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Most readers have probably seen the dazzling laser light shows at concerts and planetariums. Unfortunately the equipment necessary to perform such shows is usually prohibitively expensive. This month we present a relatively inexpensive device that can project an unlimited variety of laser graphics onto a wall or screen. Any laser—solid-state or helium-neon—can be used, which can help to reduce cost. Three rotating mirrors under remote control direct the laser beam into the unusual patterns.

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Blue-LED fabrication
Researchers at Boston University's College of Engineering and the Center for Photonics Research have developed a new method for making a gallium-nitride light-emitting diode (LED) that emits light in the ultraviolet-blue spectrum. The blue LED—the first of its kind made in the United States—is critical in the development of the much-awaited blue semiconductor laser and is expected to have a major impact on U.S. competitiveness in the technological marketplace.

Industry analysts predict that blue LEDs will constitute 20% of a $2 billion LED display market by the turn of the century. Low-cost UV-blue lasers will be significant components in the combined color copier, printer, and fax market, which is expected to grow to $8 billion by 2003. The largest market segment expected to benefit from this technology breakthrough is optical storage, which is expected to reach $30 billion by 2003.

According to Dr. Donald Fraser, director of the Center for Photonics Research, "The blue/ultraviolet semiconductor laser, when available, will revolutionize the way the world does its copying, printing, and storing of data, and create enormous markets for those companies with the technology," adding, "The Photonics Center will work with industrial partners to assure that our country retains this advantage."

Professor Theodore Moustakas and his research team first produced a long-life, room-temperature blue LED in April 1994, using a method distinctly different from that introduced the same month by Japanese researchers from Nichia Chemical Industries Ltd. The Boston University method involves the reaction of gallium with atomic nitrogen and leads to uniform deposition over large water areas. Because the LED devices do not require any post-growth treatment for their operation, some of the problems associated with the metallic chemical-vapor deposition (CVD) method used in Japan are avoided.

For more than two decades, scientists have been trying to develop semiconducting materials that produce true bright blue light efficiently. Red, yellow, and green LEDs were developed in the 1960s and became commercially available in the 1980s. The third primary color, blue, however, has eluded semiconductor researchers.

One of the most promising potential applications for the blue laser is in low-cost optical storage. It would allow a four to ten times increase in storage density over current CD-ROM systems. Blue LEDs will be used most dramatically in bright, full-color displays, such as those intended for sports stadiums. Other potential applications include their use in diagnostic and therapeutic medical equipment, true-color printing, underwater communication, and satellite to satellite communication. The same materials are also suited for electronic and electromechanical applications such as high-temperature, microwave, and spacecraft electronics.

Moustakas, a professor of electrical, computer, and systems engineering and a professor of physics, said, "Making the blue LED from gallium nitride is the first step in getting to the low-cost, durable blue laser."

NAB vs. satellite radio
The National Association of Broadcasters (NAB) submitted a point-by-point response to a document filed with the FCC by a proponent of satellite radio. The NAB says that the document, filed by CD Radio, Inc., erroneously downplays the competitive effects of satellite radio on local radio service nationwide.

"Any loss in national advertising revenues... will have a significant impact on overall (radio) station profits and the station's ability to serve local needs," the NAB report—titled "The Truth About Satellite Radio," said. In particular, it pointed out that "any diversion of audience by satellite services will reduce the revenues local advertisers will pay local stations."

The NAB reminded the FCC of a 1992 Price Waterhouse study, which revealed that three out of five U.S. radio stations lost money between 1987 and 1993, radio revenue growth has not kept pace with inflation. Small-market radio stations are particularly vulnerable to the impact of satellite radio, which "will provide virtually no opportunity for diversification of ownership and will have virtually no public interest or minority employment obligations," the NAB said in its critique.

Broadcasters also contend that there is little demand for new radio service, citing the FCC's own conclusion, just two years ago, that there were too many radio stations in the U.S. New FCC rules, adopted at the time, encouraged a market-driven consolidation.

