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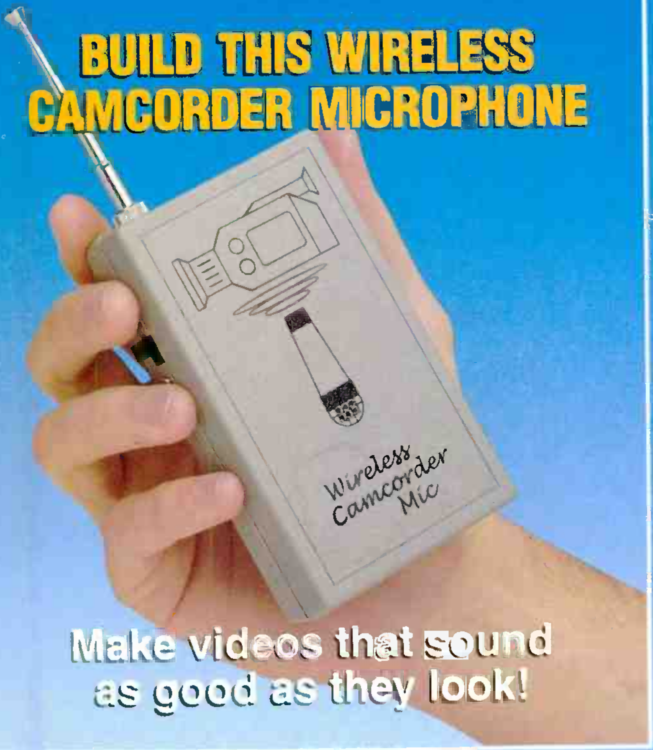

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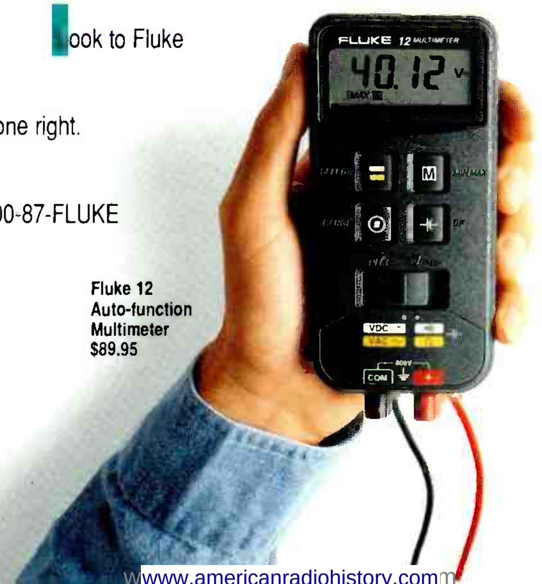

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Vol. 64 No. 2

ON THE COVER

With the growing popularity of stereo televisions and home theaters, we've become accustomed to watching video that sounds as good as it looks. How do *your* home videos measure up to today's demanding audio standards? If something's lacking from their soundtracks, it could be due to the quality of your camcorder's built-in microphone. It can't "zoom" in on sound the way the lens can zoom in on an image and it probably has a hard time picking up diaglogue when there's a lot of background noise. An external microphone can make a world of difference in the sound quality of your videos, but commercial ones can also put a dent in your wallet. That's not the case with our Wireless Camcorder Microphone. Easy to build from readily available parts, it costs less than $15! For all the details, turn to page 31.

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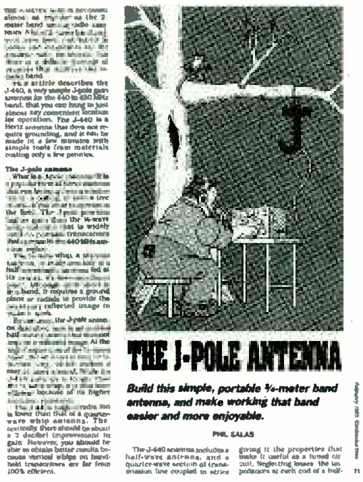

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WHAT'S NEWS

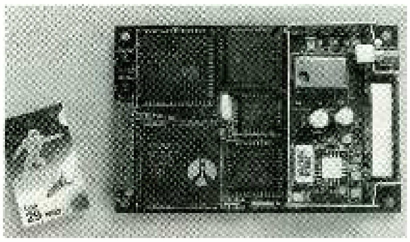
A review of the latest happenings in electronics.

THE NAVCORE V GPS RECEIVER in the small white equipment case mounted at the front of the roof of this Dallas Area Rapid Transit bus allows the vehicle's movements to be tracked precisely.

Global Positioning to track buses

The Global Positioning System (GPS), originally intended as a navigation aid for military ships and aircraft anywhere on the earth, will be put to use tracking the positions of trains, buses and emergency vehicles in Dallas, Texas. The Dallas Area Rapid Transit (DART) system expects to be able to pinpoint the location of its entire fleet of 1500 buses, vans, police cars, and service vehicles to within 15 to 100 meters at any given time.

Rockwell International's Commercial GPS Business (Richardson, TX) has a joint venture with Techsonic Industries Inc. (Eufaula, AL), to furnish DART with receivers for an Automatic Vehicle Location (AVL) system. The equipment needed to monitor and control the movement of the vehicles will be provided under a $16.4-million contract, and it will be based on Rockwell's NavCore V GPS receivers.



THE SMALL, FIVE-CHANNEL parallel GPS receiver provides operators in aircraft, ships, vehicles, and on foot with data on their position, course, and speed every second anywhere in the world.

According to DART officials, the ability to accurately monitor vehicle positions will reduce operating costs by keeping buses running on more precise schedules. It will also improve service by shortening passenger waiting time for the buses. The officials say that the DART AVL system has built-in safety features that will allow dispatchers to summon help automatically—with the push of a button—in the event of medical emergencies, fire, robberies, or shootings.

The NavCore V GPS receive circuitry will be embedded in the Techsonic *Humminbird* receiver located on top of each DART vehicle. It will determine the vehicle's position precisely from signals transmitted by the constellation of NAVSTAR satellites regularly orbiting the earth.

The receiver will send position information to a radio receiver and transmitter combination in the vehicle that will transmit the data to DART's dispatching office. A computer will take the received signal and process it for large displays. DART's vehicles will appear as small moving icons on the screens.

NavCore V was designed for integration into a variety of navigation systems for vehicles, commercial and pleasure craft, and airplanes. It can also be organized to be a navigational aid for hikers and tourists.

Its single-board receiver—the world's smallest and most powerful five-channel parallel GPS receiver, according to Rockwell—can take its first accurate reading from the satellite cluster in less than 30 seconds (compared to almost two minutes for a typical two-channel receiver). Time and velocity can then be read out once per second.

Satellite signals are picked up by a ⅛-inch-square semiconductor device that is made up of 1291 components—the equivalent of putting the entire receiver portion of a TV on the head of a pencil eraser.

LCD optical filter tunes lightwaves

Researchers at Bellcore (Red Bank, NJ) have invented an experimental tunable optical filter based on liquid crystals that allows messages to be transmitted more efficiently by separating information-carrying lightwaves into different "colors."

Today, telephone networks rely increasingly on optical-fiber transmission lines and multiplexing technologies to transmit voice and data around the network along common transmission paths. Despite optical fiber's ability to carry vast amounts

continued on page 90

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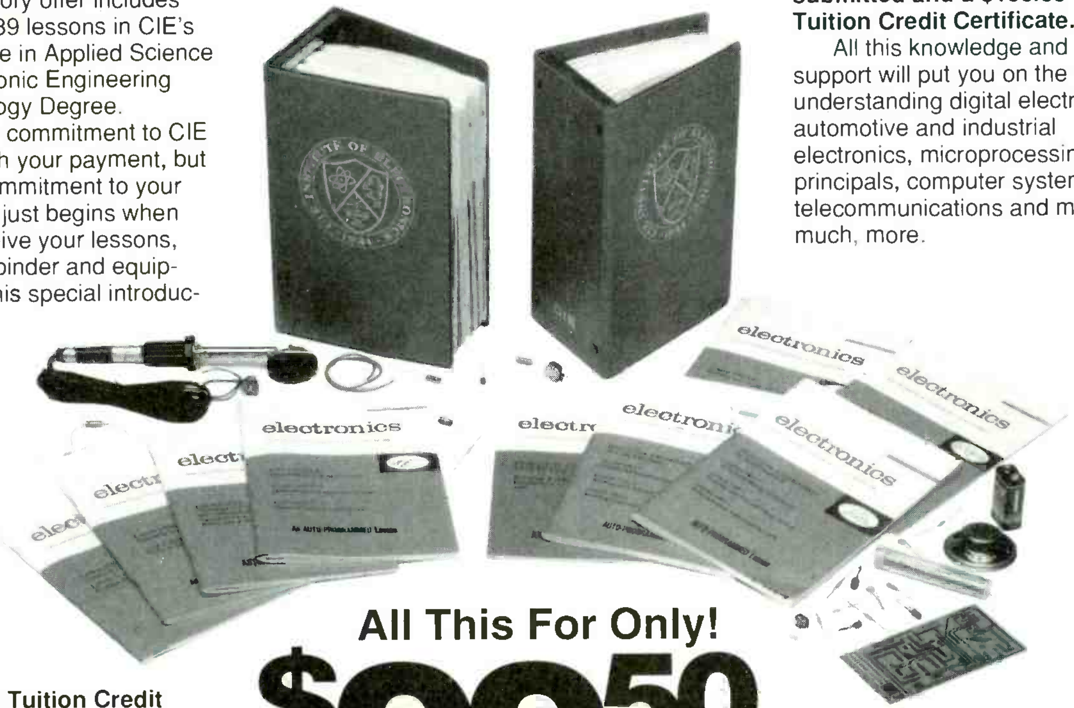

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VIDEO NEWS

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

DAVID LACHENBRUCH

• **Politics and HDTV.** The touchy subject of foreign-made TV sets was broached by one HDTV system team in what appeared to be a non-scientific lobbying effort. Thomson Consumer Electronics (RCA) and North American Philips (Magnavox), members of the Advanced Television Research Consortium (ATRC), signed a pledge to manufacture TV sets, tubes, and "other key carpentry" for high-definition sets in the United States. The statement was endorsed by two unions, the International Brotherhood of Electrical Workers (IBEW) and the International Union of Electrical Workers (IUE). A union news release appeared to imply that the ATRC system was the only HDTV system that could benefit both "American consumers and workers."

The two manufacturers later elaborated on the statement and said they would produce HDTV sets mainly in the U.S. no matter which system was chosen by the FCC. However, they did note that proponents of competing systems couldn't make the same promise. Zenith, a competitive system developer, has moved its major TV production facilities to Mexico. The other system proponents—General Instrument, Massachusetts Institute of Technology, and Japan's NHK—have no existing tube- or set-manufacturing facilities in the United States.

• **What's new in Japan?** That question usually implies some exciting answers. However, at the latest Japan Electronics Show, the answer was awkward and subdued. If there was a trend, it had to be widescreen TV sets with 16:9 proportions to receive standard NTSC broadcasts. Although there were many demonstrations of sets designed for Japan's Hi-Vision analog satellite-transmitted HDTV system, they were priced too high for the general public. Japan is developing an extended-definition widescreen transmission system (which falls short of HDTV) known as Clearvision II or IDTV (for improved definition TV), but displays in this technology seemed to be without much conviction. Some individual displays were intriguing, including a Mitsubishi demonstration of a camcorder that required no direct connection to a TV set for playback (an infrared connection was used instead)—but Mitsubishi said that its display was merely a technological demonstration to get reaction from attendees.

Panasonic showed a high-resolution camcorder with three CCD pickups instead of one. But the company said that it felt American camcorder users weren't quite sophisticated enough to appreciate it, so the camcorder would be introduced here only if demand warranted it. Panasonic also demonstrated a home CD player with full-motion video, promising "combined digital motion pictures and high-fidelity digital sound," but that system isn't quite available yet to consumers.

• **Wide screens for U.S.** Plans to introduce TV sets with 16:9 aspect ratio pictures in the U.S. are being firmed up, although initial plans for a launch in late 1992 didn't pan out. Thomson Consumer Electronics plans to bring out its "CinemaScreen" sets with 34-inch widescreen tubes under its ProScan and RCA brands late in the second quarter of 1993. Panasonic is going with projection TV's, with 50- and 58-inch screens, for shipment in April and September, respectively. Philips says it will have a 34-inch tube set in the first quarter. Sharp says its first widescreen sets for the U.S. will be either 30- or 34-inch sets available around midyear, while JVC expects to enter the widescreen business here sometime this year. Toshiba says that it will sit out the widescreen derby this year because of the lack of widescreen program material available to viewers on either cable or broadcast TV.

• **FCC approves the ghost-buster.** The ghost-canceling system developed by Philips now has a green light from the FCC, which has given informal approval to the use of line 19 of TV's vertical blanking interval for transmission of the reference signal. To eliminate ghosts, receivers must have equipment that responds to the reference signal. Because that equipment will cost $4000 to $5000 at first, it will be sold principally to cable systems for clearing up the signals that they receive over the air. The semiconductor industry now faces the challenge of developing a chip to reduce the cost to a level low enough to permit it to be built into consumer TV sets. Philips says that such a chip could be available to manufacturers as soon as next year.

• **How flat is flat?** "Flat" is an absolute term, not a relative one, according to the National Advertising Review Board. It ruled in response to a petition by Zenith protesting the widespread use of the phrase "flat tube" in connection with computers. The ruling presumably will also apply to TV sets.

Zenith said that its Flat Tension Mask (FTM) monitor tube is the only one with a truly flat face. Therefore, it was misleading for others to advertise "reduced curvature" tubes as "flat." The one company named by Zenith in its complaint—NEC Technologies—has agreed to discontinue advertising its computer-monitor tube as flat. The Review Board said, however, that it's acceptable for others to use the phrase "flat square technology," but only if it's "prominently accompanied by appropriate qualifying language." **R-E**

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AUDIO UPDATE

Multi-channel made easy

LARRY KLEIN

In the early 1970's, I wrote a series of articles—"The Four-Channel Follies"—chronicling the rise and fall of multi-channel sound reproduction. But despite the commercial failure of quadraphonics, I never lost faith. I felt—and still feel—that the only way sound reproduction is ever going to deliver you-are-there realism at home is through multiple channels. However, I never dreamed that the source and the motivation for a resurgence of interest in multi-channel sound would involve video movies and "home theaters"—but so be it.

It appears that about half the receivers expected to appear on the market in the coming year have built-in surround, delay, and/or ambience circuits. Most or all of the receivers manufactured by such major companies as Carver, JVC, Mitsubishi, Philips, Pioneer, Sony, Teac, and Technics have multi-channel capabilities. This could represents a lemming-like rush to leap on a perceived bandwagon, or it could be a real response to consumer demand. Only dealer cash-register receipts will ultimately tell.

In any case, multi-channel sound has risen like the phoenix from the ashes of past fiascoes, and is set to take flight—perhaps. Unfortunately, the process and complexities of the theater-sound setups are a bit daunting, particularly for those who own a conventional system. They might not be sure if they want to make that kind of a commitment to an unproven format. Luckily, there's a cheap and easy way of dipping your toes (ears?) in the multi-channel stream.

Hafler ambience extraction

Developed about 25 years ago by David Hafler of Dynaco fame, the basic Hafler "ambience-extraction" pseudo four-channel setup essentially consists of two small, series-connected speakers wired across the hot terminals of an amplifier. If the idea seems familiar, it might be because I mentioned the Hafler circuit in *Audio Update* of November 1992. This simple circuit won't deliver Dolby Pro-Logic performance, but it will give you a worthwhile, low-cost taste of the benefits of multi-channel audio/video reproduction. And while it isn't quite a "free, get-acquainted" offer, it comes close!

Here is how it works: When a live stereo recording is made, the hall reflections—ambience/reverberation—arrive at the microphones from all directions, and are generally recorded with random playing in the two stereo channels. In studio recordings, the phasing of the sounds of the instruments are also random, but with a somewhat more chaotic relationship.

The phases and amplitude differences between the left and right channels (L minus R) are responsible for the conventional stereo effect from music recordings and video sound tracks. When the L − R signal is delivered separately to the rear of the listening room (rather than remaining mixed in with the front channels), enhanced realism is a frequent result. Because the mix of the L, R, L + R, and L − R signals varies from recording to recording, the specific results are unpredictable. But most listeners report that the effect is pleasing most of the time.

The rear ambience speakers

Happily, the somewhat costly and complicated ground rules that determine the quality and placement of conventional four-channel ambience or theater-sound speakers don't apply to the Hafler configuration. Most Hafler setups use the regular main speakers up front, along with two inexpensive small speakers in the rear.

Small speakers such as those in the Radio Shack Minimus series serve nicely. Avoid 4-ohm units because they can reduce the total impedance of the circuit so that it is too low for your amplifier. Ideally, the ambience speakers should be barely audible; their contribution should be apparent only when you turn them off and find that the extra realism disappears.

For best results, the ambience speakers should be at least as far from your listening position as your main front speakers—the farther away the better. It might be helpful to mount them high up on the side or rear wall, toward the rear corners of the room, facing upward or parallel with respect to the walls.

There are no hard and fast rules (other than keeping them distant from the listening area), and I recommend experimentation. I see no reason why the speaker locations have to be exactly symmetrical with respect to the listening position, just as long as they are both far enough away to provide some time delay in the arrival of their signals.

Depending upon your choice of rear speakers, you might have to reduce their overall output and/or their treble response. Output is reduced simply by installing series resistors, as shown in Fig. 1.

A 25-ohm, 10-watt potentiometer (or rheostat) allows easy adjustment of speaker level, but if one is not available, you can accomplish the same result by trial and error with fixed-value power resistors. If you use circuit (a) one potentiometer will be sufficient; circuit (b) requires two.

The rear speakers you choose can, at times, produce distracting and inappropriate high-frequency

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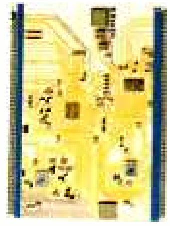

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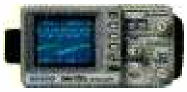
But then a lot of performance for not a lot of money is exactly what the TAS is all about. Scopes that add to a long list of low-cost Tektronix products. Like our handheld 60 MHz 224  digitizing oscilloscope.  Our fully programmable, analog/digital 2212 scope. And our family of affordable and  stackable basic test gear.

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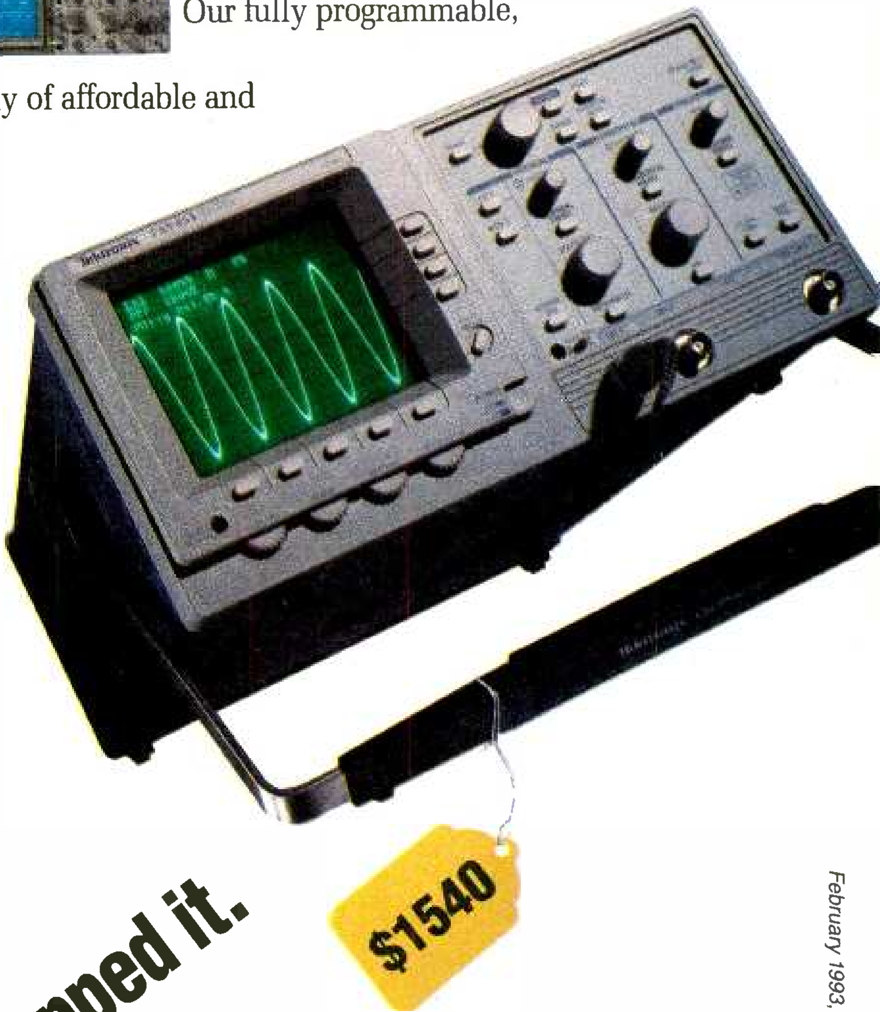

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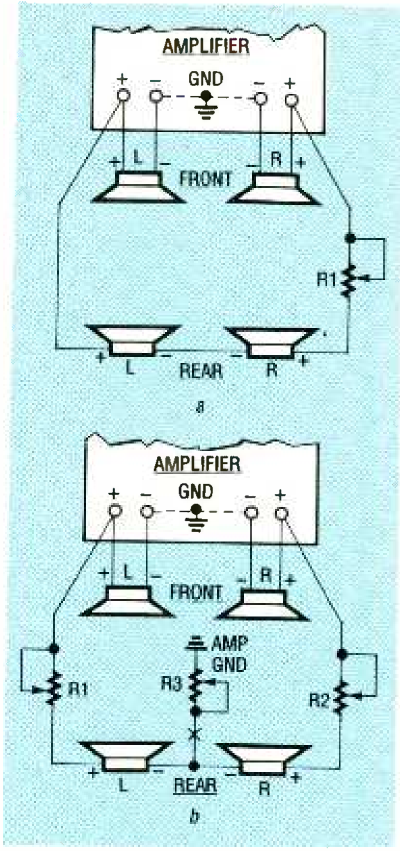


FIG. 1 (A). THE SIMPLEST CONFIGURATION OF THE HAFLER CIRCUIT. The left and right rear speakers receive the same L–R signal. If their efficiency is so low that they are not obtrusively loud on most program material, R1 can be omitted. A single rear speaker will serve if its impedance is 8 ohms or higher. (That avoids stressing the amplifier.) It should be installed in the center rear, preferably facing upward or toward the rear wall to encourage reflective bounce.

FIG. 1 (B). THIS CIRCUIT PROVIDES MORE OF A SURROUND-SOUND EFFECT than (A) and might work better with pop than classical music. Resistors R1 and R2 should be adjusted simultaneously for the proper relative front-to-rear levels. The settings will depend, to some degree, on the listener's location. Resistor R3 is adjusted by ear to provide some mixing of the front L and R signals in the rear speakers. If desired, an on/off switch can be installed at X to eliminate the mix in the rear channels.

If your amplifier has an A–B switch to handle a second set of speakers, the rear-speaker circuit, (a) or (b), can be connected directly to the positive B terminals. This will enable convenient on–off switching of the rear channels.

transients. You can reduce that effect by gluing a small piece of foam or fabric on the grille cloth over the center of the full-range or high-frequency driver in a trial-and-error process. The object of the process is to take the "edge" off the transients, yet preserve the midrange and low highs.

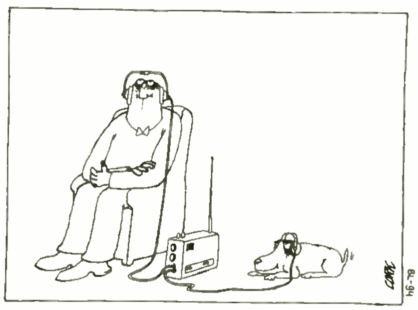
Circuit a vs. b

Circuit (a) has the advantage of simplicity. It makes use of only one gain-control resistance (which can be omitted if the rear speaker's efficiency is low enough). In addition, it allows you to use only a single rear speaker.

Circuit (b) requires a pair of gain-control resistors and an additional resistance somewhat higher (about 50 ohms) to mix some stereo signal into the ambience signal. Some people claim that this modification gives the listener an enhanced impression of space and ambience, an improvement on the original (a) circuit.

Final note: There are a few amplifiers on the market that do not have a common ground shared by both speaker terminals. And there are at least two brands that, for good technical reasons, have the polarity markings on one channel's speaker terminals reversed. (Red indicates the grounded terminal rather than black.) If you have any doubts about how to wire your amplifier's speaker outputs, you can confirm that the black speaker ground terminals are common to both channels with an ohmmeter.

The Hafler circuit won't give you something for nothing, but it will deliver surprising performance, considering the small investment required in both time and money. **R-E**



NETWORK TROUBLESHOOTING

I read with interest the third installment of "From Not Working to Networking" (**Electronics Now**, October 1992) by Gary McClellan, and I agree that giving specific case examples is an effective way to discuss practical LAN troubleshooting. Unfortunately, I found several of McClellan's examples to be deceptive because they describe situations that might occur, but they are not, in my opinion, typical of normal LAN's.

For example, in the first problem scenario, McClellan recommends running a Disk Doctor program on the server. However, approximately 60 to 70% of LAN's run on Novell's proprietary software, so that advice not helpful. Novell does not use a DOS format, and Disk Doctor software is DOS-based. Disk Doctor programs that run on Novell networks might not work—and that will confuse the trainee—or they will destroy data on the disk—and that will surprise the novice.

In the second scenario, McClellan says that ARCnet operates over RG-58/U coaxial cable, but the ARCnet specifications call for either RG-62/U coaxial cable or twisted-wire pairs. I admit there might be an ARCnet LAN connected with RG-58/U cable, but it is not typical, and this too can confuse the novice.

McClellan states that soldered coaxial connectors are far more reliable than crimp-on connectors. That might be correct in theory, but as a practical matter it is only true if the installer has consideable soldering skill.

Also in the second scenario, McClellan talks about a Compaq 386 computer "configured as a hub." While that computer can perform that function, its mention is misleading in that it implies that a Compaq 386 is a hub in typical ARCnet configurations.

When McClellan discussed the time-domain reflectometer (TDR), he said that a scope reading indicates the presence of a "sharp drop about 29 feet away." I believe he should have said "29 *meters* away."

I want to assure the author that I am not trying to "nit pick." But I did want to call attention to what I see as errors.

BRIAN L. KENNEDY
San Diego, CA 92117

I'd like to thank Mr. Kennedy for writing and expressing his concern. Prior to writing the series, I developed and marketed a LAN test product to a range of customers from "mom and pop" service companies to the largest personal computer manufacturers. This experience put me in touch with a lot of people who told me about their service problems. (One is in San Diego, so I am familiar with what happens there.)

The troubleshooting examples I used in my article were based upon the most common problems that my contacts said they encountered, but the details I wrote about reflect my own experience.

Early Novell systems had a custom hard-disk formatting scheme that can be damaged by Disk Doctors. In fact, Novell gave preformatted hard-disk drives to their customers to spare them the lengthy formatting process. Talk to a Novell representative if you are unsure about how to correct hard-disk problems.

Officially, ARCnet was designed for RG-62/U coaxial cable, a 93-ohm cable that looks like RG-58/U, a 50-ohm cable. RG-58/U has been substituted for other kinds of cable in LAN's because it is easier to obtain and somewhat cheaper than RG-62/U. In the examples cited, RG-58/U was substituted by a cost-conscious company president and an installer (who probably was the lowest bidder on the installation contract).

Although that cable type was not recommended, the system worked after repairs, and no attempt was made to change the cable. In my opinion, incorrect cable substitutions account for relatively few problems in the industry, but troubleshooters should be aware of them.

A handy reference guide to network topologies and cable selection can be found in AMP's Netconnect Open-Wiring Systems Catalog, *which can be obtained free from AMP distributors or by calling 1-800-522-6752.*

Some field-service technicians I know look upon crimp connectors as "built-in repeat-service business." Crimping is popular because it is quick and fast, but unless the technician has the necessary skill and uses the connector manufacturer's proprietary (or recommended) crimping tools, connection quality will suffer.

Last summer, I helped to solve three LAN-related service problems. One was caused by a "bug" in the LAN operating system, and the others were caused connections performed by so-called professional installers.

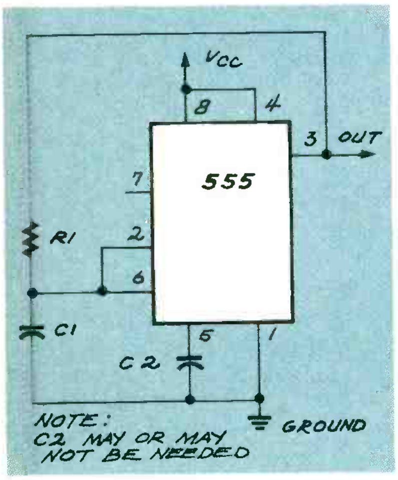
The Compaq 386 "hub" computer in the ARCnet system was a popular configuration two to three years ago. Today, most networks have gone to 486-based computers for better performance because speed is critical in this business.—Gary McClellan

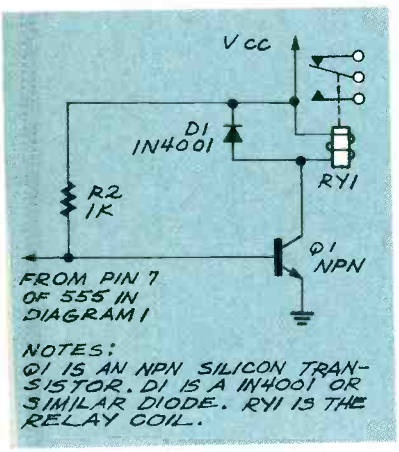
MORE 555 CIRCUITS

I was pleased to see Ray Marston's article on 555 timer circuits in the October 1992 issue of **Electronics Now**. But I was disappointed to see that one of the simplest, yet most useful, circuits was not included in the article. In fact, this circuit seems to be one of the best-kept secrets because I've never seen it published—not even in Don Lancaster's *555 Handbook*—but only referred to in literature.

In the typical circuit for an astable oscillator using a 555 timer (Fig. 3 in the article), C1 charges through R1 and R2, but discharges via pin 7 of the 555 through only R2. As mentioned in the article, if R2 is much larger than R1, then a waveform with a duty cycle close to 50% will be generated. But it's clear that unless R1 is actually zero (which would burn up the chip quite quickly!), then the waveform never will be exactly symmetrical.

But output pin 3 toggles between Vcc and ground, and it can source or sink a reasonable amount of current in both states. This is especially true for the 7555, the CMOS version of the 555. Therefore, by using that pin to charge and discharge C1 through a single resistor, as depicted in Fig. 1, the resultant output is a symmetrical waveform with a duty cycle of exactly 50%. R1 can be varied to change the frequency, and the duty cycle will remain absolutely constant.





Some asymmetry can be introduced if the output is heavily loaded. Thus, for example, if the timer is to drive a relay, discharge pin 7, otherwise open, can be used to pull the base of an NPN transistor normally biased "on" to ground Fig. 2) via a resistor of 1K or greater from Vcc (See Fig. 2).

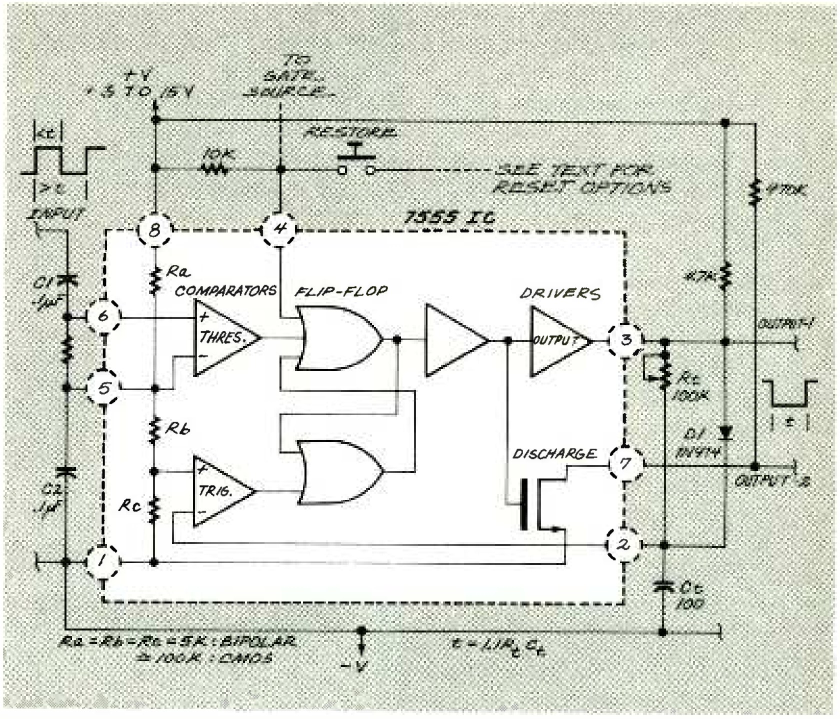
I have combined these two circuits to drive alternating flashing circuits for volunteer fire department vehicles. A CMOS 7555 with a C1 of 0.1 µF and an R1 of 10 megohms, will oscillate at a frequency of about 80 flashes per minute.

DAVID BANKS, N0ION
Colorado Springs, CO

FIGS 1 & 2 GO WITH ABOVE ITEM

The series of articles by Mr. Ray M. Marston in the September and October 1992 issues of **Electronics Now** are a welcome review of the 555 family of monolithic integrated devices and the circuits that can be made with them.

I have used the 555 in many applications since its introduction in 1972. Therefore, I am aware of the



fallacy about the minimum trigger-voltage level for a monostable oscillator based on the 555 that is being pertetuated in the articles. That, and other earlier references, have stated that a minimum falling-level voltage change of ⅓ V+ is required to trigger the oscillator output "on." I say that is not correct.

I'd like to call attention to a circuit that I developed and described. The schematic and description were published as the *EDN* magazine "Best of Issue" design in January 5, 1989. With the values shown in Fig. 3, the CMOS 7555 inverted monostable circuit will trigger on a sine-wave or other rising input signal with a level of less than 31 millivolts, rms, over a frequency range of 60 Hz to 23 kHz.

In the same circuit, the bipolar 555 will trigger on similar kinds of input signals of less than 15 millivolts, rms, over a frequency range of 10 Hz to 50 kHz. In both cases, the driving source impedance is 600 ohms, and V+ is 9.0 volts. The frequency range expands as the input signal level increases.

In those examples, I found that the key to this circuit's operation is the addition of a sufficiently conductive current path through R1 around the almost infinite impedance across the input pins 5 and 6 of the threshold comparator. As a result, the voltage developed across R1 (in the voltage divider C1, R1, C2) to V− is sufficient to trigger the threshold comparator and turn the output "on" or "high." This circuit has found several applictions as a low-level signal detector, amplifier, and sine-to-squarewave converter.

I'd also like to point out that the lower end of the three 5K voltage-divider resistor strings shown in Fig. 1 of the September article is actually connected to ground (V−) internally, as is the emitter of the discharge transistor.

JOHN J. O'FARRELL
Tallahassee, FL

DISKETTE DIFFERENCES

I am responding to a question posed by F. Foeg about the differences in 3½-inch diskettes (*Q&A*, **Electronics Now**, September 1992). I manage a company that manufactures test equipment and special alignment and diagnostic diskettes for the manufacture and service of floppy-disk drives. I gained 14 years of experience in various technical and management positions with Dysan, a diskette manufacturer, which later became Xidex. Therefore, I believe that I am qualified to explain this

continued on page 86

www.americanradiohistory.com

Global Specialties 2003 Synthesized Function Generator

New signal generator offers front-panel and computer control.

CIRCLE 10 ON FREE INFORMATION CARD

Once your test bench is equipped with a digital multimeter and an oscilloscope, a function generator is the next piece of gear you'll need. Although engineers and technicians know how important a function generator can be, even advanced hobbyists will find a host of uses for an instrument like the latest model from Global Specialties (70 Fulton Terrace, P.O. Box 1942, New Haven, CT 06512). Applications include testing the frequency response of filters and amplifiers, and troubleshooting and servicing electronic equipment.

Global's *2003* can produce sine, triangle, square, and ramp waveforms over a frequency range from DC to 1.6 MHz. Its 10-digit display provides a frequency resolution of 0.001 Hz. The generator's accuracy is rated at ±10 parts per million (ppm), with a drift of less than 5 ppm per year.

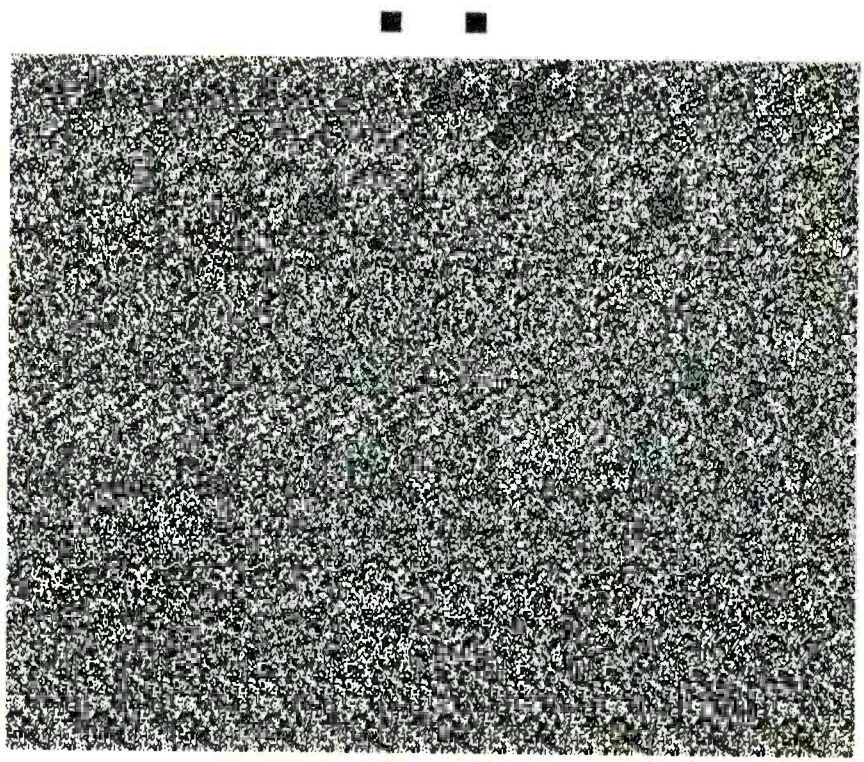
The 2003 generator is housed in a gray plastic cabinet that measures about 4×10×7 inches. The front panel features a 2-line by 16-character LCD, a 16-key membrane keyboard, a rotary, digitally encoded knob, and a BNC output jack. The rear panel holds the power switch and four BNC connectors (SYNC, TTL OUT, MARKER, and TRIG/GATE). An optional RS-485 serial interface is also provided on the rear panel.

