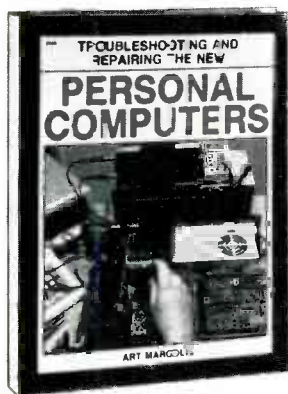
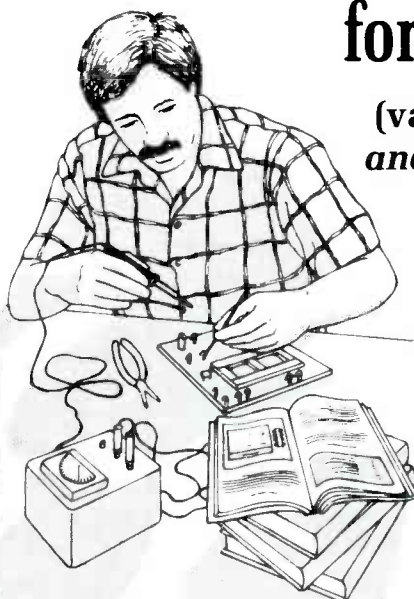


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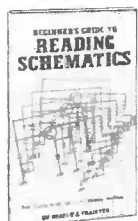
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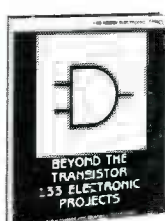
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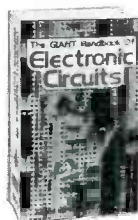
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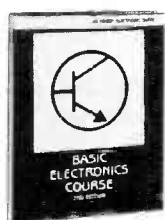
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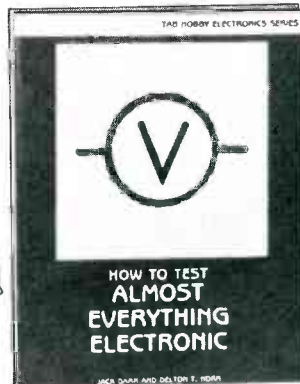
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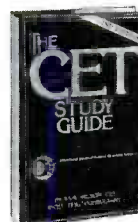
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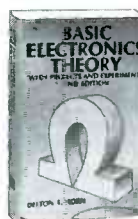
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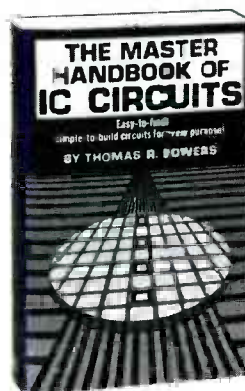
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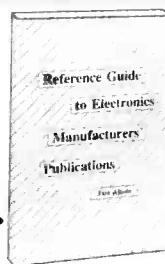
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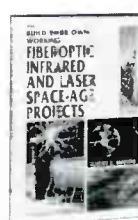
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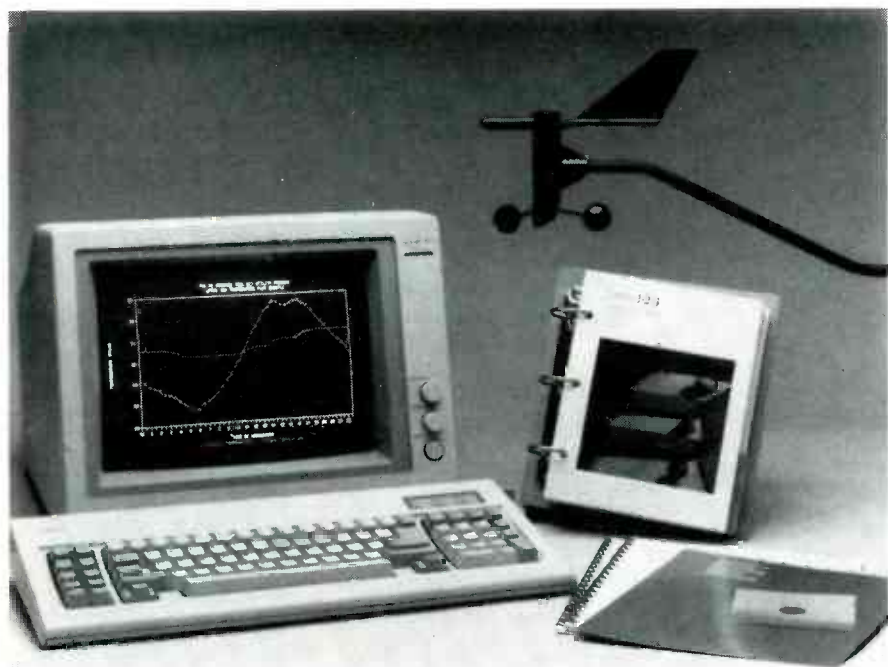


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# NEW PRODUCTS



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## WEATHER-STATION SOFTWARE.

When we reviewed the *PC Weather Pro* ("Equipment Reports," *Radio-Electronics*, March 1988), we mentioned that Technology Marketing Inc. was planning to introduce a tool and utility kit. Their new *PC Weather Toolkit*, as it turns out, does all that we'd hoped it would.

It links data gathered by the PC-based weather station with such popular programs as *Lotus 1-2-3* and Borland's *Reflex* database. *PC Weather Tool* also generates files in standard formats—DIF (Data Interchange Format) and ASCII—that are readable by other software products, such as *dBASE III*.

*PC Weather Pro* monitors and stores data on barometric pressure, rainfall, inside and outside temperatures, and wind-chill temperature. Now, using *PC Weather Toolkit*, that data can span any time frame specified by the user. Once

linked to a specific software program like *Lotus 1-2-3*, files can be displayed in any graphic format that happens to be supported by that program. Also included is a utility called *File Link Software*, which enables data from *PC Weather Pro* to be read into variables in programs written in *Turbo C*, 8088/86 assembly language, *Turbo Pascal*, or *BASIC/GW BASIC*. Using that utility, a variable such as "windspeed" can be automatically updated every minute.

The package also includes utilities for editing, merging, and translating weather-data files, documentation software, and *File Link Software* for one language, selected by the user. *PC Weather Toolkit* is priced at \$150.00; *File Link* software for additional supported languages is available for \$50.00.—**TMI**, Inquiries Manager, 4000 Kruse Way Place, Bldg. 2, Suite 120, Lake Oswego, OR 97035.

**LOGIC MONITOR.** The model *AR-80LM*'s custom-IC design automatically detects both power and ground pins. Monitor usage is a simple, clip-on-and-view operation. Both TTL and CMOS logic levels are also detected automatically by the Logic Monitor.



CIRCLE 11 ON FREE INFORMATION CARD

The unit will indicate a logic-high, logic-low, and pulsing inputs. For pulses with repetition rates over eight Hertz, the unit flashes the LED at an 8-Hz rate. Pulses up to 40 MHz can be detected.

The *AR-80LM* logic monitor sells for a suggested price of \$79.00, which includes a storage case and an operator's manual.—**ARI Media**, 9241 E. Valley Boulevard, Suite 201, Rosemead, CA 91770.

**GANG/SET PROGRAMMER.** Logical Devices, Inc. announces the *Husky*, a fast device programmer that uses that company's "Intellegent" and "Quick Pulse" algorithms to program up to four 1-megabit EPROM's, most in less than three minutes. The *Husky*





CIRCLE 12 ON FREE INFORMATION CARD

uses an ultra-efficient switching power supply to minimize the power load on the PC.

The four 32-pin zero-insertion force (ZIF) sockets support gang programming and sequential set programming of up to four 24-, 28-, or 32-pin EE/EPROM's DIP's. With optional adaptor sockets, Husky supports single-chip microcomputers, CMOS EPLD's, and other devices in PLCC/PGA packages. Husky accepts Intel hex, Motorola hex, ASCII hex, or binary formats. As a software-driven programmer, Husky can be under cursor or mouse control, and supports DOS-level file manipulation and directory utilities. It is priced at \$595.00, including the IBM PC interface. An additional IBM PC interface is available for \$99.00, PAL adapter for \$75.00, and the single-chip microcomputer adapter costs \$125.00.—**Logical Devices, Inc.**, 1321 N.W. 65th Place, Fort Lauderdale, FL 33309.

**PHONE CALL RESTRICTOR.** The Telelock TL-16 from Serret Systems prevents the unauthorized use of telephone and/or data communications equipment. The user has the option of restricting all outgoing calls, or only long distance, Operator, or specific prefix-number calls. Restriction override is performed by entering a user-programmable, three- or four-digit access code via the telephone dial or keypad. The save and relock



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codes—also programmable by means of an internal switch—allow authorized persons the option of overriding the call restriction; a special circuit prevents any fraudulent entries.

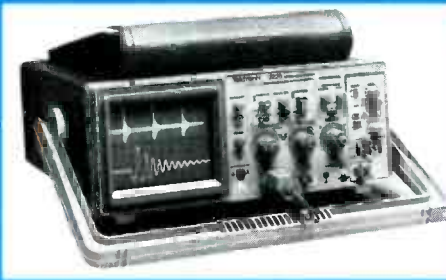
A single TL-16 can control any number of telephones on the same line. Other features include multicolor LED status indicators, DTMF and pulse operation, and non-volatile memory. The FCC-registered Telelock TL-16, has a suggested retail price of \$149.95,

including two modular connectors for easy installation.—**Serrett Systems**, P. O. Box 728, Rye, NY 10580.

**MINIATURE DMM.** Beckman Industrial's credit-card-sized Circuitmate DM79 features automatic shut-off and auto-ranging. Its many functions include 5 DC-volt, 4 AC-volt, and six resistance ranges, in addition to continuity and diode checks. A special 320 millivolt range offers very high input impedance (>100 Megohms)

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MODEL 2245 MODEL 2246

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### FAMOUS TEK 2200 SERIES 60/100 MHz DUAL CHANNEL SCOPES

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for minimum circuit loading. The DM79 offers DC-volt accuracy to 0.35%, instrument overvoltage protection to 700 volts, and also case insulation to 2000 volts.

Complete with an operator's manual, built-in test leads, and a carrying case, the DM79 lists for \$49.95.—Beckman Industrial Corporation, 3883 Ruffin Rd., San Diego, CA 92123-1898.

VCR IDLER TIRES KIT. Until recently, a worn-out rubber tire in a VCR's idler assembly, clutch and pulley assemblies, or take-up assemblies necessitated replacing the entire assembly. Now, Parts Express is offering a comprehensive



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VCR Idler Tire Kit, containing 10 each of 15 different sizes. The kit includes a cross-reference chart listing over 80 manufacturer assembly parts-numbers, and over 200 models. The kit sells for \$55.00, with storage case.—Parts Express, 340 East First Street, Dayton, OH 45402.

S-M DEVICE REMOVAL UNIT. OK Industries presents the model SMT-W2, which is a hot tweezer for the removal of surface-mount devices; the unit features variable temperature control, and high reliability.

The model SMT-W2 incorporates an ergonomically designed



handpiece that can be held comfortably by any operator, regardless of his or her hand size. Two 8-watt ceramic heating elements provide exceptional temperature stability and sufficient power to remove any surface-mount device, from chip resistors



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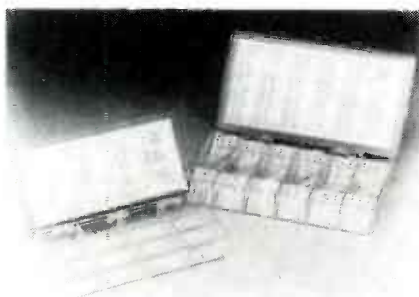
to large quad packs.

A full range of tips are available, including 5-mm tips for resistors or capacitors, mini-flats for SOIC's and right-angle tips for PLCC's to 84 pins. The model *SMT-W2* is priced at \$425.00.—**OK Industries, Inc.**, 4 Executive Plaza, Yonkers, NY 10701.

**CHIP RESISTOR AND CAPACITOR KITS.** Communications Specialists has introduced two kits: The model *CR-1* chip-resistor kit, and the model *CC-1* chip-capacitor kit. Both kits are intended as prototyping kits, but are also useful as parts kits for both repair technicians and experimenters.

The model *CR-1* contains 1540 pieces, including 10 chip resistors of every 5% value from 10 ohms to 10 megohms (145 values plus zero-ohm jumpers), plus a bonus of 10 additional resistors in eight values (0 ohms, 10 ohms, 100 ohms, 1K, 10K, 100K, 1 megohms, and 10 megohms).

The model *CC-1* contains 365 pieces composed of 5 chip capacitors of every 10% value from 1 pF to

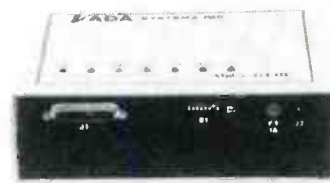


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33  $\mu$ F (67 values) plus a bonus of 5 additional capacitors (1 pF, 10 pF, 100 pF, 1000 pF, 0.01  $\mu$ F, and 0.1  $\mu$ F).

The price for each of the kits is \$49.95.—**Communications Specialists, Inc.**, 426 West Taft Avenue, Orange, CA 92665.

**RADIO/TELEPHONE INTERFACE.** Vada Systems offers the *Alpha-Tel III*, an access system for allowing 2-way radio communications from the desk telephone. The interface provides voice-actuated transmis-



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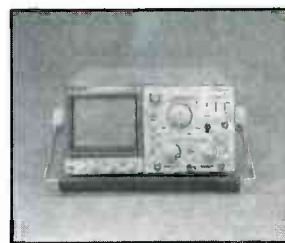
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The *Alpha-Tel III* is compatible with all conventional 2-way radio equipment. It is priced at \$895.00.—**Vada Systems, Inc.**, 9329 Douglas Drive, Riverside, CA 92503.

**LOGIC PROBE.** Global Specialties introduces the model *LP-5*, which is capable of capturing pulses as short as 5 nanoseconds and pulse trains as fast as 100 MHz. The model *LP-5* incorporates both



**CIRCLE 19 ON FREE INFORMATION CARD**

pulse and memory modes, switch-selectable TTL/CMOS thresholds, and three different color LED's for no-mixup troubleshooting.

Like all other Global logic probes, the *LP-5*'s signal inputs are protected against overvoltages, and its power leads are protected from over and reverse voltages. It is priced at \$150.00.—**Global Specialties**, 70 Fulton Terrace, PO Box 1942, New Haven, CT 06509. R-E

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## LETTERS

continued from page 17

another story), and only a business would spend \$4000 on a computer, a laser printer, or both. So how could any software developer make the enormous commitment to develop a serious desktop publishing program, when the potential market is home computerists who have little money to spend, and to whom software pirating is a game, not a breach of ethics?

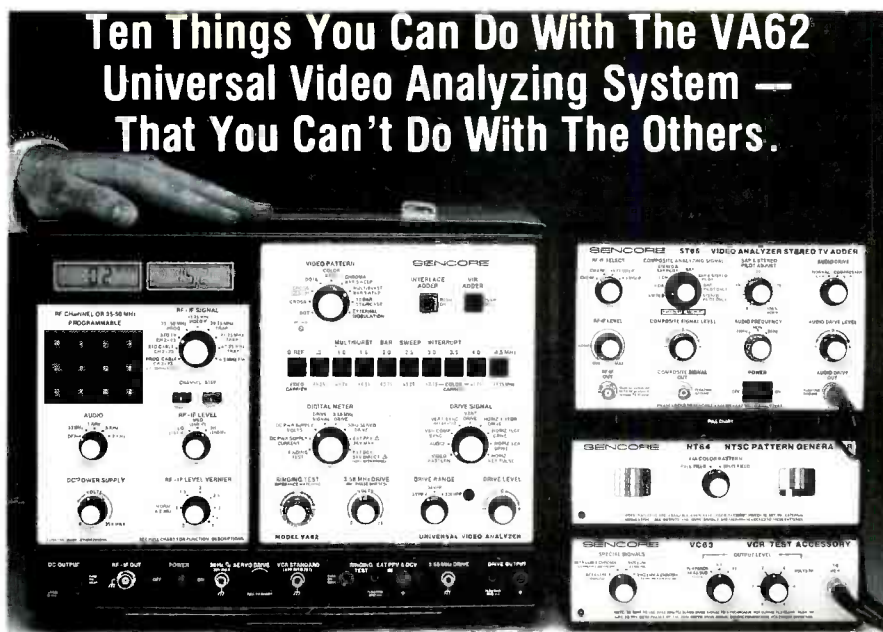
Having said all that, however, we're still fascinated by the Atari. Mr. Kona, here's our challenge: Write us an article that demonstrates your claims. No hyperbole, no IBM resentment, just facts. Tell us what it can do and how it does it. Tell us about the system software that allows it to run Mac software. Tell us what kind of speed degradation occurs, what sorts of incompatibilities arise, what (if anything) works better on the Atari than on the Mac. And do the same for IBM. Then throw in a good dose of technical background on the 520's micro-processor, memory architecture, special sound and graphics IC's, bus speed, DMA capabilities, etc. Sound like a tall order? That's just what you asked us to do!

And likewise with you owners of other systems: If you want to see your system written up, do it yourself, or help us find someone qualified to do it. Contrary to what many readers think, qualified authors are hard to find, especially when it comes to the less-popular systems.—Editor

### MAKING PC BOARDS

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to do a good exposure of the light-sensitive coating. Your exposure time will be correct, without all the guesswork. And also, there's no need to cut up the magazine you just bought.

If you have access to a photocopy machine, you can make your own copies; transparency sheets are available at commercial stationary stores, and elsewhere. However, some cautions should be observed. First, copiers sometimes shrink or distort the original image just slightly. Find one that doesn't, or where the shrinkage is so slight that you won't run into problems with lead spacing when you try to install components. That is especially critical when you are trying to produce a double-sided board.

Liquid-toner copiers operate at cooler temperatures than those that use dry or powdered toner, so there's not much of a chance of the polyester film sheets melting as they pass through the drying process.

In copiers that use dry or powdered toner, however, the fuser uses more heat to melt the toner into the page. If the transparency should get stuck in the fuser for a short time, it can easily be melted. (Some copiers can regulate the temperature.)

Finally, clear transparency sheets should be fed *one-at-a-time* from the paper tray. If you try to stack them in the tray, they sometimes stick—and if they jam inside the copier, they're really hard to get out! If you have your own copier, be sure it can accept transparency sheets, and that you use the correct ones for your specific make and model.

Scratches can be touched up with any type of black paint that doesn't have an acetone, ketone, or lacquer-solvent base. (Those could melt the transparency.) Do the touch-up on the reverse side; that is, the side *without* the toner. If some toner bleeds to an area where it shouldn't be, it can be scratched off.

That sounds much more complicated than it really is. Just use common sense, and you'll get good results with very little effort.

GERALD KOSKE

Wonder Lake, IL

R-E



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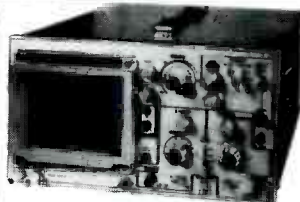
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V-423	40MHz	D.T. 1mV Sens.	Delayed Sweep DC offset	955	795	160
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V-1100	100MHz	Q.T. 1mV Sens.	Cursor meas. DVM counter	2,295	1,995	300
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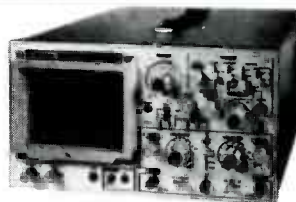


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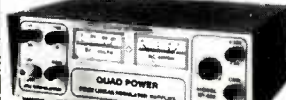
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# NEW IDEAS

## Fingertip Olympics

THIS MONTH'S CIRCUIT IS A GREAT LITTLE game that's ideal for developing hand coordination, or for putting couch potatoes in the mood for the upcoming Olympic games.

The heart of the circuit, which is shown in Fig. 1, is an LM2907 (National) frequency-to-voltage converter. That low-cost IC, which is available from several of the companies that advertise in the back pages of **Radio-Electronics**, provides a voltage output that's directly proportional to the frequency at its input. That frequency is "set" by alternately closing S1 and S2, two normally-open, momentary-contact pushbuttons. The faster they're closed in sequence, the higher the frequency.

The "skill level" of the game is set by R1. The smaller the value of that resistor, the faster you'll have to hit the switches to get a measurable output. As a rule of thumb, start with a value of about 510K; if you find that's too easy, or as you get better, substitute lower-valued

units. You can also use multiple resistors and a rotary switch to set up multiple skill levels.

### Setup and use

Any construction technique can be used to build the unit. But point-to-point wiring on a piece of perforated construction board is probably the simplest. For best play, the switches should be mounted about six inches or so apart, so be sure that you use a big enough piece of board.

To test, set R2 fully counterclockwise (minimum resistance) and tap the switches to make sure that there's an output, as indicated by M1. If there is, you are ready to go.

To play the game, set R2 at about mid-range, then place the unit in your lap or on a table top and begin tapping. Use two hands and go as fast as you can. The faster you tap the switches in sequence, the higher the output current. When you are tapping away at about your

### NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn \$25. In addition, for U.S. residents only, Panavise will donate their model 333—The Rapid Assembly Circuit Board Holder, having a retail price of \$39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.



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personal limit, readjust R2 so that M1 reads about ¾ scale (a friend is very helpful for that). Then start tapping away to see if you can get the meter to go even higher. The game can get very addicting!—**Phil Blake.**

R-E

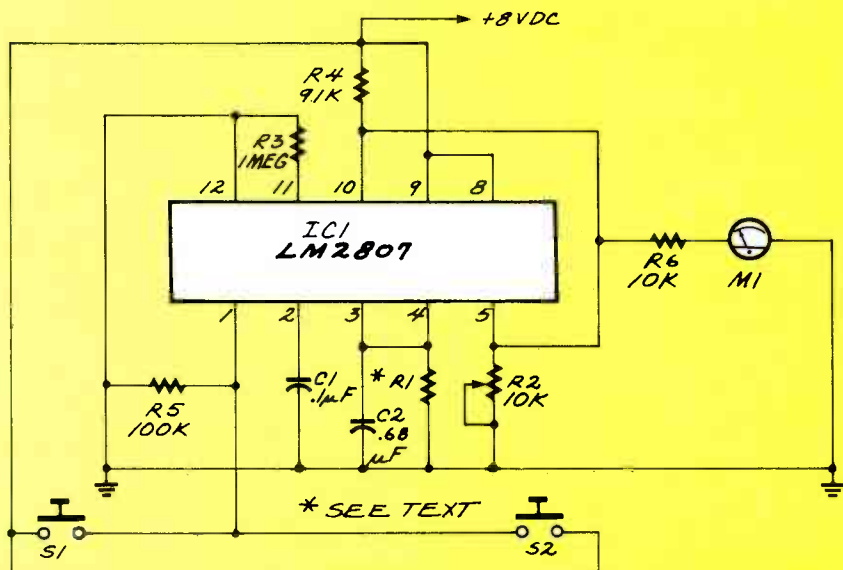


FIG. 1



Authorized

COMB

Liquidator

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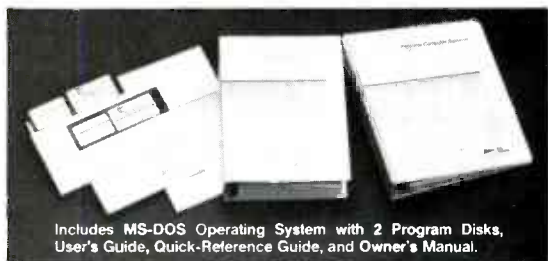
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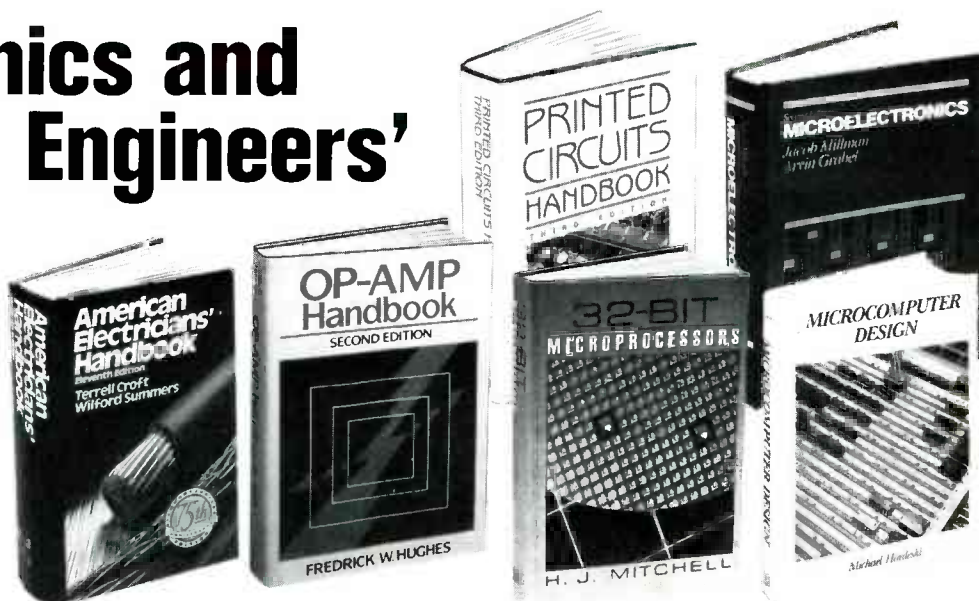
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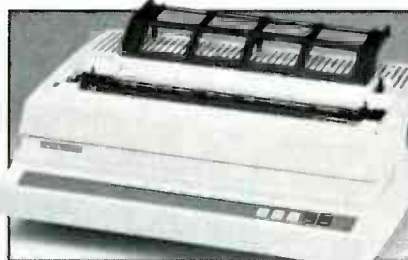
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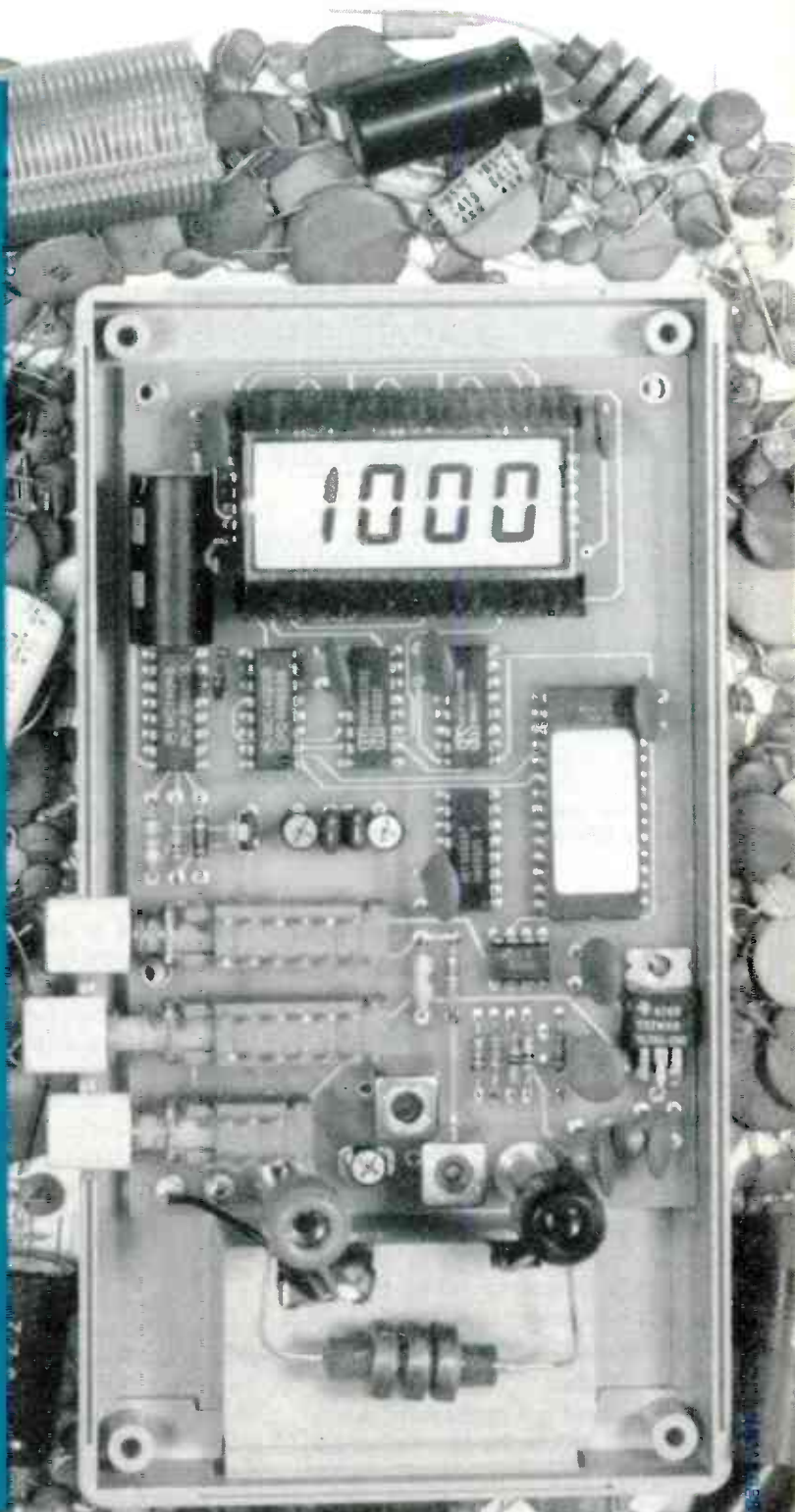
EXPERIMENTERS AND TECHNICIANS WHO WORK WITH RF filters, oscillators, and amplifiers have always needed an economical way to measure the value of small inductors. Generally, the measurement is made by inserting the unknown-inductor into an oscillator circuit having a known, fixed-value capacitor and inductor—a tank circuit. Because the capacitance and inductance are fixed values, a variation in the oscillator's output frequency is determined by the unknown-inductor. Since the oscillator's output frequency can be measured by a conventional low-cost frequency counter, the unknown-inductor's value can be easily computed by using an inexpensive hand-held scientific-type calculator. Similarly, unknown-capacitor values can be determined by again measuring how it affects the oscillator's output frequency.

Although the known-capacitor/inductor measurement technique gives reasonable accuracy for general and experimenter applications, unless extreme care is taken the end result is not what one usually accepts as "lab-grade precision." However, lab-grade accuracy can be attained by using a microprocessor-based measuring device having a built-in RF oscillator.

Whether the measuring device is a home-brew lash-up or microprocessor-based, both make measurements based on the frequency shift caused by the insertion of the component to be measured into the tank circuit of an RF oscillator. For RF circuits, that has the advantage of finding the *apparent* inductance or capacitance value as it would effect an RF tank circuit. The apparent value includes the parasitic capacitance of the inductor, or the parasitic inductance of the capacitor and its leads. That is unlike the typical capacitance meter, which inserts the component to be measured in a relaxation oscillator circuit that ignores inductance.

### Calculating values

Where  $L_x$  represents an unknown inductance, and  $C_x$  represents an unknown capacitance, the formula for calculating the value of a component



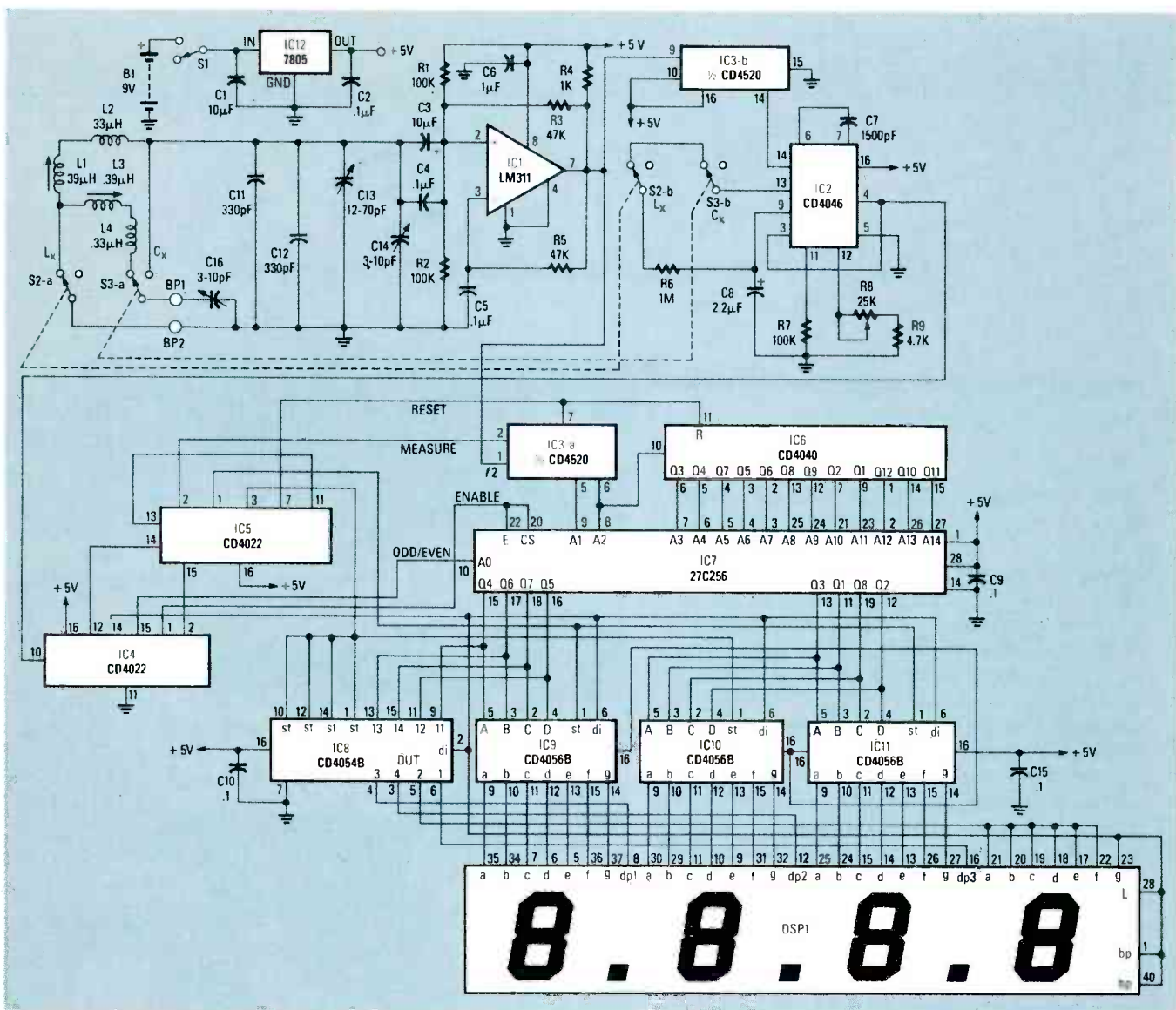


FIG. 1—THE RESULTS FOR ABOUT 15,000 EQUATIONS are stored in IC7, a pre-programmed EPROM. Input information is compared against the EPROM data.

as a function of the frequency shift it introduces into an oscillator tank circuit is:

$$L_x = ((f_1/f_2)^2 - 1) \times L_s$$

where  $L_s$  is the "standard inductor of the tank," or:

$$C_x = ((f_1/f_2)^2 - 1) \times C_s$$

where  $C_s$  is the "standard capacitor of the tank."

In both equations,  $f_1$  is the oscillator's frequency without the unknown component;  $f_2$  is the oscillator's frequency when the unknown component is installed in the oscillator's tank circuit.

### Build a meter

Since there is a mathematical relationship between the known-component and unknown-component oscillator frequencies, to determine the

value of the unknown component we simply need to build some kind of device that measures the ratio between  $f_1$  and  $f_2$ , squares the ratio, subtracts 1, multiplies by the standard value, and then displays the result.

The first approach that comes to mind is the microprocessor device mentioned earlier. Unfortunately, a microprocessor-based instrument is relatively expensive because of its high IC count that includes a CPU, RAM, ROM, Timer, I/O, a display, and a power supply.

A lower-cost approach to a homebrewed L/C meter is a microcomputer that includes all of the functions of the microprocessor-based device in a single IC. Unfortunately, the initial investment would be on the order of \$40,000, which is a tad too expensive for a home-brew project. The newer

EPROM versions of the single-IC devices are reasonably priced, but require considerable expense in support equipment to develop, test, and program the software into the EPROM.

A more cost-effective approach for the hobbyist and technician is the device shown in Fig. 1; a simple frequency-counter circuit that drives an EPROM which is programmed with a large number of solutions to the  $L_x$  and  $C_x$  equations. In that way, all the mathematical functions, except for the frequency ratio, can be done outside the unit on a computer having the necessary capabilities. A 27C256 EPROM will hold 16384 solutions divided into two bytes per solution.

### Circuit description

Since the frequency counter has a fixed resolution in cycles-per-second,



the EPROM contains solutions to the equations that are spaced apart by a predetermined number of cycles-per-second. Because resonant frequency is a function of the square root of inductance or capacitance, the size of the steps between adjacent solutions gradually increase, keeping approximately 0.1% (3 digit) resolution from 0.01  $\mu$ H to 10 mH, or 0.01 pF to 0.1  $\mu$ F. The advantage of that technique is that the unit will be auto-ranging.

Integrated circuits IC8 and IC9, the drivers for the liquid-crystal display (DSP1), are binary-coded decimal, requiring four bits per digit. Therefore, 12 bits are required for a three digit display. In order to provide the floating decimal point that's needed for the dynamic range of range of  $10^6$ , four bits are used to drive both the decimal

point and a fourth digit that is either zero or blank. Therefore, 16 bits are used to provide a direct readout in micro-henries. For capacitors, the displayed value must be mentally multiplied by 10.

The first problem was to design an oscillator that would always start, and which maintained oscillation even with very poor L/C ratios. Most oscillator circuits involve the impedance of the tank circuit in the loop gain, therefore, there are maximum values of L and C that can be used. Also, the normal output of an RF oscillator circuit is usually only a few millivolts, which requires amplification in order to drive the frequency-counting section of the instrument.

As shown in Fig. 2, the oscillator circuit uses a LM311 high-speed volt-

age comparator. Positive feedback from the output to the non-inverting input is provided by R3. The input is biased by R1 and R2 to approximately one-half of the 5-volt supply voltage. The tank circuit selected by switches S2 and S3 is capacitively coupled to IC1 by C3 and C4.

The best way to visualize the oscillator is to assume that IC1's output is a square wave. Driving the square wave into a parallel-tuned circuit through a large resistor (R3) allows the tuned circuit to filter out the sine-wave component of the square wave at the resonant frequency of the tank. (The sine wave will have a maximum amplitude when the square wave is at the resonant frequency.) Applying the sine wave to the non-inverting input of voltage-comparator IC1 produces a square-wave output of the same frequency. That, in turn, drives the tank circuit, resulting in an endless loop of oscillation. Thus, the oscillator runs at the frequency that produces the maximum sine-wave amplitude: the resonant frequency of the tuned circuit.

The inverting input of IC1 must be biased at exactly the same DC level as the non-inverting input in order for the oscillator to work. The R5/C5 RC filter from the comparator's output to the inverting input finds the average value of the square-wave output, which of course should be  $\frac{1}{2}$  the peak-to-peak voltage, which is approximately  $\frac{1}{2}$  the supply voltage. The same RC network is responsible for the starting and running of the oscillator. When power is first applied, the filter's output is zero, which causes IC1's output to be high (near 5 volts). The high charges C5 until its voltage reaches the bias level of the non-inverting input. That causes the output to swing low (near zero volts), putting a transient into the tank circuit, which causes it to ring at its resonant frequency. The ringing causes the output of the comparator to form a square wave of the same frequency which, after filtering by the tank circuit, is fed back to IC1's input to sustain oscillation.