The NAB believes that adding mobile satellite radio service to the mix would set up the nation's 11,000

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Apr 1995 Electronics Now
**Status of HDTV.** The "Grand Alliance" digital high-definition system has been delayed again. The companies charged with manufacturing a working prototype for testing failed to meet the January 31 deadline for delivery to the Advanced TV Test Center and announced a delay until March. There was some cynicism about the new March deadline, since the earlier deadline for delivery of the equipment was late in 1994. Assuming that the new deadline is met, testing could begin some time in April, but now there seems to be little chance that the timetable of a final recommendation to the FCC by early August will be met. The major equipment work remaining was completion of performance testing of the video encoder-decoder at Bell Telephone Laboratories. The remainder of the system has been assembled at David Sarnoff Research Center and waits final testing when the encoder-decoder arrives. According to a Grand Alliance spokesman: "The equipment is working, we have pictures, and we just need a little more time to finish our work."

**"TV Information Center."** Some time within the next month or portfolio updates tailored to the individual user, will be added. A hand-held remote control is used to access the information, which is delivered over ordinary phone lines. The Information Center black box will sell for $329, according to AT&T, and a "basic group" of services will cost less than $10 a month. Zenith will manufacture TV sets and cable boxes with the Information Center built in, so you'll be able to go to your local electronics store or AT&T Telephone Store and buy a black box that will link your television set to your phone lines, according to AT&T. The "Television Information Center" is designed to connect to products that almost everyone owns to supply information services. AT&T says that it's not necessary to have a computer to be "on line," since the TV is a ubiquitous display device in the home and the telephone line can feed it. Initially the Information Center will provide telephone answering and electronic banking and bill-paying with on-screen displays. Custom services, such as sports scores and stock- Zenith, which is partnered with AT&T in developing home hardware for the system, says that the system "advances our strategy to position the television as the primary source for interactive services." However, just in case someone wants to use a computer instead of a TV set, AT&T will also offer a PC interface. And for someone who wants the system but doesn't want to tie up either the TV or the computer (or the phone line), AT&T will offer a telephone with two lines and a built-in screen for $199. The basic Information System has a built-in, 2400-baud modem and more than a megabyte of DRAM and flash memory.

**Satellite Success.** The consumer-electronics success story of 1994 unquestionably was the Digital

---

RCA'S DSS SATELLITE SYSTEM was 1994's surprise consumer-electronics hit, quickly surpassing all projected sales figures.

Satellite System, or DSS, the high-powered satellite home-delivery system that is supplying TV programming to well over a half million homes in the United States that are equipped with 18-inch satellite dishes. Thomson Consumer Electronics announced that it had shipped 593,098 RCA-brand DSS receiving systems to dealers between last June's launch and the end of 1994, and that it has started a $40-million expansion of its Juarez, Mexico plant to handle the demand. Two versions of the system are available—priced at $699 and $899—with installation available for $200 or on a do-it-yourself basis.

Ironically, the very success of DSS will end RCA's exclusivity prematurely. Under the terms of Thomson's pact with its partners Hughes Electronics and U.S. Satellite Broadcasting, Thomson has the exclusive right to make and sell receivers for 18 months or until the first million systems are sold. Now the goal of selling one million units might be reached in May, since 1994's surprise consumer-electronics hit, quickly surpassing all projected sales figures.

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NEGATIVE REGULATOR

Could you please explain what a constant negative voltage regulator is and could you also draw a schematic of one?—Justin Williams

A constant negative voltage regulator is inserted into the negative supply instead of the positive supply line. Figure 1 shows the basic difference between how a 7905 negative 5-volt regulator and a 7805 positive 5-volt regulator are used in a circuit.