Sine-wave distortion (both harmonic and non-harmonic) is rated a

Stareo 3-D Print Software

Random-dots add the illusion of depth to any two-dimensional image.

CIRCLE 11 ON FREE INFORMATION CARD



The image in the box that opens this report should, at first glance, appear to be random dots. Study the image intently, however, and you should begin to see repetitive vertical strips of dots. But if you look at it as you would any normal two-dimensional image, you are not looking at it correctly.

The trick to seeing the hidden image is to focus your eyes, not on the page, but to an imaginary point several feet *behind* the page. Try to be completely relaxed, and hold the image between 8 and 16 inches from your eyes. Relax your eyes as you try to focus on the imaginary point behind the image. If you are persistent, you should see the image, better than 40 dB below the fundamental. Triangle-wave and ramp nonlinearity are rated at less than 1% up to 100 kHz; square-wave jitter is less than 1%.

The amplitude of the output waveforms can vary from 5 millivolts to 20 volts peak-to-peak (p-p) into an open circuit, 2.5 millivolts to 10 volts p-p into 50 ohms. The output can be offset +10 volts to −10 volts.

Operating modes

The 2003 offers six operating modes: Continuous, triggered, gated, sweep, hop, and burst. In the continuous mode, the selected waveform is generated continuously. In the gated mode, the selected waveform is generated continuously as long as the GATE/TRIG input on the rear panel is held at a high TTL level. When that input is low, only the offset voltage is available at the output. In the triggered mode, the signal output is toggled on and off by a trigger pulse (1 microsecond or longer) on the GATE/TRIG input.

The generator offers both linear and logarithmic sweep modes. Both modes operate similarly, with the exception that the output varies logarithmically over time in the log-sweep mode. The start and stop frequencies can be programmed into the 2003, as can the sweep time. Each sweep is marked by a positive-going pulse on the SYNC output jack for oscilloscope triggering. Sweep-marker pulses are provided at the MARKER output; they're typically used on a scope's second channel to provide a scale.

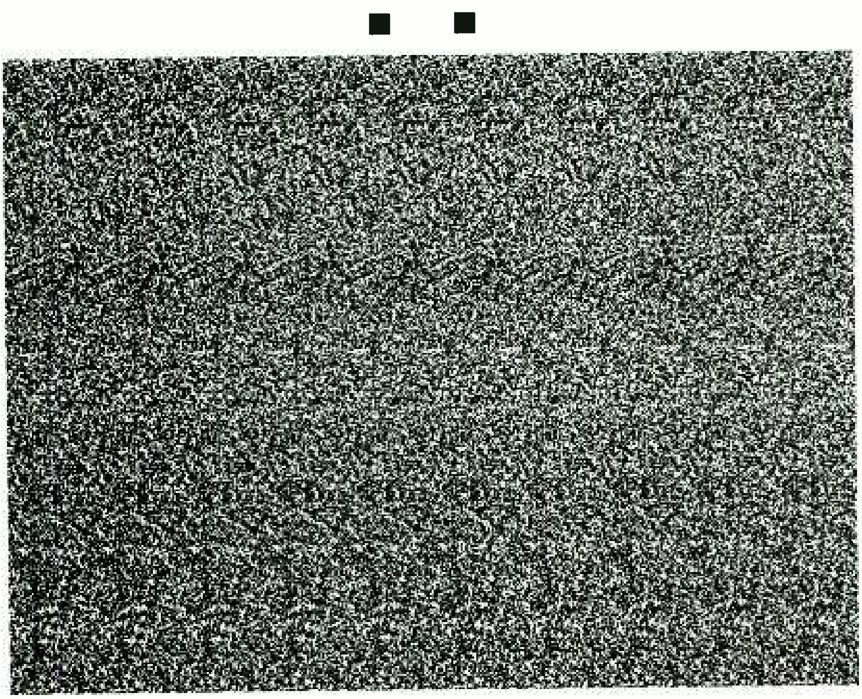
The hop mode allows the user to store up to 16 frequencies—each with its own waveshape, amplitude, offset and duration—in the generator's memory. The sequence can be played on command, so the hop mode is ideal for repetitive testing. The burst mode is a variation of the hop mode in which a frequency of 0 Hz is stored in memory in between other frequencies. The non-0 stored frequencies appear as bursts when the hop sequence is played back.

Many of the functions of the 2003 are controlled by a menu system; the rotary knob on the front panel controls a cursor on the LCD readout. Desired output frequencies can be input directly from the keyboard, or they can be set with the rotary knob by moving the cursor to the selected digit, and rotating the knob to increase or decrease the value of the digit.

The user interface is not intuitively understood. We got stuck on a couple of points and had to refer to the generally good manual to get us going. Once we understood the general operating procedures, we found the unit to be quite easy to use. Our only complaint is that the display is difficult to read in some lighting conditions.

The 2003 offers an optional RS-485 interface that can be controlled by any PC similarly equipped; all aspects of the unit's operation can be controlled through the interface. Up to 32 devices can be attached on a daisy-chained RS-485 bus, with each device having a unique address.

Thanks to its innovative user interface and the optional computer-controlled capability, the 2003 provides impressive versatility at an attractive price of $499 ($750 with the RS-485 interface.) **R-E**



or at least something strange, after only a few seconds. However, it could take up to several minutes to see the image.

If you have trouble seeing the random-dot image even after a few minutes, shift your gaze exclusively to the two square spots (known as *fusion dots*) at the top of the image. Stare at the dots until you are able to perceive the two squares becoming an apparent three. Now slowly transfer your focus from the squares to the image. Be patient. With your eyes properly "prepped," you should be able to see the three-dimensional image.

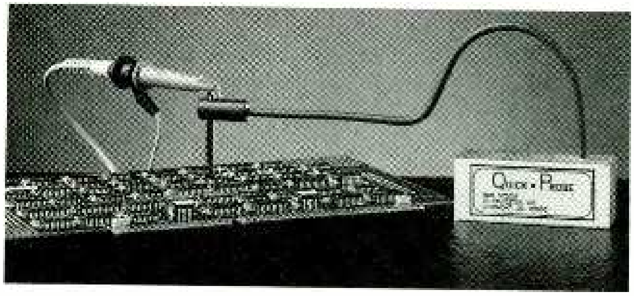
When you look at a three-dimensional object, your brain uses the slightly different viewing angles between your left and right eyes to give you three-dimensional vision. The random-dot images do the same thing by hiding different images for each eye in vertical strips of dots. The strips are as wide as the distance between the two fusion dots. When one eye is looking at a dot in one strip, the other eye should be looking at the same dot two strips over. You might even see some very unusual double images when one eye focuses on a dot three strips away from the other. Some people find it easier to see the image when they cross their

continued on page 56

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

SMC PROBE. This new probe from *R & R Design* is said to be a versatile alternative to present methods for testing surface-mount components. Handheld instrument probes allow only one test point to be observed at a time—a time-consuming chore that could cause damage to the components being tested. Clips for some surface-mount packages are available, but a different clip is needed for each surface-mount package size. And custom-made test stations are prohibitively expensive.

Quick Probe is a weighted spring-type contact probe with a flexible shaft and a connection point for coupling a test instrument. Different kinds of test points can be contacted with a single tool, and there is no need to solder test leads to components. *Quick Probe* tests most surface-mount package styles.



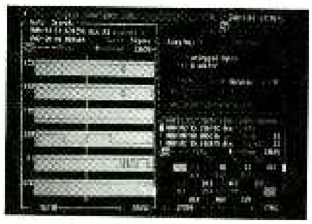
CIRCLE 16 ON FREE INFORMATION CARD

The *Quick Probe* is priced at $45.

R & R Design
20 Princeton Circle
Longmont, CO 80503
Phone: 303-678-5004

COMMUNICATIONS DEBUGGER. This upgraded version of *MicroTAP's* (formerly DataScope) communications debugging software for data capture and analysis has applications in computer programming, manufacture, and industrial automation.

According to its publisher, *Paladin Software*, *MicroTAP* permits the user to apply capture, display, and search tools to ordinarily invisible serial transmission events. This, it says, is a cost-effective alternative to expensive hardware line monitors.



CIRCLE 17 ON FREE INFORMATION CARD

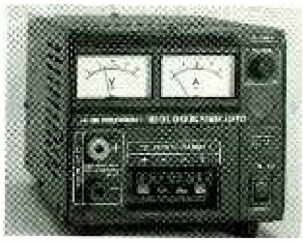
MicroTAP is said to be the only serial line monitor that includes context-sensitive Hypertext, Hypersetup, user-alterable multitasking window displays, and oscilloscope-like signal event tracing. All data and signal events are time-stamped to the nearest microsecond.

Version 2.1 also adds CUA-compliant file management, signal-pattern triggering (including "don't care" signals), and expanded data-stream triggering capabilities (logical AND and OR functions, user-selectable source streams, and wild card bytes in binary or alphanumeric trigger strings).

MicroTAP Version 2.1, including cable, connectors, and manual, costs $299.

PALADIN SOFTWARE, INC.
3945 Kenosha Avenue
San Diego, CA 92117
Phone: 619-490-0368
619-490-0177

CONTINUOUS-DUTY DC POWER SUPPLY. A new portable high-current DC power supply from *B+K Precision* is said to be a compact, reasonably priced alternative to the use of batteries.



CIRCLE 18 ON FREE INFORMATION CARD

The *Model 1686* is rated for 12-ampere continuous duty at 13.8 volts DC without overheating. If more output is required, two (or more) of the power supplies can be connected in parallel (to double the current) or in series (to double the voltage). The features of the *Model 1685* include reverse-polarity, overload protection, and short-circuit protection, as well as current limiting.

B+K lists possible applications as servicing and demonstrating car stereos, servicing camcorders, and powering amateur radios.

The *Model 1686* is priced at $199.

B+K Precision
Chicago, IL 60635
Phone: 312-889-1448
Fax: 312-794-9740

HIGH-SPEED EPROM PROGRAMMERS. New high-speed EPROM programmers from *JDR Microdevices* are capable of programing one EPROM or four EPROM's simultaneously. The manufacturer reports that both units can program up to 8-megabit, 12.5-volt EPROM's. The single-EPROM unit is the *Model MOD-MEP-1A*, and the four-EPROM unit is the *Model MOD-MEP-4A*.

Menu-driven software, located on the user's PC-compatible system, gives the operator a choice of EPROM vendor and part number. The software then automatically sets the specified programming voltage, time constants, and other variables.

The user can choose from a list of programming methods based on the device selected. The software also provides a complete list of functions. These include device reads, compares, verifies, blank-checking, and an auto-programming mode. Code can be loaded, edited, displayed, and stored to save debugging time.

A conversion utility al-

CIRCLE 19 ON FREE INFORMATION CARD

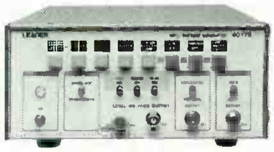
lows the programmer to use hex source as well as binary data files. The utilities include split and shuffle code. The splitting feature breaks 16- and 32-bit words into odd/even bytes for 8-bit EPROM's. The shuffle feature mixes odd and even bytes into 16- and 32-bit words, allowing existing 8-bit EPROM applications to be transferred into 16- or 32-bit forms.

The *Model MOD-MEP-1A* is priced at $199.95, and the *Model MOD-MEP-4A* is $269.95.

JDR MICRODEVICES
2233 Samaritan Drive
San Jose, CA 95124
Phone: 408-559-1200
Fax: 408-559-0250

NTSC VIDEO PATTERN GENERATOR. This NTSC video pattern generator from *Leader* produces split-field color bars, crosshatch, dots, single-cross, and flat-field (raster) patterns.

The *Model 401YB* is intended for video, TV and VCR service. The generator's flat-field rasters can be set to eight colors, including black-and-white. Its color signals are true NTSC, suitable for test and



CIRCLE 20 ON FREE INFORMATION CARD

checkout of both consumer and industrial circuits. Its outputs are baseband composite, video RF on VHF channels 3 or 4, Y/C (SVHS-type), and red green blue TTL-compatible.

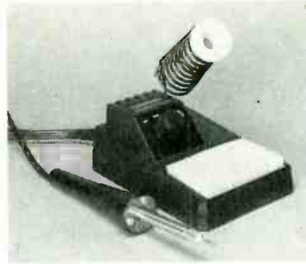
An H or V trigger signal is also available for synchronizing oscilloscopes. A choice of standard interlace or progressive scanning is offered. Progressive scanning is easier on the eyes during convergence adjustments.

The *Model 401YB* pattern generator sells for $995.

LEADER INSTRUMENTS CORPORATION
380 Oser Avenue
Hauppauge, NY 11788
Phone: 800-645-5104
(in NY, 516-231-6900)

DUAL-WATTAGE SOLDERING STATION. A new soldering station from *Ungar* permits the user to switch between 35 watts, 850°, and 21 watts, 650°, with a front-panel knob.

The dual-wattage soldering station, No. 46B991, is available from *Jensen Tools*. The station permits



CIRCLE 21 ON FREE INFORMATION CARD

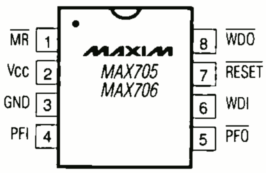
rapid heating. It is equipped with a fully grounded, ⅛-inch chisel tip specifically for soldering sensitive electronic components. A broad selection of replacement tips is also available.

The *Ungar* No. 46B991 soldering station is priced at $49.

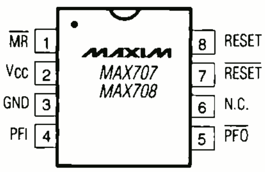
JENSEN TOOLS INC.
7815 South 46th Street
Phoenix, AZ 85044
Phone: 602-968-6231

SUPERVISORY IC's. Supervisory integrated circuits from *Maxim Integrated*

Products give reset or other warnings upon detection of a malfunction in a microprocessor's power supply or program execution. The *MAX705 to MAX708* supervisory IC's are rated for both 3-volt and 5-volt operation.



DIP/SO



DIP/SO

CIRCLE 22 ON FREE INFORMATION CARD

The chips offer different trip thresholds. The *MAX705* and *MAX707* have 4.65-volt thresholds (for 5-volt ±5% supplies), and the *MAX706* and *MAX708* have 4.4-volt thresholds (for 5-volt ±10% supplies). Three-volt versions of the *MAX706* and *MAX708* have thresholds of 2.63, 2.93, and 3.08 volts.

The devices are available in space-saving 8-pin DIP and SO packages. Because they do not require external passive components or clock signals, they simplify the design and layout of the host circuit boards.

Each IC issues a rest signal when the supply voltage falls below its threshold—during power-up, power-down, power brownout, or momentary power interruption. Reset assertion is guaranteed for a voltage as low as one volt. All the supervisory IC's have a debounced manual-reset input that lets the user generate reset pulses on command. An included independent comparator/reference circuit can monitor a supply voltage, battery voltage, or other voltage source.

The *MAX705 to MAX708* supervisory IC's are priced from from $0.88 to $1.09 in quantities of 25,000 pieces.

MAXIM INTEGRATED PRODUCTS
120 San Gabriel Drive
Sunnyvale, CA 94086
Phone: 408-737-7600, ext. 6087

MODULAR DIGITAL VOLTMETER. All of the models in this line of modular digital voltmeters from *Datel* have large (0.52-inch), 4½-digit LED readouts, and each measures only 0.85 × 0.56 × 2.17 inches.

The *DMS-40PC* voltmeters are available in a range of signal-input configurations (±2-volts DC, ±20-volts DC, and ±200-volts DC), and primary power options.

CIRCLE 23 ON FREE INFORMATION CARD

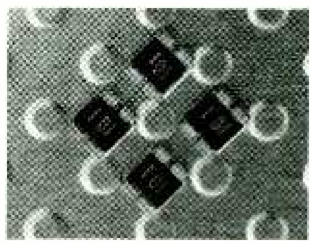
The voltmeters are manufactured by surface-mount technology. Each instrument has a laser-trimmed reference, is fully encapsulated, and receives a 100% burn-in. All models offer high-impedance differential inputs, autozero, and autopolarity indication from an internal stable reference circuit.

The voltmeters are suitable for panel or PC-board mounting. The LED displays are offered in a range of colors—red, green, yellow, orange, and amber.

The *DMS-40PC* voltmeters are priced stating at $79 ($54 in 100's).

DATEL, INC.
11 Cabot Blvd.
Mansfield, MA 02048
Phone: 508-339-3000
Fax: 508-339-6356

CERAMIC CHIP RESISTOR NETWORK. This new small ceramic chip resistor network from Rohm is said to eliminate problems encountered in picking, placing, and soldering conventional resistor networks with molded packages on circuit boards. It is intended for high-density surface-mount circuits such as those found in notebook and palmtop computers.



CIRCLE 24 ON FREE INFORMATION CARD

The *MNR-32* resistor network includes two resistor elements in a 0.1 × 0.1-inch package. The 1/16-watt device is available with resistor values from 100 ohms to 330 K. The network has a rated maximum voltage of 50 volts.

According to Rohm, the network can be placed automatically because its pinout pitch is the same as that for miniature molded IC's. This network resistor, with only two resistive elements, reduces component count, assembly time, and cost because two resistors can be placed at the same time as one.

The package has concave electrodes and large solder pads. Those features assure a strong solder bond.

The *MNR-32* is sold on reeled tape with 4000 units per tape resulting in a unit price of $0.03 each when ordered in 50,000-piece quantities.

ROHM CORPORATION
3034 Owen Drive
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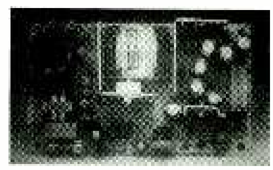
All models have automatic overvoltage, overload and 150% overload protection, 16-millisecond holdup time, a built-in EMI filter, and protective fusing. Cooling is by free-air convection, and Molex connectors are standard for AC input and DC output.



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GL power supplies are priced at $85.

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Phone: 1-800-TRY-SOLA **R-E**

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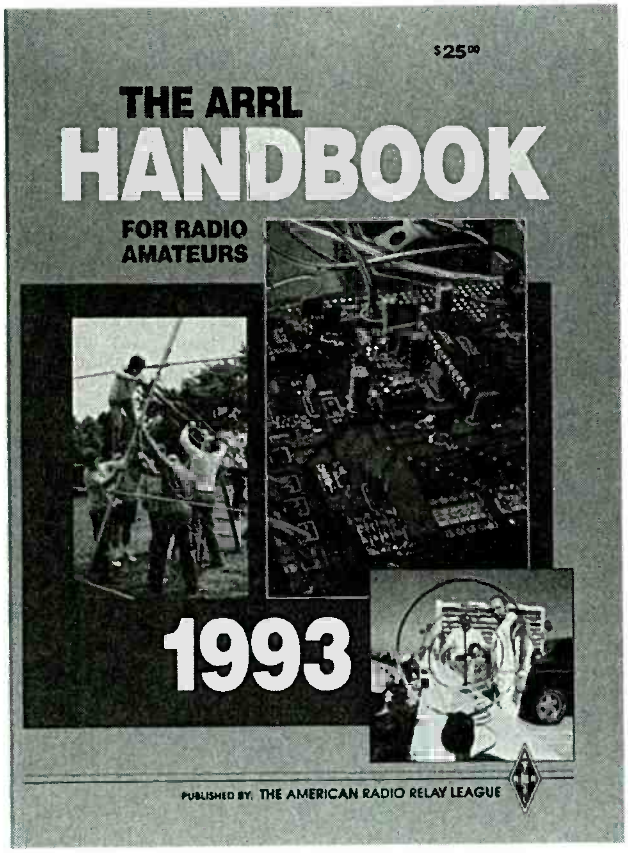
The ARRL Handbook for Radio Amateurs, 1993 Edition; edited by Robert Schetgen, KU7G. The American Radio Relay League, 225 Main Street, Newington, CT 06111; Phone: 203-666-1541; $25.00 (plus $4 shipping).

The ARRL Handbook has been the radio amateur's "bible," since the 1920's. It is a comprehensive handbook covering just about everything related to amateur radio. This edition has 39 chapters that cover everything from the fundamentals of electronics and radio to guidance on how to build your own equipment. Significant topics include modulation methods, propagation theory, test equipment, electromagnetic interference, and how to deal with it. You can also learn about simple wire antennas and baluns and slow-scan television.



CIRCLE 40 ON FREE INFORMATION CARD

The 70th (1993) edition of the comprehensive, single-volume handbook is extensively illustrated with photos, graphs, diagrams, schematics, and circuit-board foil patterns. It includes such new build-it projects as a 4.5 to 25-volt, 2.5-ampere precision power supply, a battery charger suitable for all lead-acid batteries, a low-cost high-frequency counter, and a receiver spectral-display based on DSP.

TEST MEASUREMENT INSTRUMENTS CATALOG. Bel Merit Corp., 17 Hammond, Suite 403, Irvine, CA 92718-1635; Phone: 714-586-3700; Fax: 714-586-3399; free.

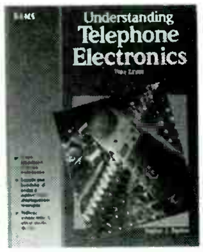
Bel Merit's 12-page brochure includes detailed specifications and descriptions of portable and benchtop test and measurement instruments for student, technicians, hobbyists and engineers who test, repair, or assemble electronic equipment.

CIRCLE 39 ON FREE INFORMATION CARD

The new products highlighted in the catalog include multifunction digital multimeters, digital clamp-on current meters, non-contact voltage detectors, continuity checkers, AC circuit analyzers, and oscilloscope probes.

UNDERSTANDING TELEPHONE ELECTRONICS, THIRD EDITION; by Stephen J. Bigelow. Sams, Division of Prentice Hall Computer Publishing, P.O. Box 90, Carmel, IN 46032; Phone: 800-428-5331 or 317-573-2500; Fax: 317-573-2665; $24.95.

This book provides a comprehensive background on the way advancement in electonics have improved telephone communication. This third edition updates the information of the author's earlier editions.



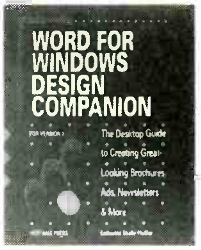
CIRCLE 38 ON FREE INFORMATION CARD

In the U.S. today, the phone network permits communication between more than 100 million phones. Advancements in electronic technology have improved the speed as well as reliability of telephone interconnection. Mr. Bigelow's book explains how telephone conversations and data are received, switched, and transmitted.

It begins with an overview of telephone networking that introduces you to the basic telephone components and explains how they are connected to the network. A discussion of the non-electronic sound-powered telephone is included to give you a better understanding of the fundamentals of telephones.

Such topics as analog and digital signal processing, telephone-line interfacing, tone and pulse generation, and ringers are included. Digital communication is introduced, and the advantages and disadvantages of digital transmission are presented. You can read about sampling, coding, and the multiplexing formats. A discussion of the central office and the differing transmission modes is included. Bigelow explains wireless telephones, cellular phone systems and other evolving concepts.

WORD FOR WINDOWS DESIGN COMPANION FOR VERSION 2; by Katherine Shelly Pfeiffer. Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $21.95.

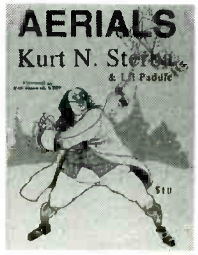


CIRCLE 37 ON FREE INFORMATION CARD

Word for Windows is intended to replace cumbersome existing software for most desktop publishing needs. Ms. Pfeiffer's book tells you how to push Word beyond simple word-processing tasks and unleash its graphics power. She has included step-by-step directions and dozens of illustrations created using Word for Windows.

Now you can take advantage of Word's desktop publishing capabilities to produce attractive newsletters, brochures, business correspondence, advertisements, catalogs, reports, forms, and surveys. The book also explains production shortcuts, helps you to manipulate fonts, and discusses printing techniques. The examples will inspire you to do your own designs.

AERIALS; by Kurt N. Sterba and Lil Paddle; Worldradio, 2120 28th Street, Sacramento, CA 95818; Phone: 916-457-3655; $10 (plus $2 shipping and handling).



CIRCLE 36 ON FREE INFORMATION CARD

This book is a compilation of articles on antennas and feed lines that the authors have had published in *Worldradio* magazine. Kurt N. Sterba and Lil Paddle debunk many of the myths and misconceptions about amateur radio that have their origins in equipment and component manufacturers' sales literature and catalogs.

The style of the articles is acerbic and irreverent. Nevertheless, the result is a sharp, witty dialogue between two experts. During their lively discourse, the authors reveal numerous discrepancies found in books on amateur radio, catalogs, and sales literature. They have purposely included 11 inconsistencies in the book, "to keep you, the reader, alert."

The spirit of the book might best be summed up by the publisher's disclaimer: "This book is sold only for its entertainment or amusement value. The publisher makes no guarantee as to the technical merit of any article. In fact, it is rather doubted that any antenna described by the author will work any better than a fifty-ohm resistor dunked in transformer oil, at the bottom of an elevator shaft." R-E

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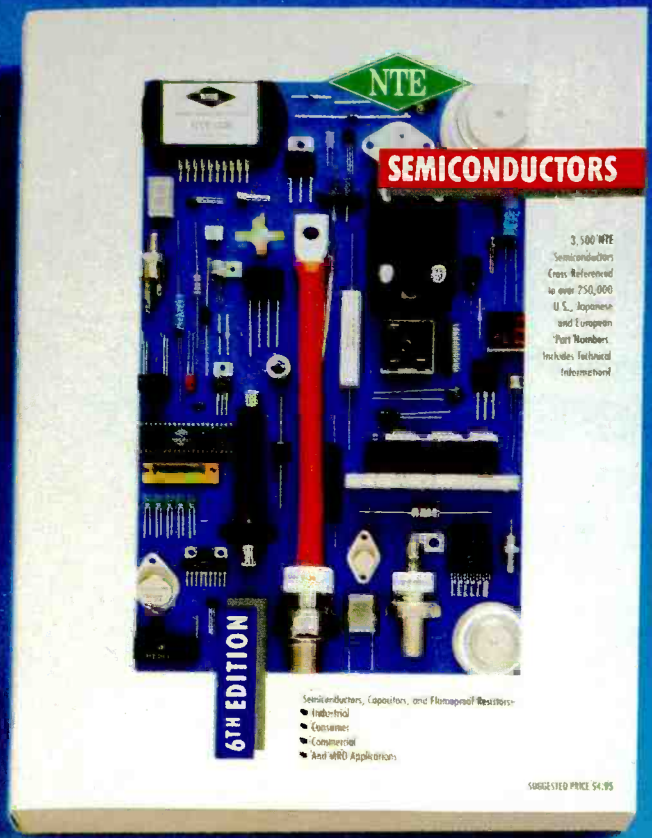

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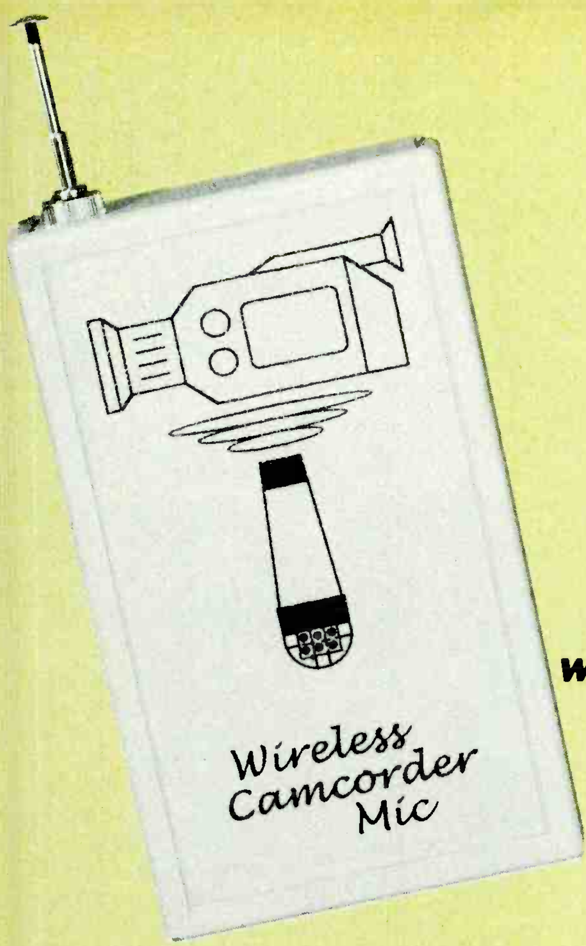


Wireless Camcorder Microphone

Add professional-quality audio to your home videos with our wireless camcorder microphone—for less than $15.00!

PAUL E. YOST

EVERY FEW YEARS, AN ELECTRONIC gadget comes along and changes our lives. Devices such as televisions, cellular phones, VCR's, and personal computers, have had a profound impact on how we live. Today's hot item is the handheld camcorder. Falling prices, smaller sizes, and greater quality have made them quite common.

If you do a lot of camcorder recording, you're sure to notice that it's always harder to record quality audio than it is to record quality video. While the camcorder might be doing a great job recording the picture, the built-in microphone might not be doing as well picking up the sound. That's particularly true for long-distance shots—remember that most lenses can zoom in on a subject, but most microphones can't.

Another difficult situation is shooting a room full of people. If there is a lot of background chatter—and there usually is—that's what the camcorder's internal mike will record. The problem is caused by the automatic audio-level control circuit that most camcorders use—it can't differentiate between the audio you want and the babble you don't want.

The only sure-fire way to get good audio, regardless of the situation, is to use an external microphone, especially if your subject is at a distance. The most convenient mike is a wireless mike, which is the focus of this article. A good wireless mike will guarantee quality audio every time, regardless of the distance to the subject. A wireless mike also eliminates recording those annoying camcorder noises such as the sound of the autofocus mechanism.

While camcorder prices have fallen, microphone prices have not. Unfortunately, a high price does not always guarantee a high-quality wireless mike. The microphone we'll present here can be built from readily available, inexpensive parts. It takes less than 30 minutes to assemble, and requires no complicated setup or adjustment procedures. You don't even need any complicated test equipment. The resulting quality will surprise you.

Operation

The wireless microphone is basically a short-range, low-power FM transmitter. The circuit, as shown in the block diagram of Fig. 1, consists of three main sections: the microphone element, the audio amplifier, and the RF oscillator. Figure 2 shows the schematic.

The heart of the circuit is the oscillator section, which is built around a 2N3904 transistor (Q1). A parallel-resonant LC, or "tank" circuit, consisting of L1, C2, and D2, determines the operating frequency.

Varactor diode D2, a voltage-variable capacitor, tunes the circuit. To understand how the varactor works, recall that a capacitor is basically two conductors separated by an insulator. A reverse-biased diode is similar to a capacitor in that it has two electrodes (the anode and the cathode) separated by an insulator (the reverse-biased junction). Consequently, a reverse-biased diode acts like a capacitor. Although all diodes exhibit that effect, a varactor diode is designed to have as much capacitance as possible.

An oscillator is basically an

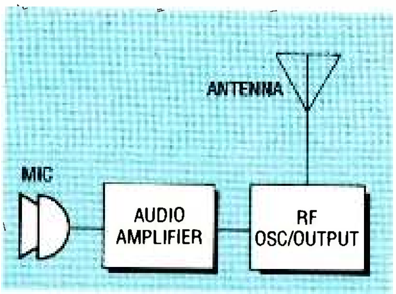


FIG. 1—BLOCK DIAGRAM. The circuit consists of the microphone element, the audio amplifier, and the RF oscillator.

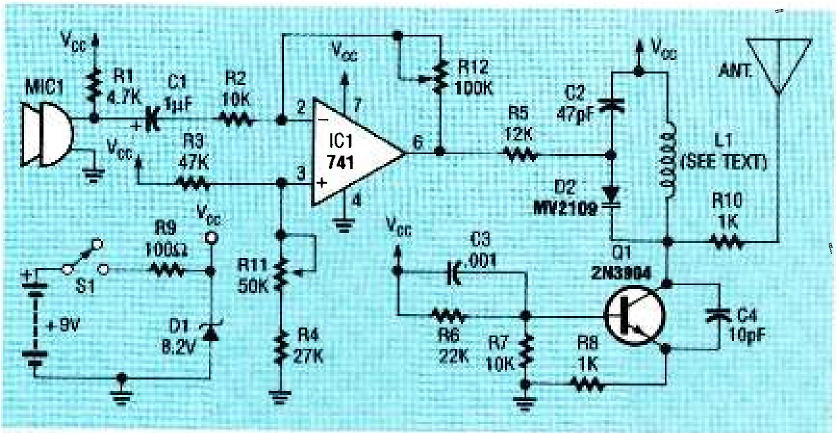


FIG. 2—The wireless microphone is a short-range, low-power FM transmitter.

amplifier with positive feedback. In our circuit, feedback is provided by capacitor C4, so that the part of the oscillation generated in the tank circuit is coupled back from Q1's collector to its emitter. Resistors R6 and R7 bias Q1. Capacitor C3 is the base bypass and R8 is the emitter load. If you want to see the oscillation, you can connect an oscilloscope to the top of R8 with a ×10 probe. The initial oscillation should be somewhere between 60 and 110 MHz, so a high-frequency scope must be used. If an oscilloscope is unavailable, you can use a frequency counter to check the signal.

The audio amplifier is a 741 op-amp chosen because it is one of the most common and versatile op-amps. It is wired as an inverting amplifier with a variable negative feedback gain control. The purpose of the op-amp is to amplify the microphone signal, and to electronically tune the oscillator frequency.

An op-amp normally requires a bipolar power supply. Fortunately, op-amp circuits can be made to operate from a single supply by placing a DC offset voltage on one of the inputs.

An op-amp is basically a differential amplifier with two inputs and one output. One input is inverting while the other is non-inverting. A signal applied to the inverting input will be phase-shifted (or inverted) 180 degrees at the output. A signal applied to the non-inverting input will remain unchanged in phase at the output. If a signal is applied to both inputs simultaneously, their difference appears at the output, multiplied by the gain of the circuit.

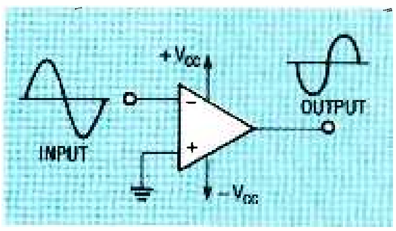


FIG. 3—NORMALLY ONLY ONE OP-AMP INPUT is used for the signal and the other is referenced to ground.

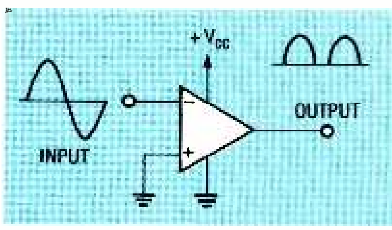


FIG. 4—IF ONLY A POSITIVE SUPPLY IS USED, the output signal can only swing positive.

Normally only one op-amp input is used for the signal and the other is referenced to ground as shown in Fig. 3. Since the unused input is referenced to ground, it effectively stays at a zero-volt potential.

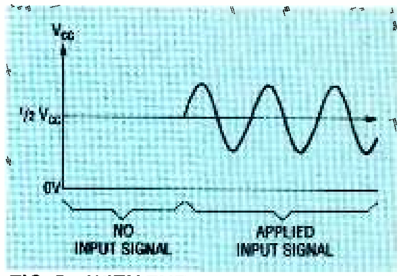


FIG. 5—WITH THE UNUSED INPUT referenced to one-half of V_{CC}, the output signal can swing both positive and negative around the new reference.

Therefore, the difference between the two inputs is the incoming signal, which is amplified and passed through to the output. This circuit works fine when both negative and positive supplies are used. However, if only a positive supply is used, the output signal would only be able to swing positive, as shown in Fig. 4.

For the op-amp to work properly from a single supply voltage, the circuit must be able to produce both positive and negative signal swings. The easiest way to do that is to offset the output reference above ground. That's accomplished by referencing the unused input to one-half of V_{CC}, instead of connecting it to ground. In our circuit, that's done by the voltage-divider network of R3, R4, and R11. The output signal can swing both positive and negative, except that it does so around the new reference as shown in Fig. 5.

Normally, the DC component of the output is removed before the signal is passed on to the next stage, usually by a coupling capacitor. In this project, however, we do not remove the DC offset. Instead, it is used later to tune the oscillator's center frequency.

The cathode of tuning element (varactor D2) is connected to V_{CC} sbC via coil L1, and its anode is connected to the op-amp output via R5. Since the cathode is at V_{CC} and the anode is at approximately one-half V_{CC}, the varactor is reverse-biased, which is its normal operating condition.

One of the primary factors that determines a capacitor's value is the distance between its plates. By controlling the amount of reverse bias applied to the varactor, we can control the thickness of the varactor's barrier region, and consequently the distance between its "plates." When you increase or decrease the reverse bias, the junction barrier increases or decreases. This, in turn, decreases or increases the effective capacitance, and raises or lowers the frequency of oscillation.

As mentioned earlier, the reverse bias is provided by the amplifier's DC offset, created by the voltage divider on pin 3 of IC1. Note that potentiometer R11 is part of that network. When you vary R11, the offset voltage varies as well. That, in turn, changes the bias on the varactor, which results in a frequency shift of oscillation. That's how the tuning is accomplished.

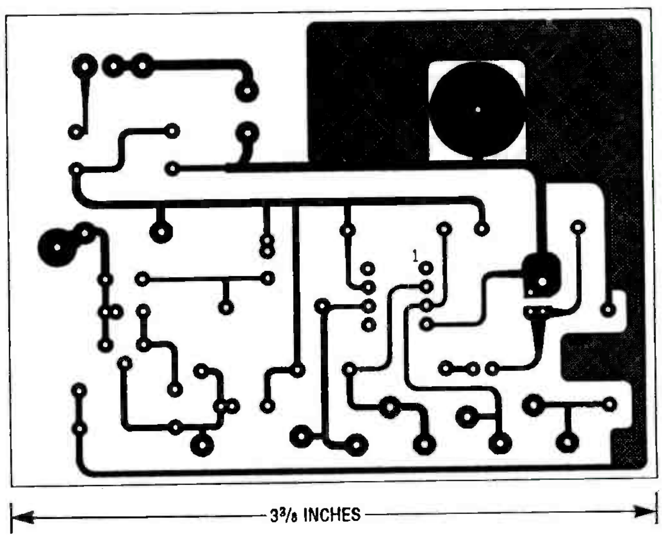
The other potentiometer, R12, is used to set the amplifier's gain. As you increase R12's resistance, you decrease the amount of negative feedback, which then increases the signal gain. The audio output rides on the DC offset, and the offset provides the tuning bias. Therefore, as the signal varies, so, too, does the bias and the oscillator frequency. That's how the frequency modulation (FM) is produced.

In FM, the frequency of the carrier varies with the frequency of the modulating signal; the amount of variation or deviation is determined by the amplitude of the modulating signal. In our case, the modulating signal is the audio picked up by the microphone, so when you adjust R12 you are adjusting the modulating signal's amplitude, which increases its deviation.

A standard FM broadcast signal has a deviation bandwidth (or carrier swing) of plus or minus 75 kHz. That amount of deviation is considered to be 100% modulation. For our transmitter to work properly, we'll need to adjust it to provide approximately the same amount of deviation.