The component to be measured,  $L_x$  or  $C_x$ , is always added to the standard inductor ( $L1 + L2$ ) or standard the capacitor ( $C11-C14$ ) in the oscillator's tank circuit. With the component under test installed, the oscillator's output frequency will always be lower than the frequency without the com-

## PARTS LIST

### All resistors $\frac{1}{4}$ -watt, 5%, unless otherwise noted.

R1, R2, R7—100,000 ohms  
R3, R5—47,000 ohms  
R4—1000 ohms  
R6—1 Megohm  
R8—25,000 ohms, trimmer potentiometer, 0.1"  $\times$  .2" spacing  
R9—4700 ohms

### Capacitors

C1, C3—10  $\mu$ F, 10 volts, tantalum  
C2, C4, C5, C9, C10, C15—0.1  $\mu$ F, 50 volt, ceramic disc  
C6—not used  
C7—1500 pF, 100 volt, Mylar  
C8—2.2  $\mu$ F, polystyrene (Panasonic ECQ-1225KZ)  
C11, C12—330 pF, polystyrene or propylene  
\*C13—12—70 pF, trimmer capacitor (Mouser ME242-1270)  
\*C14, C16—3—10 pF, trimmer capacitor (Mouser ME242-2710)

### Semiconductors

IC1—LM311N  
IC2—CD4046  
IC3—CD4520  
IC4—CD4020  
IC5—CD4022  
IC6—CD4040  
IC7—27C256 special programmed EPROM (see ordering note below)  
IC8—CD4054  
IC9—IC11—CD4056  
IC12—LM7805CT  
†DSP1—four digit LCD display, AND FE0202

### Inductors

\*L1—39  $\mu$ H, variable inductor (Toko 154ANS-T1016Z)  
\*L2—33  $\mu$ H (J. W. Miller 8230-56)  
\*L3—0.39  $\mu$ H (J. W. Miller 8230-10)  
\*L4—0.33  $\mu$ H, variable inductor (Toko BTKXNS-T1047Z)

### Other components

B1—9-volt battery  
\*BP1, BP2—5-way binding post with 8-32 thread  
\*S1, S2, S3—DPDT alternate action switch (ITT Schadow 51287)  
\*3—pushbuttons for S1—S3  
†2—LCD sockets  
\*2—8-32  $\times$   $\frac{3}{4}$ -inch threaded spacer with mounting hardware  
\*2—8-32 screws and star washers  
\*1—battery terminal clip 1!—socket for DSP1, Samtec ESQ-120-12-T-S  
1—enclosure, Pactec HPL-9VB

**Note: The following parts and kits are available from Almost All Digital Electronics, 5211 117th St. SE, Bellevue, WA 98006.**

**A complete kit containing all components in the parts list with the exception of the EPROM, display kit, enclosure, and the PC board: \$69.95. A kit of hard-to-locate parts consisting of those indicated in the parts list with the \* symbol: \$29.95. The programmed EPROM: \$19.95. The display kit consisting of those parts indicated in the parts list with a † symbol: \$14.95. The enclosure, with all holes machined and a front panel decal: \$19.95. The PC board with plated-through holes: \$19.95**

**A complete semi-kit (the switches are mounted and soldered) consisting of all of the above and a "standard" capacitor for calibration: \$149.95.**

**The completely assembled, tested, and calibrated unit: \$169.95. Add \$5 for shipping and handling per total order. Washington residents must add 8% sales tax.**

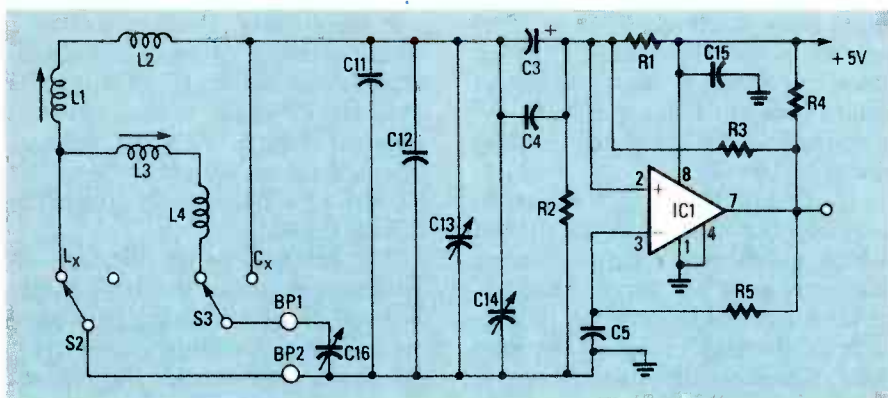


FIG. 2—A HIGH-SPEED VOLTAGE COMPARATOR, IC1, functions as an oscillator for both the capacitor and inductor tests. The unknown C and L values are determined by measuring their effect on the oscillator's reference frequency.

ponent installed. When the  $C_X$  switch (S3) is depressed, the component under test and zeroing-trimmer-capacitor C16 (which has been adjusted such that the sum of the stray capacitance + C16 = 10 pF) are connected in parallel with the C11–C14 tuning capacitors.

Similarly, when the  $L_X$  switch is depressed, the component under test and zeroing-trimmer-inductors L3 and L4 (which has been adjusted such that the sum of the stray inductance + L3 + L4 = 1  $\mu$ H), are connected in series with the L1/L2 tuning inductors.

As shown in Fig. 1, oscillator IC1 feeds a basic frequency counter consisting of counter-register IC3-a and IC6, which have a total of 16 bits; although only the last 14 are used ( $2^{14}$  = 16384). If a counter register is clocked by frequency  $f_1$ , for a period of time T, the resultant value in the register will be  $f_1 \times T$  cycles. If the measurement period is derived from  $f_2$  as  $T = N/f_2$  (where N is an integer multiplier, in this case a binary counter), then the accumulated count in the counter register will be  $f_1/f_2 \times N$ . In that way we have resolved measuring the ratio of two frequencies as required in the equation for  $L_X$ .

### Compensating for drift

Frequency drift caused by temperature, or by aging of the components, is significantly suppressed if  $f_1$  and  $f_2$  are derived from the same basic oscillator. For example, suppose  $f_1$  is 1 MHz and  $f_2$  is 500 kHz, then  $((f_1/f_2)^2 - 1) \times (L_1 + L_2) = (3.00 \times (L_1 + L_2))$ . If the oscillator drifts 0.1% for both  $f_1$  and  $f_2$ , then  $((f_1/f_2)^2 - 1) \times (L_1 + L_2)$  also equals  $(3.00 \times (L_1 + L_2))$ . If, on the other hand, only  $f_2$  drifted .1%

(which would be the case if  $f_1$  had been derived from an independent oscillator), then  $((f_1/f_2)^2 - 1) \times (L_1 + L_2) = (2.992 \times (L_1 + L_2))$ , or 0.266% error.

There is a second, and even more significant advantage to this method of drift compensation. Regardless of the frequency, if  $f_2$  is equal to  $f_1$ , then  $((f_1/f_2)^2 - 1) \times (L_1 + L_2) = 0$ , thereby forcing an automatic zero function. Under the assumption that oscillator drift will be a percentage function rather than absolute, the effect of oscillator drift is canceled. Although that is not an entirely accurate assumption, it is reasonably valid because the majority of drift comes from drift in the values of L and C in the tank circuit. Those values drift as a percentage of their nominal value due to temperature effects, thereby leaving the accuracy of the instrument almost entirely dependent upon the values of L1 and L2 and C11–C14 (which can be easily adjusted to within 1%).

Although the foregoing explains the basic theory behind the counter section and its advantages, it is not quite the whole story. That basic concept could measure frequencies down to zero hertz (zero hertz would accumulate a count of zero in the counter register and  $f_1$  would accumulate a count of 16383) just as a normal frequency counter would, and should do.

In order to make maximum use of the space in the EPROM, it is desirable to make the minimum value of the counter register correspond to the minimum value of  $f_2$  (59.774 kHz) when  $L_X = 10$  mH, or when  $C_X = 0.1$   $\mu$ F, and the maximum value correspond to  $f_1$  (713.3 kHz) when  $L_X = 0$ , or  $C_X = 0$ . By extending the range

of measurement period by "t" to  $T+t$ , the counter register will overflow back to zero after period "T" and continue counting for the period "t."

The final design has a period  $T = 2^{16}/f_1$  and a period  $t = 2^{12}/f_1$  such that the range of the counter register is 1024 to 17408 (a difference of 16384). To compensate for that, the bottom 1024 locations in the EPROM, 0–1023, contain the highest counts (16384–17408), and locations 1024–16383 contain counts 1024–16383. That is not the ideal correction for maximum EPROM usage, but it's easily achieved with simple circuitry. The 0.00 point is at location 17408 (1024) in the EPROM, while the minimum frequency of  $f_2$  occurs at count 1455. There are, therefore, 431 wasted locations in the EPROM, or 15952 stored values in the range of 0.00–9990  $\mu$ H.

The frequency measured is  $f_2/4$  (the counter register starts after the first two stages of IC3-a), so the formula to compute the accumulated value in the counter register for a given frequency of  $f_2$  is:

$$\text{Count} = f_2/4 \times (2^{16} + 2^{12})/f_1 = f_2/4 \times 69632/f_1$$

$$\text{Count} = f_2 \times 17408/f_1$$

It is that count that addresses the EPROM to get the data for the displayed value. Maximum count corresponds to maximum frequency, which in turn corresponds to minimum  $L_X$  or  $C_X$ . The formula for the value of  $L_X$  for a given count is:

Solving the count equation for  $f_2$ :

$$f_2 = (\text{count} \times f_1)/17408 = \text{count} \times 41.067$$

and since  $L = 1/(4 \times \pi^2 \times f^2 \times C)$ :

$$L_t (\mu\text{H}) = 1/(4 \times \pi^2 \times f_2^2 \times C_{11-C14})$$

and

$$L_X = L_t - (L_1 + L_2)$$

where

$$L_1 + L_2 = 70.5 \text{ mH and } C_{11-C14} = 705 \text{ pF}$$

$$L_X (\mu\text{H}) = 10^6/(4 \times \pi^2 \times 1686.52 \times \text{count}^2 \times C_{11-C14}) - (L_1 + L_2)$$

$$L_X (\mu\text{H}) = 213334.12 \times 10^6/\text{count}^2 - 70.5$$

$$C_X = L_X(\mu\text{H}) \times 10$$

Since the count value provides the EPROM address, and the  $L_X$  value provides the EPROM data, the last



formula and the pin-to-pin IC connections provides the necessary information to program the EPROM. The connections between counter register IC3-a/IC6 and the EPROM address pins may appear to be odd because they are optimized for a printed-circuit layout rather than the traditional pin assignments.

Similarly, the data bits of the EPROM are optimized for connection to the display drivers in the PC layout.

The translation for those connections is shown in Table 1 and Table 2. The "jumbled" connections are accommodated in the programming of the EPROM. A design problem which had to be overcome was that both frequencies  $f_1$  and  $f_2$  had to be available simultaneously to make the measurement. It was impossible to have the same oscillator run at two frequencies at the same time and the use of two different oscillators would negate the automatic-zero capability. Some means had to be provided to store frequency  $f_1$  while the oscillator was operating at  $f_2$ . The solution was a phase-locked loop, IC2.

### Storing a frequency

The voltage-controlled oscillator of the phase-locked loop is adjusted by the frequency discriminator within IC2 until it is the exact frequency of the signal input. The voltage that tuned the oscillator to that frequency can be stored on filter capacitor C8, thereby essentially "storing" the frequency. The frequency can be stored accurately so long as C8's voltage does not change. The only thing that will cause the voltage to change is C8's shunt resistance. The input resis-

TABLE 2—EPROM DATA BITS							
4	400	200	800	100	1	8	2
8	7	6	5	4	3	2	1
C3	C1	B1	D1	A1	A3	D3	B3
128	64	32	16	8	4	2	1
C2	dp2	dp1	0 dig	dp3	A2	D2	B2
40	/100	/100	.10	/10	10	80	20
stb A							
stb B							

tance of IC2 is specified as  $10^{12}$  ohms, which shouldn't cause any shunt-resistance problem.

On the other side of C8 are the in-use open-circuit switch contacts of S2-b ( $L_X$ ) and S3-b ( $C_X$ ), which should also be many megohms. The most significant cause of discharge is C8 itself, which must, therefore, be an extremely low-leakage device. Ceramic, tantalum, and electrolytic capacitors are unsatisfactory; C8 should be a high-quality plastic capacitor.

The test circuit is such that depressing either the  $L_X$  or  $C_X$  switch will open the control loop of the phase-locked loop, thereby storing  $f_1$  while simultaneously switching in the component under test into the  $f_2$  oscillator for measurement.

The control section of the frequency counter is IC4 and IC5. The base frequency of the oscillator,  $f_1$ , was first divided by 16 by IC3-b, and then divided by 512 by IC4 before clocking IC5. The period of the clock to IC5 is approximately 11.46 ms (87 Hz), however, IC5 is held in the reset mode by IC4 pin 2 for a period of 91.72 ms. After IC4 pin 2 goes low, IC5 advances from a count of zero to a count of one on the next positive transition of IC4 pin 12, which is 5.73 ms later. That makes the total measurement period  $91.72 \text{ ms} (2^{16}/f_1) + 5.73 \text{ ms} (2^{12}/f_1)$ , or 97.45 ms.

When pin 2 of IC5 goes low it inhibits the counter register (IC3-a/IC5), ending the measurement period. At that time EPROM IC7 is addressed with the result, which is a function of the component value  $L_X$  or  $C_X$ . Next, pin 1 of IC5 goes high for 11.46 ms, strobing the data from

IC7 into display drivers IC9 and IC11. At that time, pin 14 of IC4 is low, addressing the even addresses of IC7, which must contain the data for display digits one and three.

11.46 ms later, pin 1 of IC5 goes low and pin 3 of IC5 goes high, thereby strobing IC7's data into the digit-two driver IC10 and the decimal-point register (IC8). At this time pin 15 of IC4 is high, addressing the odd addresses of IC7, which must contain the digit two and the decimal-point data. An additional 11.46 ms later, pin 3 of IC5 goes low and pin 7 of IC5 goes high, resetting the counter register preparatory to acquiring a new measurement.

Another 11.46 ms later, pin 7 of IC5 goes low and pin 11 of IC5 goes high. The high is applied to IC5's ENABLE input, causing it to freeze at count four. IC5 remains in the idle mode until pin 2 of IC4 goes high 51.57 ms later (a total measurement/display period of 183.43 ms). The result is an update rate to the display of 5.44 times/second. An AC signal is taken from pin 14 of IC4 for display DSP1's backplane drive frequency.

### Resident data

There are an infinite number of L and C values that will resonate at a given frequency. Determining the exact values which would simultaneously provide: a capacitance display exactly 10 times the inductance display, provide at least 0.01  $\mu\text{H}$  per count in the frequency counter register up to 10  $\mu\text{H}$ , give a total count difference equal to or less than 16384 up to 10 mH with 0.1 mH per count,

*continued on page 98*

TABLE 1  
BIT WEIGHTS  
Counter Rom

1→	2
2→	4
4→	2048
8→	1024
16→	8
32→	16
64→	64
128→	128
256→	32
512→	256
1024→	512
2048→	8192
4096→	16384
8192→	4096

# Build REACTS:

## THE RADIO-ELECTRONICS ADVANCED CONTROL SYSTEM

*This month, we show you how to put REACTS to work to control the outside world.*

**Part 6** WE LEFT off last month promising to show you how to put REACTS to work. To get your imagination rolling on what you can do with a control computer, we'll show you how to build a digital door lock, an appliance controller, a security system, and a sprinkler controller for your garden.

### The digital lock

The input/output port consists of 8 wires (bits) that are labeled from 0 to 7. Using the INP command we discussed earlier, we can read the data present at the inputs. Incidentally, similar commands exist in Assembly, C, FORTRAN, and other languages.

As mentioned earlier, we input or output eight lines or bits each time we perform an input or output. In the following example we will see how to mask each line (or bit) out independently when needed.

Figure 1 shows a simple eight-pushbutton combination lock. In order to make that lock work, we simply read the input channel that is connected to the switches. That data is then compared with the combination stored in the program shown in Listing 1. If the data matches, the system releases the lock by outputting the correct command to the output line, which controls the latch solenoid. That solenoid is activated to stay open for some predetermined period, say 2 seconds. If the door is not opened by that time the door will relock.



H. EDWARD ROBERTS

That program will work quite adequately for a lock and you can program 256 different combinations. It has one major disadvantage; it uses all eight inputs of the I/O module. Listing 2 shows an electronic entry program that only uses five switches and allows for over 6500 combinations. The door-lock program will be only one subroutine in your final home-automation program. Along with the door-lock program, the final program may contain subroutines for controlling appliances and lights, a security system, and a lawn-watering system; monitoring and controlling the home environment; and allowing remote control using a modem. It takes approximately 100 microseconds to make one check of the switches. So even if the switches are checked 20 times a second, the door-lock subroutine will only take up approximately 2 milliseconds.

It is important to understand that

when outputting to a channel, all eight bits of the channel are affected. That is true even when you want to change only one bit. The technique we use is to store all the data that is output to the channel in a common location. Then, each routine that uses the storage location is responsible for seeing that only the bits relevant to that particular routine are changed. For example, in line 160 of Listing 1, we were only interested in changing the output bit (bit 0) that activated the relay that the door-lock solenoid was wired to. To keep from changing any of the other bits, we performed a masking operation by ORing them with 0. The

relay was closed by ORing a 1 at bit 0.

The two electronic door-lock programs discussed and listed in this article require simultaneous pressing of two or more switches or pushbuttons for many of the numerical entries. However, a ten or more digit keypad that uses some type of scan code easily could be implemented so that only one pushbutton is pressed for each entry number. Those types of keypads are available from several electronics hobbyist and parts houses. The supplier listed in the Sources box offers one such keypad. The keypad from that vendor comes complete with a listing of a scan-code decoding program for serial digit entry.

Figure 2 shows the connections of the external solenoid for the door control. The technique you use to actually lock and unlock the door is up to you. If you desire, an electric lock is available from commercial suppliers. Please send us any ideas that you have



that might be of interest to others; we will pass those along to other users of the system. Ideas can also be shared on the Radio-Electronics Bulletin Board (516-293-2283, 8 data bits, 1 stop bit, no parity).

## Controlling appliances

Because the relay option of this month's module can be connected directly to 117 volts AC, household appliances and lighting can be controlled by REACTS with the module as long as the current drawn from each relay does not exceed 6 amps. An ideal application is to use the system to turn-on and turn-off lamps while you are on vacation to give your home a "lived in" appearance to would be burglars. Securing the leads

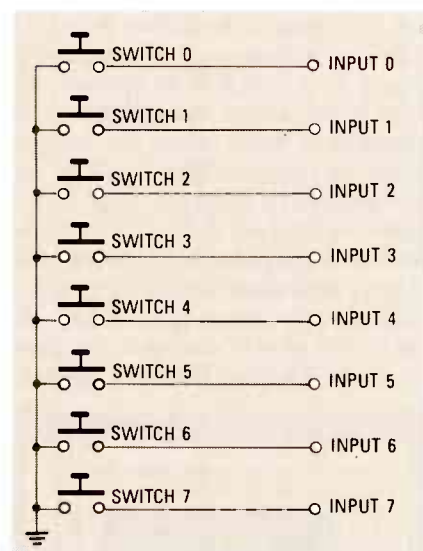


FIG. 1—A SIMPLE PUSHBUTTON LOCK. The data on the input lines is read by the computer and then compared to a combination in the lock program.

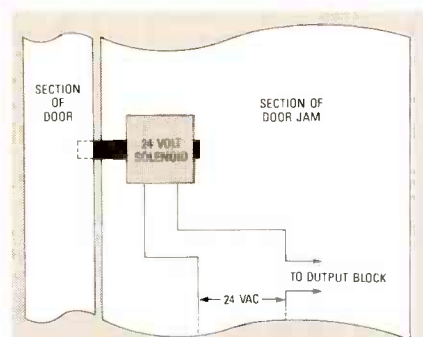


FIG. 2—ONE METHOD of implementing the door lock uses a 24-volt solenoid under computer control. Of course, many other schemes are possible.

## LISTING 1

```

10 REM Sample lock program, correct combination is 131
20 REM (10000011 binary)
30 REM
40 REM     TEST = Variable at which input byte is stored
50 REM     ENT = Entry from switches
60 REM     LCK24 = Controls output portion of module
70 REM
80 TEST = 0
90 ENT = 0
100 GOSUB "FETCH ENTRY"
110 IF TEST = 0 THEN GOTO 100
120 IF TEST > ENT THEN ENT = TEST
130 GOSUB "FETCH ENTRY"
140 IF TEST <> 0 THEN GOTO 120
150 IF ENT <> 131 THEN GOTO 80
160 LCK24 = LCK24 OR &X00000001
170 REM     This sets the last bit (bit 0) to a 1 without affecting
180 REM     any other bits. The output that controls the solenoid
190 REM     is connected to bit 0 of output channel 24.
200 OUT 24,LCK24
210 DELAY 6000
220 REM Causes program to wait for 2 seconds.
230 LCK24 = LCK24 AND &X11111110
240 OUT 24,LCK24
250 REM     This will clear the 0 bit which will relock the door.
260 REM     Here also, none of the other bits are affected.
270 GOTO 80
1000 REM ***** FETCH ENTRY *****
1010 "FETCH ENTRY"
1020 REM     This subroutine inputs the byte from I/O port 24 at
1030 REM     which the octal I/O is addressed.
1040 TEST = INP(24)
1050 TEST = NOT TEST
1060 REM     Because all the inputs are pulled high, the inputted
1070 REM     byte is complemented with the NOT command in order to
1080 REM     simplify programming.
1090 REM     TEST = TEST AND &X11111111
1100 REM     After complementing the input with the NOT command, a
1110 REM     16 bit signed integer is returned. To obtain the
1120 REM     original 8 bit complemented input from the I/O port
1130 REM     we must mask out the lower 8 bits.
1140 RETURN

```

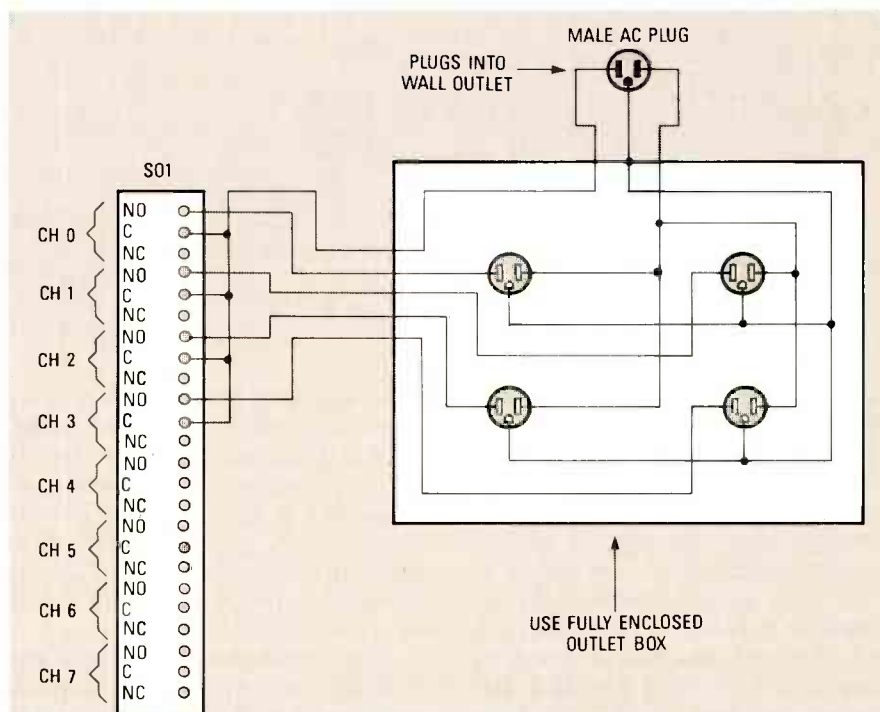


FIG. 3—FOR CONVENIENCE, use a relay interface like the one shown here when using REACTS to control household appliances.

## LISTING 2

```

10 REM This program uses 5 bits of a single input channel to
20 REM produce a sophisticated combination lock which has over
30 REM 6500 possible combinations. This program is designed to
40 REM use input channel 24. The combination for this program
50 REM is 9312. Any unused I/O channel or combination could
60 REM be used.
70 REM
80 REM COUNT() = Array where valid entries are stored.
90 REM IP_FLAG = Signifies that entry has been made.
100 REM TEST = Variable at which input is stored.
110 REM HI_IP = Temporary storage location for entry.
120 REM DIGIT = Number of valid entries.
130 REM
140 DIM COUNT(5)
150 IP_FLAG = 0
160 TEST = 0
170 HI_IP = 0
180 DIGIT = 0
190 REM ***** START LOCK *****
200 "START LOCK"
220 GOSUB "READ INPUT"
230 IF BOUNCE_OK = 0 THEN GOTO "START LOCK"
240 IF TEST = &X00010000 THEN GOTO "CLEAR LOCK"
250 IF RDY <> 1 THEN GOTO "START LOCK"
260 IF TEST = &X00000000 AND IP_FLAG = 0 THEN GOTO "START LOCK"
270 IF TEST <> &X00000000 AND TEST > HI_IP THEN HI_IP = TEST
280 IF TEST <> &X00000000 THEN IP_FLAG = 1
290 IF TEST <> &X00000000 THEN GOTO "START LOCK"
300 COUNT(DIGIT) = HI_IP
310 HI_IP = 0
320 IP_FLAG = 0
330 DIGIT = DIGIT + 1
340 IF DIGIT = 5 THEN GOTO "CK COMB"
350 GOTO "START LOCK"
1000 REM ***** READ INPUT *****
1010 REM This subroutine reads the input and maskout the 5 least
1020 REM significant digits.
1030 "READ INPUT"
1040 TEST = INP(24)
1050 TEST = NOT TEST
1060 TEST = TEST AND &X00011111
1070 DELAY 10
1080 TEST2 = INP(24)
1090 TEST2 = NOT TEST2
1100 TEST2 = TEST2 AND &X00011111
1110 IF TEST = TEST2 THEN BOUNCE_OK = 1 ELSE BOUNCE_OK = 0
1120 RETURN
2000 REM ***** CLEAR LOCK *****
2010 REM Clearing lock and setting for new entry.
2020 "CLEAR LOCK"
2030 RDY = 1
2040 DIGIT = 1
2050 GOTO "START LOCK"
3000 REM ***** CHECK COMBINATION *****
3010 REM Checking for correct combination.
3020 "CK COMB"
3030 IF COUNT(1) <> 9 THEN GOTO "START LOCK"
3040 IF COUNT(2) <> 3 THEN GOTO "START LOCK"
3050 IF COUNT(3) <> 2 THEN GOTO "START LOCK"
3060 IF COUNT(4) <> 1 THEN GOTO "START LOCK"
3070 REM Opening lock.
3080 UNLCK = UNLCK OR &X00000001
3090 OUT 24,UNLCK
3100 UNLCK = UNLCK AND &X11111110
3110 DELAY 6000
3120 OUT 24,UNLCK
3130 GOTO "START LOCK"
3140 END

```

of the device (lamps) to be controlled involves stripping the insulation on the cords back leaving approximately ¼ inch of bare wire which is inserted into the appropriate slot on the relay terminal strip. The wire is then secured by tightening a screw against it.

If your spouse doesn't take too kindly to the idea of cutting the plugs off of your lamps and stripping the insulation back, there is another alternative. You can make an interface box with a 1900-series electrical (outside-type) box, a pair of duplex outlets,

wire, and some hardware. A drawing of a typical interface is shown in Fig. 3. That device will allow you to easily connect appliances to the relay and possibly keep you out of the doghouse. If you are unsure about building the interface yourself, get an electrician to build it for you; it should be a cinch for him or her.

**Note: Powerline AC voltages and currents can be dangerous if care is not exercised; you can easily damage the computer, or yourself. If you lack experience with**

powerline voltages and currents, we strongly recommend you consult an electrician.

With the REACTS CPU and the real-time clock option, the lamp(s) can be made to come on and go off at different times during the day and at different times on different days. Also, since the program controlling the lamps would reside on the system's boot PROM, in the case of a power outage, when the system came back on it would automatically reload the program and continue its job. A free copy of a vacation home-control program is available from the vendor listed in this article if you send a self-addressed stamped envelope.

## Open window detector

The open-window detector can be used in two different ways. First, it can be used to quickly check for open windows before leaving the house. Second, by connecting one of the octal I/O port's to an alarm, REACTS can be programmed to sound the alarm if a window is opened. Of course the alarm would have to be disabled at times when the window must be opened. That could be accomplished by using one of the CPU's sense switches or connecting a SPST switch to one of the octal I/O's inputs. The system would be programmed to periodically check the switch, and when the switch was open the alarm would be disabled; likewise, when the

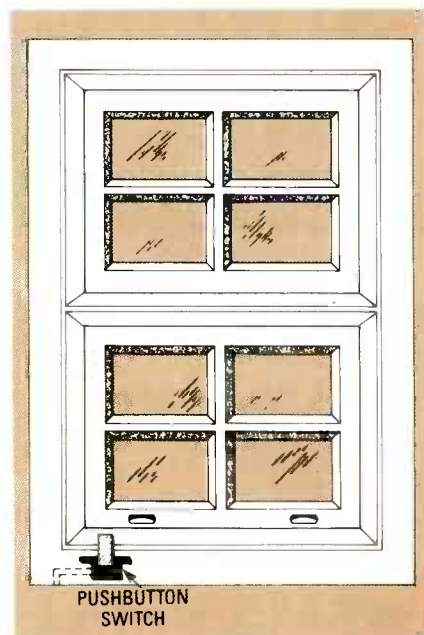


FIG. 4—A MOMENTARY SWITCH can be used to detect whether a window is open or not. When the window is fully closed, the button is depressed.



# LISTING 3

```

10 CLS                                     'Clear the screen
20 FLAG = @X00000000                     'Initializing
variable flag as all windows are closed
30 OCT_IN = INP(100)                       'Inputting from
octal I/O
40 ALARM = OCT_IN AND &X00000001         'Inputting status of
alarm enable/disable
50 CHECKW = OCT_IN AND &X11111110         'Checking window
switches
60 IF FLAG = CHECKW THEN GOTO 30         'If status of
windows has not changed keep checking them
70 CLS                                     'Clear screen,
getting ready to display new window status
80 IF ALARM = 1 THEN OUT 100,1           'If alarm is
enabled, turn it on
90 REM *** Finding out which window(s) is open ***
100 WIND1 = CHECKW AND &X00000010
110 IF WIND1 <> 0 THEN PRINT "WINDOW #1 IS OPEN"
120 WIND2 = CHECKW AND &X00000100
130 IF WIND2 <> 0 THEN PRINT "WINDOW #2 IS OPEN"
140 WIND3 = CHECKW AND &X00001000
150 IF WIND3 <> 0 THEN PRINT "WINDOW #3 IS OPEN"
160 WIND4 = CHECKW AND &X00010000
170 IF WIND4 <> 0 THEN PRINT "WINDOW #4 IS OPEN"
180 WIND5 = CHECKW AND &X00100000
190 IF WIND5 <> 0 THEN PRINT "WINDOW #5 IS OPEN"
200 WIND6 = CHECKW AND &X01000000
210 IF WIND6 <> 0 THEN PRINT "WINDOW #6 IS OPEN"
220 WIND7 = CHECKW AND &X10000000
230 IF WIND7 <> 0 THEN PRINT "WINDOW #7 IS OPEN"
240 IF CHECKW = &X00000000 THEN CLS 'If no windows are
open, clear the screen
250 IF CHECKW = &X00000000 THEN OUT 100,0 'If no
windows are open turn off the alarm
260 FLAG = CHECKW
270 GOTO 30 'Go check windows again

```

switch was in the opposite position, the alarm would be enabled.

To construct the open-window detector system, all that is needed, besides the REACTS system with the octal I/O module, is some two-conductor wire and a few window-mount SPST pushbutton switches. The switches that were used on our prototype are available for as little as \$1.29 from Mouser Electronics (2401 Hwy 287 North, Mansfield, Texas), and they're available from many of our other advertisers as well. They are mounted in the window sill so that the switch closes when the window is shut (see Fig. 4).

An alternative to using the pushbutton switches is to use magnetic reed switches. The magnetic half of the switch is mounted in the window frame, while the reed-switch half is mounted in the window casing. When the window is shut, the magnet will pull the reed switch open or closed depending on the contacts' arrangement (see Fig. 5).

There are two ways to connect the

switches to the octal I/O module: Connect only one window switch to each of the octal I/O's inputs, or connect several window switches to each input. Each method has its advantages and disadvantages. If only one window is connected to each input, it is easy to determine exactly which windows are open. However, the number of windows that can be monitored by using that method is limited to eight per I/O module because the module has eight inputs. If several window switches are connected to one input, more windows can be monitored, but you won't know which window is open. However, all the windows in one room can be connected to the same input channel; that way, an open window could be narrowed down to one room in the house.

To connect only one window switch to each input, a two-conductor wire will have to be routed from the I/O module to each window switch. One of the two leads at the REACTS end of the wire is connected to the ground slot of the input-terminal strip



FIG. 5—A MAGNETIC REED SWITCH can also be used to make sure a window is closed. When the magnet is next to the reed switch, the switch closes. When the window is opened, the switch opens.

on the I/O module, while the other end is connected to one of the eight inputs. The leads at the window end of the wire are connected to the switch's terminals. Assuming we are

## SOURCES

The following items are available from DataBlocks, Inc. 579 Snowhill Road, Glenwood GA. 30428. Or call (800) 652-1336; in Georgia call (912) 568-7101.

- DP-OCT: Design package with schematic and instructions; \$10.00.
- PC-OCT: PC board for the octal I/O, including design package; \$37.00.
- REC-OCT: Complete set of parts including PC board, IC's, terminal strips, etc., but excluding relay option listed below; \$109.00.
- REC-REL: OCTAL I/O relay option includes eight, 6-amp relays and terminal strips; \$42.00.
- REC-CASE and PANEL/REC-OCTAL: Aluminum case assembly including front and rear panels; \$19.50.
- REC-KEY: 12-button keypad with scan-code decoding program; \$9.00
- VAC-PROG: vacation home-control program; free with SASE.
- Other REACTS products are available; contact DataBlocks directly for information and pricing.

Please include \$5.00 postage for any order of \$37.00 or less and \$10.00 postage for any order over \$37.00. Georgia residents must add appropriate sales tax.

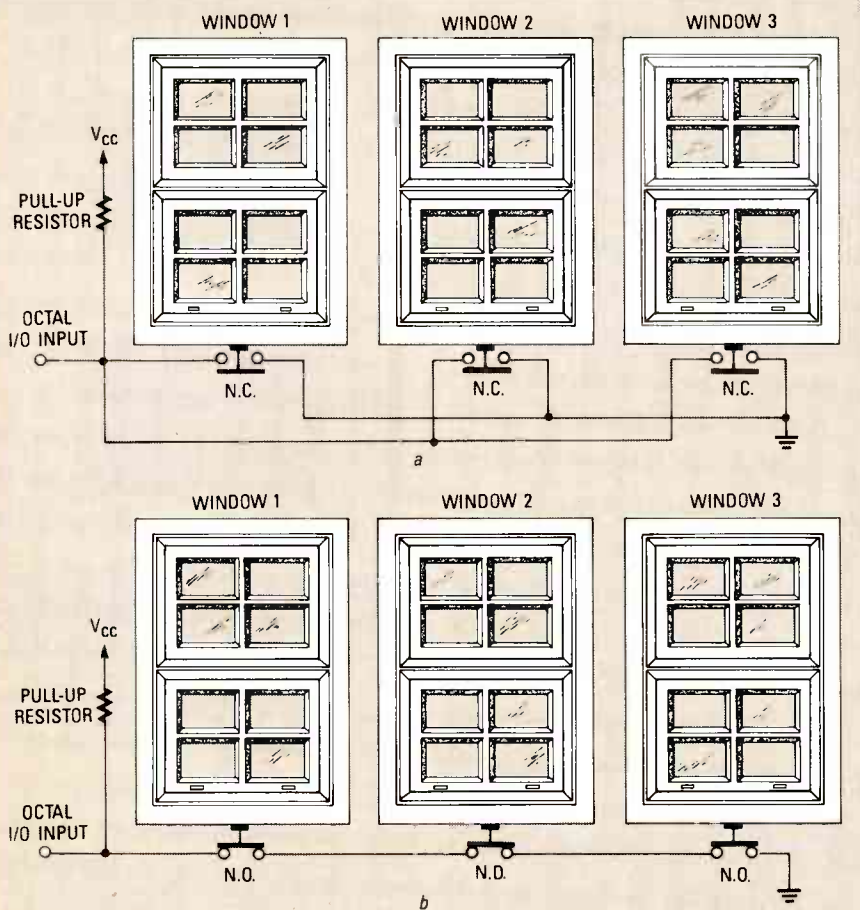


FIG. 6—SEVERAL WINDOWS CAN BE MONITORED using normally-closed switches in parallel (a) or using normally-open switches in series (b).

using normally-open switches, when the window switch is open, the input will be a logic 1 because all the inputs of the module are normally pulled high, and when the window is shut, the input will be a logic 0. If normally-closed switches are used, an open window will be a logic 0, and a closed window will be a logic 1.

The way in which the switches are connected to an input channel depends on the type of switches that are used. Normally-closed switches should be connected in parallel (see Fig. 6-a) so that when all of the windows are down, the switches are held open, resulting in a logic-1 input. If any of the windows are opened, the corresponding switch closes, causing a logic 0 to be read at the input.

The normally-open switches should be connected in series (see Fig. 6-b). When the windows are down, all of the switches are held closed, placing a logic 0 at the input. When one of the windows is opened, the corresponding switch is opened; a logic 1 is read at the input.

Listing 3 is a sample program that would control the open-window detector. For that example, we will assume the following:

- The octal I/O module is addressed at I/O port 100.
- Channel 0 (same as bit 0) of the octal I/O has a SPST switch connected to it that is used to enable and disable the alarm.
- The window switches are connected to channels 1-7.
- The alarm is connected to the channel-0 output.
- Normally open switches are being used.

The program could easily be changed to work in a system where several windows were connected to each channel. That could be accomplished by changing the print out statements to something like:

```
110 IF WIND1 0 THEN PRINT "A WINDOW IN ROOM #1 IS OPEN"
```

The program could also be made more personalized by printing: "A WINDOW IN THE UPSTAIRS BEDROOM IS OPEN"

## Lawn watering system

Besides controlling and/or monitoring devices within the home, REACTS can also be used for controlling devices outside the house. Specifically, the relay outputs of the octal I/O can be connected to electrically-actuated water valves so that the system can be used to control a lawn watering system. Indeed, by using the system's real-time clock, it can provide an extremely accurate means of cycling sprinklers on or off at pre-programmed times during the day.

The real-time clock has fourteen registers which contain the tenths of seconds, units of seconds, tens of seconds, units of minutes, tens of minutes, etc., all the way up to tens of years. By using the real-time clock, the system can be programmed to go through a watering cycle daily, every other day, every third day, or any other schedule you like.

In most cases, turning the valves on or off during the watering cycle could be done on a hourly basis. Because of that, the amount of program time needed to control the system would be minimal. A statement that checks the units of hours from the real-time clock could be placed in the main body of the program. When the units change, say an hour has passed, the processor would then go into a sub-routine to determine if it was time to turn on or off any of the water valves. Of course it probably would also be desirable to have a set of switches to manually turn the water valves on or off. Switches could be wired between the transformer and each relay to control the power to the relay, or if the inputs to the octal I/O were not being used, the switches could be wired to them. Each input would control an output.

Besides the REACTS system and the octal I/O module, some other parts that you'll need to construct the watering system are the electrically-actuated water valves, wiring, and a step-down transformer. Most standard electrically-actuated water valves that you will find use a solenoid that operates on 24-volts AC to open and close the valve.

To provide the power for those valves, you'll need a 117 to 24 volt step-down transformer, available in wall-mount packages. The required power rating of the transformer will depend on the power needed to acti-

*continued on page 98*



# BUILD THIS



## RADIATION MONITOR

*We're always surrounded by some radiation. In this article we'll show you where it comes from, how it can help or harm you, and how to use the Radaalert to warn you of dangerous conditions.*

**JOE JAFFE, DAN SYTHE, and STEVE WEISS**

HUMAN BEINGS HAVE BEEN EXPOSED TO naturally occurring ionizing radiation for millions of years because nuclear reactions take place on our sun and on other stars continuously. Their emitted radiation travels through space, and a small fraction reaches the earth. Natural sources of ionizing radiation also exist in the ground, the most familiar and most common ground-source being uranium.

Last month we showed you how to build a nuclear radiation monitor—the Radaalert. Now we'll show you how to use it, and how to interpret its readings.

### **Ionizing radiation**

Ionizing radiation is radiation that has the ability to remove electrons (the process of ionization) when it strikes or passes through an electrically neutral atom. It was first discovered about 100 years ago and given

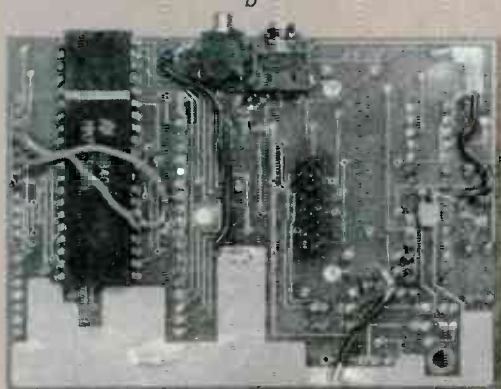
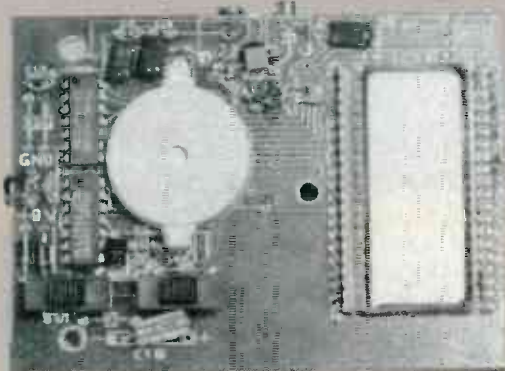
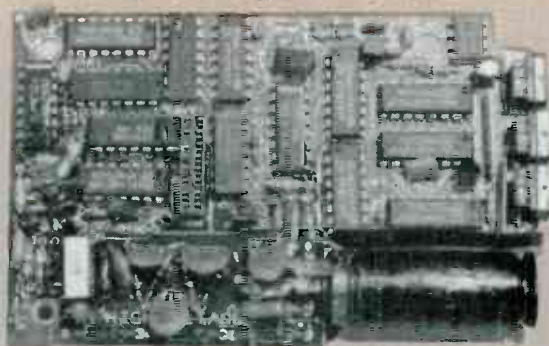
the name *X-rays* because its nature was unknown. X-rays can be generated in a vacuum tube by connecting the tube's anode and cathode to a source of high voltage: anything from 25,000 to 250,000 volts. When the cathode is heated it emits electrons that travel at high speed to the anode. The bombardment of the metallic anode by the electrons produces the X-rays. The ability of X-rays to penetrate a variety of materials, including body tissue, makes them a powerful tool in the physical and medical sciences. We now know that X-rays are a quantum of electromagnetic energy, also called photons.