![Figure 1: Difference between 7905 and 7805 regulators](image)

FM broadcasting station to cover a 10- to 20-mile radius. The language used will not be purely English. Can you comment about the legality of such a project? Is any kind of permit required, and from whom?—Bandar Al-Mashary

A low-power license-free transmitter can cover at most only a couple of miles. Your station will have to be licensed by the Federal Communications Commission (Washington, DC 20554). The best way to proceed is to find someone who is already operating a similar station, and get guidance from them.

Another option is to transmit your programs on a subcarrier of an existing FM station, like a third stereo channel. Members of your community would then use special receivers to pick up the broadcasts. Ethnic communities in a number of cities are already doing this. The station engineer of any major FM station can tell you what’s being done in your area. In fact, if your community is large enough, someone who is already in the broadcasting business may be interested in setting up a commercial radio station to serve it.

MONITOR SWITCHER

I have two 386DX computers that I am using as file servers. The two computers sit next to each other and their monitors are almost always turned off. Can I use a switch box to connect one monitor to both computers?—Brian D. Allison

In principle, yes. In practice, the high frequency of VCA analog video signals makes ordinary switches unsuitable. Frequency response has to be flat from DC to over 30 MHz, and you have to switch five signals at once without introducing crosstalk between them.

As you noted in your letter, commercial VGA switch boxes do exist, but they are expensive. I have had some success switching VGA signals with reed relays; that’s the direction to go in if you want to build your own. Alternatively, here’s a “no parts” solution: just plug the monitor into whichever computer needs it at the time. You can unplug a monitor from a running computer and plug it back in without harm, as long as you take care to touch the case of the computer first in order to discharge static electricity.

NO HOT BOOT

I have a 486 DX2 computer that boots up fine from a cold start, but if I attempt to reset it, it refuses to recognize the hard drives. I have had several professional computer technicians look at it and they are stumped. Do you have any ideas?—R. Notarfranco

One of two things might be wrong. If there’s a temperature-dependent loose connection, the computer will start when cold but not when warmed up. To track it down, substitute parts one by one, starting with the disk controller.

It's also possible that something is happening at boot-up that interferes with access to the boot ROM when you reset the computer. In that case, turning the computer off—even for a moment—will reset it correctly even if the reset button doesn’t. To solve the problem, simplify your configuration as much as possible until you find out which device driver or piece of software is responsible. Also, check your CMOS configuration settings and tell it not to copy the ROM BIOS into RAM.

READY-TO-USE TRANSMITTER

I lack the tools and expertise to build the “FM Stereo Broadcaster” (Radio-Electronics, July 1992). Can you recommend a company that can provide an assembled and tested unit?—Brian D. Murphy

How about an easy-to-assemble... Continued on page 18
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CABLE COMPLAINTS

Regarding your article and interviews on the subject of signal theft, I think you missed the boat on some points. The vast majority of customers who “steal” signals are people who would not otherwise pay for the service. To say that cable, pay television, and subscription services “lose” billions of dollars is an unfair characterization. The fact is that a certain number of people will pay regardless of the cost of the service, some will pay unless they feel the service is cost prohibitive, and some will never pay—regardless of the cost.

If you count lost revenue against the number of people you believe are “stealing” your service, and then add the number of people who you failed to properly disconnect upon termination of their service, and then add the number of people who illegally reconnect their own service upon termination, then, yes, it’s a big number of dollars. If you take reality into account and count lost revenues against the number of people who would actually pay you for the service, then the number is much smaller.

There will always be a certain element of loss in any business, and subscription television is no exception. The trick is weighing the costs of making the system so secure that it is virtually impregnable versus providing a quality product.

If you spend a lot of money providing a good quality product that you can deliver at a reasonable cost, then no one will even bother trying to “steal” your signal. If you spend a lot of money “protecting” a product of lower quality, then the consumers will feel little remorse about stealing your signal. Likewise, the money spent protecting your product will be passed on to consumers, resulting in a system that is so incredibly cost-prohibitive that the government might even have to step in to protect people from those tariffs.

Does that sound more like reality?