The FM transmitter uses an electret microphone. An electret is a permanently polarized piece of dielectric material, usually a ceramic compound. It is formed by heating the material and then letting it cool in a strong electric field. That realigns the molecular structure of the material so that it retains a mild electric field after cooling. (That's analogous to the way iron can be made into a permanent magnet.) The electret is then used as the diaphragm or moving part of the microphone. The result is a small, though very sensitive, high-fidelity microphone. The microphone also contains an internal FET amplifier that adds to the microphone's fidelity and sensitivity.

Although the wireless microphone is battery operated, it uses a Zener diode voltage regulator which is absolutely essential for proper operation. A fresh battery may start out at 9 volts but, over time, the voltage slowly drops. Because the oscillator is voltage-tuned, it is voltage-sensitive. Any change in V_{CC} will shift the oscillator frequency. This is so critical that even a 0.1-volt change can shift the oscillator by 100 kHz or more. Obviously, we want the transmitter to stay on frequency so we must make sure that V_{CC} doesn't change; the Zener diode guarantees this.



FOIL PATTERN for the wireless microphone PC board.

Construction

Despite the simplicity of the transmitter, you should build it on a PC board. Point-to-point wiring could cause problems at VHF frequencies because of too much interconnection parasitic capacitance. A foil pattern has been provided so you can make your own PC board. You can also purchase a pre-made board from the source mentioned in the Parts List, as well as a kit that includes a PC board.

Install all the parts on the board as shown in parts-placement diagram of Fig. 6. There is room on the board to mount the 9-volt battery holder included in the kit if you intend to install the board in a large enough case. A metal case, like the one used for the author's prototype (see Fig. 7), will provide the best shielding for the circuit. The prototype's case is also available from the source mentioned in the Parts List. If you use the metal case, the PC board must be cut between the two "CUT A" points indicated in Fig. 6. Also, the potentiometers must be mounted on the underside of the board with the battery holder secured to the bottom of the case and the PC board mounted on ⅞-inch spacers (see Fig. 8).

Even though a metal case provides superior shielding, we packaged the board in the pocket-sized plastic case, and the transmitter seems to work just fine. However, to get the

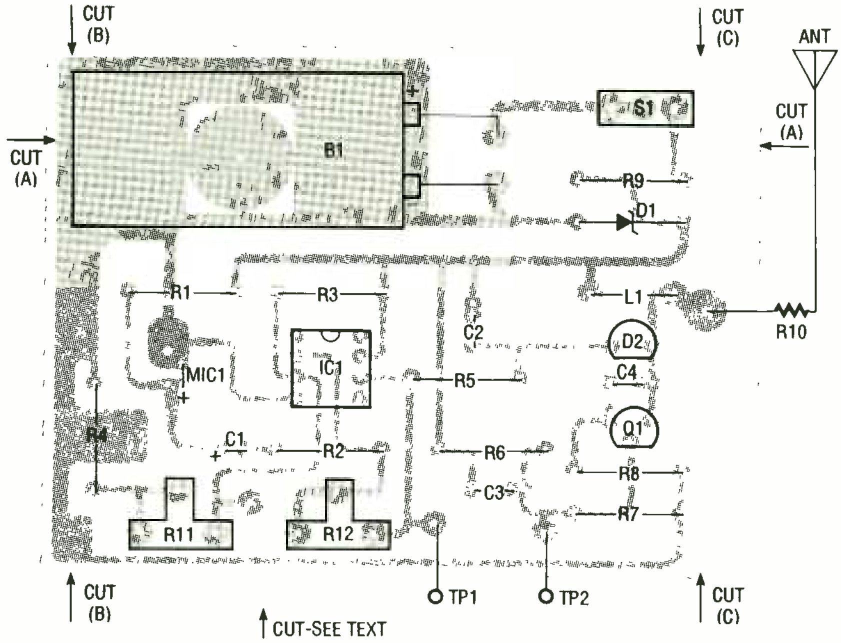


FIG. 6—PARTS-PLACEMENT DIAGRAM. There is room on the board for the 9-volt battery holder if you are installing the board in a large enough case.

FIG. 7—A METAL CASE, like this one, provides the best possible shielding for the circuit.

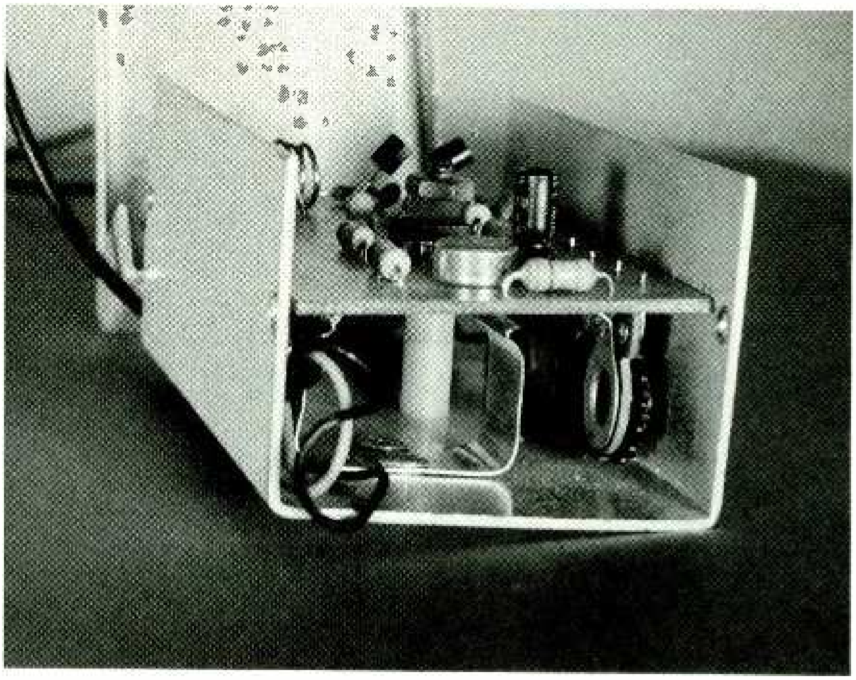


FIG. 8—TO USE THE METAL CASE, the PC board must be cut between the two "CUT A" points indicated in Fig. 6, and the potentiometers must be mounted on the underside of the board.

board to fit in that case, three cuts must be made between the "CUT A," "CUT B," and "CUT C" points indicated in Fig. 6, and R10, which connects to the antenna, must be tack-soldered to the end of L1. Also, the potentiometer leads must be trimmed as shown in Fig. 9 to decrease their overall height so that they fit in the case. The plastic case, made by Pac-Tec, has a built-in compartment for a 9-volt battery. Figure 10 shows how the board fits in the Pac-Tec case.

The final component to connect to the board is the antenna. A 30-inch length of wire is recommended because that's the quarter-wavelength of 98 MHz (the center of the FM band). But you are certainly free to use whatever length antenna works best for your needs, such as the 12-inch telescopic antenna we used for the plastic case.

The antenna connects to the collector of Q1 via a R10, a 1K resistor. The resistor provides isolation for the oscillator, greatly enhancing its stability. Unfortunately the 1K resistor does decrease the unit's range. Without it, the signal will travel about 300 feet. With it, the range is approximately 100 feet, which is comparable to most commercially available products, and adequate for most video production work.

Testing

Unless you have a defective part or have misplaced something on the board, the transmitter should work as soon as power is applied. The easiest way to test it is to tune a standard FM radio to an unused frequency, and adjust R11 until you hear your voice coming from the radio's speaker. It's usually easier to adjust R11 until the microphone can be heard over the radio, and then fine tune the signal by adjusting the receiver.

You will probably have to adjust R12 as well for the proper volume level. Simply listen to the signal on an FM radio; if R12 is set too low, the audio will sound weak. If R12 is set too high, the audio will be too loud

PARTS LIST

All resistors are ¼-watt, 5%.
R1—4700 ohms
R2, R7—10,000 ohms
R3—47,000 ohms
R4—27,000 ohms
R5—12,000 ohms
R6—22,000 ohms
R8, R10—1000 ohms
R9—100 ohms
R11—50,000 ohms, potentiometer
R12—100,000 ohms, potentiometer

Capacitors
C1—1 µF, 25 volts, electrolytic
C2—47 pF, 25 volts, ceramic
C3—0.001 µF, 25 volts, ceramic
C4—10 pF, 25 volts, ceramic

Semiconductors
IC1—741 op-amp
D1—8.2-volt Zener, ½-watt
D2—MV2109 varactor diode
Q1—2N3904 NPN transistor, or equivalent
S1—SPST switch
MIC1—electret microphone

Other components
L1—2.5 turns of #18 wire on a 5/16-inch diameter form.

Miscellaneous: 9-volt battery and connector, battery holder, project case, PC board, 30 inches of antenna wire, solder, etc.

Note: The following items are available from Paul E. Yost, P.O. Box 32291, Louisville, KY 40232:
- **A kit of parts including the PC board (no case)—$14.95 plus $1.50 S&H**
- **PC board only—$6.95 (postpaid USA)**
- **Metal project case (drilled and with rubber grommets)—$6.95 plus $1.75 S&H**

Kentucky residents must please add 6% sales tax.
- **The Pac-Tec HML-9VB plastic case sells for about $5. Call Pac-Tec at (800) 220-9800 for a distributor nearest you.**

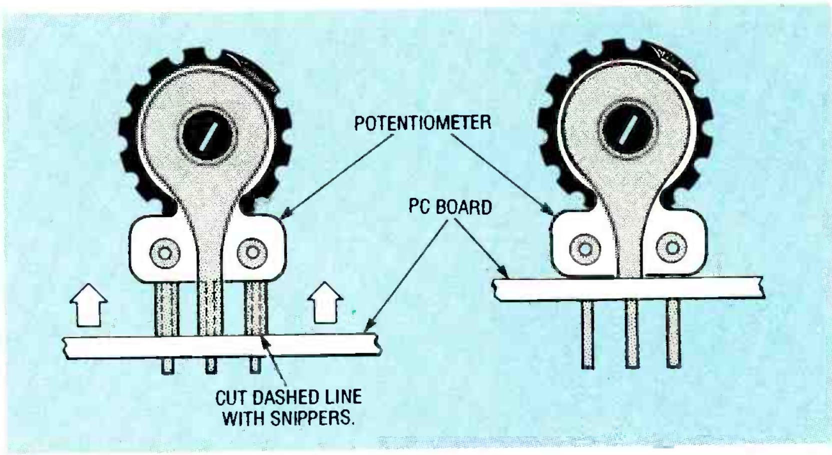


FIG. 9—TO USE THE PLASTIC CASE, the potentiometer leads must be trimmed as indicated by the dashed lines to decrease their overall height so that they have as low a profile as possible.

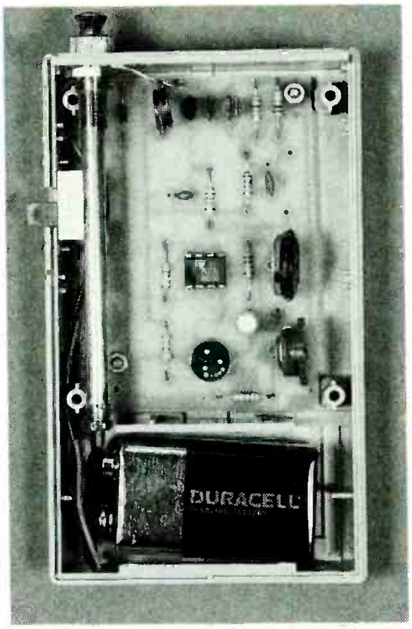


FIG. 10—HERE'S HOW THE BOARD fits in the plastic case. Remember to cut the board between the "CUT A," "CUT B," and "CUT C" points indicated in Fig. 6.

FIG. 11—THE FM RECEIVER CONNECTS to the external microphone input jack on your camcorder.

or distorted.

If you have any trouble, the following steps should help you locate the cause and solve it:
1. Check for 8.2 volts DC at the cathode of D2. If a voltage is missing or low, you either have a bad battery, a defective Zener diode, an open R9, or a short circuit on the board.
2. Check for 8.2 volts DC at the transistor collector, pin 7 of IC1, and the R1-C1 junction.
3. Check for approximately 4-volts DC on pin 3 of IC1. This voltage should be variable by turning R11.
4. Check for approximately 2.4-volts DC on the base of Q1.

If any of the voltages in steps 2, 3, or 4 are missing or the values are wrong, you have an open or short circuit.
5. You can check for an oscillation at the emitter of Q1 by using either a frequency counter or oscilloscope. Make sure that the device you use will work at 100 MHz or more. You must also use a ×10 probe to make this test. Any other probe will load down the circuit and kill the oscillation.

If the oscillation is present, but below the FM frequency range of 88 to 108 MHz, you should be able to increase it by turning R11. If you cannot adjust it high enough, then you can compensate with coil L1, which is simply three turns of wire. Separating the windings slightly will lower its inductance and raise the resonant frequency. Adjust L1 as much as necessary until you are able to correct this situation.

If the oscillator does not work, but all the proper voltages are present, then either Q1 or D2 is probably defective.
6. If the oscillator signal is present, but no audio is present, then use an oscilloscope to check for an audio signal at pin 6 of IC1 as you speak into the microphone. Remember, the signal should be riding a DC

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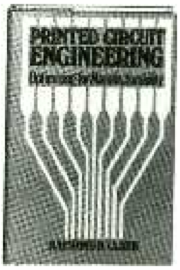

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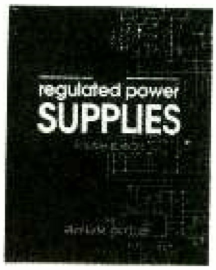

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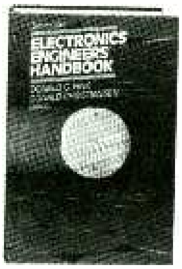

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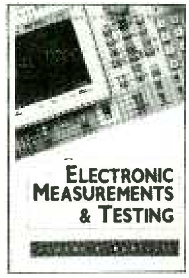

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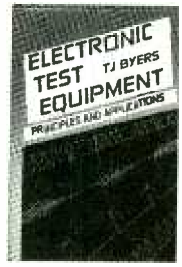

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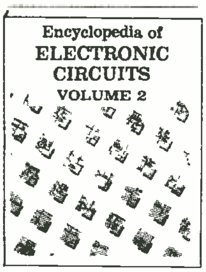

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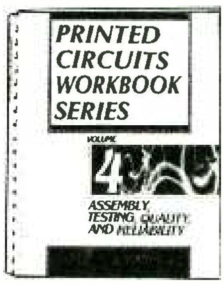

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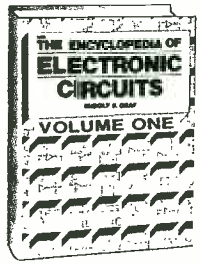

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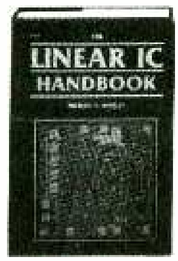

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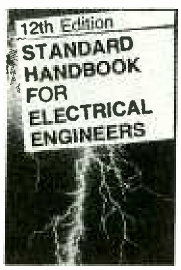

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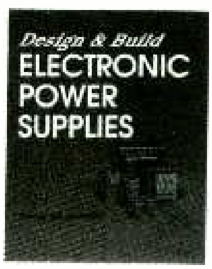

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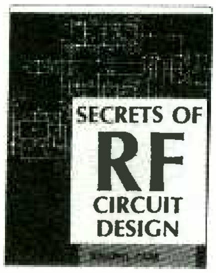

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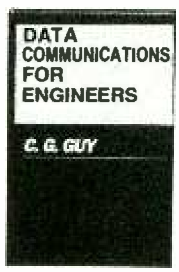

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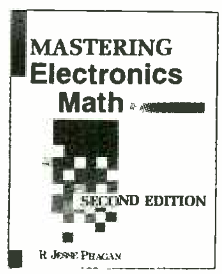

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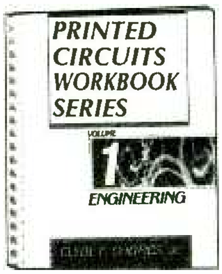

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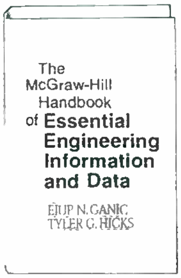

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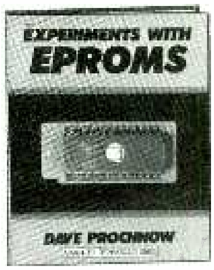

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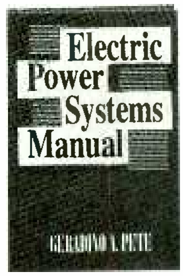

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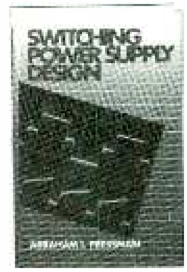

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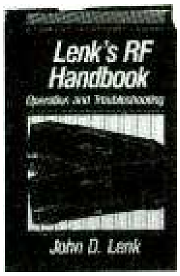

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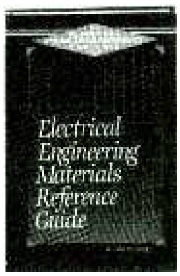

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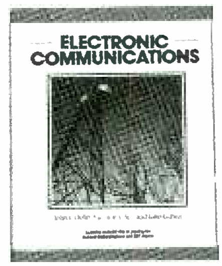

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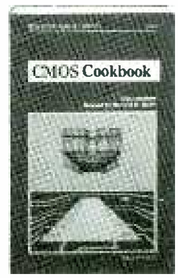

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level approximately equal to one-half of V_{CC}.

If no audio appears on pin 6, and R12 has no effect, then check for a signal input on pin 2. If a signal is present there, then IC1 might be defective. If no signal is present, the microphone might be defective.

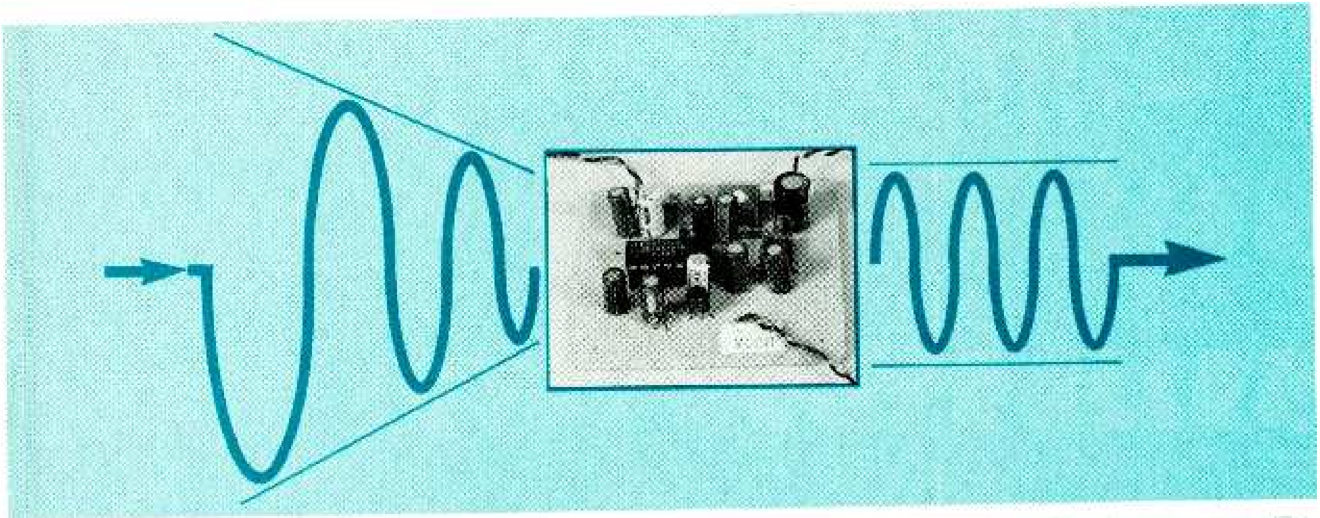
Using the microphone

The best receiver for the wireless camcorder microphone is a good-quality (sensitive) Walkman-type FM receiver because it is portable and lightweight. The only requirement for the receiver is that it must have a headphone jack.

Tune the receiver to an unused frequency, and adjust the microphone until you hear a sound clearly over the radio's headphones. Now remove the headphones from the receiver and connect an audio cable (see the Parts List) between the headset jack on the radio and the external microphone input jack on your camcorder (see Fig. 11). Experiment to find the maximum volume setting that can be used without distortion.

For best results, the antenna wire should be stretched out full length, such as down the wearer's back or side. Speaking of antennas, many Walkman-type radios use the headset wire as their antennas. Unfortunately, the audio cable used to connect the receiver to the camera is shielded, and does make a good antenna. Thus, the range of that receiver is limited to about 25 feet. If you need greater range, you can either modify the radio to accept an external antenna or use a receiver that already has a built-in external antenna.

There are many applications for this project other than for camcorders. For example, when used in conjunction with a "boom box" receiver, it makes a very effective portable public-address system. It also makes an inexpensive nursery monitor. Another application is for those of you who, like the author, teach electronics: Students always want to do "hands on" work in the lab classes, and this project makes an excellent classroom lab. **R-E**



AUDIO LEVEL CONTROLLER

Build this programmable audio-level controller to tame your receiver's input and keep it in your ear's comfort zone.

STEVE SZABO, N1AYO

HAVE YOU EVER BEEN STARTLED when the audio from your radio receiver went out of control and nearly blasted you out of your chair? Maybe you just turned up the volume in an effort to hear a distant station or a soft voice, and within seconds an unwanted burst of sound overwhelmed you. If your answer is yes, you need an automatic audio level controller.

Not all transceivers and scanners—even the most expensive high-end products—have automatic volume control circuits. Now you can build the Audio Leveler module to keep your receiver's audio volume constant, regardless of incoming signal strength. It will work in your ham receiver, scanner, marine or other mobile transceiver, television set, or stereo system.

The Audio Leveler is independent of the host receiver's volume control. You set its volume to a comfortable level, and the Audio Leveler locks in on that setting. It amplifies desired low-level audio signals while discriminating against background noise and attenuating strong random signals.

Circuit description

The heart of the Audio Leveler is a Signetics NE577, a programmable, low-power integrated circuit called a compandor. The NE577, shown as a simplified block diagram in Fig. 1, is packaged in a 14-pin DIP. The first question you might well ask is: What is a compandor, and what does it have to do with audio leveling? The answer is that it's a circuit capable of compressing and expanding an input signal to remove noise in a communications channel, and one of its sections can be organized to control audio input signal level. The term is derived from a contraction of the two words *compressor* and *expandor*.

The compandor was developed as a discrete component circuit for telecommunications applications, primarily to reduce unwanted noise. The input signal is fed to a compressor stage which rectifies and conditions it so that the input signal level always remains above the noise level. The conditioned signal is then fed to the expandor stage which restores it to its initial volume level—any noise is expanded below the audible level.

The NE577 has both a compressor and an expandor stage, but the Audio Leveler uses only the compressor stage which is configured as a programmable automatic level control (ALC). The ALC accepts a range of input signals, and produces a constant AC output level. The host equipment can have a volume control, but with the Audio Leveler in your receiver, you will only have to set the receiver's volume control once.

Figure 2 is the schematic for the programmable Audio Leveler. Only the compressor section pins on IC1, the NE577, are used; pins 1 to 3 in the expandor section are not used. The ALC function is configured with the rectifier at RECT_{in} pin 10 and $\text{GAINCELL}_{\text{in}}$ at pin 9 forming a closed loop around the internal op amp. Because the AC output level of the ALC can be programmed, you can choose a resistor value for a desired output level.

The audio signal is fed simultaneously to both pins 10 and

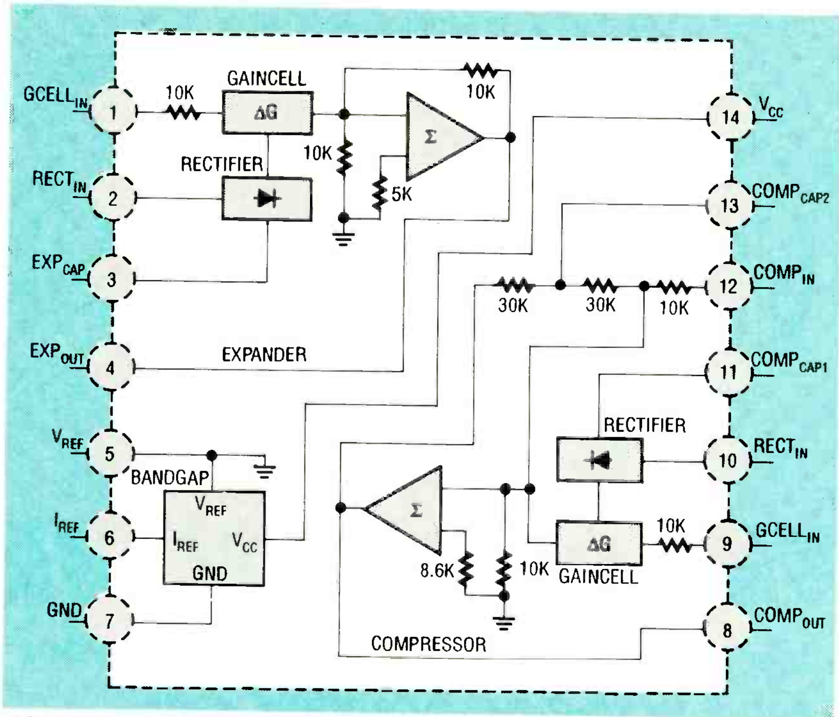


FIG. 1—SCHEMATIC FOR THE AUDIO LEVELER. The audio output stage is not needed if you can use the host receiver's audio amplifier stage.

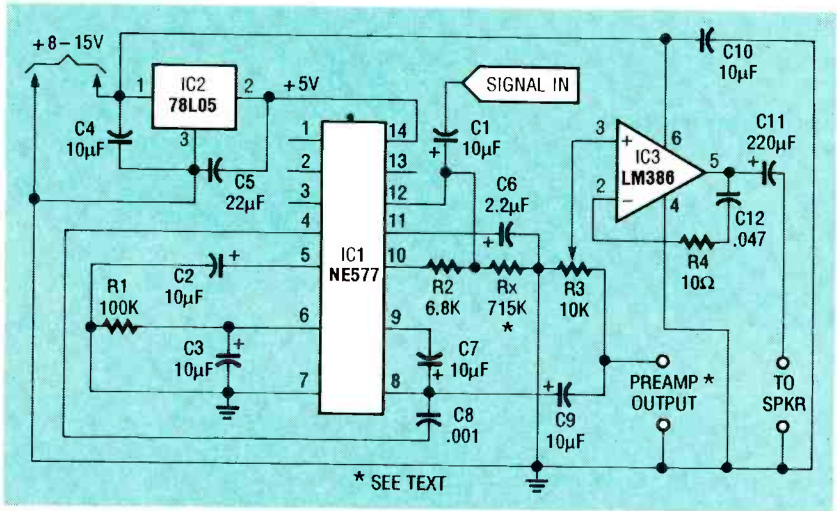


FIG. 2.—BLOCK DIAGRAM OF THE NES77 LOW-POWER COMPANDOR. This IC compresses the input signal to eliminate noise and control range, and then expands it again for normal listening

12. At pin 10, resistor R2, with a value of 6.8 K, is shunted by programmable resistor R_X, which limits maximum gain to prevent amplification of background noise. If resistor R2 is 6.8 K, R_X can be selected so that an input signal below 10 millivolts will not be amplified with a gain greater than 10. The circuit's output remains at a constant 100-millivolt (rms) level for the range of input voltages shown in Table 1.

The value of resistor R_X can vary from 64.3 K to 715 K, depending on input signal conditions. A value of 715 K for R_X was obtained in the prototype by connecting a 680 K resistor in series with a 33 K resistor.

If the input is 10 millivolts (rms) and R_X is 715 K, the maximum circuit gain is limited to 10 for an output of approximately 100 millivolts. Increasing the value of resistor R2 will increase circuit gain and output level, but reducing R_X will reduce the threshold level.

The crossover point of this circuit is defined as that point where the input signal is equal to the output signal. All input signals into the Audio Leveler circuit above the unity gain-level crossover point are attenuated, while all signals below that crossover point are amplified. The optimum threshold level for your application can be selected by choosing a value of R_X, by trial and error methods, within the limits set by Table 1.

Where practical, the Audio Leveler circuit should be installed within its host equipment enclosure in series with its volume control. Your receiver or scanner might not have enough space within its enclosure to accommodate the Audio Leveler, but do not alter the layout of the circuit board to fit a confined space unless you have enough experience to solve any interference, insulation, or thermal problems that might arise.

TABLE 1
DYNAMIC RANGE WITH DIFFERENT X RESISTOR VALUES

For a 100-millivolt rms output for different values of gain:
(1) Set input voltage, and
(2) Set RX as follows:

Input (volts,rms)	R_X (K ohms)	Gain (approx.)
1.0	6.43	1
0.050	136.0	2
0.100	715.0	10

Circuit construction

Conventional electronic circuit construction practice should be followed in building the Audio Leveler. The circuit can be built on standard perforated circuit board with a 0.1-inch grid, but a circuit board is strongly recommended. A foil pattern is provided in this article if you want to make the board. Alternatively, it can be purchased as a separate item from the source given in the Parts List. Regardless of your choice, be sure to drill holes in the corners of the board at the right locations for fastening it

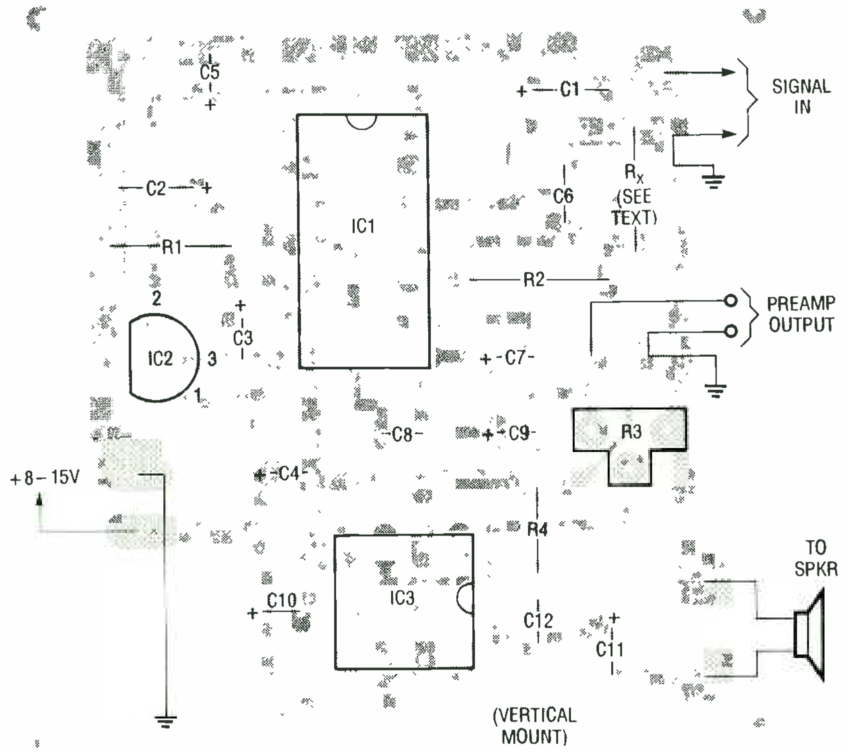


FIG. 3—PARTS PLACEMENT diagram for the Audio Leveler. If the module is bundled with the host receiver, the output stage might not be needed.

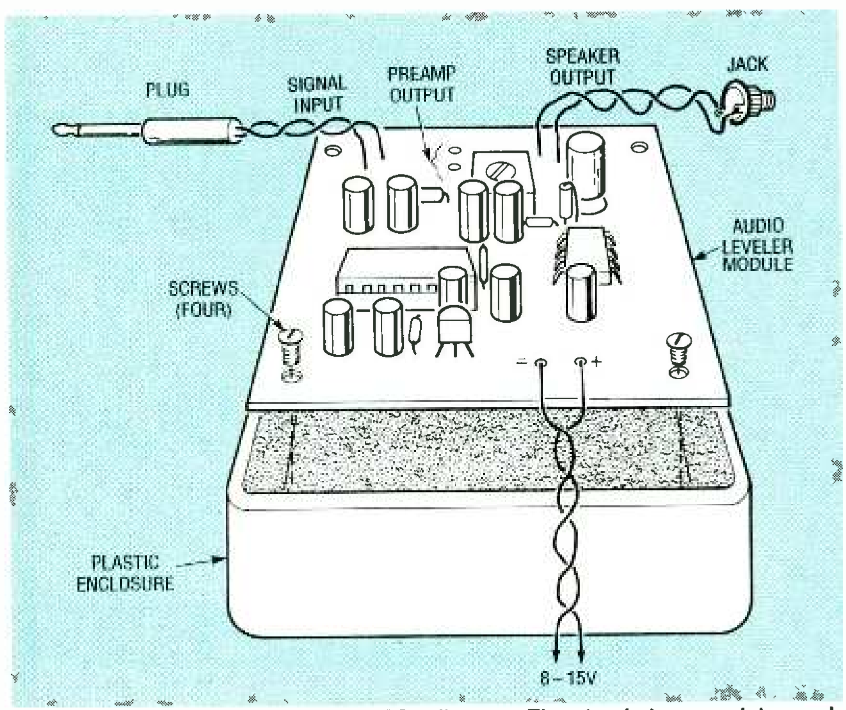


FIG. 4—MODULE ASSEMBLY AND TEST diagram. The stand-alone module can be placed in a separate plastic enclosure with a battery for power.

within your intended enclosure (host cabinet or separate plastic box) before starting assembly work.

Refer to the parts placement diagram, Fig. 3. Insert all resistors and capacitors in their proper places. (Two resistors in series might be required to obtain the desired value of R_X.) Then insert a recommended socket for IC1. Insert the ends of all input, output and power cable or twisted wires at the terminals shown in Fig. 4.

Carefully check the module for mistakes and inadvertent solder shorts, and make all corrections before inserting and soldering IC2 and IC3. The Au-

PARTS LIST

All resistors are ¼-watt, 5%

R1—100,000 ohms
R2—6800 ohms
R3—10,000 ohm, potentiometer, PC board mount
R4—10 ohms
R_X—715,000 ohms, 680,000 ohms in series with 33,000 ohms

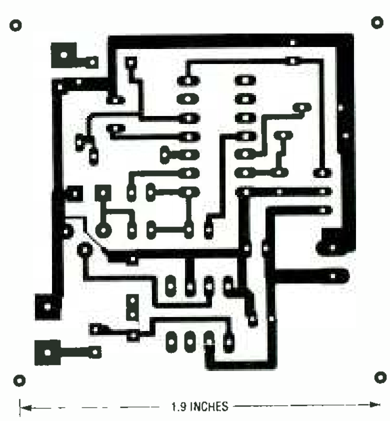
Semiconductors
IC1—NE 577 unity-gain, programmable low-power compandor (Signetics) or equivalent
IC2—LM78LO5ACZ 5-volt voltage regulator (National Semiconductor) or equivalent
IC3—LM386 audio power amplifier (National Semiconductor) or equivalent

Capacitors
C1-C4,C7,C9, C10—10 μF,16 volts, electrolytic
C5—22μF, 10 volts, electrolytic
C6—2.2μF, 10 volts electrolytic
C8—0.001μF
C11—220μF, 16 volts, electrolytic
C12—0.047 μF,

Miscellaneous: circuit board, experimenter's plastic enclosure (optional), power source (see text), twisted-wire pairs or audio cable, solder, jacks and plugs as required.

Note: The following parts are available from C & S Electronics, P.O. Box 2142, Norwalk, CT 06852-2142, phone or fax: (203) 866-3208
- Formed and drilled PC board—$12.95
- Complete kit of parts excluding power supply and cabinet—$24.95.
- An assembled and tested module (Model ALC225C)–$32.95.

Please send check or money order only. Connecticut residents add 6%. tax. Add $3.00 for postage and handling.



FOIL PATTERN for the audio leveler project

dio Leveler is a low-level audio circuit, so trim all leads as short as possible to minimize noise interference. Then insert IC1 in its socket.

The twisted-wire pair from the prototype module's SPEAKER OUTPUT terminals was terminated with a ¼-inch open-frame jack, and the pair from the SIGNAL INPUT terminals was terminated with a ¼-inch plug. The 8 to 15 volts DC are supplied over a twisted pair. Select jacks and plugs that interface directly with those on your receiver or scanner.

If you plan to install the module within a receiver enclosure and do not need the output audio stage, omit the LM386 audio power amplifier, IC3, and related components R4, C11 and C12, and use the PREAMP OUTPUT terminals for the circuit output.

If you plan to use the Audio Leveler as a stand-alone accessory, put it in a separate plastic experimenter's enclosure as shown in Fig. 4. If you want to power the module with a battery, select an enclosure that will accommodate both.

Circuit testing

Connect the completed module to an 8- to 15-volt DC power source such as a battery or universal AC-to-DC adapter with a 100-milliampere rating. (If you plan to omit the power amplifier stage, only 10 milliamperes will be required. A standard 9-volt transistor battery will meet this requirement.)

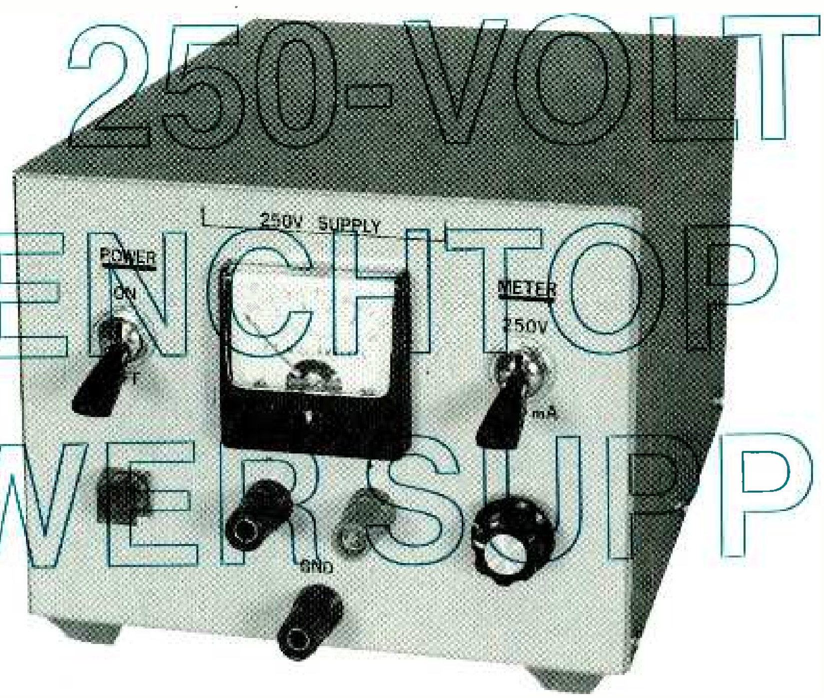
Set an audio signal generator at any frequency up to 1 kHz, turn its output level to the minimum setting, and connect it to the SIGNAL INPUT terminals. Then place an AC voltmeter or oscilloscope across the PREAMP OUTPUT terminals (see Figs. 2, 3, and 4, two drilled pads next to trimmer R3) to observe the instrument's output.

