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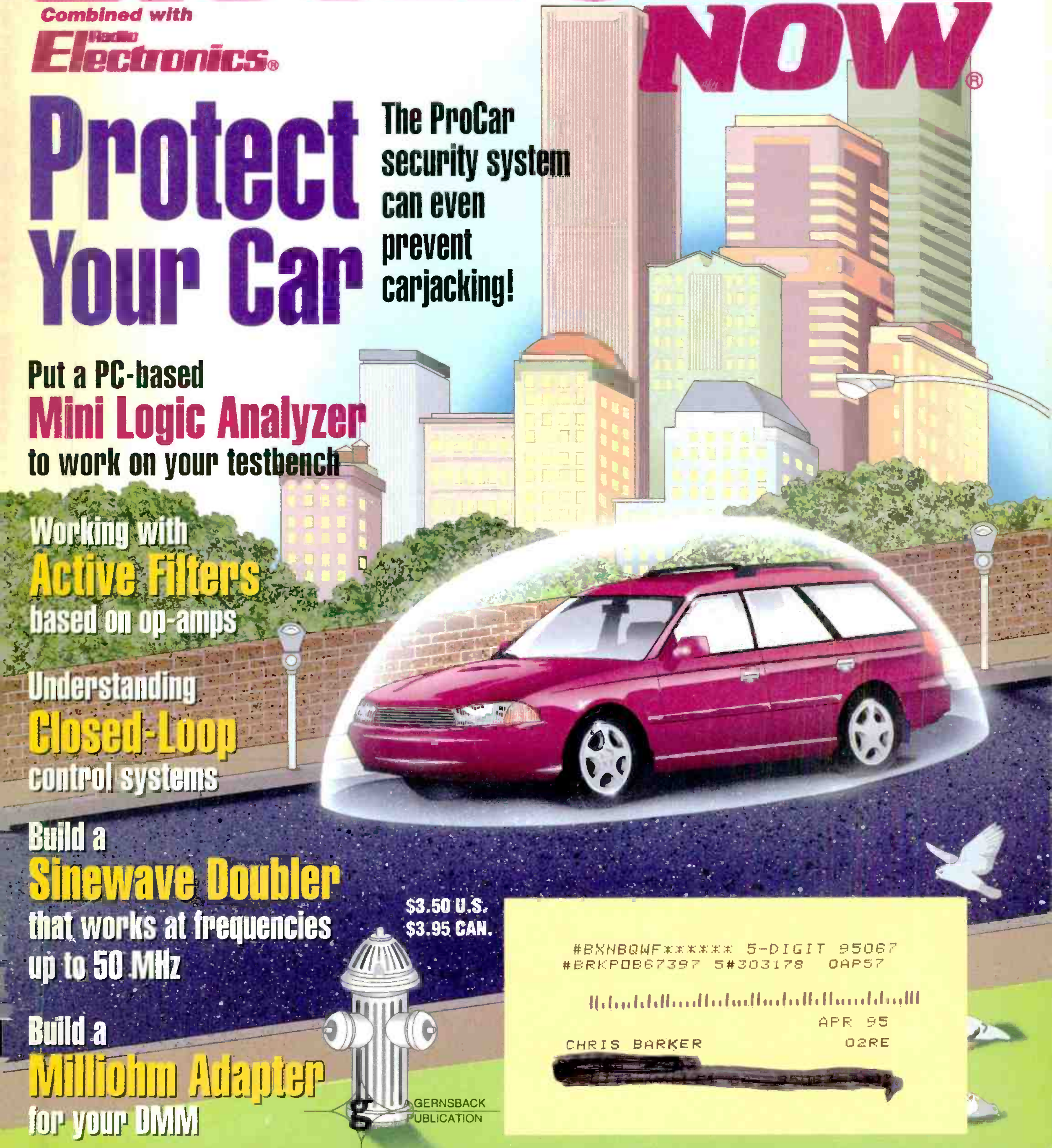

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** Approval pending.*

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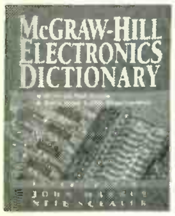

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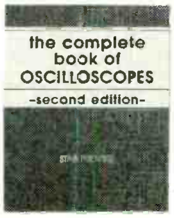

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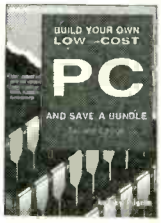

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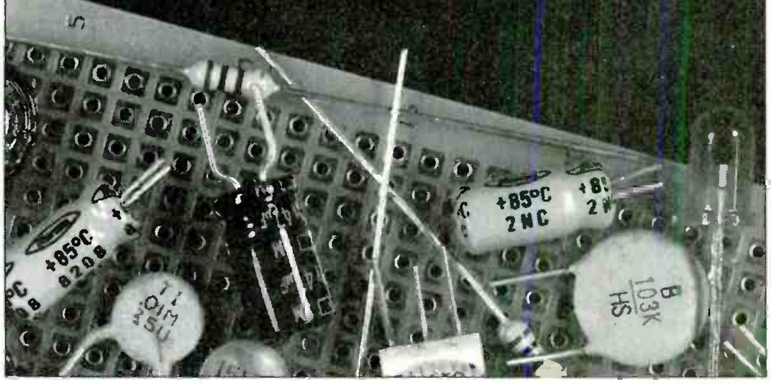

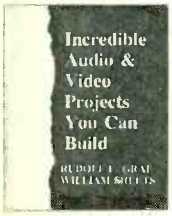

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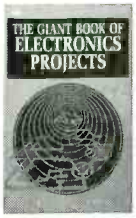

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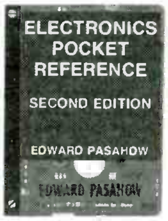

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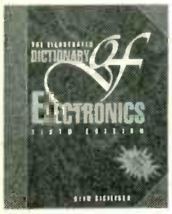

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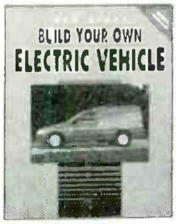

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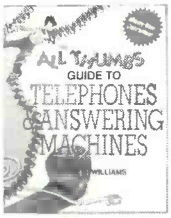

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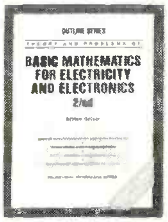

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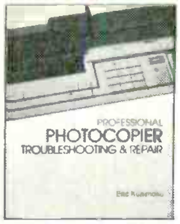

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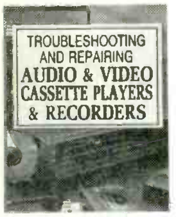

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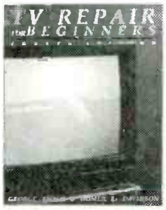

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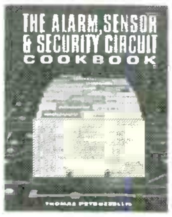

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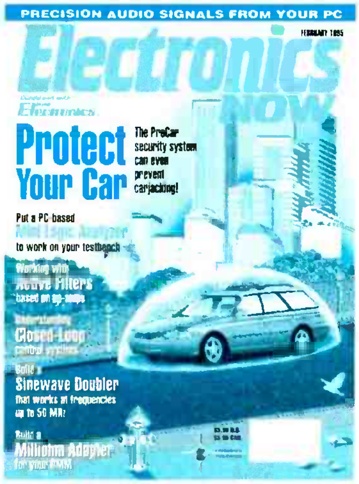

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WHAT'S NEWS

A review of the latest happenings in electronics.

Semiconductor-market predictions

The worldwide semiconductor industry will continue to grow at a 15% annual pace for the remainder of this century and that growth will exhibit greater stability and less volatility than it has in the past, according to World Semiconductor Trade Statistics, an international statistical organization composed of approximately 70 chip manufacturers.

William P. ("Pat") Weber, the vice chairman of Texas Instruments who revealed the prediction, went on to state with certainty that electronic components will continue to find places in many more products that now have little or no electronics content.

He pointed out that the integrated circuit content of electronic equipment averaged only 4% in the 1970s, but it rose to 7% in the 1980s, and approached 10% in the first three years of this decade. That content is expected to rise to 25% to 30% in such products as notebook and sub-notebook computers this year, and it will continue to rise.

"We believe the trend toward higher IC content will continue as the worldwide telecommunications infrastructure shifts from analog to digital over the next few years," Weber declared, adding. "Content will accelerate again later in this decade as the electronics content of consumer products becomes all-digital.

The Texas Instruments executive reported that the statistical forecast also predicted that total worldwide IC shipments would reach $99.9 billion by the end of last year and that they would reach $114.6 billion by the end of this year. The report also predicted sales of $130.4 billion by the end of 1996, and $153.8 billion by the end of 1997.

According to the report, the North American market will remain the largest in the world this year,but the Asia-Pacific region (excluding Japan) should eclipse the European market by 1997. Metal-oxide semiconductor (MOS) microprocessors and memory will continue to dominate in market share with their increasing consumption for telecommunications and consumer products.

Sales of mixed-signal, digital-signal-processing, and field-programmable integrated circuits, those devices at the vanguard of the digital revolution, are predicted to reach $15 million by 1997.

According to Weber, the worldwide semiconductor industry will be required to invest more than $150 billion in the next few years to set up facilities for fabricating devices with 0.25 micrometer or smaller elements. New generations of microprocessors and software will permit the doubling or tripling of memory in each computer, and powerful non-computer applications for memory will emerge.

"I remember when we dreamed that this would become a $1-billion industry, Weber reminisced. "Few of us foresaw where we would be today. But what is even more startling is the realization that the industry is still in its infancy. When you consider the vast opportunities for applying electronics around the world' you see that the possibilities are almost unlimited."

THE NEW EXPANSION OF FORD'S SCIENTIFIC RESEARCH LABORATORY was built as two building wings connected by a 40-foot, open-air atrium.

Ford dedicates scientific research facility

Ford Motor Company dedicated a research facility last October that it claims will help it to meet environmental requirements, improve customer satisfaction and provisions for safety, and bring new vehicles to market faster.

The $137-million, 175,000 square foot laboratory was added to the original 414,000 square foot structure.It is part of the automaker's 720-acre research and development complex in Dearborn, Michigan. That complex consists of more than 150 laboratories that include 28 dynamometers, anechoic chambers, computer facilities, fiber-optic communications links, a scientific and technical library, and office space for more than 600 employees.

About half of the research conducted at the complex of laboratories is focused on environmental protection and pollution control. Existing research programs are devoted to atmospheric chemistry, investigating advanced catalysts, the development of lightweight automobile body structures, and the

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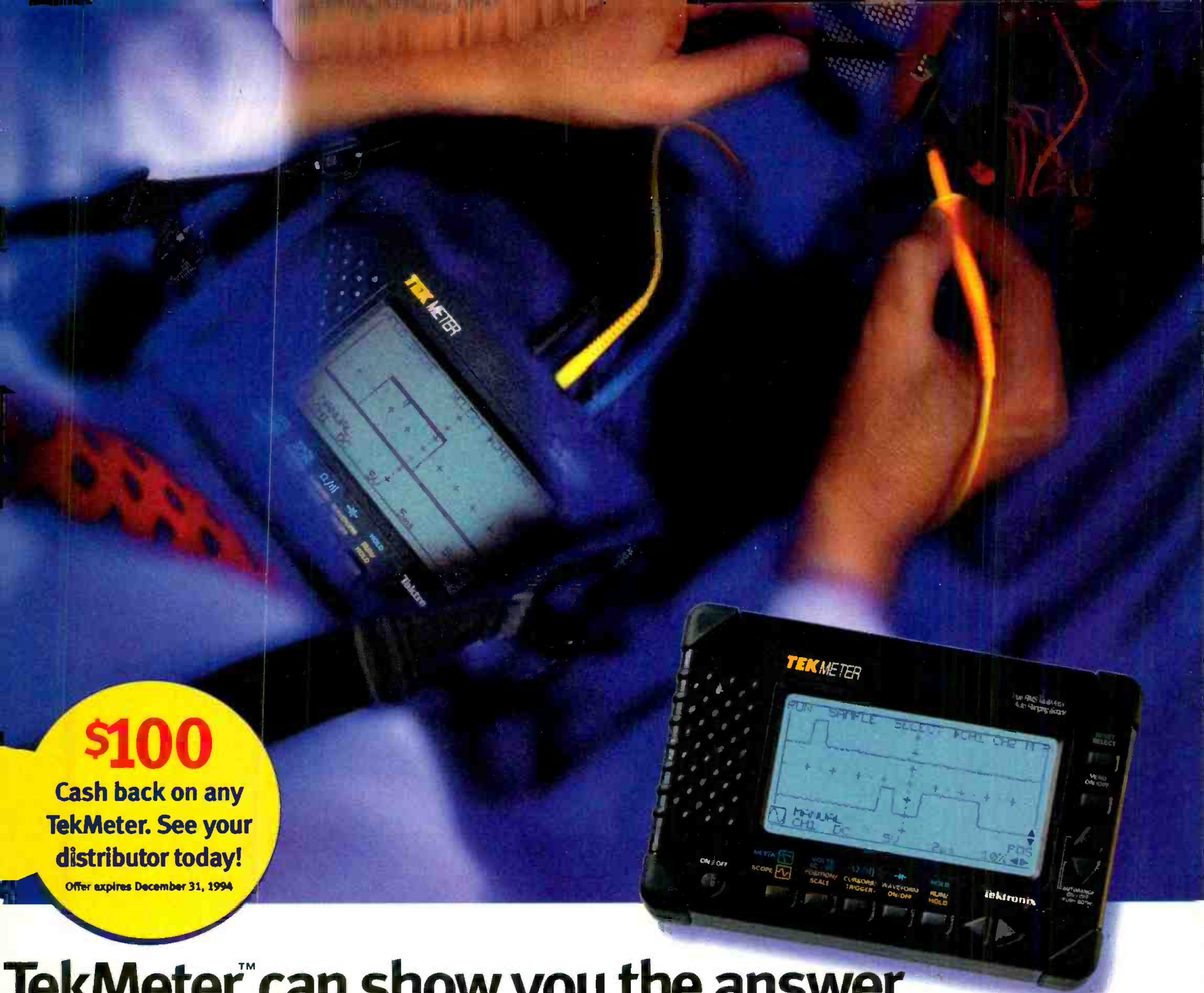

TekMeter™ can show you the answer before you even know the question.

TekMeter™ is the new handheld instrument from Tektronix that combines the functions of a DMM and an oscilloscope. It's practically "auto everything." Which in the service business means you'll get the answers you need faster than ever before.

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Weighing barely 2 pounds, TekMeter includes a host of features like cursors and spike detect that improve your ability to maintain and troubleshoot a wide range of equipment. TekMeter can even capture incoming line voltage spikes and sags, measure voltage and current simultaneously, compute true power, and more. All automatically. For as little as $875.*

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VIDEO NEWS

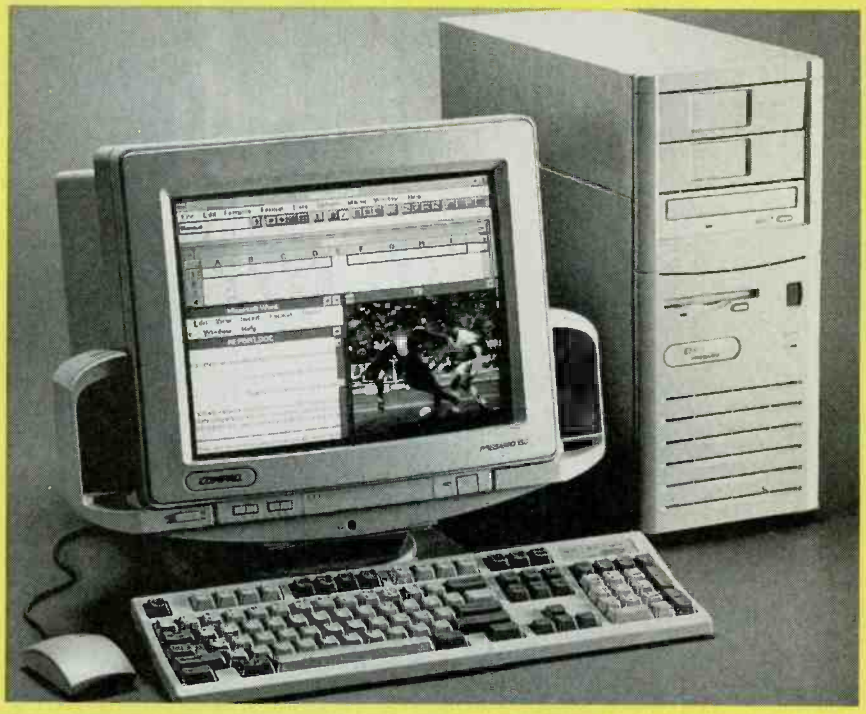
What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• TV screen info service. Scheduled for debut as a nationwide service this fall is VideoGuide, which combines some features of teletext with an on-screen program guide. Like StarSight and other systems designed to help viewers navigate the 500-channel TV future, VideoGide provides an on-screen program grid, permitting the viewer to tune in programs by manipulating an on-screen cursor and to set a VCR to make future recordings on the basis of the name of the program. Also like StarSight, it provides a synopsis of each program episode at the push of a button.

StarSight so far is being offered as a feature in some Zenith and Mitsubishi TV sets. Deals are pending with most other TV makers, and a Magnavox-brand set-top box will be offered in the future. Unlike StarSight, VideoGuide will be aimed primarily as an add-on feature and sold through retailers at less than $100. A unique feature of VideoGuide is that in addition to the program guide, it can deliver an up-to-the-minute on-screen newspaper, sports scores, and stock-market data. While StarSight uses data fed to TV network and cable via the television picture's vertical blanking interval (VBI), VideoGuide uses the nationwide paging network of BellSouth to transmit data directly to TV sets.

The VideoGuide set-top box comes with a simple four-button remote that can operate the TV as well as the box. It contains an infrared transmitter to activate a VCR for automatic recording and a short antenna to pick up RF information from BellSouth's network. Like StarSight, the system depends on subscription revenue. VideoGuide's rates are competitive with StarSight's—$4.99 monthly for program information and VCR tuning only, with other services such as sports scores and highlights and news at an additional $1.99 each, but with discounts if the service is ordered for a year at a time.



Representative of the new generation of multi-function computers, Compaq's Presario PC also serves as a television, stereo, and home telephone system.

One striking aspect of VideoGuide is the excellence of its graphics, which appear on the TV screen to have high resolution. The program grids are color-coded for easy selection, and the screen contents can be scrolled horizontally and vertically. Network insignia (such as the NBC peacock) are in full color, as are graphic icons for sports scores, etc.

VideoGuide and StarSight are just two of the many planned systems that make TV sets more like computers. They are coming at a time when computers are becoming more like TV sets.

• When is a TV not a TV? When it's a computer. That's the attitude of computer manufacturers, who increasingly are giving home PCs TV-tuning capability. Virtually every computer maker, from Apple to Packard Bell to Compaq to IBM to NEC, now offers or plans to offer computers with TV-tuning capability. This is becoming easier as semiconductor manufacturers increasingly offer TV tuners-on-a-chip to computer manufacturers.

The computer–TV combination is causing a quandary among government regulators, because of some very specific requirements imposed on television sets by federal law. As far as we can determine, many computer manufacturers are completely unaware that adding TV-tuning capability might subject them to those regulations.

There are three very basic requirements for TV sets, two imposed by acts of Congress and one by regulation with force of law: All TV receivers must be able to tune all broadcast channels, UHF, and VHF. All TV receivers with screen sizes 13 inches and larger in viewable diagonal must contain closed-caption decoders. TV-receiver screen sizes

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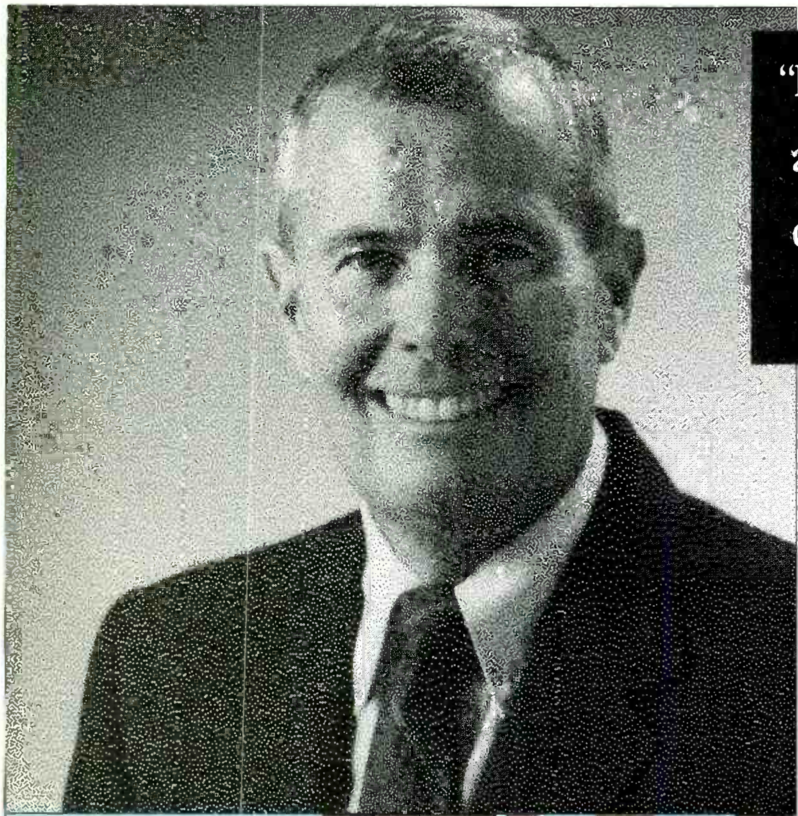

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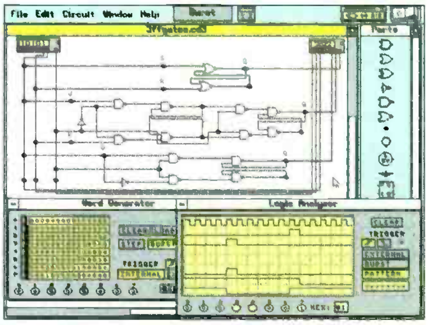

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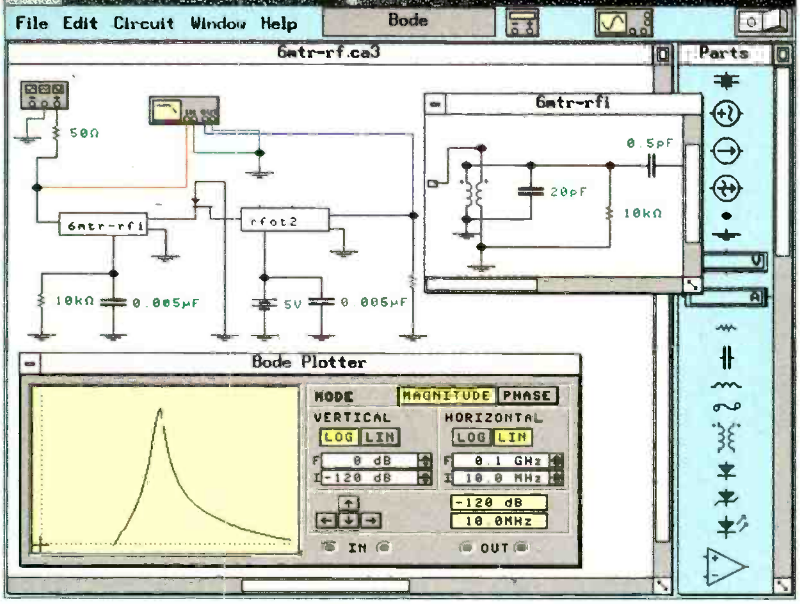
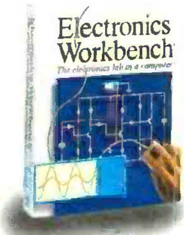


Analog Module: Tuning an RF front end.



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World's first wireless home theater system makes professional-quality surround sound affordable...

Now you can add surround sound to your home entertainment lineup with the amazing new Chase Technologies decoder that works with your existing stereo and an assortment of wired and wireless speakers.

by John Lindner

Let's face it. As much fun as renting a video can be, it's just not the same as seeing a movie in a theater. I remember the first time I saw *Jurassic Park*—I nearly jumped out of my seat when the dinosaurs roared. One of the reasons movies seem so real is because surround sound makes it seem like you're actually there when events are happening. Now there's an incredible new device that lets you use your stereo receiver to get that same surround sound in your home.

The secret of surround sound

Surround sound has become the rage of the '90s because it adds depth and realism to stereo sound, giving you the home theater experience. In short, it makes you feel like you are actually at a concert a theater.

To get surround sound, some people have tried simply adding additional speakers to their home entertainment lineup. But it takes more than additional speakers to get surround sound; there needs to be a way of separating the original signal into distinct channels so that you're not just duplicating the same sounds and broadcasting them from different areas of the room.

The new Chase Technologies HTS-1 surround sound decoder does just that, and in a revolutionary way that rivals the best Dolby Pro-Logic and THX systems available.The HTS-1 provides five channels of sound from any two-channel stereo source.

The HTS-1 works with a variety of speakers. In the front, you can use your existing stereo speakers. For the rear, choose from inexpensive wired speakers, high-quality wireless speakers, or even an audiophile-quality wireless satellite subwoofer system. The HTS-1 also gives you the ability to add a powered center channel speaker (instead of using your TV's built-in speaker).

The secret's in the signal. To get surround sound, you need to do more than simply add extra speakers. There needs to be a way of separating the signal from the musical score or movie soundtrack into distinct channel for each speaker. The new Chase Technologies HTS-1 surround sound decoder does just that, and in a revolutionary way that rivals the best Dolby Pro-Logic and THX systems available today.

Wins over critics. In the September 1994 issue of "High Performance Review," noted audio critic Daniel Kumin said "the HTS-1 can do quite a job of recreating a 3D theatrical experience...surround effects emanated with satisfying fullness...sound was clean at any level...with quite involving and natural sound ambience."

The new HTS-1 decoder won the *Design and Engineering* Award at the Consumer Electronics Show for being one of the best and most Innovative new products.

Plus, John Sunier, a leading authority on surround sound and producer of *Audiophile Audition*, a nationally syndicated radio program for audio enthusiasts, says, "...the new Chase HTS-1, when used to decode the hidden ambience in all musical recordings, definitely outperforms all the Dolby and THX processors (which could cost you up to $3,000)...I am impressed!"

Decoding breakthrough. Last year, audio industry veteran Bob Rapoport invented a new five-channel "passive" circuit for decoding the *Dolby Surround*™ signals in every stereo, videotape or laserdisc. This passive method is superior to active decoders such as Dolby and THX because it requires no AC current to decode. As a result, you experience more clarity, more detail, and a greater sense of space. Plus, you won't experience the noise or distortion which can occur with active decoding methods. You don't need any extra amps! Just connect the HTS-1 to your stereo, add your speakers, and you'll experience the magic of home theater at a fraction of the cost of other systems.

Five channel options. The HTS-1 decoder can be used with two, three, four or five channels of amplification, making it the most cost effective method for upgrading your stereo system to full home theater performance on the market. Best of all, the HTS-1 works with a variety of hard wired and wireless speakers.

In the front, most people use wired stereo speakers. Use your existing stereo's speakers or use one of a variety of wired speakers. Comtrad also offers the Chase Dialog center channel speaker. If your front speakers are more than eight feet apart, adding a center channel speaker will help keep voices and sound effects centered on the screen for stunning localization and clarity. The Dialog is self powered and video shielded to prevent interference with your television set.

The Chase HTS-1 decoder is the most cost-effective method for upgrading an existing stereo system to full home theater performance on the market.

The new Chase Technologies HTS-1 surround sound decoder gives you the option of using either traditional wired speakers like the Chase ELF-1s, or using wireless speakers or a wireless satellite subwoofer system for additional convenience and enhanced sound quality.

Speaker Options

Wired Speaker Options

Front Speakers: The Chase HTS-1 surround sound decoder can utilize your existing stereo speakers, or any of a variety of wired speakers available through Comtrad or your local electronics dealer.

Center channel speaker. If the front speakers are more than eight feet apart, adding a center channel speaker will keep voice cues centered on the screen. We offer the Dialog. It is self-powered and video shielded to prevent interference with TVs. **Dialog $75** $8 S&H

Rear channel speakers. We recommend the quality Chase ELF-1 in either white or black for inexpensive rear channel speakers. Mount them with the enclosed color-matched mounting brackets or flush mount them on the wall. **ELF-1 . . . .$99/pair** $10 S&H

Wireless Speaker Options

Rear channel speakers. Recoton W440 wireless speakers are the perfect option for people who want quality stereo rear channel speakers without having to run speaker wire. Their two-inch tweeters and four-inch woofers deliver 10 watts per channel—clear, strong stereo fill sound. The speakers work up to 150 feet from the transmitter without loss of sound quality. **TX1000 transmitter (works unlimited speakers) . . . . .$69** $7 S&H
W440 wireless speaker (each) . . . .$89 $9 S&H

Get the Chase HTS-1 half off ($49) when you buy the W440 speaker system!

Rear channel speakers. For true audiophile-quality rear channel speakers, we offer the Recoton wireless satellite subwoofer system. This first-of-its-kind system combines a 10-inch rear-firing subwoofer with a pair of 25-watt satellite speakers. The subwoofer provides that distinctive "low-end punch" that you feel in movie theaters, while the satellites are designed to coincide with surround sound processor specifications balance perfectly with the front speakers. **WHT470 transmitter. . . $69** $7 S&H
WHT421 wireless 50-watt subwoofer . . . .$299 $24 S&H
WHT462 pair of wireless 25-watt satellite speakers $329 $24 S&H

Get the Chase HTS-1 FREE when you buy the satellite subwoofer system!

Wireless freedom. When it comes to rear speakers, you can again choose standard wired speakers like the Chase ELF-1s. But if you want to avoid the hassle of running speaker wire up and down walls, behind furniture, and under carpet, you can add the freedom and convenience of wireless speakers.

Recoton wireless speakers utilize a transmitter which broadcasts sound signals up to 150 feet through walls, floors and ceilings. The speakers can be placed anywhere; they plug into a standard electric outlet. This eliminates the need to have wires running from the stereo to the speakers, which can be a nuisance with surround sound since the rear speakers are often elevated or wall mounted.

Affordable option. Recoton's W440 speakers allow you to add wireless rear channel speakers without compromising the sound quality that wired speakers deliver. Each self-amplified speaker contains a two-inch tweeter and four-inch woofer. They deliver 10 watts per channel for strong, clear fill sound. Their compact design (9" high x 6" wide x 5.5" long), make them the perfect bookshelf-sized companion to your home entertainment set up.

Audiophile quality. For the true stereo enthusiast, we offer the Recoton self-amplified wireless satellite subwoofer system. The satellite speakers in the system each bolster 25 watts of clean, distortion-free sound. The subwoofer adds a whole new dimension to your home theater with its 50-watt amplifier that's capable of creating enough rumble to make you feel like you're in the middle of an earthquake.

Even the most discriminating surround sound enthusiast will be engulfed by the abundant power and delighted with the full-range, first-rate sound from these black oak vinyl veneer speakers.

The Recoton wireless subwoofer's 50-watt 10-inch speaker delivers thunderous bass that adds depth and realism to the surround sound experience.

Easy to install. Every speaker option offered by Comtrad can be easily installed with the HTS-1 in a matter of minutes. Just connect the speaker outputs of your receiver or amp to the HTS-1, then connect speaker wire to the front and rear speakers. When using wireless speakers, connect the transmitter to the output. One transmitter will broadcast to each wireless speaker.

Risk-free home trial. The best way to evaluate surround sound is in your home—not a showroom. That's why we're offering the 30-day risk-free home trial. Try these products in your home and if you're not delighted with the the surround sound experience, return them for a full "No Questions Asked" refund.

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Q & A

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NEON POWER

Someone gave me several small neon bulbs that have flowers and other designs on them. I'd like to use them in some novelty projects I have in mind and power the circuits with batteries. Can you tell me what to do to light the bulbs?—F. Gish, Hunter, NY

Neon bulbs have modest current requirements, so it's possible to light them with a low-voltage DC supply. However, not all neon lamps work well when powered with an AC-like supply converted from DC. You might have to experiment with this circuit to light your bulbs.

Most small neon bulbs can be lit with the circuit shown in Fig. 1. The success you'll have with this circuit depends on the bulbs you have. A neon bulb needs about 90 volts of AC to light, so the 555 timer is set up as an oscillator running at about 300 hertz. The voltage swing at the 555 output is a bit less than the power supply rails, so the transformer steps it up to the voltage required by the neon bulb.

I'm using a typical audio output transformer wired backwards so it provides enough voltage across the secondary to light a small neon bulb. Remember that the circuit does not produce the "clean" AC you can get from an AC wall outlet. The bulb "sees" a pulsing DC voltage that should be high enough to light it.

Even though the circuit is supplied with only 9 volts DC, don't forget that there's a lot more voltage than that at the secondary of the transformer. Voltage that can light a neon bulb can also "light up" parts of your anatomy. Treat the circuit's output voltage with the same respect you'd give 120-volt AC.

If the neon bulb flickers or doesn't light at all, you can try lowering the frequency of the 555. If nothing you do to the circuit will light the bulb, consider powering your novelty circuit from an AC wall outlet and a suitable step-down transformer, since it's more than likely that the bulbs you have need higher quality AC voltage to work properly.

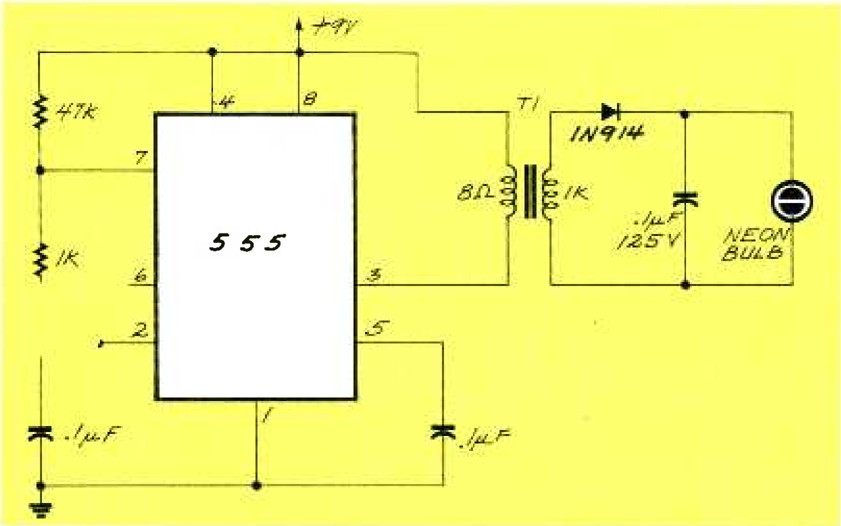

FIG. 1—MOST SMALL NEON BULBS can be lit with this circuit.

DISK ERRORS

I use a genuine IBM computer at the office and a PC clone for myself at home. I installed a 3½-inch diskette drive in my home computer because I wanted to be able to take files home from the office. Often I find that the disks from the office are unreadable on my home computer—they work fine at the office but give me "general failure" errors at home. The problem doesn't always occur, so I have no idea what's causing it. Do you?—D. Bernard, Santa Fe, NM

One of the phrases you never want to hear when someone is telling you about a computer problem is that "it doesn't happen all the time." An intermittent problem is the hardest kind to solve. Fortunately, I have a good idea about what's causing *your* difficulty. If it's what I think it is, the cause is your office PC, and not the one at home.

You didn't specify the models, but I'd be willing to bet that the office PCs are either PS/1 or PS/2 models, and probably fairly old ones at that. The reason why you're having the problem can be better understood by looking at a high-density 3½-inch disk.

There are two holes on the top of the disk. The one with the sliding cover is the write-protect indicator. Close up the hole and you can write to the disk—open it and the disk is then write-protected. The second hole, the one on the other top corner, is used by most drives to determine whether the disk is double- or high-density. The drive has an LED emitter-detector pair that straddles the hole. If the detector sees the light from the LED, the computer knows that it's a high-density disk. If the light is blocked (no hole), the computer knows that it's a double-density disk.

This detection scheme is unique to 3½-inch disks, and the report it sends back to the computer takes precedence over any other detection schemes that might be part of the operating system. Some early IBM computers had 3½-inch drives that didn't have this LED detection mechanism. The choice of high- or low-density disks was solely a function of the operating system. For what it's worth, besides not having this detection hardware, the drives had other problems as well, including a high failure rate.

What's going on in your case is that you're using double-density disks that have been formatted as high-density disks by your office computer. When you put one of them in the drive in your home computer, the drive reports back that it's a double-density disk. But since it was formatted as high-density, it is then unreadable.

The way around this problem is either to format all your disks at home (both high- and low-density), or be sure to format only double-density disks at the office. In light of all this, it's interesting to speculate whether there's any real difference between high- and low-density disks. There's supposed to be a difference between the two media, but this makes one wonder how true that really is.

LIGHT CONTROLLER INTERFERENCE

I have some automatic light controllers that were bought at Radio Shack, and I think they're causing problems with my radio reception. At dawn and dusk, the controllers will turn my lights off and on. Every time they work, they cause static on my radio. The problem is mostly on the AM band. How do I correct this?—R. Creed, Dallas, TX

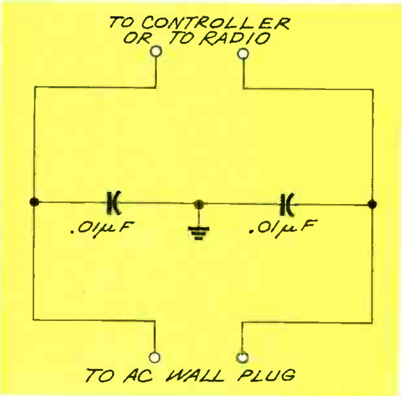

FIG. 2—ELIMINATE RFI SPIKES from the AC power line with this simple capacitive filter.

Since I assume you're locked into the idea of using these controllers for your lights, this might be one of those problems that can't be solved completely. The reason for this is simply that these controllers are

Continued on page 20

LETTERS

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

SOLVING THE RESISTOR CUBE

I read the article, "Solving the Resistor Cube" (*Electronics Now*, December 1994) with much interest. I enjoy solving puzzles, and this electronic puzzlement grabbed my attention.

Fig. 1 shows the resistor cube as the author labeled it. I'd like to offer a simpler solution to the complex puzzle. Because all the resistors are equal in value and the cube is symmetrical, the following simplification may be made:

The voltages across R1, R2, and R3 are equal, as are the voltages across R10, R11, and R12. Therefore, choosing any reference, the voltages at points B, C, and D would be equal, and it follows that the voltages at points E, F, and G would also be equal.

"Share's Shorting Law" states that all points of a circuit having the same voltage can be shorted together because no current can flow; therefore, no changes in the circuit (current or voltage) will occur. That allows a great simplification of the circuit to the one shown in Fig. 2.

Now it is a simple circuit to analyze for resistances, currents, and voltages. To find total resistance (R_T) from point A to point H, Fig. 2 reduces further to a series circuit, shown in Fig. 3.

Thus, using the author's last example of 100-ohm resistors and 25 volts (E_S) applied between A and H, $R_T = \frac{1}{3}R + \frac{1}{6}R = \frac{1}{3}\,R$, so $R_T = \frac{5}{6}R$ or 0.833 R. If all the resistors (R) are 100 ohms, then from the preceding equation $R_T = 83.3$ ohms and $I_T = E_S/R_T$, so $I_T = 300$ milliamperes. Other voltages and currents can be solved similarly with the simple circuits of Figs. 2 or 3.

DAVID SHARE
Monrovia, CA

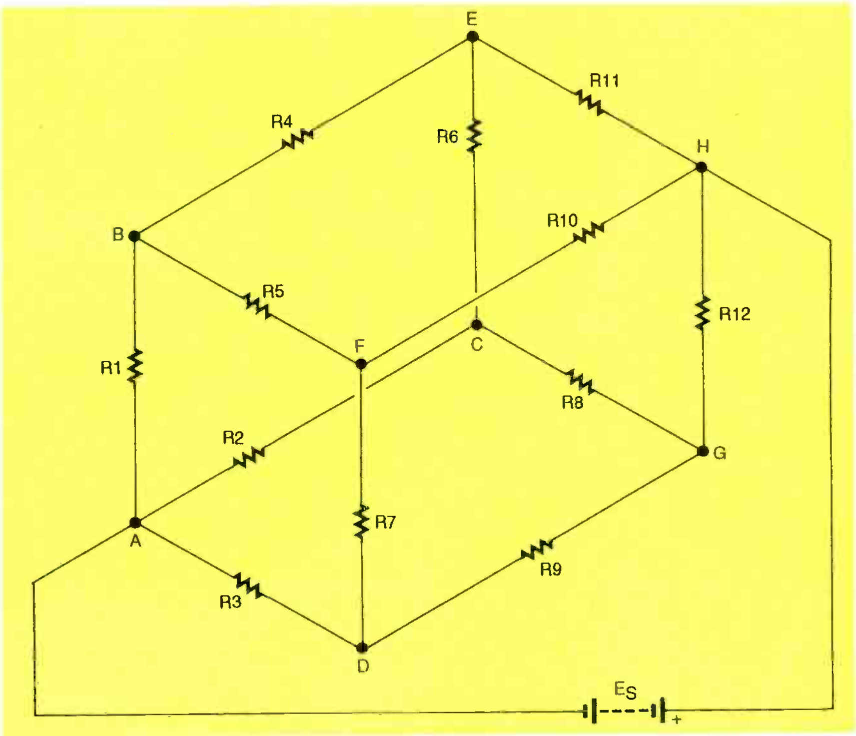

FIG. 1

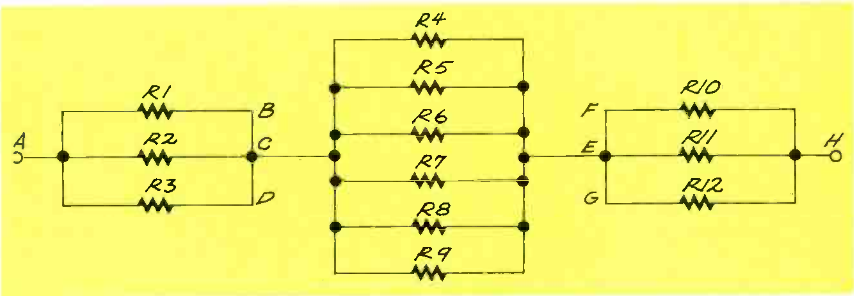

FIG. 2

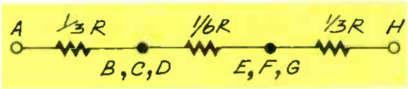

FIG. 3

ANOTHER LOOK AT OPERATING SYSTEMS

I read Jeff Holtzman's "Computer Connections" column on operating systems (*Electronics Now*, November 1994). For a person who first started using personal computers when most had eight-bit microprocessors, the size and complexity of today's crop of programs is amazing, astounding, formidable, and mindboggling. Even more surprising is the fact that the cost of the hardware and software is about the same as it was a decade ago.