Soon after the discovery of X-rays, it was discovered that uranium salts spontaneously give off radiation that penetrates matter in the same fashion as X-rays. Other supposedly inert materials were found to emit similar radiation, forming a class of radioactive

materials known as *radioisotopes*. Gamma rays, one type of radiation from those materials, are similar to X-rays. Other types of radiation from radioisotopes are alpha rays and beta rays.

The emission of a gamma ray, alpha ray, or beta ray causes the radioisotope to change from one type of atom to another. When the emission occurs, the atom is said to decay. The radioactive process is an electronic process in that it involves changes in the electrical charge configuration of the atom. A beta ray is actually a particle, an electron emitted by the atomic nucleus. A gamma ray is the photon emitted when an electron is added to the atomic nucleus. The alpha ray is a particle that consists of two protons and two neutrons, identical to the nucleus of the helium atom, emitted when the atom decays. In physics theory, particles sometimes





#### PUTTING IT ALL TOGETHER

The Radalert circuit uses two PC boards; these are the ones from the Radalert prototype. The PC-board templates shown in the PC Service section of the June issue, and the boards supplied in the kit, are slightly different from the photos so that user-assembly will be easier. Most important, jumpers are no longer required.

The main board (a) has all its components installed on one side. The display board (b and c) has components installed on both sides. The top

of the display board (b), what is usually called the "component side," has the LCD display unit, the beeper, and the two operating switches. The "solder side" (c) of the display board has the remote power and alert jacks, IC16, and the Samtec connector.

When the case is assembled the main board is automatically connected to the display board through the 16-pin Samtec connectors, forming the circuit "sandwich" shown in d (case removed for clarity).

behave like rays, which travel in waves, so the terms are quite frequently used interchangeably.

Gamma rays behave in the same manner as light waves and radio waves although the wave lengths of gamma rays are extremely short, less than 0.1 billionth of a centimeter. However the energy of gamma radiation is millions of times greater than light and radio waves, giving it the ability to penetrate matter.

The energy of ionizing radiation is measured in millions of electron volts (mev). Beta particles have energy values ranging from almost zero up to 1 mev. Alpha particles have energy values from 0.1 mev up to 5 mev, and gamma rays have energy values as high as 100 mev.

Each radioisotope has a half-life, which is the time required for half of a quantity of the material to decay. For example, thorium 234 has a half-life of 24 days. If you start out with one gram of thorium 234, at the end of 24 days, ½ gram of thorium 234 will have decayed to protactinium 234 by emitting beta rays. Note that theoretically it will take an infinite time for the thorium to decay completely because for each succeeding half-life only half the remaining material decays. To put that into perspective, after seven times the half-life, approximately 99% of the original material has decayed, and after 10 times the half-life, approximately 99.9% of the material has decayed. The decay products may still be radioactive. Because the decay process actually occurs randomly, the half-life represents the average rate of emission.

#### The decay chain

Table 1 shows the complete radioactive decay chain for uranium starting with U238 and ending with a stable isotope of lead. You can see that the half-life of the atoms in this chain range from 4.5 billion years to 164 microseconds, an astonishing span. Only the primary type of ray emitted is shown, but since radioactive decay is a complex phenomena, secondary emission of the other rays may take place to a lesser degree.

#### Natural radiation

Uranium and its decay products are the most common radioactive materials in the ground. They are found everywhere. All the isotopes in the uranium decay chain are solids except



**TABLE 1**  
**RADIOACTIVE DECAY CHAIN**

Isotope	Emits*	Half-life	Product
U238	alpha	4.5 billion years	Th234 Thorium
Th234	beta	24.1 days	Pa234 Protactinium
Pa234	beta	1.17 minutes	U234 Uranium
U234	alpha	250,000 years	Th230 Thorium
Th230	alpha	80,000 years	Ra226 Radium
Ra226	alpha	1602 years	Rn222 Radon
Rn222	alpha	3.8 days	Po218 Polonium
Po218	alpha	3 minutes	Pb214 Lead
Pb214	beta	26.8 minutes	Bi214 Bismuth
Bi214	beta	19.7 minutes	Po214 Polonium
Po214	alpha	164 microseconds	Pb210 Lead
Pb210	beta	21 years	Bi210 Bismuth
Bi210	beta	5 days	Po210 Polonium
Po210	alpha	138 days	Pb206 Lead

\*Primary emission

for *radon*, the only radioactive gas. High concentrations of radon are found in soils and rock containing uranium, granite, shale, and phosphate. Trace amounts of radon are widely distributed in the earth's crust. As a gas, radon migrates through the ground to enter the atmosphere. Radon is colorless, odorless, and tasteless; it does not burn or glow. In recent years, it has been discovered that radon is a serious problem in many homes.

According to the Environmental Protection Agency (which is more generally referred to as the EPA), radon was first noticed in the late 60's in homes that had been built with materials contaminated by waste from uranium mines. Only recently they have learned that houses in various parts of the U.S. may have high indoor radon levels caused by infiltration from the soil. The EPA has published booklets for the public on that topic; they are titled *A Citizen's Guide to Radon* and *Radon Reduction Methods*.

Phosphate deposits throughout the world contain relatively high concentrations of the uranium decay chain. In the U.S., about half the mined phosphate is converted to fertilizer; the rest is used to produce chemicals and gypsum building materials. Mining and processing phosphate ores distributes uranium and its decay products in the environment. The use of phosphate fertilizers with high levels of radioactivity may contaminate food crops.

#### Man-made radiation

The development of nuclear weap-

ons, their use at Hiroshima and Nagasaki, and subsequent atmospheric testing, significantly increased radioactive elements in the environment. The finding of high concentrations of radioactive strontium in milk and other food products led to a world-wide treaty to end atmospheric testing in 1963.

The use of nuclear reactors to generate electricity is a major contributor to man-made increases in radiation levels. The nuclear fuel cycle consists of mining and milling uranium and its conversion to fuel material, fabrication of fuel rods, use of the fuel in the reactor, reprocessing of spent fuel, transportation and storage of contaminated materials such as tools, filters, chemicals, and clothing (so-called "low-level" wastes), and transportation and storage of high-level wastes from the reprocessing of fuel rods. Each of those steps may add radioactivity to the environment.

Operation of a nuclear reactor may be accompanied by controlled small releases of radiation. There are frequent reports of uncontrolled releases, aside from major accidents such as those at Three Mile Island and Chernobyl. Unfortunately, data on radiation levels near nuclear plants are not generally available. Following the Three Mile Island accident, the people living in the area successfully sued the operator of the plant to provide funds for setting up a permanent monitoring system to give an early warning of any future releases, however, the monitoring system has yet to be implemented.

Luminous dials on watches and instrument panels incorporate radioac-

tive materials; hence, they also generate man-made radiation. Also, some early color TV sets were found to emit X-rays in excess of recommended limits, although more stringent regulations have largely eliminated that problem.

If you have ever taken a mantle-type gas lantern on a camping trip you should know that the mantle contains radioactive thorium. Although the package for replacement mantles has a warning not to keep mantles or its ash near the skin for prolonged periods, nowhere does it say that the mantles are radioactive.

Compounds containing radioactive uranium and cerium are incorporated in porcelains used in restorative and prosthetic dentistry to simulate the fluorescence of natural teeth. The amount of these radioactive materials in dental porcelain powders and artificial teeth is limited by law.

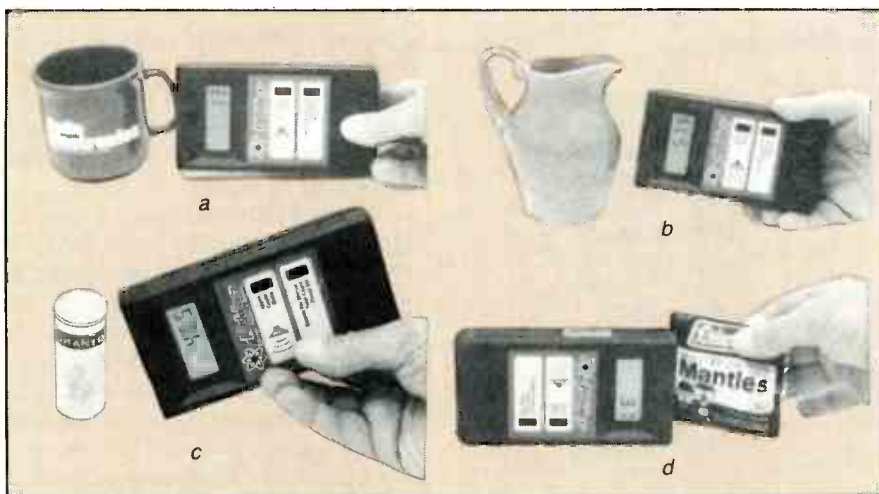
Ceramic pottery and its glazes may contain small amounts of radioactive uranium and thorium, depending on the source of the clay.

#### Beneficial radiation

The first, and best known, use of radiation is the X-ray. Almost every one of us has at some time been exposed to diagnostic X-rays. It is hard to imagine the practice of orthopedics or dentistry without the use of X-rays. Some uses of X-rays—such as measuring the fit of shoes in shoe stores—have been long abandoned because of health risks.

Radioisotopes behave the same way in chemical reactions as the stable isotope. That makes them useful in diagnosing and treating disease. If a sample of material containing a radioisotope of a chemical involved in a specific disease or physiological process is injected or ingested, doctors can follow the activity of that chemical within the body with appropriate instrumentation. Much of the knowledge of thyroid function and thyroid disease has come from the use of radioactive iodine, I<sup>131</sup>. Tumors can be localized with radioactive phosphorus, P<sup>32</sup>, and radioactive chromium, Cr<sup>51</sup>, is used in blood studies. Vitamin B<sub>12</sub> made with radioactive cobalt, Co60, makes it possible to identify diseases associated with poor absorption of that vitamin.

*Business Week* magazine has reported an interesting side-effect of using radioactive isotopes in medi-



**SOME COMMON RADIATION READINGS** found around the office. In *a*, the Radaalert's reading from a plastic drinking cup is the background radiation level, which means the cup is radiation-free. But *b* shows that the orange clay or glaze used in making the pitcher obviously is radioactive; more so than the tube of Uranium-235 samples shown in *c*. Also radioactive—but to a smaller degree—are the camping-lamp mantles shown in *d*.

cine. On two separate occasions, the Secret Service asked women visiting the White House to step out of the visitors line. A sensitive radiation detector had picked up radiation from the women. After questioning it was discovered that both women had recently had injections of radioisotope material for medical purposes, and enough of the isotope remained in their bodies to trigger a radiation alarm.

The uses of X-rays are not limited to medicine and dentistry. Industrial applications include the familiar baggage examination at airports, engineering studies of integrated circuits, and flaw detection in metals, including welded joints. Non-contact thickness measurements on moving extrusions of rubber and plastic is a common industrial application of beta and gamma rays.

### Harmful radiation

In general, the biological effects of ionizing radiation are destructive. As alpha, beta, or gamma radiation passes through the body, it interacts with the body's cells. Atoms in the cells may be ionized, or electrons in orbit about the nucleus can be displaced from one energy state to another. In either case the cells are changed from their original form to new forms, and the information contained in them is modified.

The changes that occur may cause some cells to stop reproducing; other cells may undergo mutation, or the

control mechanism in cells that limits cellular reproduction may fail, causing cancer.

It may take years before the effects of radiation become manifest, so it is almost impossible to prove on an individual basis whether there is a relationship between radiation exposure and a subsequent disease. However, two studies on large populations indicate a statistical relationship. One study involved the survivors of the Hiroshima and Nagasaki atomic bomb blasts. Another study followed children of mothers who had diagnostic X-ray procedures during pregnancy. As a result of the latter study, the use of X-rays on pregnant women has been considerably reduced.

Many experts used to think that if radiation exposure was under a certain threshold, a person would not have any harmful effects. Although some still believe in the theory, the evidence is establishing that there is no minimum radiation level that can be considered safe. *Radiation and Human Health*, by John W. Gofman, M.D., Ph.D., is a comprehensive investigation of the evidence relating low-level radiation to disease. *The Wall Street Journal* reported in February, 1988, that the National Institutes of Health has launched "...a large-scale evaluation of cancer deaths occurring among persons living near the over 100 reactors operating in the United States."

The amount of energy received from ionizing radiation by sensitive

biological tissues is a determining factor in causing harmful effects. Energy is measured in *ergs*. If 100 ergs of ionizing radiation are received by 1 gram of body tissue, the tissue has received 1 rad of radiation, a unit of exposure. The *Roentgen* is another measurement of exposure, originally used for X-ray machines. One roentgen equals 93 ergs per gram of tissue, almost the same as a rad. For some purposes it is useful to speak of rads per unit of time such as per minute, per hour, or even per year, while sometimes just the total accumulated exposure is of interest.

To assess the potential damaging effect of radiation from radioactive materials, we need to know the number of emissions per unit of time and the amount of energy of each emission. While a Geiger counter can easily measure the emission rate in counts per minute, it can only measure the energy level in rads if the specific source of radiation is known. To get around that problem, some Geiger counters are calibrated in terms of *millirads*, or *milliroentgens*, per hour (mr/hr) for a specific source such as Cesium-137; then, comparisons can be made for other materials. The Radaalert display is in counts per minute, or total counts, as its main purpose is to indicate changes in background radiation without the need to know what the radiation source is, a task for more expensive equipment. An Operating Manual for the Radaalert supplied with the parts kit includes conversion charts between counts per minute and mr/hr for common isotopes.

Further information on radiation can be found in *IEEE Spectrum*, November, 1979, and in *Report of United Nations Scientific Committee on the Effects of Atomic Radiation*, 1982.

### Using the Radaalert

As mentioned earlier, we are always exposed to naturally occurring background radiation from outer space and from the earth. After you finish assembling and testing the Radaalert you can determine the background radiation level in your area. Do that outdoors first so it can be compared with the level inside your home. Notice—by watching the count light or listening to the beeper—that background radiation occurs randomly. In a northern California labo-



ratory, an average CPM (Count Per Minute) is 12.5, but a one minute count as low as 5 or as high as 25 is not unusual. Because of the possibility for a large CPM variation, you need to collect two sets of data: one for use in setting the Alert level (which warns you if the count in any minute is higher than would be normally expected); the other to help you detect small changes that might result from radon or other sources of radiation in your home.

We suggest you set the Alert level at a value that rarely sounds a false alarm, but one that still warns you when the radiation is unusually high. To determine that value you must first find the normal variation in background level. Standard deviation is a descriptive statistical measure of the variability of a set of data.

To calculate the standard deviation, use your Radaalert in the CPM mode to measure 30 or more consecutive one-minute readings. Sum the readings and divide the sum by the number of readings to get the average value. Then take the difference between each CPM value and the average, square each of those numbers, and sum them. Divide the sum by 29 (if you have taken 30 readings, otherwise by the number of readings minus one). The square root of that number is the standard deviation. A hand calculator, or a computer, will help you do the calculations quickly.

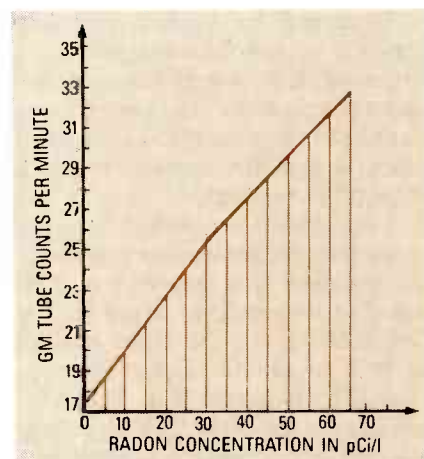
A typical set of data has an average of 12.8 counts per minute, and a standard deviation of 4.3.  $3 \times 4.3 + 12.8$  equals 25.7. Set the Alert level at 30, the next higher increment.

Use the Radaalert's Total Count mode to check for small differences in radiation (for example, between outdoors and indoors). Obtain the total count for a 12-hour period in each location. When you take the count outdoors, place the Radaalert on the ground in an unpaved area for one set of counts, then get another set of counts with the instrument about 4 to 6 feet above the ground. That procedure helps you detect alpha particle radiation from the earth, which rapidly dissipates in air.

Differences in radiation level as low as 1 CPM can be detected by comparing total counts for 12-hour periods. The differences might result from radon or concentrations of radioisotopes in the earth. Solar flares, low-level leaks from nearby nuclear

plants, or higher-level leaks from distant plants can cause small changes in the 12-hour count. If you keep your Radaalert operating continuously in the Total Count mode and take readings every 12 hours, say at 7 am and 7 pm, you will know when those events take place. For comparison purposes, it is best to convert the total count to counts per minute. After you take each 12-hour reading, switch from the Total Count mode to CPM, then back to Total Count to reset the display to zero.

There are differences of opinion on the ability of Geiger counters to detect radon. While there's no claim that the Radaalert can specifically measure radon gas, experiments in a controlled environment with different levels of radon gas indicated that average counts per minute did rise and fall with radon concentrations. (After establishing the normal background radiation for a controlled-environment test site, the background radiation was subtracted from the total counts.) Preliminary results are shown in Fig. 1. The radiation detected is a combination of the emissions from radon and its "daughters," or "progeny."



**FIG. 1—GEIGER TUBE COUNTS vs. radon concentration. The CPM scale starts at 17 CPM, which was the background radiation at the testing station. The radon concentration at the test station is assumed to be between 1 and 5 picocuries per liter.**

The Radon Technical Information Service of the Research Triangle Institute prepared a Cumulative Proficiency Report for the EPA in July, 1987. The report describes the approved radon testing methods, and the advantages and disadvantages of each method. The use of the Radaalert in conjunction with the EPA methods reduces the possibilities of error.

## Radon entrance

The most likely entrance points for radon in homes or other buildings are cracks or openings in the floor around pipes or conduit, unsealed wall-floor joints, and underground hollow block walls. Dirt floors in basements are particularly vulnerable. Unventilated basements or closets normally have higher levels of radon than well-ventilated areas. For best results, keep air exchanges between indoors and outdoors at a minimum 12 hours before and during the test.

Place the Radaalert on the floor near any suspected entrance point. Set the display for Total Count and accumulate the counts for 12 hours in each location. If the 12-hour average CPM in your home is more than 1-CPM higher than outdoors, you should do further testing for radon using carbon canisters or other EPA-approved methods.

## Common radiation

You may find that you have radioactive items in your home. Pottery and glazed dinnerware are potential sources of radiation if they are made from uranium-bearing clays or uranium oxides. If you have any ceramicware with orange glazes, check it carefully for higher radiation levels. Also, static eliminators for records and photographic film may contain polonium, an alpha emitter. Use the Radaalert in the CPM mode with the beeper on to identify those items.

Some commercial gemstones used in jewelry may have had their color enhanced by neutron bombardment, thereby making them radioactive. Also, gold jewelry has been made from reprocessed gold that was previously used in radiation therapy. Check those products with your Radaalert in the CPM mode.

Do you have a watch, clock, or other instrument with a luminescent dial? Place its face as close as possible to the alpha window on the Radaalert and see if there is an increase in radioactivity. Observe the change in CPM for different distances between the Radaalert and the dial, and you can see how much of the count was due to alpha rays, compared to beta or gamma rays. Repeat these experiment with a replacement mantle for a gas lantern. You may be surprised by the results. Do not handle the mantle directly; keep it in its plastic bag.

Radiation from outer space is at-

tenuated by collisions with air molecules so the radiation at sea level is normally lower than at higher elevations. Figure 2 shows the relationship between CPM and altitude based on 15-minute average readings taken in California from the top of the ski lift at Heavenly Valley (10,000 feet) to sea level.

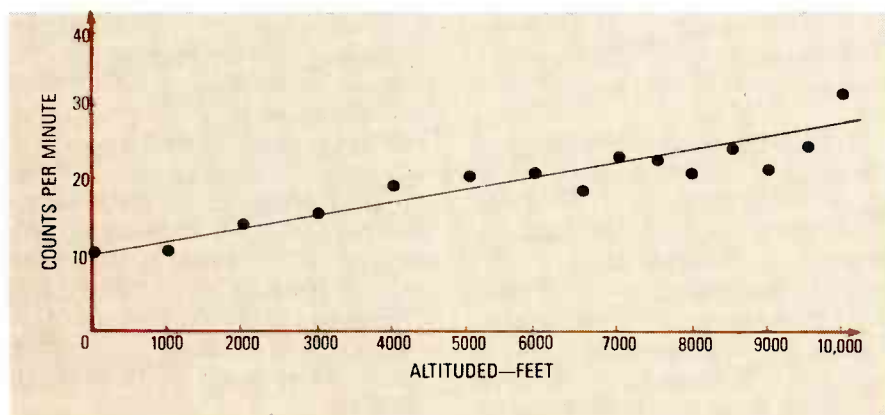


FIG. 2—THE BACKGROUND RADIATION at various altitudes, measured from a ski-lift.

The altitude effect is particularly noticeable when traveling by air at 35,000 to 40,000 feet. Radiation levels 30 to 50 times higher than on the ground have been measured at these altitudes.

At times of solar flares the radiation level may go considerably higher, so supersonic aircraft, which fly as high as 60,000 feet, have radiation-monitoring equipment to alert the pilot to move the plane to lower altitudes if the radiation reaches a predetermined level. Make some radiation measurements with your Radaalert on your next flight, with the beeper *off* so that you don't disturb any of the other passengers.

You can establish a baseline of background radiation if you live, or frequently drive, near a nuclear power plant; then you can observe changes from the baseline due to controlled or uncontrolled releases of radioactivity. A baseline of 12–14 CPM for a local nuclear plant was established during drive-bys on a number of occasions. But on one occasion the CPM increased to 22, an increase of over 50%.

Use your Radaalert in your car. You may be able to detect vehicles transporting radioactive materials, or discover you are passing a phosphate mining region, or other radioactive deposits. With the sound-selector switch set for the *Count* position the audible beeps will help you recognize

short-time radiation increases that might be masked by averaging.

Exploring for underground radioactive materials can be an interesting hobby. Gemstones may be found together with, or may contain, radioactive materials; also, high radon concentrations are present in some caves, so be careful if your Radaalert

indicates higher than normal radiation levels while exploring. Radioactive materials can be hazardous if inhaled or handled carelessly.

### In-home tests

As mentioned earlier, ordinary common household items produce a slight—though not necessarily unsafe—radioactivity. The photographs on page 54 show the readings attained when the Radaalert was used to check some of those items.

If you work in the nuclear industry, or in a hospital or laboratory that uses radioisotopes, you may want to convert Radaalert readings to mr/hr. For Cobalt-60, divide the CPM reading by 958 to obtain mr/hr. For Cesium-137, divide by 982. This relationship for the LND 712 Geiger tube was obtained at Battelle Laboratories using sources traceable to the National Bureau of Standards. If you have access to calibrated sources of other isotopes, you can determine the appropriate conversion factor for your isotopes.

What should you do if the Radaalert shows abnormally high radiation levels in the CPM mode? First, you should seek confirmation of your readings. Public Health Departments, hospital health physics or nuclear medicine departments, civil defense offices, EPA offices, police or fire departments, are possible places with radiation-monitoring equipment. Be-

fore you start doing your own measurements, you might want to find a contact you could call for confirmation if the Radaalert gives an alert signal, or other indication of unusual radiation activity. Should there be confirmation, keep in touch with your local authorities and follow their instructions. Be aware that radiation from airborne radioactive particles will be less in a closed house or inside a building.

### SOURCE

A complete kit of Radaalert parts which includes assembly instructions and an operating manual is available for \$153.50 postpaid. The Geiger tube, the LCD display, and a set of PC boards with plated-through holes are individually available.

A completely assembled and tested Radaalert including an operating manual is priced at \$229 postpaid.

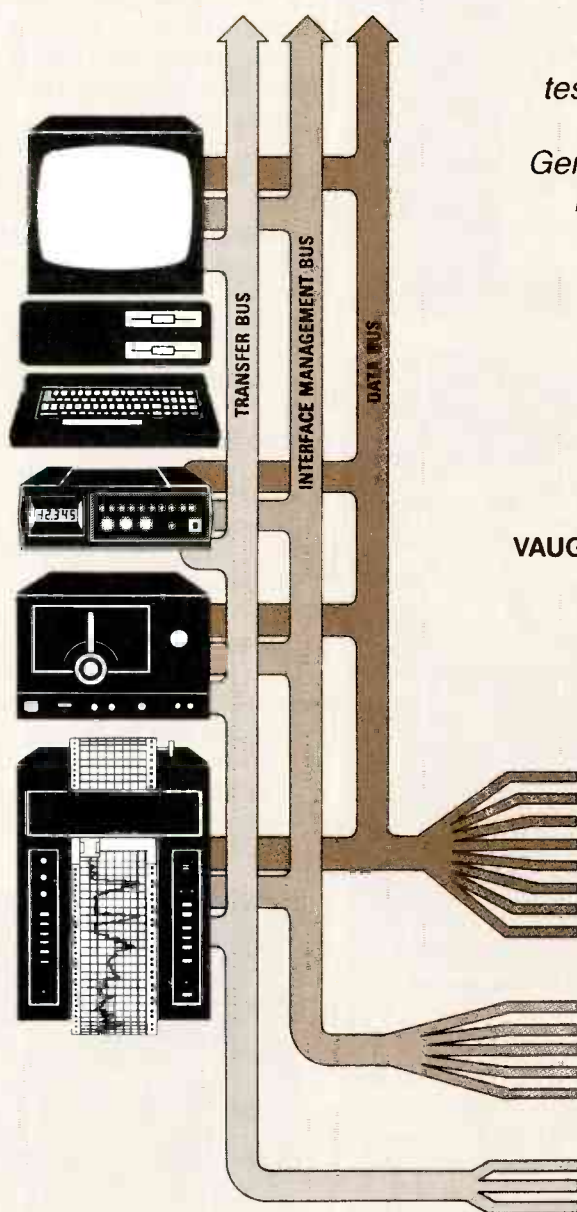
From: International Medcom, 7497 Kennedy Rd., Sebastapol, CA 95472. Or call toll-free, 1-800-257-3825. In CA 1-800-255-3825. For technical information contact International Medcom at the above address.

If you don't have (or can't get) confirmation of a general increase in radiation, you should try to identify a localized source: a parked truck with radioactive materials, an excavation that has uncovered radioactive deposits, or even a container of radioactive material that has been disposed of illegally. The radiation level from such a source will decrease by the inverse square law; that is, if you move around with the Radaalert and the level decreases by a factor of four, you will be twice the distance from the source. Or conversely, if the level goes up by a factor of four, you are only half the distance to the source. If you see evidence of a localized source, notify the authorities and get as far away as you can. Up to now, there has not been a large scale use of Geiger counters outside of laboratories and nuclear plants, which has limited our knowledge of the potential existence of localized "hot spots" of naturally occurring and man-made radiation. The dispersion of man-made radiation throughout the environment is still generally unknown. We hope the use of the Radaalert to collect and disseminate radiation data will contribute to better understanding of these important subjects.

R-E



## GENERAL PURPOSE INTERFACE BUS



*Hook up your  
test instruments  
to a  
General Purpose  
Interface Bus.*

VAUGHN D. MARTIN

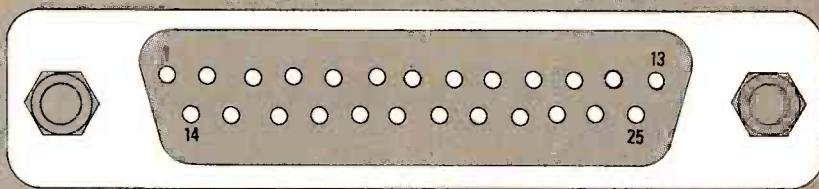
WHETHER AN INTERFACE BUS IS CALLED the I.E.E.E. 488, the General Purpose Interface Bus (GPIB), or the Hewlett-Packard Interface Bus (HP-IB), all three describe essentially the same thing; an orderly and predictable way to exchange digital data and maintain control between instrumentation devices.

First we'll concentrate on exactly what the GPIB is, and how it's configured in an instrumentation network. Then we'll give numerous practical tips on various operating data modes and cabling methods. We will look at supporting GPIB instrumentation, (such as a bus analyzer, a bus extender, a bus translator) and examine various GPIB configured systems. Finally, we'll examine the Hewlett-Packard Interface Loop (HP-IL), which is a means of accomplishing the same goals only with lower powered (sometimes battery-operated) and less expensive instrumentation and hardware.

### GPIB beginnings

The IEEE-488 instrumentation interface standard evolved with Hewlett-Packard, who began in September 1965 to examine how they would standardize their future test instrumentation. Next, the International Electrotechnical Commission (IEC) took the resulting HP proposal as a starting point, and in 1974 issued a draft, for ballot vote by its members. In 1975, the Institute of Electrical and Electronics Engineers (IEEE) published their now-famous IEEE-STD 488. In January of 1976, the American National Standards Institute (ANSI) published their MC1.1, which is identical to the IEEE-488 standard. There are now two more standards, the IEC 625-1 and the British Standard B.S. 6146, which are also both identical to the IEEE-488 standard with the exception of the type of connector used to interface the hardware.

The IEEE-488 standard and its clones have been published in nine languages, used by more than 250 equipment manufacturers in 14 countries to design more than 2,500 different instruments. To say that it was well accepted as the absolute instrument-interface standard would be an understatement!



CONTACT	SIGNAL LINE	CONTACT	SIGNAL LINE
1	DIO1	14	DIO5
2	DIO2	15	DIO6
3	DIO3	16	DIO7
4	DIO4	17	DIO8
5	REN	18	GND (5)
6	EOI	19	GND (6)
7	DAV	20	GND (7)
8	NRFD	21	GND (8)
9	NDAC	22	GND (9)
10	IFC	23	GND (10)
11	SRQ	24	GND (11)
12	ATN	25	GND (12)
13	SHIELD		

FIG. 1—IEC 625-1 USES A 25-pin subminiature D-type connector.

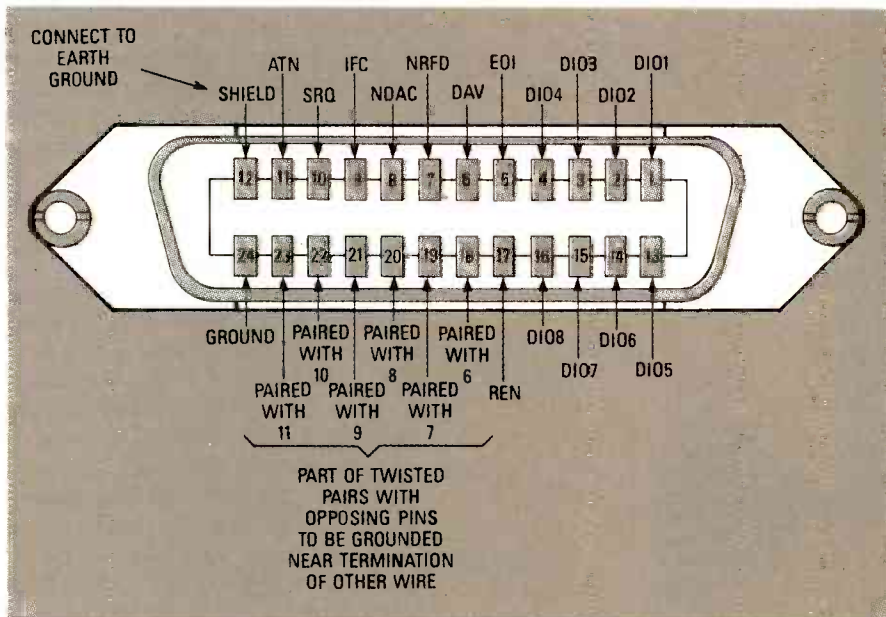


FIG. 2—GPIB USES A 24-pin miniature ribbon-type American standard connector.

standable that component damage would occur if data communication and instrument interfaces were accidentally interconnected.

In Europe, approximately 90% of bus-compatible equipment presently uses the IEEE-488/ANSI/MC1.1-type connector, and there are adaptors for interconnecting 25-pin and 24-pin connectors.

## GPIB Specifications

When the controlled device such as printers, DMM's, frequency counters, etc. are commanded to do something, such as make a measurement on a particular band of frequencies, it is said that the controller "talks" and the responding devices "listen."

Every GPIB device must be capable of performing one or more interface functions or roles. A *listener* is a device capable of receiving data over the interface when addressed. Examples of that type of device are: printers, display devices, programmable power supplies, and programmable signal sources. There can be up to 15 active listeners simultaneously using the interface.

A *talker* device is capable of transmitting data over the interface when addressed. Examples of that type of device are: tape readers, voltmeters that output data, and counters that output data. There can be only one active talker on the interface bus at a time.

A *controller* is a device capable of specifying an instrument as either a talker or a listener for an information transfer (including itself). A computer with an appropriate I/O card is an example of a controller. There can be only one active controller on the interface bus at a time; although multiple controller systems are allowed, only a single controller can be the system's master.

As shown in Fig. 3, the 15:1 ratio of controlled devices to controller may be configured in either a linear or a star form.

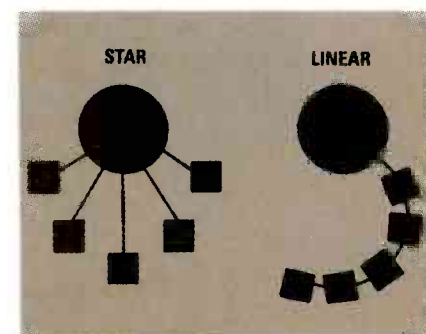


FIG. 3—THE STAR AND LINEAR form of instrument networking.

## Comparing connectors

The IEC 625-1 uses the 25-pin subminiature D-type connector, shown in Fig. 1, rather than a 24-pin ribbon type specified by the American standards, shown in Fig. 2. Unfortunately, as many of you know, the 25-pin D-type connector is used as part of the

Electronic Industry Association's Standard RS-232-C; an interface between Data Terminal Equipment and Data Communications Equipment employing serial binary data interchange. That standard uses voltages up to  $\pm 25V$  at 1/2 amp short circuit current. Therefore, it is quite under-



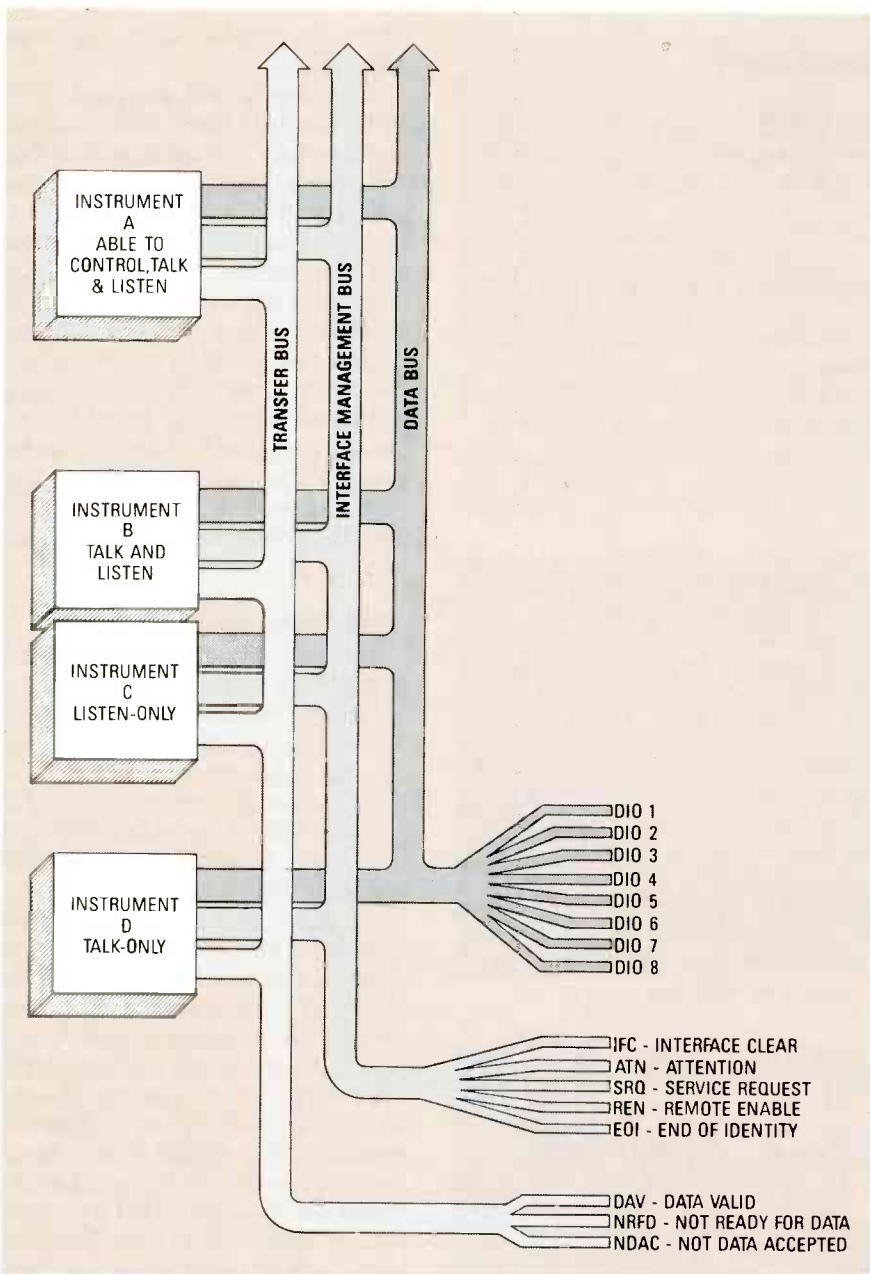


FIG. 4—THREE SEPARATE BUS LINES are used to control data flow.

TABLE 1—HANDSHAKING SIGNALS

Name	Description
DAV	<b>Data Valid:</b> Used to indicate the condition of the information on the Data I/O lines. Driven low by the source when data is settled and valid, and NRFD high has been sensed.
NRFD	<b>Not Ready for Data:</b> Used to indicate the condition of readiness of device(s) to accept data. Acceptor sets its NRFD low to indicate it is not ready to accept data. The NRFD line to the talker will not go high until all addressed listeners are ready to accept data.
NDAC	<b>Not Data Accepted:</b> Used to indicate the condition of acceptance of data by device(s). The acceptor will set its NDAC low to indicate it has not accepted data. When it accepts data from the Data I/O lines, it will release its NDAC line. However, the NDAC line to the talker will not go high until the last/slowest listener has accepted the data.

In total there are 16 active signal-bus lines; refer to Fig. 4. The term *bus* means a collective grouping of signals; those groups are either data, interface management, or byte transfer. Each bus is independent. In other words, the data bus would never have either byte transfer or bus management signals flowing through it.

#### HP-IL KIT

Hewlett Packard offers *The HP-IL interface/prototyping kit*. That kit, the HP 82166C, costs \$395 and consists of two converters, a test board, cabling, and excellent documentation which allows prototyping of loop-compatible products. Its key components consist of the HP-IL interface connection, the HP-IL transformer set, and the HP-IL panel receptacle.

The message transfer scheme used is asynchronous byte-serial/bit-parallel, with a three-wire interlocking handshake transfers. What all of that means is three handshaking lines acknowledge if the Data Are Valid (DAV); if the device addressed is Not Ready For Data (NRFD); or if the Data Are Not Accepted (NDAC). Figure 5 is a timing diagram of the handshaking signals for unambiguous transfer of data bytes. Table 1 summarizes those handshaking signals.

To ensure data transfer integrity, the following three conditions must be met:

1. The slowest device on the bus will determine the transfer rate during the transfer of that command.
2. More than one device can accept data at the same time.
3. Every byte transferred must undergo a handshake (except for parallel poll response).

The interface-management bus lines are responsible for the orderly flow of information; Table 2 lists those lines and their functions. Of particular importance is the ATTENTION (ATN) line, since all devices must monitor that line and respond within 200 ns after it becomes active (goes low). When the ATTENTION line is active, it places the management bus lines in the *Command Mode*, which serves four main functions:

1. Selection of the instruments that will send and accept data.
2. Selection of the specific interface operation, which includes five multiline commands and four uniline commands: INTERFACE CLEAR (IFC),

TABLE 2—MANAGEMENT LINES

Name	Description
<b>ATTN</b>	<b>Attention:</b> Causes all devices to interpret data on the bus as a controller command, and activates their acceptor handshake function (command mode).
<b>IFC</b>	<b>Interface Clear:</b> Initializes the GPIB system to an ideal state (no activity on the bus).
<b>SRQ</b>	<b>Service Request:</b> Alerts the controller to a need for communication.
<b>REN</b>	<b>Remote Enable:</b> Enables devices to respond to remote program control when addressed to listen.
<b>EOI</b>	<b>End or Identify:</b> Indicates last data byte of a multi-byte sequence; also used with ATN to parallel poll devices for their status bit.

mand, to provide additional command codes.

Every instrument designed to the GPIB standard has a device address that is usually selectable, and that device address is used by the active controller in the *Command Mode* to specify who talks (via a Talk Address) and who listens (via Listen Address). A device's address is usually pre-set at the factory and can be reset during system configuration by an address switch, jumpers, or front-panel entry; that switch is typically located on the outside rear panel of the device but could be internal. The decimal equivalent of the 5 least significant bits of the switch determines the device's address on the interface.

### GPIB limitations

The basic limitations on the GPIB operation are: the interconnecting cable length between GPIB devices, the maximum transfer rate of data, and the maximum number of GPIB devices that can be configured in a GPIB network. All can be effectively dealt with if you are aware of certain GPIB accessory equipment.

As shown in Fig. 6, cable-length limitations can be reduced or eliminated by using bus-extender devices.

The HP 37201A and the HP 37203A are two bus extenders that we'll consider. The HP 37201A is specifically designed to operate with a wide range of synchronous or asynchronous modems over private lines, leased lines, or public switched (dial-up) telephone networks. That data interface is compatible with RS-232C asynchronous data rates of 150, 300, 600 and 1200 bits/seconds.