Connect the SPEAKER OUTPUT of the module to an 8-ohm speaker. Set trimmer R3 to an audio output level that is comfortable for you. Then connect the SIGNAL INPUT terminals of the module to the external speaker jack of your receiver, turn the volume control to a minimum level, and slowly increase the setting until no further change is noticed. To change audio volume, only trimmer R3 need be set. As you increase the output amplitude of the signal generator, observe the circuit's output on the AC voltmeter or oscilloscope. Any change in volume will be slight if the circuit is operating satisfactorily.

Amplifier not used

If you omit the output amplifier stage, connect the module in series with the input wire of the host receiver's volume control—*not the wiper*. (If you can gain access to the host equipment's power supply, you can also omit a separate power source.) The host receiver's volume control should remain fully functional after the installation. The volume level of the host receiver will stay nearly constant, regardless of incoming signal strength. R-E

BUILD THIS 250-VOLT BENCHTOP POWER SUPPLY



Here's a DC power supply that makes working on high-voltage projects a breeze.

DAVID CUTHBERT

A VARIABLE HIGH-VOLTAGE POWER supply can be a great convenience to have on the bench. You can use it for servicing tube-type equipment, checking capacitors, and for general experimentation. This article describes the construction of a 0- to 250-volt, 100-milliamp regulated power supply. The supply is short-circuit protected and has an output impedance of 15 ohms. Output noise is less than 20 millivolts rms, while the temperature coefficient is only 0.03 percent per degree Celsius.

Operation

The circuit, shown in Fig. 1, uses two standard filament transformers to develop 300-volts DC. Transformer T1 steps down the 120-volt AC line power to 25 volts, and T2 steps the voltage back up to 120 volts. The 120-volt output of T2 feeds the full-wave doubler consisting of C7, C8, D1, and D2. Neon lamp NE2 and R11 form a combination bleeder and high-voltage warning light.

The heart of the circuit is IC1, an LM317T regulator. The regulator is powered by 16 volts derived from the secondary of T1. Resistor R5 limits the current to IC1 during short-circuit operation. Current flowing through HV ADJUST potentiometer R12 generates a 1.25-volt drop across R7. If the power supply output voltage drops, IC1 turns Q1 on harder and raises the supply voltage. Resistor R3 improves the regulation by maintaining a minimum of 3 milliamps through IC1, and R2 is a parasitic oscillation suppressor for Q1.

Components R1, R4, and Q2 form the current-limit circuit, which works as follows: When 100 milliamps flows through R1, the resulting 0.7-volt drop turns Q2 on, which then steals the base drive to Q1 and limits the supply current. A 1-milliamp analog meter is used to read 250 volts or 100 milliamps full-scale. When reading voltage, the meter is connected between the emitter of Q1 and the negative output terminal through R6, R8, and R9. When reading current, meter M1 is connected across current-sense resistor R1 through calibration trimmer R6. Diode D4 protects the supply against reverse current from the load. Switch S1-a turns power on and off, and S1-b disconnects the output when the supply is switched off.

Construction

No PC board was used to build the prototype power supply. Instead, most of the power supply circuitry is contained on a 44-pin edge-connector perforated construction board (see Fig. 2), which plugs into a matching edge connector that is mounted to the bottom of the cabinet with a couple of standoffs. The plug-in board makes the supply easier to build and to service, if that becomes necessary, in the future. However, the power-supply construction is not critical to its operation.

Power transistor Q1 must be heatsinked. The heatsink for Q1 measures 3 × 3 inches square

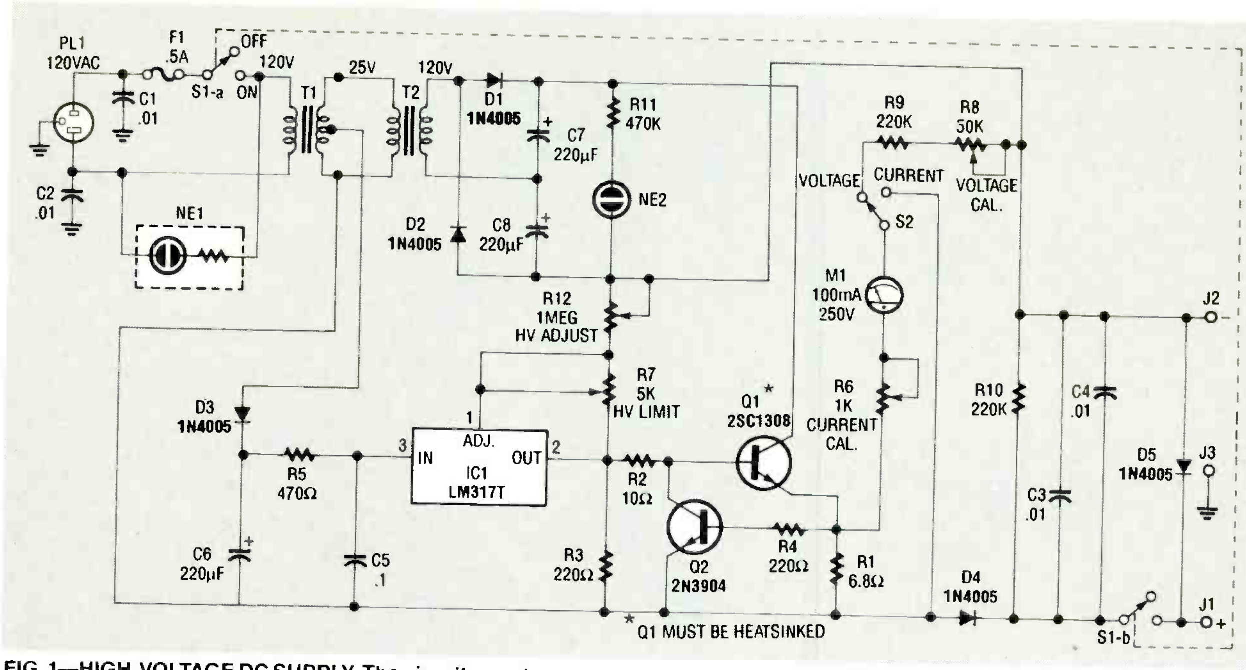


FIG. 1—HIGH-VOLTAGE DC SUPPLY. The circuit uses two transformers to develop 300-volts DC.

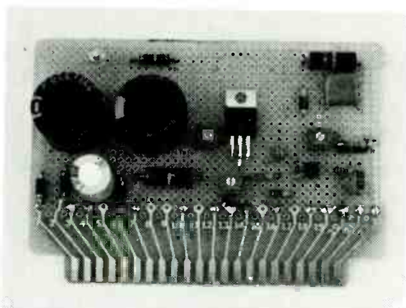


FIG. 2—MOST OF THE CIRCUITRY is contained on a 44-pin edge-connector-perforated construction board.

with 1-inch cooling fins, and is mounted on the outside rear panel of the metal cabinet, which measures 8 × 6 × 5 inches. The case of Q1 can be more than 400 volts above ground, so make sure you mount it with sufficient insulation and put an insulating cover over Q1 to prevent a shock hazard. The fuse holder is mounted on the rear panel.

Switches S1 (POWER) and S2 (METER), which must both be rated for 250 volts AC, are mounted on the front panel of the cabinet, along with the meter (M1), HV ADJUST potentiometer R12, output jacks J1–J3, and neon indicator NE1. Diode D5 is soldered directly across jacks J1 and J2. Figure 3 shows an internal view of the prototype.

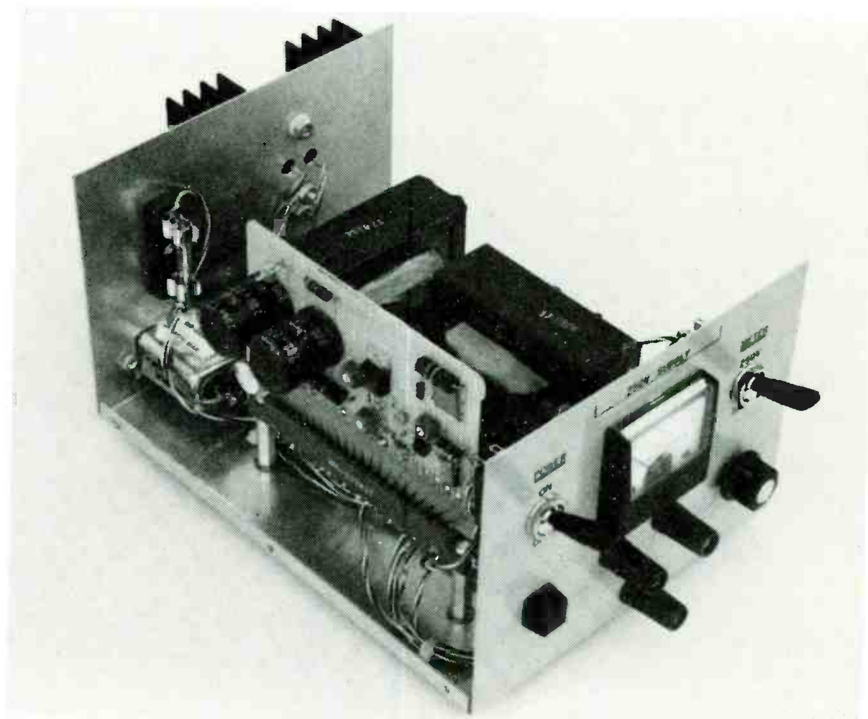


FIG. 3—PROTOTYPE POWER SUPPLY. Everything fits neatly in the metal cabinet that measures 8 × 6 × 5 inches.

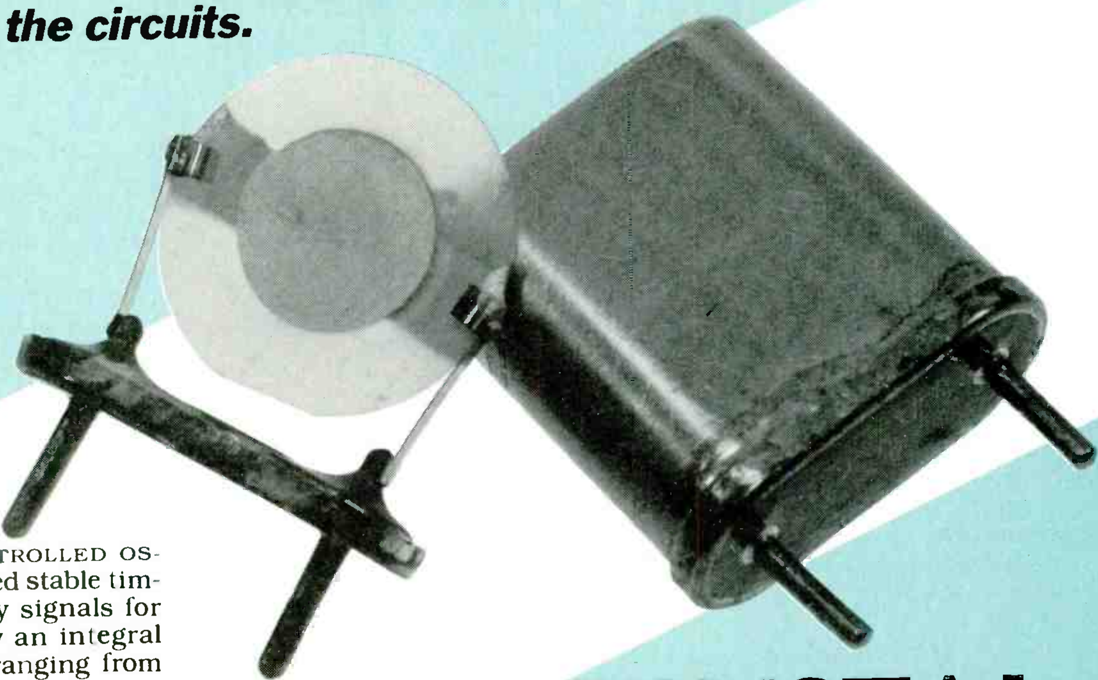
Calibration

During calibration, be very careful, as 300 volts will give you quite a shock! Set your DVM to the highest DC-voltage range, and connect it to the power supply outputs. Switch the supply on, and turn the HV ADJUST knob to maximum. Adjust HV LIMIT R7 for 260 volts. Switch the supply off, and set the DVM to the 200-milliamp range. Switch the supply on, and turn the HV ADJUST knob to maximum. The supply should limit at about 100 milliamps. Adjust the current meter calibration trimmer R6 so the current meter agrees with the DVM. Switch the DVM

continued on page 56

Learn how crystal-controlled oscillators produce precise, stable output frequencies by building the circuits.

DAN BECKER



CRYSTAL OSCILLATORS

THE CRYSTAL-CONTROLLED OSCILLATOR has provided stable timing and frequency signals for years, and is now an integral part of products ranging from watches and computers to handheld transceivers and satellite receivers. First introduced in vacuum-tube form, most are now transistorized. The word *quartz* in advertising copy and specification sheets is the clue that they're inside. A time or frequency base derived from a resonating quartz crystal is the next best thing to a national time standard.

In the first installment of this two part series, resonators based on the piezoelectric effect were introduced. It was pointed out that a piezoelectric crystal produced electricity if it is subjected to physical stress and, conversely, the crystal is physically distorted if a voltage is impressed across its faces. Both properties are put to use in depthfinder transducers.

In fact, the first practical application of a piezoelectric crystal was as a transducer to generate and receive sounds underwater for the detection of submarines during World War I. Later, crystal loudspeakers, microphones, and phonograph pickups were developed. The first quartz crystal-controlled oscillator was introduced in the 1920's.

Synthetic or cultured quartz is now the dominant material of both crystal resonators and filters. The desired physical and electrical properties are obtained by cutting the quartz blank according to a set of strict rules. Packaged quartz crystal resonators are available as low-cost catalog items, and if you can't find the frequency you need, you can order a custom-made resonator.

All this is background to the subject of crystal-controlled oscillators. This article covers the fundamentals of all transistorized oscillator circuits, and includes five schematics and eight tables covering crystal-controlled oscillators complete enough for you to build your own circuits for personal instruction, experimentation or to meet a specific project requirement. All of the components are low in cost and readily available through retail stores or mail-order houses.

What is an oscillator?

An oscillator is a circuit that generates a specific frequency and maintains that frequency within limits. A transistorized inductance-capacitance (LC) oscillator depends for its operation on the resonant interchange of energy between a capacitor and inductor for its operation; a transistor amplifier supplies pulses of energy of the proper phase and magnitude to maintain oscillations.

When used in oscillator circuits, transistors become converters that change DC electrical energy from the collector power supply into AC energy in the output circuit. The amplifying characteristic of the transistor maintains the circuit oscillations.

Two conditions are necessary to sustain oscillations. First, the feedback voltage from the collector circuit must be in phase with the original excitation voltage on the base—that is, the feedback must be positive or regenerative. Second, the amount of energy fed back to the base circuits must be sufficient to compensate for the energy losses that occur in the base circuit.

It is useful to review the concept of Q before discussing oscillator operation. Q is defined as a figure of merit in a resonant system. Equal to the reactance divided by the resistance, it represents the ability of the device or network to sustain oscillations with minimum feedback. In short, the higher the Q the more efficient the resonator.

The intrinsic Q of quartz is 10 million at 1 MHz. Although the Q value for a mounted resonator crystal is reduced to levels of 20,000 to well over a million, it is still orders of magnitude better than the best LC resonator or tank circuit.

Crystal oscillator theory.

The very high Q of a crystal oscillator significantly reduces frequency drift caused by temperature and power supply voltage variations. Moreover, crystal-controlled oscillators generate less noise than conventional oscillators with LC tank circuits, so they have a purer output signal.

The simplest crystal oscillator consists of a single bipolar transistor with a simple feedback network. Figure 1-*a* shows a block diagram for a generic crystal oscillator. Here, an NPN amplifier is connected in three feedback circuits. Appropriate DC bias is assumed but not shown. Figure 1-*b* is an equivalent circuit with components L1 and C1, and C2 shown. All of the crystal oscillator circuits to be discussed here have the same basic topology, and include at least two capacitors and an inductor. The crystal can be considered to be part of the feedback circuit.

Capacitors C1 and C2 include residual transistor and junction capacitance. Capacitor C2 can be equivalent to a parallel combination of an inductor and a capacitor. This pair functions as the crystal's third overtone selector because it is capacitive only at the crystal's overtone frequency, and inductive at its fundamental. Thus, an inductor located at C2 prevents oscillation at the crystal's fundamental frequency.

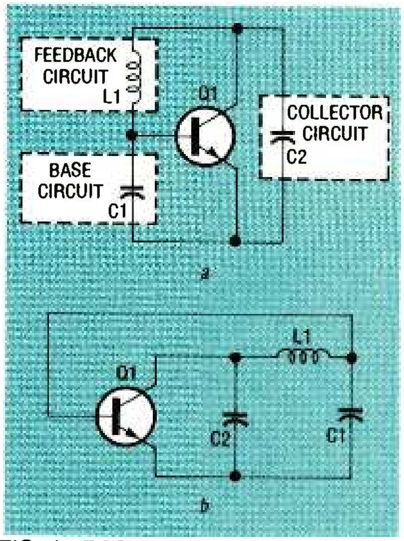


FIG. 1—BASIC OSCILLATOR CIRCUIT showing equivalent components, a and the circuit redrawn to show a feedback network, b.

In addition to amplification and feedback, an oscillator requires limiting, which occurs when an increase in the input signal no longer produces an increase in the output signal. Thus, the oscillator's output reaches a limit and stays there.

Some oscillator circuits are named for a circuit characteristic such as electron-coupled or phase-shift. However, many oscillators are named for their inventors: Among these are Butler, Colpitts, Hartley, and Miller. Five inventor-named circuit have been selected for this article; three are crystal-controlled versions of the Colpitts oscillator, one of the Pierce oscillator, and one of the Butler oscillator.

The standard Colpitts crystal-controlled oscillator has rigid load and tuning requirements, while the two semi-isolated versions are less temperamental, and are recommended as better choices for general-purpose applications. If you want very precise output frequency, the Pierce crystal oscillator is your best bet. However, if you want to experiment with oscillators, you'll find that the Butler circuit oscillates even without a crystal, you can observe the results with the crystal in or out. Table 1 compares the characteristics of each of these circuits.

Colpitts oscillators

Two versions of the Colpitts crystal-controlled oscillator are presented here: the standard and the semi-isolated. The standard circuit, shown in Fig. 2, is sensitive to variations in both crystal and load resistance. In addition, its output power is limited to less than half of the crystal's power dissipation. But, it's still a popular circuit.

Resistors R1, R2, and R3 DC bias transistor Q1. Potentiometer R2 allows up to about 1.5 milliamperes of emitter current. Capacitors C3, C4, and C6 bypass radio frequency at XTAL1's operating frequency (fundamental or overtone). Capacitor C2 functions like the feedback base circuit capacitor C1 in Fig.1. At XTAL1's operating frequency, L1 and C5 have a net capacitive reactance, and thereby form collector circuit feedback capacitor C2.

For overtone crystals, L1 and C5 act like an overtone selector, preventing oscillation at the crystal's fundamental frequency. Trimmer capacitor C1 fine tunes feedback element L1. As the value of C1 is made smaller, the oscillator's output frequency increases.

To organize a standard Colpit-

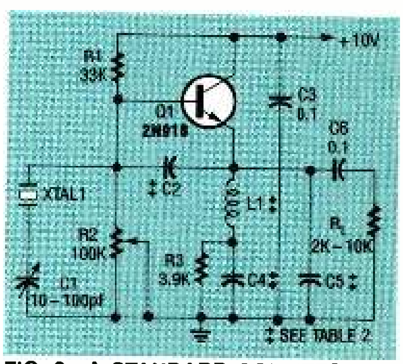


FIG. 2—A STANDARD COLPITTS crystal-controlled oscillator.

ts oscillator for your specific output frequency requirements, refer to Table 2. Note that frequencies from 1 MHz to 30 MHz are obtained with the fundamental mode, and frequencies from 35 to 60 MHz are obtained with a third-overtone crystal. The values for C2, C4, and C5 are given in picofarads, and the values for L1 are given in microhenries.

Semi-isolated Colpitts

Two versions of the semi-isolated Colpitts oscillator are described here. The first, shown in the Fig. 3 schematic, includes a fundamental-mode crystal. The second, shown in Fig. 4, is the same as that shown in Fig. 3 except that it includes overtone selector L1, C6 and radio-frequency bypass capacitor C3. Its operation requires a third-overtone crystal.

In both circuits, RF transformer T1 takes an output signal from Q1's collector current, but T1 is not part of the oscillator's feedback network. In addition, the output power is up to 100 times the crystal's power dissipation. Therefore, 15 milliwatts of output can be obtained with only microwatts of crystal dissipation! Moreover, if the output transformer is tuned to a harmonic of the oscillator's frequency, the RF load current is effectively isolated from Q1's fundamental RF current. Therefore, variations in the load or T1 do not affect oscillator tuning.

For example, if a 10-MHz crystal is used, the RF transformer can be tuned to 20 MHz, 30 MHz, 40 MHz, or higher MHz. Thus the circuit has its own built-in buffer that can drive low-impedance loads without detuning the oscillator.

However, as with the standard Colpitts circuit, the crystal is shunted by the emitter-base junction of the transistor—a low impedance. This lowers the oscillator's Q from tens of thousands to a few thousand, reducing its frequency stability. However, for most practical applications its stability is more than adequate.

Refer to the schematics shown in Figs. 3 or 4. In both circuits, resistors R1, R2, and R3 apply DC bias to transistor Q1. RF bypass capacitor C6 grounds one end of T1's primary. Capacitors C2, C5, and crystal XTAL1 form a feedback network as discussed earlier in reference to Fig. 1. Trimmer capacitor C1 serves the same function as it does in the standard Colpitts circuit. Transformer T1 and trimmer capacitor C3 (with C4) form a parallel resonant tank tuned to the desired output frequency.

If the output frequency is to be the same as the crystal's frequency, use the component values given in Table 3 or Table 5. (Tables 3 through 6 contain specifications information on winding transformer T1, which is explained under the Construction section) In this case, the oscillator, the load, and T1 are all tuned to the same frequency, and each affects the tuning of the other. (The load resistor R_L should initially be a ¼-watt resistor).

If the output frequency is to be a harmonic of the crystal's frequency, use the component values given in Table 4 or table 6. As mentioned earlier, this arrangement isolates T1 and the load, enabling the circuit to work with a wide range of load impedances.

The semi-isolated Colpitts oscillator shown in Fig. 4 requires a third-overtone crystal. Therefore, L1 and C5 appear capacitive at the third overtone, but they appear inductive at the crystal's fundamental frequency; together they form the collector circuit feedback element C2 shown in Fig. 1. Capacitor C6 bypasses DC-bias resistor R3, but it is most effective at the overtone rather than the fundamental frequency.

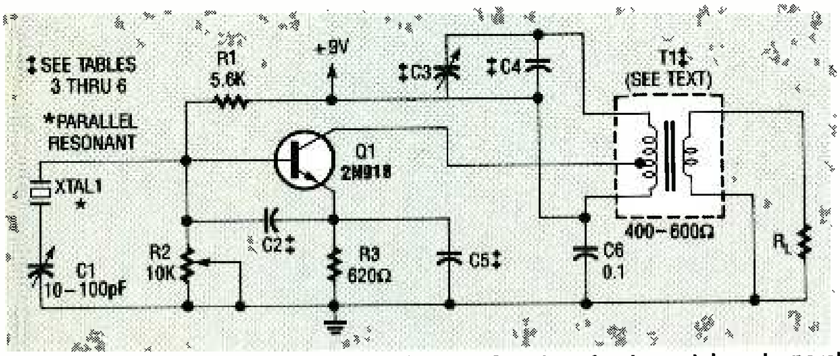


FIG. 3—A SEMI-ISOLATED COLPITTS OSCILLATOR with a fundamental-mode, parallel resonant crystal.

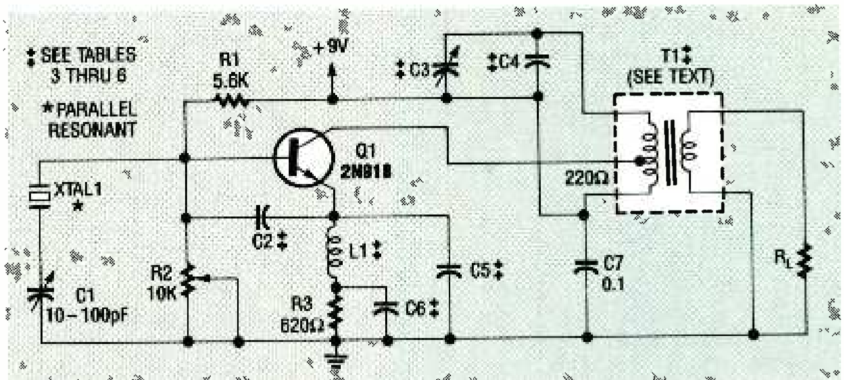


FIG. 4—A SEMI-ISOLATED COLPITTS OSCILLATOR with a parallel resonant crystal and overtone selector.

Pierce oscillator.

The best feature of the Pierce crystal oscillator, shown schematically in Fig. 5, is its very high operating Q. That very high Q is maintained because the crystal is connected between Q1's base and collector (a high impedance). This os-

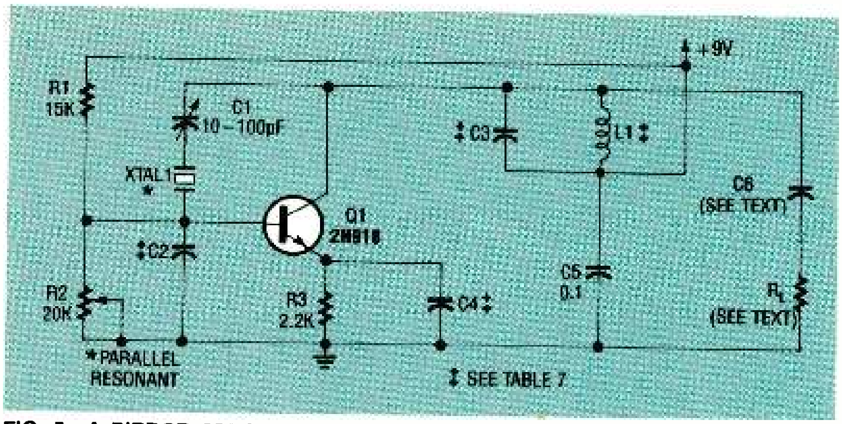


FIG. 5—A PIERCE CRYSTAL-CONTROLLED OSCILLATOR with a parallel resonant crystal.

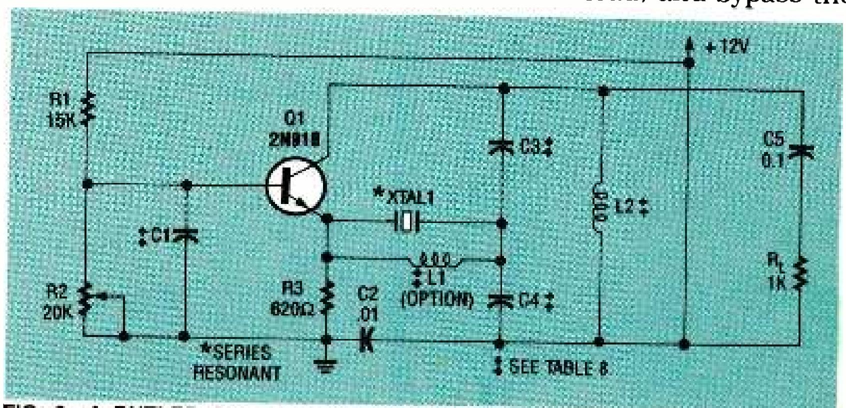


FIG. 6—A BUTLER CRYSTAL-CONTROLLED OSCILLATOR with a series-resonant crystal.

cillator provides a very stable and accurate output frequency up to about 75 MHz. It is possible to tune this oscillator to within a few hertz of the desired frequency and expect it to remain stable there (when held at constant temperature).

If an oven-controlled crystal is used, frequency change will only be several hertz over a wide temperature range. However, the Pierce oscillator does not offer very high output power. Moreover, it requires a very high load resistance of about 3000 ohms.

Resistors R1, R2, and R3 establish the DC-emitter current. Capacitor C5 bypasses RF at all frequencies, while C4 bypasses RF current at the desired operating frequency (fundamental or, overtone only). Capacitor C2 is base circuit feedback element C1 as shown in Fig.1, and the parallel network of C3 and L1 yields a net capacitive reactance at the operating frequency and is analogous to collector circuit feedback element C2 as shown in Fig. 1. Crystal XTAL1 forms feedback inductor L1 of Fig. 1, and as with the Colpitts oscillator, trimmer capacitor C1 fine tunes the circuit's operating frequency.

The component values of the Pierce oscillator also depend on frequency and are given in Table 7. Note that a fundamental-mode crystal permits frequencies from 1 to 25 MHz, while a third-overtone crystal is required for output frequencies from 30 MHz to 75 MHz.

If a load resistance of the Pierce crystal oscillator is to be less than several thousand ohms, a 1- to 5-picofarad coupling capacitor must be used at C5 to prevent the low resistance of the load from detuning the circuit and preventing circuit oscillation.

Butler oscillator

A schematic of a Butler crystal oscillator is shown in Fig. 6. The Butler oscillator demonstrates what is known as *input-resistance limiting*. Transistor Q1's DC-emitter current is directly proportional to the strength of the radio frequency input signal; in addition Q1's RF-input resistance of approximately 40 ohms is inversely proportional to the DC-emitter current. Therefore, as the RF feedback increases, Q1's DC-emitter current increases, but its RF-input resistance decreases. As Q1's RF-input resistance decreases, its RF gain also decreases, and this causes the output signal strength to reach a plateau.

The Butler oscillator's crystal circuit operates at series resonance, making it look resistive in the circuit. It is possible to substitute a 47-ohm resistor for the crystal and tune the circuit to a wide range of frequencies with variable inductor L1. But the circuit is so sensitive to variations in load resistance that a fixed resistive load must be connected to its output.

Resistors R1, R2, and R3 set the DC-emitter current. Bypass capacitors C1, C5, and C2 place transistor Q1 in a common-base configuration, couple the collector to the load, and bypass the positive supply lead, respectively. The feedback elements consist of capacitors C3 and C4, and inductor L2. The capacitors act like the base and collector elements C2, and C1 and inductor L2 act like the feedback circuit L1 in Fig.1.

Crystal XTAL1 feeds some of the RF output energy back into the emitter. Because the crystal behaves like a narrow bandpass filter, the emitter current forms clean sine waves that are low in harmonics. Inductor L1 cancels the detuning effects of the crystal's static capacitance C_p. However, if you build this circuit, get it to oscillate first without L1. Then, after it is working, install and fine tune L1 to obtain a precise output frequency.

Table 8 gives the values of the components in Fig. 6 that are shown without values. Note that a third-overtone crystal is necessary to obtain output frequencies from 20 to 55 MHz, while a fifth-overtone crystal is needed to obtain output frequencies from 60 to 100 MHz.

Selecting components

Remember that many common passive electronics components such as capacitors, resistors, and inductors that perform well at audio frequencies become inefficient and lossy in the radio frequencies. For example, the parasitic inductance of a wirewound resistor can be significant in a radio-frequency circuit. Keep this in mind when selecting oscillator components.

Power-supply regulation is important for stable oscillator operation. Low-Q oscillators that are tunable over a wide range of frequencies require very stable, low-noise supplies, but that is not a requirement for high-Q crystal- controlled oscillators because they are generally immune to voltage spikes and noise. Thus, while regulation is important, it can be obtained with low-cost integrated circuit regulators.

Even with minimal regulation, it is recommended that the power supply positive voltage lead be bypassed with a 6- to 10-microfarad tantalum capacitor and a 0.01 microfarad ceramic disc capacitor. Capacitors suitable for RF bypassing and tuning should have Q values of 100 or more, and most general purpose ceramic disc capacitors meet that requirement.

The crystal oscillators described here need only one bipolar transistor. In general, any NPN transistor with a gain-bandwidth product of at least 650 MHz is suitable. Possibilities include the 2N918 (shown in all of the circuits in this article), the MPSH-10, and the 2N2857. The 2N918 is available in plastic packages and metal cans. If you use 2N918's in metal cans, be sure to ground their cases. For frequencies below 50 MHz, a 2N3904 switching transistor will perform satisfactorily.

Inductor variety

Two basic kinds of inductors (tuning coils) are generally available: air wound, and core wound. Most are wound from number 20 to 40 AWG enamel-coated magnet wire. Inductors for RF circuits usually have both magnetic and electrostatic shielding. This is obtained by winding the coil on an iron-powder core, and then enclosing the assembly in a small metal can.

Core-wound inductors offer high Q's, good temperature stability (usually ±200 ppm/°C), and are small. Powdered-iron core materials are often mixed with other materials to make special powdered-iron alloys. Each is formulated to yield a high Q and optimum temperature stability over a specified frequency range. Oscillators or tuned circuits usually require Q's between 60 and 120. Before selecting a coil, examine the manufacturer's data to verify the coil's Q and usable frequency range.

Winding transformers

You can make your own radio-frequency transformer T1 for the semi-isolated Colpitts crystal oscillators shown in Figs. 3 and 4 from the toroidal cores and magnet wire specified in Tables 3 through 6. Under the column heading T1 (primary) these tables give the total number of primary turns, the wire gauge, and the designation for the appropriate core (e.g. T-80-2, T-50-2, T-50-10, T-50-17).

The first letter in this core code, T, stands for toroid, and the first number stands for the core outside diameter in fractions of an inch (e.g. 80 = 80/100 inch, 50 = 50/100 inch). The third number in the code designates a specific powdered-iron composition.

When winding wire on the core, first wind on approximately 12.5% of the total primary turns on the core (or three turns, whichever is larger). Then make a tap by twisting together several inches of wire to form a loop, and continue winding until all the primary turns have been wound. The loop can then be formed into a tap by cutting the loop and scraping the insulation off of the ends. This tap is then ready to be connected to Q1's collector as shown in Figs. 3 and 4 and soldered during the circuit assembly procedure.

The secondary of transformer T1 should reflect the load impedance shown on the schematics of Figs. 3 and 4 (at the primary's tap). The turns ratio between the secondary and the primary's tap should be the square root of tap resistance divided by load resistance. The secondary winding can be wouund from the same gauge wire as the primary.

For example, to reflect a tap resistance of 500 ohms, a 50-ohm load would require a primary-tap to secondary-turns ratio of 3.16:1 (the square root of 500 divided by 50). Therefore, if the primary tap consists of three turns, use a one turn secondary. After you find that the circuit oscillates with the initial transformer, you can experiment by substituting other transformers with different turns ratios.

Oscillator construction

Carefully designed printed-circuit boards are preferable to standard perforated boards as substrates for radio-frequency oscillators to minimize noise and interference. When building radio-frequency circuits, it is important that all components be inserted so they lie as close as possible to the board.

Use coaxial cable or TV twin-lead to conduct high-frequency signals for any distances over an inch. RCA-type audio connectors work well up to frequencies of 30 MHz, but BNC, F, and equivalent 50- or 75-ohm connectors should be used at the higher radio frequecies.

The Colpitts and Pierce crystal-controlled oscillator circuits discussed here include parallel-resonance crystals, but the Butler oscillator has a series-resonance crystal. In all circuits the crystal's load capacitance rating can be from 12 to 32 picofarads.

However, the higher frequencies require a smaller load capacitance so the crystal will provide enough inductive reactance to prevent oscillation above the desired frequency. Therefore, a 12- to 20-picofarad load capacitor should be used in circuits expected to operate at frequencies above 15 MHz.

After building the standard Colpitts oscillator, and before trying it for the first time, set variable capacitor C1 to its maximum capacitance value. The following start-up directions apply to all Colpitts oscillators and the Pierce oscillator, but *not* the Butler oscillator:

- Initially, couple a 4.7 K ohm resistor to the 0.1 microfarad load-coupling capacitor (C6 in Figs. 2 and 5).
- Adjust trimmer potentiometer R2 until the circuit oscillates. When the circuit is oscillating properly, a different load resistor value can be substituted. For 0.1 microfarad load-coupling capacitors, R_L must be a resistive load of 2 to 10 K ohms
- For coupling a low-impedance load, use a 1- to 47-picofarad capacitor.
- If the output frequency is to be the same as the crystal's resonant frequency, refer to the component values given in Table 3 or Table 5. In this case, the oscillator, the load, and T1 are all tuned to the same frequency, and each affects the tuning of the other. Therefore, a ¼- watt resistor should be inserted initially at R_L.

After completing the Pierce oscillator, lightly couple a radio-frequency or oscilloscope probe to Q1's collector with a 5 picofarad capacitor. Then carefully adjust trimmer potentiometer R2 until the circuit oscillates properly.

As stated earlier, a 47-ohm resistor can be substituted for the crystal in building the Butler oscillator. The circuit can be tuned to a wide range of frequencies with the variable inductor L2. Be sure to keep a fixed resistive load connected to the oscillator's output because it is sensitive to variations in load resistance.

It was also stated earlier that a second optional inductor L1 will cancel the detuning effects of the crystal resonator's parallel capacitance C_P. Complete the construction and make sure the circuit oscillates before installing L1 and fine tuning it. **R-E**

RANDOM DOTS

continued from page 23

eyes slightly. If you do that, however, the image will be inverted; whatever would appear as floating above the page would now be recessed.

Where do they come from?

Our random-dot images were created on a PC with the *Stare-EO Workshop* software from N.E. Thing Enterprises (P.O. Box 1827, Cambridge, MA 02139. 617-621-7174). The software lets you turn graphics, text, and PCX files into professional-looking random-dot images. The $40 disk for a PC-compatible computer can run on nearly any machine. All it requires is 512K of memory, and an HGA, CGA, MCGA, EGA, or VGA display. A mouse and hard disk make the program a little easier to use, but neither is required. The images you create can be printed on most graphics printers. There's also a Mac version of the software available for $35.

continued on page 90

POWER SUPPLY

continued from page 46

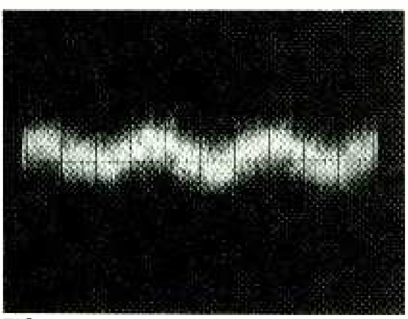


FIG. 4—THERE IS ONLY 20 MILLIVOLTS of ripple in the 250-volt DC output.

back to the voltage range and adjust the HV ADJUST knob for 250 volts. Adjust the voltmeter calibration trimmer R8 so the meter reads full scale.