All of these developments are driven by the push to high-resolution color graphics and hi-fi stereo sound. The public wants it because humans are genetically programmed to respond to graphics and sound. The recent (less than 15,0000 years) add-on skills for reading, writing, and arithmetic—the original data-compression and data-transmission methods—are non-intuitive and more difficult for humans to learn.

With the computer and digital multimedia transmission, we can go back to the good old days before paper and printing, when information was dispersed by storytellers, cave paintings, and minstrels.

The disparity in program size, then and now, emphasizes the old saw that what is easy for a human to comprehend is hard for a computer to comprehend, and vice versa.

By one definition, the term operating system (OS) applies to the entire package sold by the vendor. By another, it applies only to the active code that controls the computer and interacts with the computer user. You can call this the Working Operating System, or WOS. This confusing definition is typical of computer definitions where one word can have many meanings, or many words have the same meaning.

The utilities usually included in the OS were supposed to aid the purchaser in setting up and configuring his system. I think they were deliberately half-baked so that system vendors would not compete with their future clients, the program vendors.

A decade ago, we were happy if the OS just interacted with the console, printer, modem, and disk files. Now that the hardware has the power of a mainframe computer, the OS has the attributes of an advanced mainframe system, including such features as Virtual Machine (multiple operating systems), networking, telephony, multimedia.

Programs that have those features now give small businesses and professionals the same computer power that was once available only to large corporations. For the home, the future role of the computer, in addition to performing its traditional applications, is that of a node on the information highway. It will replace the telephone, fax machine, cable television, and game machine.

After sitting through a two-hour session that demonstrated the options for setting up the DOS window in OS/2, I realized that configuring these new operating systems was not a task for mere mortals. The winners in all this progress are consultants and value-added resellers.

The loser is the computer hobbyist, especially the beginner. The OS in the Kaypro II (a "portable" computer of a decade ago) takes 110 pages of assembly code, 70 pages for the CP/M 2.2, and 40 pages for the BIOS. Source for languages (both assembler and high level), OS clones, and modem, editor, BBS, and utility programs are available. Their length is measured in kilobytes.

Try that today. True, there are public-domain Unix operating systems and C+ compilers, but can a nonprofessional really wade through multi-megabytes of code? That is why a number of hobbyists are rediscovering the eight-bit systems and early IBM personal computers. They are understandable, inexpensive, and fun.

WALTER J. ROTTENKOLBER
Mariposa, CA

BATTERY BACKUP CORRECTION

I noticed an error in the September 1994 "Q&A" column. Figure 1, the battery backup schematic, should show the negative end of the 1µF capacitor going to ground, and *not* to the battery.

Battery B1's voltage should be 2.4 to 3.6 volts. The available supply voltage will be 0.6volts less because the diode voltage drop must be considered (Schottky diodes have lower voltage loss).

The protected memory, which must be CMOS static RAM, should be chosen so that its minimum operating voltage is maintained (refer to the manufacturer's data sheet).

I'd like to point out that nickel-cadmium batteries are a poor choice for memory backup systems. They have poor long-term characteristics in no-load, constant-charging applications, and you can expect only a moderate battery life—one to three years.

I recommend using a Super Cap (gold capacitor), which is a high-value (0.47 to 1.0 F), low-leakage capacitor that is designed for RAM backup. It can be purchased for just a few dollars from Mouser, Digi-Key, and other mail-order electronics distributors. Be sure to get a data sheet which will show the required charging circuitry.

THOMAS E. BLACK
Folsom, CA

Ω

Protek P-3502C Oscilloscope.

A cost-effective dual-channel, 20-MHz oscilloscope.

Electronics enthusiasts, whether hobbyists or professionals, love to get new test equipment. They are invariably proud of the assortment of test equipment on their benches—like mechanics and their tools. Without adequate test equipment, even the best technician can't diagnose a problem—he can only assemble a new circuit and hope that it works.

An oscilloscope is probably the most versatile piece of test equipment that a technician can have. An oscilloscope not only can duplicate all the functions of a DMM, but it can also perform many other functions not possible with a DMM, allowing the user to observie the shape of a waveform and its timing parameters.

Unfortunately, an oscilloscope is usually the most expensive of the basic test instruments, typically costing more than $500. For most electronics hobbyists, and many who earn a living in the field, that's a lot of money—perhaps even more than they can afford. Selecting the right oscilloscope can be a difficult decision, and might require compromising performance of features for a lower price.

Although some oscilloscope features are not universally required, others are essential regardless of price. For example, all oscilloscopes should be capable of displaying signals up to 20 megahertz. Dual-channel capability—which is the ability to display two signals simultaneously—is no longer a premium feature. However, other features, such as the ability to store waveforms and user-positionable cursors are luxury items usually found in only high-end equipment. They are not necessary for most hobby and service work.

The challenge in buying an oscilloscope is to find one that includes all of the necessary features for a reasonable price—less than $500 today. The model *P-3502C* oscilloscope from HC Protek (154 Veterans Drive, Northvale, NJ 07647, 201-767-7242) fits the bill. This 20-megahertz, dual-channel oscilloscope with a list price of only $440, packs enough performance to make it the last oscilloscope that most hobbyists will ever need. It includes two probes, a power cord, a fuse, and an operating manual.

Because it is a dual-channel unit, the P-3502C is a more versatile than a single-channel oscilloscope. Two channels allow two waveforms to be displayed simultaneously. This is an important feature when working with digital logic circuits where timing relationships must be observed. It's also useful when working on an amplifier, to determine, for example, how an output signal compares with an input signal.

The P-3502C can operate in Channel-A, Channel-B, Dual, and Add modes. A high-sensitivity X-Y mode permits all channel-B functions to work as horizontal amplifiers while channel-A functions remain as vertical amplifiers. A Z-axis input on the back of the unit provides for the introduction of an external intensity modulation signal.

The vertical section of the oscilloscope can be set from 5 millivolts per division to 20 volts per division, in 12 ranges. The center knob for both volts/division controls allows for variable settings.

The timebase section can be triggered externally or be made to trigger automatically. Sweep times from 0.2 microseconds per division to 0.5 second per division can be selected. A ×5 magnification can be enabled in all ranges.

To make calibration easy, a precision 0.5-volt peak-to-peak, 1-kilohertz squarewave output is available at a front-panel jack. Our test oscilloscope was properly calibrated when delivered to us; the 0.5-volt calibration waveform filled one vertical division exactly when the oscilloscope was set to display 0.5-volt per division.

A convenient component-test input is also included on the P-3502C to allow the user to use it as he would a signature analyzer. It provides a 9-volt RMS signal. The response of a components to the signal can verify its condition. For example, a resistor will display a linear, or straight-line response of voltage versus current; the lower the resistance, the steeper the response.

The P-3502C is housed in a black metal cabinet and has a 6-inch CRT. Trace rotation can be adjusted from a control on the front panel. The oscilloscope has a carrying handle attached to the left side of the cabinet and a set of rubber feet on the right side. There's also a set of feet on the back end of the cabinet that allows the scope to stand vertically.

The Protek P-3502C certainly includes the features that will make a versatile and valued instrument for most individuals, especially at its price of $440. It is a smart investment that is sure to pay off for years to come. Ω

Q & A

continued from page 11

probably built around a light-sensitive device such as a photoresistor and a Triac-type power semiconductor.

Each time the device triggers, it also generates radio frequency interference (RFI) spikes that are broadcast in the immediate area. Since these are broadband pulses, they'll be picked up on a broadband receiver—and that's exactly what an AM radio is.

To eliminate this noise, shield the controller by enclosing it in a metal box, and also try to soak the spikes up with a simple capacitive filter like the one shown in Fig. 2. Try using both of these methods on each controller. This should eliminate the radio noise, or at least get it down to the level where it's not so objectionable. If it's still too loud, you can try adding the capacitors to the radio as well.

When you experiment with any of these methods, make sure you do it safely. This means you should never work on a controller or radio when it's plugged into an outlet. Remove the fuse, open the breaker, or at least unplug the line cord before you do anything.

If none of my suggestions work, you can buy commercial RFI filters that will work more effectively. But I would invest my money in better controllers that don't emit RFI.

WIRELESS FREQUENCIES

I would like to experiment with wireless commuunications. Can you tell me what frequencies cordless phones work on?—Jimmy Daniels, Wahoo, NB.

Cordless phone handsets transmit between 49.67 and 49.97 megahertz. The base units transmit on frequencies between 46.61 and 46.97 megahertz. The base units transmit both sides of the conversation, while the handset only transmits the local side.

The base units of cordless phones more than ten years old transmit at frequencies below 2 megahertz. Some new cordless phones operate in the band between 902 and 928 megahertz. Ω

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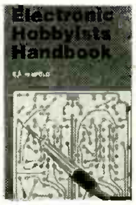

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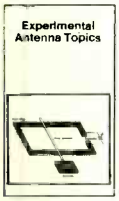

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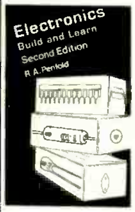

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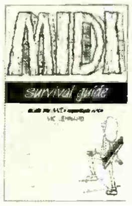

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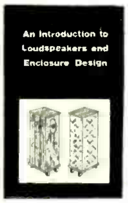

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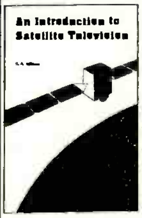

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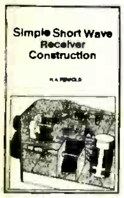
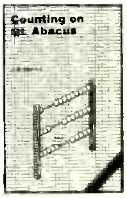


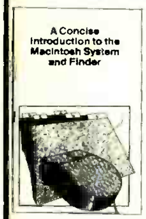
☐ **BP275—Simple Shortwave Receiver Construction...$6.95.** Contains practical designs for building a number of simple shortwave receivers. Comprehensive plans include diagrams and full coil-winding details where necessary.

☐ **BP251—Computer Hobbyists Handbook...$8.95.** Provides a single, quick reference source to bountiful data and information that the computer hobbyist will find useful. An absolutely essential addition to your bookshelf that will become a reference text.



☐ **BP162—Counting on QL Abacus...$4.95.** Shows the reader how to get the maximum use from the enormously powerful QL Abacus which is a practical spreadsheet-type of program. Useful for presenting information and data

☐ **BP58—50 Circuits Using 7400 Series ICs...$5.50.** Interesting and useful circuits and applications that cover many different aspects of electronics using this readily freely obtainable, inexpensive and fantastically versatile series of devices.



☐ **BP298—A Concise Introduction to the Macintosh System and Finder...$6.25.** If you have one of the popular Macintosh range of computers, this book is designed to help you get the most from it. Although the Mac's WIMP user interface is designed to be easy to use, much of it only becomes clear when it is explained in simple terms. All Macintosh computers are covered including the new "Classic" range.

☐ **BP101—HOW TO IDENTIFY UNMARKED ICs...$2.25.** A chart that shows the reader how, with just a multimeter, to go about recording the particular signature of an unmarked IC which should enable the IC to then be identified. By now you are probably wondering what an IC signature is. It is a specially plotted chart produced by measuring the resistances between all terminal pairs of an IC.

☐ **PCP114—Advance MIDI User's Guide...$14.95.** Although still regarded by many as nothing more than a way to get one instrument to follow the playing of another, MIDI actually has capabilities that go well beyond the simple slaving arrangement. This splendid book explains all the MIDI messages, routing MIDI in simple to advanced systems, explains how to troubleshoot when things go wrong, and much more.

Bargain Table Best Buys for Experimenters and Computer Buffs

- ☐ **BP106—Modern Opamp Projects** $5.75
- ☐ **BP137—BASIC and FORTRAN in Parallel** $3.95
- ☐ **BP138—BASIC and FORTH in Parallel** $3.95
- ☐ **BP154—An Introduction to MSX BASIC** $4.95
- ☐ **BP169—Hot to Get Your Computer Programs Running** $5.95
- ☐ **BP194—Modern Opto Devices Projects** $6.25
- ☐ **BP195—An Introduction to Satellite Televison** $6.25
- ☐ **BP198—An Introduction to Antenna Theory** $6.95
- ☐ **BP248—Test Equipment Construction** $5.95
- ☐ **BP249—More Advanced Test Equipment Construction** $6.95
- ☐ **BP260—A Concise Introduction to OS/2** $4.95
- ☐ **BP263—A Concise Introduction to dBASE** $6.95

ELECTRONIC TECHNOLOGY TODAY INC.
P.O. BOX 240, Massapequa, NY 11762-0240

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NEW PRODUCTS

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

DESKTOP CD-ROM RECORDER. The CDR4x CD-ROM desktop recorder from DataDisc records up to a 650-megabyte CD-ROM in 18 minutes. The half-height SCSI-compatible unit can be installed in IBM-compatible PC (Windows) computers for "drag and drop" CD-ROM creation. It also works with Macintosh and Unix-based computers. Files and directories can be repositioned to optimize CD performance.

CIRCLE 20 ON FREE INFORMATION CARD

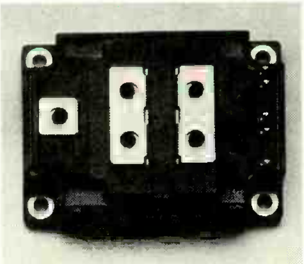
The system is bundled with DiscMaker premastering / mastering software, a SCSI plug-in card, SCSI cable, and ten blank disks. Discs in all formats can be cut including CD-ROM (standard CD-ROM recordable), CD-DA (digital audio for playing on a home stereo CD player).The DiscMaker Multimedia upgrade adds CD-I (interactive, CD-ROM XA (sound, text, images, multisession, CD-TV, and other multimedia-related formats. A recorder packaged as a stand-alone unit is also available.

The standard CDR4x DiskMaker package for PC and Mac is priced at $5995, and for Unix operating systems it is $7495. The CDR4x Multimedia DiscMaker package is priced at $6495.

DataDisc, Inc.
Route 3, Box 1108
Gainesville, VA 22065
Phone: 800-328-2347 or 703-347-2111
Fax: 703-347-9085

1200-VOLT INSULATED-GATE BIPOLAR TRANSISTORS. The MG50Q2YSXX Series of 1200-volt insulated-gate bipolar transistors (IGBTs) from Toshiba is intended for 460-volt AC general-purpose inverter applications. These include welders and uninterruptable, servo, and auxiliary power supplies.

The silicon dies of the IGBTs have non-punch-through (NPT) structures that provide more protection against short-circuits at higher voltages and increased reverse-bias, safe operating area than previous Toshiba IGBTs.



CIRCLE 21 ON FREE INFORMATION CARD

Internal fast, soft-recovery diodes reduce oscillations. This reduces ringing, spike voltage, and snubber size in host circuits. Positive temperature coefficients simplify paralleling the IGBTs. Current ratings are from 50 to 400 amperes with typical switching speeds of 0.2 microseconds.

The 50-ampere, 1200-volt MG50Q2YSXX IGBTs are priced at $55 each in quantities of 100.

Toshiba America Electronic Components, Inc.
9775 Toledo Way
Irvine, CA 92718
Phone: 800-879-4963

TV SIGNAL GENERATORS. Fluke is offering three new models of its PM5410 TV signal generators that incorporate BTSC-compliant signals for testing MTS Stereo/SAP-equipped video products. Twenty-five different signal combinations and three pre-programmed modes are provided for testing, adjusting, and troubleshooting the decoder section of products that support the BTSC standard.

Other new features added to the PM 5410s include test patterns designed for 16×9 widescreen television, Y/C video outputs for S-VHS and Hi-8 recorders, VPS/PDC for automated video recorder operations, and Teletext functions for information delivery systems.

CIRCLE 22 ON FREE INFORMATION CARD

The new test functions provide main channel (L+R), pilot, stereo (L–R) and SAP sound test signals in accordance with BTSC standards. Available in NTSC M, N, and PAL modes, those sound signals are suitable for testing frequency response, alignment, total harmonic distortion (THD), channel separation, and SAP level adjustment.

Where appropriate, the digitally generated signals are compressed in accordance with the BTSC standard to match the conditions that actually exist in broadcast systems.

The PM 5415BC provides test functions for most typical NTSC and PAL products. It supports MTS Stereo/SAP test functions, the 16×9 screen size, and U.S. Closed Caption (CC)TV. The PM 5418TDS adds further support for SECAM systems, Analog (German) stereo, NICAM digital sound, Teletext, and PDC/VPS support. The PM 5418TDSI includes IEEE-488/GPIB control for remote operation or automated testing.

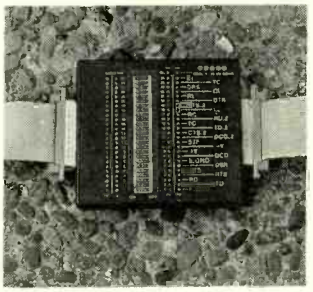
Pricing for the three signal generator is: PM 5415BC—$2985; PM5418TDS—$6085; and PM 5418TDSI—$8155.

Fluke Corporation
P. O. Box 9090
Everett, WA 98206
Phone: 800-44-FLUKE
Fax: 206-356-5116

INDUSTRIAL STRENGTH BREAKOUT BOX. The BOB 100 breakout box from Benedict Computer is intended for testing ground potential current-loop circuits. It can also be used in troubleshooting asynchronous and synchronous signals on RS-232C transmission lines such as those encountered in serial printers, terminals, and wide-area networks (WAN).

The BOB 100 isolates signal interpretation problems that can occur when two devices with different ground potentials are interfaced. LED lamps on the instrument display 80 % of the current and signal status as mark, space, clocking, or none for all 25 pins on both female and male switches. The current loop tests circuits from 4 to 80 milliamperes.

When it is testing for ground potential and current-loop circuits, power is drawn from the power lines, so no auxiliary power source is needed. Access sockets are located on both sides of the box to al-



CIRCLE 23 ON FREE INFORMATION CARD

low direct connection to other interfaces. Jumper cables can cross-patch lines and allow monitoring from external equipment. The individual switches for breaking each of the 25 interface lines are on the box faceplate.

The BOB 100 with two sets of four-plug jumper cables, a carrying case, an 11-inch cable, and a manual, is priced at $199.

Benedict Computer
220 Felton Drive
Menlo Park, CA 94025
Phone: 800-346-5186 or 415-323-0148

SUBMINIATURE LCD DIGITAL VOLTMETERS. Datel has introduced its DMS-20LCD series of digital panel voltmeters with liquid-crystal displays, said to have the smallest form factor of any 3½-digit meters in that class now available. Their fully encapsulated, 12-pin, DIP-style cases measure 1.38×0.88×0.42 inches, and they are suitable for either PCB or panel mounting.

Their 0.37-inch high LCDs are said to be readable from 10-foot distances. Backlighting is optional on models that will be installed where ambient light is low. Anti-zero and bandgap reference techniques are said to provide ±1-count accuracy without adjustment. Low-battery annunciators are standard on all models.

DMS-20LCD series

CIRCLE 24 ON FREE INFORMATION CARD

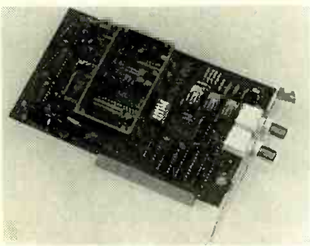
meters operate from single +5-volt supplies and dissipate 2 milliwatts. (Models powered by +9-volts are available.) Inputs are ±200 millivolts and ±2, 20, and 200 volts. Single-unit prices are $25 to $29 each; in quantities of 100 pricing drops to $22 to $26 each.

Datel, Inc.
11 Cabot Boulevard
Mansfield, MA 02048
Phone: 508-339-3000
Fax: 508-339-6356

DIRECT DIGITAL SYNTHESIZER CARD. Novatech's Model DDS4 PC is a 34-MHz signal generator on an ISA plug-in card. Intended for PC AT and later IBM-compatible personal computers, it generates simultaneous sine and TTL clock signals from 5 Hz to 34 MHz in 0.02-Hz steps.

Stability is specified as 10-ppm/year and phase noise is stated as less than −90 dBC at 1-kHz offset. Output amplitude is 1 volt RMS into an open circuit, and this signal can be attenuated in 10-dB steps to 70 dB.

The DDS4 PC is sold with a C-language program that runs under DOS. This



CIRCLE 25 ON FREE INFORMATION CARD

makes it easy to set frequency and attenuation or sweep through a set of frequency, attenuation, and dwell-time settings stored in a text file with the software supplied.

Novatech Instruments, Inc.
1530 Eastlake Avenue, No. 303
Seattle, WA 98102
Phone: 206-328-6902
Fax: 206-328-6904

PERSONAL MORSE CODE TUTOR. The MFJ-411 Personal Morse Code Tutor from MFJ Enterprises is an aid to learning the Morse code. The pocket-sized learning unit teaches letters and numbers by association and relation. Custom practice sessions allow learners to set speeds from 5 to 60 words per minute. Volume and sidetone can be set from 300 to 3300 Hz.

CIRCLE 26 ON FREE INFORMATION CARD

The MFJ-411's QSO Mode permits the student to start by practicing plain English QSOs to prepare for the FCC code examination. A word-recognition mode permits the learner to practice by copying entire words, as is done by experienced persons on the 40-meter band. Hundreds of the words widely used in amateur radio are taught so that the beginner can start recognizing entire words instead just individual letters.

The MFJ-411 Personal Morse Code Tutor is priced at $79.95.

MFJ Enterprises, Inc.
P. O. Box 494
Mississippi State, MS 39762
Phone: 601-323-5869 or 1-800-647-1800
Fax: 601-323-6551

WAVEFORM MONITOR/OSCILLOSCOPE/VECTORSCOPE. The CompuVideo 1100 series is a self-contained combination waveform monitor, 20 MHz dual-trace oscilloscope, and vectorscope. The multifunctional instrument, designed for NTSC or PAL standards, is intended for EFP/ENG operations, satellite communications, TV and cable-TV stations, and video editing.

CIRCLE 27 ON FREE INFORMATION CARD

The 1100 Series supports composite, component, and S-VHS video signals. Waveform overlays and on-screen timing references make measurements easier. Included are differential gain and phase measurement and line-select for monitoring and analyzing signals, as required by FCC regulations.

The vectorscope/waveform section offers display lines 14 through 21 in fields 1 and 2. The built-in oscilloscope section can perform signal analysis on signals from video or audio heads, stereo systems, and servos.

The *100 Series* waveform monitor/oscilloscope/vectorscope has a base price of $1429.

CompuVideo, Inc.
3861 Oceanview Avenue
Brooklyn, NY 11224
Phone: 212-213-6818
Fax: 718-714-9873

RELATIVE HUMIDITY MULTIMETER ACCESSORY. The ARH1 from Fieldpiece Instruments is an accessory that measures relative humidity when coupled to a digital multimeter.

The dielectric sensor of the ARH1 is built into the head and protected by a plastic extension tube. Circuitry in the body of the accessory head converts the signal from the sensor to millivolts DC at a conversion rate of 1 % RH per millivolt DC.

The head operates over a temperature range of 32°F to 100°F, and it measures relative humidity from 10 % to 100 %. Power is obtained from a standard 9-volt battery within the case, and the unit is equipped with both ON and low-battery LED indicators.

CIRCLE 28 ON FREE INFORMATION CARD

ARH1 pricing is: ARH1—$99; ADL2 test leads—$12.95; and an optional ANC2 nylon carrying case—$7.95.

Fieldpiece Instruments, Inc.
231 East Imperial Highway, Suite 250
Fullerton, CA 92635
Phone: 714-992-1239
Fax: 714-992-6541 Ω

VIDEO NEWS

continued from page 6

must be measured on the basis of the viewable picture only.

Most or all computers with TV tuners probably comply with the all-channel tuning act, simply because solid-state tuners available to them generally can tune all channels. However, the closed-caption law is something else again—some computer manufacturers act as if they never heard of it. Last year when Packard Bell unveiled a line of computers, which it said was designed to "substitute" for TV, RM radio, hi-fi, and phone answering machine, I asked one of its top engineers whether the built-in 14-inch monitor had a closed-caption decoder. He appeared surprised when told about the law, but dismissed the idea because "it's not a TV—it's a computer."

I followed this up by telephone with Packard Bell, explaining the problem. Packard Bell presumably considered it a trivia question, because nobody even returned my call.

The FCC, charged with administering the law, hadn't made up its mind the last time I asked. An official said his "gut feeling" was that any TV–computer in the same cabinet or box with a monitor of 13 inches or larger had to comply with the law, while those sold without monitors were exempt, as were TV tuner cards for PCs that are sold separately.

The issue came up only once, that official said, and it was solved by a technicality. That was in the case of an Apple computer with a built-in TV and a "14-inch" Trinitron monitor. When the viewable diagonal of the monitor was measured, however, it turned out to be slightly less than 13 inches, and therefore the computer was exempt from the caption law. But to be on the safe side, Apple did add caption capability to the final production monitor.

All of this leads to TV regulation No. 3. Since 1966, by order of the Federal Trade Commission, diagonal screen measurements of TV sets sold or advertised in the United States must refer to the "viewable" portion of the screen only—generally one or two inches less than the "overall" diagonal used in almost all other countries. However, the rule doesn't apply to computer monitors—home computers were unknown in 1966. So now a 13-inch picture tube would grow to 14 inches if it were used in a computer monitor.

What does the manufacturer of a combination TV/PC do for screen-size measurement? One way out would be to call it a "14-inch computer monitor with 13-inch TV," but that would be a little clumsy. In connection with a recent review of the screen-size regulations, a consumer wrote the FTC that he bought a 14-inch computer monitor, but when he got it home he found the picture measured only 13 inches diagonally. The FTC responded that it is "considering measurement problems with regard to computer monitors."

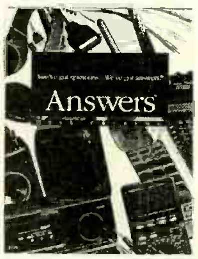
But the basic problem—when is a computer a TV and when is a TV not a TV, and what rules apply—remains unsolved. Ω

NEW LITERATURE

Use The Free Information Card for fast response.

Answers: 1995 Catalog. From Radio Shack, 700 One Tandy Center, Fort Worth, TX 76102. Available at local Radio Shack stores nationwide. $2.

Radio Shack is now offering its 220-page 1995 catalog entitled *Answers* with a theme of "You've got questions. We've got answers." The catalog contains new product information as well as definitions of many common electronics terms including the latest "buzz words" or jargon.



CIRCLE 337 ON FREE INFORMATION CARD

The catalog is written in layman's terms so that answers to common consumer questions are in clear, non-technical language. Expanded comparison/feature charts simplify the finding of the right product.

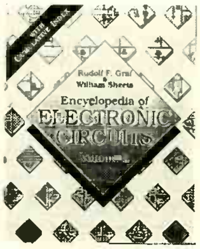
The catalog also describes three new services offered by Radio Shack: a toll-free number customers can call to order most products listed and have them sent directly to their homes or offices; Gift Express, which permits customers to send electronic gifts to friends or relatives; and The Repair Shop, which repairs name-brand, out-of-warranty consumer electronics products.

A coupon in the catalog is good for $2 off a customer's next Radio Shack purchase; it offsets the catalog's purchase price.

Encyclopedia of Electronic Circuits, Volume 5; by Rudolf F. Graf and William Sheets. Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; $34.95.

This fifth volume of "The Encyclopedia of Electronic Circuits" adds approximately 1000 new circuits to the collection of about 4000 circuits found in the four earlier volumes. The circuits, obtained from a diversified selection of electronics publications and semiconductor manufacturers' data books, cover a wide range of functions.

Alphabetically organized into more than 100 categories, the book includes an extensive index to all of the circuits presented as well as a cumulative index of those in each of the previous four volumes.



CIRCLE 338 ON FREE INFORMATION CARD

The circuits in Volume 5 include those for alarm and security systems, oscilloscopes, audio amplifiers, computers, waveform generators, frequency meters, entertainment electronics, and music systems. A brief explanation of each circuit's operation is presented along with a reference to its original source.

Solderless Breadboards and Accessories. From 3M Electronic Specialty Markets, 6801 River Place Blvd., Austin, TX 78726-9000; Phone: 800-321-9668; free.

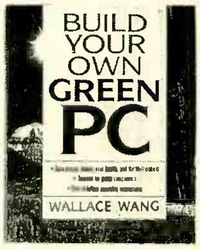
This new eight-page color brochure describes 3M's Series 300 Breadboards line of solderless, plug-in, circuit-building products for the safe and easy design and testing of PC boards.

CIRCLE 339 ON FREE INFORMATION CARD

The brochure includes product descriptions, parts information, color photographs, and technical drawings of the Series 300 and accessories including jumper wires, patch cords, probes, tie-point blocks, and breadboard strips.

Build Your Own Green PC; by Wallace Wang. Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; Fax: 717-794-2103; $19.95.

Wallace Wang's book explains how to build a personal computer system that will have minimal impact on the environment



CIRCLE 340 ON FREE INFORMATION CARD

and resources. This is a response to EPA's Energy Star Program that encourages more "green"—or low-power-consuming computers. Manufacturers are now offering "green" PCs, but they are expensive.

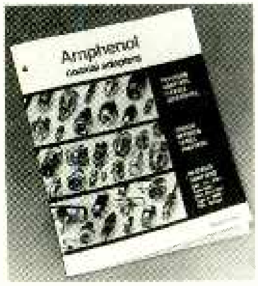
Wang's book explains the entire process of building a complete, low-cost, environmentally "aware" personal computer system that includes a printer and monitor. It begins with a list of required tools, and goes on to give step-by-step assembly instructions accompanied by helpful line drawings.

The subjects covered include motherboards, I/O ports, hard and floppy-disk drives, sound cards, CD-ROM drives, power supplies, and random-access memory. Checklists will help the reader to select the right equipment, and sources for "green" computer components are given.

Coaxial Adapters Catalog. From Amphenol Corporation, RF/Microwave Operations, One Kennedy Avenue, Danbury, CT 06810; Phone: 1-800-627-7100; Fax: 203-796-2032; free.

A new 24-page catalog

from Amphenol details 159 coaxial adapters and precision phase-matched cable assemblies for test, measurement, and instrumentation. It contains technical information on a selection of popular coaxial and twinaxial adapters.



CIRCLE 341 ON FREE INFORMATION CARD

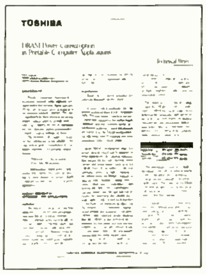
These include Precision APC-7, APC-3.5, and APC-N adapters and over 70 Between Series adapters. Also included are In-Series adapters for BNC, 75-ohm BNC, Twin-BNC, Type N, SMA, TNC, Twinax, UHF, and Mini-UHF.

The catalog also includes descriptions of Amphenol phase-matched assemblies for test and measurement equipment such as network analyzers and S-parameter and transmit/receive test sets.

Technical Brief: DRAM Power Consumption in Portable Computer Applications (Literature item number MST-1202). From Toshiba America Electronics Components, Inc., 9775 Toledo Way, Irvine, CA 92718; Phone: 800-879-4963; free.

This four-page technical paper from Toshiba America evaluates power consumption by dynamic random-access memory (DRAM) in portable and handheld computers. It was written by Toshiba engineer Kevin Kilbruck.

Kilbruck describes the market segments for these computers and provides



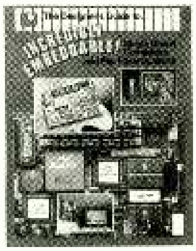
CIRCLE 342 ON FREE INFORMATION CARD

definitions. Several tables in the paper provide information on Toshiba's line of DRAMs that meet the power limitations imposed by those battery-powered computers.

The Designer's Guide to Single-Board Computers and Flat-Panel Systems. From Computer Dynamics, 107 South Main Street, Greer, SC 29650; Phone: 803-877-8700; Fax: 803-879-2030; free.

This new 36-page catalog describes many new flat-panel display and computer products from Computer Dynamics. These include flat-panel computers with large 1024 × 768 color liquid-crystal displays (LCDs) and DisplayPacs, which combine different flat-panel displays (electroluminescent (EL), monochrome LCD, and color LCD) with touchscreen controls.

Also described are single-board computers that form compact operator interface systems. Other products include the VAMP II (a combination 262,000-color LCD and touch-



CIRCLE 343 ON FREE INFORMATION CARD

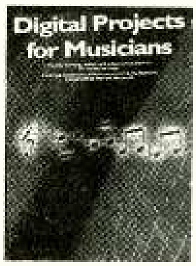
screen that plugs into any standard VGA analog output), and the FP-Kit (a PC bus flat-panel driver card with display and optional touchscreen unit).

Complete descriptions, photos, and specifications are provided for the Incredibly Embeddable line of PC-compatible, single-board computers with microprocessors that can range from the intel 8088 to the 100-MHz 486DX4. The catalog also contains information on available software development tools and various kinds of system accessories.

Digital Projects for Musicians; by Craig Anderson, Bob Moses, and Greg Bartlett. Music Sales Corporation, 257 Park Avenue South, New York, NY 10010; Phone: 212-254-2100; Fax: 212-254-2013; $24.95.

This book explains how to build a simple, inexpensive and general purpose MIDI (Musical Instrument Digital Interface) computer. The book starts out with identifying components and ends with the test and checkout of the finished unit. It also explains both MIDI and digital technology.

The computer can be configured for many different music-related func-



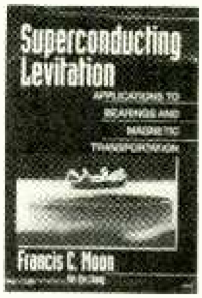
CIRCLE 344 ON FREE INFORMATION CARD

tions by plugging in different integrated circuits. It can be a MIDI data monitor, a chord generator (that creates chords from melody lines), or a keyboard mapper.

Other functions are that of a data randomizer, a multi-effects unit for MIDI data (compress, limit, gate, and delay), a "tempo tapper" (to humanize sequence tempos), and a relay driver for MIDI-controlled lighting and guitar-amplifier control. Thirteen other modifications give other effects.

Superconducting Levitation: Applications to Bearings and Transportation; by Francis C. Moon. J. Wiley & Sons, 605 Third Avenue, New York, NY 10158; Phone: 1-800-CALL-WILEY; $59.95.

This book is an introduction to the basic principles



CIRCLE 345 ON FREE INFORMATION CARD

of levitating objects by means of superconducting materials and magnetic fields. Moon explains the principles of magnetic levitation in easy-to-understand language without mathematics that does not make demands on your formal background in physics.

The author explains existing experimental MagLev projects in Germany, Japan and the U.S. They include drawings and photographs of important MagLev train prototypes.

The book summarizes research results and suggests ways that the United States could take the lead in MagLev technology Ω

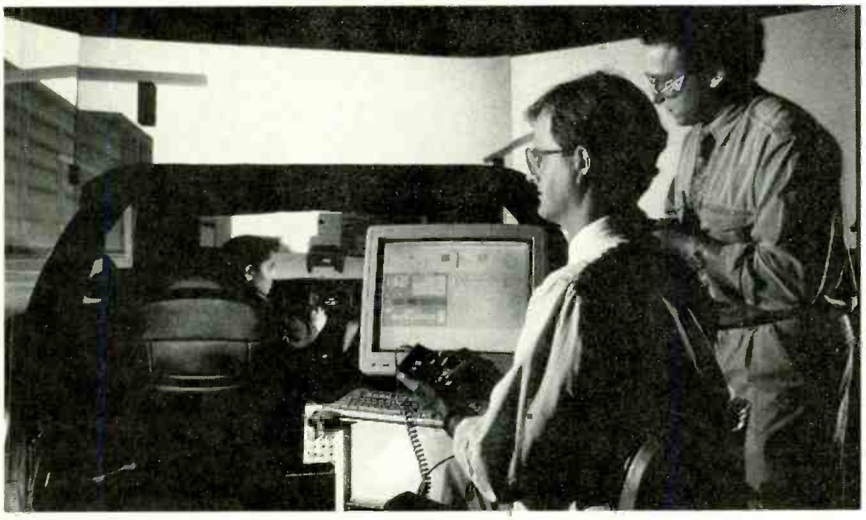
WHAT'S NEWS

continued from page 4

development of alternative power sources.

Also being investigated are built-in vehicle emission monitoring systems and automotive combustion and emission.

Safety is a vital concern at The Ford Research Laboratory. A computer-based simulator permit the researchers to study the interaction between car and driver. We are trying to avoid making automobiles more complicated than can be handled by average drivers, said Jeff Greenberg, a researcher who explained that new technologies now permit the new kinds of sophisticated controls to be made economically.



FORD's COMPUTER-CONTROLLED DRIVING SIMULATOR allows Ford researchers to test a driver's reaction to new or redesigned temperature controls, radio controls, cellular phone, and route-guidance readout.

Mr. Greenberg said that the simulator permits the study of driver responses to new controls and instruments to make sure that the driver is not overwhelmed with too much detail and information that would detract from safe operation of the vehicle.

Similar to the simulators used for training airline pilots, the Ford automobile simulator is actually the front end of an automobile wired into a network of five computers and a video projection system.

During a test session, the driver in the simulator is asked to perform many different tasks. For example, he or she might be asked to set temperature controls, tune a radio, read a message on a small screen, or converse on a cellular phone. The driver's physical reactions are recorded while a TV camera mounted over the windshield videotapes the driver's emotional and verbal responses for further study and analysis. Ω

About 25% of the research effort is spent on devising ways to improve customer satisfaction, and the rest is spent on improving product efficiency. An example of improved manufacturing is the process called precision stratiform machining, which permits prototypes of engine components to be machined in three-dimensions under computer control. The method permits complete engine prototypes to be made faster.

Engine design parameters are entered into the computer which creates a 3-D model on screen that is stratified into layers of equal thickness. This computer-generated data is then fed to a machine tool which machine out each layer from sheet aluminum. The shaped layers are then stacked and bonded together in a vacuum furnace to form a complete prototype ready for testing. "It used to take nearly a year to prototype an engine cylinder head," said Paul Killgoar, a manufacturing systems manager. "Now, it takes less than 100 days."