People who distribute videotapes, laserdiscs, and other electronic software rarely incorporate any form of copy protection into their products. Those products are readily available to anyone, and some people take advantage and illegally copy videotapes. Many are prosecuted and a lot are in jail where they belong.

Cable television, on the other hand, is a subscription product that the company can deny you if you do not comply with their standards and practices. They can simply remove the product from any household and make it extraordinarily difficult, if not impossible, for the subscriber to reconnect the service on his own. The industry does not need any protection. Cable companies are more capable of protecting themselves. All they really need are substantial and effective standards and practices. The industry is too young to have developed all of these yet, but once they are in place and accepted, there won’t be any surprises. Consumers will know what to expect of the product and of the industry as a whole. They won’t be upset about changes from one tier of service to another because, while all of the service providers will have their subtle differences in the level of service and the manner in which it is delivered, the fundamental components of that service will meet a basic standard.

To all you service providers: Get off your duffs and stop blaming the customers for all of your problems. Most consumers are honest and only want a respectable level of service for their money. If you can’t do that, technology will obviate the need for your service altogether. Big communications companies will not buy you out; you will just die a long and painful death as customers and profits migrate to these newer, better technologies and their delivery systems.

Have you seen DSS? It offers more service options than any cable company in existence. While the service may now be expensive, costs will come down. You have to compete in this market—and you desperately need competition. Up until now you have been unable or unwilling to provide a level of service that would eliminate the need for such competition. The market is ripe, and you have grown old and fat. You must compete or die.

PATRICK LEARY
Sherman Oaks, CA

THE DIALOG CONTINUES

I’m writing to respond to Donald G. Chessier’s letter in the November 1994 issue of Electronics Now, in which he commented on my letter (August 1994) concerning D.A. Butch’s “Telephone Ring Amplifier” letter (February 1994).

Contrary to Mr. Chessier’s theories, there are no errors in the design I described.

I considered Mr. Butch’s design, and my modification, to be a good way to build a simple and practical device that shouldn’t cost anything if made from readily available junkbox components. For commercial production of telephone ringers, there are several specialty ICs available, but they often carry fairly high single-unit prices.

My suggested changes to the Butch design were based on a circuit that I came up with about 11 years ago. Since then, I’ve built more than two dozen units for myself and friends, and only one has failed (due to a breakdown in capacitor C4).

The design recognized that the capacitor would only supply usable power for a limited number of rings each time (about eight or nine in the case of a 4700-µF capacitor). But that, I decided, was enough to get anyone’s attention and represented

Continued on page 17
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- Capacitance to 100 pF
- Dual digital display and bargraph

**HP 973A Versatile testing**
- 4,000 display count
- 0.1% basic dc accuracy
- 20 kHz frequency response
- Relative dB and dBm display
- 0.1 dB resolution
- Capacitance to 1000 pF
- Thermocouple temperature
- True RMS ACV response
- Dual digital display and bargraph

**HP 974A Extra precision**
- 49,999 display count
- 0.05% basic dc accuracy
- 100 kHz frequency response
- True RMS ACV response
- Relative dB and dBm display

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U.S. list price.

In Canada, call 1-800-460-2271, Dept. 110.

There is a better way.
The transmission of light waves over fiber-optic cables has become a practical alternative to the transmission of electrical signals over copper wires. The increasing availability and falling costs of conversion electronics have accelerated its acceptance. Fiber-optic communication offers many advantages over wire communication including broader bandwidth, reduced cable size and weight, signal security, and safety.

The waves of the future

In addition to transmitting far more information than comparably sized wire and cable (thus replacing big bundles of wire), fiber-optic cable saves weight and space in underground and building ducts. Optical-fiber cables are difficult (if not impossible) to tap, so they offer higher data and message security than wire and cable-based systems.

Signals transmitted over fiber-optic cable are immune to interference from nearby electrical wires or other electromagnetic interference sources. Also, because the fiber-optic cables carry no electricity, shock hazards are eliminated, and there is no danger of electrical arcing. Thus fiber-optic cables can be passed safely through places where there are explosion or fire hazards. It can also be placed under water without the corrosion problems of copper wire and cable.