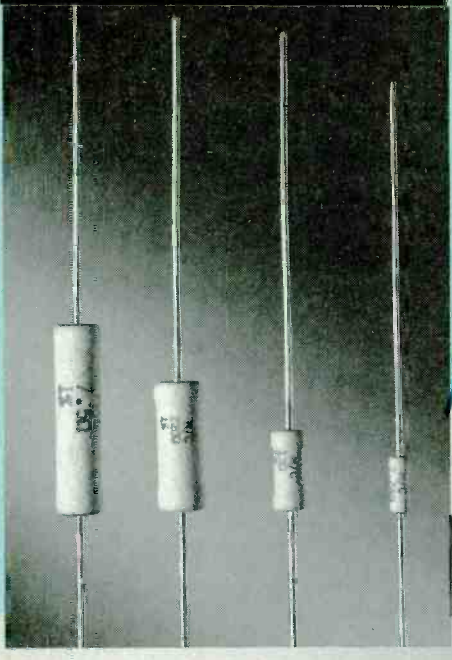
Although the outputs can "float," it's best to connect one of them to the ground jack. Due to the voltage rating of typical potentiometers we do not advise floating the output more than 150 volts above ground. **R-E**

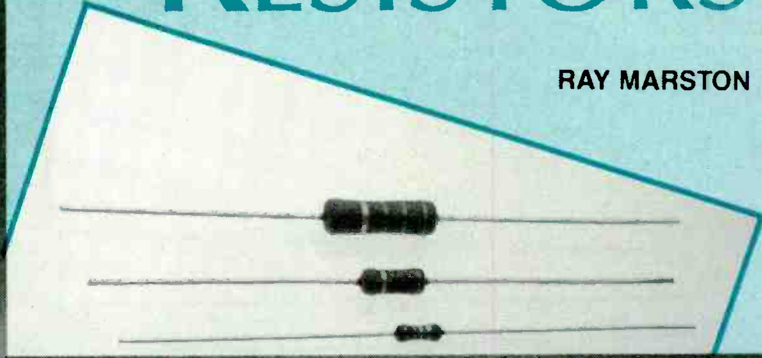
PARTS LIST

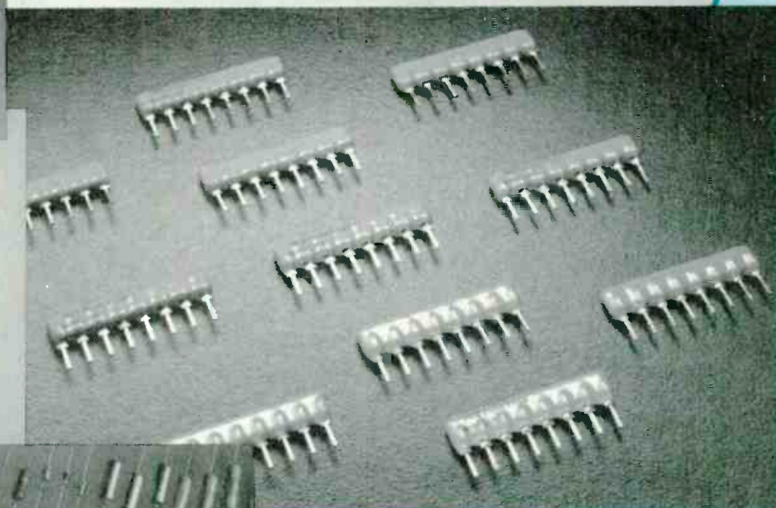
All resistors are ¼-watt, 5%, unless otherwise noted.
R1—6.8 ohms
R2—10 ohms
R3, R4—220 ohms
R5—470 ohms, 1-watt
R6—1000-ohms, potentiometer
R7—5000-ohms, potentiometer
R8—50,000-ohms, potentiometer
R9, R10—220,000 ohms, ½-watt
R11—470,000 ohms
R12—1 megohm, panel-mount potentiometer
Capacitors
C1–C4—0.01 µF, 500 volts, ceramic disk
C5—0.1 µF, ceramic disk
C6—220 µF, 25 volts, electrolytic
C7, C8—220 µF, 200 volts, electrolytic
Semiconductors
IC1—LM317T variable positive regulator
D1–D5—1N4005 diode (600V, 1A)
Q1—2SC1308 NPN high-voltage transistor, TO-3 type (Radio Shack #276-2055)
Q2—2N3904 NPN transistor
Other components
T1, T2—120/25.2 volt center-tapped 2-amp power transformer
J1—banana jack, red
J2—banana jack, black
J3—banana jack, green
F1—½-amp slow-blow fuse
S1, S2—DPDT switch, (6A, 250VAC)
M1—1 milliamp panel-mount DC meter
NE1—neon indicator lamp with built-in series resistor
NE2—neon lamp
Miscellaneous: Fuse holder, edge-mount perforated construction board and matching edge connector (optional, see text), enclosure, heatsink, TO-3 mounting hardware for Q1, standoffs, knob for R12, wire, solder, etc.

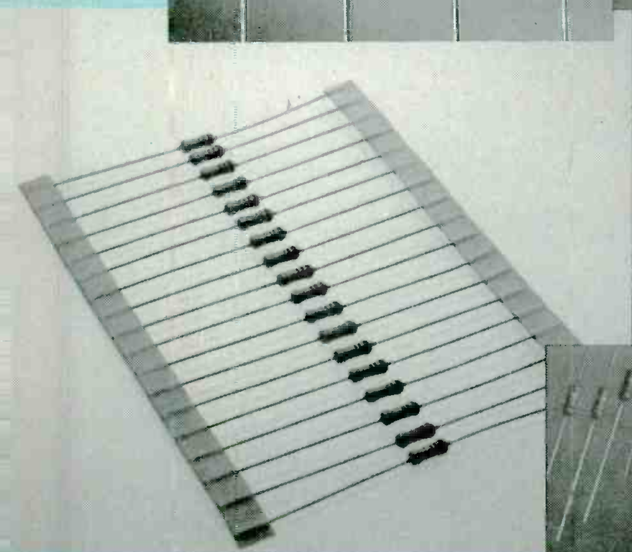
RESISTORS

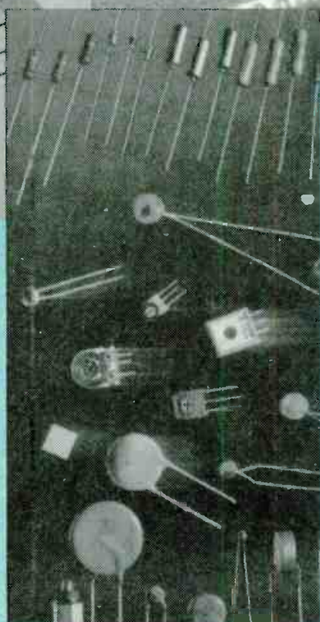
RAY MARSTON











Learn more about resistors—how they are made, and how to apply them effectively in your circuits.

THE DEMAND FOR RESISTORS TODAY directly reflects ongoing changes in the design and packaging of electronic products worldwide. Carbon-film, and metal-film fixed resistors with ratings of ¼-watt or less have displaced the carbon composition and wirewound resistors so widely specified in the past. The lower power requirements of today's integrated circuits, and the incessant push toward miniaturization have led to wider use of smaller, low-cost, low-power resistors.

Thick- and thin-film resistive networks permit automated assembly of circuits, particularly digital, where large numbers of resistors of the same value are specified. The chip resistor has moved from its origins in hybrid microcircuits to circuit boards assembled by surface-mount technology (SMT). Some other recent trends in resistor specification include:

- Increased use of fixed resistors and resistor chips with resistive tolerances of ±1% to ±5 % in preference to the ±10% to 20% acceptable in the past.
- Increased demand for planar chip resistors and networks for automated parts placement, increasing component density while saving PC board space and cutting assembly labor costs.
- Trimmer potentiometers made to withstand automated insertion or surface-mount placement, wave soldering, and high-pressure, water-based solvent cleaning.
- Decline in the demand for precision potentiometers because of the replacement of analog functions that required precise, repeatable setting with digital circuitry.

Fixed resistors

Every material impedes the flow of electric current to some extent. Materials such as copper or silver offer very little resistance to current flow, and they are called *conductors*. Other materials such as glass, ceramics, and plastic offer high resistance to current flow, and they are called *insulators*. Electronic circuits need components with known resistance values in the range between insulators and conductors; those components are called *resistors*.

The unit of resistance is the ohm (represented by the Greek letter Ω) Resistance values in thousands of ohms are expressed as kilohms (K or K ohms) and in millions of ohms as megohms (MEG or M ohms). Nominal values of resistors are given at an ambient temperature of 25°C. The graphical symbol for a fixed resistor is shown at the top of Fig. 1. The block diagram "tree" illustrates how fixed resistors are classified.

The resistance of any resistive material is given by the following equation:

$R = \rho L/A$

where R = resistance

ρ = resistivity of the material, ohms-cm.

L = length of material, cm

A = cross-sectional area of material, cm^2

Resistivity ρ (Greek letter rho) is an inherent property of materials. Values of ρ for some commonly used materials are summarized in Table 1.

The equation says that for a material with a given resistivity, the resistance varies *directly* with length L and *inversely* with cross-sectional area A. For example, a long wire has greater resistance than a short wire, and a thick wire has less resistance than a thin wire.

The voltage and current in a resistor are related by ohm's law:

$I = E/R$, $E = I/R$, $R = E/I$

where E = voltage across the resistor and I = current flowing in the resistor.

Power P (in watts, W) dissipated in a resistor can be stated with any of the following math expressions:

$P = EI$, $= I^2R$, $= E^2/R$

A number of terms define a resistor in addition to its nominal value in ohms: tolerance, temperature coefficient of resistance, power rating, and rated continuous working voltage.

- *Tolerance* expresses the maximum deviation in resistance from the resistor's nominal value, expressed as a percent. General purpose resistors have tolerances of ±5%, ±10%, and ±20%. Most carbon composition and carbon film, and some metal-film and wirewound resistors are in this class. The ±1% and ±2% semi-precision class includes some metal-film resistors and networks, while the ±0.5% and 1% precision class includes those with metal-film and wirewound elements.
- *Temperature coefficient of resistance* (abbreviated TCR, or *tempco*) states how the resistor's resistance changes with temperature. TCR is usually expressed as parts per million per degree Celsius (ppm/°C), and can be positive or negative. Semi-precision and precision units typically have the lowest TCR's.
- *Power rating* is the maximum continuous power, in watts, that a resistor can dissipate at a temperature as high as 70°C. At temperatures beyond 70°C, the power rating is reduced or *derated*. A typical derating curve for a resistor is given in Fig. 2.
- *Rated continuous working voltage* (RCWV) is the maximum voltage that can be applied non-destructively to the resistor.
- *Noise*. Electrons move randomly in all materials and produce random voltages or *noise*. Noise in resistors increases with resistance value, operating temperature, and the bandwidth of the circuit in which the resistor is located.

Resistor classification

The blocks in Fig. 1 represent the four most widely specified

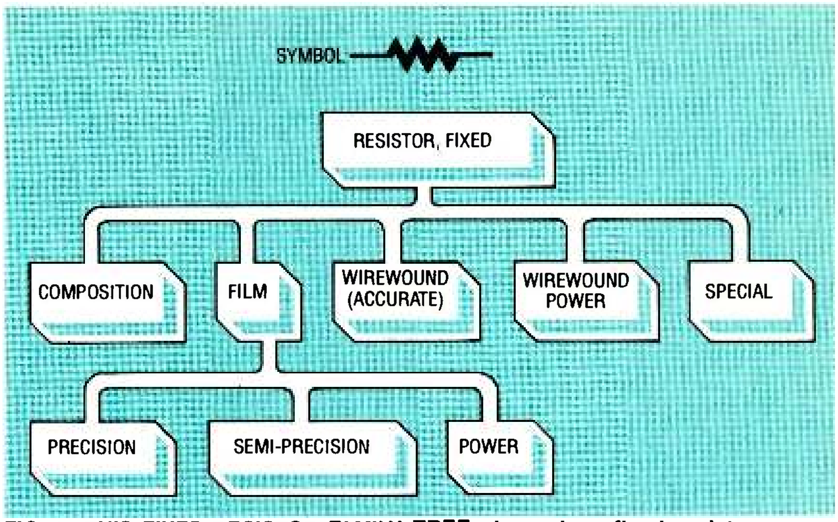


FIG. 1—THIS FIXED-RESISTOR FAMILY TREE shows how fixed resistors are classified in industry by resistive element and power handling ability.

TABLE 1
RESISTIVITIES OF COMMON MATERIALS

Material	ρ, ohms-centimeter
Silver	1.5×10^{-6}
Copper	1.7×10^{-6}
Aluminum	2.6×10^{-6}
Carbon (graphite)	30×10^{-6} to 190×10^{-6}
Nichrome	100×10^{-6}
Glass	$10^{10} - 10^{14}$

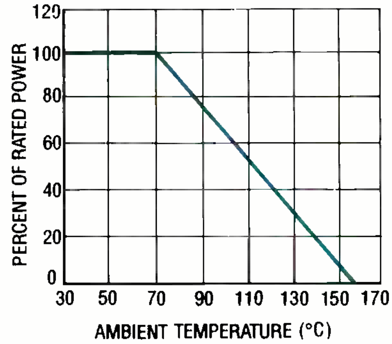


FIG. 2—A TYPICAL RESISTOR DERATING CURVE plots power against ambient temperature, the temperature of the environment in which the resistor is operating.

types of fixed resistor—carbon composition, metal-film, carbon-film, and wirewound. The "special" category includes such products as high-voltage resistors, chip resistors, and resistor networks.

Table 2 summarizes the characteristics of the most popular fixed resistors. The values given in this table state the typical extremes for any given resistor, not what is readily available as a commercial product. Manufacturers offer a limited selection of resistors with preferred ratings as standard catalog items. Thus, it may not be possible to obtain the exact resistor type and value you need off-the-shelf or from the catalog. Resistors with an application-specific combination of features can be custom ordered.

The preferred values for all fixed resistors are given later in this article. It is important to keep in mind that for many general applications, more than one resistor type will perform satisfactorily. In those instances, the purchase decision will be based on lowest unit price.

Carbon-composition resistors

Carbon-composition resistors were, for many years, the commodity products among fixed resistors. Figure 3-*a* is a cutaway view of the classical molded carbon-composition resistor. It has a resistance element made by mixing graphite, a form of carbon, with a suitable viscous binder to form a uniform bulk resistive material. These resistors were made by inserting leads in the resistive element, coating it with an insulating jacket, and molding the unit in a single step before firing it under pressure at a high temperature.

The resistance values of the molded carbon-composition element can be altered by changing the ratio of carbon to binder or the size of the element. Another form of carbon composition resistor that is made by applying a thick film of carbon in a binder on an insulating mandrel was also introduced.

Carbon-composition resistors can have resistance values from about 10 ohms to 22 megohms, and typical tolerances ranging from ±5% to ±20%. Power ratings are ⅛ to 5 watts. Their temperature coefficients are typically greater than 500 ppm/°C. Continuous working voltages can be up to 350 volts. These resistors can absorb moisture in storage or when not operating that will alter their resistance values. They generally recover after operation, because heat drives out the moisture.

Carbon-composition resistors continued in use long after cheaper carbon-film resistors were introduced because of their ability to withstand significant overcurrents without being destroyed.

Wirewound resistors

Wirewound resistors are classified as power or precision components, and both types are made by winding resistance wire on ceramic or epoxy mandrels and terminating each end of the wire with a leaded end cap as shown in Fig. 3-*b*.

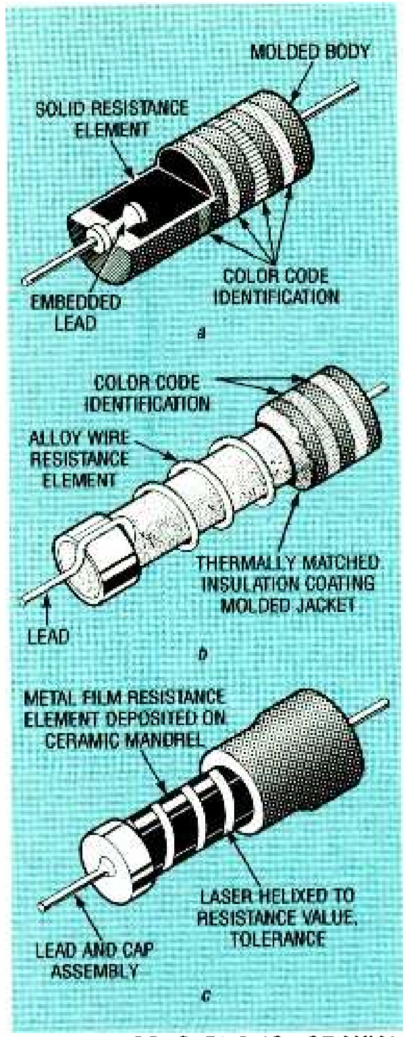


FIG. 3—The CONSTRUCTION OF AXIAL-LEADED FIXED RESISTORS is shown for carbon composition (*a*), wirewound (*b*), and metal-film (*c*).

Power wirewound resistors are made by winding a single layer of resistive alloy wire around a ceramic mandrel. The winding is then coated with an insulating material such as vitreous enamel (an inorganic ceramic) or silicone to protect it from moisture and damage while insulating it from contact with surrounding objects. The winding can become hot in normal operation.

Resistance wire is selected for uniform resistance properties, low temperature coefficient, and ability to withstand high

TABLE 2—CHARACTERISTICS OF POPULAR FIXED RESISTORS*

Resistor Type	Resistance Range (Ohms)	Tolerance Range (Percent)	Power Range (Watts)	Temperature Coefficient (ppm/°C)	Time Stability (1000 hours)
Carbon Composition	1–100 MEG	±5–±20	1/8–5	±100–±1000	±5–±10%
Carbon Film	10–10 MEG	±0.5–±10	0.1–2	±100–±200	±0.5–±3%
Metal Film	0.2–10 MEG	±0.1–±2	1/20–20	±20–±200	±0.1–+0.5%
Cermet Film	10–20 MEG	±1–±5	0.1–3	±50–±200	±0.5–±2%
Wirewound Power Precision	0.1–1 MEG 0.1–10 MEG	±2–±10 ±.001–±1	5–1500 0.4–2	±20–+450 ±0.5–±50	+2–±5% ±0.1–0.5%

*Includes general purpose, semi-precision, and precision temperature. Nickel-chromium alloy (nichrome) is commonly used to obtain high resistance values, and copper alloys are used for low resistance values.

Resistance values of commercial power wirewounds range from less than an ohm to greater than a megohm, and resistive tolerances can be from ±2% to ±10%. Power ratings can be as high as 1500 watts and TCR's can be as low as ±20 ppm/°C. A power resistor's normal power rating can be doubled by inserting it in an aluminum case with heat-radiating fins, and mounting the case on a heatsink.

Precision wirewound resistors are usually made as multilayer coils wound on epoxy mandrels. Copper-alloy resistance wire is used for low resistance values, and nichrome wire is used for high resistance values. Precision wirewound resistance values range from less than an ohm to 60 megohms, resistive tolerances can be less than 1%, and TCR's can be as low as 0.5 ppm/°C. Power ratings, less important in their applications, are typically to 2 watts.

Metal-film resistors

Metal-film resistors are made with different resistive elements, and they can be classed as general purpose, precision, and semi-precision. Thin films include nickel-chromium alloy that are less than one-millionth of an inch thick; thick films include cermet and proprietary metal glazes that are more than one-millionth of an inch thick. Metal-film resistors offer good thermal stability and generally low noise ratings.

Figure 3-c is a cutaway drawing showing the general method for making most metal-film resistors. Thin resistive films are deposited on a long ceramic rod or mandrel in a high-vacuum chamber by *vacuum deposition*. By contrast, thick films are applied by screening or spraying resistive inks on a similar mandrel before the mandrel is fired.

The mandrels are then cut apart into individual resistor bodies, and leaded end caps are fitted on the ends. Trimming to the nominal resistance value is done with a laser in a closed-loop circuit under computer control. The resistive film is removed in a spiral pattern whose length sets the desired resistance value. Insulating epoxy jackets are then applied.

Nickel-chromium alloy metal-film is suitable for a resistance range of about 1 ohm to 1 megohm with tolerances as low as ±1%. TCR's can range from as low as ±25 ppm/°C to ±200 ppm/°C. Power ratings can be up to 5 watts, and working voltages can exceed 200 volts.

Cermet-film resistor elements are prepared by mixing precious metal with a binder to form an ink and screening it on ceramic mandrels before the mandrels are fired. Cermet resistors have values to 10 megohms, resistive tolerances as low as 1%, TCR's as low as 25 ppm/° C, and power ratings to 3 watts.

Carbon-film resistors

Carbon-film resistors are made in the same general way as cermet metal-film resistors, as shown in Fig. 3-c. These resistors have gained in popularity for general purpose applications because they cost less than carbon composition resistors. Because they are widely used in protected, low-voltage transistorized circuits, they do not need to be as rugged.

Carbon-film resistors are available with resistance values from about 1 ohm to 10 megohms with resistive tolerances as low as ±5%, TCR's under 200 ppm/°C, and power ratings up to 3 watts. They are less noisy than carbon-composition resistors, and are less likely to be affected by humidity.

Common characteristics

All resistors exhibit some capacitance and inductance. Figure 4 is the equivalent circuit for a resistor operating at a high frequency. An effective inductance is in series with the nominal resistance, and both are shunted by an effective capacitance. Both inductance and capacitance are caused by the composition of the resistive element and its connecting leads. These undesirable effects, L and C, are called *parasitics*.

The inductance is negligible in carbon-composition resistors, but somewhat higher in

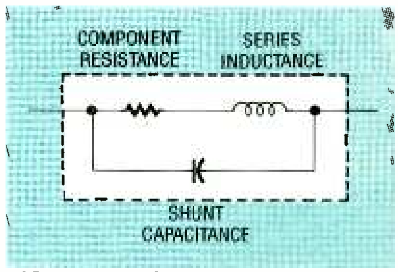


FIG. 4—THE EQUIVALENT CIRCUIT FOR A RESISTOR operating at high frequencies shows that stray inductance and capacitance, called parasitics, can be present.

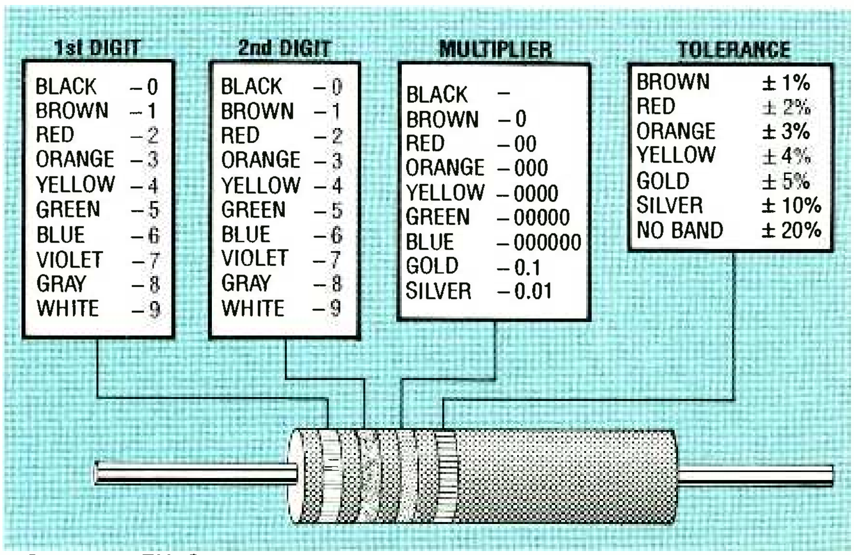


FIG. 5—THE EIA STANDARD COLOR CODE FOR FIXED RESISTORS is based on colored stripes that are read from left to right to give resistance value and tolerance.

both metal- and carbon-film units. Inductance can, however, be a serious consideration with wirewound resistors operating at high-frequency because they are coils. This inductance can be reduced by a winding technique called *bifilar* winding. A length of resistance wire is folded back on itself before being wound on the mandrel. This cancels most of the parasitic inductance.

The true value of a resistor also varies with ambient temperature, humidity, age, and applied voltage. The magnitude of these variations depends on resistor composition.

Resistor coding

The values and tolerances of axial-leaded resistors can be read from alphanumeric markings (e.g. 4.7K, 5%) or by interpreting colored bands on them. The Electronic Industries Association (EIA) color code, shown in Fig. 5, is now the most widely used code in North America. (It agrees with U.S. military specification MIL-R-11).

Bands of different color designate both resistance value and tolerance. The first two bands denote the first and second digits of the resistance value, and the third band indicates the multiplier—the number of zeros that follow the first two digits. The fourth band gives resistance tolerance.

A resistor with four colored bands can be identified by reading the colors from left to right—yellow, violet, orange, silver. These identifies it as a 47,000-ohm resistor with a ±10 % tolerance.

A fifth band found on MIL-R-39008 resistors denotes reliability:
Brown = 1.0%, Red = 0.1%, Orange = 0.01% , and Yellow = 0.001%

Wirewound resistors may have a double-width first band. A final blue band indicates the resistor is recognized by Underwriters Laboratories as failsafe. Some general-purpose and semi-precision film resistors may have a final white band to indicate that its leads can be soldered. Also, precision film resistors may have three rather than only two significant-figure bands.

As in many other areas of electronics, Government specifications and standards set the acceptance level for resistors. In the U.S., for example, military standards are referenced in most manufacturer's catalogs as a quality benchmark. Among the military specifications referenced are MIL-R-11 (four-band color code identification) and MIL-R-10509 and MIL-R-22684 for metal-film resistors. The procurement of high-reliability, military-qualified resistors is mandatory in many military and aerospace contracts.

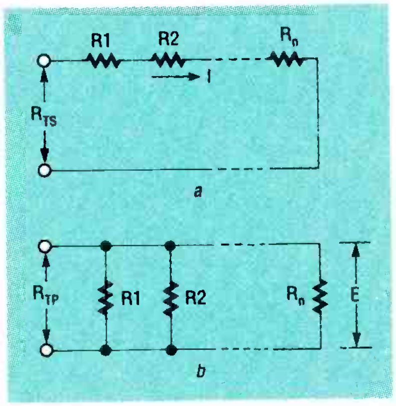


FIG. 6—THE EFFECTIVE VALUES of connected resistors can be calculated by simple formulas. Resistors connected in series are shown in (*a*), and those in parallel are shown in (b).

Resistors in series

Certain formulas apply when resistors are connected in series and parallel in DC and low-frequency AC circuits. Figure 6-*a* shows *n* resistors connected in series. In a series circuit, the current I flowing in each resistor is the same. The total equivalent resistance of the series circuit R_{total} is equal to the sum of the individual resistors:
$R_{total} = R1 + R2 + R3 \ldots Rn$

If *n* equal resistors are connected in series, the total equivalent resistance is equal to the product of the value of an individual resistor and *n*:
$R_{total} = nR$

The maximum voltage E_{max}

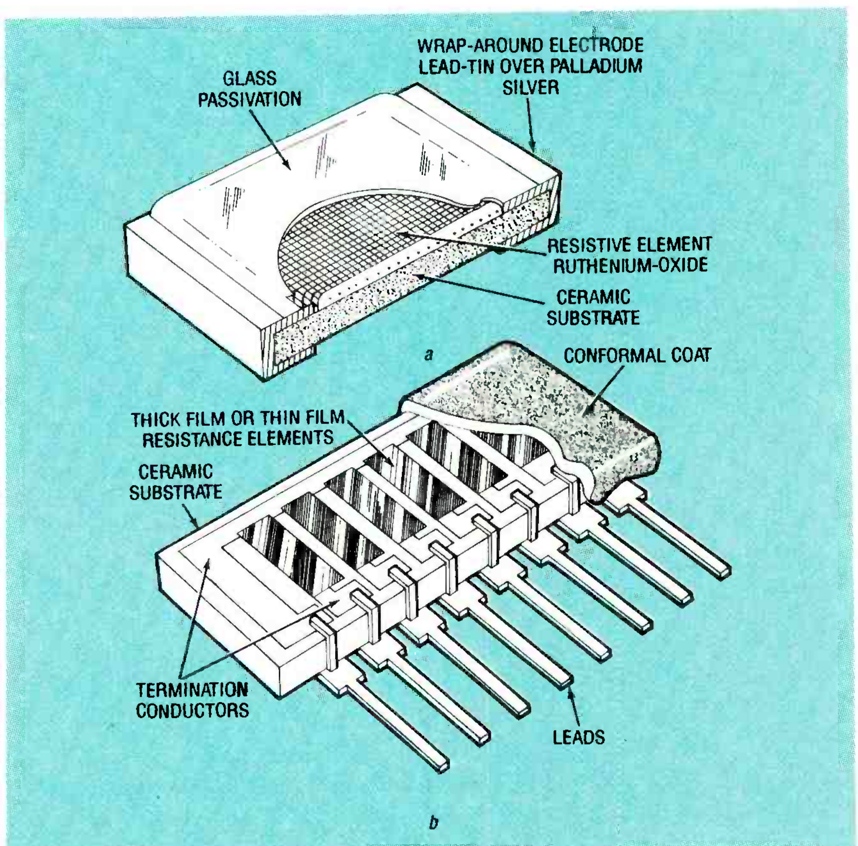


FIG. 7—SPECIAL FIXED RESISTORS include the chip resistor (*a*), and a single-in-line package (SIP) network (*b*).

that can be applied across a series of resistors is equal to the sum of the rated continuous working voltage (RCWV) of each resistor:

E_{max} = (RCWV)1 + RCWV)2... + (RCWV)n

Resistors in parallel

Figure 6-*b* shows *n* resistors connected in parallel. In a parallel circuit, the voltage E across each resistor is the same. The equivalent resistance of two resistors, R1 and R2 in parallel, is equal to their product divided by their sum:

R = R1 × R2/R1 + R2

For *n* equal resistors in parallel, the equivalent resistance is equal to the value of an individual resistor, R1, divided by *n*:

R_{total} = R1/n

For *n* resistors with different values, the equivalent parallel resistance is equal to 1 divided by the sum of the reciprocals of the individual resistor values:

R_{total} = 1/1/R1 + 1/R2 + 1/R3 + ...1/R_n

The maximum voltage that can be applied across resistors in parallel is limited by the smallest value of RCWV for a resistor in the circuit.

Special resistors

There are many different kinds of fixed resistors made for special applications. In general, most are manufactured with the same kinds of resistive elements that are used in making conventional fixed resistors. Therefore, all the technology and formulas previously discussed apply to those products as well. Special resistors include high-voltage resistors, chip resistors, and packaged resistor networks.

High-voltage resistors are resistors that are effective at voltages as high as 40,000 volts. These can be manufactured as axial-leaded, carbon-film resistors that are hermetically sealed in glass capsules.

Chip resistors are basically thin- or thick-film resistors that have been deposited on a ceramic substrate as shown in Fig. 7-*a*. Ruthenium-oxide thick-film cermet is widely used as a resistive element in commercial-grade chip resistors for surface mounting. Wraparound electrodes permit solder bonding to the circuit board, and glass passivation protects the resistive element from environmental stresses.

The typical power rating for a chip resistor is ⅛ watt or less. Chip resistors for surface mounting are formed in a 1.6 × 3.2 millimeter (0.125 × 0.063 inch) standard size to permit them to be picked up and placed by automatic machines.

Resistive networks are arrays of thick- or thin-film resistors deposited on a common substrate and packaged for ease of assembly on circuit boards. They are classed as DIP (dual-inline package) or SIP (single-inline package) networks. A SIP network is shown in Fig. 7-*b*.

DIP and SIP network conductors are formed as silver-palladium powders in a volatile binder screened on the ceramic

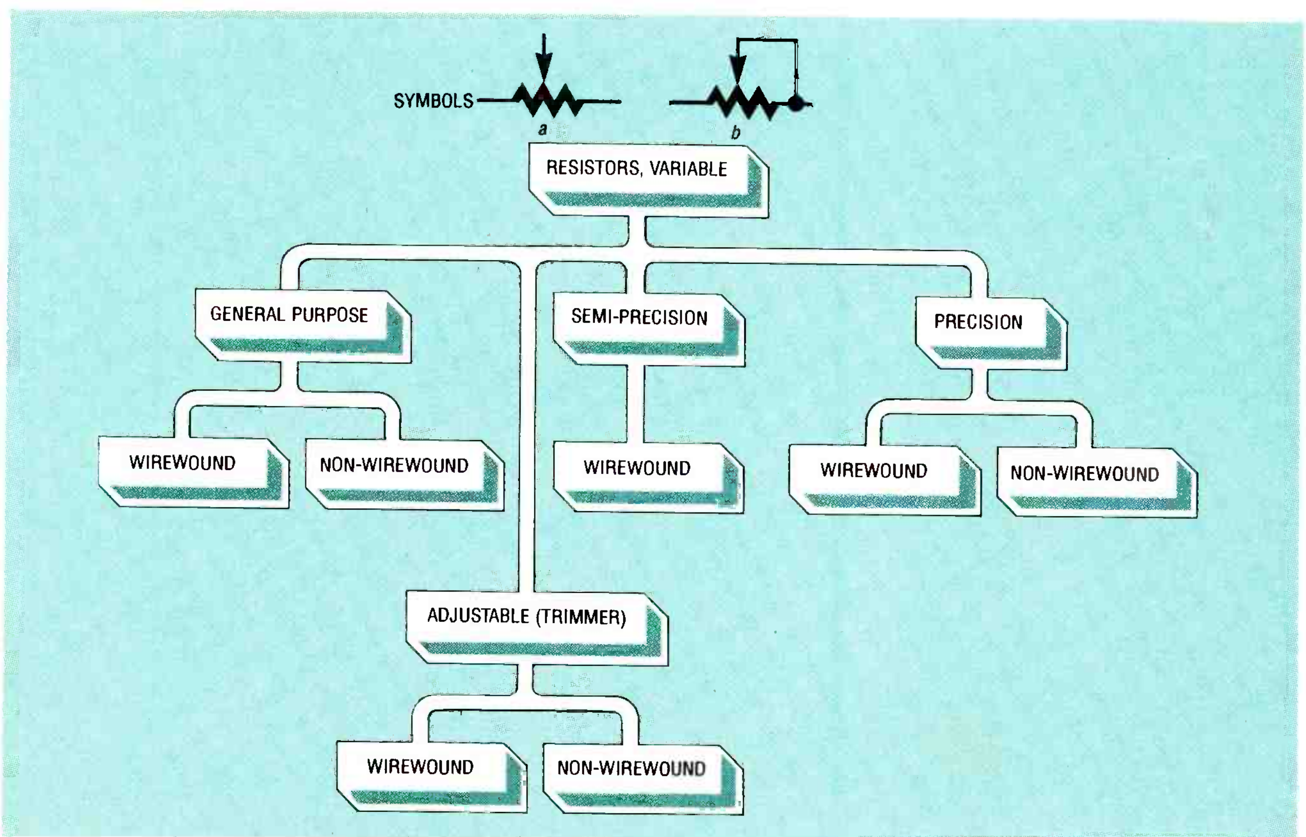


FIG. 8—THIS VARIABLE-RESISTOR FAMILY TREE shows how potentiometers are classified in industry by resistive element, function and application. Schematic symbol (*a*) shows a voltage divider, and symbol (*b*) shows a rheostat.

substrates and fired. These conductors are brought out to the pins that are brazed to the edges of the substrate. The conductors can also form a variety of interconnection patterns. In standard commercial networks, the resistors have the same value, but networks with different values can be custom ordered.

Resistive networks are used for pull-up and pull-down transitions between logic circuits, as sense amplifier terminations, and for LED display limiting. DIP networks, formed by epoxy molding, are available with 14 or 16 pins. They can be inserted by the same machines that insert DIP-packaged IC's. SIP networks, by contrast, typically have 6, 8 or 10 pins on one edge for vertical mounting to save PC board space. They are packaged by epoxy molding or conformal coating.

Standard commercial thick-film resistive networks have resistor values that range from 10 ohms to 10 megohms with TCR's of ±2%. Total power dissipation of ½-watt is a typical upper limit for the package.

Resistor networks are also available in small-outline IC (SOIC) packages—miniature DIP's with stub leads—as well as open network packages, and hermetic-sealed leadless chip carriers for surface mounting.

Preferred values

By international agreement, general-purpose resistors are manufactured in a limited number of *preferred* nominal values that are related to each other in a logical order. The number of values per decade is related to a distribution of desired resistance tolerance. Thus, if a precision of ±20% is adequate for some design requirement, the entire spectrum of possible resistance values in the 80-ohm to 800-ohm decade can be adequately spanned with just six preferred resistors with the nominal values and tolerance ranges shown in Table 3.

The values in Table 3 increase logarithmically, in increments of about 50%. This range of preferred values can be expanded

TABLE 3
COMMON FIXED RESISTOR VALUES AND TOLERANCES*

Value, nominal (ohms)	Range (ohms)
100	80 – 120
150	120 – 180
220	176 – 264
330	264 – 396
470	376 – 564
680	544 – 816

* + % spread

in decade multiples and submultiples to span all possible resistance values from below 10 ohms to greater than 10 megohms. Resistor manufacturers refer to this set of values as the *20% tolerance* series, but in most European countries it is known as the *E6 series* because it is based on six values per decade.

Variable resistors

Variable resistors are commonly called potentiometers or pots. These components include a means for changing their nominal resistance values by the manual movement of a contact or wiper over the resistive element. The qualities of variable resistors depend on their resistive elements, the size of those elements, and the configuration or package style of the component.

All potentiometers are the electrical equivalents of three-terminal resistors shown schematically at the top of Fig. 8. Symbol *a* depicts a voltage divider. However, symbol *b* depicts a rheostat, organized by connecting the wiper terminal with one other terminal. Thus, the wiper shorts out part of the resistance element so that the value of the resistive element can be changed with each setting.

Figure 8 is a block diagram "tree" showing how potentiometers are classified as general purpose, semi-precision, and adjustable (trimmer). General-purpose and semi-precision units are also called volume controls or panel potentiometers. Resistive elements are classed as wirewound or non-wirewound (e.g. conductive plastic, carbon, and cermet).

Precision potentiometers

A potentiometer with an accuracy of 1% or greater is defined as a precision potentiometer. These variable resistors are generally considered to be instruments rather than electronic components. A close relationship is maintained between the position of the wiper and the potentiometer's re-

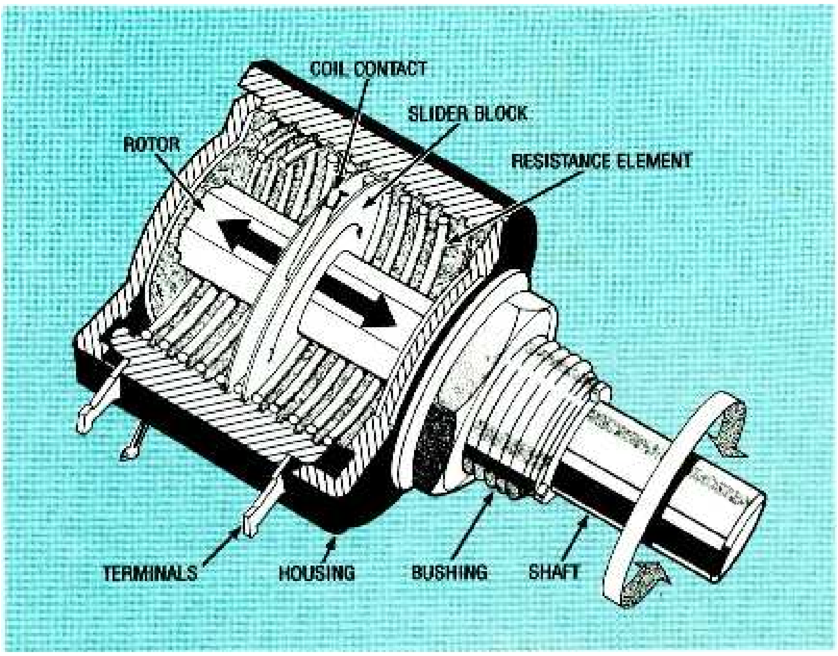


FIG. 9—A CUTAWAY OF A MULTITURN PRECISION POTENTIOMETER shows how the wiper tracks around the inside of the helical resistance element for high resolution.

sistive (or output) value.