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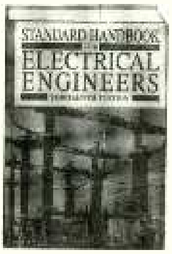

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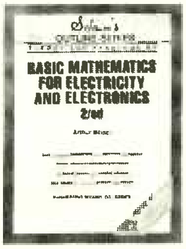

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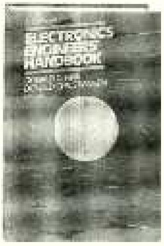

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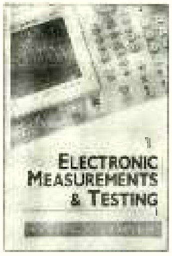

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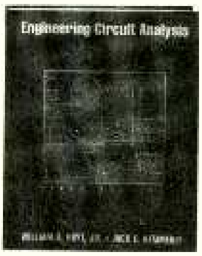

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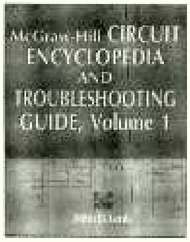

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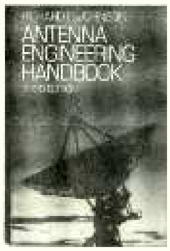

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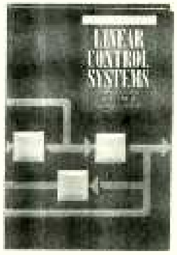

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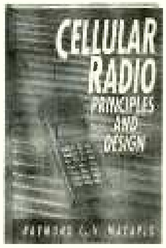

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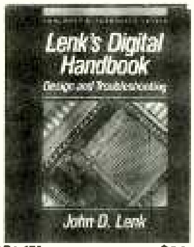

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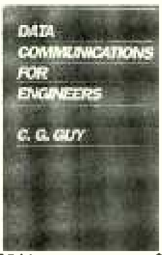

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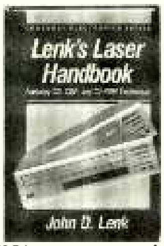

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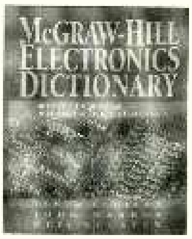

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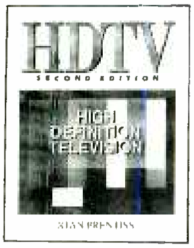

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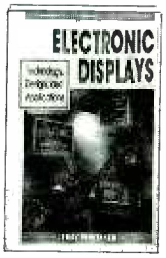

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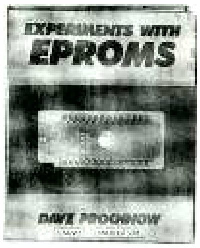

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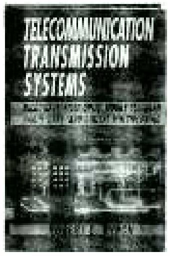

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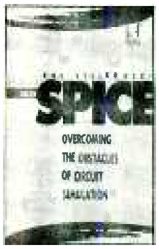

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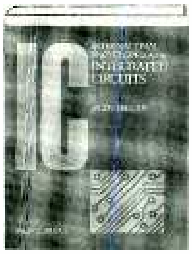

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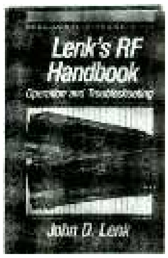

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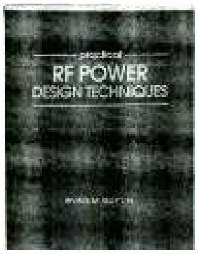

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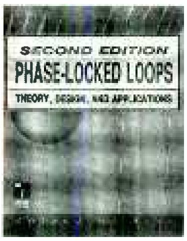

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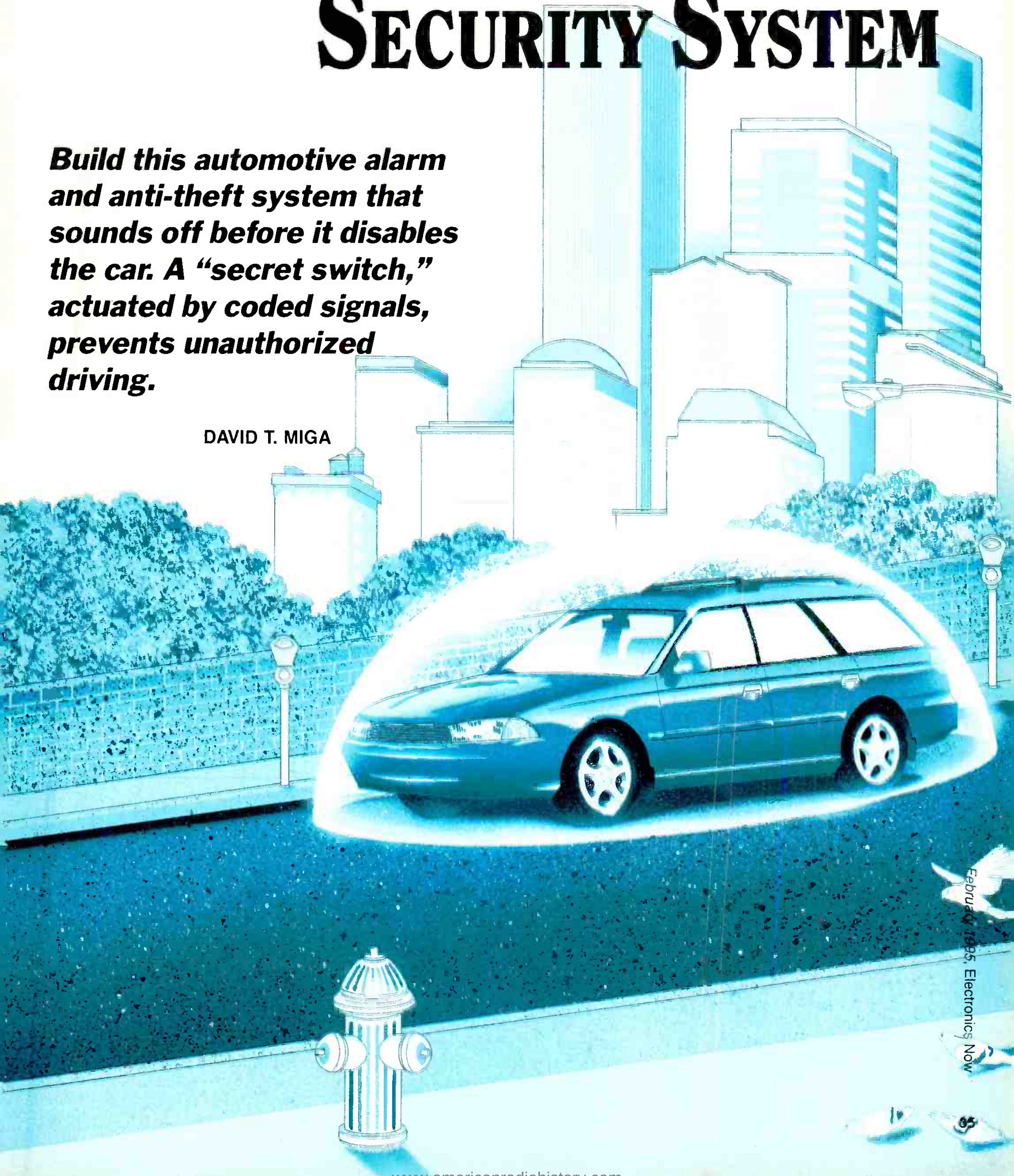
The ProCar Security System

Build this automotive alarm and anti-theft system that sounds off before it disables the car. A "secret switch," actuated by coded signals, prevents unauthorized driving.

DAVID T. MIGA



AUTOMOBILE THEFT IS A SERIOUS crime problem in most advanced countries. Existing automotive alarm and anti-theft systems have apparently helped to reduce the national theft rate but many of those systems do little more than sound audible alarms. This is the first in a series of articles on building ProCar, a unique car theft deterrent. In addition to sounding an alarm, it disables the car being stolen. It can be operated by remote control and it also offers security modes not available in commercial systems.

This article discusses the performance of ProCar and analyzes the operation of each of the circuits in the system. It then goes on to describe component insertion and soldering of the three boards in the system.

The article will cover the wiring between circuit boards in the logic module, the mounting of all off-board components in the power module, and all external wiring and cabling. It will also cover the testing the individual modules.

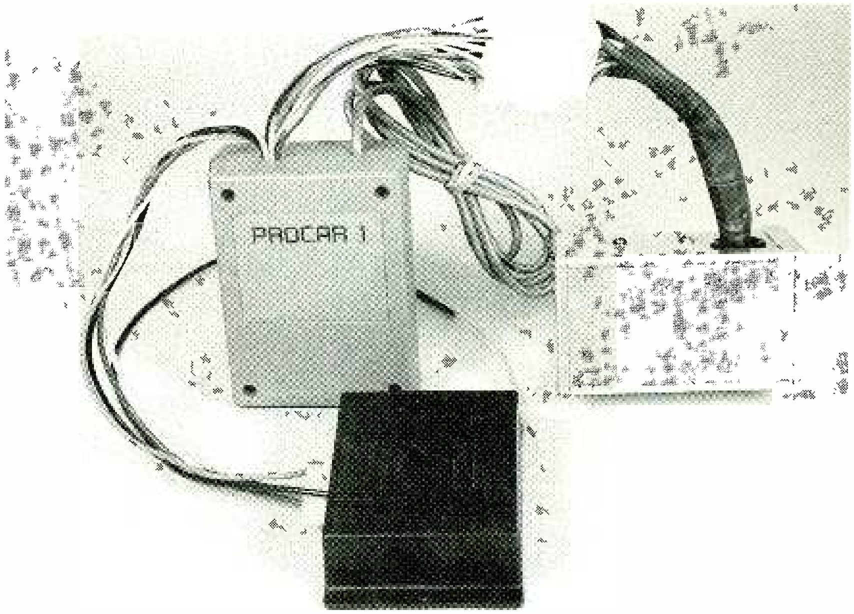


FIG. 1—MODULES OF THE PROCAR ANTI-THEFT SYSTEM. The logic module (left), is in a plastic case, the power module (right) is an an aluminum case, and the optional radio-frequency receiver (lower center) is in a plastic case. The power module is the only one mounted in the engine compartment.

Why more anti-theft features?

So many automobiles are stolen each year in the United States that reports of these thefts are usually greeted by the local police with yawns or groans. Most occur at night while the car is unattended, and involve breaking and entering to defeat the car's ignition lock. However, some cars are towed away by organized gangs operating in those parts of cities where the cars are parked where they cannot be seen from their owners' homes, often high-rise apartments. Even cars equipped with alarms are easily stolen in many locations because the thieves know that the alarms are universally ignored. Car theft exacts a stiff price on the car owner—whether the car is insured or not. In addition to the urgency of finding a replacement (if only temporary), there is the expense, frustration and lost time in notifying the police and insurance company—not to mention lost time on the job or in school, and feelings of personal violation.

Recently car theft has escalated into a far more serious crime—carjacking—a crime of violence that often results in injury to the car owner being ejected violently from the vehicle, often with the threat of shooting or stabbing. These crimes can occur at any time of day or night in any location—often outside the car owner's home. The seriousness of the crime escalates when it occurs at night or on an open highway.

Even if the car is recovered after being abandoned (or less likely—recovered by the police), it will probably be damaged as a result of neglect, deliberately destructive driving, or the forcible or inept removal of parts and accessories.

The good news is that nationally car thefts have declined nationally due in part to the effectiveness of alarm and anti-theft systems, registration numbers on automobiles, and generally improved police response. Nevertheless, even the best of original equipment and aftermarket alarm systems will not defeat bold resourceful thieves or carjackers. Most car alarm systems have shortcomings, and those weaknesses can be exploited by a skilled auto thief.

The ProCar solution

The ProCar vehicle anti-theft system has overcome the shortcomings of typical OEM and aftermarket anti-theft systems and alarm systems. Figure 1 shows its principal electronic modules and an optional radio frequency receiver. It can be built by experienced electronics hobbyists for less than $200 in components and accessories. Unlike other anti-theft systems, ProCar is based on conventional digital logic ICs. It includes no microprocessors or microcontrollers and it does not require programming.

The vehicle owner selects an existing switch within the car to be wired as a "secret switch" which accept codes that change system response. The "secret" codes are keyed in by depressing the switch and releasing it, or holding for a predetermined length of time. ProCar interprets the codes to distinguish between "authorized" commands and random switch closures made by an unauthorized person attempting to steal the car.

If an unauthorized person attempts to escape with the car, (or a carjacker forcibly ejects the authorized driver), ProCar will detect the absence of the correct codes after the car is started or driven away, and give a voice warning that the vehicle will be disabled. After 30 seconds, ProCar will disable the engine *safely* by cutting off both fuel and ignition, foiling the theft. Without knowledge of the codes, the thief will be unable to restart the car. An internal alarm will then sound at 110 dB to drive the thief from the car.

Should the thief persist, the time delay in disabling the engine will limit flight to about a quarter mile. When and if the condition of the car permits the safe return of the owner/driver, he or she can key in the correct codes and drive the vehicle away without damaging it.

This, of course, assumes that the owner knows that the thief has fled and is not lingering to take revenge for defeating the car theft. It also assumes that the car is in a condition permitting it to be driven away safely (no collision or gratituitous vandalism).

ProCar can be set so that it will:

- Automatically arm and disarm itself, and automatically lock the car doors if the owner forgets.
- Permit limited driving by an authorized person (e.g., car park attendant or service mechanic) without disabling the vehicle or setting off its alarm. Anti-theft protection will remain in force after the car has been parked.
- Permit the car to be serviced or test driven and warn the authorized driver that it is disarmed each time the car is started.
- Go into a *high security* mode that allows one person to drive the vehicle. This contrasts with the default *standard security* mode which allows authorized family members or friends who have the ignition key to drive the vehicle.

Because the system is controlled by an existing switch, the car has no hidden or conspicuously new switches inside or outside installed specifically for ProCar. Even if the "secret

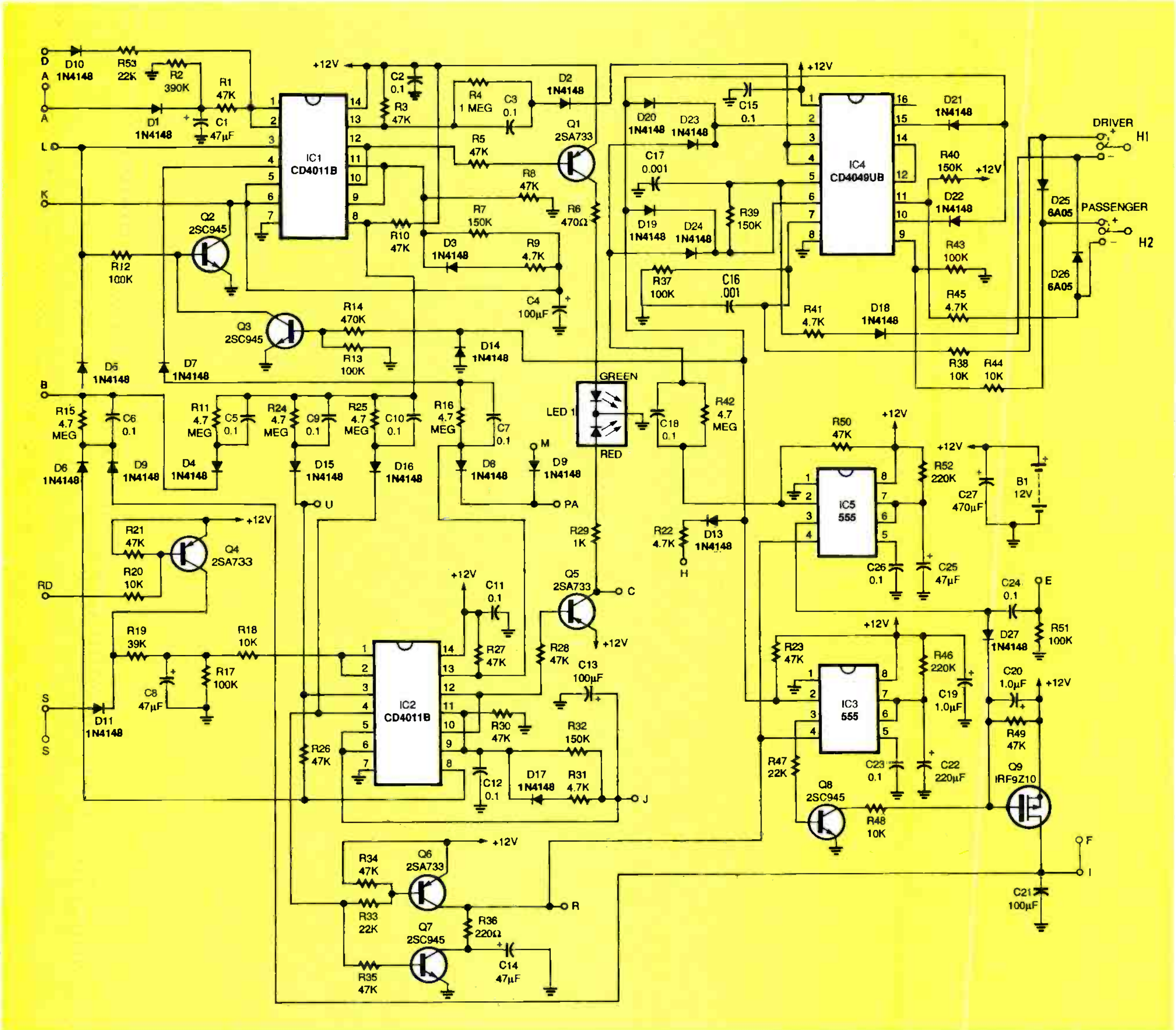


FIG. 2—SCHEMATIC FOR THE MAIN ALARM BOARD. All interconnection wiring originates at this board.

switch" is identified, the unauthorized user must know the codes.

Procar can also be operated by a remote control that has *arm*, *disarm*, and *panic* modes, as well as a feature called *insta-stop*, which signals the ProCar system that the owner is outside the car and that the person driving (or trying to drive) the car away is unauthorized.

ProCar gives a voice warning to the unauthorized driver before the engine is disabled and the inside alarm sounds.

In common with other anti-theft systems, ProCar also has an outside siren, headlight flasher, and starter disabler. It was designed for easy installation in any vehicle with a 12-volt power system. The system can be customized to satisfy the owner's personal preference. It can also be adapted to vehicles with digital-code key panels on their doors or key-ring door-lock transmitters.

General description

The two principal modules in the ProCar system are the Logic Module and the Power module. A third optional module is a factory-made RF receiver that is matched to a factory-made remote-control RF transmitter, a handheld, battery-portable unit. Both products can be purchased from the source listed in the Parts List. The system also includes provision for external and internal sirens, a motion sensor, and automatic door-locking/unlocking relays.

The completed Logic Module is housed in a small plastic case suitable for mounting in a concealed position under the dashboard. It contains the Main Alarm circuit board and the Voice/Options circuit board. The optional factory-made, FCC-approved receiver module is also mounted under the dashboard.

The Power Module, intended for installation in the engine compartment, contains the Power Module circuit board, power transistors, and integrated circuits for flashing lights, disabling the engine, and amplifying the siren. Only one three-wire cable must pass through the engine compartment firewall to connect the Logic Module to the Power Module.

Logic Module

The Logic Module contains two circuit boards: the Main Alarm Board and the Voice/Options board. Both boards are double-sided with plated-through holes; one measures $4 \times 2\frac{7}{8}$-inches and the other measures $3\frac{5}{8} \times 2\frac{7}{8}$ inches.

Figure 2 is the schematic for the Main Alarm board. A CD4011B CMOS NAND gate for latching and timing (IC1) permits the ProCar to arm itself automatically when it receives input signals from the door switches. The switch on the driver side door that normally turns on the dome light sends a pulse to ProCar when the door is closed.

The ProCar circuit can also accept negative- or positive-going pulses, as will be described later. The pulse goes through diode D2, filter pulse shaper resistor R4, and capacitor C3 to pin 13 of IC1 (an input to one of four NAND gates).

This latches that gate and a second whose inputs are pins 8 and 9 so that their output pins 10 and 11 go low and light the green section of tricolor indicator LED1. Pins 9 and 11 go high to start charging 100 μF electrolytic capacitor C4 through R7. This charging time causes a 15-second delay, giving the driver time to reenter his car to load or unload packages through another door or trunk.

The 15-second delay is reset to zero through NPN transistors Q2 and Q3 while any door remains open or motion is picked up by an electronic motion/shock sensor mounted in the engine compartment. After the driver leaves and the circuit senses no further intrusion, the 15-second timer is restarted from zero and completes its cycle. The voltage across C4 rises high enough to change the state of the third *nand* gate of IC1 (pins 4, 5, and 6) from high to low.

The low-logic pulse is passed through diode D7, capacitor C7, and resistor R16 to pin 13 of IC2, a second CD4011B. This additional 15-second timer flashes the red die of LED1 and triggers the voice module to warn that the system will be active in 10 seconds. When both the red and green LED dies are lighted, the indicator appears to glow yellow.

After the second latch/timer circuit (including capacitor C13) times out, the active low output at pin 4 of IC2 sends a pulse through diode D16, capacitor C10 and resistor R25 to turn off the green die so LED1 glows red. Simultaneously, pin 4 drives the ARM (R) line high through PNP transistor Q6. This path commands the module to turn off the engine and commands the door-lock circuit to lock all doors.

The ARM path also activates IC3, a 7555, an industry standard timer serving as a main alarm latch and IC5, a second 7555 timer that is an alarm latch timer which monitors all entry points and the motion sensor. (Low-power 7555 timers make battery drain negligible.) The timer is triggered by IC4, a CD4049UB CMOS hex buffer/inverter, when any door, trunk, hood or motion sensor is activated. The RC circuit formed by 220μF C22 and 220K resistor R46 has a 1 minute time constant.

Timer IC3 activates the inside siren through NPN transistor Q8 and P-channel MOSFET Q9, and it commands the Power Module through one of three wires in the cable passing through the firewall to activate the outside siren and light flasher for one minute.

When the driver-side door is opened, both timers IC3 and IC5 are triggered. The second timer, IC5, is set for 15 seconds, to allow the voice module to warn the driver that the sirens and lights will be activated unless corrective action is taken. Timer IC5 also inhibits MOSFET Q9 from activating the sirens and lights through diode D27 by the state of pin 3.

If ProCar is set for the default standard security mode, any-

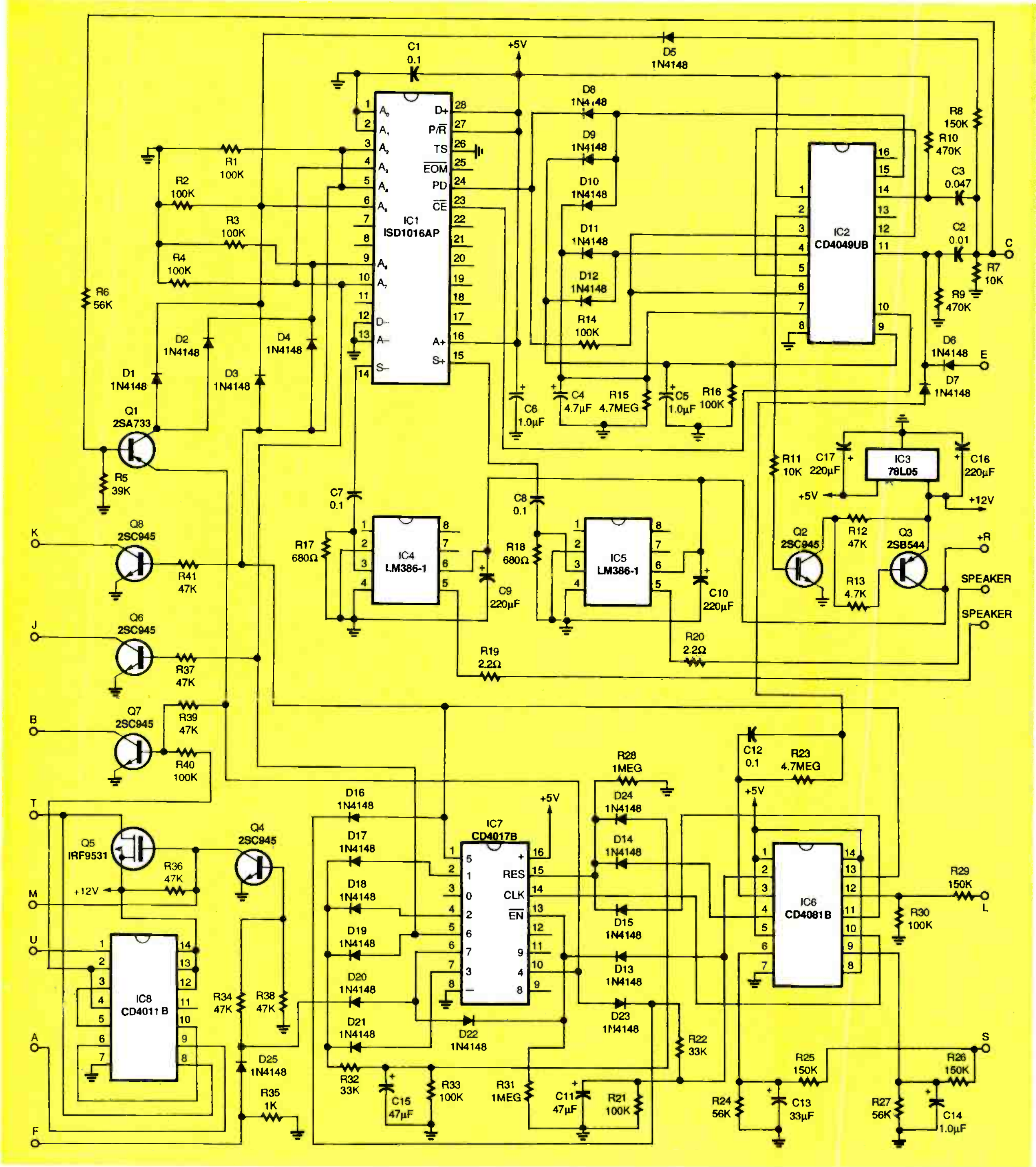


FIG. 3—SCHEMATIC FOR THE VOICE/OPTIONS BOARD. It contains the voice record/playback IC.

one with an ignition key for the car can reset ProCar as long as the ignition key is turned within the 15-second time period provided by timer IC5. Accessory power derived from the wire to the car's stereo system is applied to an input (A) through RC timing circuit R1-C1.

The application of this time constant, set for 10 seconds, will be explained as part of the description of the anti-carjacking circuit. Also, a logic high pulse to the Disarm input can be derived from a car's digital entry keypad circuit to disarm ProCar. This logic high pulse is inverted to a low logic pulse by the fourth NAND gate of IC1 at pins 1, 2, and 3 and the circuit consisting of diode D5, capacitor C6 in parallel with resistor R15 and diode D6. It resets the two NAND gates of IC2 identified by pins 8, 9, and 10 as well as the one with pins 11, 12, and 13.

As voltage is discharged from 100µF capacitor C13, it is inverted by IC2 to ground the arm line (R) which commands the power module to cut off the en-

PARTS LIST

Main Alarm Board
All resistors are ¼-watt, 10%.
R1, R3, R5, R8, R10, R21, R23, R26, R27, R28, R30, R34, R35, R49, R50—47,000 ohms
R2—390,000 ohms
R4—1,000,000 ohms
R6—470 0hms
R7, R32, R39, R40—150,000 ohms
R9, R22, R31, R41, R45—4,700 ohms
R11, R15, R16, R24, R25, R42—4,700,000 ohms
R12, R13, R17, R37, R43, R51—100,000 ohms
R14—470,000 ohms
R18, R20, R38, R44, R48—10,000 ohms
R19—39,000 ohms
R29—1000 ohms
R36—220 ohms
R33, R47, R53—22,000 ohms
R46, R52—220,000
Capacitors
C1, C8, C14, C25—47µF, 16 volts
C2, C3, C5, C6, C7, C9, C10, C11, C12, C15, C18, C23, C24, C26—0.1µF, 50 volts, monolithic ceramic
C16, C17—0.001µF, 50 volts, monolithic ceramic
C19, C20—1.0µF, 50 volts, tantalum electrolytic
C4, C13, C21—100µF, 16 volts, aluminum electrolytic
C22—220µF, 16 volt aluminum electrolytic
C27—470µF, 25 volt, aluminum electrolytic
Semiconductors
D1 to D24, and D27—1N4148, silicon
D25, D26—6A05, 6 ampere, 50 volt, Diodes Inc. or equiv.
IC1, IC2—CD4011B, CMOS NAND gate, Harris or equiv.
IC3, IC5—7555 low-power CMOS timer
IC4—CD4049UB, CMOS hex buffer converter, Harris or equiv.
Q1, Q4, Q5, Q6—2SA733 NPN silicon transistor, NEC or equiv.
Q2, Q3, Q7, Q8—2SC945 PNP silicon transistor, NEC or equiv.
Q9—IRF9Z10, P-channel, depletion mode MOSFET, International Rectifier or equiv.
Other components
H1, H2—3-pin headers with 2-pin shunts, Samtec or equiv.

Voice/Options circuit
All resistors are ¼-watt, 10%.
R1, R2, R3, R4, R14, R16, R21, R30, R33, R40—100,000 ohms
R5—-39,000 ohms
R6, R24, R27—56,000 ohms
R7, R11—10,000 ohms
R8, R25, R26, R29—150,000 ohms
R9, R10—470,000
R12, R34, R36, R37, R38, R39, R41—47,000 ohms
R13—4,700
R15, R23—4,700,000 ohms
R17, R18—680 ohms
R19, R20—2.2 ohms
R22, R32—33,000 ohms
R28, R31—1,000,000 ohms
R35—1000 ohms
Capacitors
C1, C7, C8, C12—0.1µF, 50 volt, monolithic ceramic
C2—0.01µF, 50 volt, polyester
C3—0.047µF, 50 volt, polyester
C4—4.7µF, 50 volt, aluminum electrolytic
C5, C6, C14—1.0µF, 50 volt, tantalum electrolytic
C9, C10, C16, C17—220µF, 16 volt aluminum electrolytic
C11, C15—47µF, 16 volt, aluminum electrolytic
C13—33µF, 16 volt, aluminum electrolytic
Semiconductors
D1 to D25—-1N4148 diode
IC1—ISD1016AP 16-second voice record/playback device, Integrated Semiconductor Devices (ISD) or equiv.
IC2—CD4049UB CMOS hex buffer converter, Harris or equiv.
IC3—78L05 voltage regulator, 5 volt, Motorola or equiv.
IC4, IC5—LM386-1 amplifier National Semiconductor or equiv.
IC6—CD4081B CMOS ANDgates, Harris or equiv.
IC7—CD4017B CMOS counter/dividers, Harris or equiv.
IC8—CD4011B CMOS NANDgates, Harris or equiv.
Q1—2SA733 PNP transistor, NEC or equiv.
Q2, Q4, Q6, Q7, Q8—2SC945 NPN transistor NEC or equiv.
Q3—2SB544 PNP transistor, Sanyo or equiv.
Q5—IRF9531 N-channel depletion MOSFET, International Rectifier or equiv.

gine and lock all doors through NPN transistor Q7 and 220-ohm resistor R36. As the red LED die of LED1 turns off, the change is sent to the Voice/Options board to trigger the audio announcement that the system is reset.

Buffer IC4 functions as the filter and level shifter for all trigger inputs. The noise filters formed by 0.001µF capacitors C16 and C17 and resistors R38 and R41 will filter out extraneous signals that can result from rain water retained by door switch contacts, contamination, or nearby radio transmitters.

The inverters of IC4 allow only true ground or positive signals to trigger the system. The inverters permit ProCar to be installed in vehicles with either positive or grounded domelight switching. Header pin jumpers mounted on the main alarm board (H1 and H2) permit the selection of either positive or grounded switching.

The ProCar circuit must distinguish between the driver-side and passenger-side doors, so 6A05 diodes D25 and D26 are installed so that any door opening will illuminate the domelights, but only the driver-side door will trigger IC1. This gives the ProCar circuit the signals needed if a carjacking should occur.

The authorized driver can send the appropriate coded signal to the ProCar circuit by actuating the selected "secret switch." The input labeled "S" (for SECRET SWITCH) is a multilevel communications port that permits the driver to alert the ProCar system to recognize different situations.

Any momentary switch within the car can serve as the "secret switch," provided that it switches +12 volts. Examples include, a power window UP button, a power seat adjust, a windshield washer switch, or the high-beam flashing switch. This setup permits the authorized driver to alert ProCar with familiar switches.

If the coded signal given to ProCar is ambiguous or if the high-security mode is active and any driver attempts to start the car, ProCar system will warn the driver that the system is activated, and will wait for a corrective response.

The only persons who should know the proper coded response will be the owner/driver or persons who are authorized to drive the car who have been given the code and instructed in ProCar's operation.

A response might be holding the high-beam flash lever for 3 seconds as required by the delay circuit consisting of 39 kilohm resistor R19 and 47μF capacitor C8 (at the emitter of Q4). Consequently, the random pushing of control buttons within the car by a stranger or uncontrollable child will be ignored by ProCar. The NAND gate at pins 1, 2, and 3 of IC2 inverts the signal to the low level required by the latching NAND gates at pins 8, 9, and 10 and 11, 12, and 13.

ORDERING INFORMATION

The following three complete circuit boards are offered:

- Main alarm board, double-sided—$14.00
- Voice/options board, double-sided—$14.00
- Power module board, single-sided—$8.00

The following kits of components with PC boards are offered:

- Main alarm circuit, less case—$69.00
- Voice/options circuit, less case—$79.00
- Logic Module: includes alarm and voice/options boards, all components, case, LED1, wiring harness, connectors, speaker relay RY1—$199.00
- Power module: power module board, all components, case, wiring harness, connectors and hardware—$89.00

Other system components available are:

- Programmed ISD1016 Voice record/playback device—$18.00
- Radio-frequency receiver and two remote control (two-key) transmitters (modified and assembled)—$59.00

Send check or money order to Electronic Design Specialists, Inc., 4647 Appalachian Street, Boca Raton, FL 33428, (407) 487-6103

Florida resident please include local sales tax.

TABLE 1
PROGRAMMED ANNOUNCEMENTS FOR VOICE PLAYBACK

Address (logic high)	Time (seconds)	Response
N/A	3.1	System reset. Procar standing by
A5	6.2	Procar has been activated. This vehicle will be disabled in ten seconds.
A5, A6	1.9	High security enabled.
A2, A4, A5, A6	1.9	Valet parking enabled.
A3, A7	2.0	Procar fully disabled.

Note: Up to 16 seconds permitted with the ISD1016AP

Voice/options board

Figure 3 is the schematic for the Voice/Options (VO) board. It accepts signals from the Main Alarm Board board for any of five different programmed messages and any options the driver might want the system to perform. The options are selected with the secret switch based on the number of times the driver activates the switch. Special anti-carjacking circuits are on the VO board.

A CD4049UB CMOS hex inverter, IC2, generates a positive pulse whenever the red "system armed" die in LED1 changes status. The circuit from capacitor C2 through two inverters in IC2 to pin 4 generates a positive pulse at diode D11 when LED1 turns on. The circuit from capacitor C3 at pin 14 through an inverter to pin 15 creates a positive pulse at diode D10 when the LED1 turns off.

The pulses are linked by diodes D10 and D11 to 4.7μF C4 in parallel with 4.7 megohm resistor R15, where another inverter supplies +5 volts to the PD pin 24 of the voice device IC1. This powers the chip from its "sleep state" for 10 seconds.

Similiar circuitry from diodes D12 and D9 power another inverter through resistor R16 in parallel with 1.0μF capacitor C5 to provide a negative pulse to the $\overline{CE}$ pin 23 of the voice record/playback device, IC1, an ISD1016AP, to initiate speech.

Another inverter in IC2 powers NPN transistor Q2 and PNP transistor Q3 to activate the speaker relay. This relay switches the car's left front stereo speaker to the ProCar circuit for 10 seconds. Transistor Q3 also powers the amplifier circuits, IC4 and IC5. Because power is removed from the audio chips when the voice record/playback device is in its sleep mode, standby power is very low.

The voice record/playback device is coupled to IC4 and IC5 and the LM386-1 amplifier ICs form an out-of-phase bridge circuit whose output is about 2 watts maximum into a 4-ohm output impedance. If the output is too loud for comfort, the values of resistor R17 across pin 2 of IC4 and R18 across pin 4 of IC5, can be reduced from 680 ohms to 470 ohms.

A CMOS decimal counter/driver, IC7, decodes the number of pulses from the secret switch to put ProCar into its various optional modes. The output for 1, 2, or 3 pulses is routed through diodes D17, D18, and D21 to a 2.5-second RC timer circuit consisting of 47μF C15 in parallel with 100 kilohm resistor R32, to reset IC7 automatically through diode D24.

This is the part of the circuit that makes the use of an assigned "secret switch" possible. The circuit ignores any random input such as might be introduced if a child were playing with the "secret switch."

ProCar will acknowledge only four, five, six, or seven pulses. Four pulses activate Q7 which puts the system in its *high security* mode. Five pulses activate Q8 and put the system in its *valet* mode which permits a car park attendant to park the car. Six pulses disarm ProCar temporarily, and seven or more activate Q4 to put the system in its *panic* mode by activating the outside (but not inside) siren and flashing the lights.

Because the *panic* output will inhibit the ENABLE pin 13 of IC7, any input signals after the first seven pulses will be ignored. Moreover, the other four options drive the RC timer circuit of 100 kilohm resistor R21 in parallel with 47µF capacitor C11 through isolation diodes so that a selection must be made within 3 seconds. After the circuit times out, all other selections are locked out.

This lockout timer also generates a voice chip start pulse by supplying a logic high to pin 2 of IC6. When this AND gate receives a simultaneous high on pins 1 and 2, a logic high will be passed through the parallel RC circuit consisting of 0.1µF capacitor C12 in parallel with 4.7-megohm resistor R23 and diode D7 to the inverter circuit in IC2 identified by pins 11 and 12.

The heart of the voice/options circuit is the ISD 1016AP voice record/playback IC that can be programmed for 16 seconds of voice announcements. A programmed ISD 1016AP is available from the supplier listed in the Parts List. However, the reader can program in alternative voice messages or substitute his or her own voice by programming the integrated circuit.

Instructions for building a circuit that will program the device and a description of how the device works are given in the March 1992 issue of *Radio Electronics* (now *Electronics Now*). Table 1 gives the programming, timing, and wording programmed into the author's voice record/ playback device.

To reset any mode to the default standard security mode, depress the secret switch 3 seconds to reset IC7 through the RC timing circuit of 150-kilohm resistor R25 in series with 33µF capacitor C13 timer through pins 4, 5, and 6 of IC6, a CD4081B CMOS quad, two-input AND gate.

High security mode

If you feel insecure when driving in a known high-crime area, key the secret switch four times to put the system in the *high security mode*. Pin 10 of IC7, a CMOS counter/divider goes high, and this logic state is passed through diodes D1 and D3 to program the voice synthesis circuit, IC1, so that pins 6 and 9 (A_5 and A_6) are high.

The voice record/playback device, IC1, has been programmed to say "High security enabled" at this address. The logic high from pin 10 ("4") of IC7 also puts NPN transistor Q7 in saturation. This grounds its collector through wire "B" to the *alarm*. Because the junction of C6, D5, and R15 on the main alarm board is grounded, all attempts to disarm ProCar by turning on the ignition switch will be ignored because no pulse will be passed by D5.

Upon entering the car, the owner must turn on the ignition and hold the secret switch for 3 seconds. This will disarm ProCar as described in the operation of the *alarm* board, and will simultaneously reset the options selector IC7 to standard security. Consequently, owner/ drivers must select *high security* each time *before they leave the vehicle* if they want the added protection.

Valet mode

When ProCar receives the *five* pulses for the *Valet mode*, pin 1 ("5") of IC7 goes to a logic high. Similiar to the other options, the proper address, pins 5 (A_4), 6 (A_5) and 9 (A_6) of speech synthesizer IC1 goes logic high, and the speaker says "Valet parking enabled."

Transistor Q8 pulls wire "K" low to the Alarm board to 100µF capacitor C4 in Fig. 1. Because C4 will never charge, the first 15-second timer (green die of LED1) will not complete a charge cycle. The driver leaves the car with the engine running, and when the door is closed the green LED will be lighted, but ProCar will not auto-arm.

After the car park attendant parks the car, turns off the ignition, and leaves, the timer RC circuit consisting of 390-kilohm resistor R2 and and 47µF capacitor C1 at the Accessory ("A") input of the Main Alarm board (Fig. 1) times out after 10 seconds. The gate output at pin 3 of IC1 then goes logic high to wire "L."

Back on the Voice/options board, Fig. 2) the logic high at "L" is compared with the logic high at pin 1 ("5") of IC7 (the *Valet* output) and the resulting logic high on pin 11 of IC6 resets IC7 through diode D15. Therefore, ProCar will automatically default to the standard security mode, and the car park attendant will be allowed to enter and disarm ProCar with the ignition key.

Disarm/service mode

Six pulses on the secret switch for *disarm* will cause pin 5 ("6") of IC7 to go to logic high to program IC1 to say "ProCar Fully Disarmed." Transistor Q6 will saturate, grounding wire "J." This prevents 100µF capacitor C13 on the main alarm board from charging. Similiar to the *high security* function that inhibits the first 15-second timer, the *disarm* feature inhibits the second 15-second timer.

Consequently, both the red and green dies of LED1 will be on. The yellow color will remind everyone that ProCar is temporarily disarmed. After entering the car, the driver turns on the ignition key to reset the latches in both IC1 and IC2 on the main alarm board, Fig. 1. Because the red die turnoff will generate a logic low on wire "C" to the voice/options board, Fig. 2, the speech synthesizer will again remind the driver that ProCar is disarmed.

Panic mode

Seven pulses on pin 6 ("7") of IC7 cause an output logic high. The voice synthesizer IC1 has not been programmed to say anything in this mode. Transistor Q4 (near IC8) will be biased to turn on adjacent MOSFET Q5 and it will activate the outside siren and lights flasher through the TRIGGER (T) wire to the Power Module shown in schematic Fig. 3. The panic mode will remain in force indefinitely until the secret switch signal is received from the driver.