The HP 37201A provides for error checking/correcting communications protocol that protects against errors introduced by poor-quality data circuits. That instrument even provides immunity to major interruptions in the data link, such as dropouts, line breaks and modem sync. loss; and it recovers automatically without loss of data.

*Data-Transfer-Rate* limitations mandate that every device be turned-on; that all devices participating in the data transfer use three-state drivers; that the cable length not exceed 15 meters, or have more than one device per meter of cable; and that the capacitive loading should be limited to 50 pF per device.

*continued on page 98*

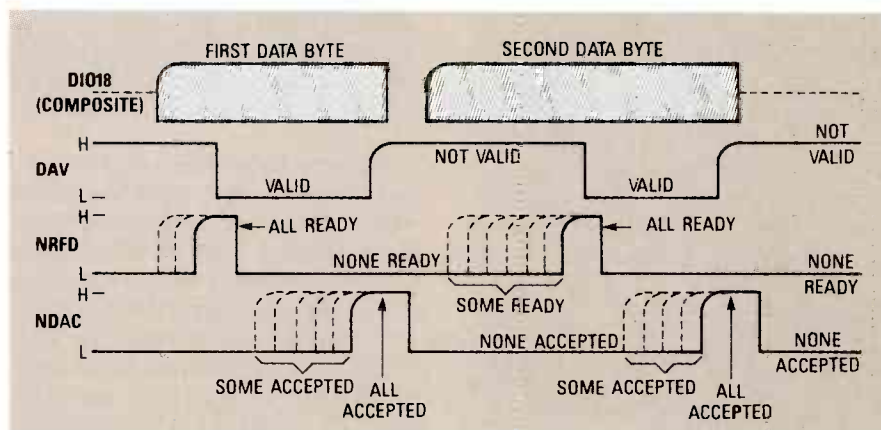


FIG. 5—TIMING DIAGRAM FOR HANDSHAKING signals on GPIB bus.

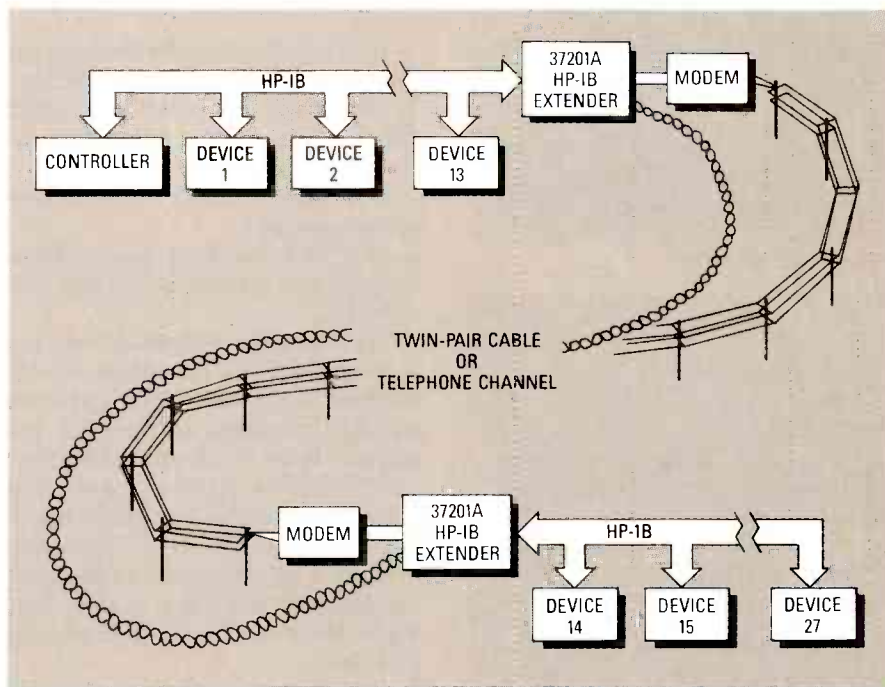


FIG. 6—USING GPIB EXTENDERS AND MODEMS, GPIB devices can be connected if separated by great distances.

REMOTE ENABLE (REN), ATTENTION (ATN), and IDENTIFY (IDY) when both ATN and EOI are active.

3. Specific device addressing for listener devices.
4. Issuing a specific secondary com-



# WORKING WITH OTA's

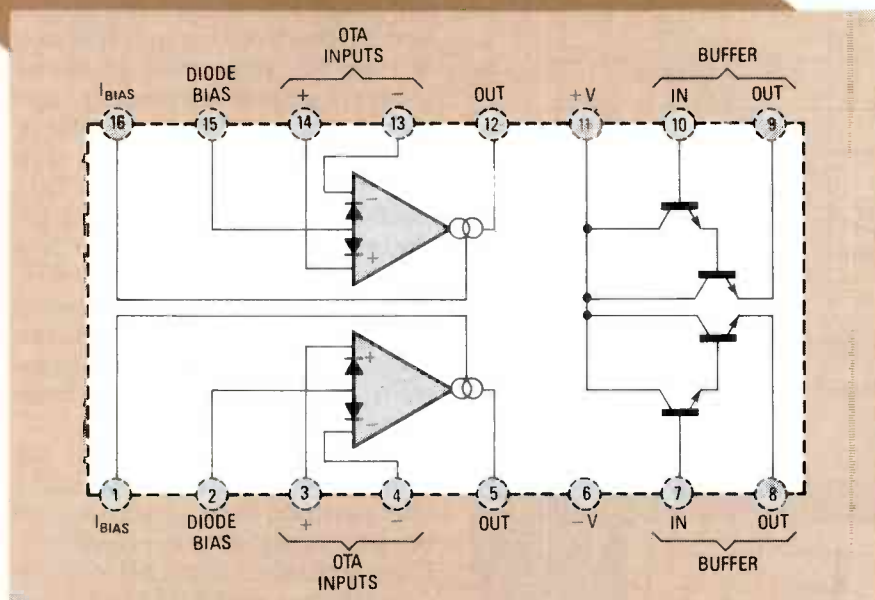


FIG. 1—PIN CONNECTIONS of the LM13600 dual OTA are as shown. You can also see how each IC contains two OTA's.

LAST TIME (MAY 1988) WE DISCUSSED THE basic operating principles of the CA3080 Operational Transconductance Amplifier (OTA), and showed how it can be used to make various types of voltage- or current-controlled amplifiers and micro-power Schmitt triggers, comparators, and oscillators. However, the CA3080 has relatively high distortion and an unbuffered high-impedance output.

In this article we will introduce you to an improved second-generation OTA; the LM13600. That device is actually a dual OTA, as shown by the pinout of Fig. 1. The package also incorporates linearizing diodes that greatly reduce signal distortion, and a coupled output-buffer stage that can provide a low-impedance output.

The two OTA's of the LM13600 share common supplies, but are otherwise fully independent. All elements are integrated on a single chip, so both OTA's have closely matched characteristics (transconductance values are typically matched within 0.3 dB), making the IC ideal for use in stereo applications. The commercial version of the LM13600 can be powered from a split supply of up to 18 volts, or a single-ended supply of up to 36 volts.

## Linearizing diodes

Figure 2 shows a basic connection diagram for one of the OTA's in the LM13600. Basically, that OTA is almost identical to the one in the CA3080, except for the addition of linearizing diodes D1 and D2. Those are integrated with Q1 and Q2, and have characteristics that are matched to the base-emitter junctions of Q1 and Q2. In use, equal low-value re-

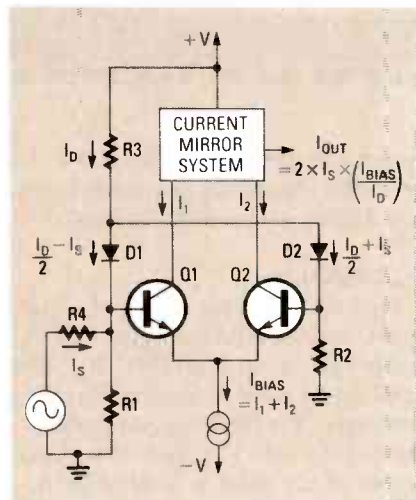


FIG. 2—SIMPLIFIED circuit of an LM13600 OTA shows one of the more basic ways of using the IC.

The LM13600 is a second-generation dual Operational Transconductance Amplifier that can be used as a voltage-controlled amplifier, resistor, filter, or oscillator. In this article we'll show you how.

RAY MARSTON

sistors R1 and R2 are wired between the inputs of the differential amplifier and ground. Bias-current  $I_D$  is fed to those resistors from the positive supply via R3, D1, and D2. Since D1 and D2 have identical characteristics, and since R1 and R2 have equal values, bias current,  $I_D$ , divides equally between R1 and R2.

The circuit's input voltage is applied via R4, which has a large value relative to R1, and generates an input signal current of  $I_S$ . That signal current feeds into R1 and generates a voltage across it, reducing D1's current to a value of  $(I_D/2) - I_S$ . Since  $I_D$  is constant, the D2 current rises to  $(I_D/2) + I_S$ . Consequently, the linearizing diodes apply a heavy negative feedback to the differential amplifier and substantially reduce the signal distortion. If  $I_S$  is small relative to  $I_D$ , the output current of the circuit is equal to  $2 \times I_S \times (I_{BIAS}/I_D)$ . The gain of the circuit can be controlled either by  $I_{BIAS}$  or  $I_D$ . In use,  $I_D$  and  $I_{BIAS}$  should both be limited to a maximum of 2 mA.

The graph of Fig. 3 shows typical distortion levels of the LM13600 at various peak-to-peak input voltages, with and without the use of the linearizing diodes. At a 30-mV input, the distortion is below 0.03% with the diodes, and 0.7% without them. At a 100-mV input, the distortion is roughly 0.8% with the diodes, and 8% without them.

## Controlled-impedance buffers

Figure 4 shows the internal circuit of each half of the LM13600. The two

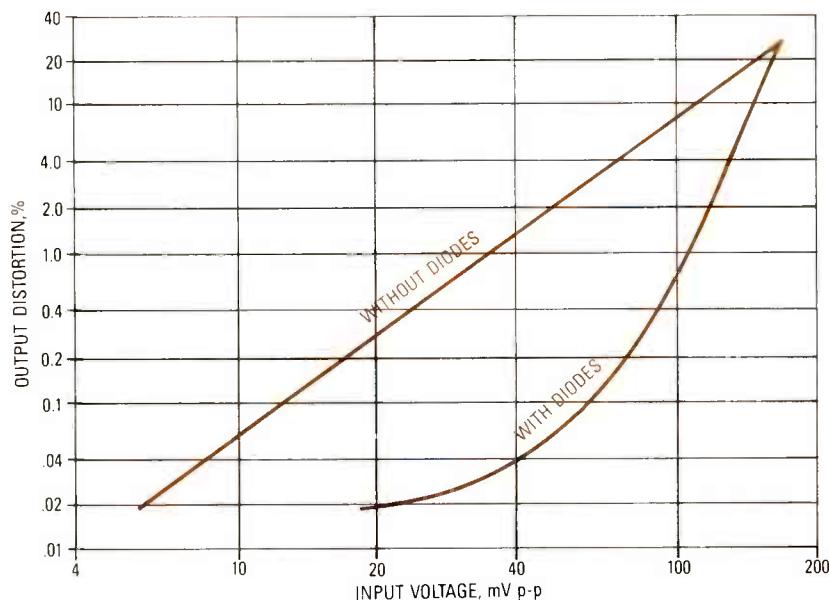


FIG. 3—TYPICAL DISTORTION LEVELS of the LM13600 OTA, with and without the use of the linearizing diodes.

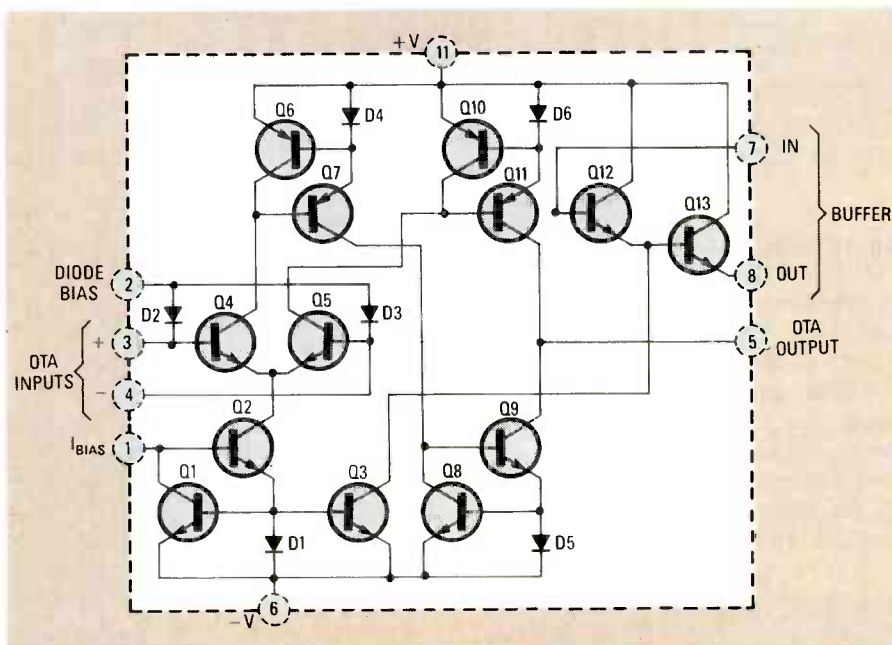


FIG. 4—INTERNAL CIRCUIT of one half of the LM13600 dual OTA. Each LM13600 IC contains two of these circuits.

output transistors (Q12 and Q13) are connected for use as a controlled-impedance Darlington emitter-follower buffer stage. When the base of Q12 is connected to the output of the OTA, and the emitter of Q13 is connected to the negative supply ( $-V$ ) via a suitable load resistor, the buffer makes the OTA's high-impedance output signal available at a low-impedance level. The output current of each buffer stage should be limited to 20 mA maximum. Note that the output of the buffer stage is about 1.2 volts (two base-emitter voltage drops) below the

output-voltage level of the OTA, so the buffer should not be used in precision DC-amplifier applications.

### VCA circuits

Figure 5 shows the circuit of a Voltage-Controlled Amplifier (VCA) using half of an LM13600 IC. The input signal is fed to the non-inverting terminal of the OTA via current-limiting resistor R4. The high-impedance output of the OTA is loaded by R5, which determines the peak amplitude of the output signal. The output signal is available at a low-impedance level

via the buffer stage, which is loaded via R6.

The circuit in Fig. 5 is powered from dual 9-volt supplies. The current  $I_D$  is fixed at about 0.8 mA via R1, but  $I_{BIAS}$  is variable via R7 and an external gain-control voltage. When the gain-control voltage is at the negative-supply level of  $-9$  volts,  $I_{BIAS}$  is zero and the circuit has an overall gain of  $-80$  dB. When the gain-control voltage is at the positive-supply value of  $+9$  volts,  $I_{BIAS}$  reaches a value of roughly 0.8 mA, and the circuit has a gain of roughly 1.5. The gain is fully variable within those limits via the gain-control input. The circuit is a non-inverting amplifier, since the input signal is fed to the non-inverting input of the OTA. It can be used as an inverting amplifier by feeding the input signal to the OTA inverting input instead.

Because the two halves of the LM13600 have closely matched characteristics, the IC is ideal for use in stereo-amplifier applications. Using both halves of an LM13600 you can make two amplifiers like the one in Fig. 5. Then, if you connect both gain-control inputs together, and feed them from a single gain-control voltage and current-limiting resistor, you'll have a voltage-controlled stereo amplifier.

The VCA circuit of Fig. 5 can be used as an amplitude modulator or 2-quadrant multiplier by simply feeding the carrier signal to the OTA input, and the modulation signal to the gain-control input. If desired, the gain-control pin can be DC-biased so that a carrier output is available while no AC-input signal is applied. Figure 6 shows a practical example of an inverting-amplifier circuit of that type. The AC-modulation signal modulates the amplitude of the carrier-output signal.

Figure 7 shows how one half of an LM13600 can be used as a ring modulator or 4-quadrant multiplier. In that circuit, there is no carrier output when the modulation voltage is at ground level, but increases when the modulation voltage moves positive or negative with respect to ground. When the modulation voltage is positive, the carrier-output signal is inverted relative to the carrier input; and when the modulation voltage is negative, the carrier output is non-inverted.

The circuit in Fig. 7 is similar to the circuit in Fig. 6, except that the com-



ponent values shown are suited for operation from a dual 15-volt supply, and that  $I_{BIAS}$  is adjustable via R7. The OTA's output (inverted relative to the input signal) feeds into the one end of R5, and at the same time the input signal feeds directly into the other end of R5. Potentiometer R7 is adjusted so that when the modulation input is tied to ground, the overall gain of the OTA is such that its output current exactly balances (cancels) the carrier input current to R5. Under that condition the circuit has no carrier output. When the modulation input goes positive, the OTA's gain increases and its output signal exceeds that caused by the carrier input to R5, so an inverted output signal is generated. Conversely, when the modulation input goes negative, the OTA's gain decreases and the carrier input to R5 exceeds the output of the OTA; therefore, a non-inverted output signal is generated.

### Offset biasing

The circuits in Figs. 5–7 are shown with the OTA's input biased by fixed-value 470-ohm resistors wired between the two input terminals and ground. In practice, that simple arrangement may cause the circuit's DC level at the output to shift slightly when the gain-control input ( $I_{BIAS}$ ) is varied between its minimum and maximum value. If desired, that level-shifting effect can be eliminated by adding a presettable offset-adjust control, as shown in Fig. 8. Potentiometer R4 enables the relative values of the biasing resistors, R2 and R3, to be varied over a limited range. To adjust the offset bias, reduce  $I_{BIAS}$  to zero, note the DC level of the output signal, and then increase  $I_{BIAS}$  to maximum and adjust R4 for the same DC-output level.

### AGC amplifier

Figure 9 shows how to make an Automatic Gain Control (AGC) amplifier in which a 100:1 change in the input-signal amplitude causes only a 5:1 change in the output amplitude. In that circuit,  $I_{BIAS}$  is fixed by R4, and the output signal is available directly across R5. The output buffer is fed from the output of the OTA and is used as a signal rectifier. The rectified output of the buffer is smoothed via R6 and C2, and used to apply the  $I_D$  current to the linearizing diodes of the OTA. However, no significant  $I_D$  cur-

rent is generated until the OTA's output goes high enough to turn on the Darlington buffer and the linearizing diodes. An increase in  $I_D$  reduces the OTA's gain, and negative feedback holds the output at a steady level.

The basic gain of the amplifier in Fig. 9, with no  $I_D$  current, is 40. Therefore, with an input signal of 30 mV p-p, the OTA's output of 1.2 volts p-p is not enough to generate an  $I_D$  current, so the OTA operates at full

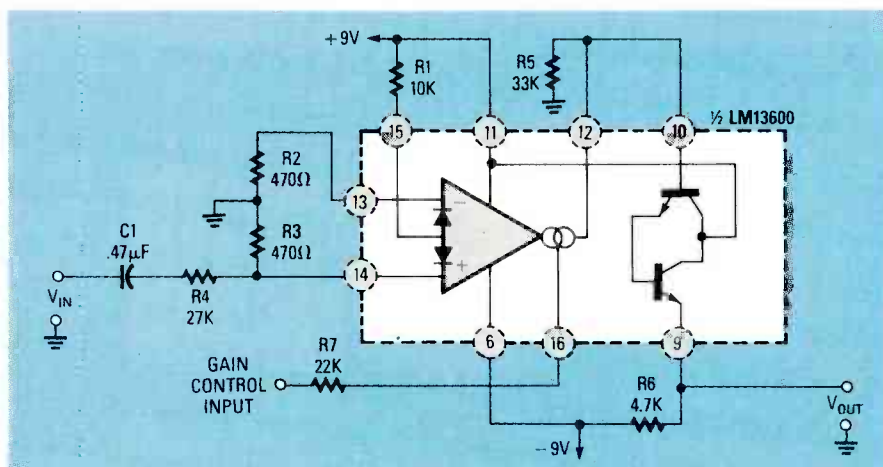


FIG. 5—A VOLTAGE-CONTROLLED amplifier (VCA) is one application for the LM13600. The LM13600 is also well suited for use as a stereo amplifier because it contains two matched amplifiers.

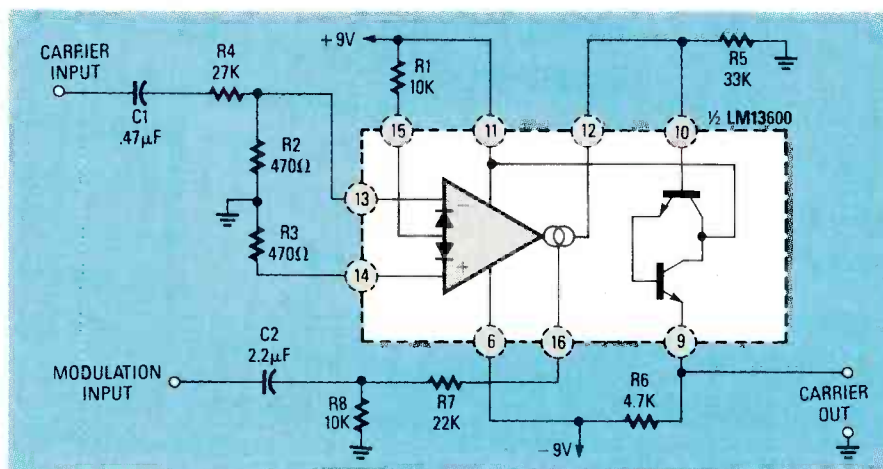


FIG. 6—AN AMPLITUDE MODULATOR or 2-quadrant multiplier can be made using one half of the LM13600.

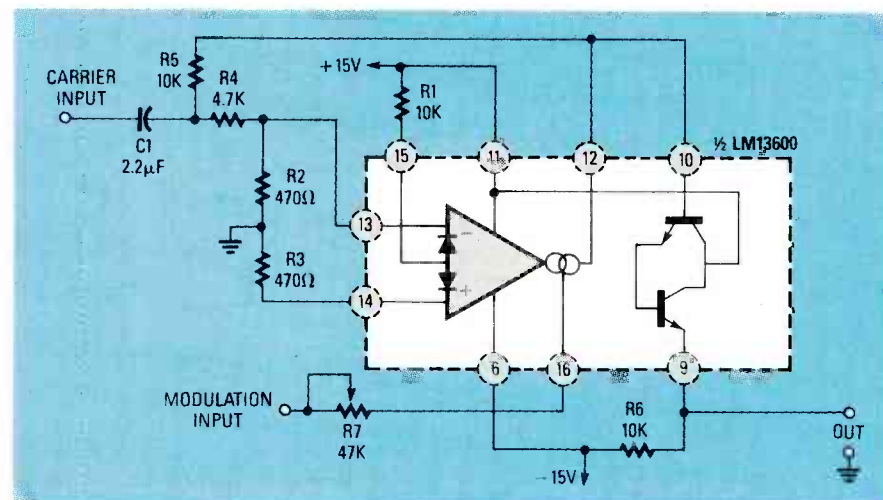


FIG. 7—THE CIRCUIT SHOWN HERE is a ring modulator or 4-quadrant multiplier.

gain. With an input of 300 mV, however, the OTA's output is enough to generate a significant  $I_D$  current, and the circuit's negative feedback automatically reduces the output level to 3.6 volts p-p, giving an overall gain of 11.7. With an input of 3 volts, the gain

falls to 2 (an output of 6 volts p-p). The circuit thus has a 20:1 signal compression over that range.

### Voltage-controlled resistors

One unusual application of the LM13600 is as a Voltage-Controlled

Resistor (VCR), using the circuit shown in Fig. 10. The basic theory is as follows: An AC signal applied to the  $R_X$  terminals feeds into the inverting terminal of the OTA via  $C1$ , the output-buffer transistors, and the  $R5/R_A$  attenuator. The OTA will then generate an output current that is proportional to  $V_{IN}$  and  $I_{BIAS}$ . Therefore, because  $R = V/I$ , the  $R_X$  terminal functions as an AC resistor whose value is determined by  $I_{BIAS}$ .

The effective resistance between the  $R_X$  terminals of the circuit in Fig. 10 equals  $(R5 + R_A)/(gm \times R_A)$ , where  $gm$  (transconductance) is approximately  $20 \times I_{BIAS}$ . That formula can be approximated as  $R_X = R5/(I_{BIAS} \times 20R_A)$ . Using the component values shown,  $R_X$  equals approximately 10 megohms when it has an  $I_{BIAS}$  current of 1  $\mu A$ , and 10 kilohms when it has an  $I_{BIAS}$  current of 1 mA.

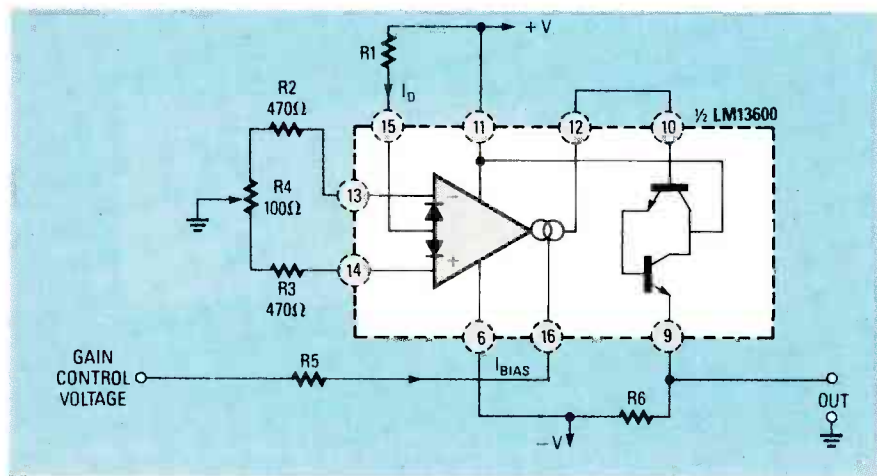


FIG. 8—A METHOD OF APPLYING offset biasing to the LM13600.

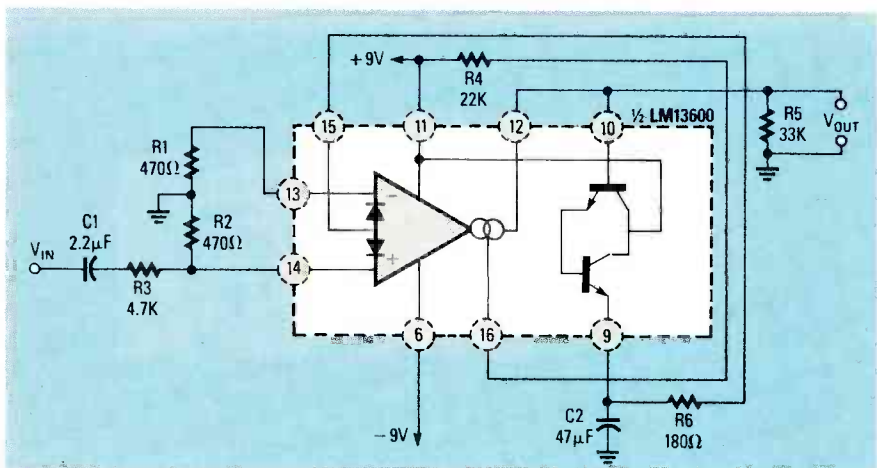


FIG. 9—AN AGC AMPLIFIER adjusts its own gain according to the magnitude of the input signal.

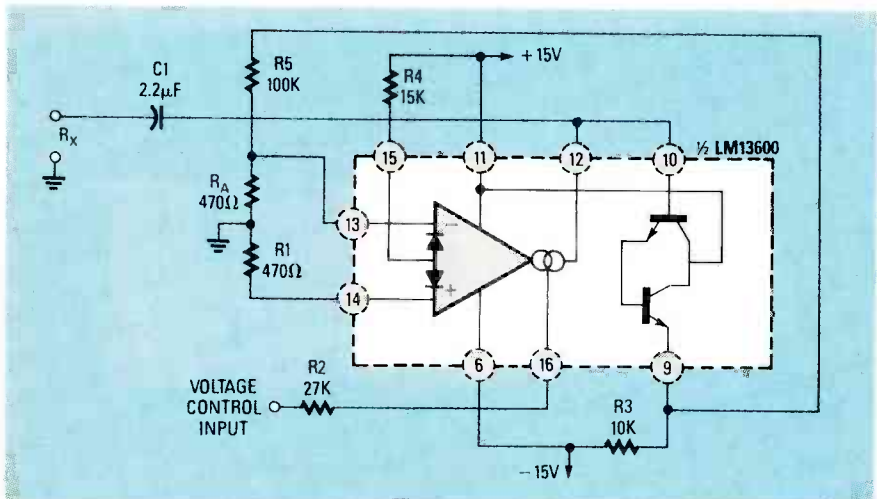


FIG. 10—A VOLTAGE-CONTROLLED RESISTOR can be used as an electronically-controlled resistor.

### Voltage-controlled filters

A voltage-controlled low-pass filter can be implemented by using one half of an LM13600 in the configuration shown in Fig. 11. In that circuit, the values of  $R5$ ,  $C2$ , and  $I_{BIAS}$  control the cut-off frequency ( $f_O$ ) of the filter. The input signal is applied to the non-inverting terminal of the OTA via voltage-divider network  $R1/R2$ . The OTA's output signal is "followed" by the buffer stage and fed back to the inverting terminal via an identical voltage-divider network,  $R5/R_A$ . The basic OTA operates as a non-inverting amplifier with a gain of  $R5/R_A$ , but because the input signal to the OTA is applied via a voltage divider with a value equal to  $R5/R_A$ , the overall circuit operates as a unity-gain voltage follower.

At low frequencies,  $C2$  has a very high impedance and is able to be fully charged by the OTA's output current, so the circuit operates as a voltage follower as was previously described. As the frequency increases,  $C2$ 's impedance decreases and is no longer able to be fully charged by the OTA's output current, so the output signal starts to attenuate at a rate of 6-dB-per-octave. The cut-off point of the circuit, defined as the point where the output falls by 3 dB, occurs when  $X_C/20I_{BIAS}$  equals  $R5/R_A$ , as shown by the formula in the diagram ( $gm$  is approximately equal to  $20 \times I_{BIAS}$ ). With the component values that are shown in Fig. 11, the filter's cut-off



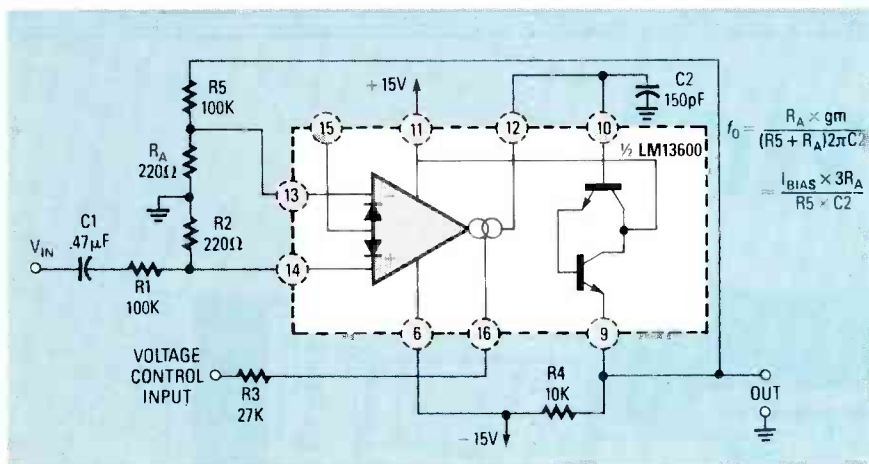


FIG. 11—A VOLTAGE-CONTROLLED LOW-PASS filter covering 45 Hz to 45 kHz.

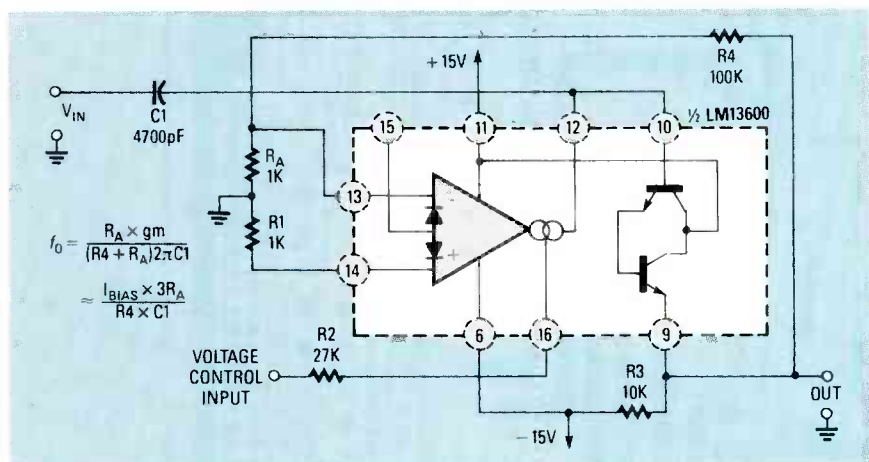


FIG. 12—A VOLTAGE-CONTROLLED HIGH-PASS filter covering 6 Hz to 6 kHz.

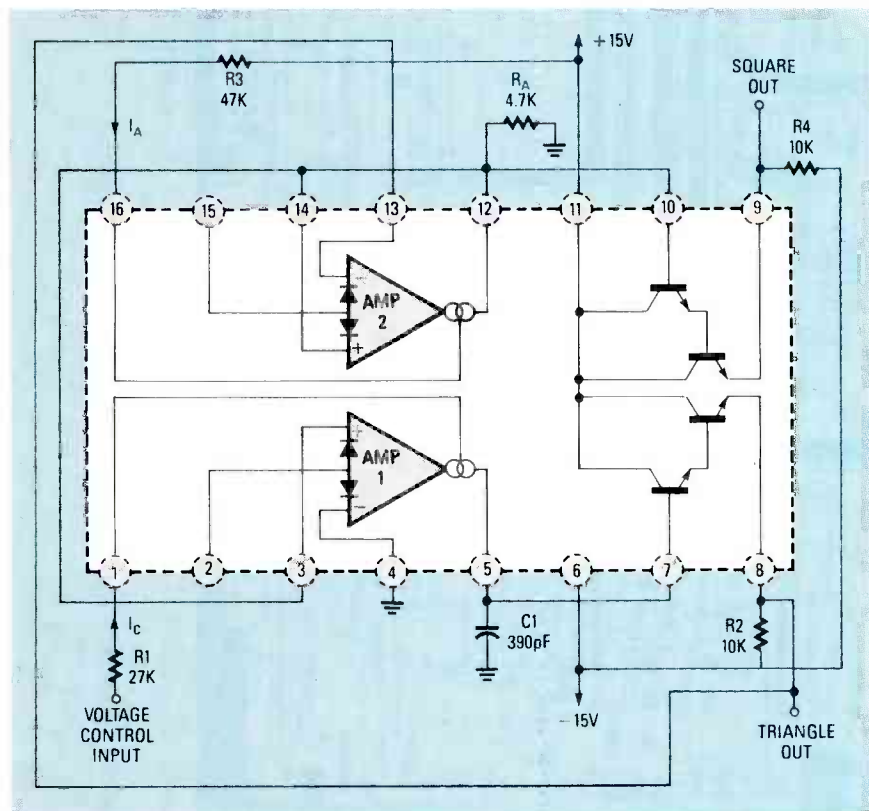


FIG. 13—A COMBINATION TRIANGLE-SQUARE-WAVE VCO covering 200 Hz to 200 kHz.

point occurs at about 45 Hz with an  $I_{BIAS}$  of  $1 \mu A$ , and at 45 kHz with an  $I_{BIAS}$  of  $1 mA$ .

A similar principle can be used to make a voltage-controlled high-pass filter. As shown in Fig. 12, that circuit has cut-off frequencies of 6 Hz when it has an  $I_{BIAS}$  current of  $1 \mu A$ , and 6 kHz when it has an  $I_{BIAS}$  current of  $1 mA$ .

## Voltage-controlled oscillators

To conclude this look at the LM13600 operational transconductance amplifier, Fig. 13 shows how to use the IC as a Voltage-Controlled Oscillator (VCO). The circuit uses both halves of the LM13600, and simultaneously generates both triangle and square waves.

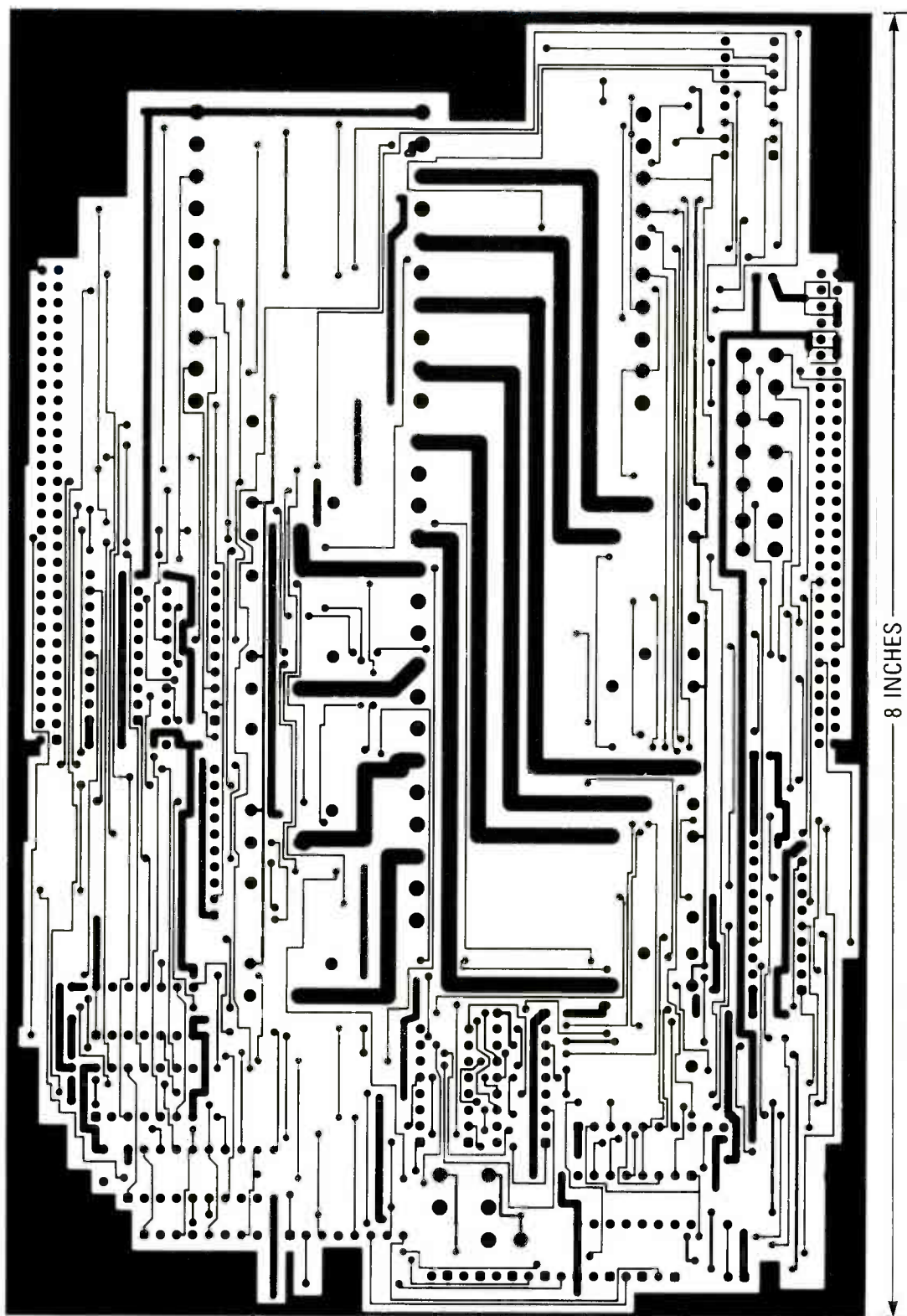
To understand the operating theory of the circuit, assume initially that capacitor C1 is negatively charged and that the square-wave output signal has just switched high. Under that condition a positive voltage is developed across  $R_A$ , which is fed to the non-inverting terminals of the two amplifiers. That voltage causes amp 1 to generate a positive output current, equal to bias current  $I_C$ , that flows into C1 and generates a positive-going linear ramp voltage.

The ramp voltage is then fed to the inverting terminal of amp 2 via the Darlington buffer stage, until it eventually equals the voltage on the non-inverting terminal, at which point the output of amp 2 starts to swing in a negative direction. That initiates a regenerative switching action, and at that moment, the signal at the square-wave output terminal abruptly goes negative.

In that new state, a negative voltage is generated across resistor  $R_A$ , causing amp 1 to generate a negative output current equal to  $I_C$ , causing capacitor C1 to discharge until its voltage equals that of  $R_A$ , at which point the square-wave output switches high again.

The process repeats over and over again, making available a triangle waveform at R2 and a square wave at R4. The frequency of those waveforms is variable via the voltage-control input; that input is what controls the value of  $I_C$ . With the component values shown, the circuit then generates a frequency of about 200 Hz when the  $I_C$  bias current is  $1 \mu A$ , and 200 kHz when the bias current is  $1 mA$ .