Precision potentiometers were important parts of analog and hybrid computers where accuracy of the output was dependent on the precision of the potentiometer. Precision was determined by such factors as resolution, thermal stability, and *repeatability*—the ability of the wiper to return to the same point on the resistive element and reproduce the same voltage or current output.

Modern commercial precision potentiometers look very much like panel-mounted volume controls. Most are made as applications-specific products, but certain commercial units are available off-the-shelf. The potentiometers can be either single-turn or multiturn for higher resolution.

Single-turn precision potentiometers have planar (circular) resistive elements, but multiturn precision potentiometers have helical elements. Figure 8 is a cutaway view of a multiturn potentiometer whose wiper rotates and traverses axially down the length of case while tracking the helical resistive element.

Most multiturn potentiometers are actuated with vernier dials to permit repeatability. Their resistive elements are wirewound or hybrid helixes. Hybrid elements are wirewound helixes coated with conductive plastic. Up to ten turns may be required for the wiper to track the entire length of the element.

The resistance elements of single-turn precision potentiometers are most likely to be conductive plastic or cermet rather than wirewound today.

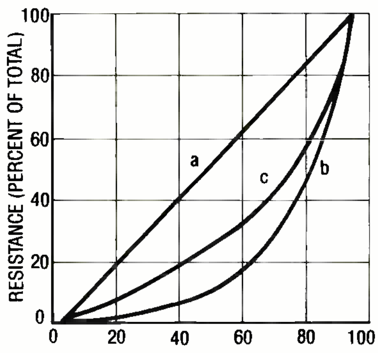


FIG. 10—POTENTIOMETER TAPERS include linear (*a*), nonlinear logarithmic (*b*) and special (*c*).

Conductive plastic elements are made by mixing carbon with a suitable plastic binder to yield a sheet with uniform volumetric resistance. It can be cut or stamped as uniform C-shaped elements or shaped for special functions. This material exhibits good linearity and long rotational life.

Most standard, off-the-shelf precision potentiometers have linear tapers—resistance values that are proportional to wiper movement between the two end terminals as shown in Fig. 10-*a*. If the resistance value is not directly proportional to wiper motion, the wiper is said to have a nonlinear resistive element. Tapers are produced by shaping the resistive element. The variation in resistance value (and output) can follow the *square law* as shown in Fig. 10-*b* or other mathematical function as shown in Fig. 10-*c*.

Panel controls

Panel or volume controls are general purpose potentiometers whose setting is determined subjectively. These controls set audio volume in radios and TV's, and brightness on TV and computer CRT's. A precise relationship between wiper setting and resistance value is not required.

Panel potentiometers have wirewound or non-wirewound (e.g. carbon, conductive plastic or cermet) resistance elements. The performance of these components is related to their resistive elements (e.g. range of values, tolerance, TCR, and power handling ability.) Carbon elements wear with repeated wiper rotation, and cermet elements tend to abrade the wiper. The elements of panel potentiometers can also be tapered as shown in Fig. 10.

Some panel potentiometers are assembled from modules and have a common shaft. This permits them to be *ganged* so that one axial shaft motion changes two or more resistive elements all at the same time. Panel potentiometers are also made for PC board and surface mounting.

continued on page 90

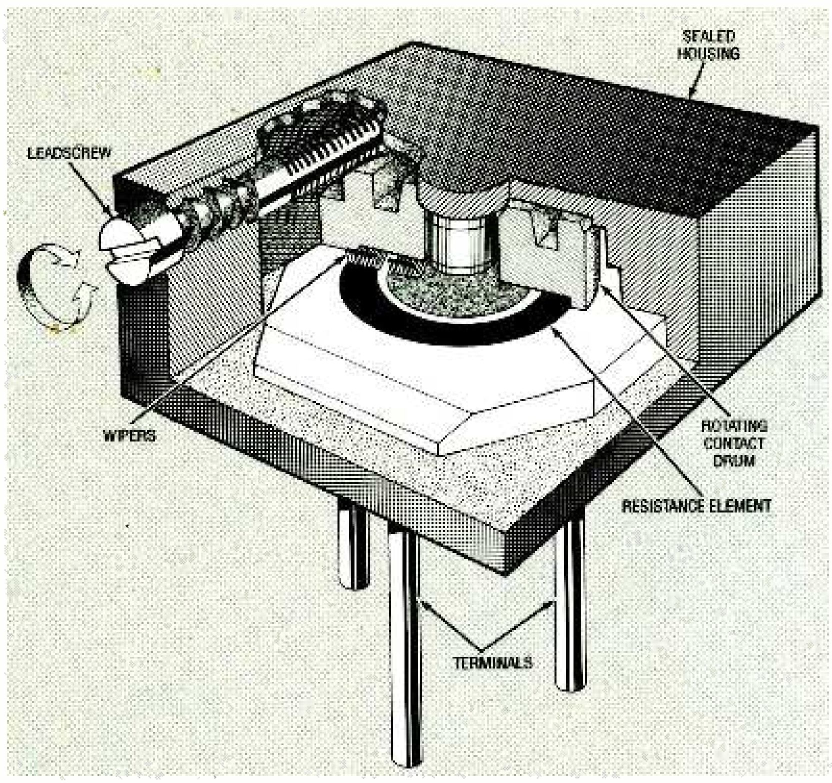
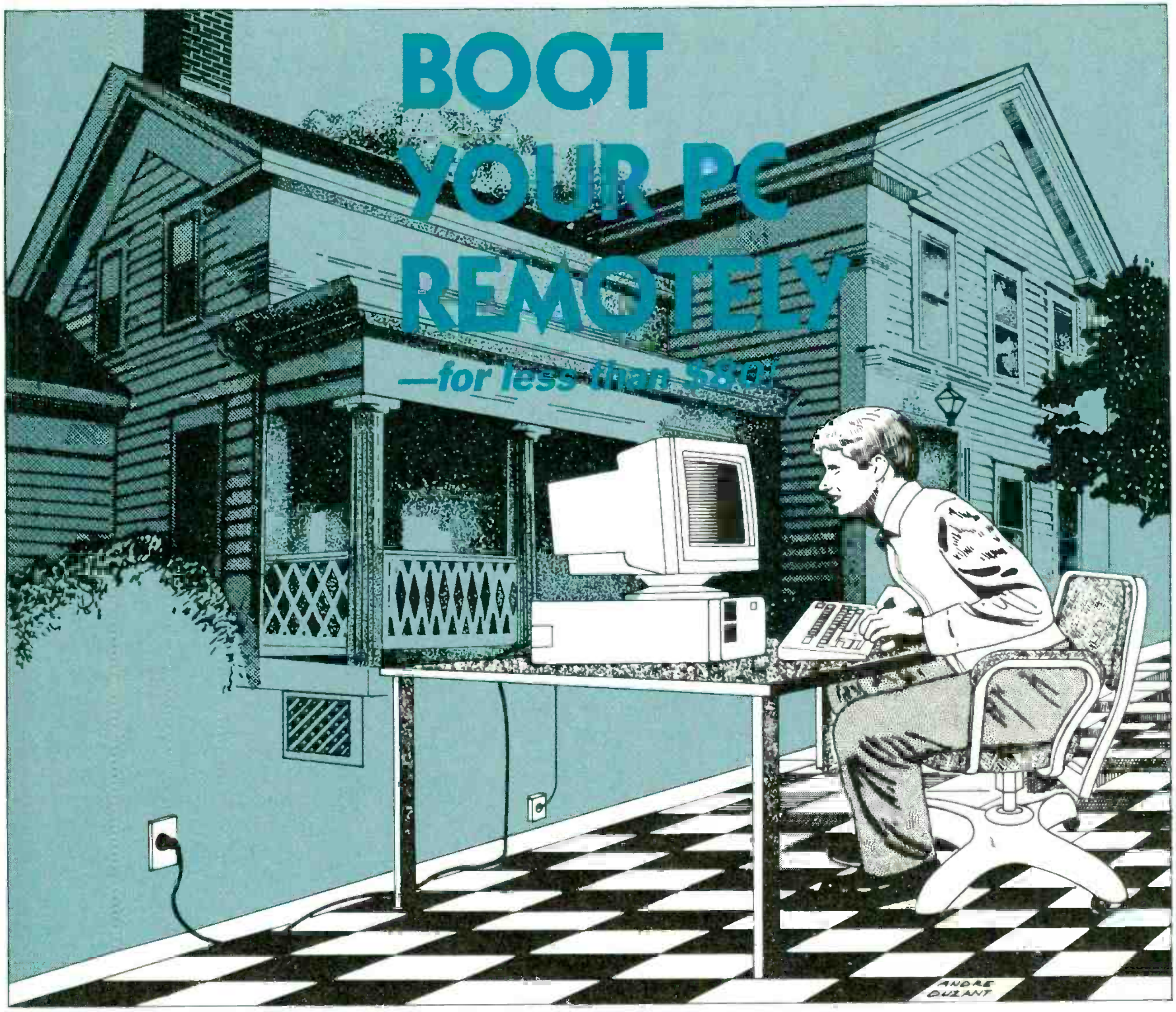


FIG. 11—A CUTAWAY OF A TRIMMER POTENTIOMETER shows the adjustment mechanism. The three pins permit it to be organized as a voltage divider or rheostat.



Part 2 of building a remote-boot controller for your PC.

THOMAS E. BLACK

RING-THING IS AN INEXPENSIVE YET extremely useful telephone-based AC power controller. You connect Ring-Thing to your phone line, and an AC-powered device to Ring-Thing. When Ring-Thing recognizes a set number or pattern of ring signals, it turns on a relay that applies 117 volts AC to whatever is plugged into the power strip. After the phone connection terminates, Ring-Thing waits about five minutes and then removes power from the power strip. Ring-Thing can control both computers and other equipment.

Last time we described operating modes and began a detailed circuit description. This time we'll complete the circuit description and move on to construction details. You can order partial and complete parts kits, and software can be found on the RE-BBS (516-293-2283, 1200/2400, 8N1).

In the descriptions that follow, remember that the control unit has three separate ground circuits: analog for the ring detector, digital for the microcontroller and functional units, and a separate relay ground.

LPT interface

Referring to Fig. 4 (shown last time), ports PB0 and PB1 of the microcontroller support the PC power-down feature by detecting inputs from the parallel port of a PC. Those inputs receive a stream of two-bit code values from a standard Centronics parallel printer port (LPT1–4). There is no false triggering because Ring-Thing must receive a specific series of codes.

The PC interface also depends on the microcontroller's PA7 output, whose main function is to control the LED2 (POWER), but which is also used to provide a handshaking signal. (The LED drive circuit was shown last time in Fig. 5.) Incidentally, LED2 will blink while Ring-Thing sends handshaking messages, but normal operation will resume thereafter.

The PC interface circuit, shown in Fig. 6, works as follows: Optoisolators IC3–IC5

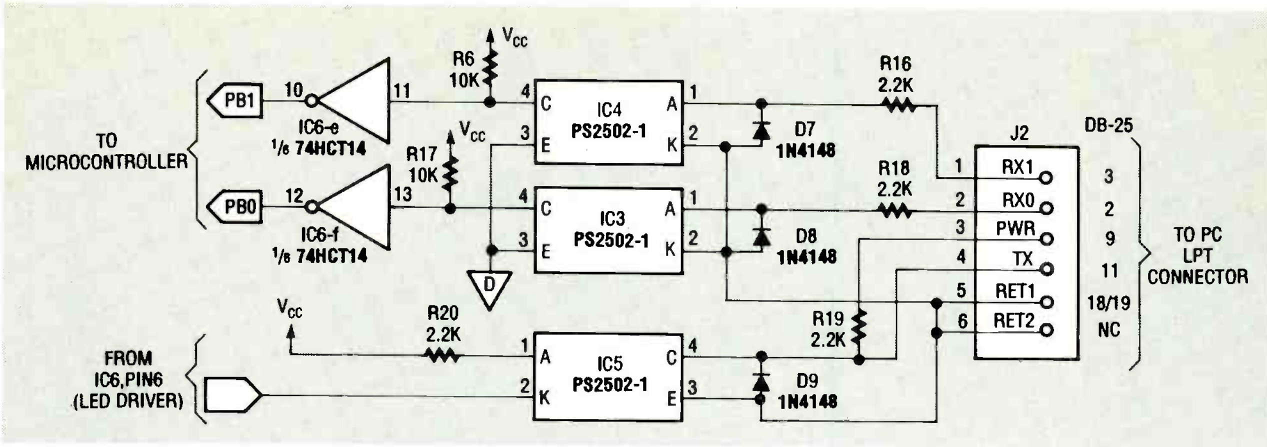


FIG. 6—PC INTERFACE CIRCUIT. Optoisolators IC3–IC5 provide electrical isolation between Ring-Thing and the attached PC.

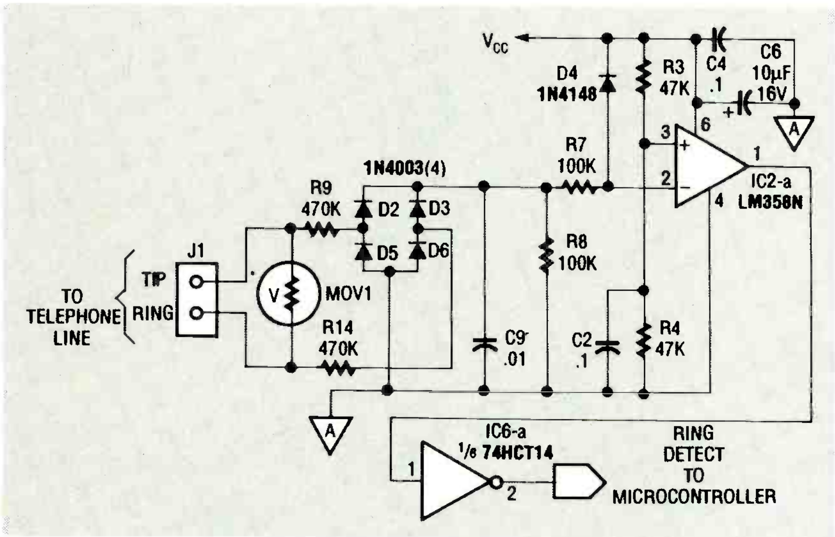


FIG. 7—THE TELEPHONE INTERFACE CIRCUIT senses the voltages present on the phone line.

provide electrical isolation between Ring-Thing and the attached PC. The Schmitt triggers in IC6-e and IC6-f condition the optoisolator outputs for the microcontroller. Diodes D7–D9 protect the optoisolators from reverse voltages that might occur if the interface were accidentally plugged into a PC's serial (RS-232) port.

Telephone interface

The telephone interface circuit, shown in Fig. 7, senses the voltages present on the phone line. A standard phone line sits at −48-volts DC when it is not in use (on-hook). When it is in use (off-hook), the nominal voltage is approximately −7-volts DC. While ringing, the phone receives a 90-volt 20-Hz AC signal. Because of the circuit's high input impedance (about 1 megohm), the phone line does not recognize that Ring-Thing is connected.

Surge absorber MOV1 protects against minor lightning strikes. Diodes D2, D3, D5, and D6 form a bridge rectifier and provide polarity protection. Op-amp IC2-a functions as a voltage comparator with a threshold reference of 2.5-volts DC, provided by the R3/R4 voltage divider. Resistors R9, R14, and R7 scale the rectified phone-line voltage by a factor of 1/10. Diode D4 limits the attenuated ring voltage present at IC2-a to safe levels. With the phone line on-hook, the input voltage at pin 2 of IC2-a is about 4.8-volts DC, which when compared with the 2.5-volt reference sets the op-amp's output (pin 1) high. Schmitt trigger IC6-a inverts that signal and feeds it to the microcontroller's active-low $\overline{\text{IRQ}}$ input (pin 4).

If the phone line goes off-hook, the input voltage at pin 2 of IC2-a drops to about 1 volt, which sets the output of IC2-a high. That, in turn, raises the output of IC6-a and triggers the microcontroller's interrupt input. If the phone is ringing, the output of IC6-a switches at the 20-Hz AC-ringing frequency. The microcontroller firmware can quickly determine whether the phone is ringing or simply off-hook.

DC supply and AC connections

Figures 8-*a*, 8-*b*, and 8-*c* show the DC power supply, AC transformer, and bypass capacitor wiring, respectively. The bypass capacitors in Fig. 8-*c* mount on the main board, as do the DC supply components in Fig. 8-*a*. The transformer and relay in Fig. 8-*b* mount on a separate board that installs inside the AC power strip. The main circuit board installs in a separate case.

The power supply (Fig. 8-*a*) provides several interesting features. Bridge BR1 rectifies the 12-volt AC input, which after filtering by C17 powers the switching relay. The unregulated DC voltage also drives IC8, which provides 5 volts for the digital circuitry. The regulator IC differs from most in that it has very low quiescent current drain, and operates with minimal input voltage. If AC power goes down while Ring-Thing is in operation, battery B1 can re-

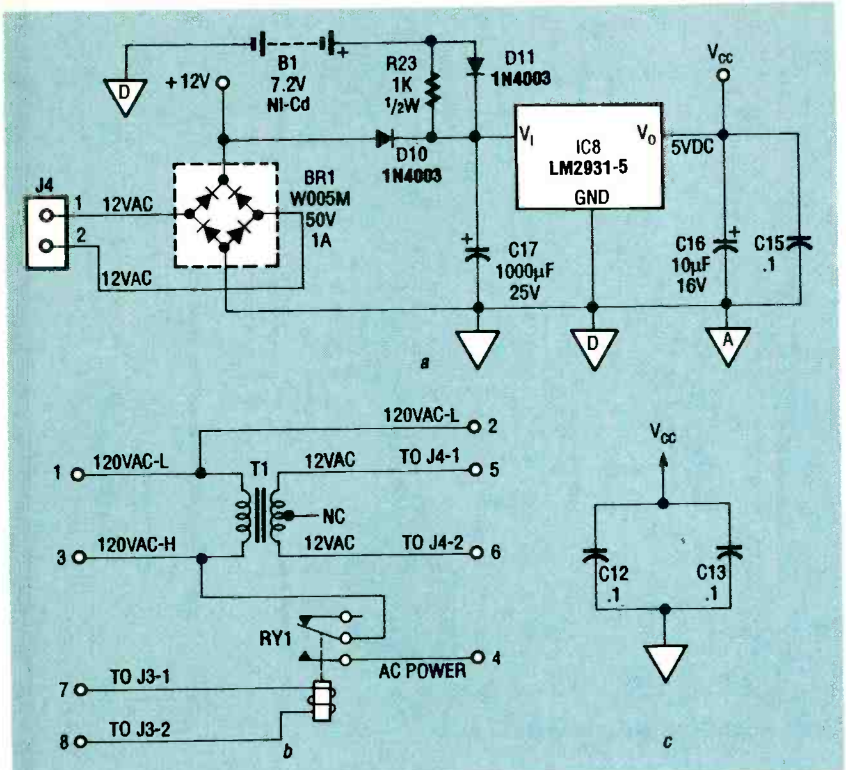


FIG. 8—SHOWN ARE THE DC POWER SUPPLY (*a*), AC transformer (*b*), and bypass capacitor wiring (*c*).

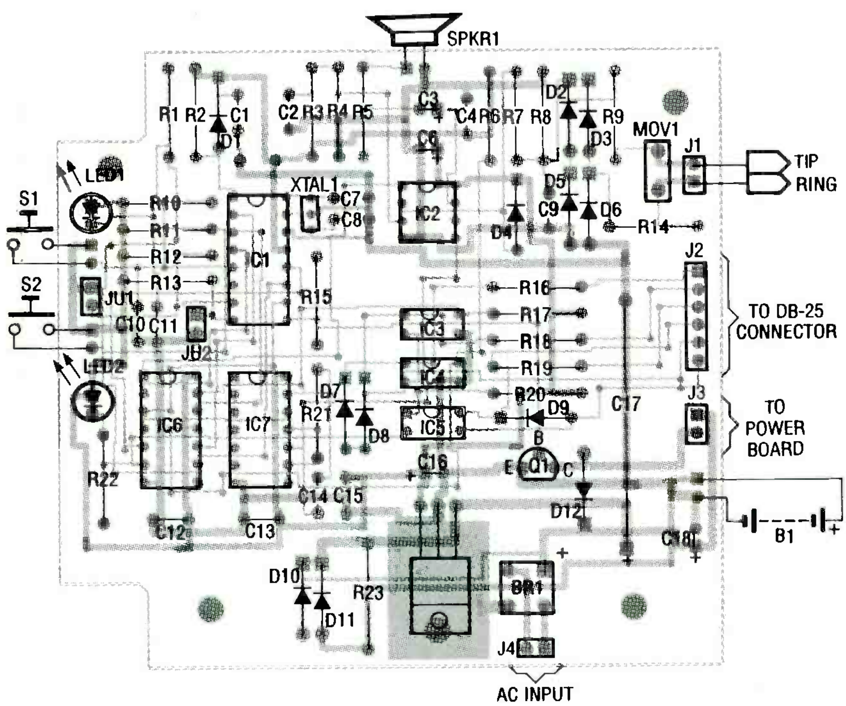


FIG. 9—PARTS-PLACEMENT DIAGRAM for the main board. If you do not want the PC power-down feature, do not install IC3–IC5, D7–D9, R16, R18–R20, and the DB-25 cable.

tain settings for about two hours. In general, all components were chosen carefully to minimize current drain and maximize battery life.

Diode D10 isolates the AC transformer during power failures, and steering diode D11 provides battery voltage to regulator IC8. Battery B1 is a rechargeable nickel-cadmium (Ni-Cd) type packaged like a traditional transistor-radio battery. It actually puts out 7.2–8.4 volts DC, which is more than adequate to drive the regulator. During AC operation, resistor R23 limits end-of-charge current to less than 5 milliamps. Note: *Do not install R23 if non-rechargeable batteries are used.*

Now that we understand how Ring-Thing works—let's put it together!

Construction

First a few general notes. Use a 25–47 watt soldering iron; temperature-controlled irons set at 700–800° work best. Use only 60/40 rosin core solder. Use the components shown in the Parts List; substitutions are not recommended. Be especially careful in selecting parts for the telephone interface—low-leakage components are a must! Read through all assembly instructions before beginning, and make sure you understand each step before continuing.

Component XTAL1 can be either a quartz crystal or a ceramic resonator. Delete C7 and C8 if you use a ceramic resonator with built-in capacitors. Use care in handling the IC's; they are static discharge-sensitive CMOS devices that can be damaged through mishan-

TABLE 4—POWER CABLE WIRING

Function	Jack/Pin No.	Cable Color
Relay power	J3/1	Red
Relay ground	J3/2	Black
12 VAC	J4/1	White
12 VAC	J4/2	Green

TABLE 5—POWER DOWN CABLE WIRING

J2 Pin No.	Cable Color	DB-25 Pin No.
1	White	3
2	Green	2
3	Red	9
4	Brown	11
5	Black	18+19

dling. Use high-quality sockets for all IC's, especially IC1 (the microcontroller).

Foil patterns for both PC boards have been provided; component-mounting diagrams for the main and power boards appear in Fig. 9 and Fig.

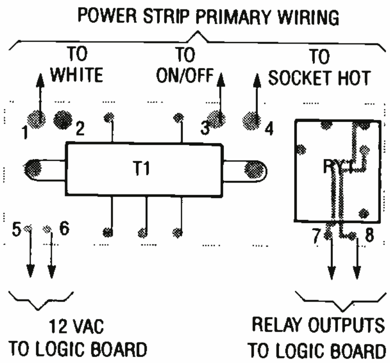


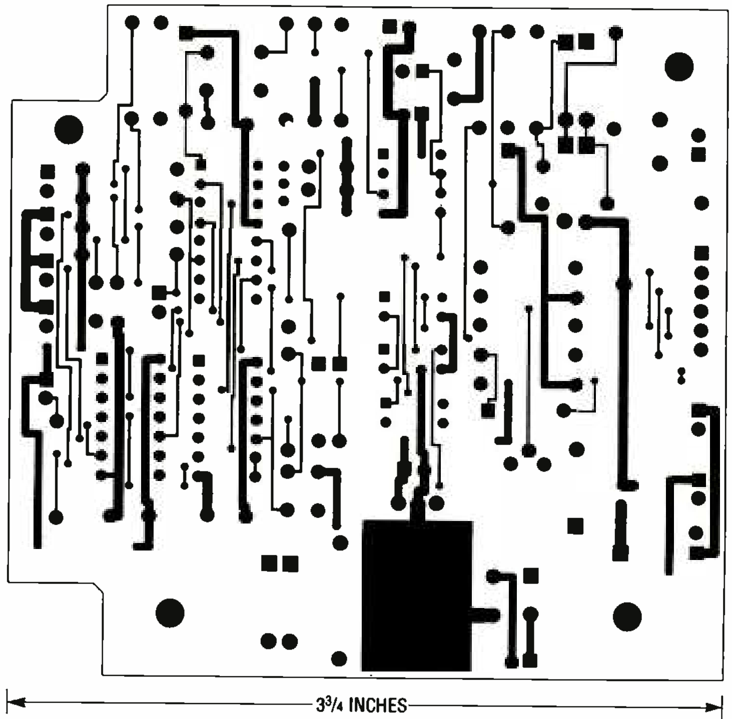
FIG. 10—PARTS-PLACEMENT diagram for the power supply board.

ORDERING INFORMATION

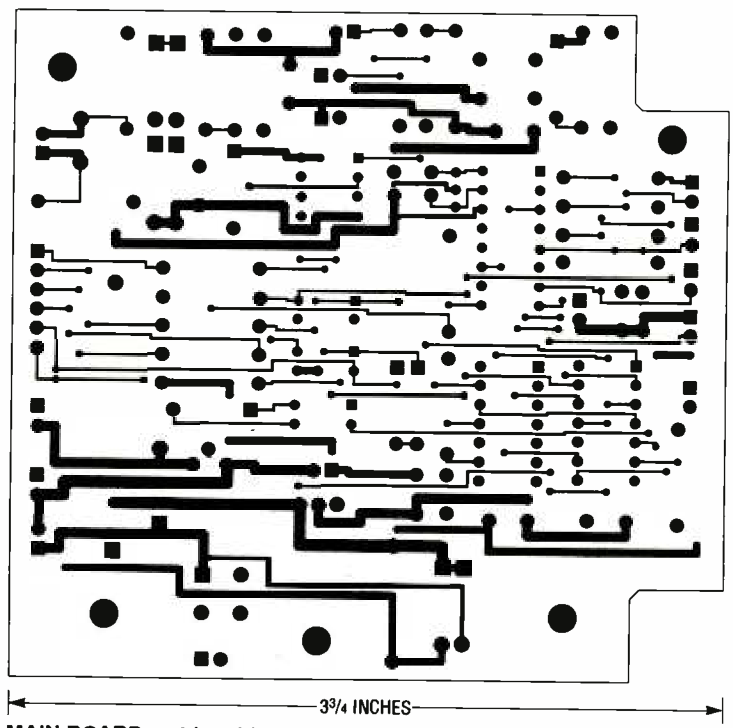
The following parts are available from Digital Products Company, Attn: Thomas E. Black, 134 Windstar Circle, Folsom, CA 95630, 24 hr phone/FAX: (916) 985-7219:

- Ring-Thing Kit (all components, programmed microcontroller, enclosure, PC board set, documentation (no PC power-down feature)—$79.95
- PC power-down kit (parts, DB25 cable, and software)—$9.95
- Basic kit (PC board set, microcontroller, transformer, relay, software, and documentation)—$59.95
- PC board set (#RT001)—$24.95
- Programmed MC68HC705K1 microcontroller—$14.50
- Six-outlet metal power strip with fuse kit—$16.00
- Rechargeable battery (9-volt Ni-Cd)—$7.00
- Documentation package with schematic—$4.75
- PC software (5-inch disk only, includes RT.EXE source)—$7.50

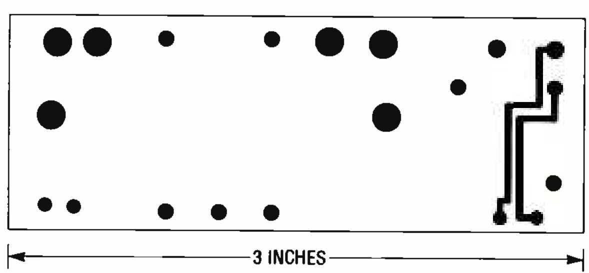
All orders add $4.50 S&H ($9.50 to Canada). CA residents add applicable sales tax. U.S. funds only. MasterCard and Visa accepted. Prices subject to change.



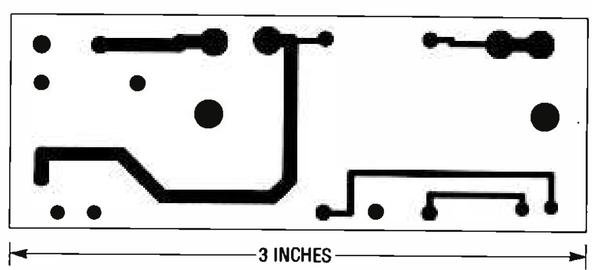
MAIN BOARD, component side.



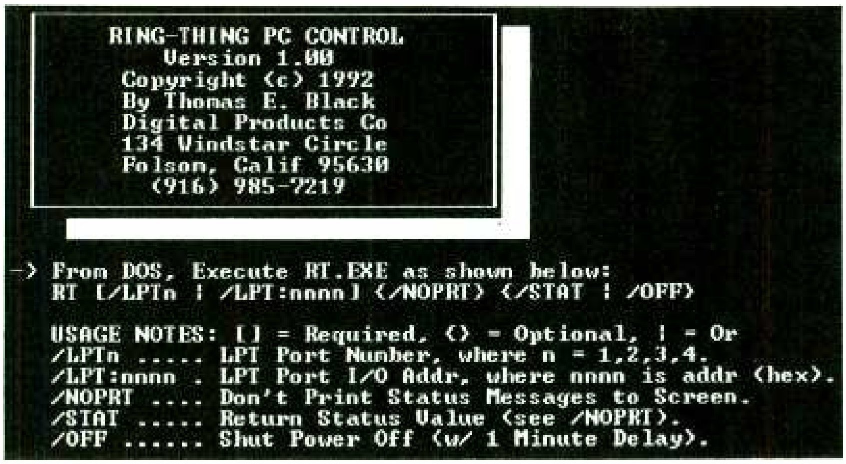
MAIN BOARD, solder side.



POWER-SUPPLY BOARD, component side.



POWER-SUPPLY BOARD, solder side.


RING-THING PC CONTROL
Version 1.00
Copyright (c) 1992
By Thomas E. Black
Digital Products Co
134 Windstar Circle
Folsom, Calif 95630
(916) 985-7219

-> From DOS, Execute RT.EXE as shown below:
RT [/LPTn | /LPT:nnnn] </NOPRT> </STAT | /OFF>

USAGE NOTES: [ ] = Required, <> = Optional, | = Or
/LPTn ..... LPT Port Number, where n = 1,2,3,4.
/LPT:nnnn . LPT Port I/O Addr, where nnnn is addr <hex>.
/NOPRT .... Don't Print Status Messages to Screen.
/STAT ..... Return Status Value <see /NOPRT>.
/OFF ...... Shut Power Off <w/ 1 Minute Delay>.

FIG. 11—THE SOFTWARE ACCEPTS command-line parameters to specify which LPT port and which I/O port you use, and a built-in help screen, shown here, that you can view by typing RT or RT /? at the DOS prompt.

10, respectively. Using those figures as a guide, mount all components. Note: *If you do not want the PC power-down feature, do not install IC3–IC5, D7–D9, R16, R18–R20, and the DB-25 cable.* Be sure to orient all the polarized components properly on the board.

Anchor the voltage regulator to the PC board with a 4-40 × ½″ machine screw. Install the main PC board in a small plastic enclosure with two machine screws mounted at opposite corners (it is not necessary to use all four screw locations).

By carefully bending the LED leads, you can insert them through the PC board and still have the bezel protrude through the front of the enclosure.

After mounting all components, trim any long component leads, and clean the flux off the circuit board, especially in the telephone interface area.

Install and label S1 and S2 on the enclosure's front panel. Check for proper clearance around the speaker, drill the vent holes, and then glue the speaker to the lid of the case.

Now make the external connections. Connect the Tip input of the telephone interface to the red wire and the Ring input to the green wire of the modular telephone cord. Solder the red and black leads of a snap-type battery holder to the appropriate inputs on the PC board. Be sure to observe correct polarity.

Drill two holes at the rear of the enclosure for the three cables: four-conductor power, modular telephone cord, and (optional) five-conductor PC power-down. Limit the cable length to seven feet each for best results.

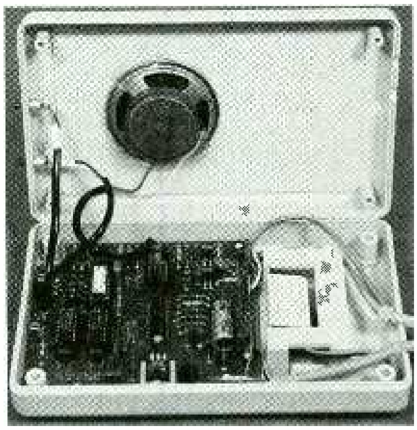


FIG. 12—HERE'S AN INTERNAL VIEW of the main board.

Wire the power cable to the main PC board as shown in Table 4. If you will use the PC power-down feature, wire a DB-25 male to the main PC board as shown in Table 5.

The power board mounts inside a common six-outlet power strip. Use a metal unit that is screwed (not riveted) together. For safety, remove the strip's 15-amp circuit breaker and replace it with a 6-amp fuse. The reduced current limit will provide greater protection for the power board's relay—and your computer equipment.

Carefully mount the PC board on plastic standoffs, and verify that no part of it contacts the power strip's conductive surfaces. For best results, install the board near the main power switch. Some power strips may require removal of one outlet to provide room for the PC board. If so, cover the opening with a blank plate.

TABLE 6—STATUS MESSAGES	
0	Abort: <message> (Usage Error)
1	Power is Off
2	Power is On
3	Power Fail: Power is <off/on>
4	Power is shutting Down
5	Auto Answer Mode
6	Unit Not Connected to PC
7	Unknown Status

Install the relay contacts in series with the hot side of the power strip's outlets by disconnecting the black 120-volt AC wire at the output of the switch. Then solder the free end to the power board at pad four. (Refer back to Fig. 3 for explicit wiring details.) The other end of the wire should still be connected to the outlets in the strip. You might want to replace the wire with an equivalent stranded wire to ease handling. Using 14-gage insulated wire, connect the power strip's 120-volt AC wiring to the power PC board. Drill a hole in the power strip near the PC board, mount a plastic strain relief, insert the four-conductor cable, and connect the ends referring to Fig. 3 and Table 4.

Double check all wiring to ensure accuracy. Any mistakes could be exciting—and dangerous—so use an ohmmeter to ensure that nothing is shorted. While you are at it, inspect the existing wiring for cold solder joints and look for loose screws (most power strips are poorly assembled). Last, reinstall the power strip's cover.

Now let's test the circuit. If any of the following tests do not give the as specified results, correct the problem before continuing. Note: *If troubleshooting is necessary you must use AC-isolated test equipment. Use battery-powered devices or an isolation transformer. Failure to do so will cause in-*

correct operation of the telephone-interface circuit.

LED and switch tests

1. Disconnect the line cord from your phone system. Plug a table lamp into the power strip as a test load.

2. Apply AC power and listen for a short beep. Verify that the table lamp is off.

3. Observe that LED1 (green) is flashing rapidly, and that LED2 (red) is flashing somewhat slower. This LED combination indicates that Ring-Thing has detected a power failure.

4. Press S1 (ON/STANDBY); you should hear a short modulated beep. Now LED1 should be blinking slowly, and LED2 should be off. Push S1 again; the modulated beep should sound, and LED1 should go out.

5. Press S2 (POWER ON/OFF); you should hear a short beep. Now LED2 should be on, and so should the table lamp. Hold S2 down; you should hear a beep, and both LED2 and the table lamp should go out. (Be sure to hold S2 for a moment; this push-and-hold requirement prevents power loss if the switch is bumped accidentally.

Power fail battery test

1. With AC power still applied, install Ni-Cd battery B1.

2. Turn LED1 back on by pressing S1. Disconnect AC power and verify that the green LED continues to blink.

3. Leave the battery in place and restore AC power.

Telephone interface tests

1. Unplug the table lamp from the power strip and plug in your computer.

2. Now plug the modular phone cord into a spare telephone jack or the back of your modem. Correct operation requires that you use a standard telephone line. Electronic keysets and PBX's are not compatible. If you can use a generic telephone or modem, Ring-Thing will probably work; if you use a special telephone set, Ring-Thing will probably not work correctly.

3. With the phone line connected, verify that LED1 blinks when a telephone is in use (off-hook), and that the LED lights steadily when the phone line is inactive.

4. Enable ring-counting mode by installing jumper JU1. Enable answer on one ring by removing jumper JU2.

5. Configure Ring-Thing as described above so that LED1 is on and LED2 is off.

6. Have someone call you and verify that Ring-Thing chirps and that LED1 flashes rapidly while the phone rings. Also, computer power should be enabled after the first ring, and LED2 should be blinking slowly to indicate ring-activated power.

7. Have the caller hang up and then do not use the phone. After about four minutes LED2 will flash rapidly, indicating that power will shut down shortly. With one minute remaining, a continuous warning tone will sound. After five or six minutes, computer power will turn off, warning beeps will cease, and LED2 will stop blinking.

If the phone line is placed off-hook during this step, the shutdown mode will be reset. In that case, merely wait an additional 5–6 minutes after the phone line becomes inactive.

Software usage

You can control Ring-Thing power via software. The software is available from the author and from the RE-BBS (516-293-2283, 1200/2400, 8N1). The file is called RINGTHNG.EXE; it is a self-extracting archive that contains source and object code for the PC control program, and object code for the firmware.

Create a directory for the software on your hard disk, put a copy of RINGTHNG.EXE there, and then run it. Several files will be extracted into the directory; READ.ME explains the purpose of each. The file called RT.EXE is the only one required to operate Ring-Thing. You may want to move it to a utilities directory.

Connect the DB-25 connector to a spare LPT port; you can use LPT1–4. The software accepts command-line parameters to specify which LPT port and which I/O port you use. The program has a built-in help screen, shown in Fig. 11, that you can view by typing RT or RT /? at the DOS prompt.