Continued on page 94

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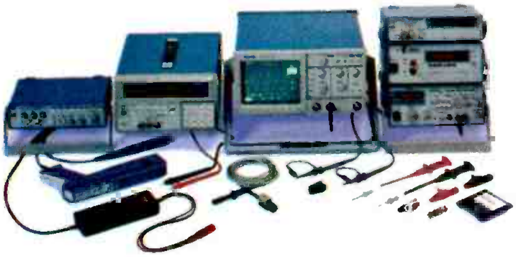

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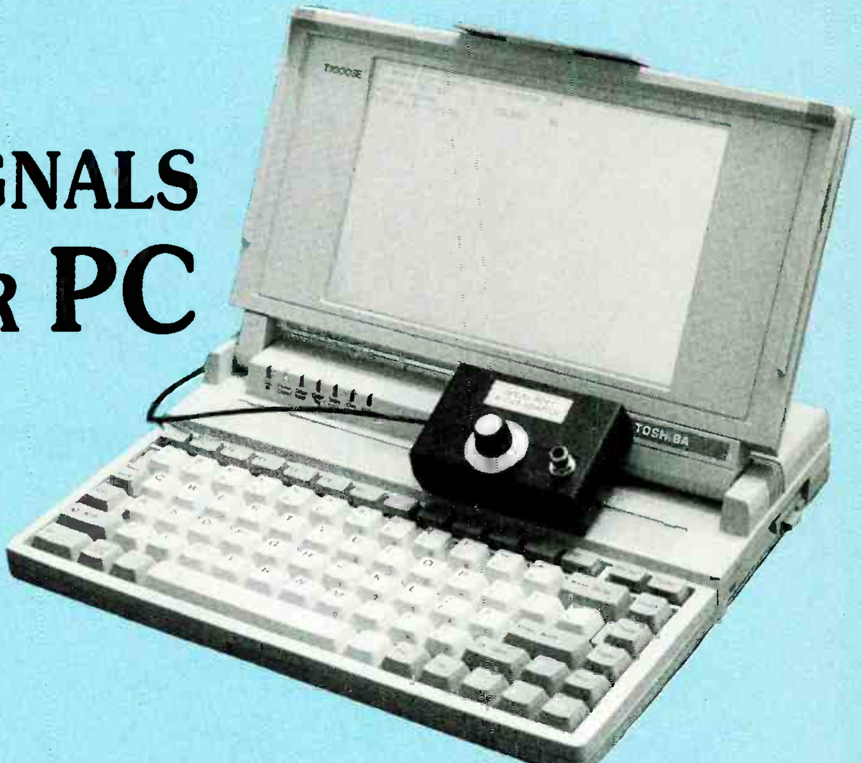


Build this computer-controlled audio generator— for under ten bucks.

MICHAEL A. COVINGTON

DO YOU NEED A PRECISION SQUAREwave generator for audio testing? If so, look no further than your computer's serial port, a handful of passive components, and a very simple 30-line BASIC program.

That combination can deliver signals with frequencies as high as 4800 hertz, and with crystal-controlled accuracy of 0.1% or better. The software was developed on an IBM-compatible PC, but it should run on just about any computer.

How it works

The trick is U, the ASCII character "U," that is. The hexadecimal value of "U" is 55, which in binary is 01010101 (with eight data bits and no parity, or seven data bits and even parity).

The RS-232 protocol specifies that the bits of an ASCII character are transmitted from least to most significant, preceded by a start bit (always 0) and followed by a stop bit (always 1). So, after adding the requisite start and stop bits, the result is 1010101010.

Now suppose a string of U's is generated at the serial port at some steady rate. The result is a continuous series of alternating ones and zeroes—a squarewave.

The frequency of the signal will be half the baud rate, which by definition is the number of transitions per second. Each cycle of a squarewave comprises two transitions so, for example, a 9600-bps baud rate produces a 4800-hertz squarewave.

In practical terms, just about any computer should be able to deliver frequencies of 55, 150, 300, 600, 1200, 2400, and 4800 hertz, corresponding to the standard baud rates from 110 to 9600. In addition, the signal can appear at many other discrete frequencies, limited only by the CPU speed of the computer. But there is a catch to this scheme.

Frequency limits

The catch is that a PC cannot generate just *any* frequency. Why not? Because the UART in the RS-232 port generates its output by dividing the frequency of a 1.8432-megahertz crystal oscillator. The UART can divide only by whole numbers. So, for example, a frequency of exactly 1000 hertz can't be generated; the nearest you can get is 993.1035 hertz.

If you want to tune a guitar, you can't quite produce a standard concert-pitch "A" (440 hertz), but you can get a very clsoe 439.6947 hertz, which is off by only 1/80 of a semitone. The software will display the nearest standard value to any requested frequency.

Another limitation is that some computers might not be able to deliver high frequencies,

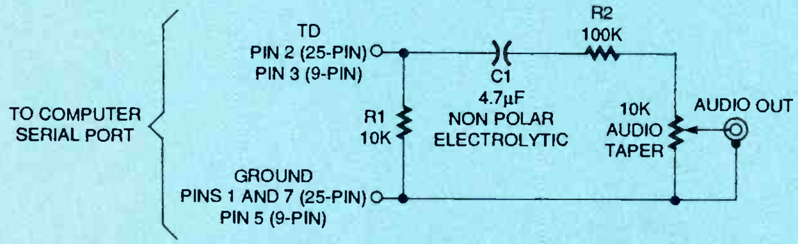


FIG. 1—COMPLETE CIRCUIT of the precision audio generator requires just a handful of passive components.

because they can't output U's fast enough. In that case, squarewave bursts, with silence in between, is generated. If you could hear that, it might sound like buzzing, flapping, or clicking superimposed on the high-pitched tone. The best way to detect this kind of problem is with an oscilloscope or frequency counter.

Even if the computer is fast, there can be breaks in the squarewave. That can happen if the computer is doing task-switching (e.g., under Windows), or if it is heavily loaded with terminate and stay resident programs (TSRs). But under DOS, the author had good results up to 4800 hertz with an old Toshiba laptop.

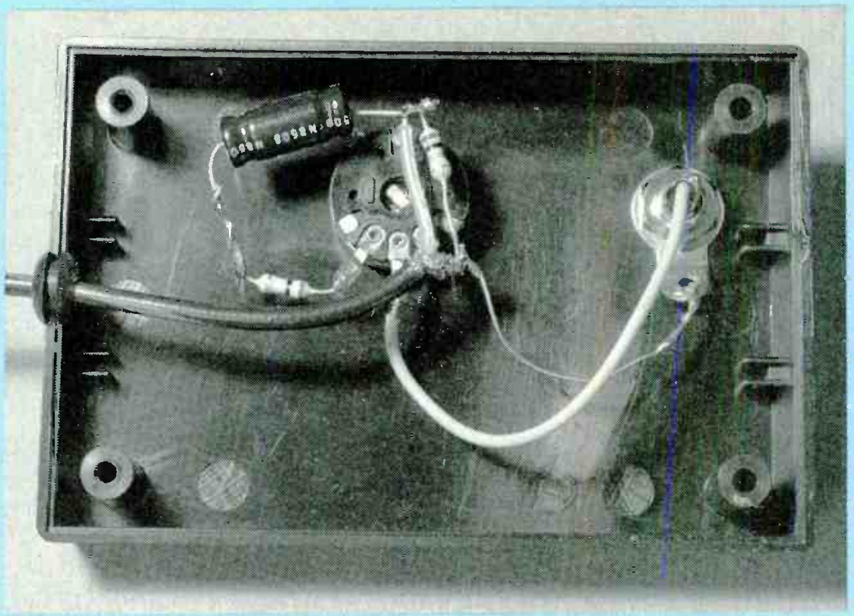


FIG. 2—MOUNT ALL COMPONENTS directly on the potentiometer, as shown here. This eliminates the need for any kind of circuit board.

Hardware and software

There's not much to the circuit, which is shown in Fig. 1. The output of a serial port is nominally 24 volts peak-to-peak, which is much too high a voltage to feed to the input of an audio amplifier. The circuit attenuates the signal to a more useful level, a variable 2-volts peak-to-peak. The circuit also protects the computer from static electricity and voltage surges. Capacitor C1, a non-polarized unit, blocks DC because the serial port, when idling, outputs approximately −12 volts.

The attenuator consists of only four components, so it does not need a PC board. The circuit was built in a small plastic case by mounting the resistors and capacitors directly to the potentiometer and output jack, as shown in Fig. 2. Figure 3 shows the assembled unit.

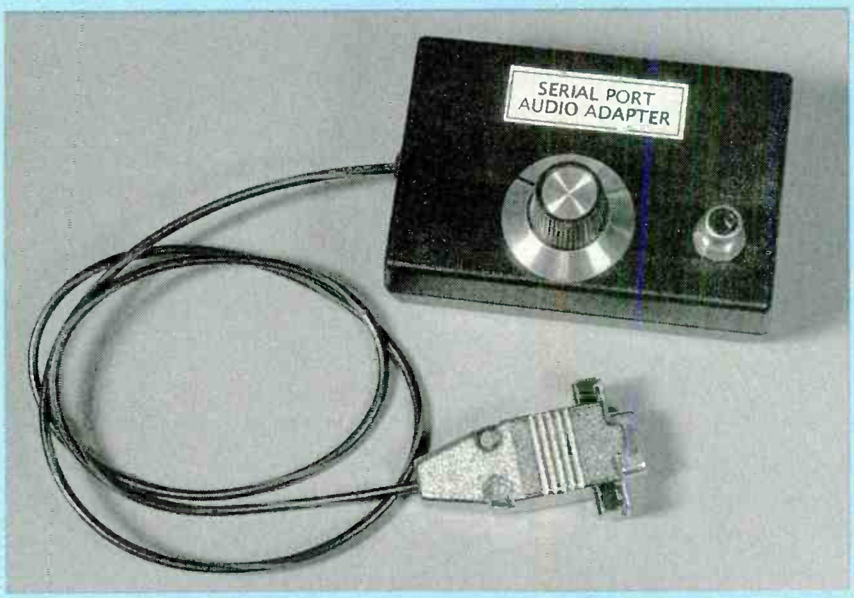


FIG. 3—THE ASSEMBLED UNIT is compact and attractive. An even smaller case than the one shown here could also be used.

PARTS LIST

R1—10,000 ohms, ⅛-watt
R2—100,000 ohms, ⅛-watt
R3—10,000 ohms, audio-taper potentiometer
C1—4.7 µF, 50-volts, non-polarized electrolytic capacitor (Radio Shack 272-998 or equivalent)
Enclosure, cables, and connectors to suit your equipment and needs.

If you want the circuit to deliver signals for testing, just run an appropriate cable from J1 to your equipment. For audio output, say for tuning musical instruments or playing audible tones, the circuit can drive a speaker directly, as shown in Fig. 4.

A word of caution before discussing applications: RS-232 ports are supposed to be tolerant of static charges, short circuits, and extraneous voltages, but be aware that some ports are not. Use extra care if your port is part of a multifunction card that also includes a disk controller.

Many of these cards include both the serial port and the disk controller in a single, fragile VLSI device. If part of the circuit fails, you're likely to lose the whole thing—including access to your disk drives. Generally speaking, when experimenting with accessories connected to a serial port, it's safer to use a card with discrete RS-232 transmitter and receiver ICs.

As for the software, Listing 1

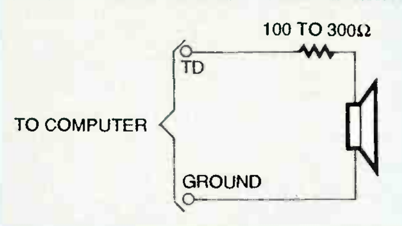


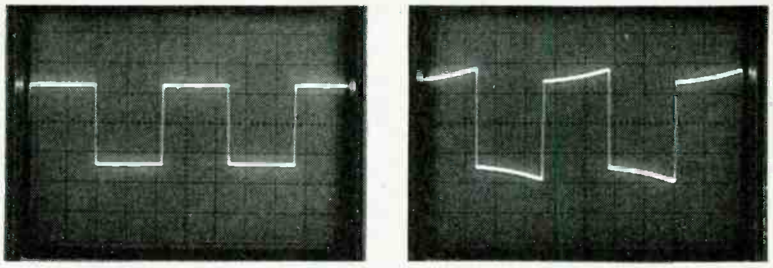
FIG. 4—TO DRIVE A SPEAKER from the generator, use this circuit.

shows the complete program. After setting up several constants, the program requests an output frequency, displays the nearest attainable value, and then starts pumping U's from the serial port. That continues until the user presses a key and then it stops.

The constants defined in lines 120 and 130 specify values for the PC's standard COM1 serial port. To use a different port, make the appropriate modifications. Also note line 190, which specifies the dividend in the frequency calculation. To run the program on another computer, that value might have to be adjusted.

Putting it to use

A precision squarewave generator has many applications. For example, you can use it to test the frequency response of an amplifier, as shown in Fig. 5. The input signal to the amplifier appears in Fig. 5-*a*; note the signal's sharp corners and flat tops. If the amplifier circuit has poor bass response, the tops of the waveform won't be flat (Fig. 5-*b*); if the treble is weak, the corners of the waveform won't be square (Fig. 5-*c*).



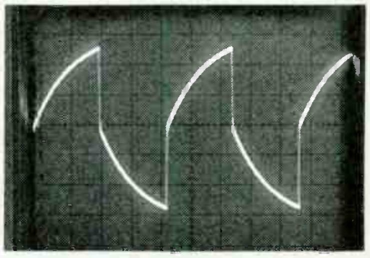


FIG. 5—TEST FREQUENCY RESPONSE as shown here. The input signal (*a*) is completely clean. Poor bass response affects the tops (*b*); poor treble response affects the corners (*c*).

In general, a clean looking squarewave at the output of an amplifier indicates a good frequency response over a 100-to-1 range. For example, an amplifier that cleanly reproduces a 1-kilohertz squarewave should provide good performance from 100 hertz to 10 kilohertz. Be aware, however, that a squarewave test won't detect clipping in the amplifier.

I have already mentioned tuning musical instruments. Another application is testing wow and flutter in tape recorders. Generate a constant frequency and record it; then play it back while comparing it to the same frequency coming directly from the computer. You can do the comparison by ear, but it's better to use an oscilloscope, with one squarewave going to the external sync input and the other to the vertical input. Then look closely to see how much the waveform jiggles from side to side. Ω

LISTING 1—BASIC PROGRAM

```
100 PRINT "PC Square Wave Generator - M. Covington 1994"
110 INPUT "Frequency (Hz)? ", FREQ
120 ADDR% = &H3F8                      ' 2F8 for COM2
130 PARM$ = "COM1:4800,N,8,1,cs0,ds0" ' or "COM2..." etc.
140 '
150 ' Open the serial port
160 OPEN PARM$ FOR OUTPUT AS #1
170 '
180 ' Choose customized baud rate
190 DIVIDEND = 115200                  ' 111850 on PCjr
200 DIVISOR% = INT(.5 + DIVIDEND / (FREQ * 2))
210 FREQ = DIVIDEND / (DIVISOR% * 2)
220 PRINT "Actual frequency: "; FREQ; " Hz"
230 '
240 ' Set serial port to new baud rate
250 WAIT ADDR% + 5, &H20
260 OUT ADDR% + 3, INP(ADDR% + 3) OR &H80
270 OUT ADDR%, DIVISOR% MOD 256
280 OUT ADDR% + 1, DIVISOR% / 256
290 OUT ADDR% + 3, INP(ADDR% + 3) AND &H7F
300 '
310 ' Transmit square wave until told to stop
320 PRINT "Press any key to stop."
330 WHILE INKEY$ <> "": WEND           ' clear kbd buffer
340 WHILE INKEY$ = ""
350   PRINT #1, "UUUU";
360 WEND
370 PRINT "Emptying buffer..."
380 CLOSE #1
390 PRINT "All done."
400 END
```

AFTER YOU HAVE COMPLETED YOUR latest logic circuit design, you will probably want to build a prototype to test its operation. If the circuit is not complex, a common logic probe is all that's needed to troubleshoot it. However, if the circuit has multiple signals that must be checked for proper time phasing, or if it requires one or more complex driving signals to exercise its operation, then you need a more powerful testing tool.

Professionals use a logic analyzer and function generator to make these tests. Experimenters, hobbyists, and those on a tight budget will want to build the PC Mini Logic Analyzer. It costs only about $30 to build, but when it is linked to an IBM-compatible computer, it is sufficiently capable for most hobby applications. The PC Mini Logic Analyzer provides up to eight driving signals (outputs) and eight inputs. Each output can be programmed with up to a 64-bit pattern. In addition to its logic analyzer function, the unit can serve double duty as a digital integrated circuit (IC) tester.

The analyzer consists of a hardware interface with applications software. The interface buffers the signals that are sent from the computer's parallel port to the circuit to be tested. It also buffers the signals that are returned from the circuit to the computer, and shifts their voltage levels so that they are compatible with the PC's logic levels. The interface obtains its power from the circuit under test, so it will always recognize the proper logic levels: TTL at 5 volts, or CMOS from 3 to 15 volts. The interface can be connected directly to any parallel port on your PC.

This mini analyzer is inexpensive, versatile, and easy to build.

JAMES J. BARBARELLO

The software displays 64 bits of the eight outputs and eight inputs simultaneously. It allows full on-screen programming of the outputs. Scan time (the time to process the 64 bits) can be adjusted from a high of about 100 bits/second on an average PC to a low of one bit every 10 seconds. The slower speeds allow you to single step through a circuit and observe how each output bit affects the prototype circuit's operation.

Best of all, the interface circuit is composed of common components, all available from most electronic component suppliers. Although a PC board layout is provided here, it is not essential for proper operation: the circuit can also be constructed on a solderless breadboard.

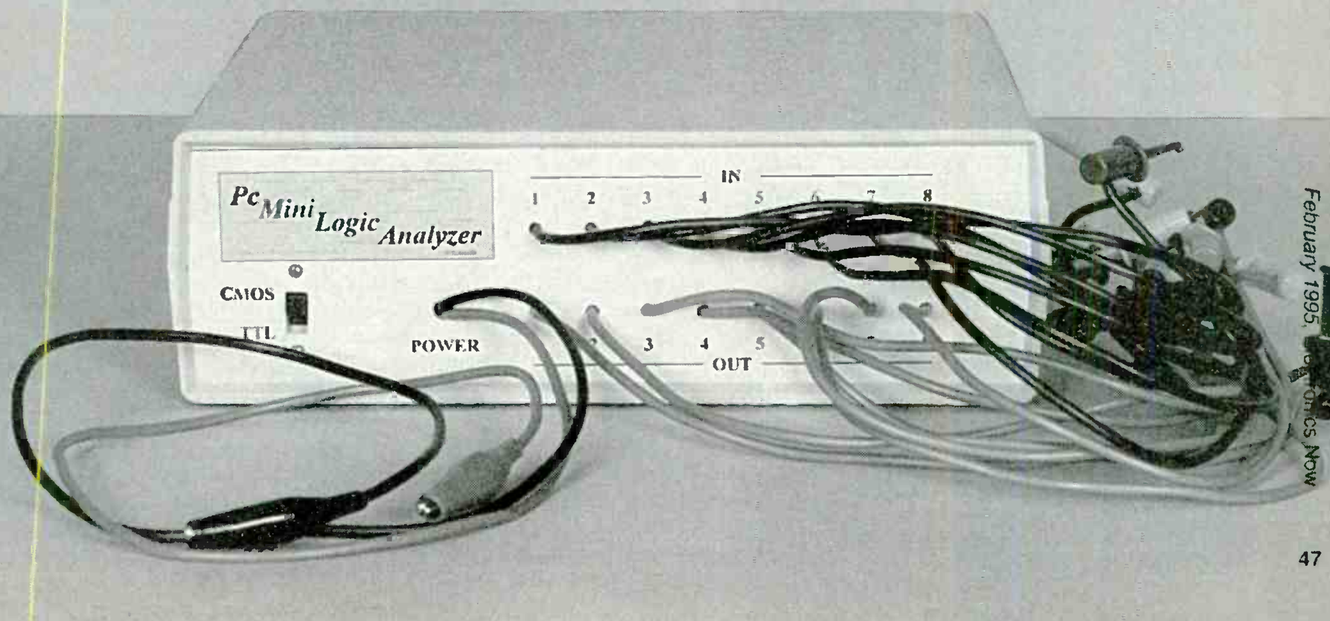
The hardware interface will be described first, followed by the software. Then, an actual logic analyzer application will be described, followed by an example of how to use the analyzer as a digital IC tester.

Theory of operation

The analyzer incorporates two basic functional blocks; a transistor buffer/inverter section, and an analog switch section that feeds voltage comparators. The transistor buffer/inverter section is shown in the schematic in Fig. 1.

Transistor Q1 in Fig. 1 is configured as a standard inverting switch. A signal greater than

MINI LOGIC ANALYZER



about 0.7 volt from the parallel port (pin 2 for Q1) causes the transistor to conduct, raising the output (O1 for Q1) to about 0.3 volt. When a signal less than 0.7 volt is applied, the transistor does not conduct, and current is provided to any load

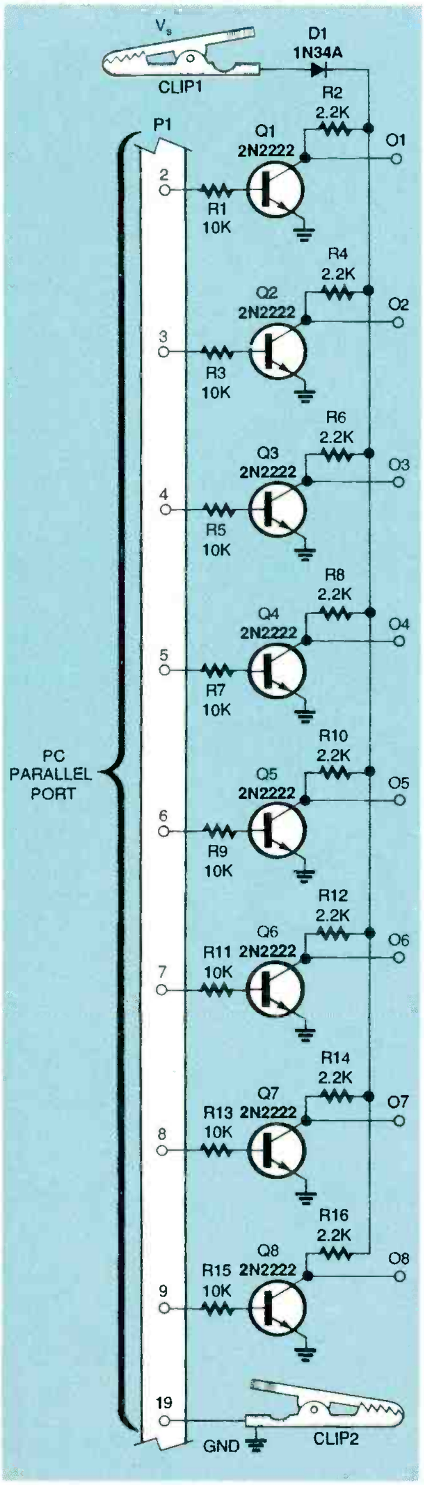


FIG. 1—THE ANALYZER incorporates two basic functional blocks. This is the transistor buffer/inverter section.

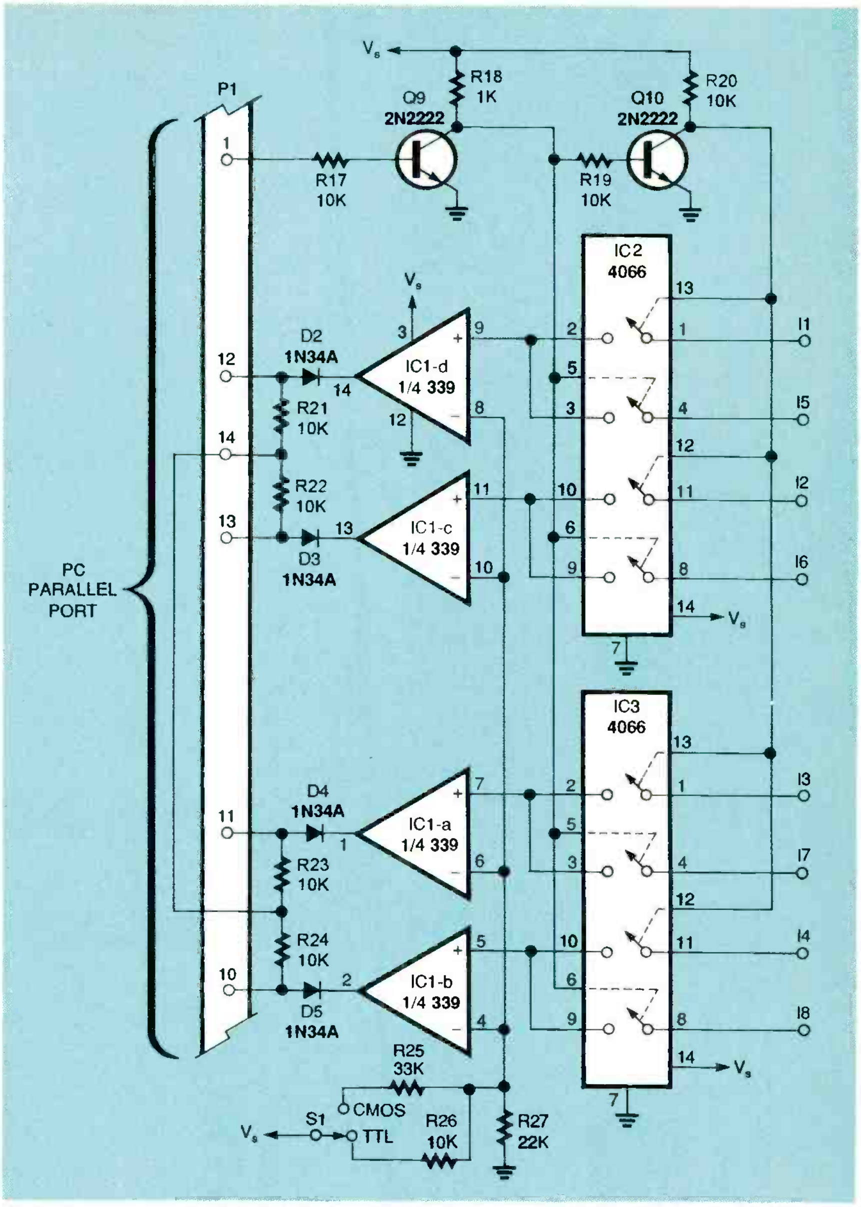


FIG. 2—THE ANALOG SWITCH SECTION feeds the voltage comparators. Two of the analog switches in a CD4066B quad-analog switch IC (IC2-a and IC2-b) feed their outputs to the non-inverting input of IC1-d, one of the four voltage comparators in an LM339 quad comparator IC.

connected to the output through the collector resistor (R2 for Q1). This signal inversion is compensated by the software. For example, when the user requests a high logic level to be output at O1, the software converts the request and outputs a low logic level at pin 2 of the parallel port. The transistor will invert that low logic level to a logic high, producing the output requested by the user.

The transistor inverter/buffer performs two necessary functions. First, it acts as a current amplifier, providing more current than the parallel port could provide directly. Second, since the transistor obtains its operating voltage through D1, the output levels will be consistent with the logic levels generated by the circuitry that is supplied by that voltage. (The output voltage level is not dependent on the input driving voltage, which will always be that provided by the parallel port).

Diode D1 protects the interface against reverse power supply voltage. The approximately 0.3 volt lost across the diode is insignificant in the operation of the interface. The transistor inverter/buffer is used eight times

(Q1–Q8) to provide eight outputs.

The second functional block is shown in Fig. 2. Two of the analog switches in a CD4066B CMOS quad-analog switch IC (IC2-a and IC2-b) feed their outputs to the non-inverting input of IC1-d, one of the four voltage comparators in an LM339 quad comparator IC. When the control pin of an analog switch is pulled high, the switch will pass the input signal to its output, also putting from about 50 to 200 ohms in series in the process. When the control pin is brought low, the path between input and output becomes a very high impedance, effectively disconnecting the input from the output.

The signal from pin 1 of the parallel port is inverted twice, once by transistor Q9 and a second time by Q10. Therefore, the control signal for analog switch IC2-b is 180° out of phase with

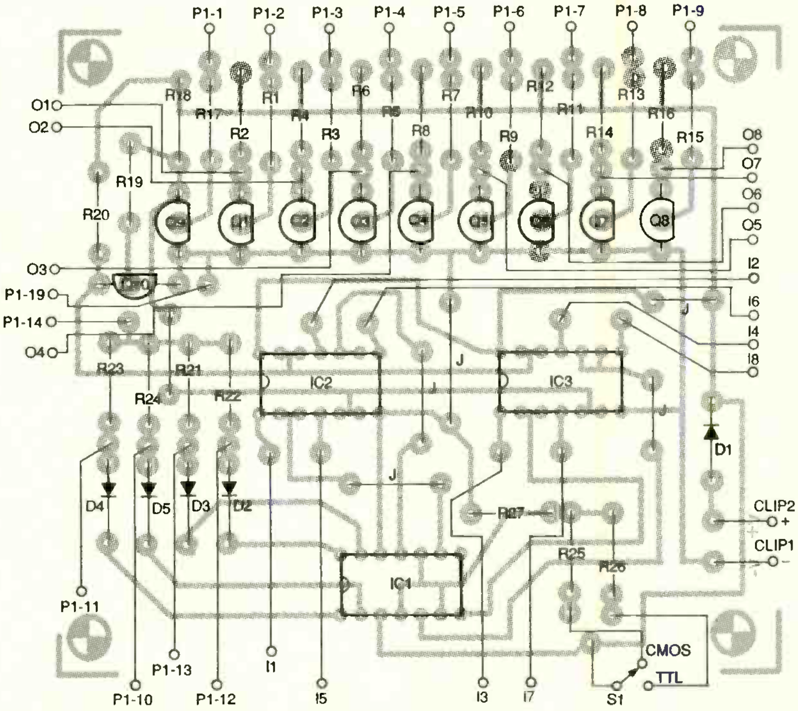


FIG. 4—PARTS-PLACEMENT DIAGRAM. The circuit layout is not critical, so you can use either the PC board an experimenter's breadboard.

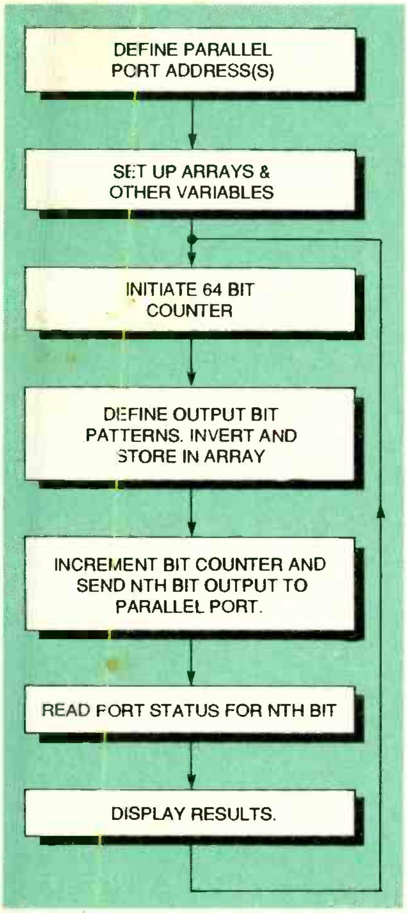


FIG. 3—BASIC PROGRAM FLOW. First, the address of the parallel port that's going to be used is identified and called ad0.

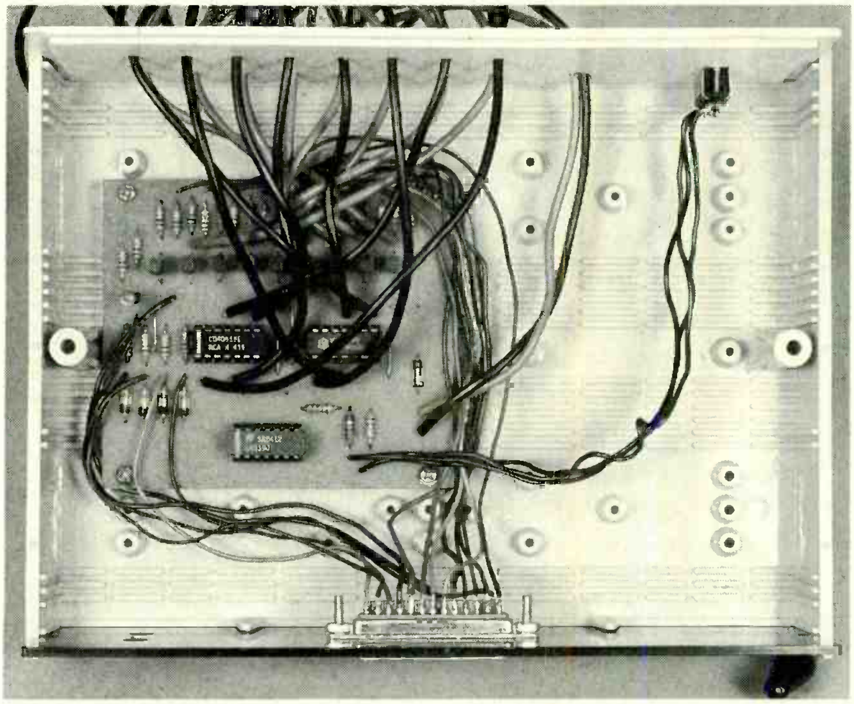


FIG. 5—AUTHOR'S PROTOTYPE. Use micro-clips for the 16 input/output lines, and insulated mini alligator clips for the power and ground leads. Route the wires through holes in the enclosure and attach the connectors.

the signal for IC2-a. With a high signal at pin 1 of P1, switch IC2-a will be on, and IC2-b will be off. Conversely, with a low signal at pin 1 of P1, the switch IC2-a will be off, and IC2-b will be on. This allows the two switch outputs to be connected together (sometimes called a "wired OR"), because only one switch will be on at a time.

Comparator IC1-d compares the signal at its positive input to the reference voltage at its negative input. When the signal is greater than the reference, the

TABLE 1

Connection	Output	Voltage
None	O1	Vbattery–Vdiode
None	O2	Vbattery–Vdiode
None	O3	Vbattery–Vdiode
None	O4	Vbattery–Vdiode
None	O5	Vbattery–Vdiode
None	O6	Vbattery–Vdiode
None	O7	Vbattery–Vdiode
None	O8	Vbattery–Vdiode
O1 to P3	O2	0 to 0.5V (approx)
O1 to P4	O3	0 to 0.5V (approx)
O1 to P5	O4	0 to 0.5V (approx)
O1 to P6	O5	0 to 0.5V (approx)
O1 to P7	O6	0 to 0.5V (approx)
O1 to P8	O7	0 to 0.5V (approx)
O1 to P9	O8	0 to 0.5V (approx)
O2 to P2	O1	0 to 0.5V (approx)

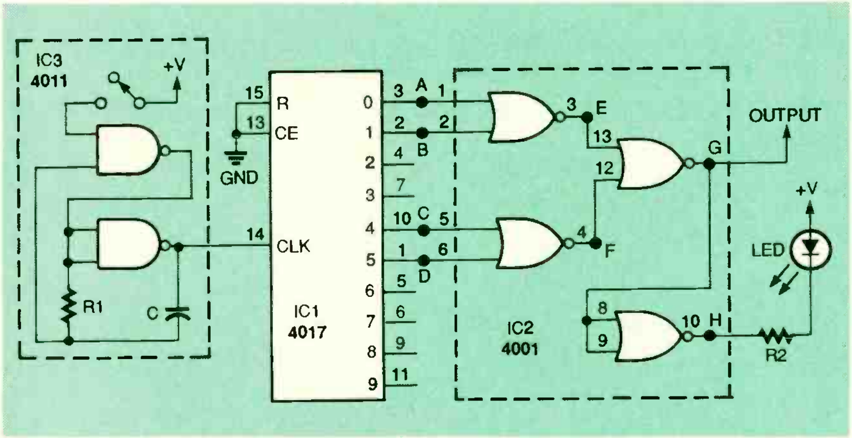


FIG. 6—LOGIC ANALYZER APPLICATION. This self-clocking circuit is supposed to provide a squarewave output that has one quarter of the input frequency.

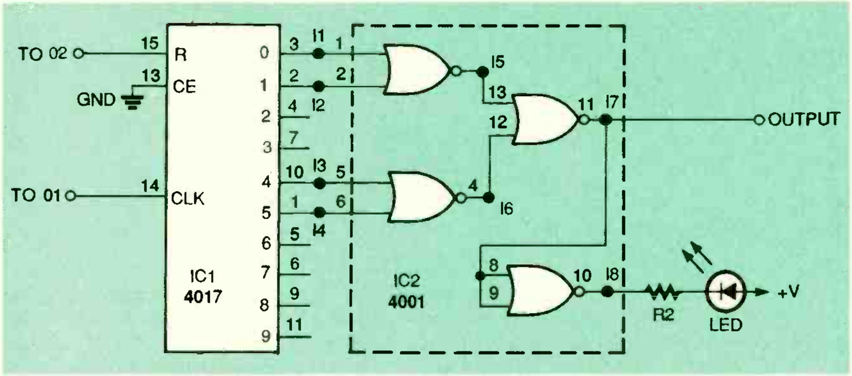


FIG. 7—MONITORING ALL POINTS in the circuit will reveal any problems quickly. Here's the test circuit with the CD4011B replaced by the analyzer.

comparator's output goes high, and blocking diode D2 is reverse-biased. The high output at pin 14 of the parallel port pulls the parallel port pin 13 input high. A low signal from the comparator output allows the parallel port pin to sink voltage from pin 14 into the comparator's output through the diode. This pulls parallel port pin 13 low when a low signal is provided to the comparator. This arrangement allows signals greater than the 5-volt level of the parallel port to be processed. The analog switch/comparator block is used four times to accept eight inputs and provide them to the four comparators for input into the PC.

The reference voltages for the comparators are created in the voltage divider consisting of R25, R26, and R27. When switch S1 is in its TTL position, the voltage across R27 (provided to the comparators) will be about 2 volts with a 5-volt power supply. With S1 in its CMOS position, the voltage across R27 will be about 70% of the power supply voltage. Those voltage levels correspond to the lower limits of valid high logic levels for those logic families. A common ground reference is provided from the power supply through to the PC via the parallel port's pin 19 and clip 2.

Software

While a lot of software code is devoted to making a convenient interface for the user, the basic program flow is fairly simple (see the flowchart in Fig. 3). First, the address of the parallel port is identified and called ad0. Since the parallel port must be addressed with three sequential addresses, the two addresses that follow are defined as ad1 (ad0 + 1) and ad2 (ad0 + 2). Because the analyzer has 16 lines, each with a 64-bit sequence, an integer array is set up to hold each bit's value for each line. The array has maximum dimensions of 16 by 64, or a(16,64). Other necessary variables are also set up at this time. Pin 14 is also brought high to serve as the pull-up voltage for the parallel port inputs.

Next, a counter to loop between 1 and 64 is set up. The software then makes sure the desired output pattern(s) are defined, and if they aren't, it defines them. The desired patterns are inverted (to compensate for the hardware inversion in the interface transistors) and stored in the integer array. Next,

LISTING 1

```
REM**** MINITEST.BAS
REM**** QUICK CHECKOUT OF MiniAnal
REM**** V940708    (c) 1994, JJ Barbarello
CLEAR : COLOR 7, 0: CLS
DEFINT A-X: DEFSTR Y-Z: DIM o(8), i(8): DEF SEG = 64
LOCATE 1, 15
PRINT "QUICK CHECKOUT OF Pc MINI LOGIC ANALYZER INTERFACE" LOCATE 2, 1: PRINT
STRING$(79, 220)
LOCATE 5, 15: INPUT "PARALLEL PORT ADDRESS (Enter for default): "; ad0
IF ad0 = 0 THEN ad0 = PEEK(8) + 256 * PEEK(9)
ad1 = ad0 + 1: ad2 = ad1 + 1:  OUT ad2, 0: PRINT : PRINT
FOR i = 0 TO 7: a = 2 ^ i
OUT ad0, a XOR 255: GOSUB status1
IF 0 <> o(i + 1) THEN
      PRINT "Problem with Output"; i + 1; "(Should be low)"
      x = 1
END IF
IF 1 <> i(i + 1) THEN
      PRINT "Problem with Input"; i + 1; "(Should be high)"
      x = 1
END IF
OUT ad0, a: GOSUB status1
IF 1 <> o(i + 1) THEN
      PRINT "Problem with Output"; i + 1; "(Should be high)"
      x = 1
END IF
IF 0 <> i(i + 1) THEN
      PRINT "Problem with Input"; i + 1; "(Should be low)"
      x = 1
END IF
NEXT i
IF x = 0 THEN LOCATE 10, 32: PRINT "INTERFACE TESTS OK"
END
REM******** GET STATUS OF PRINTER PORT PINS *******
status1:
o(1) = INP(ad0) AND 1
o(2) = (INP(ad0) AND 2) / 2
o(3) = (INP(ad0) AND 4) / 4
o(4) = (INP(ad0) AND 8) / 8
o(5) = (INP(ad0) AND 16) / 16
o(6) = (INP(ad0) AND 32) / 32
o(7) = (INP(ad0) AND 64) / 64
o(8) = (INP(ad0) AND 128) / 128
OUT ad2, 0: REM: Pin 1 High
i(1) = (INP(ad1) AND 32) / 32
i(2) = (INP(ad1) AND 16) / 16
i(3) = -(((INP(ad1) AND 128) / 128) = 0)
i(4) = (INP(ad1) AND 64) / 64
OUT ad2, 1: REM: Pin 1 low
i(5) = (INP(ad1) AND 32) / 32
i(6) = (INP(ad1) AND 16) / 16
i(7) = -(((INP(ad1) AND 128) / 128) = 0)
i(8) = (INP(ad1) AND 64) / 64
RETURN
```

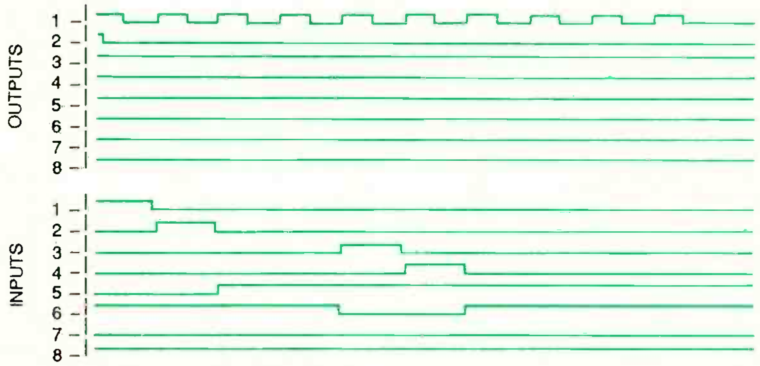


FIG. 8—RESULTING BIT PATTERN. The immediate problem is that the LED does not light, verified in the bit pattern showing that inputs I7 and I8 are not switching.

the bit counter is incremented and the next bit is sent out to the parallel port. The status of the port is then read and the results are displayed. The software then loops back to the bit counter, and the input/output process continues. There is more to the actual program code, but the basic analyzer operation is captured in just those few steps.