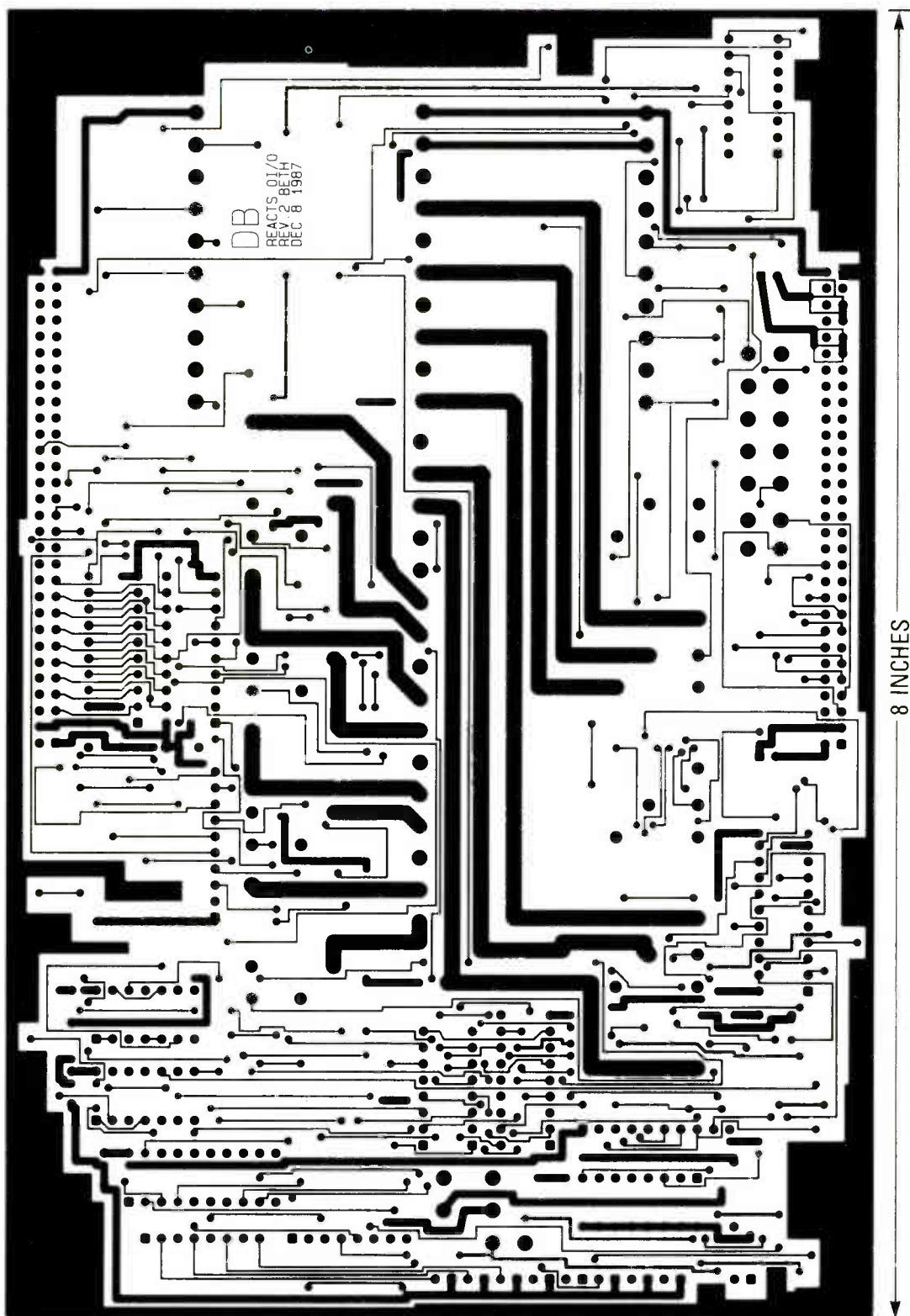
# PC SERVICE



THIS IS THE PATTERN FOR THE solder side of the REACTS I/O board.

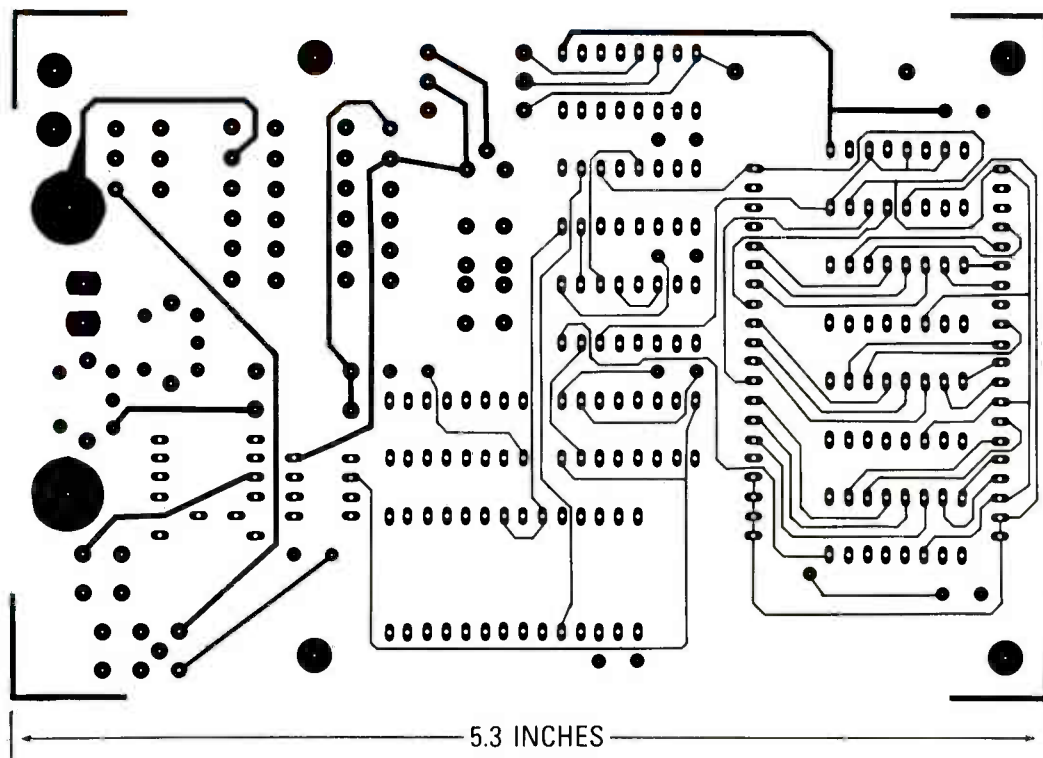


# PC SERVICE

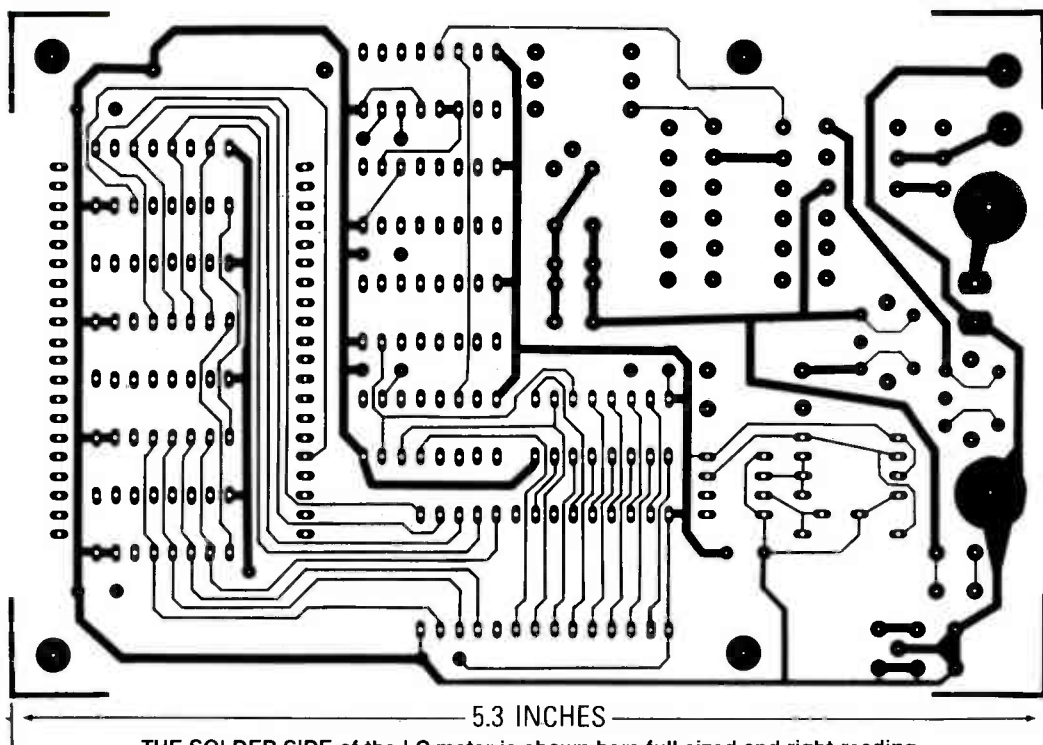


THE PATTERN for the component side of the REACTS I/O board is shown here.

# PC SERVICE



THE COMPONENT SIDE of the LC meter shown here is full sized and right-reading.



THE SOLDER SIDE of the LC meter is shown here full sized and right-reading.



# HARDWARE HACKER

Absolute navigation ideas  
Telephone line recording  
Ring equivalency numbers  
Data access arrangements  
New printed circuit layouts

DON LANCASTER

## Making PC-board layouts, and more!

OUR FREE HARDWARE-HACKER HELP LINE sure has been busy lately. As many as fifty of you a day have called in with well-thought-out, interesting, and very challenging problems. But, on the other hand, I've been getting far too many calls from those of you who simply did not read the story or else paid no attention whatsoever to all of our very carefully researched Names and Numbers sidebars.

So, please, to make it fair for everyone else: (1) Read the entire column twice and the Names and Numbers box three times before you call. (2) Pre-list your questions. (3) Have a pencil and paper on hand. And, finally, (4) please call only between 8 am and 5 pm week days Mountain Standard time.

If you have trouble keeping track of time zones, just remember that all California clocks are laid back. By the way, Arizona does stay on Mountain Standard Time all year round. We have so much daylight that none of it is worth saving.

Needless to say, if you find my answers of value, I wouldn't mind too terribly much if you bought something from Synergetics, or sent me some interesting reprints, some nuts and berries, or whatever. Or helped me out with my hobby of collecting federal reserve notes.

Uh, whoops. Several of you auto mechanics on our helpline have chided me for using the wrong acronym in naming that thirty-cent three-way surplus pneumatic valve we looked at back in the April issue. The correct name for those

are TCS or SCS valves, as in Transmission Controlled Spark or Speed Controlled Spark.

They were apparently used at one time as pollution controls that delayed the vacuum advance in lower gears or at lower speeds.

Some additional stock numbers on those are the JerryCo 1296, Edmund Scientific P42533 or P36716, or C & H Sales SV7904.

There's lots of interesting things going on this month in the trade journals and in some other tech publications. Check back to the January 21, 1988 issue of *EDN* for a great review of new stepper-motor drivers and circuits.

Two major new publications on superconductivity now include the *Cambridge Report on Superconductivity* and the *Journal of Low Temperature Physics*. Since those are both insanely expensive, you will want to visit a major technical library to view them.

Steve Ciarcia has started up a brand new hacker magazine called *Circuit Cellar Ink* that looks like a real winner. Steve had a classic story back in our September 1980 *Radio-Electronics* on the BSR home power controllers that I still refer many helpline callers to.

*Powerconversion* has renamed

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itself *PCIM*. That free trade journal is a great place to go for info on "big mutha" power semiconductors as are found in welders, electric vehicles, in high-voltage deflection circuits, and larger robotics.

A competing magazine to *PCIM* is called *Motion* and emphasizes such things as steppers and servo drives. As is typical with trade journals, you qualify by making a professional request on a business letterhead. Your own letterheads, of course, are utterly trivial with today's PostScript laser printers.

Our biggie this month is a brand new way of doing hacker printed circuits that minimizes or outright eliminates any need for camera work, yet will quickly and cheaply produce first-quality results. But first, let's dream just a little....

### Absolute navigation

It's fun to try and predict when and where the next big hacker breakthrough opportunity might come from. The one I am waiting for is a dramatic price reduction in a simple, accurate, and extremely low-cost system used for absolute navigation.

Figure 1 shows you one big possibility—a \$9.95 and three inch NaviCube that will always know where it is, how far it has moved in just what direction since last reset, which way true north is, and which way is up.

I am one of those spelunkers that often will spend a lot more time underground than above. Cave mapping is a weary, exasperating, tedious, and time-consuming task that is prone to all

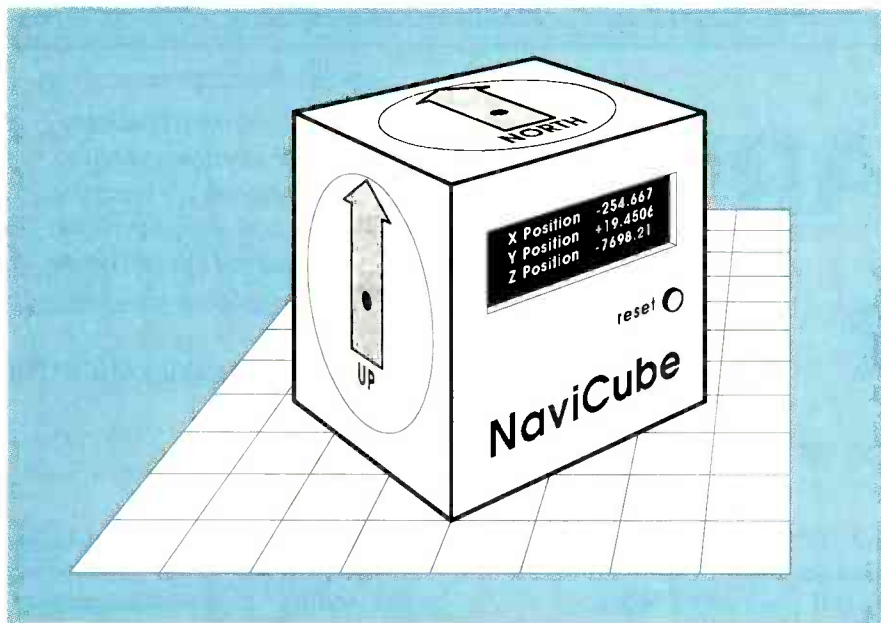


FIG. 1—THE \$9.95 NAVICUBE ALWAYS KNOWS up, north, and its own absolute position since it was last reset. Its only tiny problem is that it doesn't quite exist yet—or does it?

sorts of errors. It sure would be nice to throw one of those NaviCubes into my speleo pack, waltz on through the cave, and return with a ready-to-use map.

It would be even nicer if you put the NaviCube inside a rubber ball.

At each cave station, you simply would bounce it off the ceiling, floor, and walls to instantly map the passage size as well as its current position.

The traditional approach to the NaviCube is to use one or more gyroscopes. Basically, you take a freely supported large mass and spin it as fast as you can, while recording any deviations from its initial path. It usually takes three of those, one each for the X, Y, and Z directions.

You can still get surplus World War II gyros from such outfits as C & H Sales, Fair Radio Sales, and JerryCo. But those are bulky power hogs that are hard to use.

Today, we do have optical solid-state gyroscopes that consist of nothing but a roll of fiber optics, a pair of diodes, and a directional coupler. Coherent laser-light is squirted in both directions around the fiber coil, and then the phase difference caused by the Doppler effect is measured to tell you how much the coil has rotated.

Unfortunately, solid-state gyros are being built today by the wrong people for the wrong reasons, so they remain outrageously priced. But I feel it will only be a matter of a very few months before some Hong Kong toy company builds a \$9.95 solid-state laser gyroscope or its equivalent. And all of us hackers should be more than willing to glomp onto that jewel.

A third possibility would be to use some sort of satellite-based radio direction finding inside the NaviCube. While that is certainly possible, I feel that the resolution of that approach is unlikely to ever get much better than a few feet, and that there would be some very serious antenna and reception problems that would limit both the minimum size and the coverage.

Not to mention that it would not work very well underground.

There's a fourth approach to the NaviCube, and it is something that all you hackers can experiment with right here and right now. The price of new high-quality accelerometers has just dramatically dropped to the \$10 range, led by such outfits as SenSym and the IC Sensors people.

What you do is to take the output from a silicon solid-state accelerometer and A/D convert it into a series of pulses. You sum the pulses into an up-down counter to get the current velocity. Then, at precise time intervals you sum up the current velocity to get the current NaviCube position.

Talking some math, the rate of change of position is velocity and the rate of change of velocity is acceleration. Conversely, the first integral summation of acceleration is velocity, and the second integral summation of acceleration is the position. Details appear in almost any college-level physics book.

Newton's law and all that.

For this month's contest, let us assume that the \$9.95 three-axis NaviCube is a reality and that its stability and long-term accuracy is "good enough". Tell me what you would do with it. There will be all the usual books and tinaja quests as prizes. Also as usual, send your entries to me per the box and not to the **Radio-Electronics** offices.

Oh yes, if you are the sort of person that does thoroughly enjoy having ice water drip down your back while trying to eat a soggy and spent carbide-flavored sandwich by the light of a fading greenish *cyalume*, then give the National Speleological Society a call. They will in turn put you in touch with a local grotto or two in your immediate area.

Are we having fun yet?

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## Data-access arrangements

A data-access arrangement is any scheme to get modem tones or other audio or control signals onto or off of the phone line. The laws on how you do that will vary from country to country, but in the US you are supposed to exactly follow FCC Regulations part 68.

Simply meeting the regulations is not near enough. Besides that, your circuit or product has to be type approved before it can be sold. Getting the FCC type approval usually turns out to be a costly and very drawn-out bureaucratic nightmare.

Figure 2 shows you the essen-

tials of a typical data access arrangement. You start with an 800-volt, or so, varistor or a telephone-grade transient suppressor on the phone-line side. A pair of 10-ohm resistors is then used to drive an audio-coupling transformer. That transformer usually has 600-ohm input and output impedances, and must have a breakdown voltage of at least 1500 volts.

A de-glitching capacitor will be required over on the transformer secondary, as are a pair of series-connected Zener diodes that will prevent you from ever applying more than plus or minus four volts of peak-to-peak signal onto the telephone line.

Ready-to-use and already type-approved data-access arrangements are available from such outfits as Cermetek and Dallas Semiconductor. The prices are ridiculous.

The leading US manufacturer of the special transformer needed is Prem Magnetics. As an alternate,

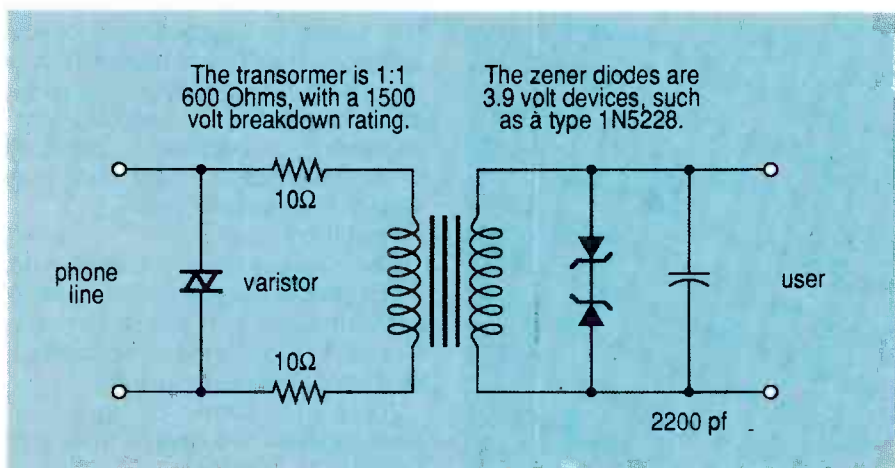


FIG. 2—A DATA-ACCESS ARRANGEMENT such as this one must provide surge suppression, signal limiting, and safety isolation, as well as being FCC part 68 type-approved.

Newark Electronics lists a Stancor TTPC-7 equivalent that sells for \$5.63 in modest quantities.

Another variation is the audio-access arrangement shown in Fig. 3. That circuit might let you automatically record any phone messages. There are two primary areas to the circuit.

The first area consists of a sensitive reed relay that pulls in only when the phone is on hook. When you pick up the telephone handset, the DC loop-current goes through the reed relay and thus activates it. Since the reed switch itself is normally open, the switch turns on the recorder whenever

the telephone's handset is picked up off the hook.

The second area of the circuit is a suitable audio transformer that couples the phone-line audio into the recorder. Note that that is a one-way circuit—you can record the phone messages, but you can't play the recorder back into the telephone line.

Because of the drop across the relay coil, the circuit only works with a single telephone. Fancier circuits are needed when extension phones are present.

The Radio Shack model 43-228 phone-recording control uses a circuit similar to that one.

## Ringer-equivalency numbers

There sure seems to be a lot of confusion on what is really a very simple concept. Most of the urban telephone systems let you put five of the older telephones on them using five electromechanical bell ringers. The smaller of the rural companies may limit you to three bell ringers.

Each and every piece of new equipment that is placed on your phone line must have a label on it that tells you just what the Ringer-Equivalency Number, or REN is. A plain electromechanical bell has a REN of 1.0.

When you add up all of the REN values for everything that you have hung on your line, the total must be less than five for an urban phone and less than three for a longer rural phone line.

In theory, your phone company can adjust your line for higher ringer loads, but my local phone company refuses to do so.

Phone ringing is done by placing a high-voltage and low-frequency sinewave on the line, typically in the range of 40 to 150 volts with a frequency of 15 to 68 hertz.

In previous columns, we have seen several special integrated circuits used for ring detection and for speaker or piezo-transducer driving. Figure 4 shows you a simpler and much more flexible approach that uses an ordinary optocoupler instead.

## New printed-circuit layouts

I have been putting together a brand new way of doing hacker and student printed-circuit layouts that seems to have a bunch of advantages. It will instantly, and without using any photography, produce for you 1X, 2X, or 4X layouts, frontwards or backwards, positive or negative, of any size from one square inch to one acre.

And it is cheap.

The system uses your favorite word processor with your chosen computer and can directly drive a LaserWriter or some other PostScript-language printer.

A layout is shown in Fig. 5; we have overlaid the design grid, the foil side in black and the component side in gray. Up to a dozen layers can be supported at once.

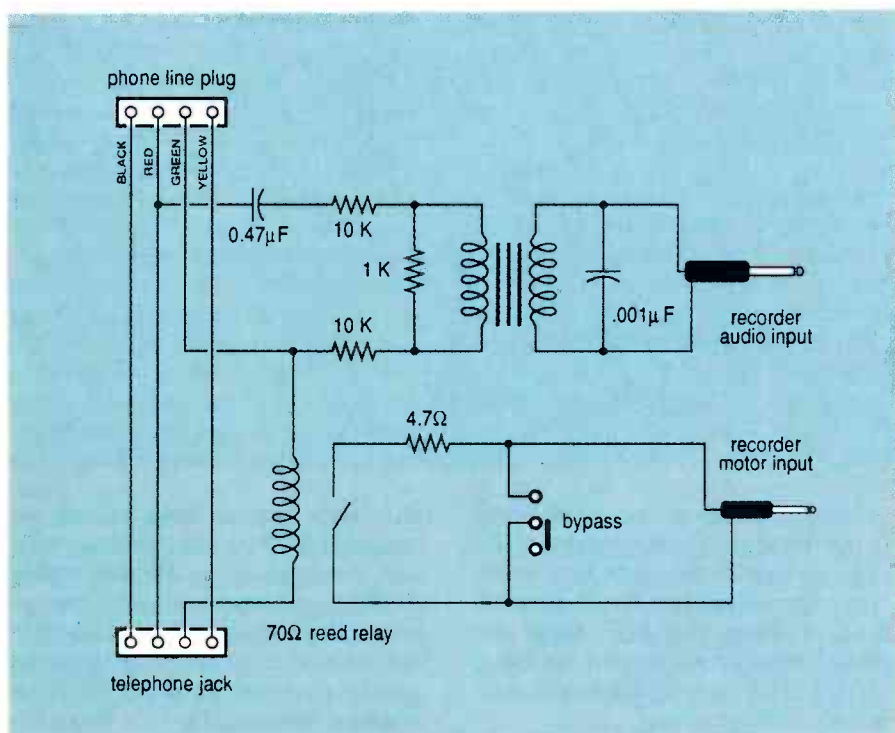


FIG. 3—AN AUDIO-ACCESS ARRANGEMENT can record both sides of a telephone conversation, but is only legal for use under certain circumstances.

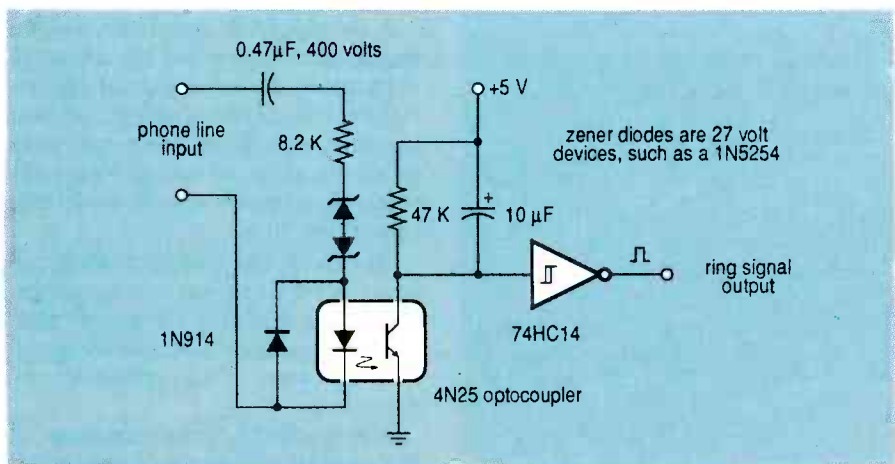


FIG. 4—A TELEPHONE RING DETECTOR. The optocoupler provides safety isolation, while the integrating capacitor converts the individual rings into a continuous signal.



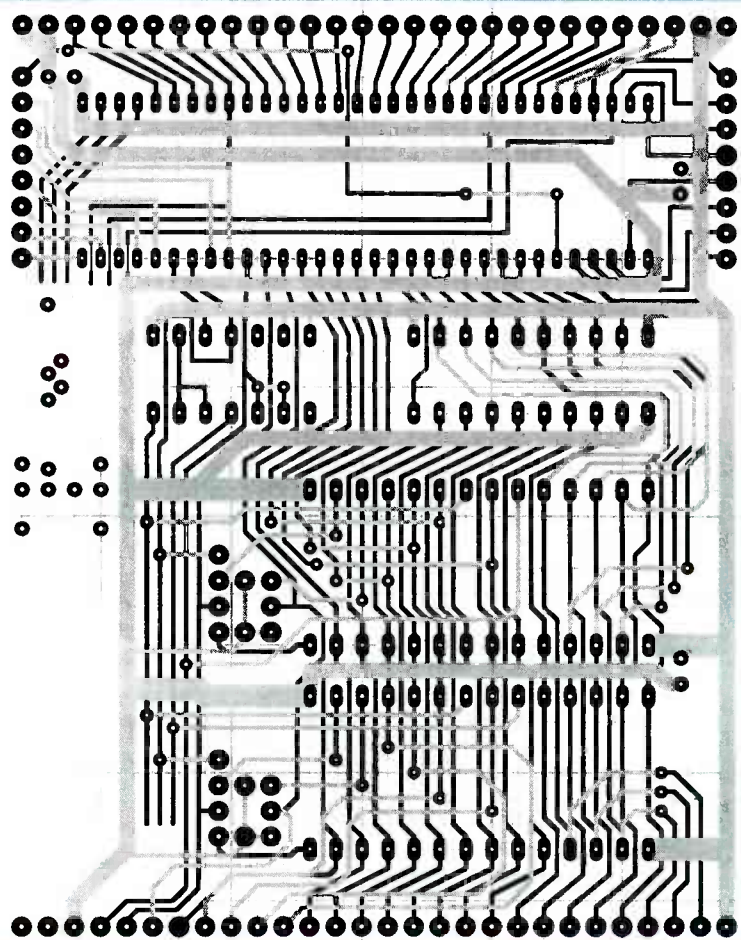


FIG. 5—THE POSTSCRIPT LANGUAGE EASILY lets you do your own custom printed-circuit layout using nothing but your favorite word processor. Here we have combined and shown you a foil side in black, a component side in gray, and a background layout grid.

Since everything is done in "raw" PostScript text, you can very easily rearrange the scenery to suit yourself in any way you like. I usually start with a fine gray grid, and then overlay the foil and component sides as needed, using some of my opaque grid-based "icons" that handle the traces and pads.

The process now has a 3-mil resolution and supports details of 10 mils or wider. You might directly print 1:1 onto mylar overhead transparency material, thus generating your negative or positive as needed for your final board.

For more serious applications, you can work two-times or four-times final size with the corresponding increase in resolution or precision. Should the final image be larger than one page, it can be automatically printed on as many

pages as is needed. Those pages can then be taped together.

You can instead run your final results on a PostScript-language-speaking phototypesetter when extreme accuracy is needed.

Let me know if you want any more details or some working code examples using that new printed-circuit layout process.

One very intriguing additional possibility is to do a 1:1 layout onto a suitable transfer material and then ironing the transferred toner directly onto your bare PC board, followed by an immediate etch. Unfortunately, that process is not quite reliable just yet.

#### New tech info

Newark Electronics has just released their fat new 1042-page  
*continued on page 100*

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# AUDIO UPDATE

## Two common record-player problems



LARRY KLEIN,  
AUDIO EDITOR

YOU MAY HAVE NOTICED THAT DESPITE the success of the compact disc, old-fashioned black LP records—and the equipment used to play them—continue to sell. And some of the people who buy them continue to experience a variety of minor and major difficulties. In this column I'm going to discuss two common and, judging from my mail, very puzzling problems.

### Howling hi-fi

One common complaint usually goes this way: Ever since I upgraded my speakers, rearranged my furniture and relocated my speakers, and installed a new turntable, my amplifier makes a howling noise when I turn up the volume or bass control. And to make matters worse, even when the system is not howling, I sometimes hear a sort of "ringing" in the music. What causes my amplifier problem and how do I cure it?

The symptoms described above are caused by one of the most common (and most misdiagnosed) problems in hi-fi. Although reproduced by the amplifier, the howling and ringing are certainly *not* caused by the amplifier. Those symptoms are the result of *acoustic* feedback from the loudspeakers to the record player, as illustrated in Fig. 1. What happens is the acoustic energy (sound waves) from the speakers reach the record player with sufficient intensity to set up vibrations between the disc and the tone arm. Those vibrations are interpreted by the phono stylus as a groove signal, sent through the amplifier to the speakers, then fed back to

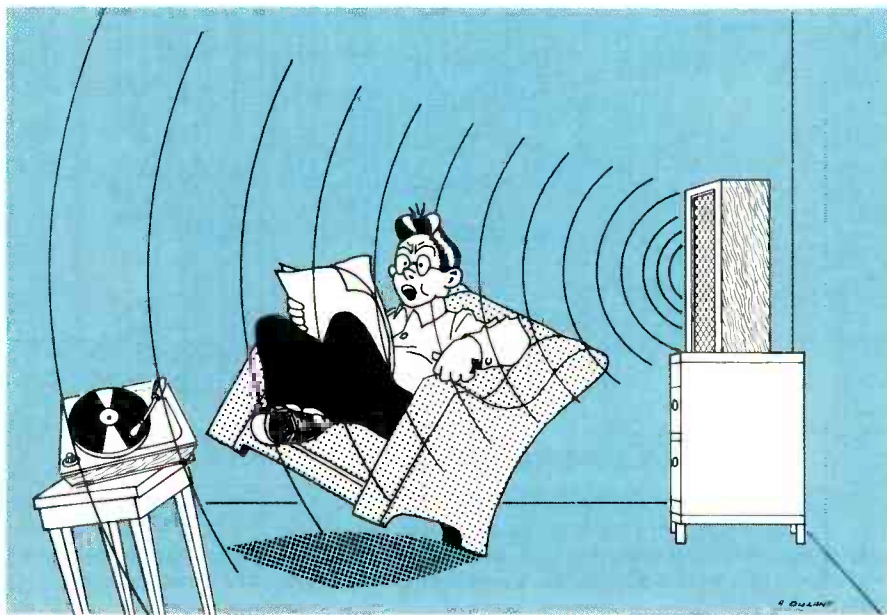


FIG. 1

the turntable, and the feedback goes around again, and again, and again. The effect is identical to what occurs when a microphone picks up the sound of the speakers in a sound-reinforcement system.

The cure for amplifier howling and ringing is to "open" the positive-feedback loop. Keep in mind that some models of turntables, aside from their other virtues or deficits, are more sensitive than others to air-borne or structure-borne vibrations. In such cases, accessory isolating feet or platforms available from many hi-fi dealers can make a difference; even a rubber typewriter mat might do the job. Installing the turntable on a solid structure—not bookshelves—and as far away from the speakers as possible can also be of help. Turntables should

never be operated with their hinged dust covers raised; dust covers can act as diaphragms to catch acoustic energy, which then gets passed to the phono stylus.

### Groove skipping

Then there's the fellow who complains that his new—and expensive—phono cartridge causes his tone arm to skip grooves. His sad story is as follows: I have a large record collection of 1960's rock and roll. Most of the discs are in good shape except for some warpage here and there. I bought a new cartridge hoping to minimize groove wear, but now some of my records tend to jump grooves. I switched back to my old cartridge and the records play fine. Is my brand-new cartridge defective?



No, your new cartridge probably isn't defective, but its physical properties are the non-obvious cause of the groove jumping. To understand what's happening we need to know something about resonance, where it comes from, and how it works. A resonance can be thought of as a specific frequency at which a mechanical system—or the parts of it—prefer to move. Every mechanical system has resonances, the frequencies of which are determined by the masses and compliances; a "compliance" is a flexibility. Most musical instruments are tuned to resonate at specific musical frequencies by adjusting the tension (compliance), the size, or the length of their strings or diaphragms. Wind instruments use air-column resonances, but that's another story altogether.

Every phono-cartridge/tone-arm combination has several resonances whose frequencies are determined by the areas of flexibility and mass in the system. A major low-frequency resonance—somewhere between 4 and 20 Hz—results from the interaction of the stylus compliance with the effective tone-arm mass, which includes the mass of the cartridge body. The higher the compliance of a cartridge's stylus assembly, the lower the resonant frequency with a given tone arm; the higher the tone-arm mass, the lower the resonance with a given cartridge. A low-compliance cartridge in a low-mass tone arm will result in an excessively high resonant frequency; a high-compliance cartridge in a high-mass arm will result in an excessively low resonance. A high-compliance cartridge in a low-mass arm works out just fine.

A response peak in the 15-Hz to 20-Hz area may not be audible as such, but it tends to waste amplifier power and it is likely to increase a record player's sensitivity to rumble, acoustic feedback, and external vibration. It may also cause visible woofer-cone flutter in vented speaker systems. On the other hand, an excessively low resonant frequency, 6 Hz or so, can increase a player's sensitivity to external shock, such as foot falls and record warps.

When a tone arm vibrates at res-



FIG. 2

onance, the stylus tracking force fluctuates rapidly between too high and too low. In fact, the tracking force can hit zero—at which point groove jumping occurs. And even if the stylus never totally leaves the groove, the loss of stylus tracking force during resonance can cause severe distortion of other frequencies on the record.

#### Warp Data

More than 12 years ago, Shure Brothers undertook an in-depth research project on the effect of warps on the record-playing process, and much of the following data is derived from their report. Record warps come in various shapes and sizes. Some warps are an unsolicited gift from the pressing plant, while others result from bad storage conditions. Warps can be rated by amplitude/velocity and frequency; the frequency being determined by how rapidly the turntable moves the warp beneath the playing stylus.

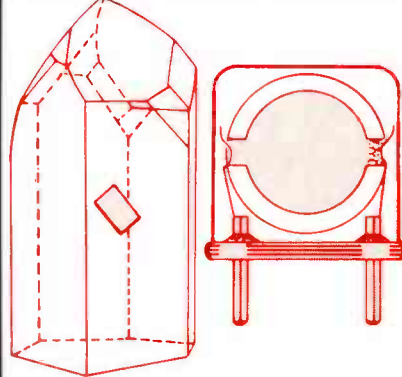
To prevent the tone-arm/cartridge resonance from being triggered by warps, most of which occur in the range below 6 Hz, it's good engineering practice to design for an arm/cartridge resonance well above that frequency. And since the recorded audio frequencies start around 20 Hz, it's also a good idea to place the resonance well below that frequency. Engineers aim for 10-14 Hz or so as a good compromise frequency. Whatever the resonant frequency, mechanical damping added to the arm or cartridge, as Shure does in Fig. 2, can reduce the effects of tone-arm/cartridge resonance.

*continued on page 100*

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# DRAWING BOARD

## Clock, I/O, and BIOS



ROBERT GROSSBLATT,  
CIRCUITS EDITOR

WE'VE ALREADY FINISHED A LOT OF THE design work that had to be done to turn our memory circuit from a neat idea to a practical reality. There are still a few things left,

however, before we can start filling the memory with data. We're still missing a system clock, an I/O control system, and let's not forget a BIOS of some sort to make the

whole thing work. Don't forget that our memory system will only do the job as long as the Z80 keeps executing instructions. If the Z80 stops, all of our refreshing goes

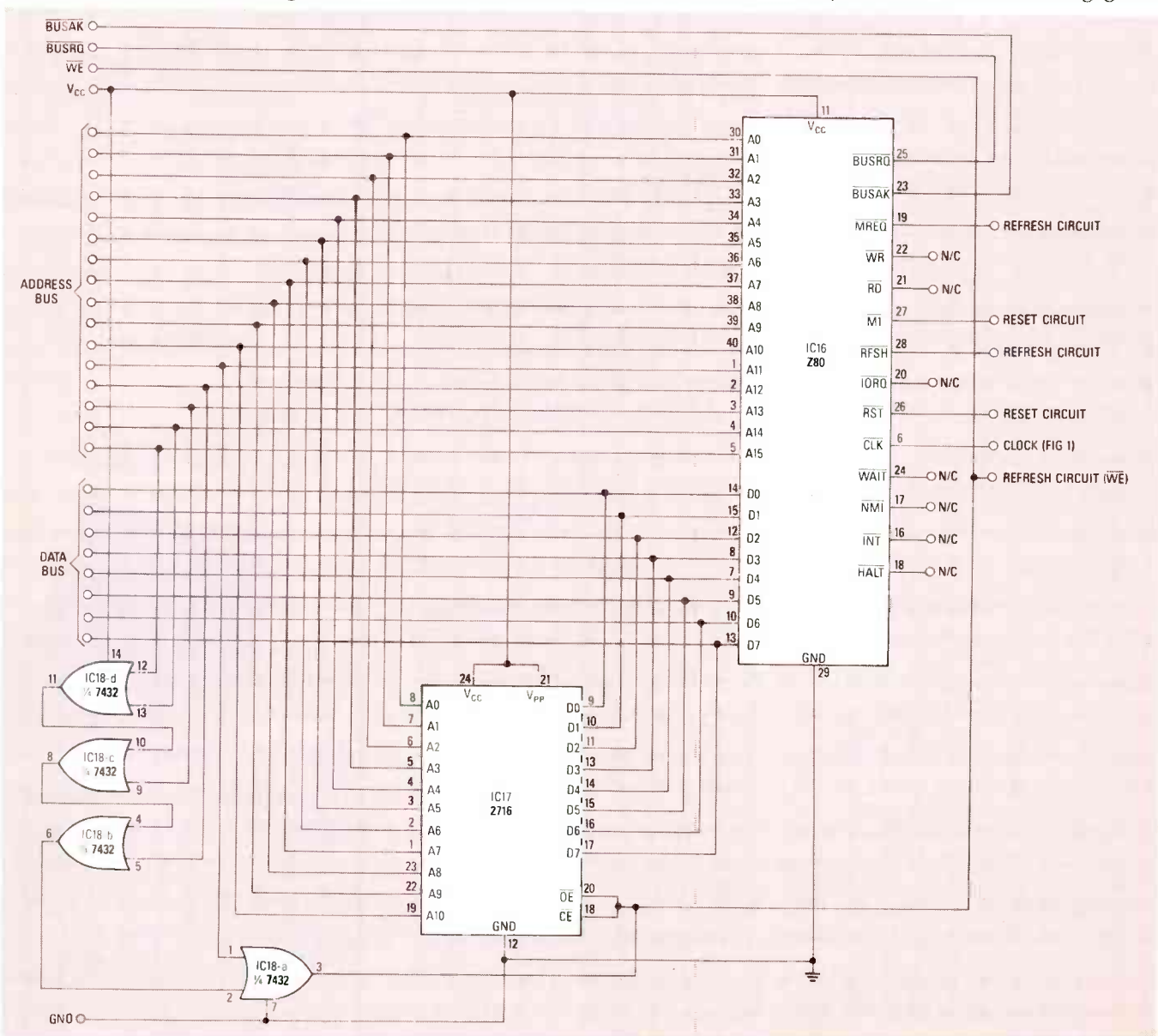


FIG. 2



out the window and, unfortunately, takes our data with it.

There are all sorts of clocks than can be used for our system but there's nothing like a crystal for stability, reliability, and total freedom from brain damage. Although there's no problem designing a crystal oscillator, there's sometimes a problem getting parts. We need a crystal frequency that meets two criteria: It has to be dividable down to 2.5 MHz, and it also has to be easy to find. After seconds of intense thought, I've settled on 10 MHz.

The circuit shown in Fig. 1 is a good, hassle-free, crystal oscillator. It's sure-starting, easy to fine tune, and, best of all, it's really tolerant to variations in component values. Even though you can get away without them, it's a good idea to use mylar capacitors. Ceramic discs have terrible tolerances and even though the circuit will put up with a lot of variation, remember Grossblatt's Third Law: HE WHO ASKS FOR TROUBLE....GETS IT

and that, as we all know, is the absolute truth.