The nation's telephone operating companies are replacing large bundles of conventional cables with thin fiber-optic cables. The cables are also serving in computer local area networks (LANs) and in industrial process control systems. Reports of new applications for fiber-optic technology appear regularly in newspapers and magazines.

The FO-30 Fiber Optics kit

The FO-30 Fiber Optics Kit from Elenco Electronics (150 W. Carpenter Ave., Wheeling, IL 60090, 708-541-3800) offers an excellent opportunity for anyone who wants to learn more about the fascinating subject of fiber optics while, at the same time, gaining hands-on experience. With this $19.95 kit, one can build a working system in a single evening and then have the necessary hardware to perform many different interesting and educational experiments.

Fiber-optic fundamentals

Glass or plastic optical fibers function like wires, but they are actually waveguides for the transmission of light rather than electricity. Light passes easily through the core, but it is reflected back from the cladding because of its different optical properties, thus confining the light to the core as it travels.

Thus lightwaves reflect back and forth off the cladding as they propagate down the fiber, much as radio frequency waves bounce off the ionospheric layers as they are transmitted around the world. However, lightwaves, like radio waves, are attenuated as they travel, so they lose strength in transmission. Thus amplifying relays are required for long-distance links.

All signals to be transmitted over a fiber-optic cables must first be converted into a light signal (photons). Those photons must then be converted back into electrical signals by the receiver.

Transmitter and receiver

The Elenco Electronics Fiber Optics Kit consists of a transmitter and receiver board that must both be built from scratch. Each circuit board contains only a few components, so the whole project can be built in less than two hours. For those not in a hurry to complete the project, the work can be spread out over a couple of evenings by building only one board each night.

The transmitter board contains a microphone, an amplifier IC, an infrared-emitting diode (LED), and a collection of other simple components. In one position a slide switch applies the signal from the microphone to the amplifier, and in its second position the amplifier IC is converted into an oscillator.

The signal from the amplifier IC (either the amplified microphone signal or the oscillator tone) is converted to a light signal by the LED. A second switch turns power on and off, and a LED lamp lights to indicate that power is turned on.

The receiver board contains a fiber-optic phototransistor, an amplifier IC, a speaker, and a few other components. A switch here also turns power on and off, and a potentiometer permits the speaker volume to be adjusted. Another LED lamp indicates when power is on. The signal received at the phototransistor is amplified and can be heard from the speaker. Two 9-volt batteries are required to power the system, one for each board.

The kit includes a 3-foot length of fiber-optic cable. After preparing the cable ends, this cable makes the connection between the transmitter and receiver board. The ends of the optical fiber must be cut off at 90° with respect to the fiber axis with a
Measure It All!
The DMM/LCR Meter/ Frequency Counter. All in One.

Troubleshoot down to the component level — any component! Verify poorly marked parts, test for tolerances and damage. Wavetek’s new DM27XT is not only a full-function DMM, but also includes complete inductance, capacitance, and frequency measurement capabilities.

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How to get surround sound without buying the theater...

Chase Technologies brings you an amazing new patent pending surround sound decoder that turns your stereo into a five-channel home theater.

By Charles Anton

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

It takes more than five speakers to get surround sound; there needs to be a way of separating the signals. The new Chase Technologies HTS-1 decoder does just that, and in a revolutionary way that rivals the best Dolby Pro-Logic and THX systems.

Wins over critics. In the September '94 issue of "High Performance Review," noted audio critic Daniel Kumin said "the HTS-1 can do quite a job of recreating a 3D theatrical experience...surround effects emanated with satisfying fullness...sound was clean at any level...with quite involving and natural sound ambience...Plus, John Sunier, the leading authority on surround sound and producer of Audiophile Audition, a nationally syndicated radio program for audio enthusiasts, says, "...the new Chase HTS-1, when used to decode the hidden ambience in all musical recordings, definitely outperforms all the Dolby and THX processors (which could cost you up to $3,000)...I am impressed!"