Note that the LPT port parameter is required whenever you communicate with Ring-Thing. For example, if you were connected to LPT2 and wanted to view current status, you would type: RT /LPT2 /STAT followed by the Enter key. Assuming a proper connection between Ring-Thing and your PC, you would see one of the messages listed in Table 6.

The numerical values in column one are ERRORLEVEL numbers returned by the program; your batch files can use these values to branch to appropriate routines. (See your DOS manual on how to use the IF statement to test ERRORLEVEL values.) Also, include the /NOPRT parameter before the /STAT switch to obtain ERRORLEVEL values without displaying screen messages.

Although the program is designed for PC (or compatible) operation, the C++ source code could easily be modified for other architectures. Or you could use it as the basis of your own custom application.

Power down test

1. Plug the DB-25 connector into your LPT1 printer port. (Any LPT port could be used, but for the first test, use LPT1.)

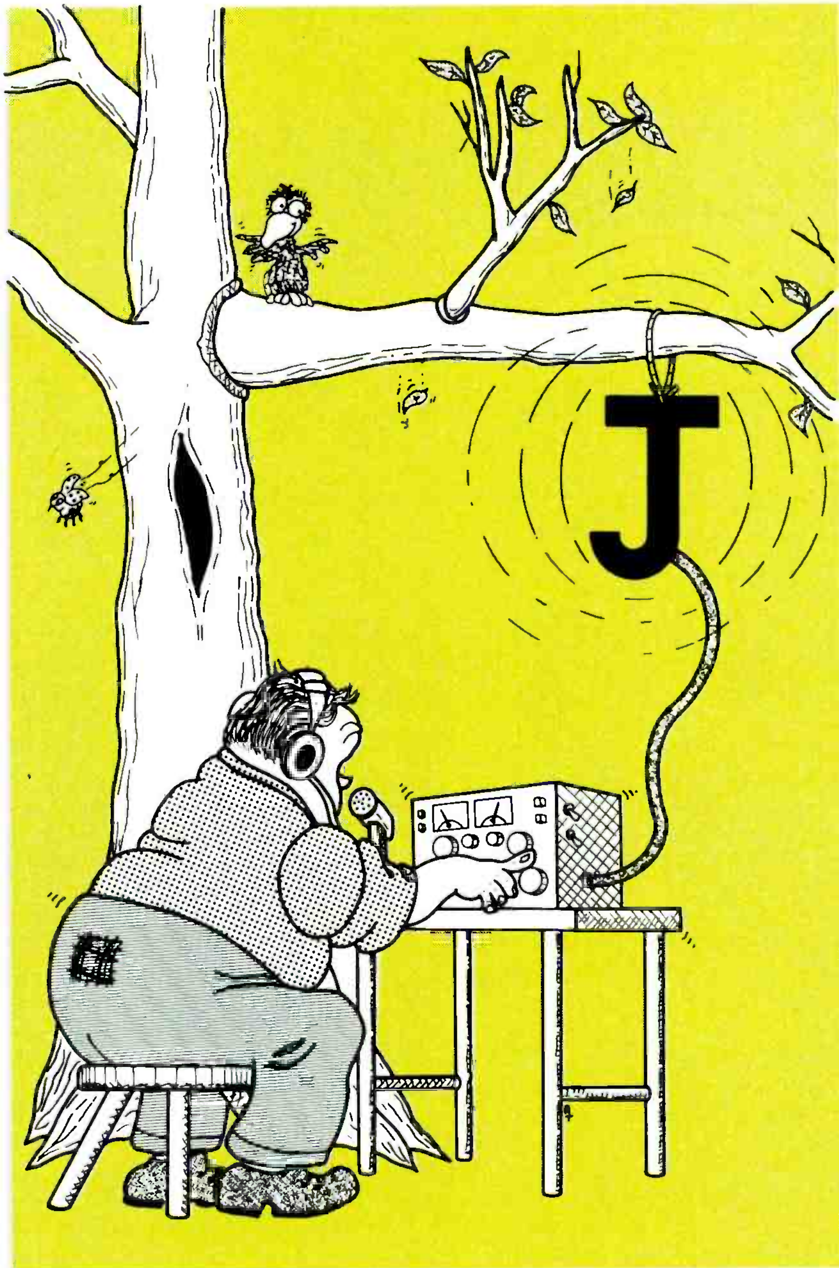
2. Turn on your computer by pushing S2.

3. Execute RT.EXE by typing RT /LPT1 /OFF·CS followed by pressing ENTER key.

4. You should immediately hear the one-minute warning beep, and LED2 should be flashing. After one minute the PC will shut off. To cancel the power-down, tap S2.

Final installation

Ring-Thing's handy AC power switch will let you place your tested unit in a convenient location. One recommended mounting arrangement uses velcro or double-sided tape to mount it to the side of your computer case or monitor. R-E



THE J-POLE ANTENNA

Build this simple, portable ¾-meter band antenna, and make working that band easier and more enjoyable.

PHIL SALAS

THE ¾-METER BAND IS BECOMING almost as popular as the 2-meter band among radio amateurs. A lot of 2-meter band projects have been published in books and magazines for the amateur radio enthusiast, but there is a definite shortage of projects that address the ¾-meter band.

This article describes the J-440, a very simple J-pole gain antenna for the 440 to 450 MHz band, that you can hang in just almost any convenient location for operation. The J-440 is a Hertz antenna that does not require grounding, and it can be made in a few minutes with simple tools from materials costing only a few pennies.

The J-pole antenna

What is a J-pole antenna? It is a popular form of Hertz antenna that can be hung from a window frame, a ceiling, or even a tree trunk—if you want to operate in the field. The J-pole provides higher gain than the ¼-wave whip antenna that is widely used on portable transceivers that operate in the 440 MHz amateur region.

The ¼-wave whip, a Marconi antenna, is really one-half of a half-wavelength antenna fed at its center, its low-impedance point. Although quite short in this band, it requires a ground plane or radials to provide the necessary reflected image to make it work.

By contrast, the J-pole antenna described here is an end-fed half-wave antenna that does not require a reflected image. At the high frequencies of the ¾-meter band, the antenna is only 17 ½-inches long, which makes it easy to move around. While the J-440 antenna is longer than the ¼-wave whip, it is also more efficient because of its higher radiation resistance.

The J-440's angle of radiation is lower than that of a quarter-wave whip antenna. Theoretically, there should be about a 2 decibel improvement in gain. However, you should be able to obtain better results because vertical whips on handheld transceivers are far from 100% efficient.

The J-440 antenna includes a half-wave antenna, and a quarter-wave section of transmission line coupled in series giving it the properties that make it useful as a tuned circuit. Neglecting losses, the impedances at each end of a half-

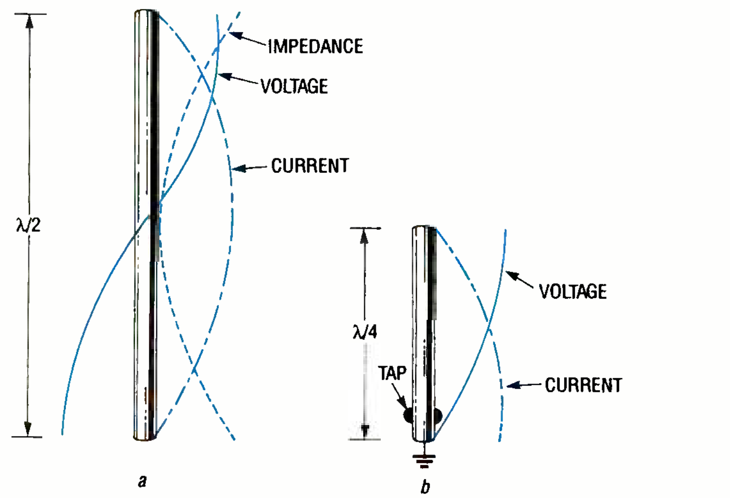


FIG. 1—HALF-WAVE HERTZ ANTENNA has high voltage (and impedance) but zero current at both ends (*a*), and shorted ¼-wave section has high voltage at one end and high current at the other (*b*).

wave transmission line are very high, as shown in Fig. 1-a. Therefore, a quarter-wave matching section is needed to transform that high impedance to a low impedance, preferably about 50 ohms.

A ¼-wave shorted transmission line, shown in Fig. 1-b, looks like an open circuit at its open end at the length corresponding to the desired frequency. At a point between the shorted and open ends of the transmission line, a low impedance point that provides an adequate match to 50-ohms can be found. Figure 2 illustrates what happens when to the voltage and current waveforms shown in Figs. 1-a and 1-b are connected in series.

Antenna construction

Figure 3 is a scaled drawing of the J-440 antenna made from readily available, low-cost, unshielded television lead-in cable. It consists of two parallel stranded No. 22 to 20 AWG copper conductors. Although three different styles are available with typical impedances of 300 ohms, the lowest-priced cable was selected. That cable has parallel stranded conductors covered and joined together with polyethylene insulation that forms both the jacket and spacer.

The *velocity factor* in transmission lines determines the difference between the *physical* length of the antenna and its *electrical* length. The velocity of wave travel along the antenna is less than it would be in free space. This has the effect of making the physical half wavelength *too long*. To compensate for this, the physical length of the antenna must be made shorter than the corresponding wavelength in free space. This is calculated by making use of known velocity factors.

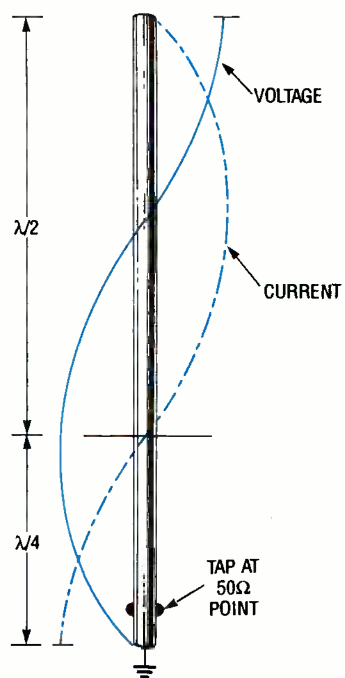


FIG. 2—HALF- AND QUARTER-WAVE antenna sections are combined to produce ¾-wave antenna matched to its transmission line.

The velocity factor for unin-sulated wire is 95%, while the velocity factor for 300-ohm TV lead-in cable is 85%. The upper ½-wave section has only a single active insulated wire so a velocity factor of 90% was used, but the 85% factor was used in calculating the length of the ¼-wave stub. The antenna length was determined as follows:

1. Wavelength = 300/f(MHz) meters = 300/446 MHz = 0.067 meter
0.067 meter × 39.37 inches/meter = 26.48 inches
2. ½-wave section length = wavelength/2 × velocity factor = 26.5/2 inches × 0.90 = 11.9 inches
3. ¼-wave matching section = wavelength/4 × velocity factor = 26.5/4 × 0.85 = 5.6 inches
4. Overall J-440 antenna length = 11.9 + 5.6 = 17.5 inches

The calculated 17.5-inch overall length provides the best

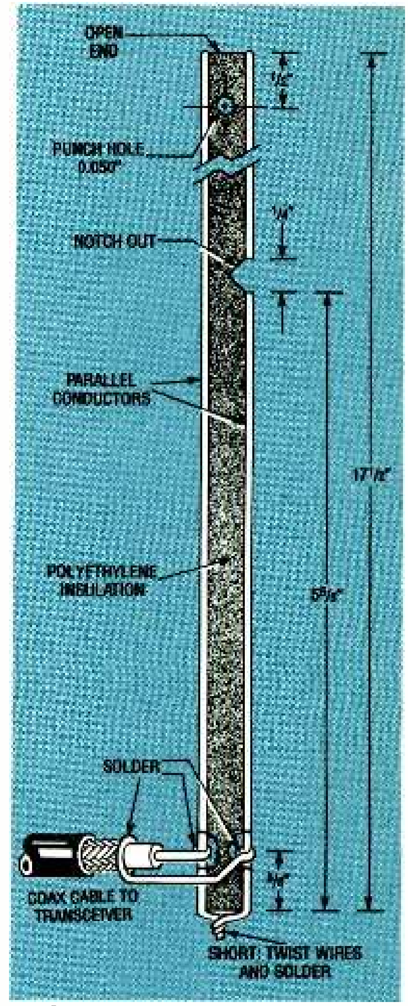


FIG. 3—J-ANTENNA IS EASILY MADE from a length of standard TV lead-in cable.

standing-wave ratio (SWR), the ratio of the maximum voltage or current to minimum voltage or current distribution. The author has built several of these antennas and has obtained favorable results with each. Therefore, you can cut the cables to the dimensions shown in Fig. 3, and be certain that your antenna will work well in the ¾-meter band.

Before cutting the cable to length, strip approximately an inch of insulation from both lead-in cable conductors on one end. Twist the bare wires together to form a short, solder the joint, and trim off the excess wire. The optimum 50-ohm tap point was found to be ⅝-inch up from the short. Carefully trim back the insulation around both conductors at that point.

Strip the end of the coaxial cable to your transceiver about ½ inch, and make one turn of the center conductor of the coax around one lead of the TV cable. Then connect the coax shield to the other twin lead conductor with a short length of wire as shown in Fig. 3. Solder both connections and trim off any excess wire.

Notch out a ¼-inch section of the lead-in cable 5 ⅝ inch up from the shorted end, as shown. This ¼-wave matching section also doubles as a 1:1 balanced-to-unbalanced transformer (or balun). Punch a hole with a diameter of about 0.050-inch in the polyethylene webbing between the conductors about ½-inch from the open end of the cable. This permits the antenna to be hung from a convenient hook or tied up with a nylon cord for operating either indoors or out-of-doors.

The standing-wave ratio was measured on several antennas made to the dimensions shown in Fig. 3. The measured SWR's at three different frequencies were found to be: 1.5 @ 442 MHz, 1.25 @ 446MHz, and 1.40 @ 449MHz

These measurements verified that the lowest standing-wave ratios were obtained at 446 MHz, which is the middle of the ¾-meter band. **R-E**

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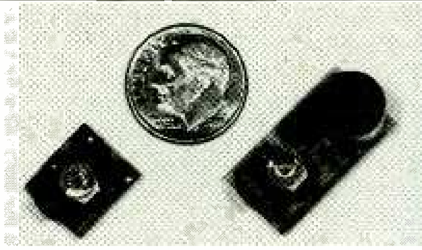

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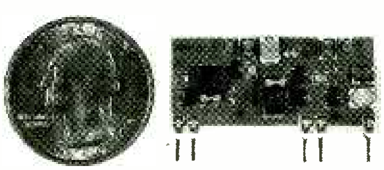

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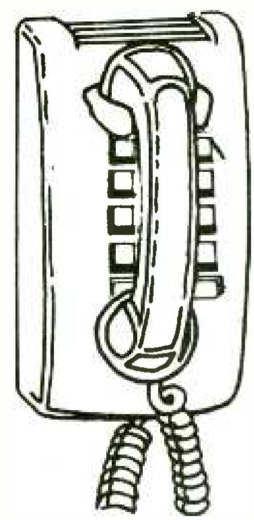

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Relaxation oscillators, Newtek's Video Toaster, broadcast trade journals, synchronizing video sources, and electronic-discharge machining.

DON LANCASTER

This month, we seem to have a pair of really exciting new opportunities from opposite ends of the broad hardware-hacking spectrum. Before we begin, though, our usual reminder that you can pick up technical help, consultant referrals, and off-the-wall networking by calling me per the box below—or by accessing our superb *GEnie* PSRT, which has just seen its 40,000th library download. You can voice call my (800) 638-9636 number for connect information.

Let's start off with...

Newtek's video toaster

Tim Jenison recently sent me one of his *Newtek* Video Toasters to play with. What follows is just some of my preliminary impressions and random comments, rather than a thorough or unbiased review.

The Video Toaster is basically an Amiga computer with some special software, a plug-in card, and several extra jacks on the back. At a street cost of $2000 (card only) or $4000–$5300 (a full slow or fast system), the Video Toaster can replace something like $100,000 worth of real broadcast-quality video postproduction editing equipment. It doesn't imitate; it replaces outright, or even totally blows away.

In theory, you can now produce total broadcast-quality videotapes cheaply and quickly in your own home. The genlocking and switching abilities of the Video Toaster seem to be three years or so ahead of anything Mac-based, and eons beyond anything based on an IBM or PC platform.

The Video Toaster's performance is absolutely and totally stunning. But let's knock it anyway, just so you are sure what you are getting into.

First, if you just want to slap some titles or computer art onto any old home video, the virtually unknown $129 *Apple II Video Overlay card* is much cheaper, surprisingly powerful, and vastly easier to use. *A2 Central* is one remaining source of the card.

Second, you can't simply drop this beast down on your kitchen table. An *entire room* dedicated *exclusively* to the Video Toaster is your minimum possible workspace. Although quite compact by itself, the toaster often will attract bulky and expensive high-tech goodies like a huge magnet.

Third, plain old VHS is not suitable for *any* serious production or editing. Period. One big reason is the *generation loss* effects because copies simply are not as good as an original. Another is the inability of the user to selectively edit a single frame. An ability to write a single frame is essential for any animated sequence. Many of the Toaster's more exotic features are definitely not VHS compatible. No way.

Yes, you can handle fairly fancy production with the latest Super-VHS or Hi-8 equipment. But if you're the least bit serious about creating a commercially marketable product, a minimum of *Sony Betacam* should be used for your taping and editing.

Fourth, by the time you pick up a "real" camera or two, a "real" VCR or two, the three quality color monitors required, the two time-base correctors demanded for the VCR's, the station synching genlock, an extra AC circuit breaker, your storyboards, and some support furniture, your price for the toaster itself seems insignificant by comparison.

Fifth, the Toaster does not address any audio mixing or processing. It simply passes the audio on from input tape to output tape. There's a kind of unbalance here, since the toaster does so much so well on the video tracks. Yet it almost completely ignores the audio side.

Finally, the Toaster has a very steep learning curve. Bunches of time and effort are required to do the job right. Just because your toaster *potentially* can do full broadcast quality work doesn't mean that you still can't create totally and utterly atrocious results.

So, what is in the box?

Figure 1 shows a typical Toaster configuration. The toaster card and software consist of nine very fancy subsystems. These are the *switcher*, *keyer*, *framestore*, *chroma FX processor*, *digital video effects*, *character generator*, *ToasterPaint drawing program*, *Lightwave 3D* modeling program, and the *genlock*.

The production switcher forms the heart of the system. There are three buses, called the *program* bus (which is your *current* output), the *preview* bus (which often will be your *future* output), and the *overlay* bus (which can determine how your preview and future outputs will be combined).

Each bus can be connected to seven different sources, either manually or by software. The sources include four live video inputs, two still picture frames, and a background color.

Say you want to switch from live video to a color title screen. To do

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an instantaneous switch, you would put the live video on the program bus, the title art on the preview bus, and press the *take* button. To do a manual gradual fade, there's a large mouse-controlled "T" handle which lets you gradually shift between the two. There's also lots of pre-programmed wipes and fades available, which can be controlled either manually or automatically in three speeds. Plus you can write your own font software or use third-party effects.

It gets complicated from there, but you can easily do picture-in-picture, and pretty much every other special effect that you'll see on a network or cable program. Full animation is certainly possible, but *only* when you use those video formats and control hardware that let you do single-frame writes under exact control.

The luminance keyer lets you put live action over a fixed background. As a selected "white" or "black" level is tripped, your switcher instantly changes between the action and the background. The frame grabber does what you would expect: it freezes an instant of live video for future use—except that it actually grabs *four* fields at once. That is needed because there are two fields per frame and two frames used for the NTSC color-phase sequence. A number of options are available to remove any blurring or motion in any particular field.

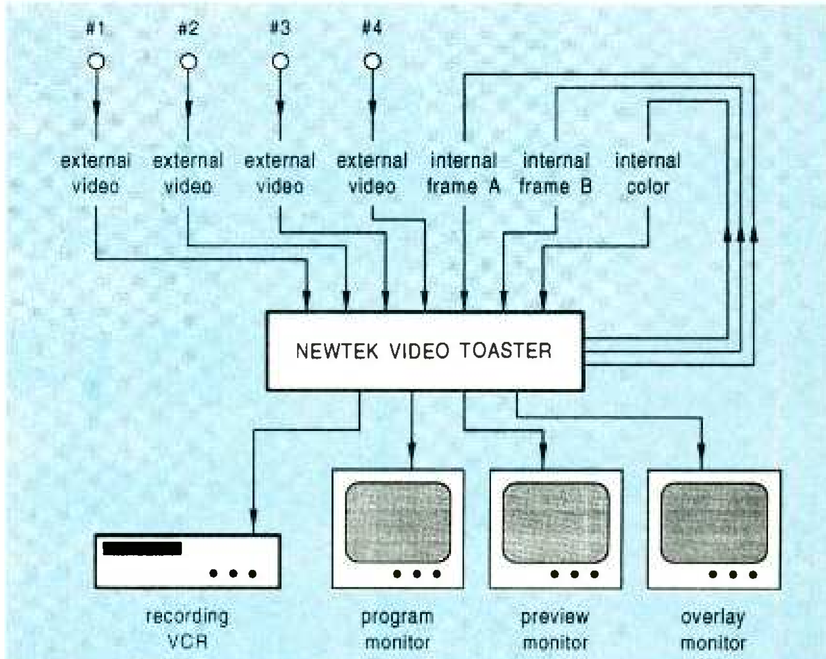

FIG. 1—NEWTEK'S VIDEO TOASTER 2.0 can cheaply replace as much as $100,000 worth of video editing and post-production equipment, while still offering full network broadcast quality. Best results are obtained with fancier video formats that allow single frame writes.

The chroma FX processor lets you do all sorts of neat color stuff, while the digital video effects give you lots of wowie-gees like sliding, spinning, zooming, or a spherical mapping—all of which are software programmable. The key to all those effects is the processor's ability to reach into RAM and address it in a non-obvious manner.

The character generator can place messages on your screen. It offers some very fancy special effects such as glitter, highlights, chromes, and drop shadows.

ToasterPaint is a powerful drawing program, while Lightwave 3-D is a sophisticated image-rendering and animation system. Once again, actual animation is useful only on the video standards and support hardware that allow single-frame writes. Animation sequences can be up to 120 frames, or four seconds long.

Ah yes, that genlock. When you take any old pair of video sources and try to switch between them, you will get a horrible and useless glitch. The only way around this is to make sure that *each* of your video sources is carefully locked to the *exact* same timing. An exact lock means that all horizontal lines must start precisely at the same instant and last exactly the same time. Color phase on all the lines must precisely match. The vertical synchronization pulses must be precisely aligned. And finally, those four NTSC color-phase fields must be precisely positioned in the correct time sequence.

Now, *if* you have *one* live video camera source or *one* off-the-air live video broadcast, your toaster will automatically lock all of its effects. Genlock here will be no problem. But if *any other combination* of sources is used, careful thought must be given to the way genlocking is done.

Most VCR's introduce a second big problem, even if you are only using one of them. Mechanical differences, alignment changes, and tape stretch will slightly but continuously jitter the timing obtained from a prerecorded source. A twenty-nanosecond error is noticeable.

To clean up the output from any

recorder, one or two steps might be needed. A *Timebase Corrector* (TBC) simply eliminates jitter. If you are using *one* recorder as your *only* video source, then a plain old TBC will suffice. On the other hand, if you are using two or more video sources, your recorder output will have to be routed through a much fancier combination TBC and *frame synchronizer*.

Typical low-end TBC's are the *Digital Processing* VT-2000 and the *Iden* TR-7. Fancier TBC/synchronizer devices include the *Hotronic AP41* and the *Iden IVT-7*. The typical street pricing ranges from $750 to $1600. With widely expanding world markets, it's likely that those prices will soon drop dramatically.

Grass Valley Group and *Ikegama* offer full broadcast-quality switchers, synchronizers and correctors, but these are not cheap.

At any rate, if you want to use multiple video sources, you pick your best source and use it for the *station sync*. Additional sources that accept external synchronization can be cable-connected to the station sync source. Sources that cannot be externally synchronized have to go to their own TBC/synchronizers, which in turn are cable-connected to your station sync.

Figure 2 shows a typical synchronization hookup. Remember that *all* recorders *must* be time-base corrected, and that *only one* source is allowed to provide station sync. All other sources must be locked.

What's wrong with it?

While the current 2.0 version of the Video Toaster is a stupendous product, I believe this product could be further improved. First off, a true Mac-based version is a must. Commodore might have a temporary and illusory lead on genlocking, but the Mac color-image generation and editing has long ago passed up the Amiga (and everybody else). Obvious examples of these include Pixar's *Renderman*, Apple's own *QuickTime* and Adobe's *Photoshop*.

Newtek's new *Mac Desktop Video Gateway* is a good first step toward full Mac compatibility.

Speaking of Adobe, some toaster compatibility with its PostScript language and its *Carousel* offspring sure would be useful. PostScript is ideal for most video artwork, either regular or animated. While the public domain *GhostScript* (now available cheaply on my *Genie* PSRT) could be used immediately, a genuine Adobe Display PostScript is the best choice. PostScript type I and type III fonts are incomparably better than the current crop of

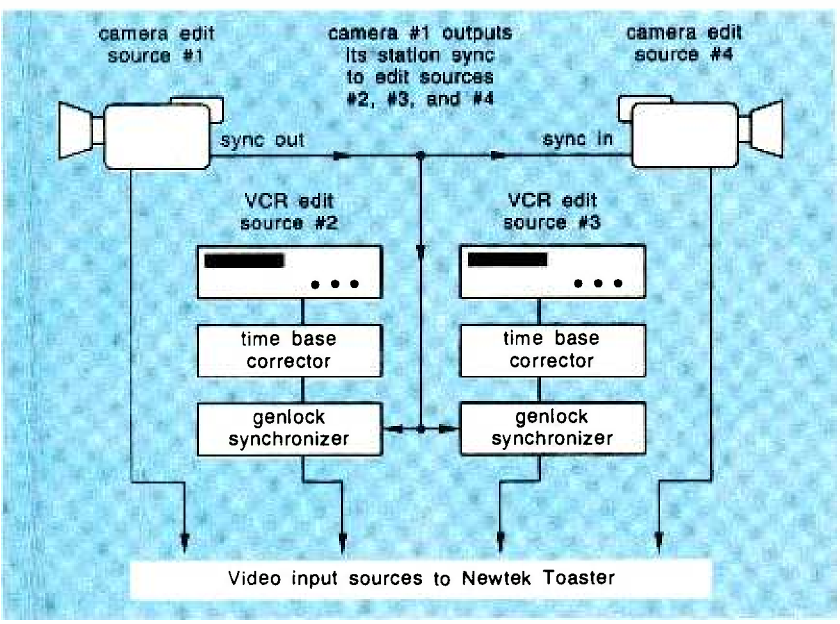

FIG. 2—AS WITH ANY VIDEO EDITING SETUP, all input VCR's must be time-base corrected, and all input video sources must be carefully synchronized together. This arrangement uses Camera no. 1 for your station sync.

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toaster characters.

Full compatibility with Kodak's new *PhotoCD* technology is also a must. As are better audio processing; full support for wavelet, fractal, and the MPEG compression options; and improved time-code use.

Their Toaster would be even more useful if some other technical improvements could be made such as a method to effectively single-frame edit plain old VHS. Or getting true read/write CD ROM out of the starting gate. Or speeding up a CD ROM access by a hundred or more. Probably the best way to do this is with the use of multiple heads and some sort of holographic sensing. Orange or (sigh) blue laser diodes would also help considerably with their shorter wavelengths and higher densities. As would a giant two-port buffer.

The price of time-base correctors and synchronizers also has to drop bunches. But that will surely happen as this market expands. We also need a newer *GoVideo*-like product with multiple genlocked and single-frame writable recorders, all in one low-cost system package.

Also needed are lots of improved "on the fly" techniques similar to an instant replay. That's where a full minute of RAM-based video could be instantly synchronized with, and then real-time overlaid to *any* video format.

Who needs it?

Judging by the number of people who immediately piled up on my doorstep on the mere *rumor* that I was getting a Video Toaster, pretty near anybody. In fact, your chances are good that "Wanna play with my toaster?" is now the number one singles-bar pickup line.

Its amazing who your friends are.

Let's see who was in the pile. Phil runs the alternate cable service here, and is about to offer ultra-cheap local ads. Diane is the public information officer (a.k.a. the directorate of the ministry of propaganda) for a federal bureaucracy. Henry now consults for a university multimedia department. Craig is a timber-management type. Kathy is big into theater arts. Bee is into how-to papermaking. Irene sells weaving and loom stuff.

Boyd shoots rodeo events. Dan is heavy on his computer servicing. Jeff now publishes a high-tech magazine. And Chris is shooting sprinler-hookup videos for the fire department. Myra is now busy networking all her regional bed and breakfasts. Mike is editing down his UFO stuff. Jay has been making a big flap in avian raptor research. Also birds. Keith is the honcho of a large regional rent-a-vid chain. And I am now producing PostScript intro videos.

To get started with the Newtek Video Toaster, first get a copy of the mind-blowing free video demo, either by calling them or circling the bingo card. Newtek also has an outstanding tech support helpline. One of many retail toaster sources is *B & H Video*, that also stocks TBC cards.

The leading magazine is *Video Toaster User*, while *Coffee and Toast* is an interactive video service. One source for toaster fonts is *Kara Computer Graphics*, while public domain disks of toaster effects are available at $6 each from *Timmins/ Kingsway*.

Two associates of mine who offer custom video editing work and post production include Limel Schneiker of *HDS Systems* (for Mac based apps) and Boyd Bairn of *Rodeo Video* (for Sony Betacam).

More on this whenever.

Electric-discharge machining

EDM, otherwise known as *spark machining*, has held a rather obscure corner in the odd world of industrial electronics. But EDM has recently moved out of the toolroom and onto the production floor. There's nothing inherently expensive or complicated about EDM. It has some great new hacker potential. Especially since it lends itself so well to CAD/CAM and computer control.

Figure 3 shows you the basic idea. You place a *workpiece* of metal to be machined in a pan filled with a normally recirculating and insulating dielectric fluid. While kerosene was originally used, deionized water with a polymer resin is more popular today. You then bring a tool close to *but not touching* your workpiece and then discharge a capacitor between the two—which creates an arc.

The arc vaporizes some of the dielectric, and blasts a crater out of the workpiece, creating a liquid-metal puddle. After the arc ceases, the puddle solidifies and the circulating dielectric washes the dregs away. The "dirty" electrolyte is then filtered and recycled for reuse.

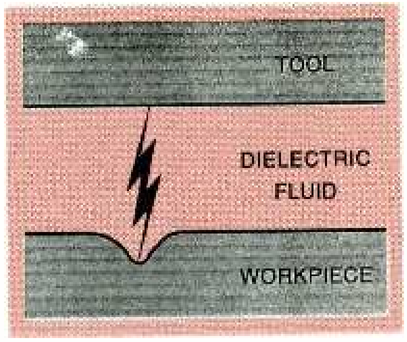

FIG. 3—ELECTRIC DISCHARGE machining uses a spark to blast craters out of a workpiece. The dielectric fluid washes the dregs away after each spark. Surprisingly, sub mil accuracies and microinch finishes are easily and cheaply obtainable. The trick is to use lots of sparks and tiny craters.

The process is repeated zillions of times. The next arriving arc strikes somewhere else, since the crater just increased the average spacing. As the workpiece erodes, the tool can be lowered. Eventually, the workpiece will assume the exact shape of the tool. Servo controls can sense the spark intensity and control the descent rate, making sure that optimum spacing between a tool and workpiece is maintained.

Although spark machining sounds rather crude, EDM can easily do ultra-smooth microinch machining with accuracies to a fraction of a mil.

Figure 4 shows several popular variations. With *die sinking EDM*, a master pattern is "pushed" into the workpiece. The tool can be exceedingly complex and virtually any shape as long as there are no undercuts. *Wire EDM* works like a bandsaw. You start with a supply reel of brass or other wire above your work and have a take-up reel below the work. The wire speed is adjusted so that the wire will erode and be "used up" at an acceptable rate. Wires are typically from two to ten mils in diameter.

With *small-hole EDM*, tiny holes can be "drilled" very deeply and very accurately. An obvious use for small-hole EDM is drilling pilot holes in the workpiece to start an internal path wire for the EDM machining process.

Finally, a *metal disintegrator* is a coarser EDM process which uses a vibrating electrode and an arc welder to blast some holes into your workpiece. Important uses for this process are the removal of snapped studs, stuck taps, or broken drills.

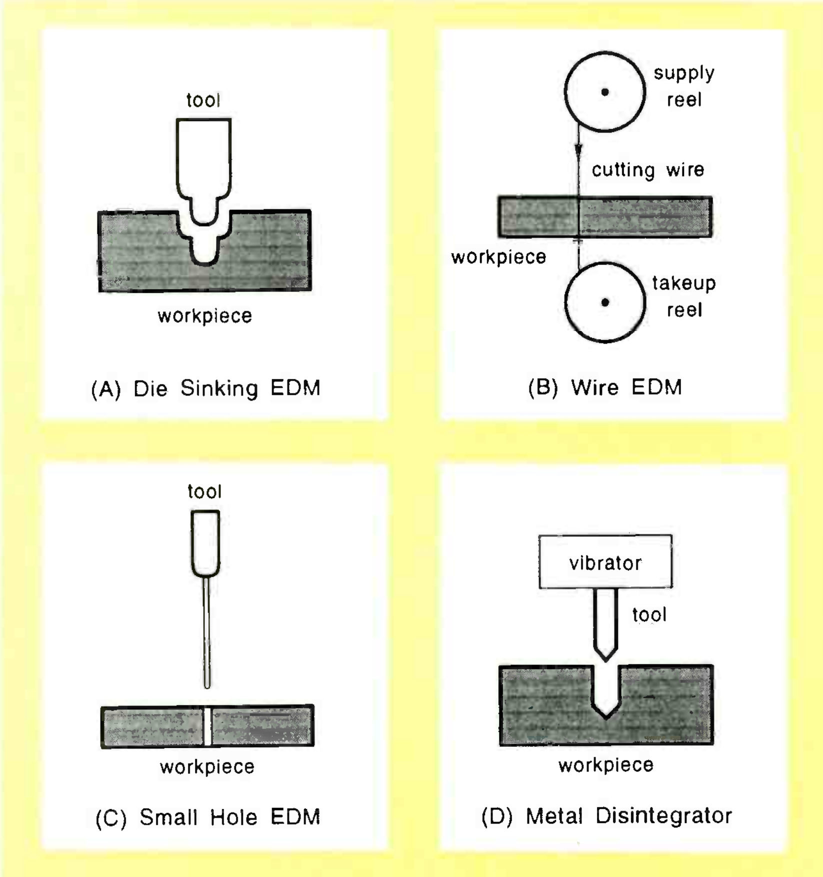

FIG. 4—FOUR POPULAR VARIATIONS on Electrical Discharge Machining.

There are several unique advantages to EDM. The tool can be much softer than the workpiece, so you can now routinely use brass, copper, or carbon to cut up hardened steel, titanium, or carbide alloys. Ideally, there is no tool contact, so there is no friction, chatter, or side loading.

By choosing the correct discharge polarity, the workpiece erodes much faster than your tool. Since you can now temper or harden the workpiece *before* you start to machine it, the final results are more accurate.

Those EDM tool paths can be very complex. You can easily perform such tricks as "drilling" a deep and blind square hole that has sharp bottom corners. With wire EDM, a punch and a die can be *simultaneously* cut from a single piece of steel, guaranteeing a perfect fit with exact clearances between the two pieces.

The disadvantages to EDM? Both the tool and your workpiece must be conductors. Tool life is fairly short. And the machining rates are rather slow, say a cubic inch an hour for die sinking, or thirty square inches per hour for wire EDM. Thus,

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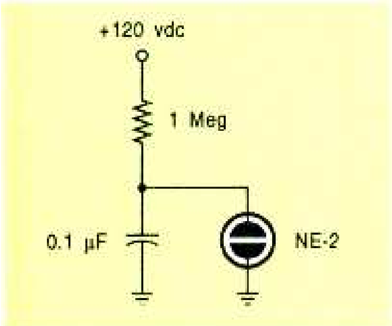

FIG. 5—THE CLASSIC NEON LAMP micropower relaxation oscillator. The lamp flashes several times a second. Some EDM circuits have a much faster and far more powerful version of this circuit, substituting the tool spark gap for the neon gas breakdown.

a job might take overnight, even using stacked work and multiple heads. But this easily automated process can be done largely unattended.

The voltages and currents needed are not excessive. Since your arc is less than a mil long, 80 volts or so is all you usually need. Typical EDM power requirements are several kilowatts. Or roughly the same as those for operating a larger milling machine or lathe.

Spark repetition rates for EDM are usually 20,000 to 500,000 sparks per second.

Most EDM circuits are a variation of the simple *relaxation oscillator*. Sort of a big brother to the neon-lamp flasher circuit we have shown in Fig. 5.

In any relaxation oscillator, a capacitor will slowly charge up to its critical voltage which breaks down the capacitor's dielectric and turns on some nonlinear switch (e.g. creates a gas plasma or a spark gap).

The capacitor normally continues discharging at a high current rate until it drops below a current threshold. At that point, gas deionizes or the spark quits, and the capacitor is free to once again begin recharging again. The cycle then repeats.

Typical EDM capacitors are in the 50-microfarad region. The value of the capacitor determines the size for each spark crater, thus trading off surface smoothness against cutting time. High-quality capacitors with a low ESR (equivalent series resistance) are an absolute must. Electrolytics are a no-no.

In modern EDM, triacs or other electronic switches can speed up and improve the operation of the simple relaxation oscillator. But the idea is still the same. Charge a capacitor to its breakdown voltage. Then discharge the capacitor into the spark gap. Repeat the cycle over and over again. Spark times and duty cycles are adjustable over wide ranges.

As our resource sidebar for this month, I've gathered together the names of places to go for more information on EDM. The leading trade journal on the subject is called *EDM Today*, while ads and articles occasionally show up in *American Machinist* and *Metalfax*. In addition to all the other great machinery and home shop books, *Lindsay Publications* offers a *Practice and Theory of Electrochemical Machining*, and the *Ramah Machines Metal Disintegrator*. Several other resources listed give a random sampling of prominent manufacturers and distributors for EDM equipment.

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New tech lit

There's loads of interesting new chips piling up. Particularly the *Aria* sound circuits from *Sierra*, or the new TMC22190 digital video layering engine, and the TMC22070 genlocking video digitizer from TRW.

A multimedia stereo audio mixer applications note is now offered by *Analog Devices*.

The *Black Book Official Auction Report* is like a car blue book for shop machinery. It also lists bunches of auction houses likely to conduct electronic auctions.

A great cable and television station tabloid technical magazine is *TV Technology*. Among other stuff, it's got lots of ads for toaster support products. A similar publication for commercial radio stations is called *Radio World*.

For all the fundamentals of digital integrated circuits, be sure to check into my *TTL Cookbook* and *CMOS Cookbook*. Autographed copies are available as per my nearby *Synergetics* ad. And my NUTS10.PS on *GEnie* PSRT offers a brand new tutorial on *PostScript for Hardware Hackers*.