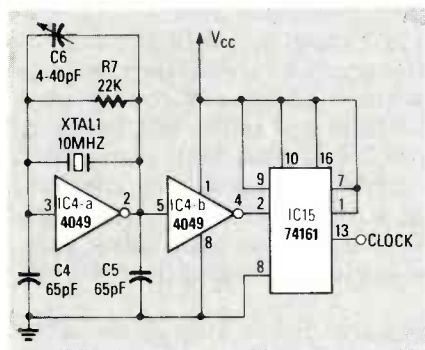


FIG. 1

You can use any kind of TTL inverters you want, but stick with the 4049-type if you're going to use 4000-series CMOS. The basic oscillator is comprised of R7, C4, C5, and XTAL1, and it oscillates at approximately the frequency that is marked on the crystal. If you find your circuit is off the mark, the trimmer (C6) will give you a few kHz of adjustment either way. If the frequency is way off, the crystal you're using is probably no good, so you should try another one.

I'm using a 74161 TTL IC to divide the 10 MHz down to 4 MHz but, as with the oscillator itself, there are

many parts you can use that will do the same job. The only proviso here is because of the frequency. It's asking just too much of standard 4000-series CMOS to handle 10 MHz with a  $V_{CC}$  of 5 volts. If you insist on using CMOS parts (and it's always a good idea to use them if you can), get your hands on some of the newer HCT parts such as a 74HCT161. They're CMOS parts that have the same drive and frequency capabilities as LSTTL parts.

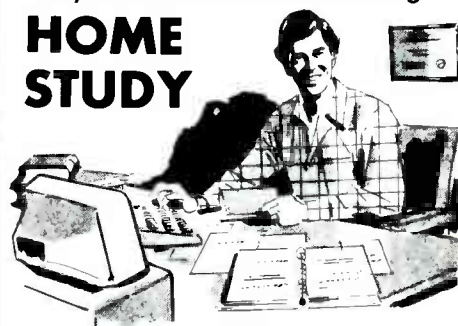
The 74161 is a versatile base-16 counter but we're just using it to divide the input signal by four. Of course we'll get a nice freebie in the form of wave shaping. The output will be a nice square wave that swings pretty close to the supply rails.

The next step in putting our circuit together is to take a look at the Z80 itself. We've spent most of our time designing all the subsystems, but the CPU is what ties everything together. Figure 2 will give you an overview of the entire memory circuit. If you have the block diagram we drew a few months ago (*Radio Electronics*, July 1987), get it out because it will make things a bit easier to understand.

We'll put our BIOS in a 2716 EPROM since 2K is more than enough room for the code that we need to control the system. As you can see, the EPROM (IC17) sits on the address and data lines and both its enable pins are tied together. That is done because the EPROM's current requirements drop considerably when it's completely deselected. Now I know that we need the EPROM on line most of the time because we can only maintain data in the system if the Z80 keeps on executing instructions. But, as we've seen, the EPROM only has to be on line during the instruction-fetch cycles and we can deselect it when it's not needed.

If you draw a memory map of our system, the EPROM would live at the bottom 2K and the rest of the address space (62K) would be for our data storage. What we need now is some method of automatically letting the RAM and EPROM know which of the two is being accessed by the CPU. Once again, there are lots of ways to do that but

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the one that's the most understandable is to simply decode the address bus. Whenever there's a high on any address line from A11 to A15, we're talking to RAM. We select either the RAM or the EPROM using OR gates, as shown in Fig. 2.

The 74HCT32, (or any quad OR gate), watches the upper 5 address lines and controls the enable pins of the EPROM. The only way the output of the final OR gate can be high is if there's a high on any of the address lines it's watching. If there is, it will turn off the EPROM. That kind of automatic selection is handy because it's one less thing to worry about when you work out a BIOS for the system.

All that's left to do in the way of hardware is work out a way for external circuitry to get data in and out of the system. On the face of it, that would appear to be a tremendous design problem involving I/O requests, latches, and lots of tri-state buffers. Fortunately for us, there's another way out. The designers of the Z80 have given us BUSRQ and BUSAK lines to allow DMA

(Direct Memory Access) operations to be done. That means that what would have been a messy I/O business is reducible to just about no problem at all.

DMA allows us to let another system take complete control of all the address, data, and control lines handled by the Z80. At the end of the last T-cycle of every instruction, the Z80 takes a look at the BUSRQ line. If the line is active, (brought low), the CPU finishes the T cycle activity and then tristates the three sets of lines. Once that has been done, it informs the rest of the world by bringing the BUSAK line low.

Things will stay like that for as long as the BUSRQ remains low. It's the responsibility of the external device to release control as soon as it's finished. The Z80 will look at the BUSRQ at the start of every T cycle and as soon as the line is released, it will begin executing instructions at exactly the point where it was interrupted in the first place.

The circuitry that has to be designed to let all that happen is totally dependent on the external system that's doing the DMA. In the simplest case, all we have to do is to make the control, address, and data lines available to the external system. That would be true as long as the external system had some way of OR'ing into the Z80 system. If you don't want to assume that the external system is going to provide the tristate buffers, you'll have to get some 74245's and use them to buffer all the Z80 lines.

Figure 3 is an example of how you would use the 74245's (or some other kind of buffers) to resolve bus contention. The 74245's enable control (pin 19)

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should be tied to the **BUSAK** line since both are active low. That means that the Z80 would be able to control access to the external system, and allow it only when it is safe to do so.

DMA is a terrific way to put our memory system to work, but there are restrictions. Remember that the Z80 is taking care of the refresh operation for us, and while DMA is going on, the whole refresh operation is being put on the back burner. If it takes too long, you can be sure that your data is going to disappear.

The big question then is "how long is too long"?

Since our system is running at 2.5 MHz, the outside limit for a DMA operation is going to be about 1 millisecond—and that's a lot of time when you're journeying into microprocessor land. Since our DMA will be limited to storing or retrieving data from memory, there's more than enough time to have some external system execute the needed few bytes of its code.

All we need is a BIOS to make

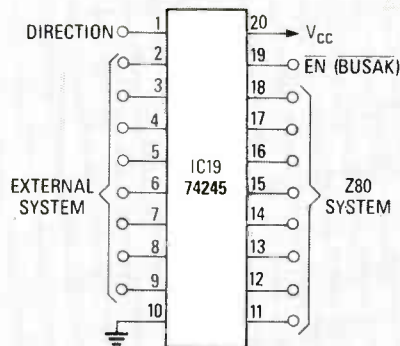


FIG. 3

the Z80 operate. That is trivial since the only job the Z80 has is to refresh the system's RAM. All we have to do is have it execute one instruction over and over again. That's right, we can load our EPROM with a "JMP \$0000" at location \$0000 and that, believe it or not, can be the extent of our BIOS! If that's all you want, you can replace the EPROM with a small PROM, (similar to an 8223), rework the enable logic, and use all 64K of address space for dynamic RAM.

I'll have a few words to say about the circuit next month. R-E

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# ANTIQUE RADIOS

Antique radios for antique autos



RICHARD D. FITCH

THE HORSELESS CARRIAGE AND WIREless sort of grew up together. Many prominent inventors from both fields knew each other and some, like Henry Ford and Thomas Edison, often socialized together. Automobile historians can probably trace the horseless carriage back as far as I've traced wireless. In the late 1920's, there was much discussion for and against the use of radios in autos, and many people thought that they should be outlawed because they were a dangerous distraction to the operator. Others thought the auto radio would be a noisy nuisance. But, as you know, the auto radio did survive. By the mid 1930's, auto manufacturers began to take the built-in receiver seriously, and started providing in-dash factory installations.

## Problems

The auto-radio pioneers of the 1920's had a few extra considerations in designing the auto radio. The chassis had to be built to withstand the jarring it would be subject to due to road irregularities and the crude suspension systems of those days. All of the components had to be secured to the chassis, including the tubes in their sockets. The auto's six-volt battery fluctuated slightly, so the tubes had to be able to handle those fluctuations without affecting the receiver's operation. The receiver had to be sensitive, and also had to be encased in a metal box to shield it from interference. As a result, the auto radio ended up being built better than a comparable home receiver.

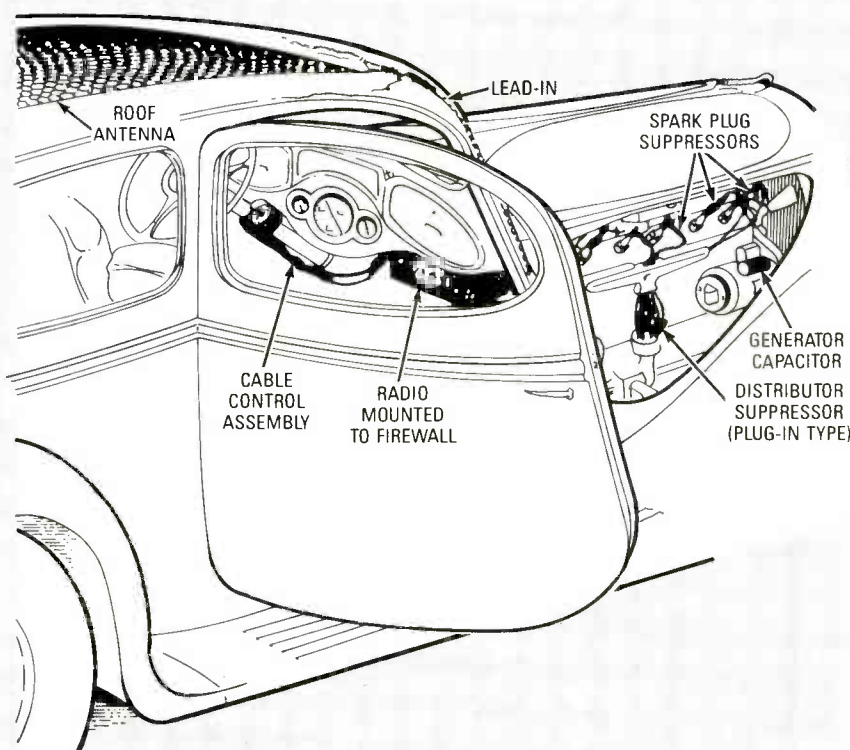


FIG. 1

In the late 1920's, the auto's 6-volt operating battery powered the radio's "A" filament, and a separate metal box lined with sponge rubber had to be installed for the "B" batteries. That box could be mounted under the rear floor boards, in the luggage compartment, or possibly in the rumble-seat compartment.

The early auto radio was mounted on the firewall under the instrument board (dash), as shown in Fig. 1. Usually the controls were right on the set, but some, even in

the 1920's, had a cable-tuning arrangement, which was placed in a convenient location for the operator, such as on the instrument board or the steering column. Consequently, that assembly added considerably to the installation of the radio.

In high sedans, the ideal place for the reproducer (speaker) was under the center of the roof. Since convertibles couldn't use that method, mounting the speaker under the dash became the most-common, yet least-desirable loca-



tion. Different types of magnetic and dynamic reproducers were used in those early autos. The field coil of an electro-dynamic reproducer to be used in an automobile had to be specially wound to operate from a six-volt battery, which, because of a large power drain, was not a particularly desirable situation. An electro-dynamic loudspeaker, however, can usually be replaced by a regular speaker, which is a big plus for the auto's storage battery.

There were many efforts to come up with a suitable aerial. Because extreme height was impractical, other methods had to be considered. In one, a flat metal plate was mounted beneath the wooden running boards, insulated from the frame, under each side. The two plates were connected to the set's aerial terminal; however, that low-slung aerial left a lot to be desired in signal pickup.

Factory aerial installations were usually between the roof and the inside upholstery (the headliner), with the shielded lead-in wire led down one of the front door posts, as seen in Fig. 1. The aerial consisted of a cloth-covered screen or some other type of insulated wire mesh. You have to remember that the roof on sedans and coupes was not a conductor. Even the frames and braces were made of wood, which made possible the roof aerial. Some sedan and coupe owners found simpler ways to install a roof aerial themselves; sewing a flexible wire through the roof liner with a large darning needle was one method used.

The engine's spark plug was the primary source of noise in an automobile's radio. To solve that problem the resistor spark plug has long been available, although I'm not sure if the resistor plug or the auto radio came first. Also, special resistors (suppressors) were available that connected directly to the spark-plug terminal and the high-tension wire, which can be seen in Fig. 1. I would consider those early resistors themselves as collectibles, and an antique auto with the original resistors on the spark plugs would be a real classic. However, even if you had those resistors, when stopped at a traffic light, the other car's ignition sys-

tems would drown out your radio. Also, the high-tension circuit wasn't the only source of interference. Electrical disturbances from the generator, and even the wheels, caused radio interference. Putting a condenser across the generator brushes and a grounding spring between the axle and the wheel helped to solve those problems.

Moving out of the 1920's, the vibrator power supply became popular. There were two basic types of vibrators that were used in auto-radio supplies: The non-synchronous, and the synchronous. The synchronous vibrator had the advantage of rectifying the voltage, and thus not requiring a rectifier tube. While it was a little noisy, the vibrator created a voltage that could be transferred up or down, eliminating the need for any storage batteries other than the automobile's.

### Early manufacturers

Who were the manufacturers of the pioneer auto radios? Well, many were the same companies that made home radios. The National Company made a five-tube TRF for auto use. Atwater Kent collectors will be interested to know that that company was also in the auto-radio market, and that their AK-666 was a vibrator-operated superheterodyne. RCA Victor was in the auto market and made five- and six-tube sets with a synchronous vibrator for the mid-1930's Hudson & Terraplane.

Companies whose names appeared on early auto receivers (some dating back to the 1920's) include Stewart Warner, Majestic, Pilot, Gulbranson, Gilfillan Bros. Belmont, Wells Gardner, Silver Marshal, and United American Bosch. Franklin Radio Corp. made radios for the early 1930's air-cooled Franklin autos, and many others.

The model SA-37, by RCA Victor, was made to be installed in the 1937 Hudson and Terraplane; it is a five-tube superheterodyne set. The entire unit was housed in a metal case, except for the remote unit, which would be mounted on the steering column. The loudspeaker is mounted in the cover of the metal case.

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Built for Plymouth and Dodge, the Mopar model 604 was a popular set in later autos. The set contains five tubes and a rectifier. Unlike previous sets, it has push-button tuning. Also, the set was designed to mount directly in the dash. It has a non-synchronous vibrator that is still somewhat available. Setting the pushbuttons is done by pulling off the chrome pushbutton caps. The buttons can then be unlocked by turning the screw slightly counter-clockwise; the desired station is then tuned in with the knob, and the button is pushed in while holding the knob. The screw can then be tightened and the chrome caps replaced.

One unusual receiver is the Philco model C-4608, may have been seen in a 1936 Dodge. It has a rectifier tube and a non-synchronous vibrator. While the set was designed to mount directly in the dash, the entire side cover could be opened by removing one wing nut. That was an advantage for the radioman who might have been able to repair it without removing it from the vehicle.

## Repairing auto radios

The auto radios of the 1920's, if you can find one, can be serviced in much the same manner as the home-battery receiver. The additional problems that may occur in an auto-radio are usually due to vibration, and possibly moisture. As in home receivers, corrosion is the prime cause of trouble. A dead radio is a good indication of a problem with either the fuse or the vibrator.

How do you repair a vibrator? You don't!

First, they are not designed to be dismantled. If you do manage to pry one open, most likely you'll find that the contacts are burned or welded together, or that the coil windings are shorted. In any case, it isn't something that isn't worth repairing.

Radiomen of today who can't solve a vibrator problem in their antique radio might be able to solve it with transistors. While I don't recommend the use of transistors in any antique radio, there can be exceptions—such as when there is no other solution.

Over the years there have been many transistorized vibrator substitutes. Most are too large to fit in the case of the radio and have to be mounted outside and plugged into the vibrator socket using a cable.

## This and that

If you enjoy reading about wireless history and antique radios, you should join the "Antique Wireless Association". Their *Old Time's Bulletin* is informative and authoritative. Those interested in Nikola Tesla, will enjoy a publication prepared by Leland I. Anderson, available to members. Applications can be obtained from Bruce Roloson, Box 212, Penn Yan, NY 14527.

A reprint of a 1938 *Radio Craft* magazine should make interesting reading. Contact Vestal Press Ltd., P.O. Box 97, 320 Jenson Road, Vestal, NY 13850 for info and catalog.

In a previous column I mentioned the difficulty in finding replacement caps for push buttons on radios. If you need those caps, send an SASE to K. Parry, 17557 Horace Street, Granada Hills, CA 91344.

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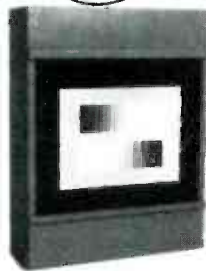
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# COMPUTERDIGEST

VOL. 5 NO. 7 JULY 1988

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

## BUILD LINE-CARRIER MODEMS

For cable-free computer interfacing

A  
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## CD CLASSROOM

Adding dynamic RAM circuitry

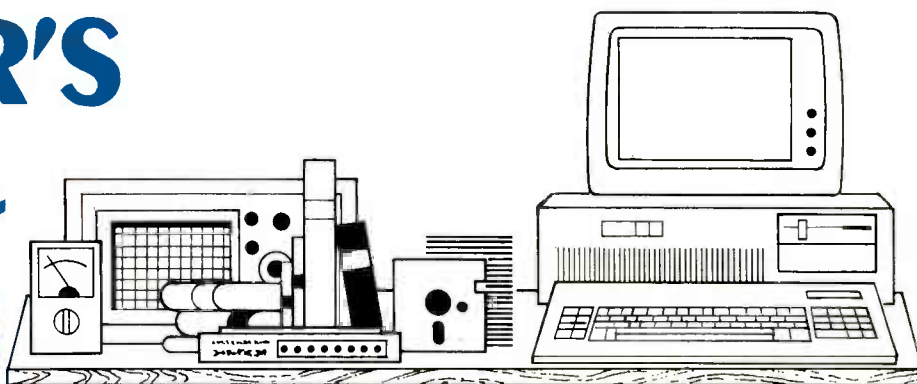
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## A LOOK AT CeBIT

The greatest computer show on earth

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# EDITOR'S WORK- BENCH



## CeBIT: The Greatest Computer Show On Earth

If you've been to what you thought was a big computer trade show without having been to CeBIT in Hannover, West Germany, "you ain't seen nothin' yet."

CeBIT is the world's largest computer, office, automation, and voice/data communications exhibition in the world. The name is an acronym derived from the German show name—World Center for Bureau (office), Information, and Telecommunications Technology—rather a mouthful. Originally, CeBIT was part of the larger Hannover Fair Industry founded in 1947. The CeBIT portion became so large that in 1986, it was spun off as a trade fair on its own.

In 1988, CeBIT exhibits were spread over 2,350,000 square feet of exhibit space in 13 buildings. The show, which is held every year in March, included 2,674 exhibitors from almost 40 countries displaying state-of-the-art technology and the latest in product research and development worldwide. Over 400,000 international visitors toured CeBIT.

The exhibits included 588 office and information-systems, 151 bank equipment and security systems, 357 software management and consulting, 438 office and organizational technology, 321 on applications for small businesses and professions, 373 on peripheral equipment, 182 on Computer Integrated Manufacturing-Computer Aided Manufacturing/Computer Aided Design (CIM-CAD/CAM), and 264 on telecommunications. One hundred thirty eight American exhibitors were part of the show.

If CeBIT had any overall themes this year, they were integration and standardization of electronic equipment and systems.

CeBIT is the place to find the latest industry controversies as well as the latest technology. For example, Atari called a press conference to introduce their new work station and instead, attendees were treated to a lecture by Atari CEO Jack Tramiel who claimed the DRAM shortage is a scam. According to Tramiel, the shortage of DRAM's is artificial. He explained that there is plenty of semiconductor-manufacturing capacity in the world, but it is not being fully used due to trade agreements between the US and Japan.

Tramiel illustrated the point by explaining that Micron Technology, Inc. of Boise, Idaho convinced the US government to impose sanctions on the Japanese for selling low-cost DRAMS in the US, and then promptly proceeded to raise their own prices. Using adjectives such as "greedy" and "stupid" to describe Micron's action, Tramiel announced that Atari had filed suit against Micron for breach of contract and violation of anti-trust laws.

### Printer standards

Then there was the press conference that wasn't. The Japanese were scheduled to officially announce the International Printer Standard (IPS) but they didn't show up. Instead, Peter Ohrt, the public relations manager for the Japanese printer initiative read a ten minute statement detailing how the subcommittee for office and information technology at the German Industry Association (VDMA) had started a massive campaign claiming that IPS would disturb the world market by introducing a second standard in addition to the existing European EPPT standard.

So the entire group of Japanese manufacturers decided not to inform the world about IPS even though each of their booths featured printer products based on the IPS standard. All of their brochures discussed the standard, and

thousands of press releases about IPS had been mailed to journalists worldwide.

### Japanese dumping

Grundig's general manager called a press conference to complain about Japanese and Korean dumping practices. He was talking about Europe but if your eyes were closed, it sounded like any number of American executives talking about the unfairness of Japanese and Korean dumping in the United States. And when the subject reached the discussion of jobs lost due to dumping practices there could be no doubt that many of our American industry concerns are the same as industry concerns in other countries.

Beyond the various controversies swirling about the fairgrounds, there were so many new products to see, it caused sensory overload for most attendees. CeBIT lasts for eight days and the only way to fully see it is to remain on site for the duration, a feat few can manage. Products on display included many items that were being introduced for the first time anywhere, some of which will make an American debut at COMDEX in May, and a multitude of products we won't see in the United States for several years. CeBIT is where we find out what is on the horizon; if a product is coming down the pipeline from almost any country in the world, it's coming via CeBIT.

It would be impossible to describe in one magazine article, all of the working models, prototypes, or conceptual mockup formats of new products on display at CeBIT. However, let's look at some of the items we may see in the US in the not-too-distant future. It might interest you to know that many Japanese products are developed first for the European market and then adapted for US distribution at a later time.

Macintosh is being cloned in the Orient. The Taiwanese and Koreans are convinced that there will be a big market



worldwide for Mac clones, and they even hope they can find a way to export those machines to the US without encountering patent infringement. Thus far those systems are reverse engineered but Mac-BIOS cloning is probably not far in the future.

Apple is fighting back with a development that will probably be shown at COMDEX as well. Dubbed the "dream machine," the system will run both IBM DOS and MAC software on a single diskette. Apple is said to be developing a 1.7 MB floppy-disk drive to accommodate that dual capability. Don't run to your local computer dealer yet though—the system is not scheduled to be available for awhile.

New laptops abounded. Key to the laptop market were more power, faster speeds, and higher resolution screens. CeBIT is famous for being the place to introduce laptops; just three years ago Toshiba unveiled the T1100 at the show.

Handheld devices with full QWERTY keyboards, some complete with spell

checkers, were popular items at CeBIT. Those little computers could ultimately change business practices and invade the school classroom where only a few years ago teachers forbid the use of calculators. Many of the hand-held office-automation units are already on the market in Japan and are heading for European distribution this year. They should appear in American retail outlets within a year or two.

The UNIX/XENIX operating system seems to be gaining favor as a standard for multiuser applications in Europe as well as the USA because it offers the broad-based ability to integrate a variety of computers into one system. IBM, however, isn't taking that lying down. They introduced System Application Architecture (SAA), a set of software standards that allows the exclusive communication of IBM operating systems to IBM machines. Could that be a new attempt to create a monopoly?

The latest advances in Integrated Services Digital Network (ISDN) tech-

nology could be found everywhere at CeBIT. The German Bundespost (Federal Post Office) made news by presenting its new telecommunications services that establish important criteria for future ISDN developments on a worldwide level. Just a year ago, ISDN was an obscure telephone technology. At CeBIT, ISDN high-quality color-image transmission and reception became a reality thanks to a cooperative effort between Japan's Canon and Germany's Siemens companies.

What you've read is just a tiny bit of the vast quantity of new products originating from all parts of the world, that may or may not wind up in American stores. As one veteran showgoer explained, CeBIT is one of the tougher shows to cover—it takes a real world class attendee to absorb everything. But it's worth the effort because it is the world's largest show in the field and only at CeBIT is current and future technology from all over the world gathered together and displayed each year.—Janet Endrijonas



Microsoft's Mach 20

**A**midst all the hoopla over the 80386, it's easy to lose track of the fact that, at the present time, most people simply can't afford 80386-based systems. Consequently, an accelerator card is a highly attractive option to the twelve million or so owners of PC's, XT's, and clones. Comparative reviews of several popular models appeared in our November 1987 cover story. When that story was written,

Microsoft had announced, but had not shipped, the Mach 20 accelerator card. After months of delays (including an unexpected audit by the FCC), the board was finally released. We received one of the first production versions, and we're impressed.

The Mach 20 is actually a three-part system: the \$495 accelerator, an optional \$395 memory card, and an optional \$99 disk controller. The disk controller and the memory card plug into the accelerator card; the assembly occupies a single full-length expansion slot.

The accelerator card, which was designed by the Personal Computer Support Group, uses a moderately speedy 8-MHz 80286. We might have wished for a faster card, but it's easy to see Microsoft's reasons for building a slower card. Typically, accelerator cards that run at 10 or 12 MHz cost 33%–50% more than 8-MHz cards. Keeping the price down should make this card highly attractive to millions of PC users who can't afford a faster card,

especially if the usual mail-order discounts on Microsoft products prevail. In any case, its on-board 16K cache memory greatly speeds up operation so that the Mach 20 is roughly equivalent in speed to an 8-MHz AT, even when accessing memory via the PC/XT's eight-bit bus.

The Mach 20 accelerator card has several advantages over the vast majority of the 80286-based competition (excluding SOTA's MotherCard and Orchid's PCTurbo 286e). First, the card can run in the 80286's protected mode. That means it can run OS/2—but you'll need the Memory Plus option to do so. In addition, the accelerator has a built-in InPort mouse port, so you plug a Microsoft mouse directly into the card without using either a slot for a bus mouse, or a port for a serial mouse.

Whether or not you want to run the Mach 20 in protected mode, the Memory Plus is an attractive option. For \$395, you get 512K of memory that can function in real (i.e. DOS) mode as EEMS memory, or in protected mode as extended memory. The EEMS memory is highly useful for running DesqView or TaskView; the fact that that memory can also be configured for protected-mode operation provides a path for upgrading to OS/2 when desired. The board will accept an additional megabyte of 256K RAM IC's, as well as two megabytes of 1-megabit IC's, for a grand total of 3.5 megabytes of memory. In addition, the modular design of the Memory Plus will allow Microsoft to develop upgrades to handle even more RAM.

The Disk Plus option is a small board that allows PC's, XT's, and clones without support for high-density disk drives (1.2-

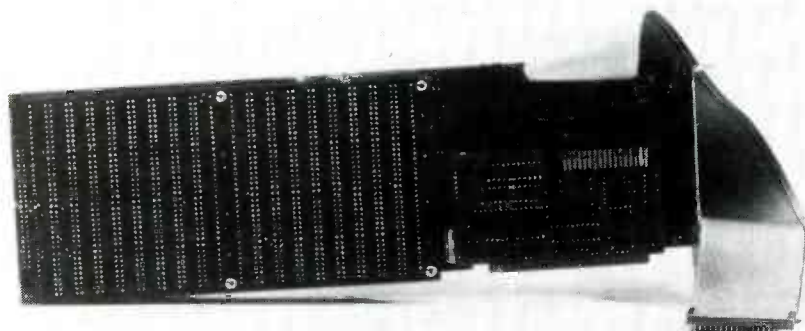


FIG. 1

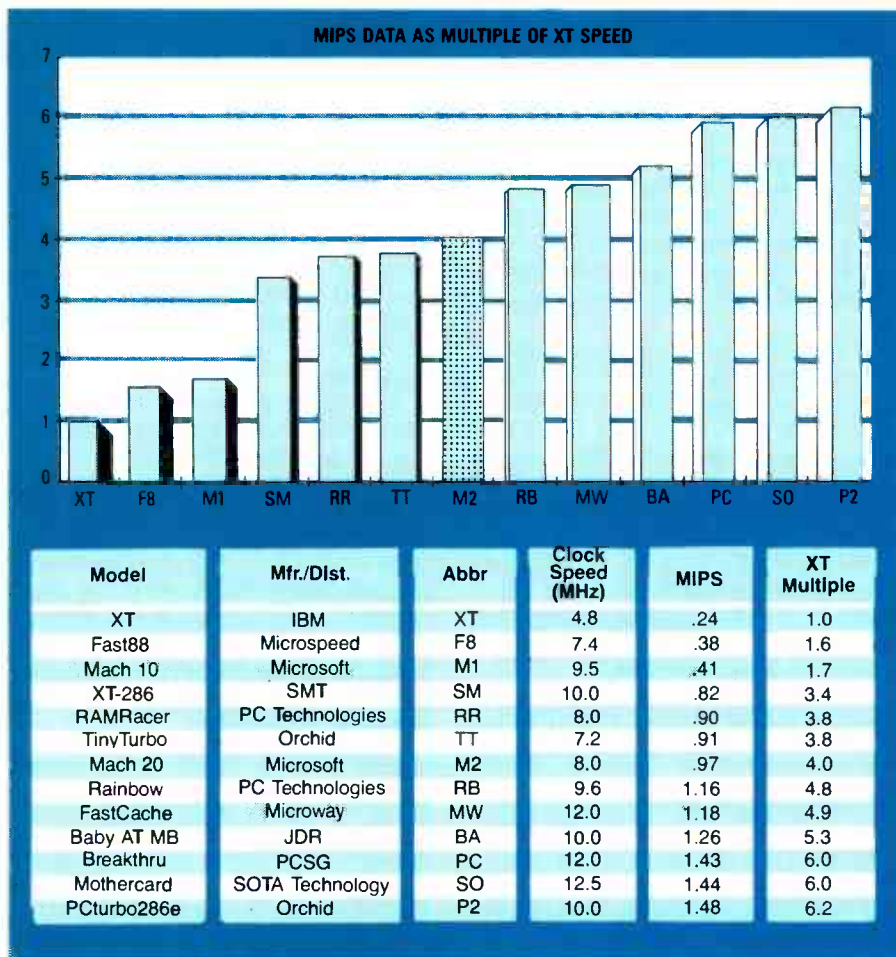


FIG. 2

megabyte 5¼-inch or 1.44-megabyte 3½-inch drives) to run those drives. You need a high-density drive to install OS/2, and merely having a high-density drive can be useful for backing up a hard disk and for swapping disks with AT owners. You'll have to purchase the high-density disk drive separately.

The sum total is a compact, modular system for upgrading PC's and XT's. You can start off with just the accelerator card and add the memory and disk options when necessary. If you're starved for slots, you can combine four functions in one slot: accelerator, mouse interface, expansion memory, and disk control.

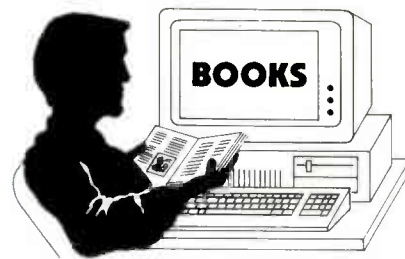
Installing the card is simple. Set a few jumpers on the Mach 20, insert it in an empty expansion slot, remove the 8088 from your motherboard, and run a cable from the Mach 20 to the vacant socket. Microsoft's typically well-illustrated manual makes the procedure simple. To install the disk or memory options, the appropriate board(s) must be attached to the Mach 20 card and screwed together. The adapter kits contain all of the necessary components.

To use the EEMS memory, you must add a device driver to your CONFIG.SYS file. (Another driver allows you to control the Mach 20's speed from the keyboard.) Then you can let your applications use

EEMS memory directly, or set it up as a disk cache, using a program that is included. Unfortunately, Microsoft's documentation does not specify how Memory Plus may be configured as protected-mode memory. (Microsoft's version of OS/2 for the Mach 20 will configure memory automatically.)

To get some idea of the board's speed, see Fig. 2, which shows the MIPS (Millions of Instructions Per Second) performance of a dozen accelerator cards of various types. As the figure shows, the Mach 20 is about four times as fast as a standard 4.77-MHz XT, about twice as fast as Microsoft's Mach 10 (an 8086-based accelerator), and about two-thirds the speed of the fastest boards (which cost from 50% to 200% more).

All in all, the Mach 20 is an impressive piece of computing equipment. It provides useful if not astounding acceleration at a reasonable price, and, with the memory option, provides a means of moving from DOS to DesqView to OS/2. Microsoft's previous attempt at acceleration hardware was unimpressive, but the Mach 20 is a winner. A sales promotion can get you the Mach 20, the memory option, and a copy of Excel (reviewed last month) for about 70% of the cost of the three items together. That's a winning combination.




## Reading up on OS/2

For those interested in getting the jump on the new operating system, Osborne McGraw-Hill is first on the stands with OS/2 reading material. The *OS/2 Programmer's Guide* was written by Ed Iacobucci, one of OS/2's principal designers at Microsoft; *Using OS/2* was written by Kris Jamsa, author of several books on DOS-related topics.

Jamsa's book begins by discussing the basics of OS/2 and how it compares with DOS. It then goes on to discuss the OS/2 commands and how they compare with their DOS counterparts. Then Jamsa goes on to discuss system configuration, device control, and batch-file processing. Quick reference cards with information on all OS/2 commands are included; a disk containing all the example programs is available directly from the author for under \$20.

From a technical standpoint, the *OS/2 Programmer's Guide* picks up where *Using OS/2* leaves off. In some 1100 pages, Iacobucci covers topics ranging from the Intel family architecture (comparing the 8086, the 80286, and the 80386), multi-tasking and dynamic linking under OS/2, the OS/2 file system, device drivers, device monitors, etc. The last third of the book contains summaries of OS/2 function calls and error codes, and approximately 150 pages of sample programs, which are available on disk for about \$25.

To those used to working in the DOS environment, the transition to OS/2 should be fairly smooth. To those used to programming in the DOS environment, the transition to OS/2 will be much more difficult. There are many new concepts to learn, and a much more complicated programming interface. If you couldn't afford Microsoft's \$3000 developers kit, Iacobucci's book is a good place to start. 

## PRODUCTS REVIEWED

- *Using OS/2 and OS/2 Programmer's Guide*, Osborne McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710 (800) 227-0900, (800) 772-2531 (CA).



# BUILD A PAIR OF



# LINE-CARRIER MODEMS

*Build a pair of modems that communicate over the AC lines—  
for less than \$100!*

KEITH NICHOLS, CRC ELECTRONICS

**H**ow do you connect two PC's together? Solutions range from "Sneaker Net" (wherein the user carries a diskette from one machine to the other) to complex and expensive proprietary network systems. For occasional use, Sneaker Net is easy and reliable, but as usage increases, a more efficient means of data transfer becomes necessary. The problem is that a full networking system requires dedicated wiring, expensive network servers, and lots of user training. Clearly, a midrange solution is required.

The line-carrier modem presented here is one such solution. The LCM100 is inexpensive (about \$100 for a pair of modems), easy to build and use, and uses existing AC wiring to transmit and receive signals. The LCM100 can operate at any baud rate up to 9600, and relies on your communications software to transmit and receive data.

For example, you could use a pair of modems to transmit files between two PC's in an office. You'd use your normal communications software (Crosstalk or ProComm, for example) to send files in Xmodem or Kermit format. Another possibility would be to transmit manufacturing data from a factory floor back to the central office for processing. At home, you might use the LCM100

to transmit files from the PC in your study to the kids' PC in the basement. You might also use a pair of LCM100's to transfer data between dissimilar machines—an IBM PC and a Macintosh, for example.

## Background

The LCM100 operates in much the same manner as the familiar telephone modem, but sends its signals via electric-power wiring instead of telephone lines. Each module translates serial asynchronous data between RS-232C and frequency-shift-keying data formats.

A normal telephone modem translates the voltage levels of the digital input signals into two distinct audible tones, one of which represents a logic 0, and the other, a logic 1. The process of shifting the frequency of the output tone as the logic levels change is called *Frequency Shift Keying*, or FSK. The pair of frequencies representing the two logic states are conventionally called "mark" and "space".

The LCM100 converts RS-232C signals into FSK form, but the mark and space frequencies are above 100 kHz, which is well above the audible range. To permit communication in two directions simultaneously (full duplex mode),

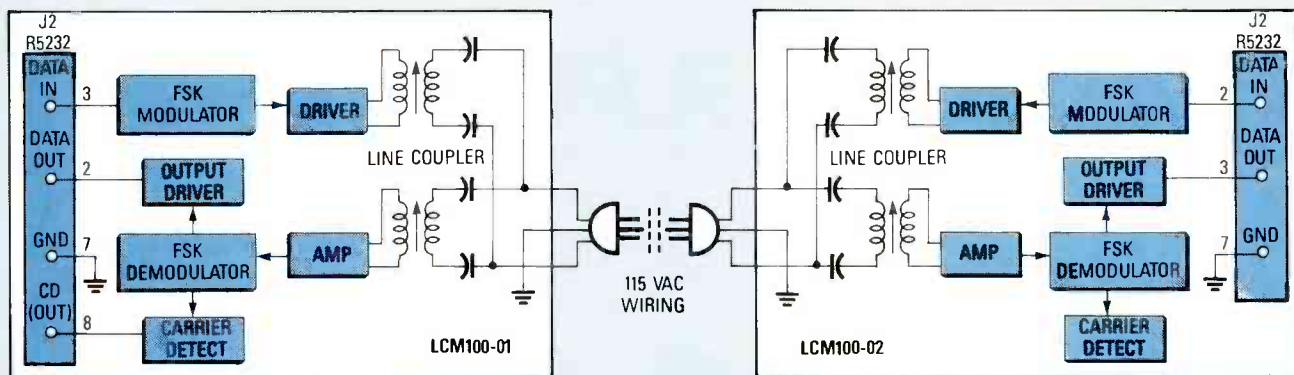


FIG. 1—BLOCK DIAGRAM of the LCM100 data-communication system. The AC-power wiring of the building is used to carry the FSK transmission.

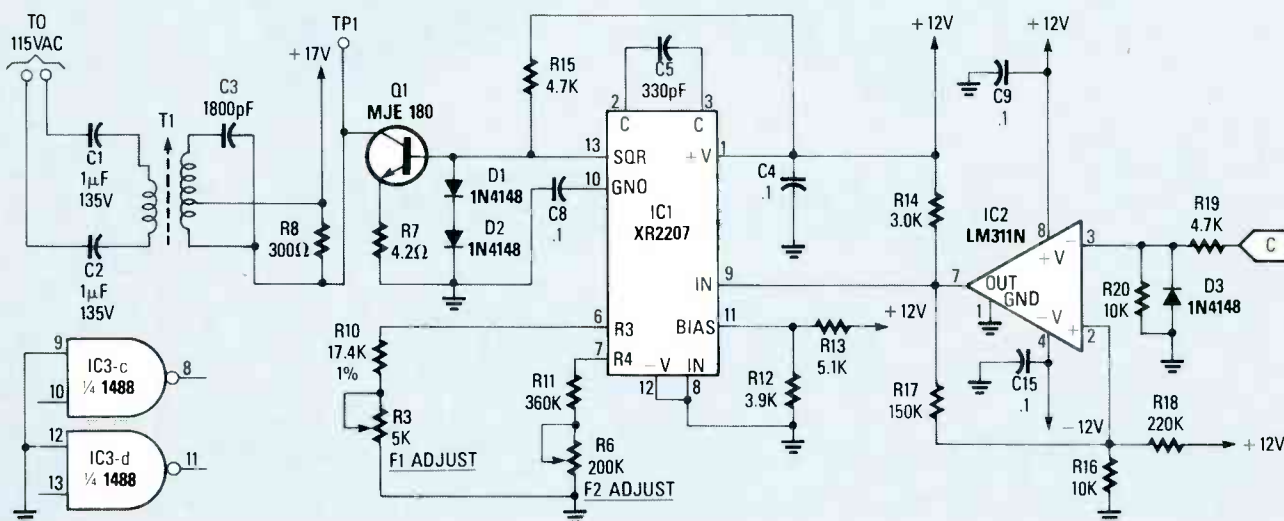


FIG. 2—TRANSMITTER SECTION of the LCM100. Op-amp IC2 shapes RS232 data and presents it to the FSK modulator, IC1. After amplification, the signal is coupled to the AC line by T1.