Construction

The circuit layout is not critical, so you can use either the PC board and parts-placement diagram shown in Fig. 4, or follow the schematic diagram and build the circuit on an experimenter's breadboard. For either assembly method, IC sockets are recommended.

Once the circuit is constructed, and before you begin the final wiring, decide on the case style (if any) for enclosing the analyzer. Because 16 wires and test clips extend from the circuit board, it is wise to choose a wire-coding arrangement that will help you easily recognize each input and output lead.

Use No. 20 stranded hookup wire for the 16 input/output leads, connecting one end to the 16 points identified as O1–O8 and I1–I8. Again using No. 20 stranded wire, connect a red lead to Clip 1 and a black lead to Clip 2, and also connect switch S1.

Decide if you want to have the parallel port cable connected to the board directly, or if you want to add a DB-25 connector. For the integral cable option, obtain 15 four-foot lengths of No. 22 or 24 stranded wire, or a four-foot length of 15-conductor cable. Then use those leads to connect the appropriate points from the circuit board to the pins of a male DB-25 plug. If you use a connector, make the appropriate connections from the circuit board to a female DB-25 socket mounted on the back of the case with wire cut to the size of the enclosure.

The last step is to attach connection devices to the 16 input/output lines and power leads. Use micro-clips for the 16 input/output lines, and insulated mini alligator clips for the power and ground leads. Route the wires through holes in the enclosure and attach the connectors. Complete the assembly

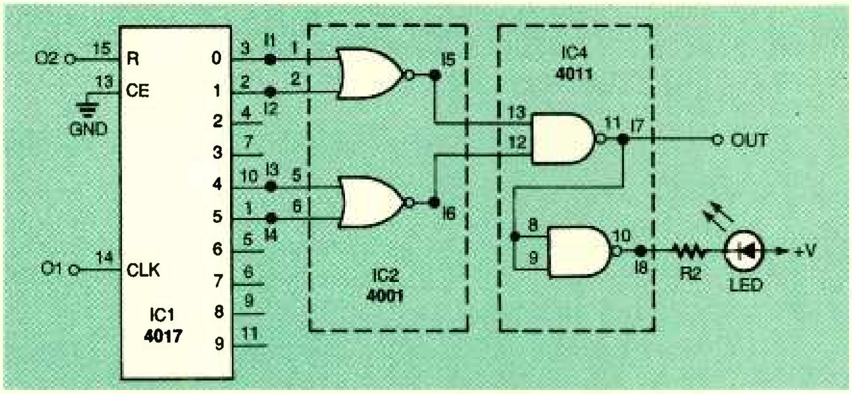


FIG. 9—A NAND FUNCTION will produce a low logic level when the two inputs are high, and produce a high logic level otherwise. Here's the revised circuit.

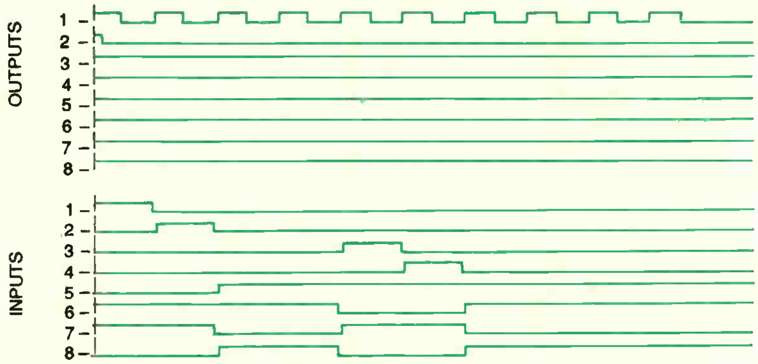


FIG. 10—RESULTANT BIT PATTERN of the circuit in Fig. 9.

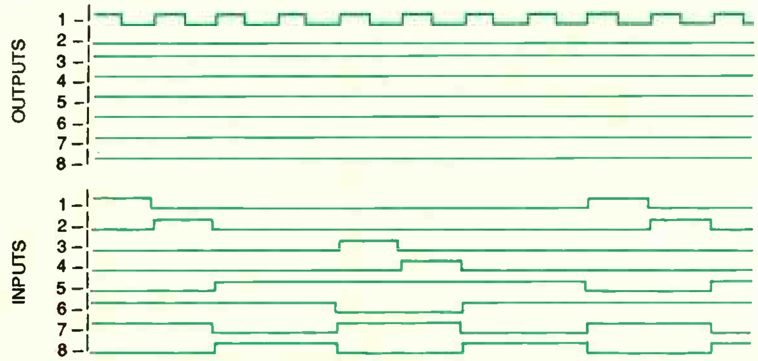


FIG. 11—THE I7 AND I8 WAVEFORMS would both be symmetrical if they ended after the eighth clock pulse. Routing the ninth output of IC1 to the reset pin will do this.

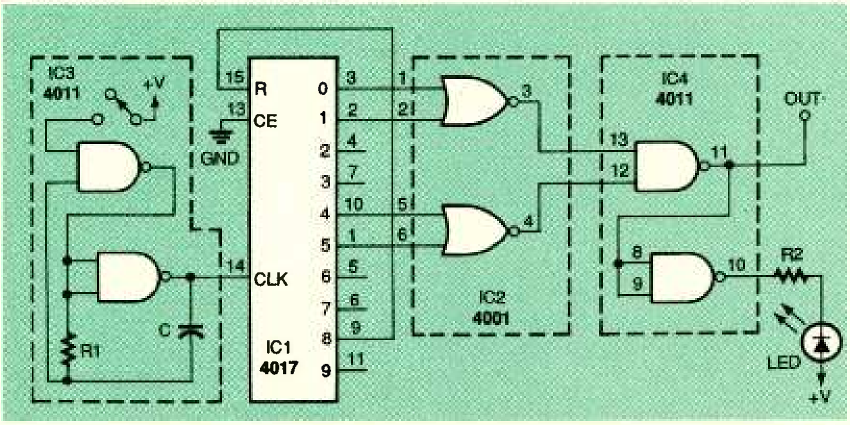


FIG. 12—THIS FINAL CIRCUIT configuration meets all of the original requirements; the output is the input divided by 4, it is symmetrical, and the LED lights.

by mounting the circuit board in the enclosure and mounting S1. Figure 5 shows the author's prototype unit.

Checkout

To test the analyzer, you'll need a 9-volt battery, a voltmeter, and a few jumpers. First make sure that there is no continuity between the board and the eight output leads O1–O8. Then connect the power terminals to the 9-volt battery (red to +, black to −). The voltage between each of the output leads and ground should be the battery voltage less the voltage drop across diode D1. For example, if your battery terminal voltage is 8.9 volts, the voltage at O1 should be about 8.6 volts. The actual voltage is not critical, because the drop across D1 and the individual transistors will vary slightly depending on the actual devices installed.

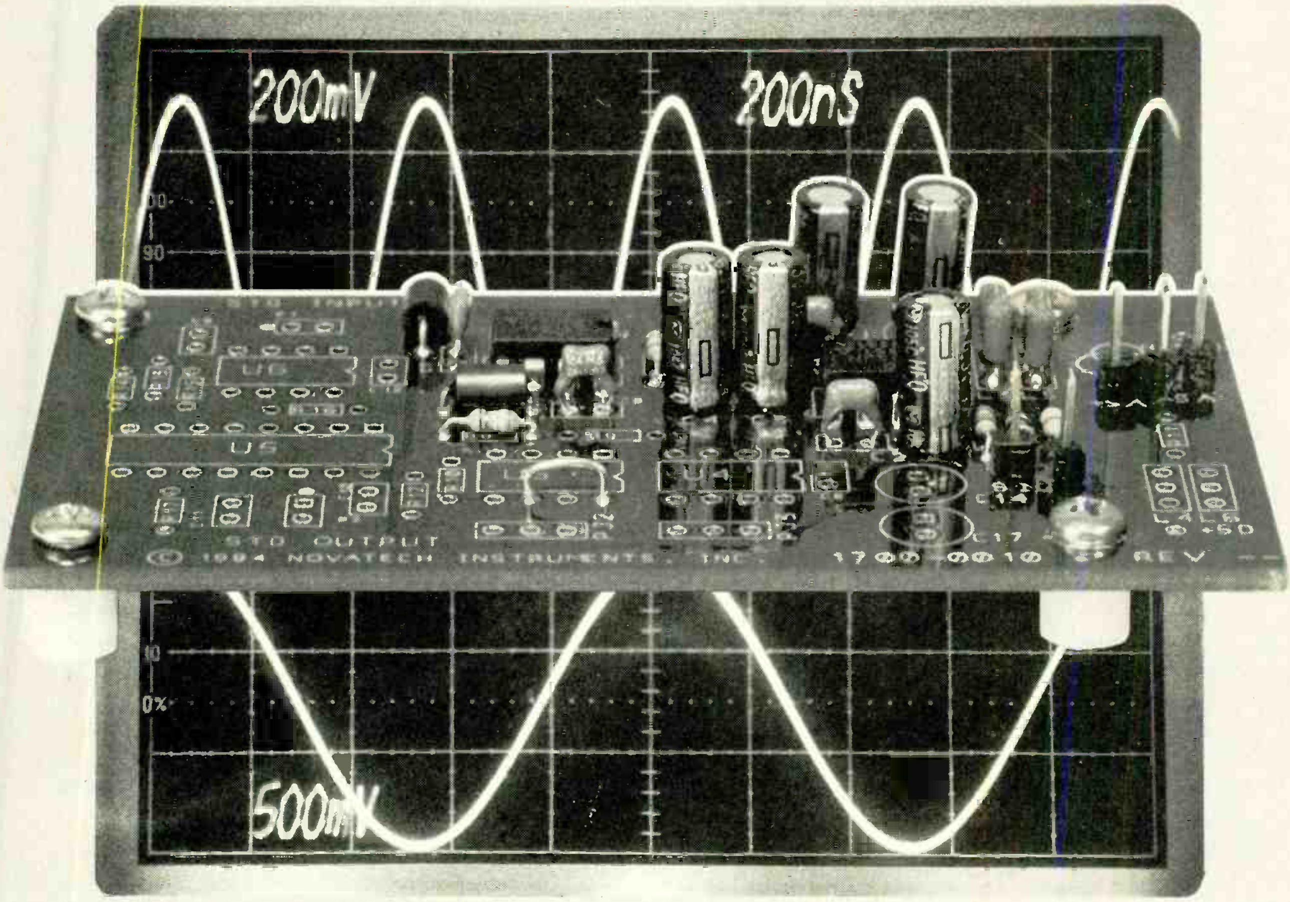
Next, connect O1 to P1 pin 3; O2 should now read between 0 and about 0.5 volt. Connect O1 to P1 pins 4 through 9 in turn, reading the outputs (O3 through O8 respectively). Finally, connect O2 to P1 pin 2 and read the output at O1. This entire procedure is summarized in Table 1.

To check the interface input circuits and parallel port connections, use the program MATEST.BAS shown in Listing 1. (All of the software for this analyzer project will be made available on the Gernsback BBS, 516-293-2283, v.32, v.42bis, as a file called MINIANAL.ZIP.) Extract the program MATEST.EXE from the zipped file or type it in by hand and run it from QBasic. Connect each numbered output to its corresponding input (O1 to I1, O2 to I2, etc.). Connect the power leads to a 9-volt battery, and connect the analyzer output to your computer's parallel port. Place S1 in the CMOS position.

The program will use the outputs to create a logic 1 and then logic 0 for each of the eight inputs. It will read the inputs to determine if they were processed correctly. When you execute the program, it will ask

Continued on page 81

SINEWAVE DOUBLER



Double the frequency of any sinewave from 10 Hz to more than 50 MHz.

STEVEN D. SWIFT

HOW OFTEN HAVE YOU WISHED THAT your signal generator would generate a higher frequency? The small module described in this article doubles the frequency of any sinewave input, providing outputs from 10 hertz up to and beyond 50 megahertz. It measures less than 2 × 3.5-inches, and consumes about one-third of a watt. It can be permanently installed in almost any signal generator or used as an outboard module.

Theory of operation

A schematic of the frequency doubler module is shown in Fig. 1. The core of the module is IC1, an Analog Devices AD834 wideband four-quadrant multiplier. This IC provides wideband analog multiplication of two input signals, regardless of their polarity. In this circuit both X and Y inputs are tied together to provide a squaring function.

The operation of IC1 is best understood with the aid of simple mathematics. If the input is assumed to be a normalized (amplitude of 1) sinewave of frequency f, then the input can be written as:

$$\text{Input} = \sin(2\pi f)$$

where

$\pi = 3.14159\ldots$
f = frequency
t = time

The AD834 performs the following function:

$$XY = \sin(2\pi f) \times \sin(2\pi f) = (\sin(2\pi f))^2$$

A fundamental trigonometric identity gives:

$$(\sin(2\pi f))^2 = (1 - \cos(2(2\pi f)))/2 = (1 - \cos(2\pi 2f))/2$$

The last term shows a DC offset as well as a cosine term with twice the frequency as the input. This performs the frequency doubling function. The cosine term exhibits a 90° phase shift from the original input, but phase is of no concern in this circuit. Note, however, that the amplitude is cut in half.

Since the AD834 provides differential current-mode outputs, load resistors R4 and R5, gain resistors R6 and R7, and IC2 are added to convert the signal to an amplified and buffered single-ended output. The AD811 wideband current-mode feedback amplifier (IC2) is configured as a differential amplifier. Capacitors C3 and C4 remove the DC offset from the output. Resistor R8 provides a nominal 50-ohm output impedance, and R1 and R2 attenuate the input signal and provide a low-impedance source to IC1.

Inductors L1, L2, L3, and L5 and capacitors C5, C6, C7, C13, and C15 perform high-frequency filtering and decoupling. Resistors R3 and R18 and capacitors C1, C2, and C16 provide decoupling and biasing for IC1.

The circuit requires a +5-volt supply at about 30 milliamperes and −5 volts at about 40 milliamperes. Higher voltages, up to ±9 volts, can be used if the bypass capacitor voltage ratings are increased. Higher voltages provide higher bandwidths with higher power dissipation.

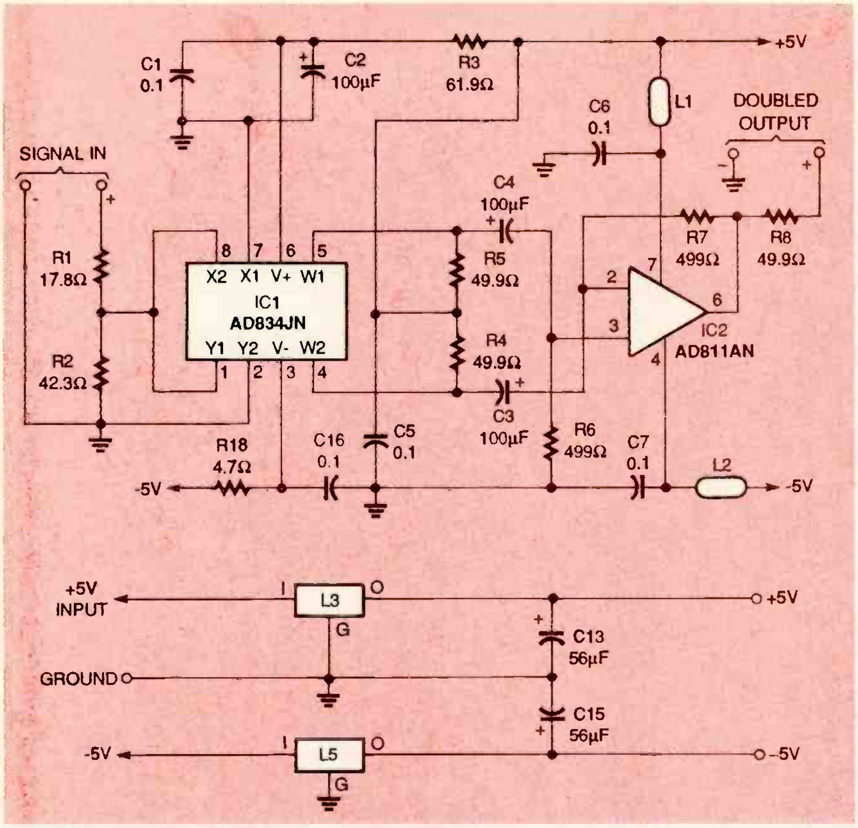


FIG. 1—SCHEMATIC OF THE FREQUENCY DOUBLER. An Analog Devices AD834 wideband, four-quadrant multiplier (IC1) provides wideband analog multiplication of two input signals.

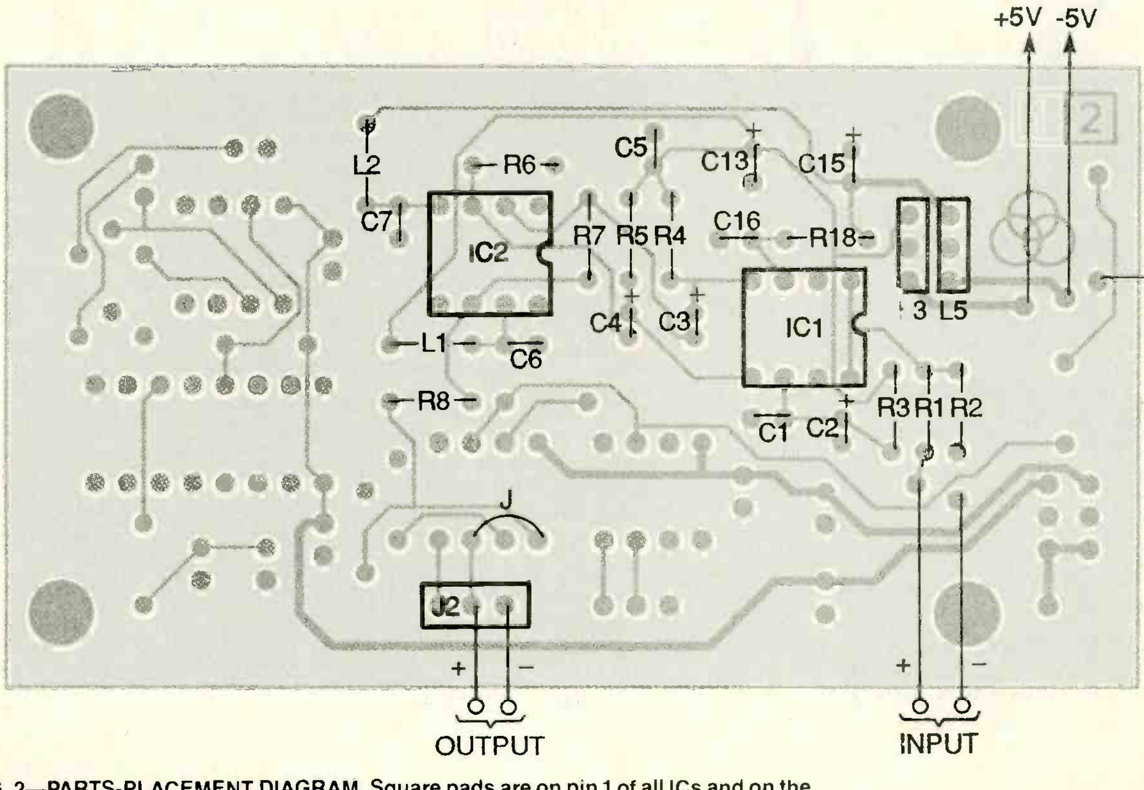


FIG. 2—PARTS-PLACEMENT DIAGRAM. Square pads are on pin 1 of all ICs and on the positive leads of all polarized capacitors.

PARTS LIST

All resistors are ⅛-watt, 1%, metal film, unless noted.
R1—17.8 ohms
R2—42.3 ohms
R3—61.9 ohms
R4, R5—49.9 ohms
R6, R7—499 ohms
R18—4.7 ohms, ⅛-watt, 5%

Capacitors
C1, C5–C7, C16—0.1 µF, ceramic
C2–C4—100 µF, 6.3 volts, high-frequency aluminum electrolytic
C13, C15—56 µF, 16 volts, high-frequency aluminum electrolytic

Semiconductors
IC1—AD834JN wideband multiplier (Analog Devices)
IC2—AD811AN current mode amplifier (Analog Devices)

Other components
L1, L2—Leaded EMI bead (Panasonic EXC-ELSA35, Digi-Key P9820BK-ND)
L3, L5—3-terminal EMI filter (Panasonic EXC-EMT103DT, Digi-Key 9809CT-ND)
L4—not used

Miscellaneous: PC board, wire jumpers, seven 0.025-inch square posts (if desired), solder.

Note: The following items are available from Novatech Instruments, Inc., 1530 Eastlake Ave. East, Suite 303, Seattle, WA 98102:

- **Complete kit of all parts (Model DOUB-1, includes PC board and documentation)—$50.00**

Please add $5 shipping and handling for US and Canada. $10 overseas. Add $10 for COD orders. Washington State residents must add 8.2% sales tax. Check or money order only.

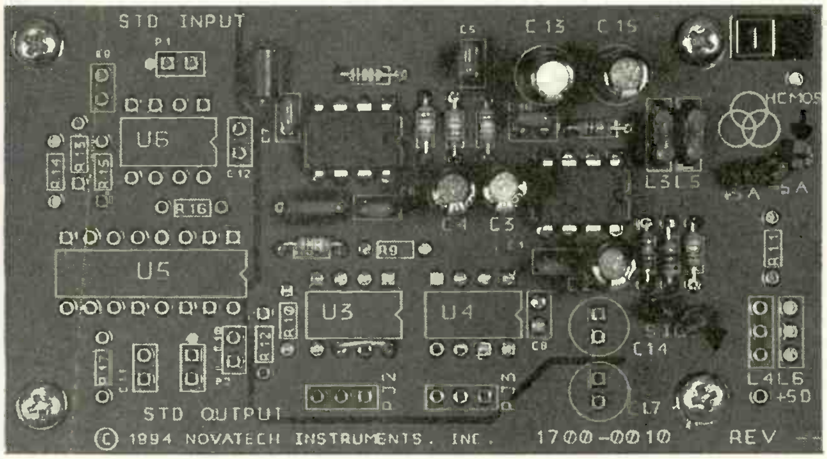


FIG. 3—THE COMPLETED BOARD. The locations for extra components are for other board applications.

Construction

Because IC1 and IC2 are high-frequency components, you must be extremely careful to prevent high-frequency oscillations if you build the circuit on a breadboard. It is preferable to use a PC board. A foil pattern is provided here. Keep all wires short and place the bypass capacitors as close to IC1 and IC2 as possible. A solid ground plane on the component side of the PC board is recommended, and IC sockets are discouraged. If you must use sockets, use machined-pin, open-frame sockets only.

As can be seen from the parts-placement diagram, the board has locations for extra components not related to the doubling function discussed in this article. The additional features were included to allow the board to be used with other Novatech synthesizers.

The parts-placement diagram is shown in Fig. 2. Install all the components as shown, taking care to observe polarity on diodes and capacitors. Square pads indicate pin 1 of all ICs and the positive leads of all polarized capacitors.

All resistors specified for this circuit (except R18) are ⅛-watt, 1% metal-film types. Their small size and tight tolerance improves high-frequency performance and circuit matching. If resistors other than metal-film are substituted, the performance of the frequency doubler

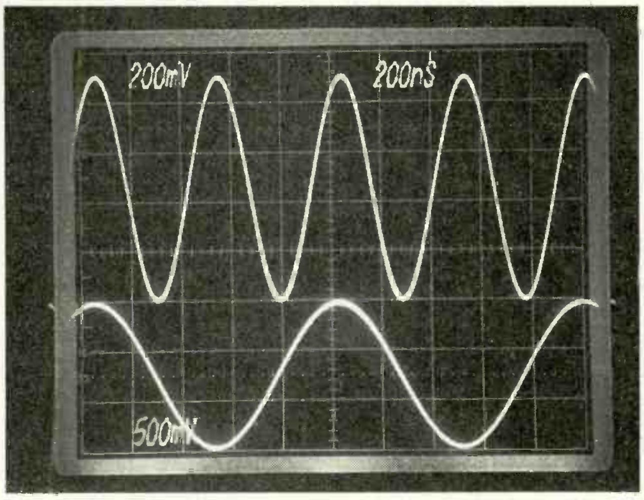


FIG. 4—INPUT AND OUTPUT. The top trace is the output of the doubler with a 1-megahertz, 1.5-volt peak-peak input signal, and the bottom trace is the input signal.

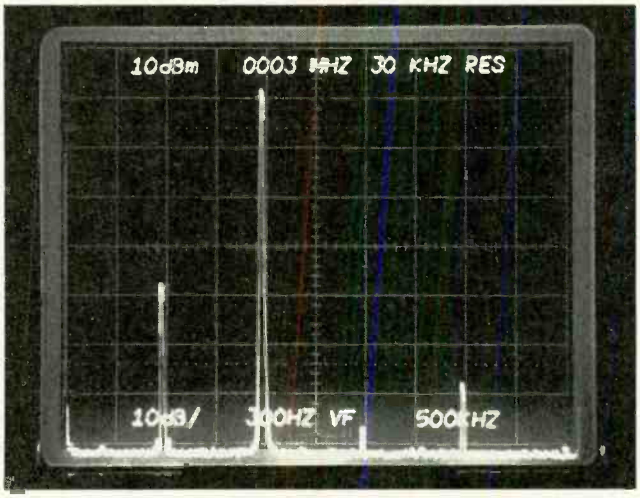
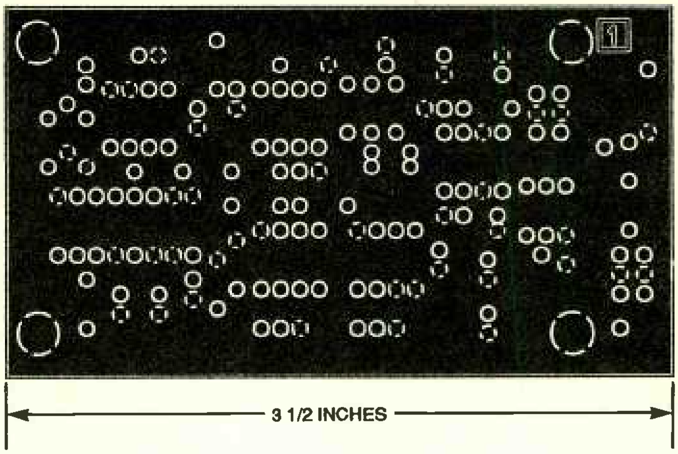
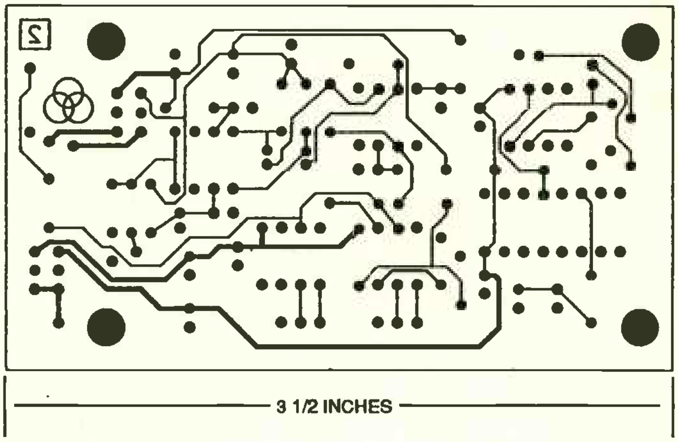


FIG. 5—FREQUENCY SPECTRUM of the output signal in Fig. 4. The fundamental frequency is about 40 dB down from the doubled frequency.



COMPONENT SIDE FOIL PATTERN.



SOLDER SIDE FOIL PATTERN.

will be degraded. In particular, its distortion will increase, and its bandwidth will decrease.

As mentioned before, C3 and C4 provide DC blocking. The values specified allow operation down to about 10 hertz. If you intend to use this circuit exclusively above 5 kilohertz, better high-frequency performance can be obtained by substituting 0.1 µF ceramic capacitors. The extra capacitors are included with the kit for this purpose. Figure 3 shows the board.

Checkout

Verify that all components are installed properly and that there are no solder bridges. Apply power to the board as indicated in Fig. 2 (plus and minus 5 volts DC, both ± 0.25 volt). Also connect a function generator set to approximately 1 volt RMS to the signal input as shown. Connect an oscilloscope or frequency counter to the output pin (the center pin of J2).

Observe that the output is double the frequency of the input signal as the input is varied. The typical 3 dB point of the doubler is greater than 30 megahertz at the output. You can adjust the input to vary the output, but with an input above about 1.5 volts RMS, the output might be clipped.

The top trace in Fig. 4 is the output of the doubler with a 1-megahertz, 1.5-volt peak-to-peak input signal, shown at 200 millivolts per division. The bottom trace is the input signal at 500 millivolts per division. Figure 5 shows the frequency spectrum of the output signal in Fig. 4. The fundamental frequency is about 40 dB down from the doubled frequency, the second harmonic is more than 65 dB down, and the third is about 60 dB down. This fundamental frequency feedthrough increases to about −20 dB below the carrier as the output is increased to 50 megahertz. Ω

BUILD THIS MILLIOHM TESTER

Measure low resistances with this super simple circuit that connects to your DMM.

ROBERT A. HEIL

THE MILLIOHM ADAPTER ALLOWS resistances from 1 milliohm to 1 ohm to be measured with a high degree of accuracy on any digital multimeter. The circuit loads the device under test with a current of 100 milliamperes at 5 to 6 volts. The adapter connects to a DMM that is set on its millivolt- or 2-volt scale.

Ohm's law says that resistance equals voltage divided by current, or R = V/I. Thus, a DMM reading of 5.7 millivolts would correspond to 0.057 ohms. (5.7 mV/100 mA = 57 milliohms or .057 ohms.)

Circuit description

The milliohm adapter circuit, shown in Fig. 1, is powered from a 9-volt battery. A resistor to be tested (R_X) is connected across banana jacks J1 and J2, and a pair of banana plugs, connected directly to J1 and J2, plugs into the voltage input jacks of a DMM.

Switch S1 applies battery power to 7806 voltage regulator IC1. Capacitor C1 removes voltage transients. Resistors R1 and R2 form a voltage divider for the ground pin of IC1. Potentiometer R2 trims IC1's output voltage to exactly 6-volts DC. Potentiometer R3 sets the output current through R_X to 100 milliamperes. Because R3 is a relatively large resistance compared to R_X, the error introduced by different values of R_X (1 milliohm to 1 ohm), or the effect it will have on the 100-milliampere current source, is below 2%.

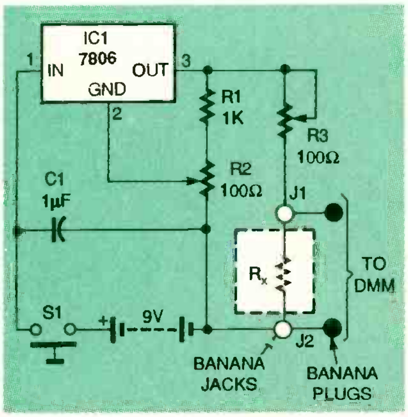


FIG. 1—MILLIOHM ADAPTER CIRCUIT. A resistor to be tested (R_X) is connected across banana jacks J1 and J2, and a pair of banana plugs, connected directly to J1 and J2, plugs into the voltage input jacks of a DMM.

Construction

A PC board is available from the source given in the Parts List, but the project is also easy to breadboard. You must select a case for the project before beginning the assembly. The prototype's case measures approximately 2 by 3¼ inches and is about 1 inch deep. The case has an aluminum cover.

A parts-placement diagram is shown in Fig. 2. Stuff the board as indicated, and check your work before continuing. Remove the covers from the banana plugs and place them into the common and the volt/ohms terminals of your DMM. Dab some petroleum jelly or other similar substance on the ends of the jacks protruding from the DMM. With the lid attached to the project case and facing up, press the upper left back of the plastic case onto the ends of the plugs stuck in the DMM. The petroleum jelly will transfer onto the project case and will mark the hole locations for drilling, allowing the adapter to plug directly into the DMM. Permanently mark those locations before continuing. Then turn the case over and similarly mark

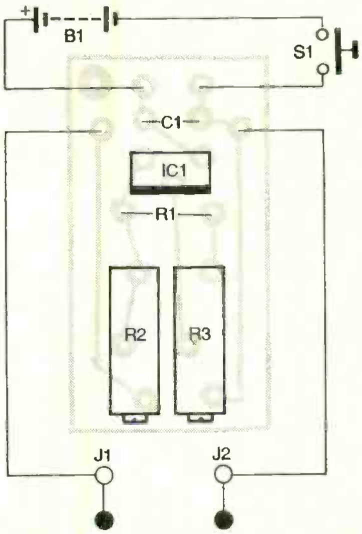
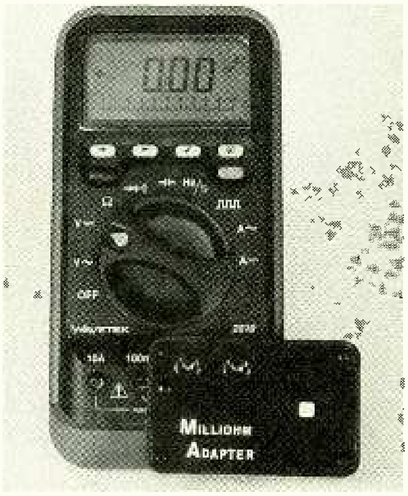


FIG. 2—PARTS-PLACEMENT DIAGRAM. This circuit is simple enough to point-to-point wire.

the locations on the lid of the case for the two banana jacks directly above the holes for the plugs.

Drill appropriately sized holes in the case bottom and lid for the banana plugs and jacks. Be sure to use insulated jacks if your case has an aluminum nal plug covers. Next install the



THE ADAPTER looks like it was custom made for this meter.

PARTS LIST

R1—1000 ohms
R2, R3—100 ohms, 20-turn potientiometer
C1—1 µF, disc capacitor
IC1—7806 6-volt regulator
B1—9-volt battery
S1—SPST momentary switch
J1, J2—banana jack/plug combo
Project case (Radio Shack No. 270-230 or similar unit), PC board, wire, solder.

Note: the following items are available from RAH Projects, P.O. Box 15904, N.B., CA 92659:
- **Etched and drilled PC board—$3.95 plus return postage**
- **Parts kit including PC board (no case)—$10.95 plus $2.50 S&H**

Check or money order, only. California residents please add sales tax. Allow 4 to 6 weeks for delivery. Personal check orders will be shipped after the funds have been cleared.

cover. Solder a 3-inch piece of test lead wire to each banana plug and install them in the bottom of the plastic case with No. 10-32 nuts instead of the origi-

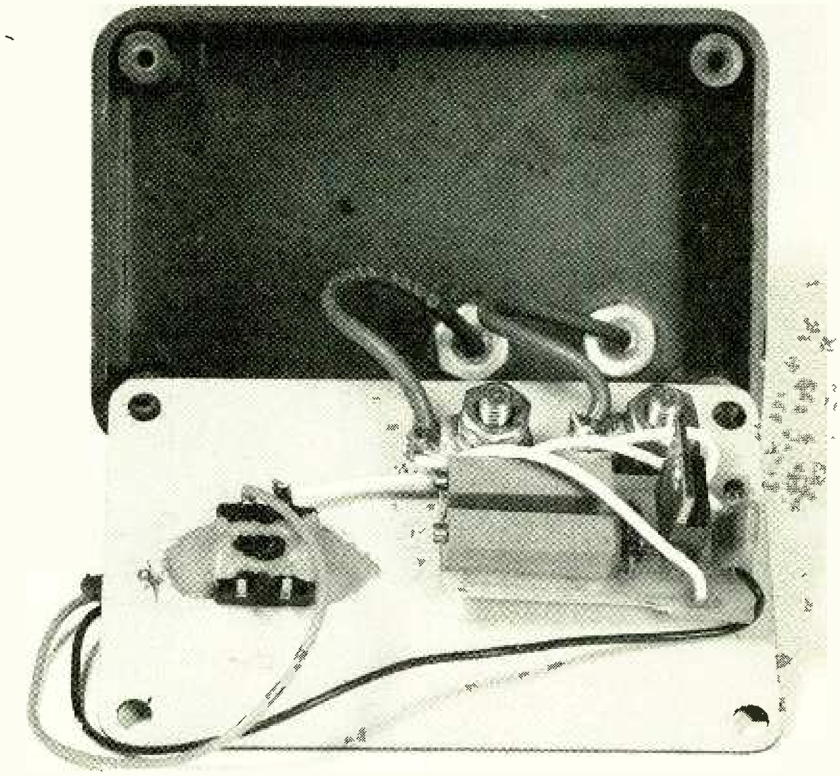
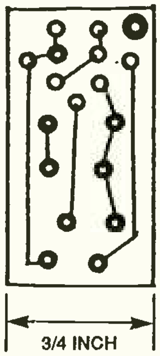


FIG. 3—THE INSIDE of the completed unit. The case is large enough to contain the 9-volt battery.



MILLIOHM ADAPTER FOIL PATTERN.

banana jacks in the case cover. Mount the PC board on the cover as close to the jacks as possible. You can secure it with No. 4-40 hardware on one corner with a plastic spacer.

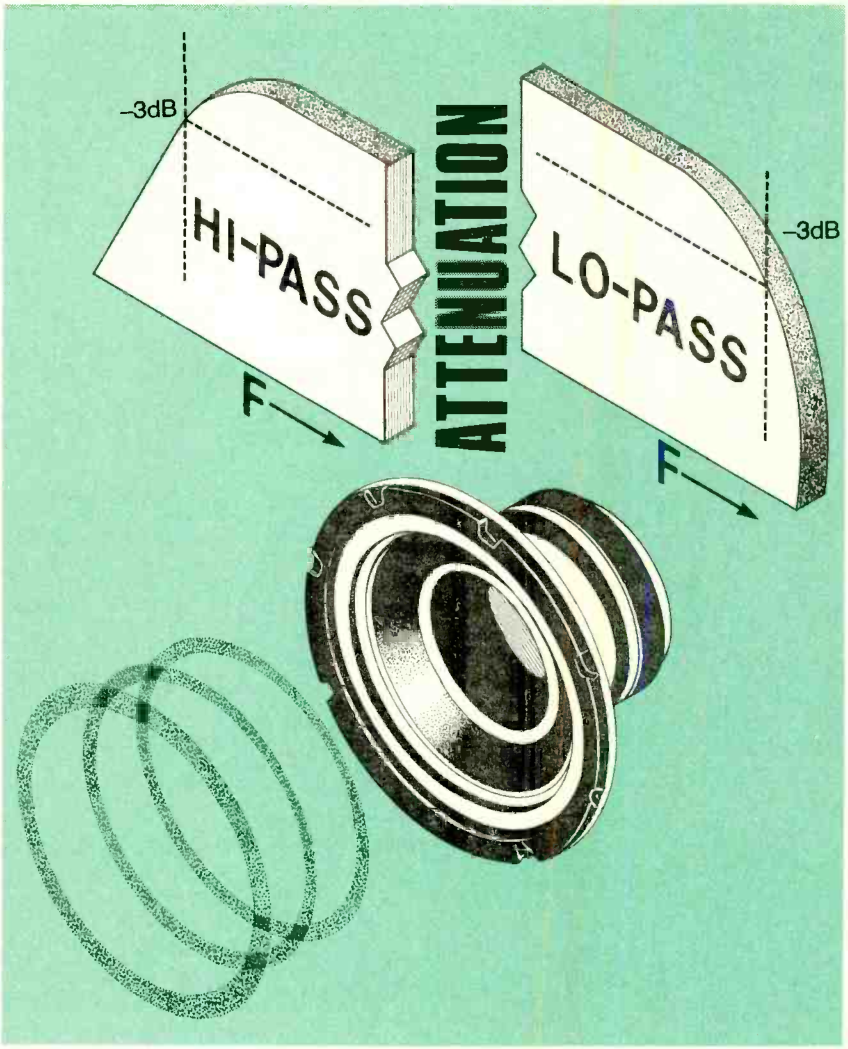
Any momentary switch will work in the circuit, but make sure there's enough room in the case for the 9-volt battery. The battery connector can be made from an old 9-volt battery. Remove the old battery case and cut the leads from the cells to the connector at the top. Solder on new wires, and keep in mind that the small connector is now negative and the large one is positive.

Attach the negative side of the battery to the negative PC board input and the positive side to one side of the momentary switch. Solder another wire from the remaining side of the momentary switch to the positive PC board input. Solder one output from the PC board and one banana plug wire to a spade lug on the back of one banana jack. Do the same for the other jack. Figure 3 shows the inside of the completed unit.