Our new *Synergetics Consultant's Network* is also now up and running. Do give me a call at (602) 428-4073 if you want to participate in this, or need any information on any other technical topic. Let's hear from you. **R-E**

A PLL circuit will help us generate missing horizontal sync pulses.

ROBERT GROSSBLATT

Once upon a time, when gated sync was the last word in video signal scrambling, it was relatively easy to descramble the system there were two constants you could count on. The first was that the missing horizontal sync pulses were recoverable from information that was buried elsewhere in the RF signal. The second, more subtle, constant was that the horizontal sync pulses were always missing from each line of video.

The SSAVI system makes this part of the descrambling process a bit more difficult.

As we've discussed over the last couple of months, the horizontal sync pulse in the SSAVI system is considerably sneakier than in any previous scrambling technique. In any given field of video, the pulses can be absent or at the wrong levels. They could be present, although the chances of that are small. The only constant is that the horizontal pulses will be there during the vertical interval—and that's while the electron beam is off the screen.

Given all that, the job us is to come up with some way to generate horizontal pulses only when they're needed. Not only that, but we have to be sure that the pulses we create are placed correctly on each line, and are produced at the exact same rate as the horizontal frequency of the incoming scrambled video signal. This sounds like an insurmountable design problem but, in fact, it's not really that difficult. The key to the design is the use of a phase-locked loop, or PLL.

The phase-locked is one of the most useful subcircuits, and one of the most underused as well. Back in prehistory, when dinosaurs roamed the earth and the IC hadn't been invented, the design of phase-locked loops was a real pain in the neck. They were complete circuits in themselves, and several people were usually required to complete the designs. That changed completely with the introduction of IC's in general, and the CMOS family in particular.

Before we get into the details of how a phase-locked loop circuit is going to solve our sync problem, it's worth spending a few minutes on the basics of phase-locked loops. Since this is such an important part of our total circuit, it's impossible to understand how the descrambler works without a foundation in the theory of phase-locked loops.

The basic components of a standard phase-locked loop are shown in Fig. 1. There are two basic parts: the first is an input conditioning circuit that cleans up the signal applied to the phase detector, and the second is a local oscillator whose frequency is determined by a control voltage. That part is usually referred to as a voltage-controlled oscillator (VCO) or voltage-to-frequency converter.

The output of the VCO is compared to the input frequency, and the phase detector generates an error voltage that's proportional to the difference between the two frequencies. The error voltage controls the frequency of the VCO, and the result is that the VCO's output is always in-phase—or synchronized, if you prefer that term—with the input frequency.

By setting the VCO's base frequency to some multiple of the input frequency, we can have the counter/divider chop the VCO frequency down to the input frequency and keep the VCO in sync with the input, even though the frequencies aren't the same. So, PLL's let us easily multiply frequencies, build filters, and—more to our point—keep signals in sync.

Phase-locked loops are basic building blocks in circuit design, and it's well worth your time to learn as much as possible about them. I might spend more time on them in the future, but at the moment my only interest is how they can be used in descramblers. I strongly urge all of you out there to read about, experiment with, and build PLL circuits. There's a lot of good information around regarding phase-locked loops and a good deal of it comes from the semiconductor

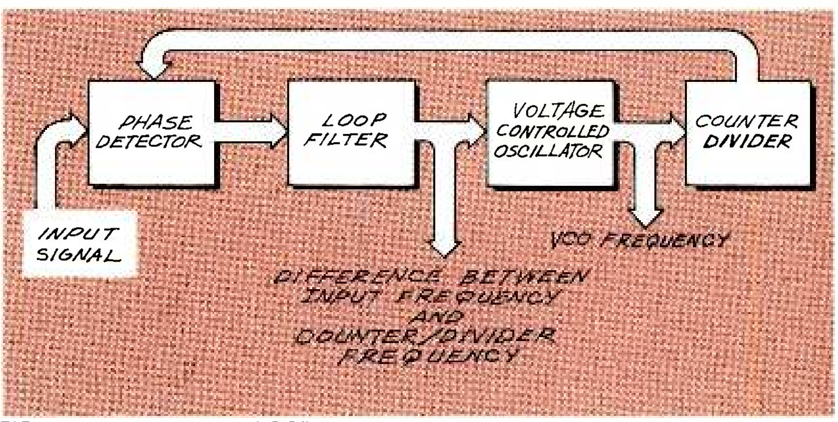

FIG. 1—PHASE-LOCKED LOOP BLOCK DIAGRAM. The two basic parts of a phase-locked loop are the input conditioning circuit and the voltage-controlled oscillator.

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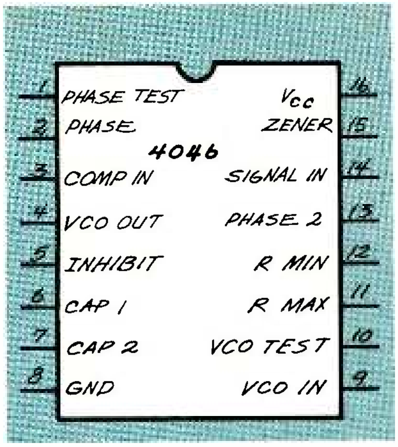

FIG. 2—PINOUT DIAGRAM for the tried-and-true 4046 PLL.

manufacturers themselves. I know that Signetics has a whole data book devoted to phase-locked loops. Give them a call (408-991-2000) and find out how you can get a copy of their "Phase Locked Loop Handbook." While it's not really the kind of reading that will keep you up at night, it's a very good source of information.

The phase-locked loop we'll be using is the old tried-and-true 4046. The pinout for the chip is shown in Fig. 2, and a block diagram of the chip is shown in Fig. 3. The frequency of the VCO is determined by RC constant of the resistors at pins 11 and 12, and the capacitor between pins 6 and 7. A second factor affecting the VCO is the control, or error voltage on pin 9.

The VCO will stay in sync with the input frequency that's applied to pin 14. If you put a divider circuit between the VCO output on pin 4 and the comparator input on pin 3, the VCO frequency will be the input frequency multiplied by whatever value you're using for the division.

There are lots of things to watch out for when you're designing a circuit around a 4046, or any PLL for that matter, but we're more interested in the application than the theory. I'll leave the theory for another column—and by that time you'll have gotten the data books and learned a lot about phase-locked loop theory on your own. Right?

In our descrambler, the PLL is the perfect solution for solving the horizontal sync problem. Remember that the only time we can be sure of receiving transmitted sync pulses is during the vertical-blanking interval. The question we had to answer is how any circuit could "know" when to generate a horizontal sync pulse if there's nothing that can be used as a reference. The way to make that happen is to do a couple of creative things with a PLL. To start off with, the 4046 setup we need is shown in Fig. 4.

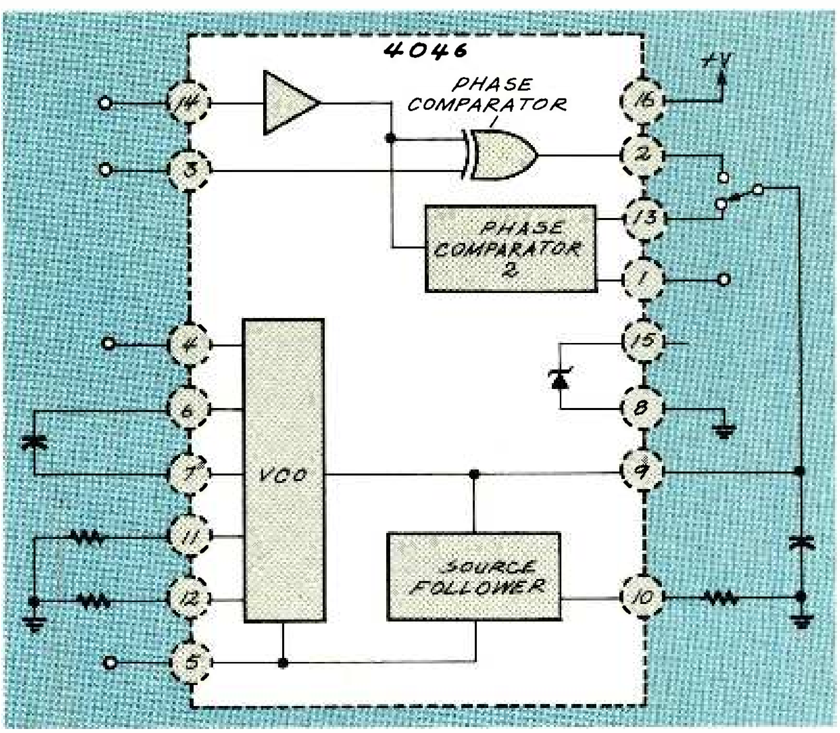

FIG. 3—4046 BLOCK DIAGRAM. The frequency of the VCO is determined by the resistors at pins 11 and 12, the capacitor between pins 6 and 7, and the control voltage on pin 9.

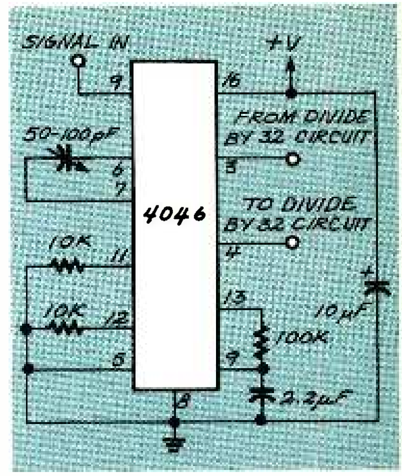

FIG. 4—4046 PLL SETUP. The VCO base frequency is set at 504 kHz, which is the horizontal scan rate (15750 Hz) multiplied by 32.

The VCO base frequency is set at 504 kHz. That frequency is an even multiple of the standard horizontal scan rate (15,750 Hz × 32). During the vertical interval, we get 26 usable horizontal sync pulses from the broadcast signal. When line 27 comes along, the picture starts and the horizontal sync is missing. But because the VCO is still running, the divider produces a horizontal sync signal anyway. The pulse is fed back to the input video amplifier and injected into the video signal so that line 27 is displayed correctly on the TV.

The artificially generated sync signal is then split from the video signal by the sync-separator circuit and routed to the PLL. The 4046 has no way of knowing that the sync pulse isn't a "real" one, so it treats it exactly the same as one obtained from the television broadcaster. This kind of self-bootstrap operation continues for the rest of the video frame until the next vertical interval is reached, when the whole thing starts all over again.

As you can see, the success of this whole scheme depends completely on the stability of the VCO in the phase-locked loop. In fact, while that might seem to be a real concern, it's really much less of a problem than you might think. I'm not

continued on page 90

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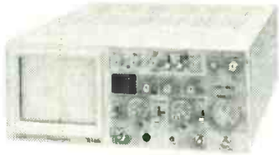

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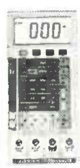

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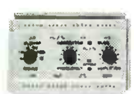

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LETTERS

continued from page 18

controversial and apparently misunderstood subject.

First, I have read the advertisements for diskette punches that supposedly turn a *double-density disk* into a *high-density disk* by forming a second hole in the disk's protective shell. I cringe whenever I see those ads because they usually claim that there is no difference between the two diskettes—at least in terms of media.

That notion is pure hogwwash! It comes from those people who will profit from selling those punches to the unwary consumer. Unfortunately, they will work in some cases, but that can result in dire consequences. So, buyer beware!

The data-storage capacity of a diskette is a function of two variables: track spacing or density per unit area, and bit density per unit length of track. While track density is identical in the two formats—approximately 135 tracks per inch—the problem lies in bit density.

The high-density diskette track packs exactly twice the number of bits (magnetic pulses) as the double-density track, which means it stores twice as much data. This can be confusing until you learn that the double-density disk was so named because it holds twice as much data as a *single-density disk*—not a high-density disk. Single -density disks are rare these days, particularly in the 3½-inch size.

Q&A noted correctly that many drives have an internal optical sensor to distinguish between the two disk formats. The presence of that sensor will prevent the user from accidentally inserting the wrong format, which would cause data errors. Unfortunately, IBM did not include that kind of sensor in some of its drives, which puts the burden of inserting the disk with the correct format on the user.

How can a diskette permit reliable doubling of its bit density per unit of track length? Simply stated, that variable is controlled by the thickness of the magnetic material and its composition. Thinner coating thickness permits higher bit density.

Unlike common 5¼-inch diskettes, the magnetic material thickness on both of the 3½-inch diskette formats is about the same—40 to 50 microinches. A 40-microinch coating thickness was the minimum practical limit for the production equipment in use when the 3½-inch diskettes were introduced. That equipment was not suitable for making the coating any thinner, so product yields would have suffered from "dropouts" if it had been used, and disks would have been useless for systems requiring error-free media.

As a result, when faced with the challenge of doubling the disk's capacity, designers relied primarily on changing the composition of the magnetic coating. Therefore, the significant difference between the two disk formats is in their magnetic coating. The magnetic particles in double-density disks have a coercivity of about 600 oersteds. (An oersted is a unit of magnetic field strength, and coercivity is the magnetic field strength required to reduce the flux density of fully saturated magnetic material to zero.) By contrast, high-density diskettes have magnetic particles that measure about 720 oersteds.

If a disk is fully magnetized in one direction, an opposing magnetic field is required to demagnetize the media. The magnitude of that field is the disk's coercivity. The higher the coercivity, the higher the magnetic energy that is required from the recording head to magnetize or demagnetize the media. Also, the higher the coercivity, the greater the bit density per track (within limits).

The 3½-inch drive's magnetic read/write heads had to be redesigned to accommodate the increased recording currents and data rate (frequency) of the high-density format.

Why does punching a second hole (to fool the drive's sensor), and formatting the 600-oersted disk to a 720-oersted capacity often work? The answer is that because the diskettes have similar media thickness and coercivity, the latest disk drives (designed to work with a reasonable tolerance) can't always discriminate between them.

Although hole punching might work initially, you might find out later that your data can't be recovered from the diskette. This is especially true when data is written on one drive and read with another.

Moreover, as you continue to "overwrite" previously recorded data, you are likely to encounter read errors and lost data. Because a disk can be formatted with no errors, you do not have a guarantee that it will work reliably. That is the purpose of the analog certification test. If a disk passes that test you are assured a reasonable expectation that the disk will operate error-free throughout its life.

I do not recommend cross-formatting diskettes—unless you just don't care if your programs and data are lost! If you do choose to cross format, at least be aware of the risks involved. Despite what you might have read in some unscrupulous ads, disk suppliers have not conspired to cheat the consumer.

BRAD BAKER
President, Accurite Technologies Inc.
San Jose, CA

COMPUTER CONNECTIONS

Video computing

JEFF HOLTZMAN

Video computing is *the* hottest area of development right now. Last month I presented an overview of some of the issues involved, and discussed one of the more robust solutions, Intel's Digital Video Interactive (DVI). Until very recently, DVI was only available in expensive, proprietary board sets. By the time you read this, Intel and Microsoft will have introduced a software-only version of DVI, made possible by the widespread proliferation of low-cost high-powered CPU's (486's and 68040's).

Software approaches

Generally speaking, all data-compression algorithms are software-based. However, the software approaches discussed here typically use a general-purpose CPU (i.e., the system's 80x86 or 680x0) for processing, rather than a special-purpose chip or board set.

Two names that crop up frequently are JPEG and MPEG, acronyms for Joint Photographic Experts Group and Motion Picture Experts Group, respectively. Both groups are sponsored by the International Standards Organization (ISO), which gives their algorithms broader appeal than proprietary ones like DVI. Both JPEG and MPEG are lossy, which means that some data is thrown away. The advantage of that is much higher compression ratios than with lossless algorithms.

MPEG provides two-dimensional, spatial, or intra-frame compression. MPEG provides temporal or inter-frame compression, in which only the part of each frame changed relative to the preceding frame is stored. The advantage is higher compression, but random access becomes more difficult and less efficient. MPEG has just emerged from the standardizing process; it deals only with video data; MPEG-II is on the way; it deals with synchronized audio and video data.

M-JPEG (Motion JPEG) is a kind of hybrid that compresses a series of JPEG frames without regard for common contents among adjacent frames. JPEG is coming into common use in the desktop publishing community for compressing single-frame images. M-JPEG and MPEG have been implemented only by a few vendors (including Intel on its DVI board set), but broad support is yet to come.

Another important compression algorithm is $p \times 64$, also known as CCITT recommendation H.261. The *p* represents a parameter that specifies some multiple of a 64-kilobit data rate; that use stems from high-speed T1 telephone lines, which consist of 24 64-kilobit channels. When p gets up to about 6 (i.e., there is a 384K bit rate), fairly respectable motion video is possible. The $p \times 64$ algorithm standard is fairly well supported in the videoconferencing market, although major providers there (PictureTel and Compression Labs) also exploit proprietary algorithms.

More immediately relevant to the personal-computer industry are commercially available compression technologies that include Apple's QuickTime, introduced in December, 1991, and Microsoft's Video for Windows, slated for release by the time you read this. QuickTime is actually more than just a compression algorithm; it includes compression technology, file formats, system software, and user-interface guidelines. The compression technology includes four types: JPEG (for photos), animation (for low frame-rate computer-generated images), video (providing 15 frame/second software-only decompression at a resolution of 160 × 120 pixels), and graphics (similar to video, but higher compression and slower playback). An updated version, QuickTime 1.5, doubles both resolution and frame rate; the latter, however, is achievable only on very high-end Mac computers (Quadra 900's and 950's). Version 1.5 also supports Kodak's Photo CD (discussed here in the December 1992 column).

QuickTime is important because it was the first software-only video-delivery system available for desktop computers. It is a native part of the Macintosh system software, hence is available via a documented API to any application. And, as usual, pioneering editing tools were available on the Mac first. Also, Apple has demonstrated, and is scheduled to release soon, a Windows-based QuickTime player, reportedly by the end of 1992.

Like QuickTime, Video for Windows includes several compression algorithms—a derivative of DVI is a very important one. Last summer, Asymetrix, (a company that sells a slick Windows-based object-oriented programming environment and authoring tool called ToolBook), released a CD-ROM containing a soft-video demo, in which several company officers present their visions of the multimedia industry. Click on a small snapshot (about ¼ of a standard VGA screen), and talking heads come to life. Both audio and video tracks came directly from the CD. The audio was perfect, but audio-video synchronization was not. Sync should be better in the final version of the product. The important point is that the demo indicates a trend. There is something magical about seeing motion video on a computer screen.

Conclusions

Poorly synced soft video reminds me of CGA graphics in the early 1980's. Lack of resolution and color depth appear almost laughable in today's light; nonetheless, CGA represented a start. Recent acceleration in the evolution of CPU and memory technology means that video computing won't take as long to reach prime time as did high-resolution graphics.

But we're not there yet. The question is: Will users accept software-based—or even hardware-assisted—DVI-level video? Not in the long run. Right now, anything that puts motion video on a computer screen falls in the category of novelty. But the lack of quality will become apparent, and people will demand more. Remember how FM superseded AM, and FM stereo supplanted FM; how stereo overcame mono recordings; how CD's overcame LP's; how color TV overcame black and white; and how HDTV is likely to render obsolete NTSC. The real question is not if but when video computing will become widespread.

Until then, anyone with a 386-, 68030-, or better based computer can enjoy software-only video. The effect is startling at first, but the lack of synchronization between audio and video tracks, not to mention the extremely small images sizes, clearly add up to an interim solution. Now the industry has taken the all-important first step. But the media-integration game is not over yet. Not by a long shot.

Product watch

I've run across several nice accessories and utility programs recently. The Writer's Toolkit is a Windows application that squeezes a grammar checker and six reference works into about 6.5 megabytes of disk space. The works include the American Heritage Electronic Dictionary, the Dictionary of Common Knowledge, Roget's Electronic Thesaurus, the Concise Columbia Dictionary of Quotations, an abbreviation program, and an online grammar and style reference. Writer's Toolkit comes on ten floppy diskettes, and though no match for a CD-based work like Microsoft's

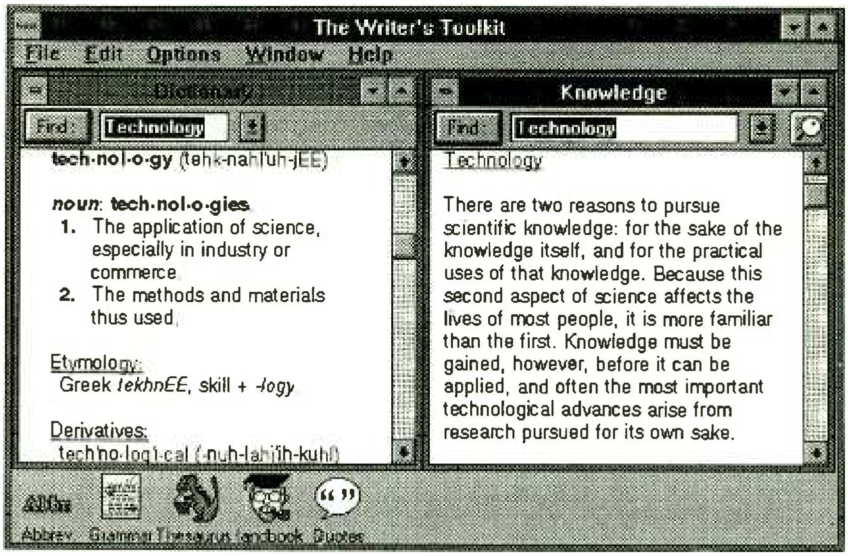


FIG. 1—THE WRITER'S TOOLKIT includes six reference works and a grammar checker. CD-ROMless writers will find it indispensable.

Bookshelf, manages to cram a lot of useful information into very little space. You can bring up each reference work in a separate window, and even synchronize look-ups among windows (whatever you look up in one window is also looked up in all open windows, as shown in Fig. 1). One nice feature is that you can cut and paste information from the package and directly into your word processor. My main complaint is with the grammar and style guide, which is hard to use and is not well indexed. If you're Windows-based, do a lot of writing, and have no CD-ROM, the Writer's Toolkit is a worthwhile addition to your hard disk.

The Supra V.32bis FAXModem is Hayes compatible, runs at bit rates as fast as 14.4K, has V.42bis data compression and error correction, and also includes a 14.4K fax. The external model is about ⅔ the size of a standard modem, and has a two-character status display in addition to several status LED's. DOS and Windows bundles are available; the Windows package includes a "lite" version of WinFax pro, which installs as a Windows print driver and allows you to fax documents directly from the source application, complete with fonts and graphics. The most intriguing feature of the Supra is its upgradability to voice processing and caller ID, unreleased as of press time. The modem lists for $399.

The NotePort from Kodiak Technology is an external Ethernet adapter that connects via a standard parallel port. The device has a pass-through printer port, both 10Base-T and BNC connectors, and a built-in power supply (i.e., no bulky wall transformer). Drivers are available for Netware, Vines, and Lantastic, and high-performance drivers for bidirectional parallel ports are also available.

I tested the NotePort on a Lantastic network, and learned several interesting things in the process. The NotePort driver requires the latest version of Lantastic (4.1), and it must be the Adapter Independent (AI) version. The regular version runs only on Artisoft's Network Interface Cards (NIC's); the AI version runs on all popular cards. So I upgraded my network to Version 4.1, and obtained a single-user license for an AI node. I tested the NotePort on several machines, with varying results. It worked just fine on an AST Premium 286, but would not work on an IBM PS/2 model 70. The driver simply refused to recognize the parallel port, and the company had no explanation for that behavior as of press time.

I downloaded the NotePort and Lantastic drivers with LapLink to a Zeos PalmTop PC (discussed here last time), and got the drivers to work just fine. However, the PalmTop PC has no free drive letters, and it boots from a ROM-based CONFIG.SYS with no LASTDRIVE statement, so I couldn't map any network drives to the machine, although test software indicated that the drivers were running just fine. However, Quarterdeck Office System's 386 memory manager QEMM includes a program that allows you to alter the LASTDRIV setting from the DOS command line. I added several drive letters, and was soon accessing the network via the PalmTop PC and the NotePort. Sweet. All in all, the NotePort is an elegant solution for making notebook and other temporary Ethernet connections. It lists for $399.

HiJaak for Windows is the long-awaited Windows version of one of the best screen-capture, format-conversion, and image-manipulation utilities around. If you've ever fought and lost the conversion battle among multiple flavors of TIFF, PCX, BMP, GIF, and other file formats, you need a copy of HiJaak. Enough said.

News bits

The Microelectronics and Computer Technology Corporation, together with eleven major corporations (including Kaleida, Apple, Kodak, Philips, Bellcore, US West, Corning, among others) has launched the most ambitious effort so far to provide interactive multimedia services to a general consumer market. The idea is to define a network infrastructure based on telephone, cable-TV, and upcoming fiber-optic cabling, then figure out applications that will use the infrastructure. The project is called First Cities. Watch this one.

TI has introduced a digital signal processor (DSP) that spells the beginning of the end for dedicated fax, modem, sound synthesis, speech-recognition, and image-compression chips. TI will sell the chips to OEM's, and is expected to introduce PC expansion cards based on it in early 1993. A $150 board will include 8- and 16-bit MPC audio, audio compression, a text-to-speech converter, JPEG image compression, Sound Blaster compatibility, and MIDI and joystick ports. A $350 board with microphone and headset will include V.32 modem, Group III fax, and intelligent telephone-answering capabilities.

RESOURCES

- SupraFAXModem ($399), Supra Corp., 7101 Supra Drive S.W., Albany, OR 97321. (503) 967-2400.
CIRCLE 41 ON FREE INFORMATION CARD
- NotePort ($399), Kodiak Technology, 1338 Ridder Park Drive, San Jose, CA 95131. (408) 441-6900.
CIRCLE 42 ON FREE INFORMATION CARD
- Hijaak for Windows ($249), Inset Systems, 71 Commerce Drive, Brookfield, CT 06804-3405. (800) 828-8088, (203) 740-2400.
CIRCLE 43 ON FREE INFORMATION CARD
- Writer's Toolkit ($129), Systems Compatibility Corporation, 401 N. Wabash, Suite 600, Chicago, IL 60611. (312) 329-0700.
CIRCLE 44 ON FREE INFORMATION CARD
- Lantastic, Artisoft, Inc., 691 East River Road, Tucson, AZ 85704. (800) TINY-RAM, (602) 293-4000.
CIRCLE 45 ON FREE INFORMATION CARD

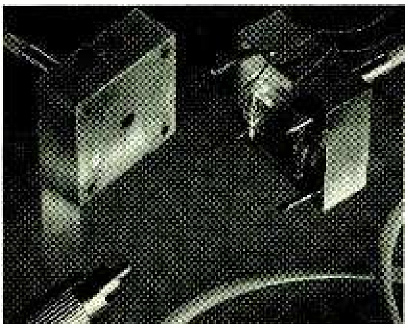
Intel finally named the next-generation x86, aka the P5, aka the 80586: It will be called Pentium, because it is the fifth in the series (8086, 80286, 80386, 80486). (Yes there is an 80186, but it has the 8086 CPU core.) The name-for-number switch was done to protect Intel from cloners, who found it easy to bury x86 somewhere in their part numbers. The chip itself, however, remains unreleased; Intel now estimates delivery in the first quarter of 1993. There are also strong hints that the company will release a Pentium Jr. that will plug into the overdrive socket built on recent 486 motherboards.

Intel also announced a 486SL microprocessor, which includes 3.3-volt operation, 486SX compatibility, and power-saving features. The latter are accessible via a System Management Interrupt (SMI), which puts the chip into a System Management Mode (SMM). That in turn provides a different address space for performing system-level functions (e.g. putting unneeded peripherals—or the CPU itself—to sleep). However, Intel is also committed to providing system-management features in the 486SX and DX lines. And that has angered several laptop computer manufacturers that had already committed to the more-expensive 486SL. R-E

WHAT'S NEW

continued from page 4

of information at super-fast speeds, many scientists doubt that the existing technology can keep pace with rising consumer demand for new multimedia services (e.g. pay-per-view video, and computer shopping networks).



BELLCORE'S OPTICAL FILTER, based on liquid crystals, increases the speed and efficiency of fiberoptic data transmission by separating lightwaves into different colors.

Bellcore researchers have been working on experimental devices to boost fiber's data-carrying capacity. They claim that their tunable optical filter is the first practical device that could be used by local telephone operating companies to send hundreds of messages through a single optical fiber simultaneously. The liquid crystals, similar to those in computer and watch displays, do the filtering.

Most fiberoptic networks transmit just one color at a time. The prototype tunable optical filter includes a paper-thin film of liquid crystal sandwiched between two glass mirrors separated by a micrometer (millionth of a meter). If a voltage is applied across the liquid crystal layer, its property that allows a specific wavelength of light to pass through both mirrors is changed.

According to Bellcore researcher, Jay Patel, the prototype represents "a potentially low-cost approach to wavelength selection, which could lower the cost of installing and using fiber in the local loop" (the link between the central office and customers). The research team is now seeking to increase the lightwave sorting speed. **R-E**

RESISTORS

continued from page 64

Trimmer potentiometers

Trimmer potentiometers are called "set and forget" components because they are usually set only during final test and checkout of a product. Figure 11 shows a cutaway view of a trimmer. However, trimmers are also reset after circuit repairs, or during instrument recalibration to overcome the effects of component aging. Trimmers are usually inaccessible to the end user.

Made as printed circuit board or surface-mount components, trimmers can have wirewound resistive elements or those made of carbon or cermet. As in panel potentiometers, performance and cost relate to the resistive element selected. Some trimmers can be set directly with a screwdriver, and others are set indirectly with precision multiturn lead-screw wiping mechanisms as shown in Fig. 11. Trimmers with linear resistive elements are set by manually sliding the wiper along the element.

Trimmer case sizes have been standardized. Some trimmers have open cases with their resistive elements exposed, and others are sealed to prevent the intrusion of solder flux and circuit-board flux cleaning solutions. **R-E**

DRAWING BOARD

continued from page 84

going to go into the math, but your TV has a tremendous amount of tolerance, and even a ten percent drift in the VCO frequency won't cause much in the way of noticeable shakiness in the TV picture.

Get the phase-locked loop circuit working and closely examine the horizontal sync pulses on your scope. The demo scrambler we built some time ago is the perfect circuit to shut off the transmitted horizontal sync signals periodically. Do that and then watch the results on the oscilloscope. **R-E**

RANDOM DOTS

continued from page 56

The drawing program operates the same way as many other drawing programs; it lets you draw lines and shapes, and also add text in one of two fonts in 18 sizes. If you have a specific image that you would like to be made into a random-dot image, the program will accept PCX files—that's how we got our logo into the image at the beginning of this article. (Oh well, so we gave it away!).

When you use the software, different levels into and out of the image are represented by different colors on your monitor (or shades on a non-color display). You work on an image that is easy to see. At any time while you are working on the image, you can get a preview of the random-dot image on your monitor.

The software can add many special effects to the simple shapes that you draw; for example, it can turn them into pyramids, spires, domes, and more.

As was mentioned before, you can import PCX files into the program. However, you don't have the same flexibility with imported PCX files that you do with images that you create. That's because once a PCX file is imported, it stays right where it lands—it can't be changed, moved, resized or added to. Before previewing the random-dot image, the imported image is shown in one color against a background of another color. All you can do to the PCX image is change the color—or level—of the image and/or background. Therefore, any manipulation of the PCX file must be done in another program.

In addition to its ability to send random-dot images to many kinds of printers, the software lets you generate output in PCX, TIFF, and bitmap formats. That way you can import random-dot images into other programs.

If you want to see more random-dot images, contact N.E Thing Enterprises; it has plenty of random-dot posters, puzzles, and calendars for you to stare at, and some free information and sample images. Or get the software and make them yourself. **R-E**

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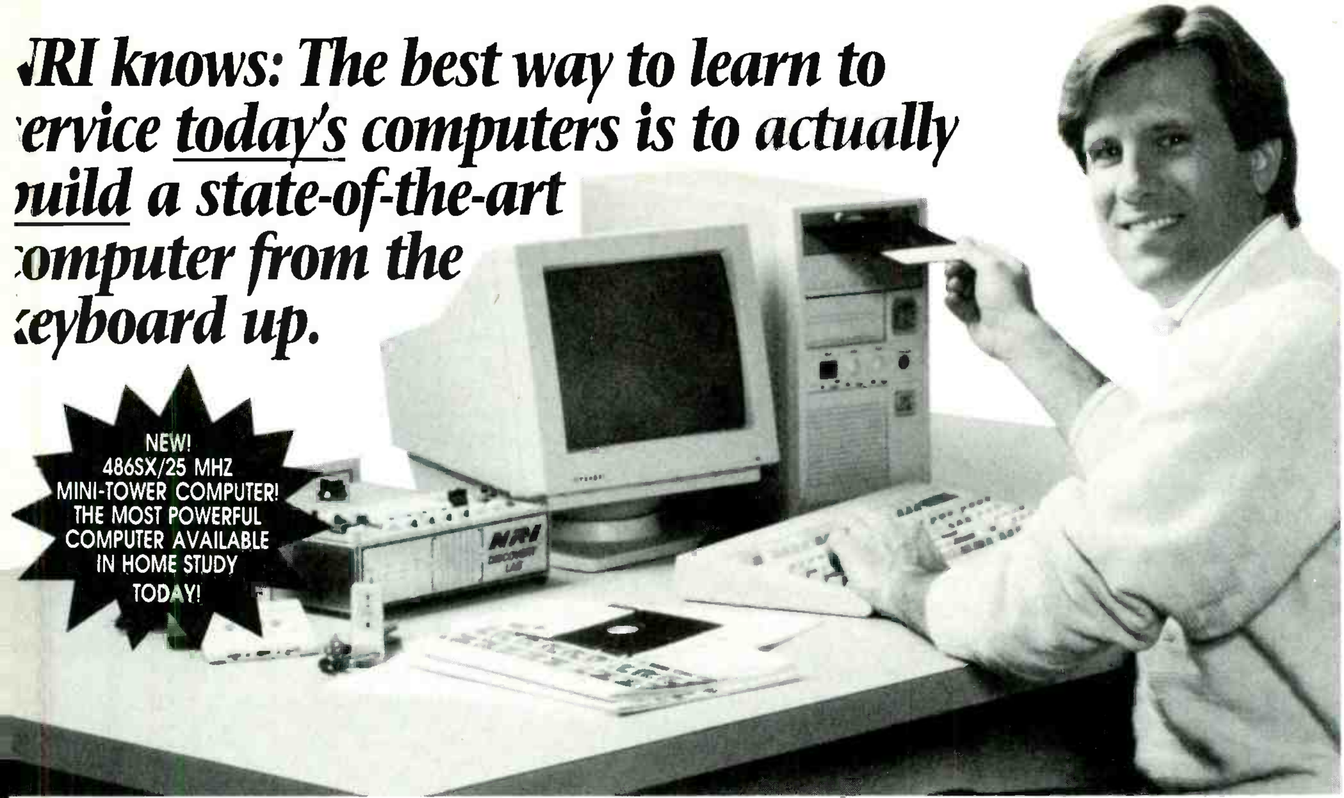

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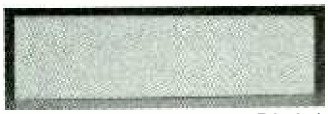

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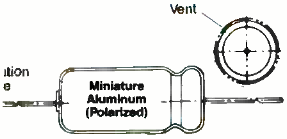
See our Catalog for more kits

Capacitors



Axial Lead Electrolytic Capacitors

t No.	Cap.	Volt.	Price
10866	1µF	50V	$.15
0997	22µF	50V	.29
0911	100µF	50V	.29
1121	470µF	50V	.49
1033	2200µF	16V	.69

Mylar Capacitors

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26884	.01µF	100V	.11
26956	.1µF	100V	.19
27001	1µF	100V	.69

Linear ICs*

t No.	Product No.	1-9
33241	TL082CP	$.59
23579	LM317T	.59
23683	LM324N	.35
23771	LM336Z	1.09
23851	LM339N	.45
27422	NE555V	.29
24328	LM556N	.49
24467	LM723CN	.49
24539	LM741CN	.29
23131	LM1458N	.39
23157	LM1488N	.45
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27385	NE5532	1.19
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2R37372	16LP	16-pin low profile	.12
2R39335	24LP	24-pin low profile	.19
2R40301	28LP	28-pin low profile	.22
2R41110	40LP	40-pin low profile	.28

LEDs

Part No.	Product No.	Description	Price
2R34761	XC556G	T1 3/4, (green)	$.16
2R34796	XC556R	T1 3/4, (red)	.12
2R34825	XC556Y	T1 3/4, (yellow)	.16

Transistors And Diodes

Part No.	Product No.	Description	Price
2R28628	PN2222	TO-92 case	$.12
2R28644	PN2907	TO-92 case	.12
2R35991	1N4004	DO-41 case	.10
2R38236	2N2222A	TO-18 case	.25
2R36126	1N4735	DO-41 case	.25
2R38359	2N3904	TO-92 case	.12
2R36290	1N751	DO-35 case	.15
2R38421	2N4401	TO-92 case	.15
2R36038	1N4148	DO-35 case	.07
2R38308	2N3055	TO-3 case	.69

Switches

Part No.	Product No.	Description	Price
2R21936	JMT123	SPDT, on-on (toggle)	$1.15
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2R26622	MS102	SPST, momentary (push-button)	.39

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2R29663	1.0K	1.95/C	2R29997	100K	1.95/C
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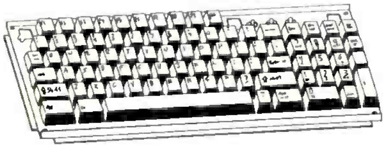

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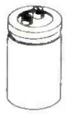

4 1/4" high X 2 1/2" dia.

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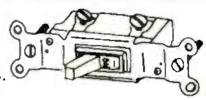

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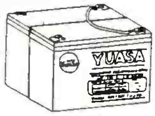

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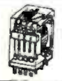

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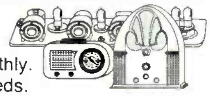

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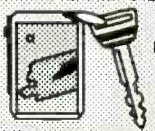

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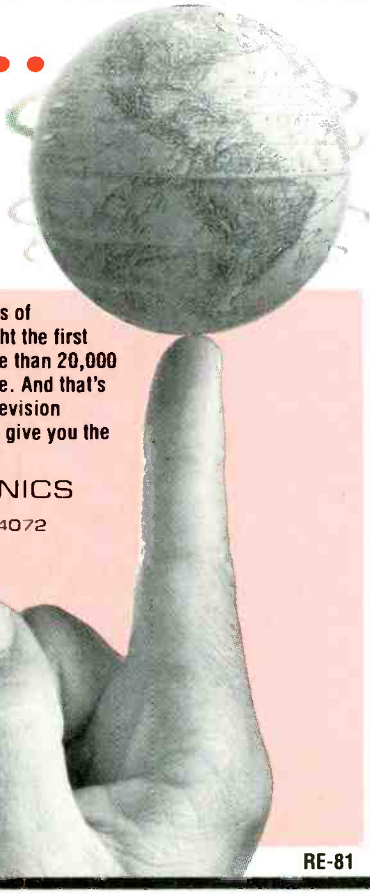

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