Passive circuit. Last year, audio industry veteran and Chase president Bob Rapoport invented a new five-channel "passive" circuit for decoding every surround sound encoded movie available. This new decoder can be used with two, three, four, or five channels of amplification, making it the most cost effective method for upgrading an existing stereo system to full home theater performance on the market today.

Breakthrough. The HTS-1 is able to decode the Dolby Surround™ signals in a stereo, videotape or laserdisc because the spatial and depth cues have been matrixed into the "out-of-phase" L minus R portion of the program. By decoding passively, the HTS-1 avoids costly and noisy signal processing. Plus you don’t need any extra amps! Just connect the HTS-1 to your existing stereo, add two speakers for the rear, and you’ll experience the magic of home theater at a fraction of the cost of all other systems.

The secret of surround sound
Surround sound has become the rage of the 90’s because it adds depth and realism to stereo sound, giving you the home theater experience. It makes you feel like you’re actually at a concert or theater. To "fill a room" with surround sound, you need more than two channels. The HTS-1 provides five channels of sound from any two-channel stereo source.

Free center channel. By connecting your VCR or laserdisc player to your TV, you get sound from your TV speaker; this acts as the fifth or "center channel."

Upgradable. The new HTS-1 gives you the ability to upgrade by adding the "Dialog" powered center channel speaker (instead of using your TV speaker). The decoder can also feed an extra amp for the rear speakers if you want the ultimate in discreet five channel performance.

Submerge yourself in rich surround sound.

Easy installation. Hooking up the HTS-1 is easy—just connect the speaker outputs of your receiver or amp to the HTS-1, then connect speaker wire to the front and rear speakers. The rear channel speakers don’t have to be big. We suggest the Chase ELF-1 in either black or white finish to match your decor.

Center Channel. The "Dialog" powered center channel speaker is the perfect add-on for home theater. It keeps voices and sound effects centered or screened for stunning localization and clarity.

Risk-free home trial. The best way to evaluate surround sound is in your home, not in a showroom. That’s why we’re offering this risk-free home trial. We’re so sure that you’ll be delighted with the quality of these products and the surround sound experience that we are giving you 30 days to try them for yourself. If they’re not everything we say, return them for a complete "No Questions Asked" refund.

HTS-1 Home Theater Decoder........$99 $10 S&H
Speakers designed by Chase for the HTS-1:
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DIALOG Center Channel Speaker........$75 $8 S&H
Please mention promotional code 117-ET1108.

For fastest service call toll-free 24 hours a day
800-992-2966

The ELF-1 rear channel speakers integrate perfectly with the HTS-1.

The Dialog powered center channel speaker is video shielded.

AWARD WINNING DESIGN

At the 1994 Summer Consumer Electronics show in Chicago, the HTS-1 won the Design and Engineering Award for being one of the best and most innovative new products of 1994. This award-winning design from Chase Technologies is a breakthrough for it's ease of use, affordability and outstanding performance.

The new award-winning HTS-1 Decoder.

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a good capacitor recharge time compromise.

Mr. Chessier's claim that the 4148 diode's ratings aren't sufficient is in error! First of all, the old Bell ring voltage specifications allow a Central Office level between 85 and 100 volts AC RMS (and that voltage can drop to as low as 55 volts AC at the end of a long loop). Even at maximum voltage levels, the worst that can happen is that the diodes break down and Zener at a safe level determined by the two 33 kilohm resistors. No harm is done to either the diodes or the other circuit components. If you want to use 1N4004 diodes, by all means do so, but it isn't necessary. Mr. Chessier's claim that doing so would impart some protection against electrical storm transients is a bit much. If you want that kind of protection, it won't come about from just changing some of the components (a chain is no stronger than its weakest link). Instead, that would best be done by putting a 250-300 volt MOV (metal oxide varistor) across the phone line where it enters the building.