Calibration

With the cover still off, plug the adapter into the DMM and set the range of the meter to 20 volts. Press S1 and adjust R2 for 6 volts DC. Next, place an ammeter across the banana jacks and adjust R3 for a reading of 100 milliamperes. To calibrate the circuit when used in conjunction with test leads, short circuit the leads together and write down the reading; then subtract that reading from any readings you take with the test leads. Now get out that junkbox and start testing those components with unknown values. Ω

RAY MARSTON



High- and Low-Pass ACTIVE AUDIO FILTERS

Learn about high-pass and low-pass active audio filters, and design them for your experiments and projects.

ACTIVE FILTERS OVERCOME THE shortcomings of passive filters. They are formed by adding external passive networks to an operational amplifier. This article focuses on low-pass and high-pass active audio filters that include the industry-standard 741 op-amp. It explains how they can be tailored to meet specific audio requirements.

The last article in this series (January 1994) described the basics of the operational amplifier. Emphasis was given to its application in audio-signal processing. Some simple, op-amp-based, linear amplifier circuits were presented.

Audio filters

Audio filters reject unwanted frequencies in signal processing circuits and pass only the desired frequencies. As with filters for all other frequencies, there are audio high-pass, low-pass, bandpass, and notch or band-rejection filters. The simplest audio filters are passive, two-component resistor-capacitor (RC) filters.

Figure 1-*a* is the schematic for a simple L-section resistor-input filter in which capacitor C1 acts like an open circuit to low frequencies and a short circuit to high frequencies. As a result, this filter, called a *low-pass* filter, passes low-frequency signals, but rejects (severely attenuates) high-frequency signals. The output of this filter falls 3 decibels (dB) at a *cutoff* frequency (f_C) where:

(1) $f_C = 1/(2\pi RC)$

As shown in Fig. 1-*b*, frequency rolls off at a rate of 6 dB/octave (20 dB/decade) as the frequency is increased beyond cutoff. Consequently, a 1-kHz, low-pass filter attenuates a 4-kHz input signal about 12 dB, and a 10-kHz signal about 20 dB.

A second simple, passive RC filter is shown in Fig. 2-*a*. It is a capacitor-input, L-section filter. Here the capacitor also acts like an open circuit to low frequencies and a short circuit at high frequencies. Therefore, this *high-pass filter* passes high-frequency signals but rejects low-frequency signals.

The output of this high-pass filter is 3 dB down at a cutoff frequency, as determined by the formula (1) applied for the low-pass filter of Fig. 1-*a*. As shown in Fig. 2-*b*, it rolls off at a 6 dB/octave rate as the frequency is decreased below this value. Consequently, a 1-kHz, high-pass filter attenuates the signal 12 dB to 100 Hz.

Both of these filter circuits have single RC stages and are known as *first-order* filters. If an indefinite number of the same filter stages are cascaded together, the resulting circuit is known an *nth order* filter, it

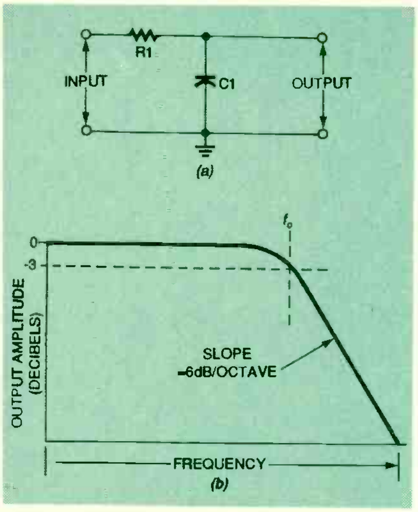


FIG. 1—RESISTOR-INPUT, FIRST-order RC filter (*a*) and response curve (*b*).

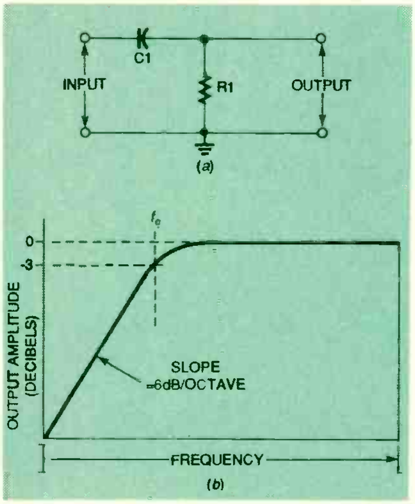


FIG. 2—CAPACITOR-INPUT, FIRST-order RC filter (*a*) and response curve (*b*

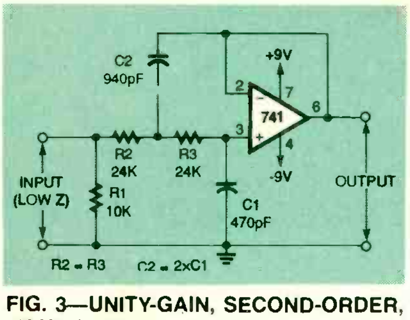


FIG. 3—UNITY-GAIN, SECOND-ORDER, 10kHz, low-pass active filter.

would have an output rolloff, beyond cutoff frequency of (n × 6dB)/octave.

For example, a fourth order, 1-kHz, low-pass filter would have a slope of 24dB/octave, and it would provide 48 dB of rejection to a 4-kHz signal, and 80 dB to a 10-kHz signal.

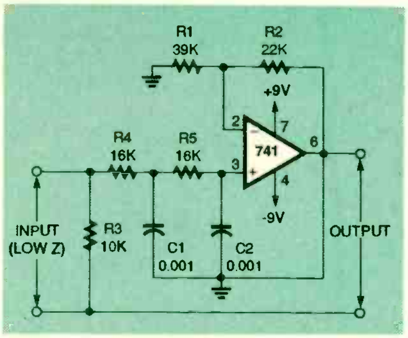


FIG. 4—EQUAL COMPONENTS, second order, 10kHz, low-pass active filter.

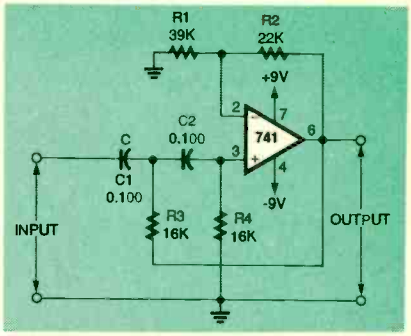


FIG. 7—EQUAL COMPONENTS, second order, 100-Hz, high-pass filter.

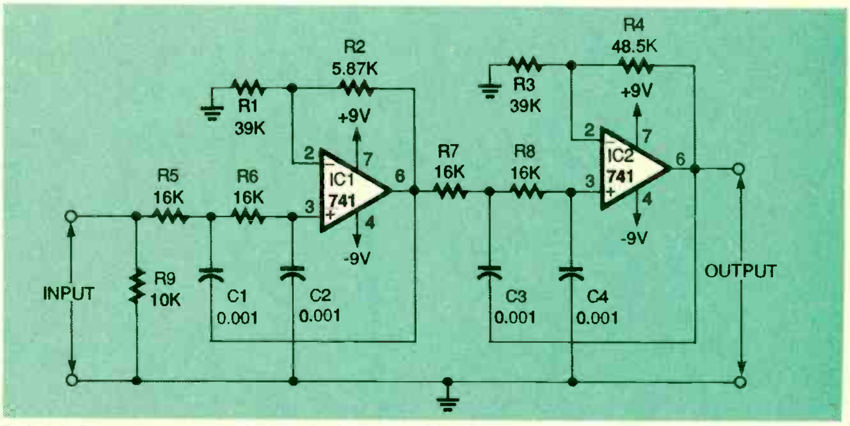


FIG. 5—FOURTH-ORDER 10-kHz, low-pass filter.

Active filter circuits

Simple RC filters cannot be directly cascaded because their interaction would adversely affect the results. However, they can be effectively cascaded through the use of feedback networks around operational amplifiers. Active filters based on operational amplifiers can be formed with external resistors and capacitors, avoiding bulky inductors.

Figure 3 is the schematic for a Butterworth filter. It is a unity-gain, second order, low-pass filter with a 10-kHz cutoff frequency. The Butterworth filter exhibits a maximally flat amplitude response in the passband

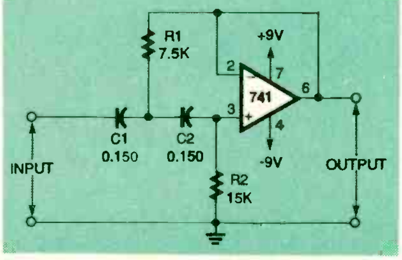


FIG. 6—UNITY-GAIN, SECOND ORDER, 100-Hz high-pass filter.

combined with moderate settling time and moderate overshoot. This circuit's output rolls off at 12 dB/octave beyond 10 kHz. The output would, for example, be 40 dB down at 100 kHz.

The formula for determining the cutoff frequency of this Butterworth filter is:

(2) $f_C = 1/(2.83\pi RC)$

The cutoff frequency can be altered by changing the values of the resistors and capacitors in the active filter. The terms in formulas (1) or (2) (as appropriate) can be rearranged to solve for a specific cutoff frequency, provided that either the value of the resistor or capacitor is set.

A minor drawback to the Fig. 3 schematic is the requirement that one of it's capacitor values should be precisely twice the value of the other. (In Fig. 3, capacitor C2 has twice the value of C1). This constraint typically calls for finding nonstandard capacitor values.

Figure 4 shows an alternative active low-pass filter. It is a second-order filter with a 10-kHz

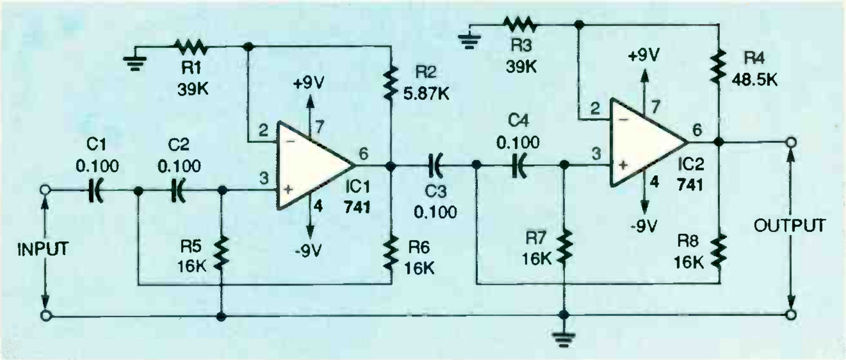


FIG. 8—FOURTH ORDER, 100 Hz, HIGH-PASS FILTER.

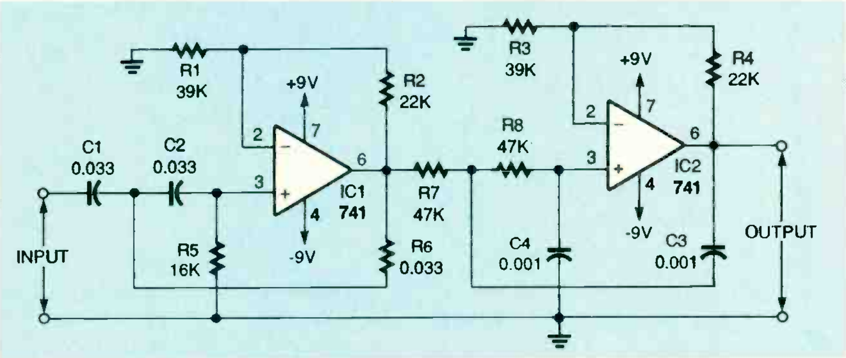


FIG. 9—SECOND-ORDER SPEECH FILTER FOR 300 Hz to 3.4 kHz speech filter with a second-order response.

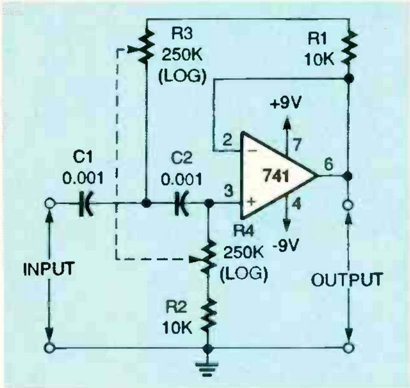


FIG. 10—VARIABLE HIGH-PASS FILTER covering the 23.5 to 700 Hz band.

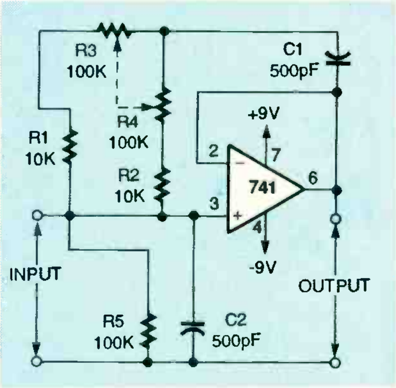


FIG. 11—VARIABLE LOW-PASS FILTER covering the 2.2 to 24 kHz band.

with a rolloff of 24 dB/octave. In this example, the gain-determining resistor ratio of R1/R2 is 39 kilohms divided by 5.87 kilohms or 6.644.

The ratio of R3/R4 equals 39 kilohms/48.5 kilohms, which equals 0.805, and the overall voltage gain of the circuit is 8.3 dB. The nonstandard values of R2 and R4 can be obtained by connecting two standard 5% tolerance resistors in series to equal the values shown.

Figure 6 is a second-order, 100-Hz, high-pass filter with unity gain. Resistor R2 has twice the value of R1. Figure 7 is an "equal component" version of that filter in which R3 equals R4. Figure 8 illustrates a fourth-order, high-pass filter. The operating frequencies of the filters in Figs. 6 and 7 and those of Figs. 4 and 5 can be altered the same way as can be done with the Fig. 2 schematic. The resistor and capacitor values can be increased to reduce the cutoff frequency, or vice versa.

Figure 9 shows how the high-pass filter schematic of Fig. 7 and the low-pass filter schematic of Fig. 4 can be connected in series to make (with suitable component value changes) a 300-Hz to 3.4-kHz speech bandpass filter. It gives 12dB/octave rejection to all signals outside of that frequency range.

In the high-pass filter of Fig. 7, the capacitor values are one-third of the original values to raise the cutoff frequency from 100 Hz to 300 Hz. In the low-pass filter of Fig. 4, the original cutoff frequency that overcomes the drawback of the circuit in Fig. 3. The capacitors R4 and R5 have equal values. The industry standard 741 op-amp, specified in both Figs. 3 and 4, provides a voltage gain of 4.1 dB through resistors R1 and R2. These must have the values shown in Fig. 4. The cutoff frequency for this "equal components" filter can be determined by formula (1), given earlier.

Figure 5 shows how two of these "equal component" filters can be cascaded to make a fourth-order, low-pass filter

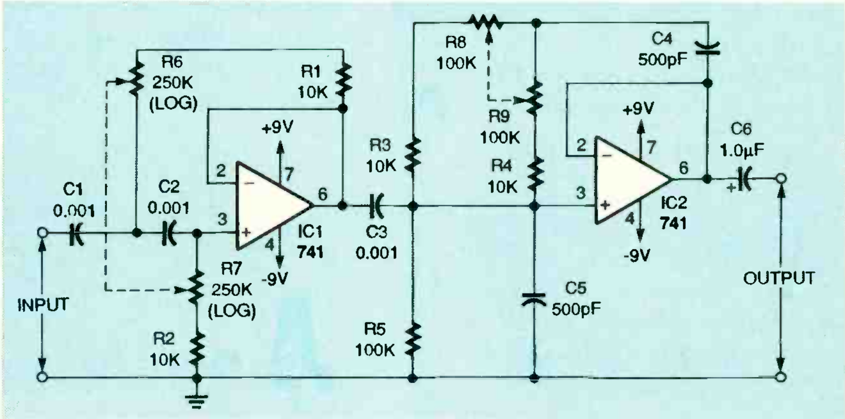


FIG. 12— VARIABLE HIGH-PASS/LOW-PASS FILTER for filtering rumble, scratch, and speech.

resistor values are multiplied by 2.94, to reduce the cutoff frequency from 10 kHz to 3.4 kHz.

Variable active filters

The most versatile active filter is one whose crossover frequency is fully and easily variable over a fairly wide range. Figures 10, 11, and 12 are three practical schematics of second-order variable active filters.

The Fig. 10 schematic is a simple modification of the high-pass filter shown in Fig. 6, but its cutoff frequency is variable from 23.5 Hz to 700 Hz by uniformly adjusting matched potentiometers R3 and R4. (They can be mechanically ganged.) In this circuit the resistors in the RC networks have identical values (unlike those in Fig. 6), so this design does not give the maximally flat Butterworth filter characteristic. Nevertheless, it still offers very good filter performance.

This circuit can function as a high-quality rumble filter for an LP disk turntable. "Fixed" versions of this filter usually have a cutoff frequency of 50 Hz.

The Fig. 11 schematic is a modification of the high-pass filter shown in Fig. 3, but its cutoff frequency is fully variable from 2.2 kHz to 24 kHz by uniform adustment of matched potentiometers R3 and R4. (Again, these can be ganged.) As in the Fig. 10 schematic, this filter does not provide the maximally flat Butterworth characteristic. This is a high-quality filter for removing scratch noise. "Fixed" versions of this filter typically have a cutoff frequency of 10 kHz.

Figure 12 is a schematic showing how the filters in Figs. 10 and 11 can be combined to form a versatile, variable, high-pass/low-pass filter for removing rumble and scratch noise from speech. Both the low-pass and high-pass cutoff frequencies are fully variable. By uniformly adjusting matched (or ganged) potentiometers R6 and R7, the high-pass cutoff frequency can be varied from 23.5 Hz to 700 Hz. Similarly, R8 and R9 can vary the low-pass frequency from 2.2 kHz to 24 kHz.

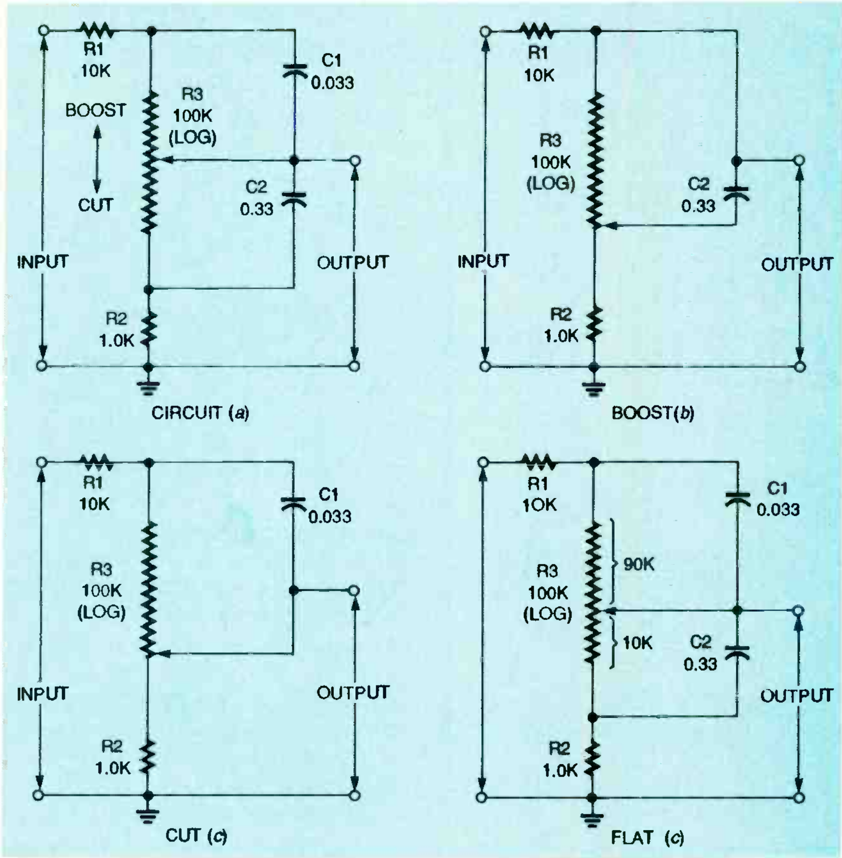


FIG. 13—BASIC CIRCUIT FOR A BASS tone-control network (*a*) and equivalent circuits for boost (*b*), cut (*c*), and flat (*d*).

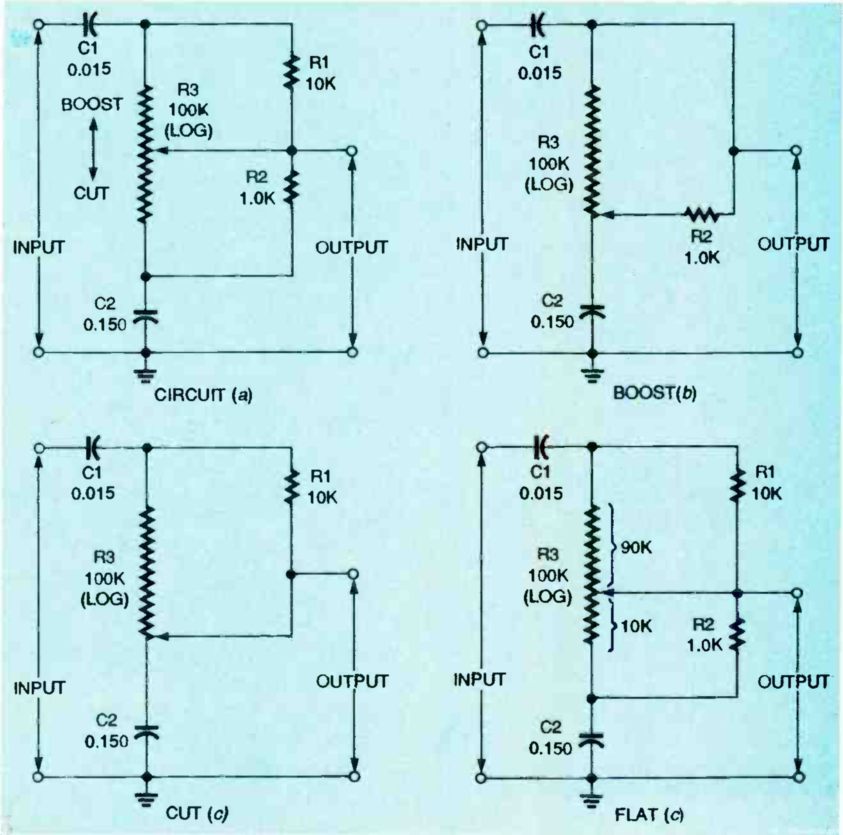


FIG. 14—BASIC CIRCUIT FOR A treble tone-control network (*a*) and equivalent circuits for boost (*b*), cut (*c*), and flat (*d*).

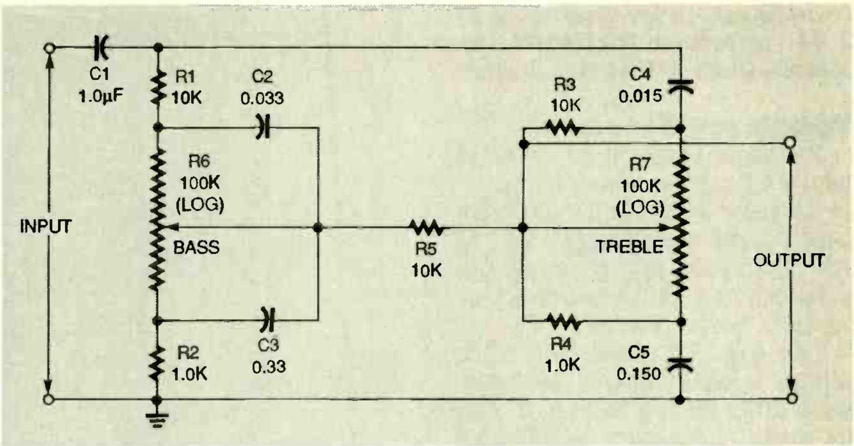


FIG. 15—PASSIVE BASS AND TREBLE tone-control network.

Tone-control networks

The most popular variable filter circuits are those dedicated to audio tone control. They allow the system's frequency response to be altered to suit individual hearing requirements or moods. Moreover, they can compensate for anomalies in room acoustics.

Before discussing tone-control circuits, some basic tone-control concepts and circuits will be analyzed.

Figure 13-*a* shows a typical passive, bass, tone-control network. It can boost or reduce (cut) the low frequencies within the audio spectrum of 20 to 20,000 Hz. The vertical double-ended arrow next to trimmer potentiometer R3 indicates the direction of wiper movement to obtain *boost* (up) and *cut* (down).

Figures 13-*b* to 13-*d* illustrate the equivalent circuits when potentiometer R3 is set for maximum boost, maximum cut, and *flat* positions, respectively. Capacitors C1 and C2 are effectively open-circuited when the frequency is at its lowest bass value.

Consequently, as shown in Fig. 13-*b*, the boost circuit is equivalent to a 10-kilohm resistor divided by a 101-kilohm resistor. Bass signals are only slightly attenuated.

The Fig. 13-*c* reduction or cut equivalent circuit, by contrast, is equal to a 110-kilohm resistor divided by a 1.0-kilohm. This results in about a 40 dB attenuation of bass signals. Figure 13-*d* shows potentiometer R3 set to its flat position. In that position, 90 kilohms of the resistive element is above the wiper and 10 kilohms is below it. The circuit is equal to a 100-kilohm resistor divided by an 11-kilohm resistor.

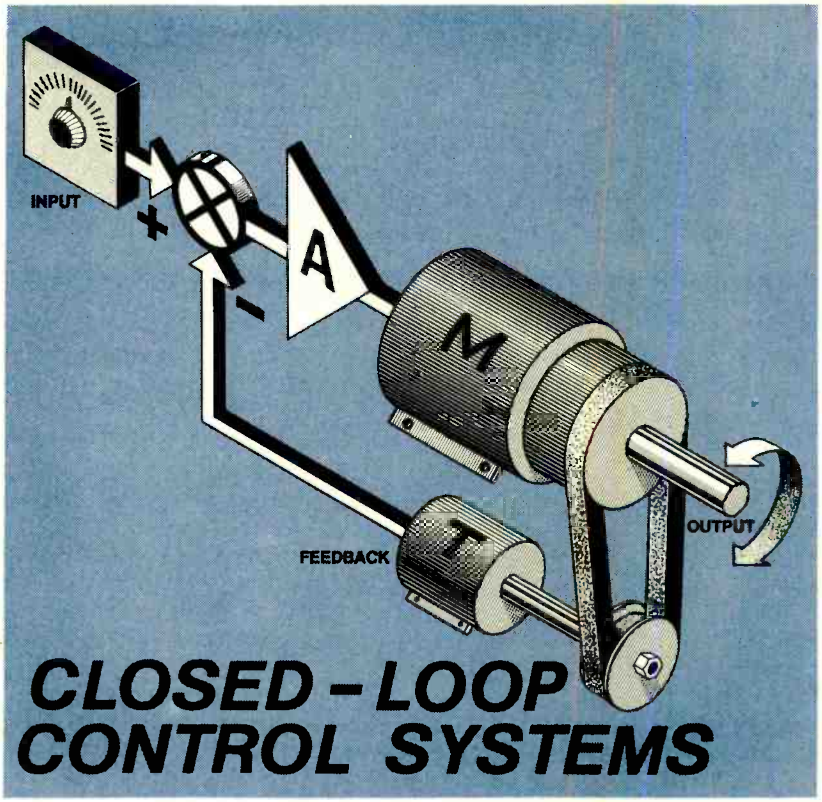
This circuit arrangement produces about 20 dB of attenuation at all frequencies. As a result, the circuit gives a maximum bass boost or reduction of about 20 dB relative to the flat signals.

Figure 14-*a* is a typical schematic for a passive treble tone-control network. The network can effectively boost or reduce the high-audio frequencies within the 20 to 20 to 20,000 kHz audio spectrum.

Figures 14-*b* to 13*d* illustrate electrically equivalent circuits under the maximum boost, maximum reduction, and flat operating conditions, respectively. This circuit gives about 20 dB of signal attenuation when R3 is in the flat position, and maximum treble, boost, or reduction values of 20 dB relative to the flat performance of the filter.

Figure 15 shows how the circuits in Figs. 13-*a* and 14-*a* can be combined to make a complete passive bass and treble tone-control network. Ten-kilohm resistor R5 has been added to the circuit to minimize unwanted interaction between the two sections of the circuit. The input to this circuit can be taken directly from an amplifier's volume control, and the output can be fed to the input of a main power amplifier. Ω

DENNIS EICHENBERG



CLOSED-LOOP CONTROL SYSTEMS

Learn the fundamentals of closed-loop control systems—their design and applications.

WE ARE SURROUNDED BY BOTH open-loop and closed-loop control systems that are not usually recognized by those names. An open-loop control system can perform a useful function without having its performance continuously corrected. By contrast, a closed-loop system requires continuous monitoring and correction to carry out its function.

Both of these systems play important parts in our lives, but the availability of low-cost, reliable, solid-state electronics is making closed-loop control, especially servosystems, more cost-effective than ever.

Generally speaking, the terms open-loop and closed-loop control systems apply to electronic, mechanical, and electromechanical systems, but biological systems also exhibit many of the same characteristics. Some common examples of open-loop systems are a table fan, a space heater, an electric drill, and a vacuum cleaner. Those appliances are usually powered from the AC line and turned on and off with a switch. A change in load, voltage, motor speed, or operating environment can cause a change in their operating characteristics.

As a result, some of those appliances have controls that permit speed, temperature, airflow, or some other variable to be adjusted within limits. While those controls compensate for changes in operating conditions or environment, continuous adjustment of their controls is not required for the appliances to perform their intended functions.

Figure 1 is a block diagram of an open-loop control system that is drawn with standard control engineering conventions. An arrow at the input side of the two blocks represents the desired function. The first box labeled *controller and amplifier* represents those components that translate the input setting into a means for controlling an actuator—in this diagram a motor—and its load. The output represents the desired performance of the appliance.

By contrast, a closed-loop control system, as shown in Fig. 2, requires continuous correction for optimum performance. The loop is closed by a sensor or transducer capable of measuring some physical variable and translating that measurement into a signal that can be mixed with the system input signal, which is a reference signal or *setpoint*. The objective of the system is to make its output equal to its input.

The feedback sensor measures a physical variable such as voltage, current, velocity, position, temperature, or pressure, and a signal proportional to that measured value is compared with (subtracted from) the input. The difference is called the *error signal*, or simply the *error*.

Both the feedback signal and the input or reference signal must be in the same domain (such as a voltage or current level) for the signals to be mixed. The output of the mixer, the error signal, is proportional to the difference between the feedback and the input signal. That error signal is then applied to the system amplifier as a correction signal.

If the output is equal to the input, this difference is zero, and no signal reaches the actu-

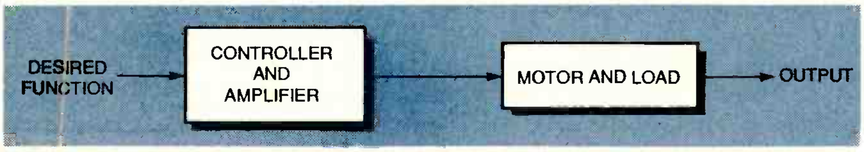


FIG. 1—A DIAGRAM FOR AN OPEN-LOOP CONTROL SYSTEM that could represent any of a number of different household appliances.

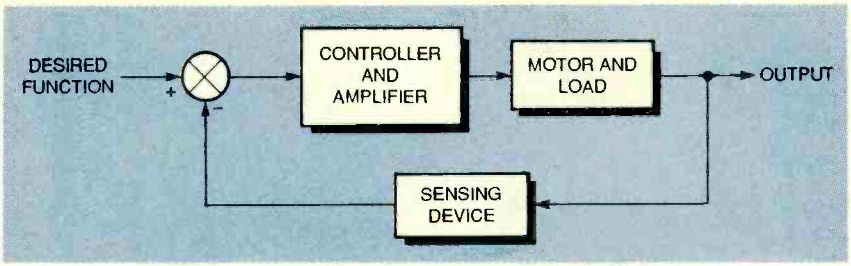


FIG. 2—A DIAGRAM FOR A TYPICAL CLOSED-LOOP SYSTEM that could represent a machine tool, a process control, or a robot axis.

ator (also a motor in this diagram) with its load. Hence the system output remains at its existing value. In a properly designed system, if the error is not zero, the error signal causes a response in the actuator that is intended to reduce the magnitude of the error to zero.

A closed-loop system is essentially insensitive to changing conditions in the system and. therefore, will continue to function correctly despite changes in load, amplifier gain, wear on the mechanical components, and even changes in the ambient temperature.

However, a system consisting of these elements is inherently unstable, and it can be considered as analogous to a spring with a weight on one end. Care must be taken to ensure that the system is not subjected to too great an error signal or a destructive chain of events could follow.

The controller and amplifier perform an interface role which includes filtering out irrelevant signals from the actuator. It is usually not practical to apply the error signal directly to the actuator. Among the many forms of closed-loop systems are the home-heating system, automobile cruise controls and antilock-braking systems (ABS), and linear and switching power supply voltage regulators.

Figure 3 is a block diagram of a home heating system with a single feedback loop. Here, a furnace (gas-, oil-, or electric-fired), a motor, and a fan form the *plant*, and the air in a room or house is the *load*. If this system did not have a feedback loop (i.e., it was operated open-loop), once switched on, it would continue to run indefinitely until it was shut down manually.

Most home heating plants are designed so that if they ran continuously, they would raise the room or home interior temperature well above human comfort level even during the winter, making the living space too hot for the comfort of its occupants. Except during the most extreme cold weather, the well designed heating plant does not run at full capacity. Under normal winter weather conditions, the excess heat is neither desired nor required, so continuous operation would only waste both electric power and fuel.

In the regulated home-heating system, the input is the manual setting of the thermostat, which performs two functions. If an increase in room temperature is desired, the setting on the thermostat is increased. The thermostat also functions as the sensor in the temperature feedback loop.

A thermal switch based on a bimetal element which bends up or down when the temperature changes, the home-heating thermostat is wired in a separate low-voltage circuit. Its contacts close when the ambient air temperature is below the manually adjusted temperature setpoint. When those thermostat contacts close, a low-voltage step signal is sent to the coil of the power relay which closes its AC line contacts and applies power to the plant.

Servosystem Terms

Encoder—An electromechanical component that converts motion into output pulses that can be counted to determine the position of an actuator or servomotor. The most common form of encoder for a robot is an optical shaft encoder that can measure shaft revolutions per minute or shaft angle. These sensors contain a rotating disk whose opaque areas intermittently break or "chop" an internal light beam between a photoemitter and a photosensor.

The two basic types of optical shaft-angle encoder are the *incremental* and *absolute* encoders. There are also linear encoders that measure machine movement over a straight-line path.

Robots are usually fitted with incremental optical shaft encoders because they are easier to interface to computers than absolute encoders. Their up-down counting circuits accumulate output pulses which permit them to indicate extremely small changes in the encoder's shaft position.

Absolute encoders measure actual shaft position and retain that information even after power shutdown. They are more expensive but, unlike incremental encoders, do not have to be synchronized or reset after they are stopped.

Resolver—A rotary electromechanical transformer that contains a rotor and a stator with two winding 90° apart so that they provide sine and cosine outputs as a function of rotor position. Its construction is similar to that of an electric motor. Brushless resolvers permit the primary excitation voltage to be coupled through a transformer rather than through brushes and slip rings. It is an alternative to the encoder for providing position feedback.

The rotor winding is excited by an AC reference voltage. The magnitude of the voltage induced in any stator winding is proportional to the cosine of the angle between the rotor-coil axis and the stator-coil axis.

Resolvers measure this phase angle difference between the AC reference voltage input and the output of the rotor coils. Rotor position can be determined by comparing the time-phase shifted output signal with the input signal. Resolvers are usually mechanically coupled to the servomotor.

Position can be converted into a digital format with electronic circuits that count the number of pulses between the zero crossing of the two signals. There are three widely used techniques for converting resolver outputs into digital format: (1) tracking, (2) successive approximation, and (3) time/phase shift.

Tachometer—A generator that produces a DC output voltage that is proportional to the angular speed in revolutions per minute at which it is driven. When used as a sensor in the velocity feedback loop of a servosystem, it is coupled mechanically to the rotating shaft of the servomotor, usually through gears. When the tachometer output signal is mixed with a reference signal or setpoint, it produces an error.

Transfer function—The mathematical relationship between the output and the input of a control system.

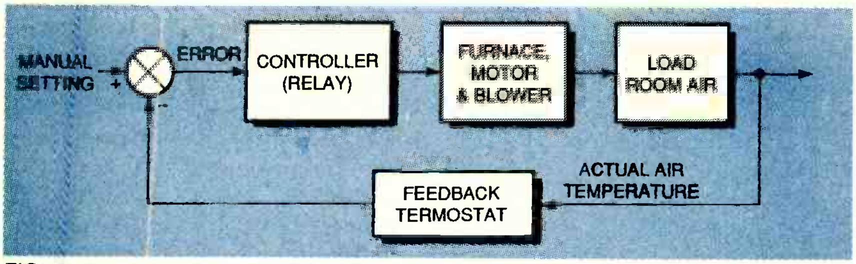


FIG. 3—A HOME HEATING SYSTEM diagrammed as a closed-loop servosystem. The thermostat is both the setpint control and feedback sensor.

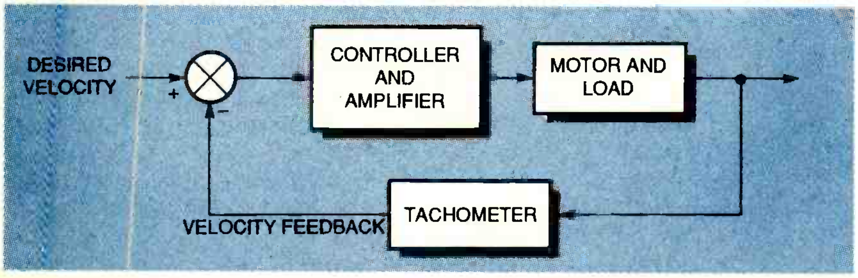


FIG. 4—A VELOCITY-CONTROL SYSTEM with a single feedback control loop suitable for a portable drill.

In this system, the relay functions as an amplifier and buffer that filters out unwanted transients in the feedback loop. Once turned on, the plant will remain on until the ambient temperature of the room reaches or slightly exceeds the setpoint. At that temperature, the thermostat contacts open, causing the relay contacts to open, which shuts down the plant.

A home heating system is classed as a "bang-bang" control system because the thermostat contacts are either open or closed. However, the error is, nevertheless, proportional to the difference between the setpoint and the ambient room temperature.

In an actual home heating system, there are likely to be a time delays in the relays that control the fan and furnace. Fan turn- on might be delayed until the furnace reaches a specified temperature to prevent it from blowing cold air, and its shutdown might be delayed so that it will dissipate residual heat in the furnace.

Regulators vs. servosystems

Because of differences in their characteristics and objectives, closed-loop control systems are usually classed as *regulators* or *servomechanisms*. If the control system must maintain a physical variable at some constant value in the presence of disturbances, the system is usually called a *regulator*. Regulators typically control such variables as voltage, current, light intensity, pressure, or pH factor.

Power supply voltage regulators (as discussed in *Electronics Now*, December 1994, page 69) are examples. They maintain the supply's output voltage at a constant value despite changes in the electrical load. Another example is the human physiological response system that maintains the temperature of the body at approximately 98.6°F in temperature environments that can vary widely from the human comfort zone of about +72°F ±10°.

The term servomechanism was originally applied to systems that are mechanically driven by the error signal between the input and the output or load position so that the load position output will agree with the input in position or motion. However, the term *servosystem* is now widely applied to any automatic control system in which a physical variable must follow, or track, some desired time function.

One example of a servomechanism is the automatic pilot that keeps an aircraft flying at a preset altitude and speed on a fixed course, despite wind shifts, turbulence, and engine speed changes. Another example is the robot in which the *end effector* or robot hand is moved over a path in space to accomplish some task. Both of these systems include multiple servomechanisms, each of which might have multiple feedback loops to control different variables simultaneously.

Velocity and position control

Figure 4 is the block diagram for a *velocity control system*. In this servomechanism, the motor is called a *servomotor*. A *tachometer* in the feedback loop senses the speed of the servomotor and feeds back an electrical signal (voltage or current) that is proportional to motor shaft speed or velocity. Here the feedback loop ensures constant motor output velocity.

This closed-loop system can be included in a machine tool or power drill to compensate for differences in the load—the material it is cutting or drilling. Hard materials will slow down the drill or other cutting tool, while soft material will allow the motor to speed up.

In a motor velocity feedback loop containing a tachometer, tool speed will remain constant because, if the cutting tool slows, the feedback signal commands the motor to speed up. Similarly, if the tool cuts through the work or encounters unusually soft material, the feedback loop will prevent the motor from racing.

However, if required by the application, additional control circuitry can be included to bring the motor up to a desired velocity gradually (ramp up) and then gradually ease it back to a stop (ramp down). The velocity profile can be a triangle (ramp up and ramp down) or it can be a trapezoid (ramp up, hold at a specified velocity for a specified time period, and then ramp down).