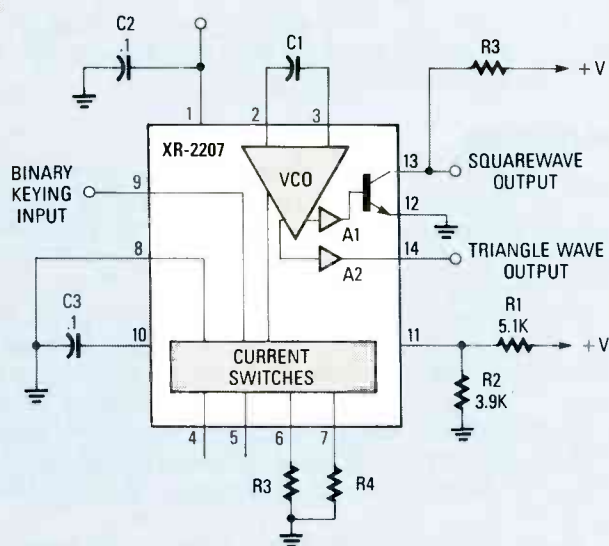


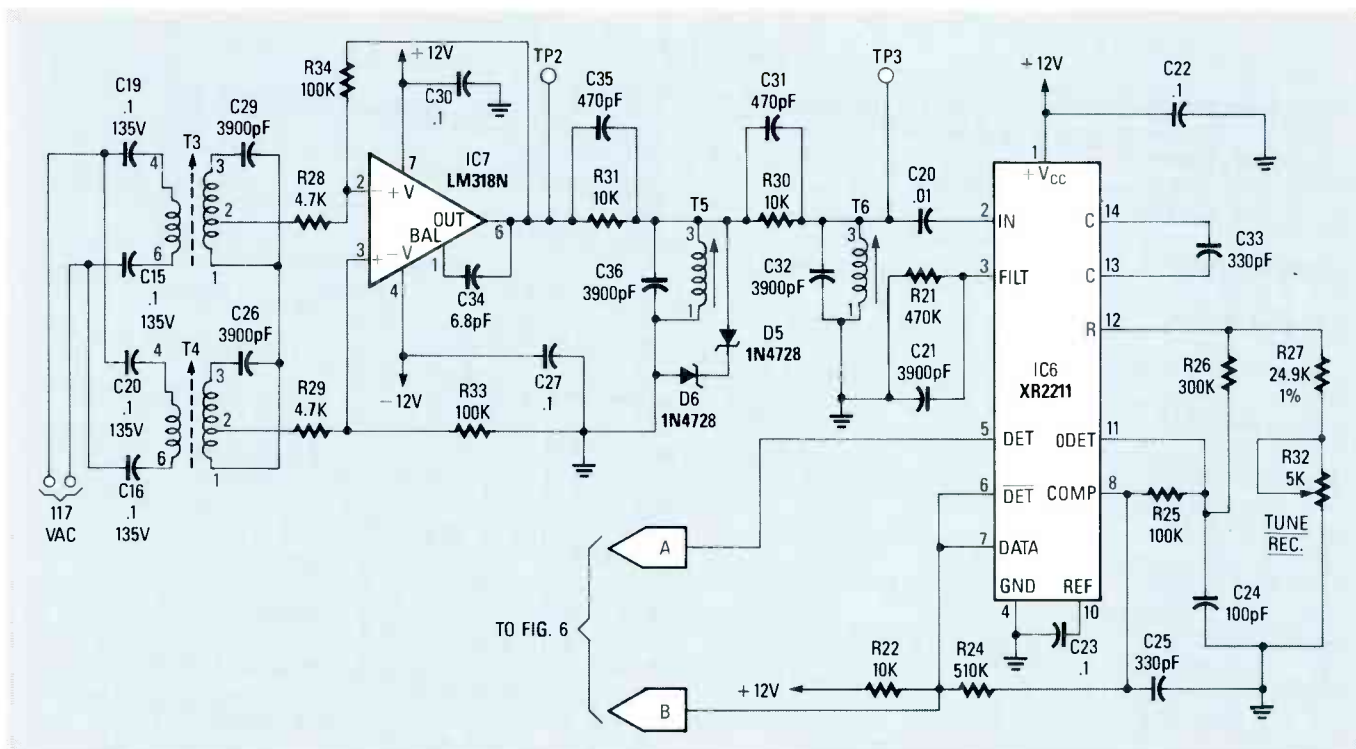
FIG. 3—BLOCK DIAGRAM AND PIN-OUT of the XR2207. The binary keying inputs (pins 8 and 9) determine output frequency.

two pairs of frequencies are used, one called highband, and the other, lowband. (The two frequency pairs are also known as the originate set and the answer set. Those terms designate only the frequencies that each unit is using and do not imply the source or content of the data itself.)

The LCM100 system consists of two modules, the LCM100-01 module, and the LCM100-02. The designation is arbitrary, but it shall be assumed herein that the LCM100-01 module transmits on the highband and receives on the lowband, and the LCM100-02 module transmits on the lowband and receives on the highband. The frequencies that are used by each of the modules are shown in Table 1.

The AC-power line is similar in some respects to the telephone line. However, although the telephone line has well-defined characteristics (a nominal impedance of 600 ohms, relatively little noise, etc.), the AC line can be a harsh environment for data signals. With an impedance as low as 2 ohms and occasional thousand-volt noise spikes, it is less than an optimum communications medium. The LCM100 system must be able to impose an FSK carrier of sufficient strength onto the low-impedance power line, as well as filter out the 60-Hz signal and any other noise components that may be present, thus demodulating only the transmitted signal.





### Circuit description

The modulator/driver and its associated line coupler comprise the transmitter stage, and the amplifier/demodulator, together with its line coupler, defines the receiver stage of the modem circuitry. Each stage is discussed in detail as we continue.

Serial input signals are fed via RS-232C port (J2) to the input-conditioning circuit surrounding IC2 (See Fig. 2). Negative-going pulses are clipped by D4, and positive-going pulses are conditioned by voltage-comparator IC2. That signal shaping ensures that the input signals to modu-

### Exar XR2207 modulator

Four main functional blocks comprise the XR2207: A Voltage-Controlled Oscillator (VCO), four current switches (which are activated by binary keying inputs), and two buffer amplifiers for the triangle- and square-wave outputs. The VCO is actually a current-controlled oscillator that gets its input from the current switches. Output frequency is proportional to input current; four discrete frequencies may be selected by two binary inputs (pins 8 and 9). Those input currents are set by timing resistors connected to pin 4—pin 7. The values for those resistors can be seen in Table 2.

$$f1 = 1/(R3 \times C1)$$

### TABLE 1—LCM FREQUENCIES

### TABLE 2—TIMING RESISTORS

## PARTS LIST

**Note: Component values in parentheses are for the LCM100-02 board; other values are for the LCM100-01 board.**

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

R1, R2, R4, R5, R15, R19, R28, R29—4700 ohms  
 R3—5000 ohms, PC-mount trimmer potentiometer  
 R6—200,000 ohms, PC-mount trimmer potentiometer  
 R7—4.2 ohms  
 R8—300 ohms  
 R9—not used  
 R10—17,400 ohms, 1% (24,900 ohms, 1%)  
 R11—360,000 ohms  
 R12—3900 ohms  
 R13—5100 ohms  
 R14—3000 ohms  
 R16, R20, R22, R30, R31—10,000 ohms  
 R17—150,000 ohms  
 R18—220,000 ohms  
 R21—470,000 ohms  
 R23, R35—820 ohms  
 R24—510,000 ohms  
 R25—100,000 ohms  
 R26—300,000 ohms  
 R27—24,900 ohms, 1% (16,200 ohms, 1%)  
 R32—5000 ohms, PC-mount trimmer potentiometer  
 R33, R34—100,000 ohms (47,000 ohms)

### Capacitors

C1, C2—1  $\mu$ F, 135 volts  
 C3—1800 pF (3900 pF)  
 C5—330 pF  
 C6—1000  $\mu$ F, 35 volts, electrolytic  
 C4, C7—C10, C13, C18, C22, C23, C27, C30—0.1  $\mu$ F, 25 volts, monolithic  
 C11—100  $\mu$ F, 25 volts, electrolytic  
 C12, C17—10  $\mu$ F, 25 volts, tantalum  
 C14, C25, C33—330 pF  
 C15, C16, C19, C20—0.1  $\mu$ F, 135 volts  
 C21—3900 pF  
 C24—100 pF

C26, C29, C32, C36—3900 pF (1800 pF)

C28—0.01  $\mu$ F, disk

C31, C35—470 pF

C34—6.8 pF

### Semiconductors

BR1—50 volts, 1 amp

D1, D2, D3, D6—1N4148

D4, D5—1N4728 (3.3-volt Zener)

LED1—standard red

LED2—standard green

IC1—XR2207, FSK modulator

IC2—LM311N, op-amp

IC3—1488, RS-232 line driver

IC4—78L12ACZ, precision +12-volt regulator

IC5—79L12ACZ, precision -12-volt regulator

IC6—XR2211, FSK demodulator

IC7—LM318N, op-amp

Q1—MJE180, NPN power transistor

Q2—PN2222, NPN switching transistor

Q3—2N3906, PNP switching transistor

### Other components

J1—115-volt AC receptacle J2—25-pin D connector P1,

P2—3-pin header strip P3—2-pin header strip MOV1—

150-volt varistor T1—RF coil, TOKO RAN10A6729HK

T2—24-volts, 180 mA, PC mount (Dale PL-13-07)

T3—T6—RF coil, TOKO RAN10A6729

### Miscellaneous

**Note: The following are available from CRC Electronics, 13547 S. E. 27th Place, Suite 3D, Bellevue, WA 98005, (206) 747-9636: Etched and drilled PC boards with plated-through holes, \$24.95/pair; Partial kit (includes PC boards, all transformers, coils, jacks, and high-voltage capacitors) \$49.95/pair; Complete kit excluding case and power cords, \$99.00/pair; Assembled and tested PC-board assembly without cases and power cords, \$119.95/pair; Complete assembled and tested system, \$159.95/pair. Individual components are also available.**

$$f_2 = f_1 + \Delta f_1$$

where  $\Delta f_1 = 1/(R_4 \times C_1)$ . In both equations,  $f_1$  is specified in Hz, R3 and R4 are in ohms, and C1 is in farads.

In an actual circuit, R3 and R4 can have values between 2K and 2 megohms, and the timing capacitor should be polycarbonate, polystyrene, or mylar, for optimum temperature stability. Table 2 shows the resistor values used to obtain the highband and lowband frequencies, in both cases using a 330-pF timing capacitor. Note that the value of R4 is the same for both the frequency bands. That is because the difference between the mark and space frequencies is the same for both frequency pairs. Because non-standard values are obtained, a series combination of a fixed resistor and a potentiometer permit fine tuning the mark and space frequencies.

The square wave output of the XR2207 (pin 13) is an open-collector stage that drives power transistor Q1. Resistor R15 is a pull-up resistor for the IC's output.

Power transistor Q1 drives the tuned line coupler (T1 and C3) that effects the impedance transformation necessary to impose the FSK carrier onto the 60-Hz power line. Protective capacitors C1 and C2 isolate the modulation circuitry from the power-line voltage.

## Receiver Stage

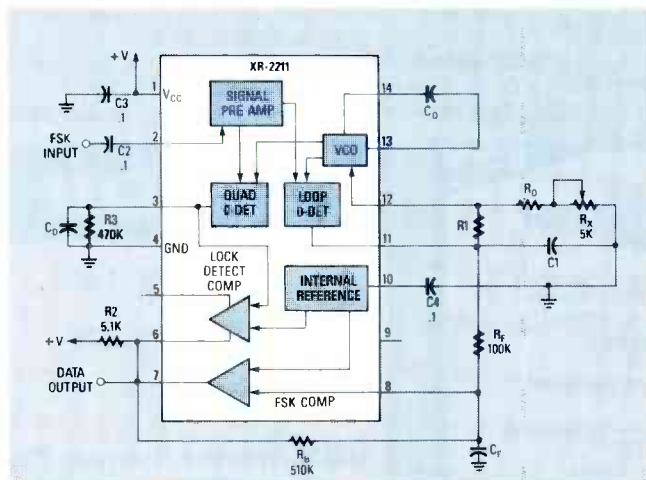
As shown in Fig. 4, the parallel line couplers, T3/C29 and T4/C26, are capacitively isolated from the AC line by protective capacitors C15, C16, C19 and C20. One of the LC circuits is tuned to the "mark" frequency of the line-carrier signal, and the other is tuned to the "space" frequency. The line couplers effectively present a high impedance to the 60-Hz power-line signal while presenting a low-impedance path to the tuned frequencies.

Next, the received signals are amplified by IC7, an LM318N high-slew-rate op-amp. The output of IC7 is fed through a bandpass filter network composed of C35 and R31, T5 and C36, C31 and R30, and T6 and C32. Those components shape the signal and reject noise; Zener diodes D6 and D7 clip the peak-to-peak signal voltage to 6.6 volts to avoid damaging the demodulator (IC6).

## Exar XR2211 Demodulator

The XR2211 is a Phase-Locked-Loop (PLL) IC designed especially for data communication and particularly suited for FSK-modem applications. It operates over a frequency range from 0.01 Hz to 300 kHz and can accommodate analog input signals between 2 millivolts and 3 volts. A block diagram of the XR2211 and a typical FSK-demodulator hookup are shown in Fig. 5.





**FIG. 5—BLOCK DIAGRAM and basic hookup of the XR2211 FSK demodulator. See the text for information on calculating resistor and capacitor values.**

Frequency-shift-keyed input signals are fed to pin 2 of the IC through a 0.1- $\mu$ F coupling capacitor. The internal impedance is 20 kilohms and the minimum recommended input signal is 10 mV.

The center frequency of the demodulator's passband must be set at the center of the frequency band that is to be detected. In the LCM100 the passband is set halfway between the frequency pairs:  $(106.5 + 100)/2 = 103.25$  kHz for the LCM100-01 demodulator, and  $(156.5 + 150)/2 = 153.25$  kHz for the LCM100-02.

In Fig. 5, the oscillator's center frequency is calculated as follows:

$$f_o = 1/(R_o \cdot C_o)$$

where  $R_o$  is in ohms and  $C_o$  is in farads. Using a 330-pf capacitor for  $C_o$  the computed values for  $R_o$  are 29.35K and 19.77K for the LCM100-01 and LCM100-02 modules respectively. With a 5K trimmer wired in series, 1% resistors with values of 24.9K and 16.2K are used. Capacitor  $C_o$  should be mylar, polycarbonate, or polystyrene.

System bandwidth is set by  $R_1$ , and  $C_1$  sets the loop-filter time constant and damping factor. The value of  $R_1$  is determined by the mark/space frequency difference:

$$R_1 = (R_o \cdot f_o)/(f_1 - f_2)$$

The calculated values for  $R_1$  are 395 kilohms ( $f_o = 103.25$  kHz) and 382 kilohms ( $f_o = 153.25$  kHz). However, in order to increase the detectable bandwidth, both LCM100 modules use a 300K value for  $R_1$ .

The equation for computing the loop-damping factor associated with  $C_1$  is complex, but there is a convenient rule of thumb. The damping factor should be approximately 1/2, and a value of  $C_1 = C_o/4$  will produce that. With  $C_o$  equal to 330 pf,  $C_1$  equals 82.5 pf. Because the loop low-pass filter time constant  $T$  equals  $R_1 \times C_1$ , the LCM100 uses a 100-pf value for  $C_1$  in order to compensate for the lower value of  $R_1$ .

Resistor  $R_b$  provides positive feedback across the FSK comparator and facilitates a rapid transition between output states. A value of 510K is normally used.

Components  $C_f$  and  $R_f$  form a single-pole post-detection filter for the FSK data output ( $R_f$  generally = 100K). Capacitor  $C_f$  smoothes the data output; its value is calculated roughly as:

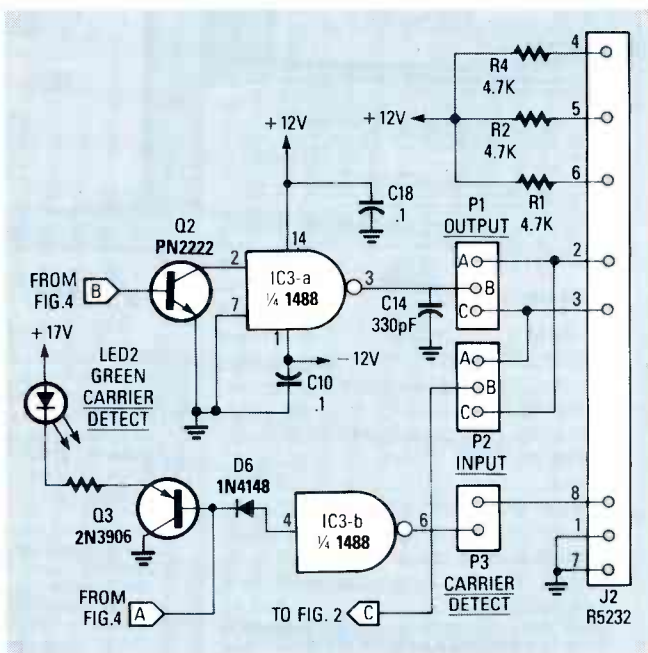
$$C_f = 3/\text{data rate in bits per second}$$

where  $C_f$  is in microfarads. Since the LCM100 is designed for operation up to 9600 bps (bits per second), a value of 330 pf is acceptable.

The final area requiring calculation is the lock-detect section of the XR2211, which is used in a carrier-detect function. The open-collector lock-detect output (pin 6) is connected to the data output (pin 7). That disables any output created by noise, unless a carrier signal is present within the detection passband of the PLL. Presuming a parallel resistance of 470 kilohms, the minimum value of the lock-detect filter capacitor,  $C_D$ , is:

$$C_D = 16/(f_1 - f_2)/2$$

The LCM100 uses a 3900-pf capacitor for  $C_D$ .



**FIG. 6—OUTPUT AMPLIFIER AND CONNECTORS. Transistor Q2 amplifies the output of the XR2211. Line buffer IC3-a then converts the signal to RS-232C form.**

### Output driver

Referring to Fig. 6, the data output of the XR2211 (pin 7) is amplified by NPN-transistor Q2, which drives IC3-a, one section of a 1488 quad RS-232C line driver. It produces the positive- and negative-voltage levels required by the RS-232C interface.

The carrier-detect output of the XR2211 (pin 5) drives the base of transistor Q3, which controls LED2, the carrier-detect LED. The LED provides a convenient means of verifying that the two modems are "talking" to each other.

### Next time

The only circuitry that we have not discussed yet is the power-supply section. Unfortunately, we have run out of room in this issue. However, the power supply's circuitry and operation will be discussed in detail in next month's **ComputerDigest**. We'll also give you the construction details, PC board patterns, and the testing and tuning instructions, so that you can get your system up and running. At this time, it might be a good idea for you to gather up all the parts you'll need, or order any of the kits that are offered at the end of the Parts List. ♦♦♦

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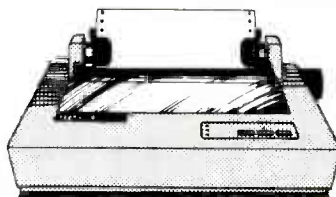
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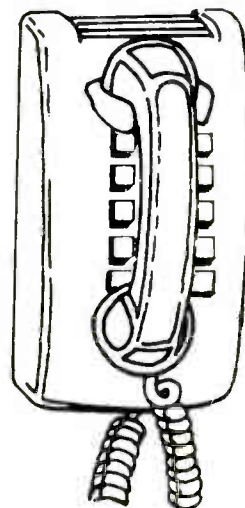
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# BUILD THE PT-68K

*This month we  
install the DRAM circuitry.*

PETER A. STARK



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Last month we discussed the internal structure of dynamic RAM (DRAM), and how it works. This month we'll describe and build the DRAM circuit actually used in the PT-68K. We've already discussed the general principles behind DRAM circuits, so let's start by discussing the specific circuits used in the PT-68K.

## DRAM operation during CPU accesses

Let's begin our discussion with the timing circuit shown in Fig. 1. First, assume flip-flops IC49-a and IC49-b are reset, which is the condition most of the time, because IC49-a is reset every time  $\overline{AS}$  (Address Strobe) goes low. Since IC49-b is reset, its  $\overline{REFRESH}$  output is low and  $\overline{REFRESH}$  is high. Furthermore, since IC49-a is also reset, the  $\overline{CAS}$  and  $\overline{DRAM DTACK}$  outputs are both low.

When the 68000 wants to access DRAM (either to write to it or to read from it), it places a valid address on the address bus. The address decoder (discussed in the January issue and shown in Fig. 3 of that article) recognizes the address as referring to the DRAM, and sends out the  $\overline{DRAM}$  enable signal which goes to IC51-c (shown in Fig. 1) to initiate a DRAM cycle. The signal travels a long distance on the board, so C68, a 33-pF capacitor, is used to reduce noise pickup. When  $\overline{DRAM}$  goes low, pin 10 of IC51-c is also low (as we will see in a moment), so IC51-c sends a low pulse to pin 10 of IC37-c.

(Actually, IC51-c is an OR gate, but it is shown as an AND gate with bubbles on both its inputs and its outputs. That notation was explained in the January 1988 installment.)

So, to recap, when the 68000 wants to access DRAM, the  $\overline{RAM}$  signal is asserted, and that in turn makes pin 8 of IC51-c go low. Then pin 8 of IC37-c goes high. That signal now does two things.

First, it is inverted to a low by IC66-d to generate  $\overline{RAS}$ , the Row Address Strobe that tells the DRAM IC's to accept a row address.  $\overline{RAS}$  also goes to pin 12 of IC51-d; because

pin 13 is already low (just like pin 10), pin 11 of IC51-d also goes low. That provides a second low to IC37-c, ensuring that it continues to output a high on pin 8 even if the  $\overline{DRAM}$  signal should disappear. That's not important now, though, because the  $\overline{RAM}$  signal will not disappear until after the DRAM operation is complete. (In other words, that circuit is only needed during refresh.)

Second, the high on pin 8 of IC37-c also goes to IC52, a 150-nanosecond delay line. That IC does what the name implies—it delays signals. It has several outputs, of which we use two. Whenever a logic signal is applied to its input on pin 1, that signal is delayed and appears on the outputs at a specified delay-time later. The total delay line is specified as 150 nanoseconds (ns), which means that the input comes out the last output, pin 8, 150 ns after it entered. But the delay line also has an intermediate output on pin 12, which provides only a 30-ns delay. (When you think about it, 30 ns is a very short time. For example, a beam of light—the fastest thing we know of—travels only about 30 feet in 30 ns!)

Until now, the input to the delay line was low, so both of its outputs were low. Pin 8 of IC52 therefore has been sending a low back to IC51-c and IC51-d. Meanwhile, pin 12 of IC52 has been sending a low to flip-flop IC49-a, to pin 4 of IC35-b, and to the  $\overline{A/B}$  SELECT line. After the 30-ns delay, however, pin 12 of IC52 goes high. That toggles the  $\overline{A/B}$  SELECT signal from low to high, and it also clocks flip-flop IC49-a. Since the data input (pin 2) of the flip-flop is already high (since flip-flop IC49-b was reset,  $\overline{REFRESH}$  was high), the flip-flop now sets and sends out a high on  $\overline{CAS}$  and  $\overline{DRAM DTACK}$ .

Now let's jump ahead to Fig. 2 and see what is happening in the DRAM address multiplexers. As mentioned last time, the DRAM address pins receive three separate addresses. During normal memory operation, first they receive a row address, then a column address; during

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## Further Help

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## Ordering Information

Complete details were given in part one (in the October 1987 issue). To summarize: the basic kit (PT1, \$200) contains all parts except power supply, case, and video terminal or personal computer to get a small system (ROM monitor, 2K RAM) up and running. The full basic system (PT-68K, \$530) includes 512K of dynamic RAM, floppy-disk controller, parallel port, battery-backed clock/calendar, three PC-compatible expansion slots, SK\*DOS operating system, editor, assembler, and system utilities. To order, or for more information, contact Peripheral Technology, 1480 Terrell Mill Road #870, Marietta GA 30067, (404) 984-0742.

refresh, they receive a refresh address. The multiplexers shown in Fig. 2 select which of those three addresses is applied when.

In our circuit descriptions until now, REFRESH has been low and REFRESH has been high. The circuitry at the top of

Fig. 2 generates the refresh address, which can be sent to the DRAM's through a set of three-state buffers in IC61 if their  $\overline{OC}$  (Output Control) input goes low. But since REFRESH is high, that keeps  $\overline{OC}$  high and therefore prevents the refresh address from getting to the DRAM's.

Instead, the low REFRESH signal is applied to the  $\bar{g}$  (gate) inputs of IC88, IC75, and IC62. Each is a "quad two-input multiplexer", meaning that it contains four multiplexers, each with two inputs. The A/B SELECT input on each IC selects which of the two inputs is sent to the output of each multiplexer. Scanning down the inputs of IC88, for example, A1 goes to output MA3 if the A/B SELECT input is low, or A5 goes to MA3 if the A/B SELECT input is high. Similarly, either A2 or A6 goes to MA2, depending on the A/B SELECT input. Notice that the A inputs and MA outputs seem to be mixed up in a crazy order, which seems as though the memory is going to be very confused. In actual operation, it simply means that every time the 68000 stores something into memory it will go into what looks like the wrong location; but the next time the 68000 wants to read it back, it will be read back from the same wrong location, so the correct data will come back out.

At the beginning of the operation, A/B SELECT was low, so each of the multiplexers chose one set of nine bits to send to the MA outputs. But after the delay line outputs a high A/B SELECT, the multiplexers switch and send the other nine address bits to the MA outputs. The first set of nine bits was the row address; the second set is the column address. Although it looks as though the column address comes out just 30 ns after the row address, actually the

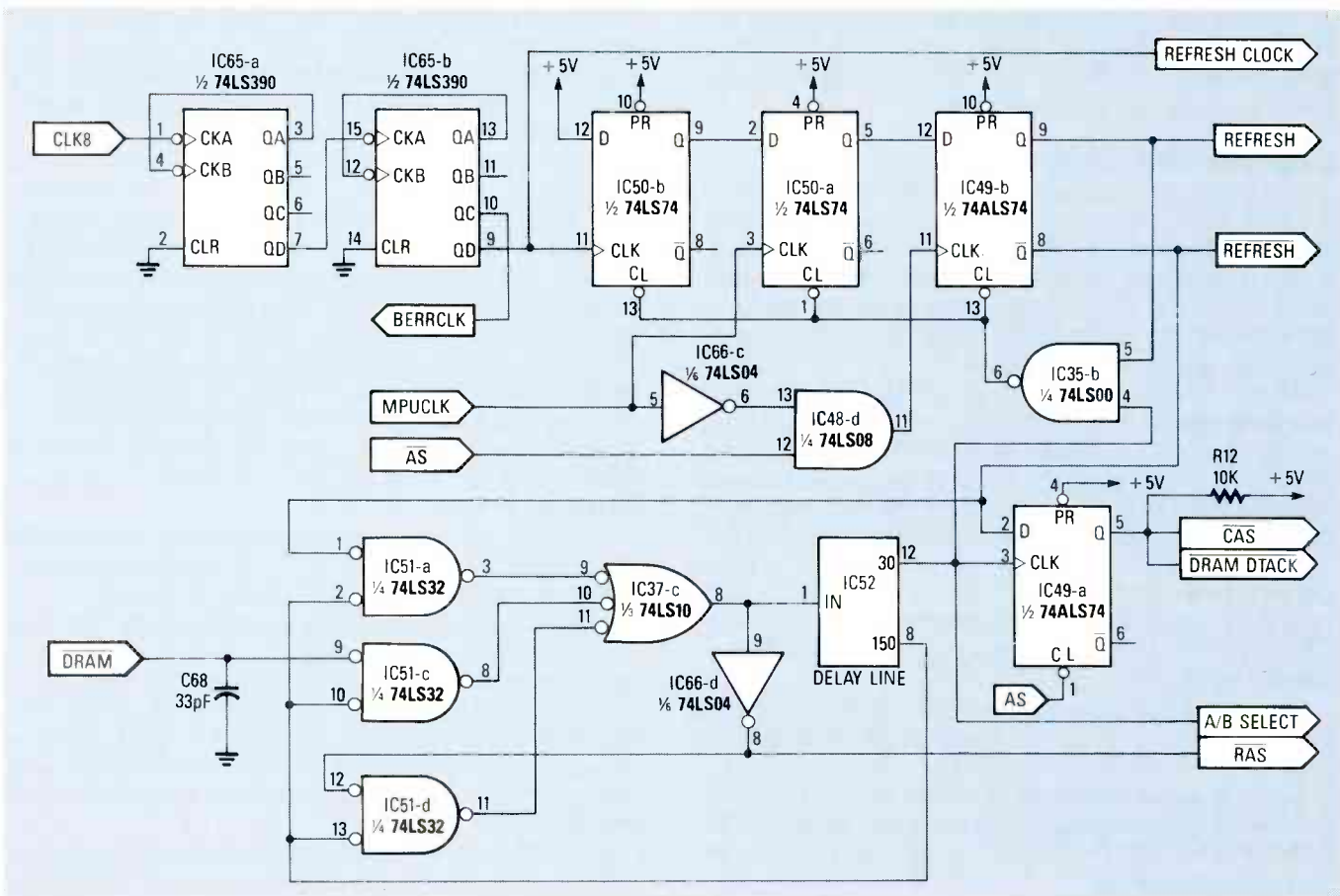


FIG. 1—THE PT-68K'S TIMING CIRCUITRY. The system clock (CLK8) is divided by 100 by IC65-a and IC65-b; it, in combination with MPUCLK, AS, and DRAM generate the refresh-enable signals that allow DRAM to be refreshed.



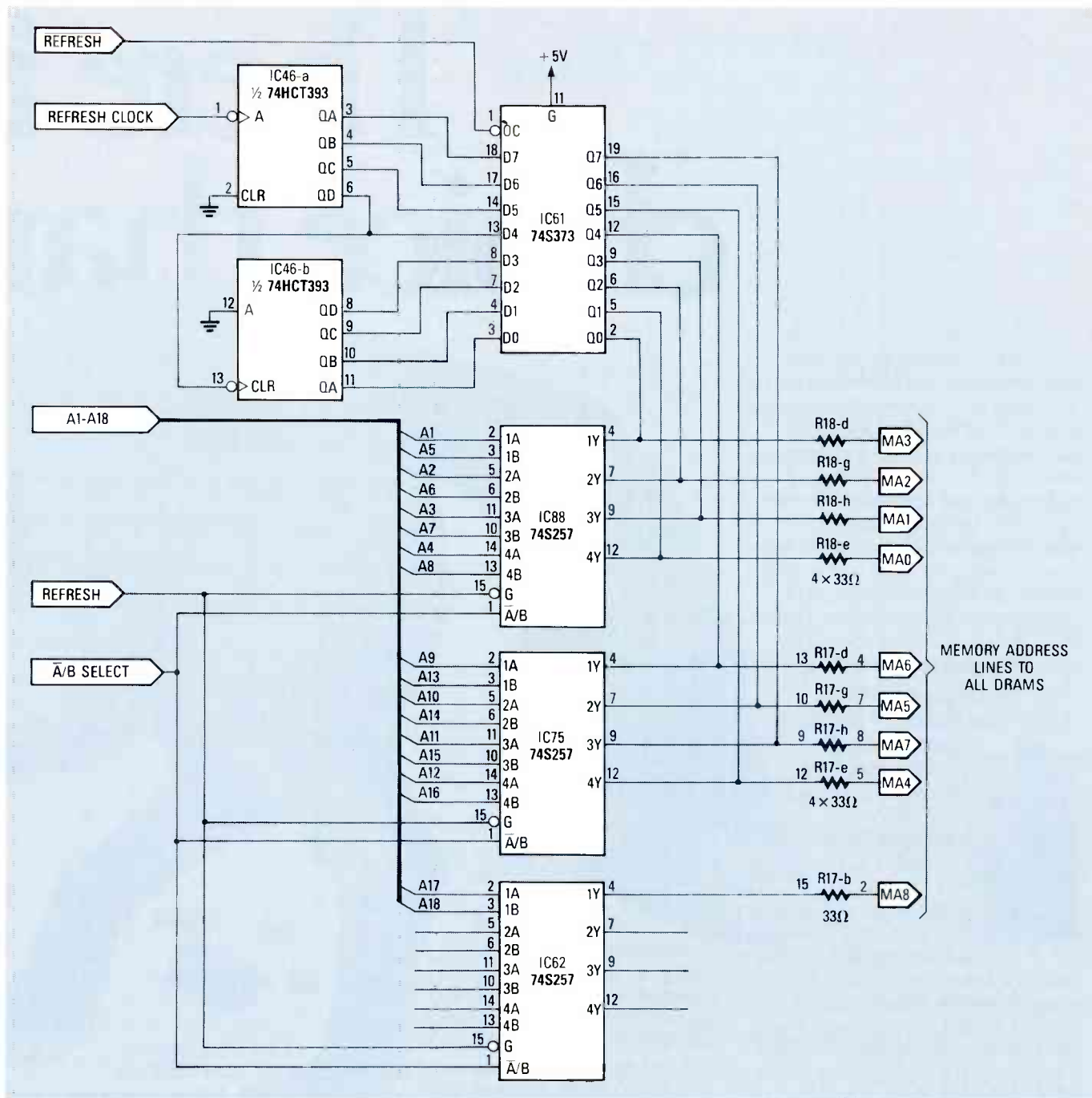


FIG. 2—THE PT-68K'S ADDRESS MULTIPLEXERS. IC61 provides the refresh addresses; IC62, IC75, and IC88 provide row and column addresses.

delay is somewhat greater. The row address is applied to the DRAM IC's as soon as the 68000 starts its memory operation; the column address is not applied until after the address decoder has recognized the DRAM address and sent out the  $\overline{RAM}$  signal, which must then go through IC51-c and IC37-c before even entering the delay line.

To summarize, operation proceeds as follows:

1) The 68000 sends out an address; since REFRESH and A/B SELECT are both low, nine bits of the address go to the DRAM's as a row address.

2) The address decoder sends out  $\overline{RAM}$ , which starts the DRAM circuitry.

3)  $\overline{RAS}$  goes low.

4) After a short delay, A/B SELECT goes high and sends the other nine address bits (column address) to the DRAM's.

5)  $\overline{CAS}$  goes low.

6)  $\overline{DRAM DTACK}$  goes low.

Note that  $\overline{DTACK}$  normally signals the 68000 that a data transfer is completed, yet the DRAM access is nowhere near being finished. To operate the computer at maximum speed,  $\overline{DTACK}$  is sent to the DTACK circuitry (IC36, shown in Fig. 5 of the January issue) before the DRAM actually finishes the operation. The 68000 doesn't respond for several more clock pulses, so the DRAM will have enough time to finish what it is doing before the 68000 continues its operation.

Regrettably, our discussion must wait until next month because we've run out of space. However, when we return, we'll continue our discussion on the DRAM circuitry's operation.

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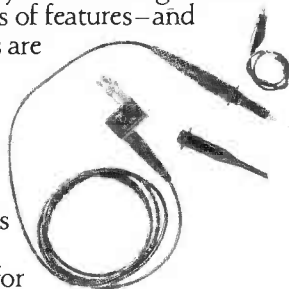
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timers, Series 48, are also available with timing ranges from 0.1 seconds to 3.0 minutes. All have input transient protection to prohibit false triggering or damage to circuitry and are UL approved. And because Philips ECG relays replace more original relay types than any other brand, there's no smarter choice.

## **Philips ECG's PR-60 & PR-200: The Answer to Your Scope Probe Needs.**

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## REACTS

*continued from page 50*

vate the water valves, and how many valves will be activated simultaneously. When you are calculating the power that is needed, remember to consider the amount of current that is used by the water valve's solenoid when it is first activated (the inrush current), which will be somewhat higher than the holding current of the solenoid.

In most cases, each of the octal I/O relays would activate only one valve. Therefore the relays, which are rated at 6 amps, will have no trouble at all, as the average consumer water valve requires less than 1 amp. Be sure to protect the transformer against shorts and overloads with the proper size fuse.

Also, follow the water-valve manufacturer's guidelines pertaining to the minimum diameter of the wire to be used, and their recommendations on waterproofing the wire and the connections. Finally, be sure to adhere to any local building codes that may apply to the installation. It's worth it in the long run.

For information on water valves, sprinkler heads, etc., contact your local lawn and garden supply store. Two major manufacturers of consumer sprinkler-system products are Toro and Rainbird. You should be able to find them, and many other manufacturers of such equipment, in the yellow pages.

### In conclusion

By now, we hope that the wheels in your head have started turning as to what the REACTS modular system can do for you. It is no secret that computers are now being used for more than just number crunching, word processing, drafting, etc. The system we have been showing you makes computerized home control affordable. It also bridges the gap between process controllers and personal computers.

In the articles to come, we will discuss and build more of the process-control modules. We will also construct modules that will enhance the system, such as the battery-backed power supply and the CRT controller/printer interface. We hope you will stay with us.

R-E

## LC METER

*continued from page 45*

and work with a simple binary counter scheme composed of inexpensive CMOS chips, required an Apple II program that ran for almost 4¼ hours.

The program that calculated all the required function addresses for the EPROM for each of the approximately 15,000 solutions to the equation ran for another 2½ hours. And after all the time spent calculating the EPROM data, the builder would need access to an EPROM programmer. To simplify everything, a programmed EPROM is available from the source listed in the Parts List.

Just in case you decide to test the EPROM data against your own calculations, bear in mind that the EPROM data have been compensated for the parasitic capacitive and inductance values that exists across the instrument's input terminals.

That's it for the theory. Next month we'll build and align the LC meter so that you can begin using it in your lab.

R-E

## GPIB

*continued from page 60*

There are system and measuring-related constraints that also affect the data-transfer rate. Examples of those are high resolution (5 1/2 to 6 1/2 digit) voltmeters that use the very slow integrating A-to-D (analog-to-digital) techniques, precision low frequency counting, and narrow band spectrum analysis. Those slow real-time measuring processes were fine when a human could wait 5 or 10 seconds for a measurement to come up; however, with automated test instruments that make measurements within the millisecond range, that time frame is no longer acceptable. As a result, the test-equipment industry is converting to high-speed sampling techniques, burst measurements, smart peripherals, block-memory transfers, direct-memory accesses, and other such methods that allow the data throughput rate to be bound only by the transfer-rate of the computer-interface combination.

When we continue, we'll look at GPIB accessories and how to analyze and troubleshoot the bus.

R-E

# Radio-Electronics



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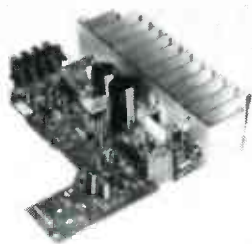


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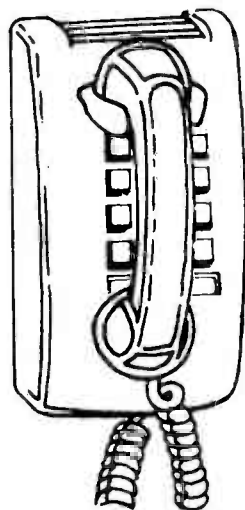
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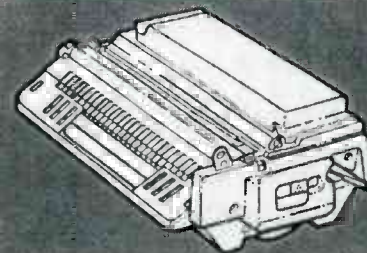
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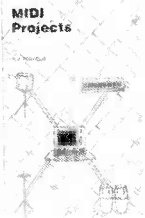
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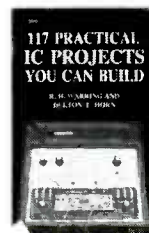
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## HARDWARE HACKER

*continued from page 73*

catalog number 109. Of all those traditional "old line" electronics distributors, they have always been one of my favorites. They stock just about everything, but you'll find that they tend to be both pricey and more than a tad anti-hacker.

Or, for a much smaller "new age" distributor that goes out of their way to stock single quantities of interesting and oddball hacker integrated circuits, try Circuit Specialists. Among their numerous other goodies, they now stock the Sprague ULN2429 liquid-level detector we looked at a few columns back. The cost for that device is only \$1.80.

The Micro Switch people have a new and free *Specifier's Guide for Pressure Sensors* in print. But the SenSym people have far better ap-notes and much more affordable pricing when it comes to hacker pressure-transducer and interface stuff.

The Mitsubishi Series 740 CMOS Microcontrollers are outlined in a new and free brochure. Those 6502-style devices are the best selling microcomputer IC's in the world today. My personal fa-

vorite here is the M50734, A 128K beastie that includes 40 parallel I/O lines, a built-in serial UART, four A/D converters, two stepper-motor drivers, a watchdog, five timers, a pulse-position modulator, and, last but not least, a soft ice-cream dispenser.

There's even enough pins on it that you may be able to use it in a pinch as an emergency cheese grater.

We'll see much more on that hacker gem in future columns. By one of those absolutely astounding coincidences, that M50734 just happens to drop right into the printed circuit shown in Fig. 5. Any old Apple IIe, IIc, or IIgs works just beautifully with that as a development system.

Turning to my own stuff, check into my classic *TTL* and *CMOS Cookbooks* if you happen to be interested in the fundamentals of digital integrated circuits. Something like 1,400,000 copies are now in print, which must be some sort of a record for technical paperbacks.

And I do have a "zeta release" available on all my new PostScript printed-circuit layout stuff available for you if you want to get in on all the action ahead of the hoarders.

Let's hear from you.

R-E

## AUDIO UPDATE

*continued from page 74*

By now, if my short tutorial on resonance has been absorbed, attentive readers should have some insight into the groove-skipping problem. The new cartridge was obviously heavier, or more compliant than the old one. That shifted the arm/cartridge resonant frequency downward into the warp danger-zone, and tone-arm lift-off occurred when the resonance was triggered by a warp at or near the critical frequency of the arm/cartridge combination.

The obvious solution is a cartridge whose compliance, or weight more closely resembles the old one, which apparently worked out well with the tone arm. The moral of the story—for those who want such things—is that there's a risk in choosing a cartridge or a tone arm in isolation. The two must be selected (or designed) as a compatible team to ensure that the resonances occur in the preferred range. Incidentally, because there are no mechanical interactions between a compact disc and the laser beam that "plays" it, CD players, as a rule, do not generally suffer from any resonance problems.