Figure 5 is the block diagram for a *position control system*. In addition to a tachometer in its velocity control feedback loop, this servomechanism has a separate position feedback loop

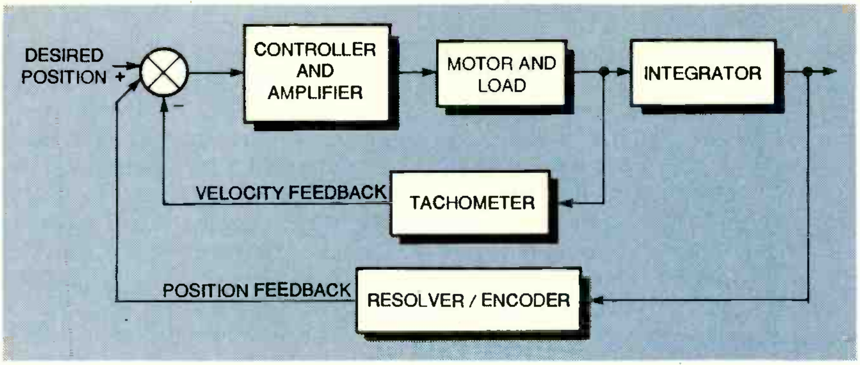


FIG. 5—A POSITION CONTROL SYSTEM with both velocity and position feedback control loops.

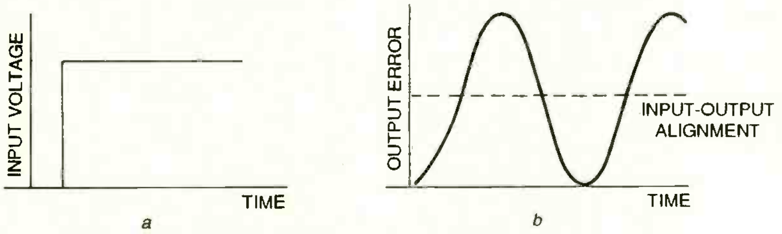


FIG. 6—PLOT OF A VOLTAGE STEP FUNCTION at the input of a servosystem (*a*), and the plot of oscillations at the output of an unstable, undamped servosystem (*b*).

that includes either an *optical encoder* or a *resolver*.

Either of those sensors can determine when the servomotor shaft has arrived at the desired angular position by counting pulses and comparing them with the input signal before stopping the shaft when the counts are equal. There is also a block labeled *integrator* in Fig. 5. It is usually an electronic circuit that controls shaft position. A velocity sensor in the feedback loop of a position control system helps to stabilize it.

In a *torque control system*, servomotor torque is kept constant. Because servomotor torque is proportional to servomotor current, a constant current must be furnished to the motor to maintain the torque. This is typically done with a circuit that compares the servomotor's output current with its input current and amplifies the difference for use as a torque-control feedback circuit.

Incremental motion control systems include a means for switching from one control mode to another to obtain the desired performance. A velocity/position control, for example, can control motion with velocity in accordance with a desired velocity profile, but it can be switched to position control to stop the shaft more accurately. This system is included in advanced robots to be discussed later.

Servosystem features

The components of all servosystems are essentially the same, but the refinements depend on desired performance requirements. As stated earlier, the objective of all servosystems is to maintain zero error and respond to all deviations as fast as possible. Feedback in closed loops provides the necessary accuracy because the servosystem continually tries to correct any error that exists.

However, this corrective action can cause dangerous instability in the system if the components have large amplification characteristics and are allowed to respond over periods that are too long. An unstable system does not maintain zero error and permits large variations or even sustained oscillations of the system actuator or servomotor.

For stable system operation, it is necessary that the system be designed with an adequate margin of stability. This will permit the system to recover rapidly and smoothly from the shock of irregular or "step" inputs. However, the requirements for accuracy and speed of response are not independent of the requirements for stability.

If a servosystem requires high amplification, the time allowed for corrective action must be minimized. The consequences of a long time delay are usually less serious in a low-gain system. After corrective action has been initiated in a servosystem, it is important that the output not be driven beyond the desired position.

It is also important that there be sufficient compensation for inherent delays in the system. Attempts to improve accuracy can cause instability; conversely, providing wide margins of stability can decrease accuracy.

Step function response

The stability of a servosystem can be determined by subjecting it to a large input error called a *step command* or *step function* and observing the response. A step function is illustrated as a fast-rising voltage level in Fig. 6-*a*. A stable control system will always return to a stable operating state unless it fails catastrophically. However, an unstable system will go into oscillations, and these will usually continue until some key component fails.

There are four possible responses to a step command in a closed-loop servomechanism: *underdamped*, *overdamped*, *critically damped*, and *unstable*. Figure 6-*b* shows the effect of a step function on a frictionless velocity control (single-feedback loop) servosystem such as the one shown in Fig. 4. The output pattern looks like a sinewave.

The amplifier amplifies the error signal and the load on the output shaft has inertia (it is sluggish in its response). As a result, the system has the ability to store energy and release it to sustain oscillations. Thus, if the input shaft is suddenly displaced by a step function, the large resulting error is amplified. This causes the servomotor to accelerate in the direction necessary to cancel the error, shown as the positive sloping curve starting at the origin of Fig. 6-*b*.

Nevertheless, because of energy stored in the load, the output shaft continues turning past the position of input-output alignment (indicated by the dotted horizontal line in Fig. 6-*b*). This response, called *overshoot*, occurs because there is no friction in the system to damp it out.

However, once the output shaft has passed the alignment position, the polarity of the error will be reversed, and this error will also be amplified. The reversed error causes a reversal of motor output torque, which then opposes the movement of the load initiated by the step function.

The output shaft continues to move in the same direction because of its inertia. Meanwhile, the reverse error signal and motor torque increase until the motor torque is great enough to overcome the inertia of the load and bring the output shaft momentarily to a halt.

Nevertheless, the negative error persists and the motor torque accelerates the output shaft back in the opposite direction as shown in the negative going curve in Fig. 6-*b* toward the alignment position. But it continues on in what is termed *undershoot*. This undesirable and potentially destructive oscillation, known as *hunting*, will continue unattenuated in a frictionless system, unless a means is found to remove energy from the load.

Friction braking is one of the most effective methods for damping out or suppressing undesirable hunting. If a brake is mounted on the output shaft, it will remove energy while the shaft is in motion. The speed of damping depends on how the friction is applied to the output shaft.

Figure 7 illustrates graphically the three other forms of response to a step function: overdamped, underdamped, and critically damped. As friction is increased, the number and amplitude of overshoots and undershoots decreases. The *underdamped* curve is labeled as curve 1. By contrast, if excessive friction is applied to the system, the result is the *overdamped* curve 2.

When the system is critically damped, the response is shown as curve 3. This curve is the result of just enough braking to prevent minimal overshoot. However, most servosystems are designed for slight underdamping because they are more responsive than if they were designed either critically damped or overdamped.

The inertia of the servosystem's mechanical load stores energy like a flywheel. Another distinguishing characteristics of these systems occurs if a sinusoidal voltage rather than a step voltage is applied to the servomotor. The output shaft will move sinusoidally and will lag the motor voltage. Other time lags are introduced by the motor itself.

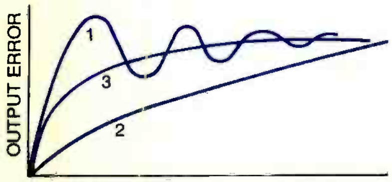


FIG. 7—RESPONSES OF A servosystem to the braking of a step input command: Curve 1—underdamped; Curve 2—overdamped; and Curve 3—critically damped.

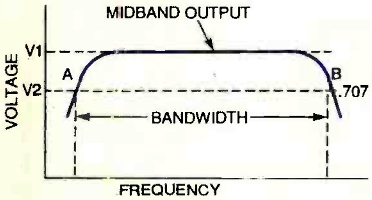


FIG. 8—DIAGRAM ILLUSTRATING bandwidth, the band of frequencies between the half-power points A and B.

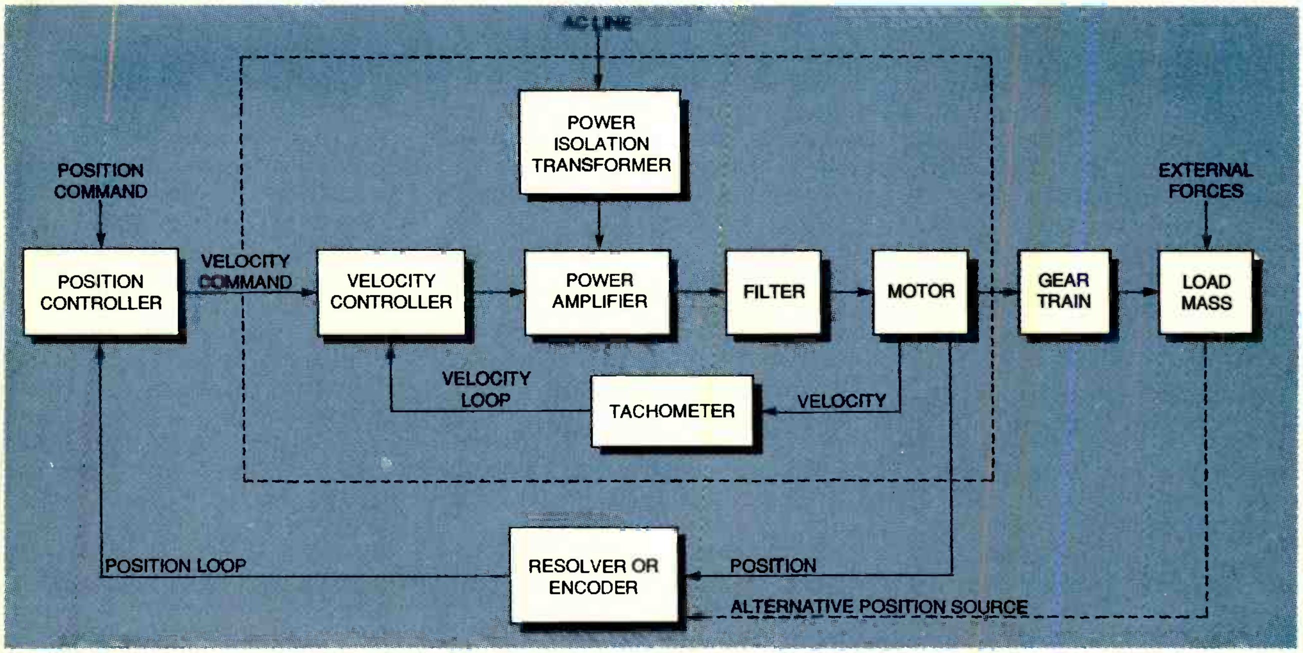


FIG. 9—A DC SERVO SYSTEM for one axis of a robot. The position and velocity controllers can be one computer.

System bandwidth

The *bandwidth* of a servosystem is the frequency band over which amplifier gain is essentially constant. It is defined as the frequency difference between the *half-power* points, labeled A and B in Fig. 8., plotted on a graph of output voltage vs. frequency. If it is assumed that load resistance is constant, the *midband* output voltage is the amplitude of the constant output voltage between the half-power points A and B.

The half-power points are those points at both ends of the frequency curve where output voltage has fallen to 70 % (0.707) of its midband voltage. Bandwidth can also be defined as the response of a system as frequency is increased from its lowest value of useful output, A, to its highest value of useful output, B.

Digital vs. analog systems

A digital servocontrol system has at least one digital component in its control loop. That component could be a microprocessor, a microcontroller, an optical encoder or a pulse-width modulated (PWM) servomotor amplifier. In general, digital components improve system performance by allowing more flexibility in the design.

A digital servosystem might also have analog elements such as the servomotor, a resolver, or amplifier. If the system has a digital controller such as a microprocessor or microcontroller, it processes the data in digital format. This conversion calls for the inclusion of such components as resolver-to-digital and digital-to-analog converters that interface between the two data formats. A servomotor can be driven by either digital or analog signals.

However, an optical encoder quantizes actuator or servomotor shaft position and produces a digital signal which can be fed directly to the digital controller circuit with no additional conversion.

Practical applications

The modern automobile is classified as an open-loop system although it might contain as many as a half dozen closed-loop regulators or servosystems. However, when the automobile is being driven, it can be considered to be a system whose multiple loops are closed around a human driver.

The eyes, ears, nose, and tactile senses are all sensors that feed information to the brain about driving conditions. In addition to viewing the condition on the road such as traffic, the color of traffic lights, and construction obstructions, the eyes can also scan the instrument panel to determine the status of such variables as speed, engine temperature, engine revolutions, and fuel level.

The ears detect open-doors, unusual engine noises, or audible warning signals. The nose can detect burning smells indicating engine or brake trouble, and the tactile sensors can warn of rough patches on the road that call for slowing the car and perhaps making a detour around them.

The brain, acting as the controller, filters all of those incoming (multichannel) messages and directs the hands to turn the steering wheel and the foot to apply pressure to the accelerator (and alternately to the brake pedal). In this situation, human muscles are analogous to the servomotors.

The robot is a kind of limited capability substitute for a human being. It is defined as a reprogrammable, multifunction manipulator that moves objects through programmed motions for the performance of various tasks. Thus a robot is able to perform monotonous, heavy-duty jobs in dangerous or inhospitable environments such as welding, paint spraying, grinding, and heavy materials handling.

Nevertheless, light-duty robots can measure and inspect finished products and pick up and place miniscule components on circuit boards at high speed with high accuracy. These machines relieve humans of monotonous but not necessarily dangerous tasks.

However, the programmable controller separates the true robot from a *telecheric* or robot-like systems such as a remote-controlled, tracked land crawler for bomb disposal or a remote-controlled, submersible vehicle for undersea exploration. Those machines are, like the automobile, manually operated. This might not be obvious because the human operator could be hundreds of feet or even several miles away. The platform is guided by a picture obtained from a TV camera, and commands are sent over cable or radio links.

A true robot can complete a well defined task without human intercession, and it might also include the capability for adapting to certain minor changes in the environmental or working conditions. Today, the feedback loops of most robots are closed around microprocessors programmed with software or microcontrollers programmed with firmware.

Robot servosystems

To be useful, the robot's end effector or hand must be capable of moving in three dimensions with three degrees of freedom: pitch, roll, and yaw. To accomplish this, some sophisticated robots have as many as six movable axes, each including some form of actuator or servomotor. Those permit precise positioning of the end effector that contains the tool.

Today, most industrial robots are driven by DC electric motors because they offer fast, accurate response. (Some light-duty robots have pneumatic servomotors, and some heavy-duty robots have hydraulic servomotors.) Figure 9 is a block diagram of a typical robot DC servomotor system for one axis. Not shown are blocks representing A/D and D/A converters and associated multiplexing circuitry for signal processing and transmission.

Multipurpose machine tools and industrial process controls might also include servosystems similar to those found in robots, especially if they are computer controlled. Ω

HARDWARE HACKER

Scientific resources, online services, automotive computer basics, servicing intermittent problems, and "mystery band" opportunities.

DON LANCASTER

A pair of new scientific resources might be of interest to you. One is Shawn Carlson's new *Society for Amateur Scientists*. It is intended to foster collaboration between amateurs and professionals. It offers some new methods for individuals who want to do credible research.

Carlson says, "We are preparing to support amateur projects with grants, awards, equipment and expert advice. Our philosophy is to focus on people and let the science largely take care of itself."

Meanwhile, Carl Helmers of *Byte Magazine* fame is starting up a new *SETIQuest* magazine. The subjects will include bioastronomy tutorials, amateur microwave and optics experiments, reviews, and do-it-yourself projects. Only recently have useful SETI power tools for serious amateur research become generally available.

Car computers

I recently had an unpleasant and outrageously expensive experience with a "factory certified" mechanic at a major automobile dealership. He could not even *find* my car's engine control computer, let alone repair it. In the process, I learned a lot more than I wanted to about car computers and servicing.

A gasoline engine basically mixes aromatic hydrocarbons with air. It then compresses the mixture, and ignites it with an electrical spark from the spark plug. In general, there must be real-time control over air flow, gasoline feed, and timing of the sparks.

A car computer optimizes this control process to give knock-free power and fuel economy while minimizing the pollutants exhausted. Figure 1 is a typical setup.

In any chemical reaction, there must be some optimum mix of constituents. If too much gasoline is introduced, the mixture will be *rich* and there will be a lot of leftover hydrocarbons in the exhaust.

If there is too much oxygen from the air, the mixture will be *lean*. Leftover oxygen is not bad by itself, but, at the high cylinder temperatures and pressures of a modern engine, it readily combines with all the unused nitrogen in the air to form highly polluting nitrogen oxides. These, in turn, form smog.

A *stoichiometric* mix gives just the right chemical ingredients so that zero input will remain when the reaction is completed. Combining 14.7 parts of air with one part of gasoline results in minimum pollution. On the other hand, a mix of 12.6:1 gives maximum power and 15.4:1 gives the best fuel economy. But there is surprisingly little degradation of fuel economy at a minimum pollution point.

One of the two main tasks of a car ignition computer is to set up a *closed-loop system* that continuously adjusts fuel and air to maintain an optimum stoichiometric mix-

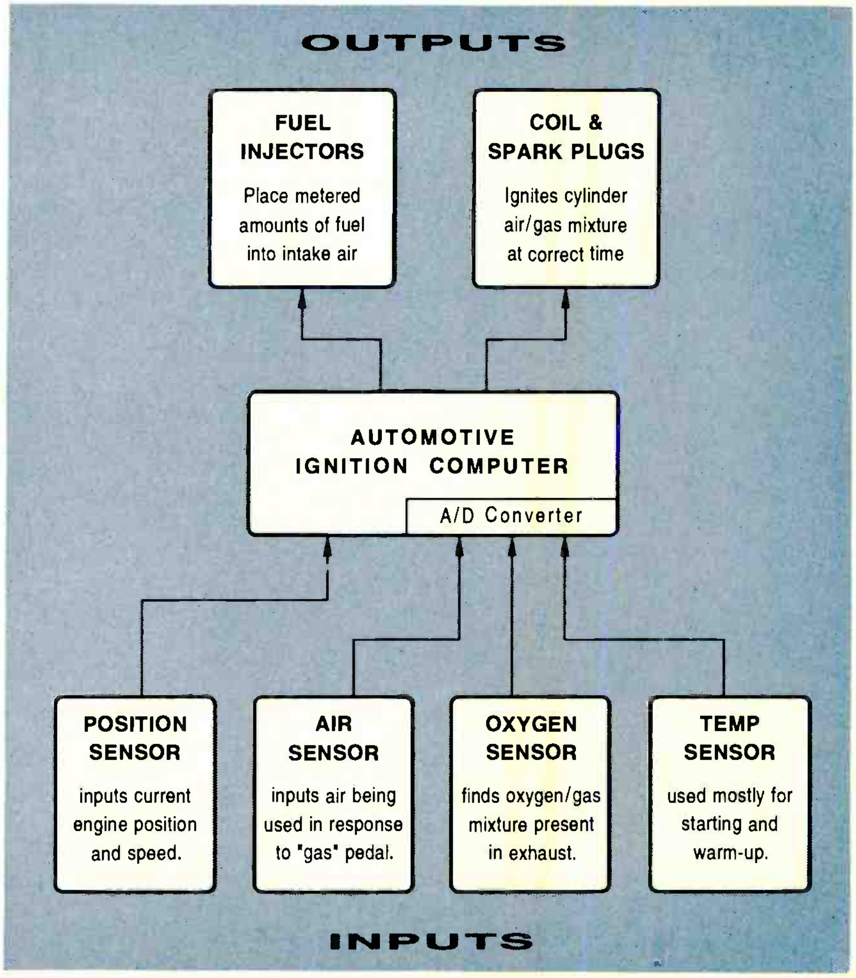


FIG. 1—THE TWO MAIN TASKS of an auto ignition computer are to optimize the air to gasoline ratio for pollution and to control the spark timing for performance.

ture—a mixture that is neither too rich nor too lean.

An *oxygen sensor* is a device that generates an output voltage in the *absence* of oxygen and no output in its presence. Figure 2 shows a typical output.

The oxygen sensor is normally located in the exhaust stream just *before* the catalytic converter and muffler. The voltage output of an oxygen sensor is A/D converted and routed to the engine computer. The computer then adjusts the gas/air mixture so that it has low pollution and good fuel economy.

Figaro is one resource for oxygen sensor information.

How does your computer adjust its gasoline/air mixture? The precise details depend on your car's system. I'll describe an older Bosch system that uses an airbox, individual pulsed fuel injection, and dated "electronic over mechanical" ignition distribution. In this system, the throttle controls the air going into the engine, *not* the gas.

The quantity of air selected must be measured and A/D converted into a computer input. An airbox vane drives a potentiometer whose resistance changes with the airflow. Air temperature also is measured simultaneously.

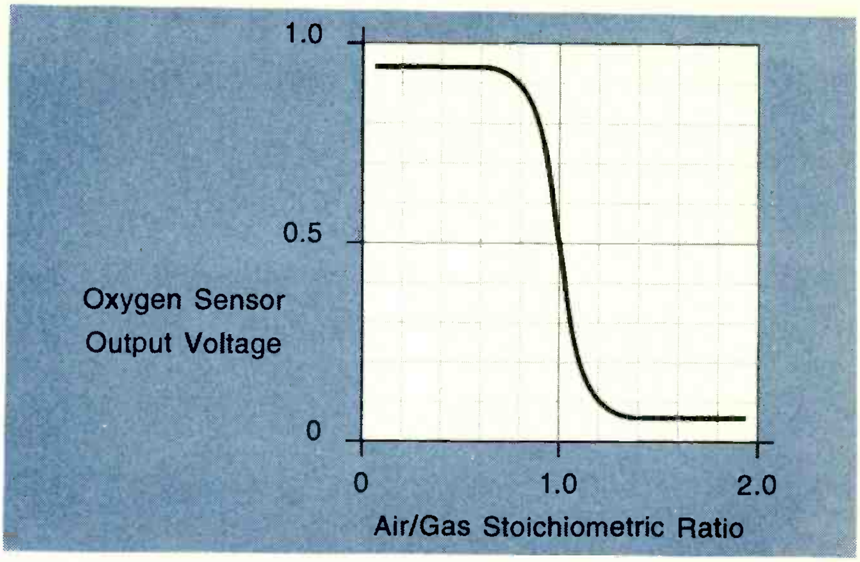


FIG. 2—AN OXYGEN SENSOR produces a voltage in the absence of oxygen. Placed in the vehicle exhaust, it forms the key feedback element to maintain a gas/air mixture that is neither too rich nor too lean. The mixture has neither excess polluting hydrocarbons nor nitrogen oxides.

Newer systems have more accurate *mass air flow* sensors. They work by measuring the differential cooling rates of heated wires. Either way, an analog voltage is generated, A/D converted, and sent to a digital engine computer.

The gasoline is pressurized to about 29 psi with an electric fuel pump that has a pressure relief valve. The gasoline is then routed to the fuel injectors which intercept the air paths, one per cylinder, near the intake valves.

In this system, the injectors are *not* locked to individual cylinder timing. They are *all* driven identically. But in other systems, there is one master injector or individual high-pressure injectors that replace input valves.

An injector is basically a solenoid valve. Pulse duty-cycle modulation regulates the amount of gas metered. The engine computer makes use of feedback from the air flow and oxygen sensors to adjust the injector duty cycles. These are helped along by other inputs like engine temperature, idle stabilization, and engine startup "choke" enrichment.

Once again: As you step on the gas pedal you increase the air. The increase in air is compared with the previous gas/air mixture. The computer then adjusts the amount of injected fuel.

The second major task for any car ignition computer is to adjust the timing, deciding precisely when the compressed mixture is to be ignited by the spark plug.

If the spark arrives too early the car will lose power; if it arrives too late it will cause an erratic and power-robbing *knock*. The optimum timing is determined by engine speed, mixture, load, and the temperature. In the past, a *vacuum advance* rotated the points as speed increased.

In this Bosch system, the points were replaced with a solid-state *Hall-effect* sensor that pulsed *before* the appropriate time for cylinder ignition. The set of rules that determine how much to advance a spark is called an *ignition map*.

The rule map is stored in a digital read-only memory (ROM) whose addressing is controlled by speed, load, mixture, temperature, and other factors. The output of the map sets a timing delay. After the delay times out, the computer pulses a Triac switch that discharges an energy storage capacitor into the coil and spark plugs.

Unlike classic systems, the delay (amount of advance) and the pulse width (dwell time) are independently controllable. Actually, dwell time is set by capacitor energy storage.

By today's standards, my car

computer is rather primitive. A Motorola 6805 microcontroller and an EPROM are helped along by a simple multichannel A/D converter. A Triac drives the coil, a Darlington transistor drives the injectors, and a transistor drives the fuel pump.

A book that explains all this is *Bosch Fuel Injection and Engine Management* by Charles Probst. Other titles appear in the SAE *Library*.

Two major publishers of automotive books are *Robert Bentley* and *Chilton*. Also see *Automotive Industries* magazine.

Servicing intermittents

Back to my horror story. My 1987 *Synchro* four-wheel drive van started showing an intermittent loss of power. Naturally, I did not suspect for an instant that all those 138,000 off-road desert miles I put on it had anything to do with the problem.

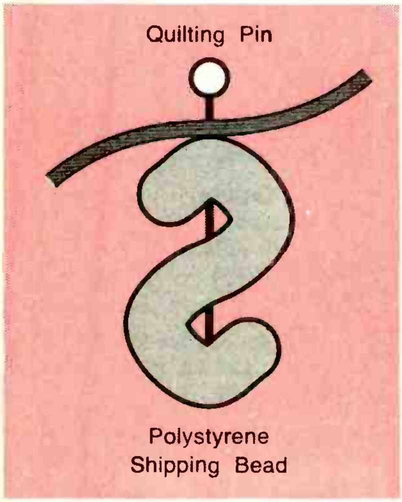


FIG. 3—A QUILTING PIN makes a safe test point along a stranded wire.

I found that cleaning up the airbox, checking the connectors, and swapping the fuel filter did not help. Hauling it off on a 350-mile trip to my nearest factory-authorized service center cost me an outrageous amount of money.

For zero improvement.

In all fairness, it is hard to fix an intermittent problem when it doesn't show up on demand. But as soon as I started treating this as an electronic service problem, rather than an automotive problem, the cause became obvious.

I next sent away for a shop manual, something I should have done years ago. The *Robert Bentley* manuals are really outstanding. Meanwhile, I decided to make an effort to catch this intermittent in action while driving down the road.

So, I hooked up an oscilloscope. My first guess as to the source of the problem was the Hall-effect sensor, so I monitored the green wire from the sensor with a temporary test pin that I have shown in Fig. 3. The sensor output was continuous, even during a dropout.

Finally, a stroke of blind luck. I hit the computer with my fist and the engine died! It was something that I should have thought about long before—something that the mechanic certainly should have tried.

Cleaning the connector didn't help, so I resoldered the computer. The culprit was a bad solder joint on a steel-lead power resistor. Aging and corrosion caused the failure.

In hindsight, the tachometer would drop to zero during failure, with the engine obviously still stumbling over. Because the tachometer is connected directly to the coil primary, the problem had to be in the computer or wiring.

Interestingly, there is a new wiring harness/filter available that's supposed to eliminate the very same symptom that is apparently caused by the steel lead on that big computer resistor. Solder will not adhere to the steel lead. I suspect the manufacturer never found the real problem and probably still does not have a clue.

All of this did get me thinking about servicing intermittent problems in general. So, Fig. 4 is a set of my rules that should get you started. The key points are (1) *always* have documentation on hand; (2) be *certain* you can cause the problem to show up; (3) divide-and-conquer by finding out where the problem is *not*; (4) attack probable causes first; (5) think logically, paying attention to *all* of the symptoms.

Yeah, there are fairly low-cost data loggers out there. But nobody has yet come up with a universal intermittent "flight recorder" that a car mechanic, a cardiologist, or an air conditioning repairman would fight over. There's opportunity there for the successful inventor.

1. Make certain the problem is real.
2. Have *all* service manuals on hand. *Read them!*
3. Make the problem show up. Collect data *during* the fault.
4. Divide and conquer. Find out where the problem is *not*.
5. Assign probable causes. Look, smell, touch, and listen.
6. Associate mechanical problems with connectors; time ones with solder joints; temperature ones with memory chips.
7. Cause the patient no harm. *Never* hot plug!
8. Isolate temperature problems with fans, cold, or hot boxes.
9. Pay attention to *all* symptoms. Be willing to change tactics.
10. Hit it with your fist or otherwise apply *controlled* shock.
11. Attack the disease, not the symptom. Things "burn out" for a reason. Find and fix that underlying reason.
12. Reduce the system to the simplest possible.
13. If all else fails, try to make the problem *worse*.
14. When possible, compare against an identical working unit.
15. Back off and give it a rest; let your subconscious do the work.

FIG. 4—INTERMITTENTS CAN BE A BEAR TO SERVICE. If it ain't broke, it certainly can be hard to fix. Here are several attack guidelines.

Many thanks to real-world auto expert Bob McKnight for his superb help on this matter.

Some contests

There is a lot of interest in car computers showing up on our helpline. The big problem in getting straight answers is the traditional automotive industry secrecy. There is also a "swap the module" mentality. And there is the fact that the EPA has made it a felony to *reduce* the emissions from any car by tampering with it.

Still, I'd really like to put together a set of car computer resources. As our first contest this month, just tell me about any useful book, service, publication, or online resource that can be of help to others.

As our second contest, please find a clean, late model Synchro for me. Or else tell me about *any* old substitute vehicle that is mid-sized, rugged, economical, gets 22 mpg, has high clearance, positraction, is granny geared, and has full time 4WD. I really need a van that sleeps six cavers, Bowseretta, and a full sheet of plywood.

There'll be all the usual *Incredible Secret Money Machine II* books for the dozen or so better entries, with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

The "Mystery Band"

How far is it from radio to heat? Both are electromagnetic waves whose wavelengths differ only in length. How far apart are they, spectrum wise?

Figure 5 tells all. Between radio and heat lies what I will label as the *mystery band*. It is otherwise known as the *submillimeter wavelengths* or the *quasi-optical frequencies*.

A 32:1 frequency range whose 8.7 terahertz (THz) bandwidth can easily contain 1,600,000 HDTV signals. This band does not require a license and is unregulated, so it has incredible future hacker potential.

Reviewing the basics, the *frequency* of any signal is simply how many full cycles pass a point per second. The *wavelength* is the inverse of a frequency, and the distance along the wave required to get back to exactly the same *phase* point.

For example, if an X-band speed radar has a transmission frequency of 10 *gigahertz* (GHz), its wavelength is 3 centimeters, or 30,000 micrometers.

A warm human body radiates at a frequency of 30 terahertz (THz), otherwise known as 30,000 GHz. It has a wavelength of 10 micrometers or 10μ.

If this mystery band is so great, why doesn't anybody know about it or use it very much? Until recently, there have been no effective amplifiers or oscillators that will work in this range. The high-end microwave electronic devices listed in *Wireless Design & Development*, *Microwaves & RF* and similar magazines to run out of steam at 100 GHz or so.

At the other end, most infrared detectors can't handle anything longer than 10 micrometers, although a few costly IR sensors from *EG&G Judson* can get close to 50 micrometers. That's a long way from 6 THz!

New advances in what is called *nanotechnology* should lead to all kinds of new low-noise, high-gain,

COMMERCIAL ONLINE BBS RESOURCES

Apple eWorld
Box 4493
Bridgeton, MO 63044
(800) 776-2333

America Online
8619 Westwood Center Drive
Vienna, VA 22182
(800) 827-6364

CompuServe
500 Arlington Centre Blvd
Columbus, OH 43220
(800) 848-8199

Delphi Internet Services
1030 Massachusetts Avenue
Cambridge, MA 02138
(800) 695-4005

Dialog Information Services
3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700

GEnie
401 N. Washington St
Rockville MD 20850
(800) 638-9636

Prodigy Services
445 Hamilton Avenue
White Plains, NY 10601
(914) 448-8811

The Well
65 N. Gate Five Road
Sausalito, CA 94965
(415) 332-4335

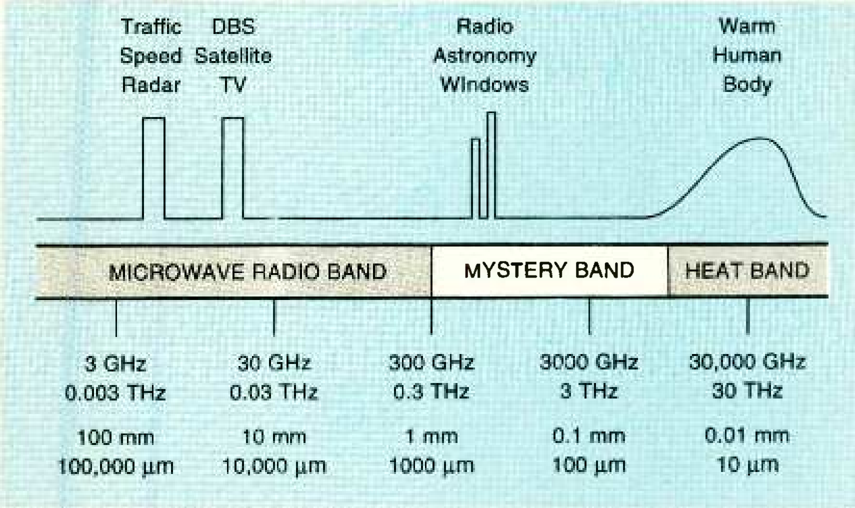


FIG. 5—THE MYSTERY BAND of submillimeter wavelengths between "radio" and "heat" is five octaves wide and offers an incredible bandwidth. This band is unregulated and unlicensed. Yet its many opportunities still go begging.

high-power devices that can combine the best of microwave and optical techniques.

This mystery band demands line-of-sight transmission. Or, better yet, optical pipe or fiber waveguides. While extremely high-gain antennas can be small, they must be made with extreme precision.

Sadly, the atmosphere in the 0.3 to 10 THz frequency range changes from murky to totally opaque.

At best, attenuation will be something like a decibel per kilometer. At its worst, its molecular absorption (notably oxygen and water vapor) absorbs everything. Thus, rain could result in total disaster for outdoor terahertz communications.

Hot objects could also cause grief. Although a warm human body has a peak energy wavelength of 30 THz, there is a long *tail* that drags on down into the mystery band. Hotter objects contain even more mystery-band energy, although their *peak* wavelengths are much higher.

Some applications demand cooling to cryogenic temperatures. At the very least, an awareness of possible heat interference is important.

What good is the mystery band? For now, radio astronomers are about the only users. But wireless modems and mice are an obvious possibility. As are other forms of personal communication or short-haul telemetry.

I'll also predict that the mystery band will turn out to be important for new SETI research.

You could make a lot of friends in a big hurry by hacking up a $5 mystery band device with 20 dB of gain, a 2 dB noise figure, and 100 milliwatts of output power at 3 THz. Even at $6.42 it would still sell.

The best mystery band information is found in the *International Journal of Infrared and Submillimeter Waves*.

Near ground, atmospheric mystery band attenuation might be poor, but radio astronomers must look up through the entire atmosphere. For most of the mystery band, the full atmosphere is uselessly opaque.

But there are many interesting windows. One at 680 GHz has about a 70 % loss and a second at 760 GHz offers a 60 % loss. Dirty windows yes, but still useful.

In a September 1994 IJISW story (on p.1465–1481), authors Harris and Schuster describe a noise floor breakthrough in a cooled receiver for 680-GHz radio astronomy.

NEED HELP?

Phone or write your Hardware Hacker questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(602) 428-4073

For fast PSRT access, modem (800) 638-8369, then an HHH. Then JOINGENIE. On keyword prompt, enter DMD524.

Internet email access link:
SYNERGETICS@GENIE.GEIS.COM.

The best strategy to apply when you don't have any workable amplifiers available is to "Get out of Dodge." Do a first-stage downconversion to less hostile frequencies.

The authors built up a handcrafted niobium Josephson tunneling mixer diode. For their local oscillator, they started with a 110-GHz Gunn diode source. Then they tripled the frequency and doubled it to reach 660 GHz. The mixer difference was extracted as a medium microwave frequency.

With their new technology, they managed to get their input noise temperature down to 800°, compared to an older 2400° model based on a Schottky diode. While much better, a lot more can be done.

Another resource for the mystery band is the *Society of Amateur Radio Astronomers*.

As a third contest this month, just dream up some new hacker use for mystery-band frequencies. Or perhaps you could send me a sample amplifier with the specifications mentioned earlier.

Online resources

Naturally, it is totally unthinkable to attempt any technical research or idea development without the aggressive use of computer online resources. Not getting online is almost as dumb as not using a personal computer.

These days, everybody wants to get on the Internet; doing so in the past often meant expensive and unresponsive services, phone charges, arcane commands, and having to become Unix literate.

By the time you read this, all of the major commercial BBS services will be offering fast, powerful, and very friendly direct Internet access. Hourly rates will be as low as a local phone call.

I have listed the commercial BBS biggies in our resource sidebar this month. Of the more useful services, *CompuServe* is the largest, *America Online* is the friendliest, and *GEnie* has the most and best in the way of technical downloads.

Obviously, I like *GEnie* the best. On my *GEnie* PSRT RoundTable, you will find preprints and reprints of all my *Hardware Hacker* and other columns, along with unique design tools not found elsewhere. I've just added new features, including major *Acrobat* support, Steve Hansen's high-vacuum *Bell Jar* and the *Nomadics Notes* from Steve Roberts.

Internet E-mail technical questions asked of PSRT will be answered in Category 1, Topic 33—often in two hours.

I've often been asked to post my files, reprints, and research studies directly to some Internet site. But the inquirer never seems to get around to explaining who would pay for this. But, if the inquirers can get *Safeway*, *Texaco*, and the *Purina* dog chow folks to offer all their products free over the Internet, I'll be most happy to do it also.

NAMES AND NUMBERS

Automotive Industries
PO Box 2056
Radnor, PA 19080
(215) 964-4876

Robert Bentley
1033 Massachusetts Avenue
Cambridge, MA 02138
(617) 547-4170

BKL
421 Feheley Drive
King of Prussia, PA 19406
(610) 277-2910

Chilton
Chilton Way
Radnor PA 19089
(610) 964-4000

EG&G Judson
221 Commerce Drive
Montgomeryville, PA 18936
(215) 368-6900

Figaro Engineering
Box 357
Wilmette IL 60091
(708) 256-3546

Fuzzy Systems Engineering
12223 Wilsey Way
Poway, CA 92064
(619) 748-7384

GEnie
401 N Washington St
Rockville MD 20850
(800) 638-9636

Jnl Infrared & Millimeter Waves
233 Spring Street
New York NY 10013
(212) 620-8495

Master Bond
154 Hobart Street
Hackensack NJ 07601
(201) 343-8983

Maxim
120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800

Microwaves & RF
611 Rt #46 West
Hasbrouck Heights NJ 07604
(201) 393-6286

Old Colony Sound Labs
PO Box 243
Peterborough NH 03458
(603) 924-6371

Railbike Newsletter
3502 Buckskin Road
Coeur d'Alene, ID 83814
(208) 765-2831

Redmond Cable
15331 NE 90th Stret
Redmond WA 98052
(206) 882-2009

SAE Library
400 Commonwealth Dr
Warrendale PA 15096
(412) 776-4841

Soc. Am. Radio Astronomers
247 N Linden St
Massapequa NY 11758
(516) 798-8459

SETIQuest Inquiries
174 Concord Street
Peterborough, NH 03458-0874
(603) 924-9631

Society for Amateur Scientists
1549 El Prado
San Diego, CA 92101
(800) 873-8767

Wireless Design & Dev
301 Gibraltar Dr
Morris Plains NJ 07950
(201) 292-5100

New tech lit

From *Maxim* a *1995 New Releases Data Book*. It contains lots of great video stuff, waveform generators, and *RF-to-Bits* communication chips. Maxim is quite liberal with its engineering samples, and it offers a toll-free order hotline.

Much more on sonoluminescence in Robert Heller's story in the Oct. 14, 1994 issue of *Science*.

I guess I'm kinda down on fuzzy logic. The wildly ludicrous claims of early proponents gave the entire field a bad name. *Anything* you could do with fuzzy logic you can also do just as well without it.

Still, there are times and places where concepts such as "short" or "tall" or "cold" or "warm" could form useful system inputs. A reasonably hype-free new book is *Fuzzy Logic: A Practical Approach*. It is published by *Fuzzy Systems Engineering*. It also has *Fuzzy Thought* software.

Product MB6A from *Master Bond* is an effective epoxy stripper.

Electroluminescent panel kits are available for $45 from BKL.

For custom and stock cables and interfaces, including *Nintendo* and *Sega*, contact *Redmond Cable*.

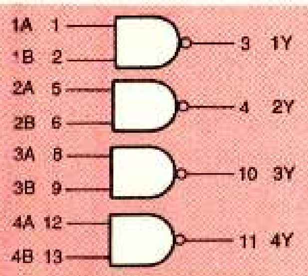
There are lots of audio and other technical books listed in a new catalog from the *Old Colony Sound Labs*.

A *Railbike Newsletter* from Dick Smart. Adapter kits are shown in

Continued on page 88

MINI ANALYZER

continued from page 54



INPUTS		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

FIG. 13—TO USE THE ANALYZER to check a CD4011B NAND gate, begin with the truth table and functional diagram.