R-E



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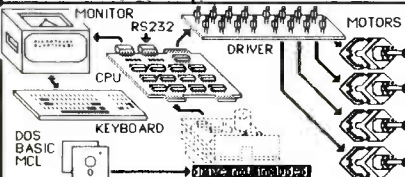
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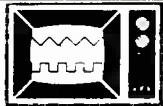
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7446	.89	.79	74181	1.95	1.85
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7474	.39	.29	74273	1.95	1.85
7475	.45	.39	74365	.65	.55
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74LS05	35	25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.19	.09
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74LS08	29	19	74LS191	.59	.49
74LS10	29	19	74LS193	.79	.69
74LS14	49	39	74LS221	.99	.89
74LS27	35	25	74LS240	.69	.59
74LS30	29	19	74LS243	.69	.59
74LS32	35	25	74LS244	.69	.59
74LS42	49	39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	39	29	74LS273	.89	.79
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74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
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74LS90	.49	.39	74LS368	.49	.39
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74S85	1.79	74S287*	1.49
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74F08	29	74F193	2.95
74F10	29	74F240	.99
74F32	29	74F244	.99
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CD4013	.29	CD4083	.35
CD4015	.29	CD4094	.89
CD4017	.49	CD40103	2.49
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CD4027	.49	CD4511	.69
CD4030	.29	CD4520	.75
CD4040	.65	CD4522	.79
CD4049	.29	CD4538	.79
CD4050	.29	CD4541	.89
CD4051	.59	CD4543	.79
CD4052	.59	CD4553	.495
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CD4066	.29	CD4566	2.49
CD4067	1.29	CD4583	.89
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CD4070	.25	CD4585	.39
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Z80	1.25	99	99	8250A	6.49
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Z80A	1.69	99	99	8254	.495
Z80A-CTC	1.79	99	99	8255A-5	1.89
Z80A-DART	4.95	99	99	8257-5	1.95
Z80A-PiQ	1.69	99	99	8259-5	2.25
Z80A-S/O	5.75	99	99	8272	4.95
Z80B	3.49	99	99	8279-5	2.95
Z80B-CTC	3.95	99	99	8741	9.95
Z80B-PiQ	4.99	99	99	8742	2.95
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6502	3.95	99	99	8751	39.95
6502	6.49	5.49	99	8751	14.95
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65C802(CMOS)	1.95	99	99	ADC0804LCN	4.99
6800	1.95	99	99	ADC0808CCN	5.95
6802	3.95	99	99	ADC0809CCN	9.95
6810	1.25	8203	9.95	ADC1606CCN	11.95
6821	1.75	8212	2.29	ADC1205CCJ-1	19.95
6840	3.95	8224	2.25	DAC0808LCN	1.95
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8203	9.95	99	99		
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*4164-100	65,536 x 1 (100ns)	3.49	SI3052P		2.49
*4164-120	65,536 x 1 (120ns)	2.75	6502		2.65
*4164-150	65,536 x 1 (150ns)	2.49	6504A		1.95
*4164-200	65,536 x 1 (200ns)	1.95	6507		4.39
*TMS4416-12	16,384 x 4 (120ns)	1.49	6510		9.95
*41256-80	262,144 x 1 (80ns)	11.95	6520		1.95
*41256-100	262,144 x 1 (100ns)	11.49	6522		3.95
*41256-120	262,144 x 1 (120ns)	9.95	6525	4.95	3.49
*41256-150	262,144 x 1 (150ns)	9.49	6526	14.95	12.95
*50464-15	65,536 x 4 (150ns) (4464)	9.95	6529		2.95
*51100P-10	1,048,576 x 1 (100ns) 1 Meg.	49.95	6532		6.49
*514256P-10	262,144 x 4 (100ns) 1 Meg.	69.95	6545-1	4.95	3.95
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*5101	256 x 4 (45ns) CMOS.	1.25	6569		24.95
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*6264P-15	8192 x 8 (150ns) CMOS.	5.99	8360		14.95
*6264LP-15	8192 x 8 (150ns) LP CMOS.	6.39	8501		10.95
*6514	1024 x 4 (35ns) CMOS.	3.49	8502		7.95
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2764-25	8192 x 8 (250ns) 21V.	3.75	901227-03		11.95
2764A-25	8192 x 8 (250ns) 12.5V.	3.95	901229-05		11.95
2764A-45	8192 x 8 (45ns) 21V.	3.95	*No specs. available		
27C64-15	8192 x 8 (150ns) 21V (CMOS).	6.49	**Note: 82S100PLA = U17.(C-64)		
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27128A-25	16,384 x 8 (250ns) 12.5V.	5.95			
27C128-25	16,384 x 8 (250ns) 21V (CMOS).	6.95			
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27C256-25	32,768 x 8 (250ns) 12.5V (CMOS).	7.95			
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27512-25	65,536 x 8 (250ns) 12.5V.	11.95			
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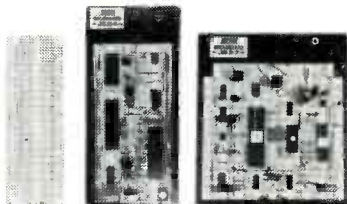
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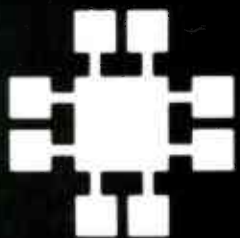
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HM6116-4	2048x8	(200ns)(CMOS)	1.79
HM6116-3	2048x8	(150ns)(CMOS)	1.85
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.90
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.45
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49
HM43256LP-15	32768x8	(150ns)(CMOS)(LP)	12.95
HM43256LP-12	32768x8	(120ns)(CMOS)(LP)	14.95
HM43256LP-10	32768x8	(100ns)(CMOS)(LP)	19.95

## DYNAMIC RAMS

4116-250	16384x1	(250ns)	4.9
4116-200	16384x1	(200ns)	8.9
4116-150	16384x1	(150ns)	9.9
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-150	65536x1	(150ns)	1.79
4164-120	65536x1	(120ns)	1.99
MCM6665	65536x1	(200ns)	1.95
TMS4164	65536x1	(150ns)	1.95
4164-REFRESH	65536x1	(150ns)(PIN 1 REFRESH)	2.75
TMS4416	16384x1	(150ns)	2.75
41128-150	131072x1	(150ns)	5.95
TMS4464-15	65536x4	(150ns)	4.95
41256-150	262144x1	(150ns)	3.95
41256-120	262144x1	(120ns)	4.95
41256-100	262144x1	(100ns)	5.49
HMS1258-100	262144x1	(100ns)(CMOS)	6.95
1 MB-120	1048576x1	(120ns)	31.95
1 MB-100	1048576x1	(100ns)	34.95

## EPROMS

2708	1024x8	(450ns)(25V)	4.95
2716	2048x8	(450ns)(25V)	3.49
2716-1	2048x8	(350ns)(25V)	3.95
TMS2532	4096x8	(450ns)(25V)	5.95
2732	4096x8	(450ns)(25V)	3.95
2732A	4096x8	(250ns)(21V)	3.95
2732A-2	4096x8	(200ns)(21V)	4.25
27C64	8192x8	(250ns)(12.5V CMOS)	4.95
2764	8192x8	(450ns)(12.5V)	3.49
2764-250	8192x8	(250ns)(12.5V)	3.69
2764-200	8192x8	(200ns)(12.5V)	4.25
MCM68766	8192x8	(350ns)(21V)(24 PIN)	15.95
27128	16384x8	(250ns)(12.5V)	4.25
27C256	32768x8	(250ns)(12.5V CMOS)	7.95
27256	32768x8	(250ns)(12.5V)	5.95
27512	65536x8	(250ns)(12.5V)	11.95
27C512	65536x8	(250ns)(12.5V CMOS)	12.95

## 6500 1.0 MHz

6502	2.25
65C02 (CMOS)	7.95
6520	1.65
6522	2.95
6526	13.95
6532	5.95
6545	2.95
6551	2.95

## 2.0 MHz

6502A	2.69
6520A	2.95
6522A	5.95
6532A	11.95
6545A	3.95
6551A	6.95

## 3.0 MHz

6502B	4.25
-------	------

## 6800 1.0 MHz

6800	1.95
6802	2.95
6803	3.95
6809	2.95
6809E	2.95
6810	1.95
6820	2.95
6821	1.25
6840	3.95
6843	4.95
6844	6.95
6845	2.75
6847	4.75
6850	1.95
6883	22.95

## 2.0 MHz

68800	2.95
68802	3.95
68809E	5.49
68809	5.99
68821	1.85
68845	4.95
68850	1.75
68000	9.95

## Z-80 2.5 MHz

### 4.0 MHz

Z80-CPU	1.25
Z80A-CPU	1.29
Z80A-CTC	1.69
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80A-SIO 0	5.95
Z80A-SIO 1	5.95
Z80A-SIO 2	5.95

### 6.0 MHz

Z80B-CPU	2.75
Z80B-CTC	4.25
Z80B-PIO	4.25
Z80B-DART	6.95
Z80B-SIO 0	12.95
Z80B-SIO 2	12.95
Z8671 ZILOG	9.95

## DISK CONTROLLERS

1771	4.95
1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2797	29.95
8272	4.39
UPD765	4.39
MB8876	12.95
MB8877	12.95
1691	6.95
2143	6.95
9216	6.29

## UARTS

AY5-1013	3.95
AY3-1015	4.95
TR1602	3.95
2651	3.95
IM6402	3.95
IM6403	9.95
INS8250	6.95
NS16450	10.95

## MISC.

ADC0804	2.99
ADC0809	3.85
DAC0800	3.29
DAC0808	1.95
DAC1022	5.95
MC1408L8	1.95
82T8	1.29
8797	5.9
DP8304	2.29
9334	1.75
9368	2.85
9602	7.9
ULN2003	7.9
MAX232	7.95
MC3470	1.95
MC3487	2.95
AY5-3600 PRO	11.95

## CLOCK CIRCUITS

MM58167	9.95
MM58174	9.95
MSM5832	2.95

## BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM8116	8.95

## INTERSIL

ICL7106	9.95
ICL7107	10.95
ICL7660	1.99
ICL8038	3.85
ICM7207A	5.95
ICM7208	15.95

## ★ ★ HIGH-TECH ★ ★

### 8052AH WITH BASIC \$34.95

- ★ SINGLE CHIP MICRO-CONTROLLER WITH BASIC IN ROM
- ★ BUILT-IN SERIAL PORT, THREE 16 BIT TIMERS, FIVE INTERRUPTS AND 256 BYTES OF RAM
- ★ REQUIRES VERY FEW PARTS TO BUILD AND EASY-TO-PROGRAM CONTROLLER
- ★ BASIC INTERPRETER IS OPTIMIZED FOR CONTROL APPLICATIONS

## ★ ★ SPOTLIGHT ★ ★

### 8000

8031	3.95
8035	1.49
8039	1.95
8052AH BASIC	34.95
8080	2.49
8085	1.95
8086	6.49
8088	5.99
8088-2	7.95
8155	2.49
8155-2	3.95
8741	9.95
8748	7.95
8749	9.95
8755	14.95

### 8200

8203	14.95
8205	3.29
8212	1.49
8216	1.49
8228	2.25
8237	3.95
8237-5	4.75
8243	1.95
8250	6.95
8251	1.29
8251A	1.69
8253	1.59
8253-5	1.95
8255	1.49
8255-5	1.59
8259-5	1.95
8257	2.25
8272	4.39
8274	4.95
8275	16.95
8279	2.49
8279-5	2.95
8282	3.95
8283	3.95
8284	2.25
8286	3.95
8287	3.95
8288	4.95

## MATH COPROCESSORS

8087	5 MHz	\$99.95
8087-2	8 MHz	\$159.95
8087-1	10 MHz	\$229.95
80287	6 MHz	\$179.95
80287-8	8 MHz	\$249.95
80287-10	10 MHz	\$309.95
80387-16	16 MHz	\$499.95
80387-20	20 MHz	\$799.95



## 74LS00

74LS00	16	74LS112	29	74LS241	.69
74LS01	18	74LS122	45	74LS242	.69
74LS02	17	74LS123	.49	74LS243	.69
74LS03	18	74LS124	2.75	74LS244	.69
74LS04	16	74LS125	.39	74LS245	.79
74LS05	18	74LS126	.39	74LS251	.49
74LS08	18	74LS132	.39	74LS253	.49
74LS09	18	74LS133	.49	74LS257	.39
74LS10	16	74LS136	.39	74LS258	.49
74LS11	22	74LS138	.39	74LS259	1.29
74LS12	22	74LS139	.39	74LS260	.49
74LS13	26	74LS145	.99	74LS266	.39
74LS14	39	74LS147	.99	74LS273	.79
74LS15	26	74LS148	.99	74LS279	.39
74LS20	17	74LS151	.39	74LS280	1.98
74LS21	22	74LS153	.39	74LS283	.59
74LS22	22	74LS154	1.49	74LS290	.89
74LS23	23	74LS155	.59	74LS293	.89
74LS28	26	74LS156	.49	74LS299	1.49
74LS30	17	74LS157	.35	74LS322	3.95
74LS32	18	74LS158	.29	74LS323	2.49
74LS33	28	74LS160	.39	74LS365	.39
74LS37	26	74LS161	.39	74LS367	.39
74LS38	26	74LS162	.49	74LS368	.39
74LS42	39	74LS163	.39	74LS373	.79
74LS47	75	74LS164	.49	74LS374	.79
74LS48	85	74LS165	.65	74LS375	.95
74LS51	17	74LS166	.95	74LS377	.99
74LS53	29	74LS169	.95	74LS390	1.19
74LS74	24	74LS173	.49	74LS393	.79
74LS75	29	74LS174	.39	74LS341	.19
74LS76	29	74LS175	.39	74LS624	1.95
74LS83	49	74LS191	.49	74LS640	.99
74LS85	49	74LS192	.69	74LS645	.99
74LS86	22	74LS193	.69	74LS670	.89
74LS89	39	74LS194	.69	74LS682	3.20
74LS92	49	74LS195	.69	74LS688	2.40
74LS93	39	74LS196	.59	74LS783	22.95
74LS95	49	74LS197	.59	25LS2521	2.80
74LS107	34	74LS221	.59	26LS31	1.95
74LS109	36	74LS240	.69	26LS32	1.95

## 7400

7400	.19
7402	.19
7404	.19
7406	.29
7407	.29
7408	.24
7410	.19
7411	.25
7414	.49
7416	.25
7417	.25
7420	.19
7430	.19
7432	.29
7438	.29
7442	.49
7445	.69
7447	.89
7473	.34
7474	.35
7475	.45
7476	.35
7483	.50
7485	.59
7486	.35
7489	2.15
7490	.39
7493	.35
74121	.29
74123	.45
74150	.35
74151	.55
74153	.55
74154	1.49
74157	.55
74159	1.65
74161	.69
74164	.85
74166	1.00
74175	.89
74367	.65

## LINEAR

19	TL071	.69	LM567	.79
19	TL072	1.09	NE570	2.95
19	TL074	1.95	NE592	.98
23	TL082	.95	LM723	.98
23	TL084	1.49	LM733	.98
24	LM301	.34	LM741	.29
19	LM309K	1.25	LM747	.69
19	LM311	.59	MC1330	.19
49	LM311H	.59	MC1350	1.19
25	LM317K	3.49	LM1458	.35
25	LM317T	.69	LM1488	.49
19	LM318	1.49	LM1489	.49
19	LM319	.95	LM1496	.69
29	LM320 see7800		ULN2003	.79
29	LM323K	3.49	XR2206	3.95
49	LM324	.34	XR2211	2.95
29	LM331	3.95	LM2917	1.95
89	LM334	.19	CA3066	.69
33	LM335	1.79	CA3146	1.29
33	LM336	1.75	MC3373	1.29
33	LM338K	4.49	MC3470	1.95
33	LM339	.59	MC4840	8.95
50	LM340 see7800		MC3487	.79
59	LF353	.59	LM3900	.49
35	LF356	.99	LM3911	2.25
15	LF357	.99	LM3909	.98
29	LM358	.89	LM3914	1.95
25	LM359	.89	MC4024	3.49
24	LM383	1.95	MC4044	3.99
49	LM386	.89	RC4136	1.25
49	LM393	.49	RC4558	.69
55	LM393H	5.95	LM13600	1.49
55	TL497	4.20	75107	1.95
55	TL497	3.25	75110	1.95
49	NE555	.29	75150	1.95
55	NE556	.49	75154	1.95
55	NE558	.79	75188	1.95
69	NE564	1.95	75189	1.25
85	LM565	.95	75451	.39
89	LM566	1.49	75452	.39
89	NE590	2.50	75477	1.29



## CAPACITORS TANTALUM

1.0µF	15V	12	1.0µF	50V	45
6.8	15V	42	2.2	35V	19
10	15V	45	4.7	35V	39
22	15V	99	10	35V	69

## DISC

10µF	50V	05	001µF	50V	05
22	50V	05	005	50V	05
33	50V	05	01	50V	07
47	50V	05	05	50V	07
100	50V	05	1	12V	10
220	50V	05	1	50V	12

## MONOLITHIC

0.1µF	50V	14	1µF	50V	18
0.47µF	50V	15	47µF	50V	25

## ELECTROLYTIC

RADIAL			AXIAL		
1µF	25V	14	1µF	50V	14
4.7	50V	11	10	50V	16
10	50V	11	22	16V	14
47	35V	13	47	50V	19
100	16V	15	100	35V	19
220	35V	20	470	50V	29
470	25V	30	1000	16V	29
2200	16V	70	2200	16V	70
4700	25V	145	4700	16V	125

## RESISTOR NETWORKS

SIP	10 PIN	9 RESISTOR	69
SIP	8 PIN	7 RESISTOR	59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	99
DIP	14 PIN	13 RESISTOR	99

## 38 PIN CENTRONICS

ICEN36	RIBBON CABLE	3.95
CEN36	SOLDER CUP	1.85
ICEN36/F	RIBBON CABLE	4.95
CEN36PC	Rt Angle PC Mount	1.85

## EDGE CARD CONNECTORS

100 Pin ST	S-100	125	3.95
100 Pin WW	S-100	125	4.95
62 Pin ST	IBM PC	100	1.95
50 Pin ST	APPLE	100	2.95
44 Pin ST	STD	156	1.95
44 Pin WW	STD	156	4.95

## IDC CONNECTORS/RIBBON CABLE

DESCRIPTION	ORDER BY	CONTACTS				
		10	20	26	34	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.50	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.51	3.29
WIREWRAP HEADER	IDHxxW	1.86	2.98	3.84	4.50	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1.29	1.49
RIBBON HEADER	IDMxx	---	5.50	6.25	7.60	8.50
RIBBON EDGE CARD	IDExx	.85	1.25	1.35	1.75	2.05
10' GREY RIBBON CABLE	RCxx	1.60	3.20	4.10	5.40	6.40

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS BELOW

## D-SUBMINIATURE CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS					
		9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	45	59	69	75	1.35
	FEMALE	DBxxS	49	69	75	75	1.39
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	49	69	---	79	2.27
	FEMALE	DBxxSR	55	75	---	85	2.49
WIREWRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60
	FEMALE	DBxxSww	2.76	4.27	---	6.84	9.95
IDC RIBBON CABLE	MALE	IDBxxP	1.39	1.99	---	2.25	4.25
	FEMALE	IDBxxS	1.45	2.05	---	2.35	4.49
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	---
	GREY	HOODxx	.39	.39	---	.39	.69

## ORDERING INSTRUCTIONS:

INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE ORDER BY: PART NUMBER LISTED. EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

## MOUNTING HARDWARE 59¢

## IC SOCKETS/IDP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS								
		8	14	16	18	20	22	24	28	40
SOLDERTAIL SOCKETS	xxST	.11	.11	.12	.15	.18	.15	.20	.22	.30
WIREWRAP SOCKETS	xxWW	.59	.69	.69	.99	1.09	1.39	1.49	1.69	1.99
ZIF SOCKETS	ZIFxx	---	4.95	4.95	---	5.95	---	5.55	6.95	9.95
TOOLED SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WW SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIERS	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	---	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS ABOVE

## BYPASS CAPACITORS

0.1µF CERAMIC DISC	100/\$5.00
0.1µF MONOLITHIC	100/\$10.00
1µF CERAMIC DISC	100/\$6.50
1µF MONOLITHIC	100/\$12.50

## 25 PIN D-SUB GENDER CHANGERS \$7.95



## EMI FILTER

\$4.95

## LINE CORDS

2 conductor 39¢  
3 conductor 99¢  
3 conductor w/ female socket \$1.49

## SOLDER STATION

- UL APPROVED
- ADJUSTABLE HEAT SETTING W/ TIP TEMP READOUT
- QUICK HEATING & RECOVERY
- RANGE: 200°-900°F

\$49.95

## EXTENDER CARDS FOR IBM

EXT-8088 \$29.95  
EXT-80286 \$39.95



## SHORTING BLOCKS 5/\$1.00



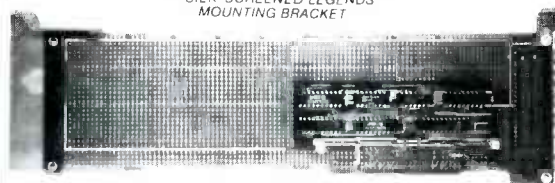
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GOLD-PLATED EDGE-CARD FINGERS  
SILK SCREENED LEGENDS  
MOUNTING BRACKET



## FOR P512

JDR-PR32 \$69.95  
32 BIT PROTOTYPE CARD  
JDR-PR16 \$49.95  
16 BIT WITH I/O  
DECODING CIRCUITRY  
JDR-PR16-PK \$15.95  
PARTS KIT FOR ABOVE  
JDR-PR16V \$39.95  
EXTENDED CONNECTORS  
FOR VIDEO APPLICATIONS

## FOR XT

IBM-PR1 \$27.95  
WITH .5V AND GROUND PLANE  
IBM-PR2 \$29.95  
AS ABOVE WITH DECODING LAYOUT

## FOR AT

JDR-PR10 \$34.95  
16 BIT WITH DECODING LAYOUT  
JDR-PR10-PK \$12.95  
PARTS KIT FOR ABOVE

## SOLDERLESS BREADBOARDS

WBU-D	100 TIE POINTS	2.95
WBU-T	630 TIE POINTS	6.95
WBU-204-3	1360 TIE POINTS	17.95
WBU-204	1660 TIE POINTS	24.95
WBU-206	4390 TIE POINTS	29.95
WBU-208	3220 TIE POINTS	39.95

## PAGE WIRE WRAP WIRE

PRECUT ASSORTMENT  
IN ASSORTED COLORS \$27.50

100ea: 5.5", 6.0", 6.5", 7.0"  
250ea: 2.5", 4.5", 5.0"  
500ea: 3.0", 3.5", 4.0"

## SPOOLS

100 feet	\$4.30	250 feet	\$7.25
500 feet	\$13.25	1000 feet	\$21.95

Please specify color:  
Blue, Black, Yellow or Red

## SOCKET-WRAP 1.0™

- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON THE PLASTIC; SUCH AS AN IC #

PINS	PART #	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)

## SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N/O	.39

## DIP SWITCHES

4 position	85	7 position	.95
5 position	90	8 position	.95
6 position	90	10 position	1.25

## "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO  
MAKE ANY SIZE HEADER,  
ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE LEAD	.49
2x40	2 STRAIGHT LEADS	2.49
2x40	2 RIGHT ANGLE LEADS	2.99



## 3 VOLT LITHIUM BATTERY \$1.95

HOLDER \$1.49



TERMS: MINIMUM ORDER \$10.00 FOR SHIPPING AND HANDLING INCLUDE \$2.50 FOR UPS GROUND AND \$3.50 UPS AIR. ORDERS OVER 1 LB. AND FOREIGN ORDERS MAY REQUIRE ADDITIONAL SHIPPING CHARGES—PLEASE CONTACT THE SALES DEPARTMENT FOR THE AMOUNT. CA RESIDENTS MUST INCLUDE APPLICABLE SALES TAX. PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE. WE ARE NOT RESPONSIBLE FOR TYPOGRAPHICAL ERRORS. WE RESERVE THE RIGHT TO LIMIT QUANTITIES AND TO SUBSTITUTE MANUFACTURER. ALL MERCHANDISE SUBJECT TO PRIOR SALE. A FULL COPY OF OUR TERMS IS AVAILABLE UPON REQUEST. ITEMS PICTURED MAY ONLY BE REPRESENTATIVE

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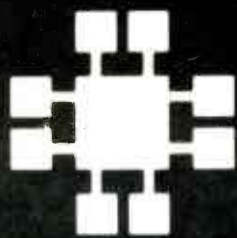
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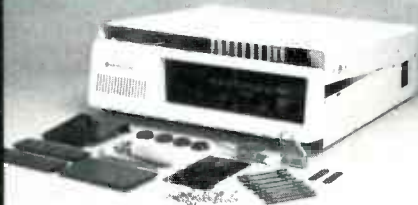
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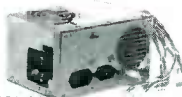
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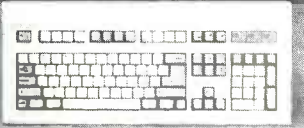
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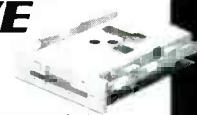
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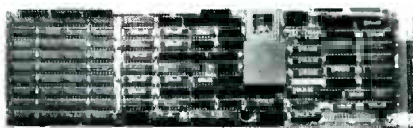
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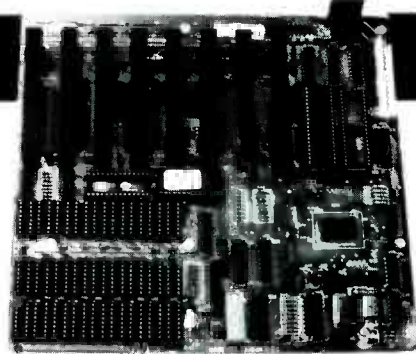
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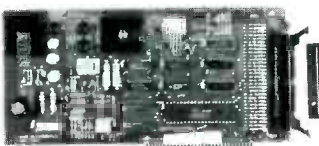
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12 Vac @ 930 ma. \$3.50

CAT# ACTX-1293

18 Vac @ 1 Amp. \$3.50

CAT# ACTX-1885

## PROTO BOARD

Large enough to  
design most  
experimental circuits.  
This proto board  
measures  
6 3/4" X 2 1/2".  
Contains main board  
and two power buss  
strips.

CAT# PB-101

\$11.00 each

## WATER TIGHT ENCLOSURE

ROSE# 02081905  
Molded fiberglass enclosure  
with neoprene gasket.

2" X 3" X 7 1/2". Light blue.

CAT# WP-905 \$7.50 each

## LIGHT EMITTING DIODES (L.E.D.)

### STANDARD JUMBO LED

DIFFUSED

T 1-3/4 size

RED

CAT# LED-1 100 for \$1.50

1000 for \$110.00

GREEN

CAT# LED-2 100 for \$2.00

1000 for \$17.00

1000 for \$150.00

YELLOW

CAT# LED-3 100 for \$2.00

1000 for \$17.00

1000 for \$150.00

### FLASHING LED

with built in

flashing circuit.

operates on 5 volts...

RED

CAT# LED-4 100 for \$1.00

1000 for \$9.50

GREEN

CAT# LED-4G 100 for \$1.00

1000 for \$9.50

BI-POLAR LED

Lights RED one

direction, GREEN the

other. Two leads.

CAT# LED-6 2 for \$17.00

### LED HOLDER

Two piece holder.

CAT# HLED

10 for 65¢

### CLIPLITE LED HOLDER

Makes a L.E.D. look

like a fancy indicator.

Fits T 1-3/4 size LED.

CLEAR

CAT# HLDCL-C

RED

CAT# HLDCL-R

GREEN

CAT# HLDCL-G

YELLOW

CAT# HLDCL-Y

## TRANSISTORS

PART	TYPE	CASE	PRICE
PN2222	NPN	TO-92	5 for .75
2N2904	PNP	TO-5	3 for \$1.00
2N2906	PNP	TO-18	3 for \$1.00
PN2907	PNP	TO-92	5 for .75
2N3055	NPN	TO-3	\$1.00 each
PN3569	NPN	TO-92	5 for .50
2N3904	NPN	TO-92	5 for .75
2N3906	PNP	TO-92	5 for .75
2N4400	NPN	TO-92	5 for .75
2N4402	PNP	TO-92	5 for .75
2N5400	PNP	TO-92	4 for \$1.00
2N5880	PNP	TO-3	\$2.00 each
2N5882	NPN	TO-3	\$2.00 each
MJ2955	PNP	TO-3	1.50 each
MJE2955T	NPN	TO-220	75 each
MJE3055T	NPN	TO-220	75 each
TI30	NPN	TO-220	75 each
TI31	NPN	TO-220	75 each
TI32	PNP	TO-220	75 each
TI41	NPN	TO-220	75 each
TI42	PNP	TO-220	75 each
TI121	NPN	TO-220	75 each
TI126	PNP	TO-220	75 each

## 10 AMP SOLID STATE RELAYS



ELECTROL# S2181

CONTROL:

Rated 5.5 to 10 Vdc

will operate on 3-32 Vdc

LOAD:

10 Amp @ 240 Vac

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

CAT# SSRLY-10B

\$9.50 each

10 for \$8.50 each

QUANTITY DISCOUNT!

25 for \$7.00 each

50 for \$6.00 each

100 for \$5.00 each

## SWITCHES

MINIATURE TOGGLE  
SWITCHES  
all rated 5 Amps

S.P.D.T.(on-on)

Solder lug terminals.

CAT# MTS-4

\$1.00 each

10 for \$9.00

S.P.D.T.(on-on)

Non threaded bushing.

P.C. mount.

CAT# MTS-40PC

75¢ each

10 for \$7.00

D.P.D.T.(on-on)

Solder lug terminals.

CAT# MTS-8

\$2.00 each

10 for \$19.00

## MINI PUSH BUTTON

S. P. S. T. momentary.

Push to make. 1/4"

threaded bushing.

Red button.

CAT# MPB-1

35¢ each • 10 for \$3.25

## ITT PUSH BUTTON

ITT MDPL Series. 3/4" X 1/2"

gray rectangular key cap.

S.P.S.T. N.O. Push to close.

RATED:

0.1amp

switching,

0.25 amp

carry current. P.C. mount

CAT# PB-8 65¢ each

10 for \$6.00 • 100 for \$50.00

## HALL EFFECT SWITCH

MICROSWITCH #4BE3

Slanted keyboard

switch with hall

effect sensor.

Snaps into 5/8"

square chassis

hole. Hall effect

sensor slides easily from

switch and can be used in

other applications.

CAT# HESW 4 for \$1.00

10 for \$2.00

100 for \$15.00

## NICKEL-CAD (RECHARGEABLE) BATTERIES

AA SIZE \$2.00 each

1.25 Volts 500 mAh

CAT# NCB-AA

AA SIZE \$2.20 each

WITH SOLDER TABS

CAT# NCB-SAA

C SIZE \$4.25 each

1.2 Volts 1200 mAh

CAT# NCB-C

D SIZE \$4.25 each

1.2 Volts 1200 mAh

CAT# NCB-D

## SOUND ACTIVATED SWITCH

This circuit is designed to react to

high pitched sounds. Each board

contains many useful parts including

a condensor mike. Operates on

6 Vdc. CAT# SAB \$2.50 each

## SOUND & VIDEO MODULATOR

T# UM1381-1.

Designed for use

with T.I. comput-

ers. Can be used

with video came-

ras, games, or

other audio/

video sources.

Built in A/B

switch enables

user to switch

from T.V. antenna without dis-

connection. Operates on chan-

nel 3 or 4. Requires 12 Vdc.

Hook up diagram included.

CAT# AVMOD \$5.00 each

## GRAB BAGS

\$1.00 each

## 50 ASSORTED DISC CAPS.

Cut leads. Many common

values, some 500 volts.

CAT# GRABDC

## ASSORTED 1/4 WATT RESISTORS

Approximately 200

pieces of assorted values

some cut leads.

CAT# GRABRE

## ASSORTED PARTS

Strips of 100 assorted

parts. Each strip contains

an assortment of resis-

tors, capacitors, diodes,

coils etc. 100 parts.

CAT# GRABTR

## 15 VALUES OF ELECTROLYTICS

Assortment contains 15

values from 1 Mfd up.

Some with cut leads.

CAT# GRABCP

## 600 / 600 OHM COUPLING TRANSFORMER

600 ohm

c.t.

P.C. mount

1" centers

on mounting tabs.

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

CAT# CPTX

\$1.25 each

10 for \$11.00

## XENON FLASH TUBES

3/4" long X 1/8" diameter

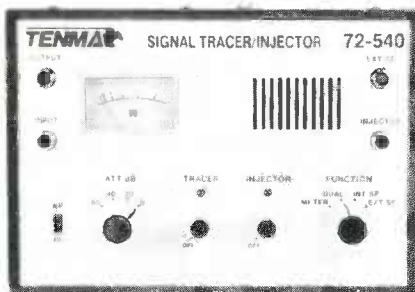
CAT# FLT-1 2 for \$1.00

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- Variable level 1KHz injection signal
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- Comes complete with test probe and owners manual

#72-540



## Autorange DMM

- 3½ digit LCD display ■ Autorange/manual range selector ■ Data hold: Holds display reading after meter is removed from circuit ■ Memory: Removes stored measurement from future readings ■ Audible continuity tester ■ Low battery indicator
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- Comes complete with test leads, carrying case and owners manual

#72-560

**NEW**

**SURGE STOPPER**

## Swivel Power Center

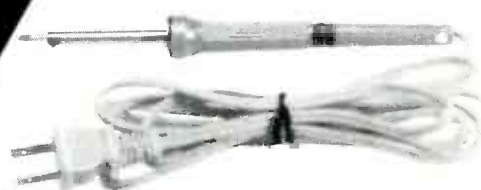
- For 9" to 12" monitors ■ Swivels 360° ■ Tilts 25° up and down ■ Built-in EMI filter and surge suppression
- Power receptacles for computer, monitor, printer, and two auxiliary ■ All peripherals are switched on power center ■ Illuminated master power switch ■ Built-in circuit breaker

#83-0120

## Anti-Static Field Service Kit

- 24" x 24" electrically conductive work mat with two built-in storage pockets
- Provides electrostatic protection for sensitive boards during transport or installation ■ Wrist strap and ground cord are included ■ Kit folds to 8½" x 12" x ½"

#21-740



## Micro Iron

- 16 watt ■ 117VAC ■ Small size ideal for soldering ICs
- Low wattage for heat sensitive devices

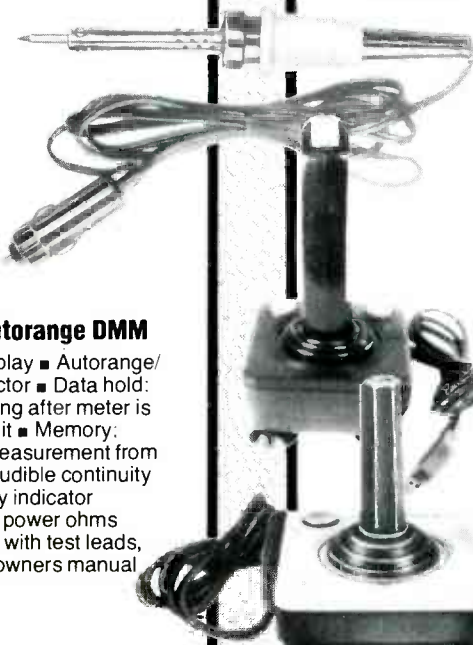
#21-775



## 12 Volt Soldering Iron

- This iron is specially designed for the autosound installer ■ Fast heat-up and recovery heating element ■ 7', 18 gauge cord with 12V cigarette lighter plug

#21-780



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- Atari #CA012994-3

#83-080

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- 16 oz. aerosol can ■ 12 cans per case

#20-490

## Circuit Cooler

- Will not leave residue ■ Cools circuits instantly for rapid location of heat related problems ■ Adjustable spray nozzle ■ 16 oz. ■ 12 cans per case

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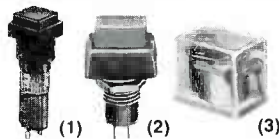
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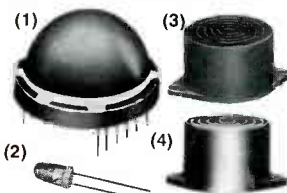
(1) Includes Two Cassettes



(2) Great Beginner Book

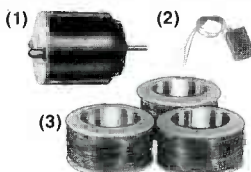
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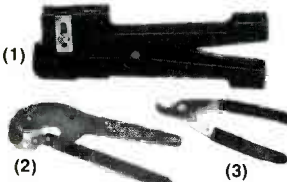
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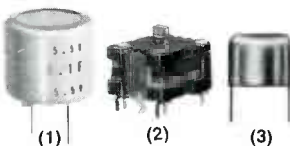
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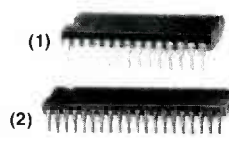
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With Probes

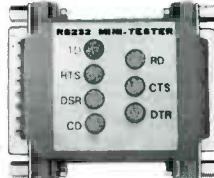
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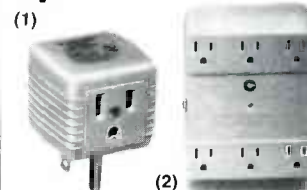
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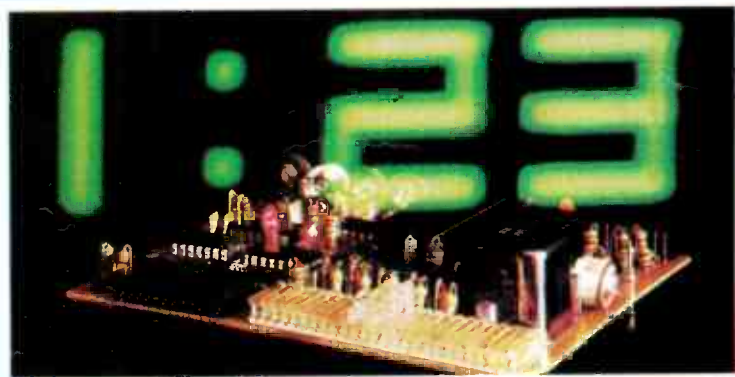
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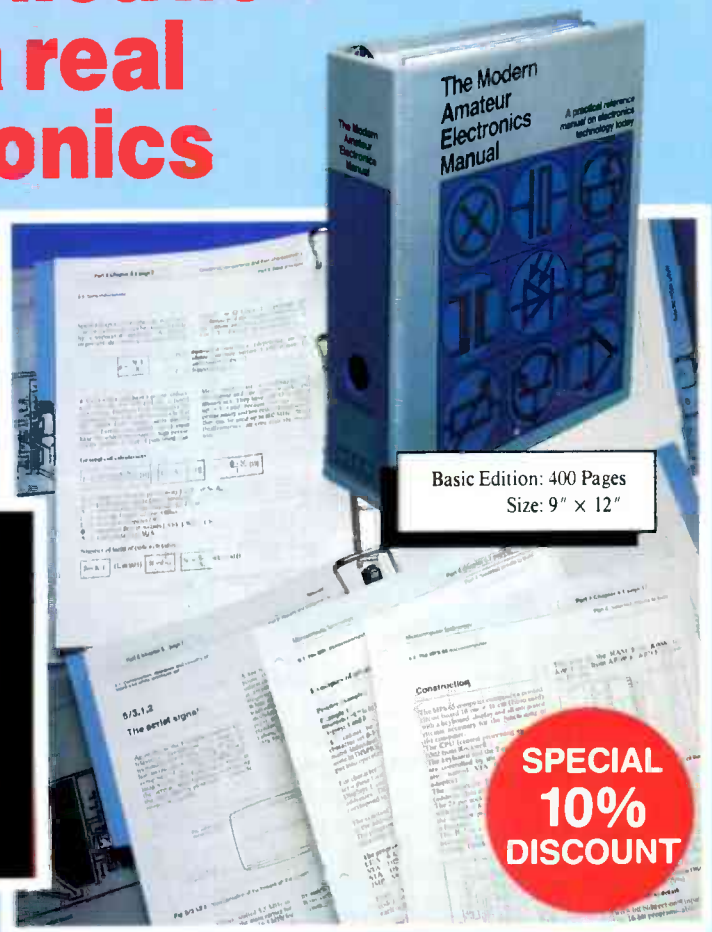
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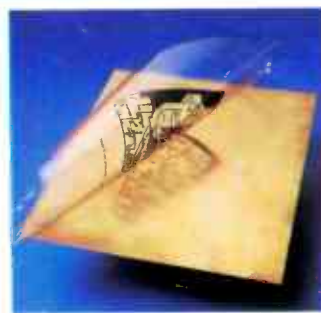
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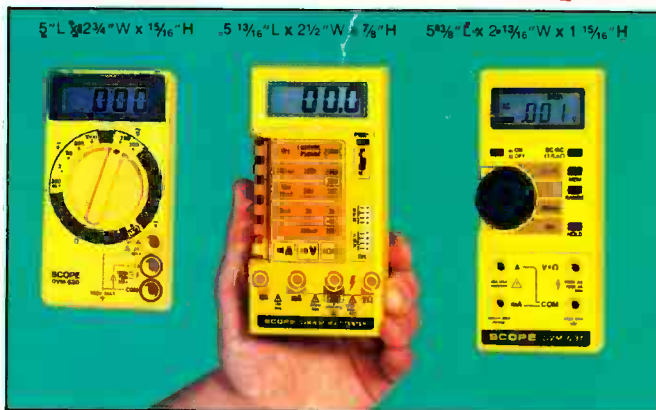
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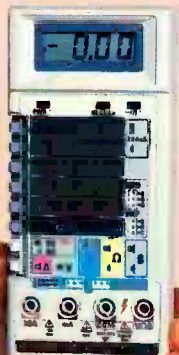
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