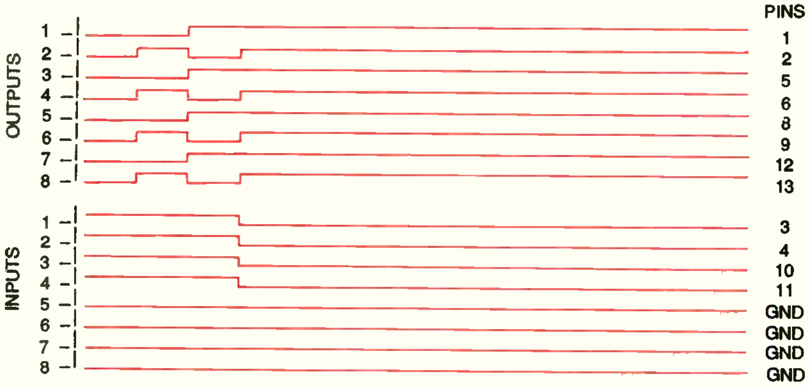


FIG. 14—THE TRUTH TABLE of the CD4011B is implemented in this bit pattern.

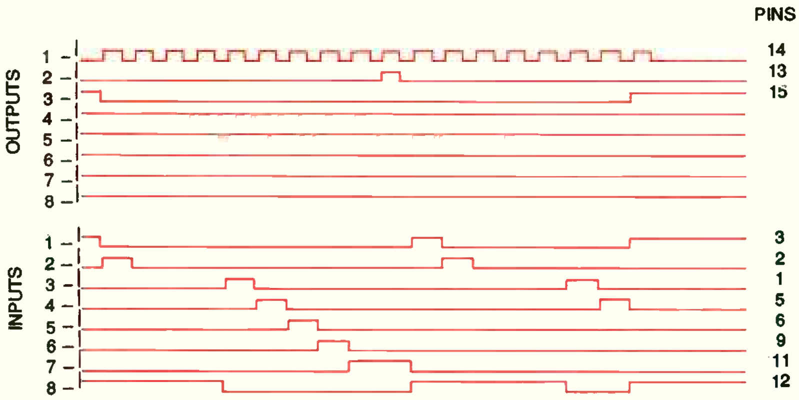


FIG. 15—BIT SCAN for the CD4017B CMOS decade counter/divider.

you for the parallel port address. Press ENTER if you're using LPT1 at the standard address of 888. Otherwise, type in the decimal address of the parallel port and press ENTER. The program will then test all inputs and outputs, and give you the results. You will either get a message "Interface Tests OK," or one or more messages indicating which inputs or outputs did not perform as they should.

Logic analyzer

To use the unit as a logic analyzer, begin with the following sample problem: Assume Fig. 6 is a self-clocking circuit that you designed to provide a squarewave output that is one quarter of the input frequency. The clock can be disabled with an external switch, and the LED should turn on with the rising edge of the clock. If wired as shown, the circuit does not operate properly. Most notably, the LED doesn't flash.

Before testing the circuit, IC3, a simple squarewave generator, must be replaced with one of the analyzer's outputs. If IC3 were left in the circuit, there would be no way to synchronize it with the analyzer, and the display would drift, resembling an oscilloscope trace without proper sync. The IC3 oscillator is therefore simulated by programming an analyzer output to produce a squarewave.

Although IC1 is a divide-by-ten counter, the analyzer has a 64-bit pattern that is not evenly divisible by ten. Again to avoid pattern drifting, a second output must be programmed to reset IC1 after ten clock pulses.

Finally, the correct monitoring points must be determined. For the best understanding of circuit operation, all possible points (A through H) should be monitored. The resulting test circuit is shown in Fig. 7.

The bit pattern obtained is shown in Fig. 8. The fault with the circuit was that the LED would not light. The problem is verified in the bit pattern showing that inputs I7 and I8 are not switching. However, the outputs of IC1 are performing as expected, and the outputs of the first two NOR gates (I5 and I6) are also valid. Re-examining the circuit with the help of the analyzer reveals the fault: At least one of the inputs (I5 and I6) to the third NOR gate (I7) is always logic high. That makes the output always logic low. The circuit really needs a NAND function to produce a low logic level when the two inputs are high, and to produce a high logic level at other times. The solution is to change the circuit to incorporate a NAND gate. The revised circuit is shown in Fig. 9, and the resultant bit pattern is shown in Fig. 10.

Replacing the NOR gate with a NAND gate has provided the desired signals at I7 and I8. (The fourth NOR gate was also replaced with a NAND gate arbitrarily—either gate can serve as an effective inverter/current sink for the LED). By looking at the new bit pattern, you might notice another problem. The circuit is dividing by four, but it is not producing a symmetrical squarewave. The pattern is symmetrical through the eighth positive clock pulse (O1), but then stays low for the remaining two clock pulses. In viewing the

PARTS LIST

All resistors are ¼-watt, 5%.

R1, R3, R5, R7, R9, R11, R13, R15, R17, R19–R24, R26—10,000 ohms
R2, R4, R6, R8, R10, R12, R14, R16—2200 ohms
R18—1000 ohms
R25—33,000 ohms
R27—22,000 ohms

Semiconductors

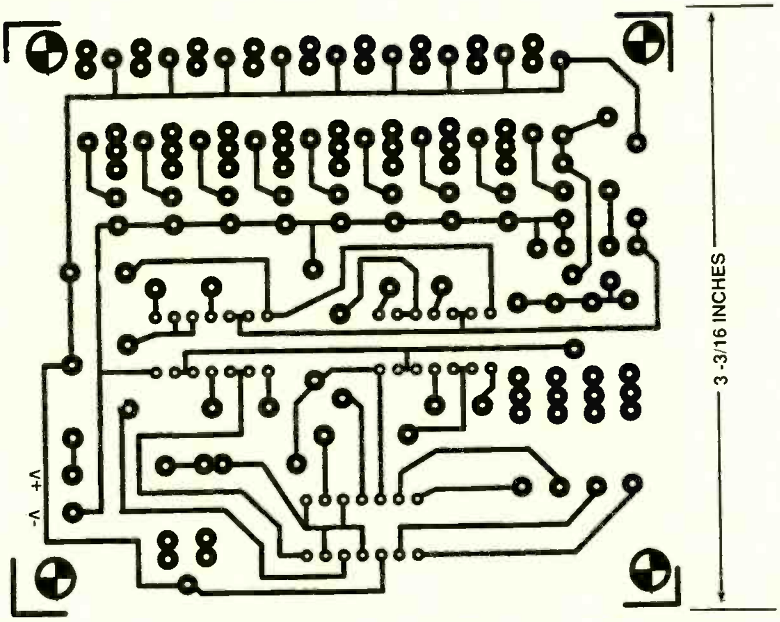
D1–D5—1N34A Germanium diode
Q1–Q10—2N2222A NPN transistor
IC1, IC2—CD4066 CMOS Quad Analog Switch
IC3—LM339A quad comparator

Other components

S1—SPDT switch
P1—Female DB-25 connector and male-to-male DB-25 cable (or use integral cable with male DB-25 on one end, see text)
Clip 1—Red miniature alligator clip
Clip 2—Black miniature alligator clip

Miscellaneous: Sixteen micro clips, three 14-pin IC sockets, 4-foot length of 15-conductor cable or 60 feet of No. 22 stranded wire (see text), No. 20 stranded wire, PC board, suitable case.

Note: The following items are available from JJ Barbarello, 817 Tennent Road, Manalapan, NJ 07726:
- **PC Board (MA-PC)—$15.00**
- **Disk containing both source code and executable file of the mini analyzer program, which includes additional capability for saving and retrieving data, on-line help, on-line directory of files, and more (MA-S)—$12.00**



FOIL PATTERN FOR THE MINI ANALYZER.

bit pattern this will be immediately obvious, and it is much better than attempting to watch the LED while determining what's wrong.

A look at the I7 and I8 waveforms shows how to solve the problem. They would both be symmetrical if they ended after the eighth clock pulse. This can be accomplished by routing the ninth output of IC1 (called output 8 because the first one is called output 0) to the reset pin. This will create a divide-by-8 counter instead of a divide-by-10, and it will generate the bit pattern in Fig. 11. Notice that the O2 reset pulse has been removed—it is no longer needed because a hardware reset has been incorporated. Because the circuit divides by 8, and the 64-bit pattern is divisible by 8, the bit pattern is stable, or synchronized. The final circuit configuration is shown in Fig. 12. It meets all of the original requirements in that the output is the input divided by 4, it is symmetrical, and the LED lights on the rising edge of the clock.

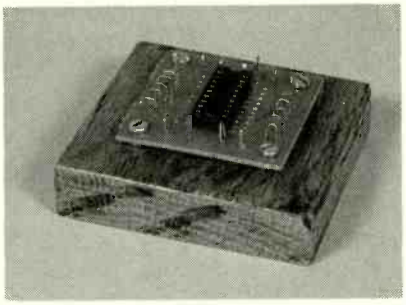


FIG. 16—THIS SIMPLE JIG makes connections to the IC pins easy.

IC checker

This example will expand on the last example. The analyzer will check for proper operation of the CD4011B NAND gate. Begin with the truth table and functional diagram of the 4011 shown in Fig. 13. Any combination of inputs other than both logic high will produce a "1" output; a logic high to both inputs of any of the four NAND gates will cause that gate to produce a "0" output. To test the IC, you must program the four possible input bit patterns for each gate and view the corresponding outputs. If each gate stays high except when both inputs are high, the IC is functioning properly.

The truth table is implemented in the bit pattern of Fig. 14. Note that the pin connections are indicated to the right of the traces. Inputs 5 through 8 are grounded to avoid stray pickup. Instead of a single bit, a group of bits (five in this case) will be used for each state. Each set of inputs to the 4011 (O1 and O2, O3 and O4, O5 and O6, and O7 and O8) have the same pattern. The first five bits of each set are low. Then the second five bits are low on the first input and high on the second. Then the pattern flips, with the next five bits high on the first input and low on the second. Finally, the bit pattern shifts to both inputs high. In each instance, the expected IC output pattern (I1, I2, I3 and I4) show a high input until the inputs shift to both high. Then the IC output goes low.

A bit scan for the CD4017B CMOS decade counter/divider is shown in Fig. 15. The input bit pattern from a reference book was used directly, except that IC outputs 2, 3, and 4 were not sensed (because the IC has 11 outputs, and the analyzer has only eight). This approach checks all the functions of the 4017, including reset, clocking, clock enabling, and carry out. A second scan could be performed

Continued on page 95

AUDIO UPDATE

Audio Instructions

LARRY KLEIN

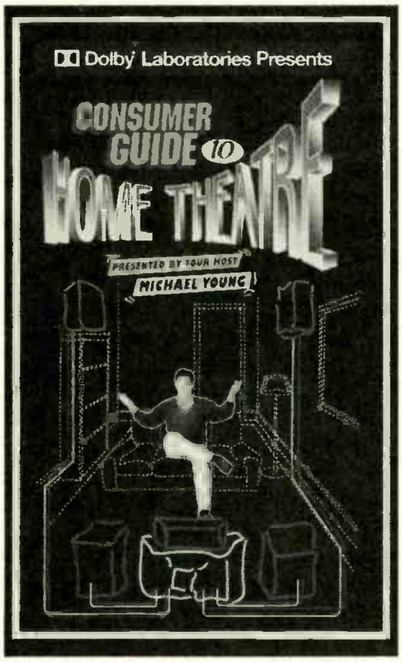
In the early days of hi-fi, the instruction sheet that accompanied a new component was usually just that: a mimeographed (remember mimeographs?) page of bare basics. If you needed more, the salesman in the audio salon (remember "audio salons"?) stood ready to help—after having already given you a few basic hi-fi lectures and perhaps installed the equipment himself as part of the purchase. My, how things have changed since the mid-1950s!

Keep in mind that all this took place before discounters became a fact of life on the U.S. retail scene. Hi-fi equipment was basically price controlled, and any dealer that sold below the manufacturer's mandated (not "suggested") retail price could lose his franchise. True, if you and the dealer had established a relationship a small discount might be worked out—but the sales slip always showed the full list price.

As the era of knowledgeable service with a smile was washed away by the rising tide of mass merchandisers and discounters, and the equipment sprouted knobs, functions, and displays rivaling a *Popular Electronics* "do-nothing-box" project, the instruction sheets necessarily metamorphosed into multipage instruction manuals.

As someone who has written and edited such manuals for amplifier kits, equalizers, and other audio products—not to mention having served two years each as the technical (projects) editor of *Popular Electronics* and *Electronics Illustrated*—I'm not unsympathetic to the task and problems of the manual writers.

But truth to tell, incomprehensible manuals remain a problem. In any particular case, the difficulties may derive from the writers' incompetence, the readers' impatience when confronted with written technical material, or the sheer magnitude and complexity of the information that needs to be conveyed. And recently having worked on a couple of manuals for home-theater receivers, I have an enormous appreciation for the communication problem they present.



DOLBY LAB'S "CONSUMER GUIDE TO HOME THEATER" video instruction book is a fine example of how technical information can be imparted in a manner that is clearly understandable to the layman.

Video solutions

Given all of the above, I was interested to receive a press release titled "Dolby Laboratories Introduces First Video Guide To Home Theater"—plus the VHS tape it described. The program on the tape is divided into two 24-minute segments narrated by a personable young man named Michael Young, an experienced TV "host." He did a fine, straightforward job, appearing neither know-it-all condescending nor overawed by the complex material he was handing. The first segment is an introduction to the history, theory, and practice of the Dolby surround-sound moviehouse setup and how it relates to the home-theater Pro-Logic system. The Pro-Logic system is described in its various options and permutations.

Even in this basic section I learned some things that perhaps I should have already known. For example, the surround channel in the movies (and at home) is actually only a single time-delayed channel, unlike the various quadraphonic schemes of years past. I was also interested to hear the definitive Dolby position on THX—a development whose significance has remained unclear to me. The full statement of the tape's narrator, which I assume reflects the official Dolby attitude, was that "THX was the Dolby Pro-Logic system but with a few equipment embellishments that had the seal of approval of the Lucasfilm group sponsoring THX." I take that as something less than a ringing endorsement.

In any case, the first half of the tape was a fine overview of the home-theater scene with basic guidance on everything from equipment options to TV screen size.

Nuts and bolts

I was surprised to find nothing to complain about in the first part of the tape and vowed to be more critical for the second, more technical, "Nuts and Bolts" section. To my further surprise, I again found little or nothing to disagree with.

The following verbatim discussion of subwoofer placement is a good example of the narrator's approach:

"A subwoofer out in the open will give you minimum bass, against a wall it will give you more bass, and in the corner it will give you the most. Although placing the subwoofer in the corner of the room will give you the most bass, it will not necessarily give you the best bass. You want smooth bass at all frequencies, not one-note thumping type bass. So you will have to experiment with moving your subwoofer around to find where the best bass is.

"Place the subwoofer where you would normally sit. Then, while listening to music with good bass content, walk around the room to find the place where you might want to locate your subwoofer. Listen for the smoothest, deepest, tightest sounding bass, not the loudest. Once you find the best sounding spot, that's the location for your subwoofer."

This technique, which depends on the reciprocal relationship of listener and speaker, is a clever procedure that is rarely recommended, despite its technical validity.

Or, on the subject of cables: "Speaker wire comes in all shapes, sizes, and prices, from zip-cord you buy at your local hardware store to high-end audiophile cables that can literally cost up to thousands of dollars—for wire! And there are many schools of thought as to how important speaker wire is to the sound quality of a system. Some think it's a world of difference, more think it doesn't matter at all. But it's safe to say that you should use a reasonably good quality wire for your home theater." (In the first section of the tape, 16- or 18-gauge was recommended for most setups.)

The section on the whys and wherefores of speaker-wiring polarity also covers all bases simply, completely, and accurately. (Incidentally, don't be put off by what seems to be a words-of-one-syllable approach. With spoken technical material, the best approach is to keep it simple.)

Test signals

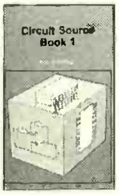
A valuable part of the guide is the test-signal system setup section. The Pro-Logic system owner is led through checks for phasing and level balance among the three front and two rear speakers.

I didn't recognize the names of the four writers in the final credits, but as someone who has labored in the same vineyard for almost 40 years, I congratulate them on a job well done. Anyone setting up or contemplating setting up a home theater system could benefit from a multiple viewing of this tape. If I were into product ratings, I would give Dolby's Consumer Guide to Home Theater four stars and a best buy!

The Dolby video has a suggested retail price of $19.95 and is available for sale or rental at video stores or selected audio/video dealers throughout North America. It also can be ordered via a toll-free number: 1-800-241-4115. Be sure to tell them I recommended it. Ω

Electronics Paperback Books

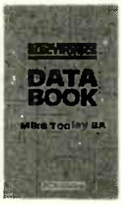
☐ **#226—How to Build Advanced Short Wave Receivers...$5.75.** Practical construction details of a number of shortwave receivers which should have levels of performance at least equal to that of commercially built sets of similar complexity. Also included are a number of add-on circuits, such as, Q-multiplier, S-meter, noise limiter, etc., which can be used to aid and improve the listener's shortwave reception.



☐ **BP321—Circuit Source-Book 1... $6.50.** A collection of over 150 analog-signal circuits on audio signal and power amplifiers, DC amplifiers, signal filters (high-pass, low-pass, band-pass and notch), tone controls, voltage-controlled amplifiers and filters, triggers and voltage comparators, gates and electronic switching, bar graphs, mixers, phase shifters, sensors, digital circuits, etc. (See BP322 at right)

☐ **BP322—Circuit Source-Book 2... $6.50.** Contains over 170 circuits on signal generation, power supplies and digital electronics. A continuation of BP321. Topics are: 555 oscillators, sinewave and function generators, CMOS oscillators, voltage-controlled and RF oscillators, (555, TTL and CMOS) monostables, precision long timers, power supply and regulator circuits and many other useful circuits. (See BP321 at left.)

☐ **PCP108—Computers and Music...$9.95.** The text leads you through the topics on computers and music software. Learn how to choose the right components for a system to suit your personal needs and fully equip yourself to exploit that system.



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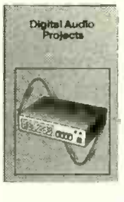

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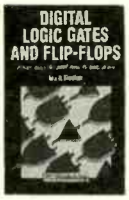

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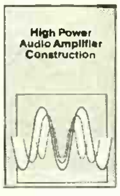

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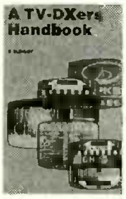

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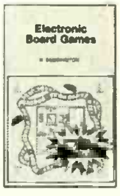

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DRAWING BOARD

This month we finish up the tachometer circuit by adding a 3-digit display.

ROBERT GROSSBLATT

The last part of the tachometer circuit is the display. Before I get to the design of the display section, however, I want to review the circuitry that has been covered so far. The spark count is being totaled by a series of CD4040B binary counters (see Electronics Now, November 1994, page 87, Fig. 2). Every half second, the count at the next 4040 in turn is stored in its associated latch, and then the 4040 is cleared to start a new count. As soon as this is completed, the base-rate counter (IC18), which receives its clock from rate-multiplier IC17, is reset by a 2-hertz clock. The rate multiplier outputs 20 pulses to the display circuit for each clock pulse it sends to the base-rate counter. When the base-rate count reaches 20, AND gate IC19-a stops the rate multiplier and nothing else happens until the base-rate counter is reset to start the whole cycle again.

To count the base-rate and multiplied-rate pulses correctly, the timing relationship between these two outputs of the rate multiplier must be understood. Figure 1 shows that the base-rate pulse appears only at the end of the multiplied-rate cycle.

The rate multiplier is clocked by pulses produced by IC20, a 555 timer set up as a free-running clock generator with a frequency of about 50 kilohertz. That is fast enough to ensure that the rate multiplier operation is completed in the half-second time period. I've already shown why the frequency of the rate multiplier clock has no effect on the accuracy of the rate multiplier's operation.

The display

Putting together a display circuit for the tachometer requires circuitry to total the multiplied rate pulses that are output from the rate-multiplier circuit. The only decision left to be made is the number of digits in the display. The number of revolutions per minute will require four digits. If you want to see them all, you'll need a four-digit display—but there are some good reasons why this isn't absolutely necessary.

In the first place, the chances are that this four-digit number is inaccurate because compromises were made in both how the sparks are counted and which bits are going to be transferred to the rate multiplier. Even if the spark-counter bus and rate-multiplier circuit were widened to 11 bits, the additional information wouldn't be of much use. Even if the engine were running at only 1000 rpm, the last digit would be only 0.1% of the reading. And since it would probably be changing with each update, it wouldn't be terribly informative. It would be much wiser, and less complex, to limit the display to three digits and understand that the reading has to be multiplied by 10 to give the actual engine rpm.

To do that, the multiplied pulses must be divided by 10. Circuitry could be added to the tachometer to do the division, but it's much easier to change the multiplication factor from 20 to 2—just change the number being decoded by IC18. Since IC18 will now be decoding a count of 2, AND gate IC19 can be discarded, and the rate multiplier's INHIBIT input can be connected directly to the Q1 output of IC18. So, deciding on a three-digit display not only simplifies the display circuit, but it also cuts down on the circuitry needed in the rate-multiplier section.

The best display setup is shown in Fig. 2. The CD4553B, whose pinout diagram is shown in Fig. 3, has a built in counter, latch, and multiplexer to drive three digits directly. If the correct signals are sent to the display from the rest of the circuit, the 4553 will do the rest.

The multiplied-rate pulses are fed

PIN	A	B	C	D
STATE	L	H	H	L

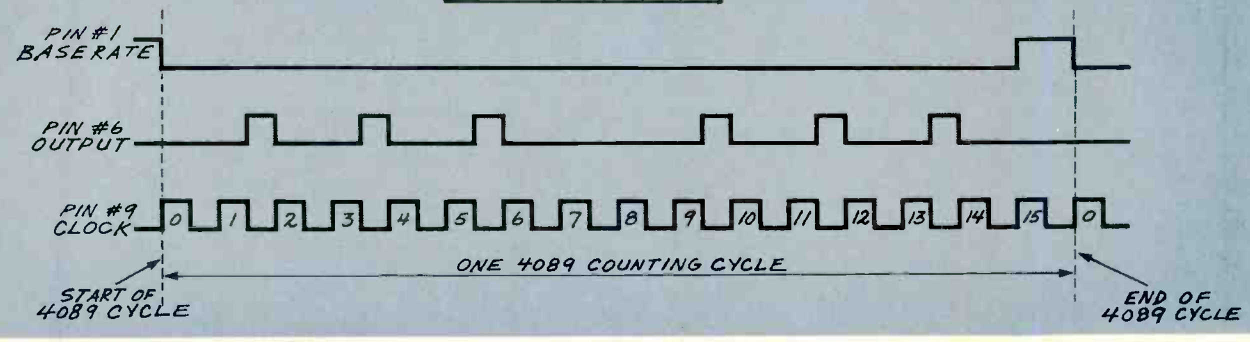


FIG. 1—NOTICE HOW THE BASE-RATE PULSE appears only at the end of the multiplied-rate cycle.

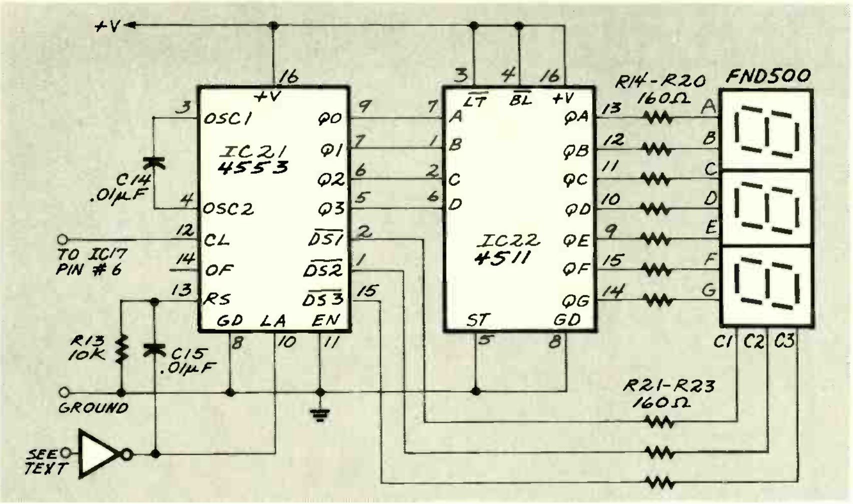


FIG. 2—THREE-DIGIT DISPLAY CIRCUIT is more than adequate for a tachometer, and it requires fewer parts than a four-digit one.

to the 4553's clock input, and the chip's latch is controlled by an inverted version of IC18's Q1 output. By doing this, the 4553's internal counter will add up the rate-multiplier pulses until IC18's Q1 output goes high. This will put a low on the 4553 latch control and the count at that point will be transferred to the CD4511B and on to the display.

The 4553's internal counter must be cleared in preparation for the next count, so the positive-going edge of the signal at the latch control is used to put a pulse, through capacitor C15, at the RESET pin of the 4553. Since the negative-going edge causes the count to be stored and the positive-going edge of the same pulse clears the 4553's counter, things will always happen in the proper sequence.

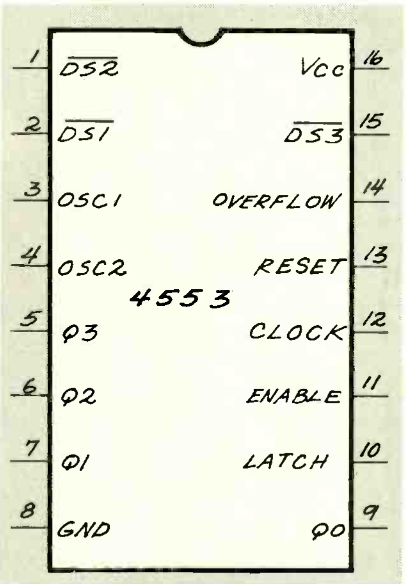


FIG. 3—4553 PINOUT DIAGRAM. The 4553 has a built in counter, latch, and multiplexer to drive three digits directly.

Finishing touches

The tachometer is now fully functional, but it's far from being complete. There are several additions that can make the tachometer more useful. The first thing that could be done is to add an analog display. Nothing is more informative at a glance than a needle moving around a dial—and you don't need a real needle to do it.

A CD4514B addressable 1-of-16 decoder can drive 16 LEDs arranged in a circular fashion. The output of the spark counter can be decoded to drive the binary inputs of the 4514 so that the 16 LEDs give an analog-like reading around the dial. If you put the seven-segment display in the center of the dial, you'll wind up with an attractive and very useful instrument for your car.

I'm not going to design the analog portion of the display here, but if you understand the tachometer circuit, you shouldn't have any trouble putting it together yourself. There's already a way of getting an accurate spark count every half second, so all you have to do is decide which of the bits should be sent to and latched in the 1-of-16 decoder. Since there are 16 outputs, you can have one LED indicate each successive 500-rpm increment. That will give you a range of 0 to 8000 rpm—which should be adequate for almost any engine in use today. (Some exotic engines might run faster than that, but the odds are that such a vehicle already has a tachometer in it.)

Go through the arithmetic that's done by the circuit and work out the relationship between the numbers and the 500 rpm increments you can get from the decoder. Going through some empirical examples, you should see which bits are important. Once you've done that, the last thing you need is a way to control the latch in the decoder. The basic control signal is the 2-hertz sequence signal, but you'll have to add some stuff to it to make the decoder that drives the LEDs work correctly. The final result will be well worth the extra bench time, and the tachometer you put in your car will be a real eye opener. Send in the details of the additional circuitry and I'll publish the best ones. Ω

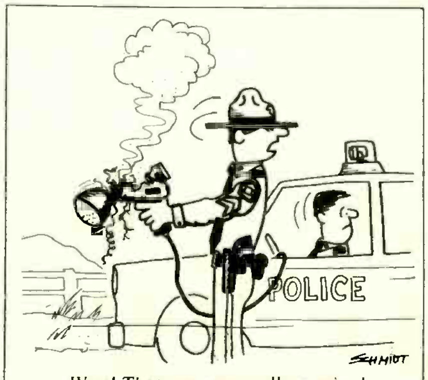
HARDWARE HACKER

continued from page 80

the 1908 *Sears-Roebuck* catalog, but they might no longer be in stock.

I've just picked up a great heaping bunch of classic Apples, including rare and collectable Apple III's. Apple II+ and IIe computers are cheap enough to use as dedicated BASIC controllers or for general lab applications. Give me a call if you want a complete list.

A reminder that unique downloads, freebie insider secrets, catalogs, and technical help are available on *GEnie* PSRT. Also, a 10-hour free trial offer for *GEnie* is available per the *Need Help*? box, although a credit card is required. Ω



Wow! That guy was really moving!

COMPUTER CONNECTIONS

Ten years of progress—for better or worse.

JEFF HOLTZMAN

Innovation is flourishing. Today an incredibly vast array of computer products is available with power undreamt about a decade ago. Sure, most people don't need all that power, but for those of us who do, the progress has been breathtaking.

A decade ago, few could afford a color graphics system; today multimedia systems that can easily handle high-resolution, true-color graphics, motion video, and high-fidelity digitized and synthesized sound are taken for granted.

Back then, 10-megabyte hard disks cost well over $1000. For the same cash outlay, today you get 100 times the storage. Back then, 64 kilobytes of memory cost $40. Today, $40 gets you a megabyte of memory. Modems running at 1200 bps cost $450; today, 28,800 bps costs half that. Then, networking was prohibitively expensive and difficult. Now you can buy a couple of Ethernet cards for less than $100, with plenty of change to spare. Less than $200 more will buy you easy-to-install and easy-to-use software for sharing files, disks, printers, faxes, modems, and more.

Back then we depended on noisy, finicky, dot-matrix printers with resolutions specifiable in two digits. Today, laser printers with resolutions of 300 dots per inch (DPI) are available for as little as $400. Pin-drop quiet ink-jet printers are even less expensive.

Back then, IBM controlled the hardware standards. A machine that was not "IBM compatible" was nothing but an expensive doorstop. Today, no single vendor controls any standard, whether it is microprocessors, bus architectures, video technology, or mass storage. The result has been relentless competition that continually decreases cost and increases performance and functionality.

Back then, the industry still wasn't sure whether a spelling checker should be sold as part of a word processor or as an add-on. Spreadsheets crunched numbers; presentation was irrelevant. The Macintosh was one year old; PostScript was just being introduced; and the DOS world was smug in its rejection of mouses and the graphical user interface.

Today we have fewer choices, but better ones. Instead of half a dozen quirky programs from as many pub-

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lishers on dozens of diskettes, we can install a complete suite of applications from a single vendor from a single CD-ROM. And the applications themselves are beginning to share more common components, such as dictionaries and drawing tools, as well as relatively consistent user interfaces.

That's one way of looking at it.

On the other hand . . .

Innovation is dead. There have been no real new ideas in either hardware or software for years. Innovation is no longer a creative endeavor for the purpose of enhancing human experience; it is a calculated risk designed to increase profit.

The way I see it, the computer industry is now controlled by MBAs whose only concern is the bottom line. Bright young minds that want to make a difference are being drawn to other fields, leaving only those who want to make a buck.

Large companies are gobbling up small companies; those that aren't gobbled up commit hara-kiri. Within large corporations, those adept at politics lord it over those who love what they do.

It wasn't always this way. Throughout the 1980s, small hardware and software startups experimented and continually pushed the bounds. Countless good ideas emerged from those efforts. Those ideas were highly visible, but doomed, like flowers in the snow.

Today, a few monolithic megacorporations are either strangled or they buy up all the competition. Already there is little reason to innovate; soon there will be none. Out of fear of being swallowed, new businesses will not start up, or if they do, it will be for the cynical reason of making a fast buck and then selling out. As the MBAs perfect their pandering techniques for the computer industry, every last vestige of meaningful individuality will give way to already rampant "me-too-ism."

Sure, today's machines are faster. But that just means they waste more CPU cycles between keystrokes. Sure, today's software is more capable. But that just means there are more features going unused. Sure, the growth of networking supports inexpensive local and wide-area communications. But networks are really just the latest infrastructure that permits a computing priesthood, formerly associated with mainframe computers and screwed-up telephone bills, to attempt to seize control.

Ten years ago, hard-disk storage cost $100 per megabyte. Today, it costs $0.50 per megabyte. That is good—or would be if that storage were put to good use. But it isn't, because of bloated software.

Software developers are taking advantage of declining hardware costs to produce inefficient code. Then they have enough nerve to release it before testing it fully. Installation routines modify key system files and leave trash all over a disk.

Today's hardware is still pitifully sensitive to environmental conditions. A small brownout can easily cause the typical power supply to shut down. And a small surge can easily fry it. Why, after 15 years of development, do personal computers still lack built-in power conditioning circuits?

Why is a backup system optional? Backup should routinely be part of the operating system. The only time users should hear anything at all about the backup system is when something goes wrong and the backup kicks in. Then the operating system should inform them so they can initiate repair or replacement. But their work should never be jeopardized.

Why have personal computer users settled for such incomplete solutions in both hardware and software? What other major purchase asks for such a high-level of trust yet does so incredibly little to earn it?

Gadget mania

In my opinion, the answers to all those questions center around the love for gadgets and the increasing laziness when it comes to producing results. For three generations, the insidious idea has been spreading that favorable results come about merely by pushing buttons. Results are what count. The process of getting there is irrelevant.

If I am your boss, I just want you to produce; I don't care how you do it. If you think more powerful (more feature-laden) tools will help, I'll buy them for you. I just want results.

But you might expect to plug that tool in, turn it on, and immediately produce the results I demand without study. So developers are doing their best to put intelligence into the software, thereby lowering the knowledge and experience required to operate it. That's good, because pretty soon I won't need you. I can hire someone with much less education and save a bundle.

Really though, the problem is not tools that are better than workers. The tools automate the part of the job that requires the least knowledge. That word processor will produce gorgeous looking documents—but it won't teach you how to organize your thoughts and write them down. That spreadsheet will automatically sum rows and columns of numbers, but it won't tell you which are the important values. That database package will help you build pretty screens, but it won't help you design a mathematically correct database structure.

Part of the problem is the rah-rah computer press. In the interest of selling magazines and attracting advertising, publishers invariably adopt a breathless attitude toward new gadgets, thereby insidiously encouraging a witless public to lust after them.

What little assistance the press does offer comes in the form of trivia ("A Million and One Ways to Change Your System Colors"); substantive content is almost totally lacking. It teaches you how to use a tool; it doesn't ask you to reflect on why you're using it or what you're doing. The assumption is that either A) you already know what you're doing and just need a little help with the tool, or B) you don't know what you're doing and wouldn't buy magazines if they tried to help with that.

There is a raging debate in the business community over what is called *The Productivity Paradox*. The paradox is that although billions of dollars have been invested in this country in improving productivity through computer technology, there is nothing to indicate that the investment has paid off. Some say there simply has been no productivity improvement. Others say it's there, we just don't know how to measure it. Some can point to isolated instances of improvement, but we still lack broad-based standards to indicate overall trends.

In my experience, large amounts of time and other resources are wasted on doing the job right, whereas little or no consideration is given to doing the right job. Most people figure it's better to do something than nothing, so they lose themselves in the process of tool operation. Eventually something results, and as the automation features of the tools improve, that something takes on more and more of a professional look. By analogy, you can build an outhouse from brick. Just don't lose sight of the fact that it will still be an outhouse.

End of harangue

There are several points I want to make:

1. It's all right to be seduced, as long as you remember you're being seduced. At some point, the intensity will wear off, and you'll be left with a box full of tools and a job to do. Learn how to use the tools to accomplish real work. Sure, you love technology, or you wouldn't be reading this magazine. Just remember that technology is the means, not the end.

2. Always keep clearly in your mind what the real work is. When you're in the seduction phase, acknowledge it as that and enjoy it. But bring it to an end when it's time to work.

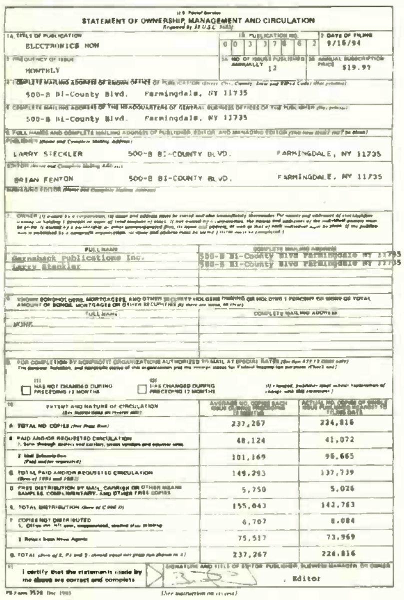
3. Ask what *benefits* a tool provides; don't get caught up in *features* that might appear sexy but will actually be useless to you.

4. Demand from manufacturers features that help accomplish real work, and not ones that just enhance appearance.

5. Don't be seduced by the computer press.

6. Process counts just as much as results. Pay attention to the way you accomplish your work. Over time, you'll notice some patterns that you'll be able to perfect, drastically increasing your efficiency, and others that you'll simply want to drop.

Innovation is not dead. And things might not be as bad as painted here. But there is a trend in that direction. Keep your eyes open and your ears to the ground. Don't be seduced by what is not important. Comments to jkh@acm.org. Ω



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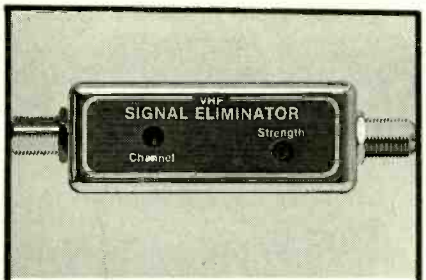

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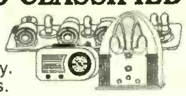

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CIRCLE 87 ON FREE INFORMATION CARD

PROCAR

continued from page 42

Anti-carjack mode

When the ignition key is on, opening and closing the driver-side door will start the first 15-second timer circuit (Fig. 1) and light the green die in LED1. No action is taken immediately—the timer starts only when the door is closed. This gives the carjacker enough time to drive away from the owner/authorized driver before any siren will be sounded. Not only does this interval permit the thief to distance him or herself from the driver and the site of the theft, but it also lessens the possibility that a startled and frustrated thief will retaliate by harming the car or driver.

Should the carjacker try to reopen the door to deliberately inhibit the timer in the package-loading timer reset mode described earlier), his efforts will fail because pin 3 of IC1 (Fig. 2, main alarm board) is low. This disables transistor Q2. The first timer circuit will time out in 15 seconds, and when the second latch becomes active, the voice module will be triggered by the red die in LED1.

With a logic high on pin 6 (A_5) of the voice synthesizer IC1, the output is three warning beeps followed by a warning that Pro-Car has been activated and that the vehicle will be disabled within 10 seconds.

If the carjacker attempts to defeat the warning by turning the ignition key off and on, the RC timer circuit consisting of R2 and C1 keeps the system armed because the key must be off for 10 seconds to reset this timer circuit.

When the second 15-second timer circuit has timed out, the *armed* line to the Power Module

(Fig. 3) goes to logic high and the engine is shut off. The motion/shock sensor will detect the carjacker's movement. As a result, the *trigger* (T) line also goes to logic high, activating the sirens and lights flasher. After the siren stops , the vehicle will still be protected.

Pins 8 and 9 of the CMOS NAND IC8 on the Voice/Options board (Fig. 2) will be logic high only when alarm pin 8 is triggered at the same time ignition pin 9 is logic high. Consequently, pin 10 will go low and latch on outputs for two other *nand* gates (identified by pins 1 to 3 and 4 to 6). This will cause pin 4 of one gate to go high, simulating the *high security mode* by turning on the high security transistor Q7.

This response will protect the vehicle in the event that the carjacker returns after the sirens stop sounding, and tries to restart the car.

When the owner/authorized driver gives the secret signal, the latch in IC8 will be reset to *standard security* because pin 1 is connected through wire "U" to the reset section of latch IC2 on the main alarm board, Fig. 2.

We will pick up next month with a discussion of the Power Module. Ω

MINI ANALZYER

continued from page 82

to sense the previously unchecked outputs instead of IC outputs 6, 7, and 8.

Most digital ICs can be tested in a similar process. That is, you must determine the necessary inputs to exercise all functions of the IC, program those inputs, determine where to observe the outputs and what those outputs should be. Then you can compare the results.

To make a simple jig for this purpose, you can use a general-purpose IC PC Board (Radio Shack Part No. 276-159) and a 20-pin IC socket. Solder the socket in place, and solder a solid wire loop on each of the input/output pads. The jig is shown in Fig. 16. Ω

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You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

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The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

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The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

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To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.

DC-2000 MHz

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CERAMIC SURFACE-MOUNT	RAM-1 4.95	RAM-2 4.95	RAM-3 4.95	RAM-4 4.95	RAM-6 4.95	RAM-7 4.95	RAM-8 4.95	
PLASTIC FLAT-PACK	MAV-1 1.10	+MAV-2 1.40	+MAV-3 1.50	+MAV-4 1.60				MAV-11 2.10
	MAR-1 0.99	MAR-2 1.35	MAR-3 1.45	MAR-4 1.55	MAR-6 1.29	MAR-7 1.75	MAR-8 1.70	
Freq.MHz,DC to	1000	2000	2000	1000	2000	2000	1000	1000
Gain, dB at 100MHz	18.5	12.5	12.5	8.3	20	13.5	32.5	12.7
Output Pwr. +dBm	1.5	4.5	10.0	12.5	2.0	5.5	12.5	17.5
NF, dB	5.5	6.5	6.0	6.5	3.0	5.0	3.3	3.6

Notes: + Frequency range DC-1500MHz ++ Gain 1/2 dB less than shown

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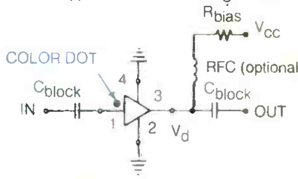

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