As for Mr. Chessier's second point (also wrong), the base current trough Q1 is design limited to about 30 μA, so the transistor never fully switches on, giving a collector current that is well within specified limits. Transistor Q2, although fully switched on during part of a ring, is also current-limited through the internal resistance of the buzzer.

Point three: I've done a lot of playing around with various piezo buzzers and one thing I've found common to all those I've tested is that they can all handle a 50-volt supply in intermittent service (such as with a phone ringer), regardless of their rated voltage. Some were bought at Radio Shack, some as surplus, and others came out of discarded greeting cards (where they played a tune) and broken "Hong Kong" telephones.

Although no polarity was shown for the buzzer in the original figure, anyone who knows which end of a soldering iron to grab should have no problems figuring that one out. As for the voltage rating of transistors Q1 and Q2, the 2N3904s, at 60 volts, are quite adequate.

If the unit has rung itself out (nine rings or so), the C4 capacitor will not go below the off-hook voltage of about 6 volts and would still be able to signal another incoming call (although at low volume) immediately after hanging up. Even when newly installed, with zero charge on C4, it will ring several times after only four or five minutes (not the 15 minutes claimed in Mr. Chessier's letter).

RUNE H.J. SODERMAN
Jandrain, Belgium

A READER'S SUGGESTIONS
Your fine January 1995 issue prompted me to comment on two articles that appeared there. The first is the article by Doyle Whisnant: "Build an Isolation Transformer." The information is fine, but the project might be improved by keeping the filament windings and connecting them, with suitable switching, to provide adjustable output voltage. Besides compensating for incorrect line voltage, this allows the equipment under test to be run above or below normal voltage to help uncover latent faults.

The second comment is directed to Tom Heal and his very helpful article, "Phantom of the Ether." It's possible that he's looking for an electronic solution to a problem that is essentially optical. Fluorescent tubes contain argon gas (or perhaps xenon or krypton), which has strong spectral lines in the 1000-nanometer region. If those lines could be suppressed by changing the composition of the glass in the tube or by some overcoating that would absorb in this region but be transparent to visible light, the problem would go away.

Keep up the good work. I've been a regular reader of Electronics Now and its predecessors for at least 50 years and have found it to be at least as helpful as a number of "professional" journals that I use regularly.

E. FRED CLOSE
Apache Junction, AZ

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kit? Try the FM-10 from Ramsey Electronics (793 Canning Pkwy., Victor, NY 14564), featured in the February, 1995, issue of our sister magazine, Popular Electronics. Alternatively, maybe you can use one of the low-priced FM transmitters designed to transmit a CD player's output to a car radio.

BATTERY ISOLATOR
Do you have plans for the circuitry used in automotive dual-battery isolators? Do the batteries have to have similar or identical output-current ratings? If they're not isolated, will one battery just drain the other?—Randal Christman

You could probably connect two batteries in parallel without harm if they are both in good condition and are matched for voltage (not necessarily matched for capacity). If one battery developed a shorted cell, it would discharge the other battery; otherwise, they'd be OK.

The purpose of a battery isolator is to let you use one battery without discharging the other one. The main battery can remain available for starting power even if you run the other battery down operating camp lights or other accessories.

Figure 3 shows the circuitry inside an isolator. The diodes act as one-way valves so that current can flow into both batteries from the alternator, but the main battery can't feed the accessory system, nor vice versa.

The diodes must be able to handle heavy current (80 amps or more) with as little forward voltage drop as possible. Suitable diodes, such as the NTE 6075 or ECG 6075, cost over $13 each. You'll probably do just as well buying a complete isolator from an auto parts store. One source for the NTE 6075 is Tandy National Parts (800-322-3690).

CONCRETE DRAIN
Please! Educate me, or help me put a myth to rest. All my life I've been told that lead-acid batteries will lose their charge if they're stored resting directly on concrete. I can see no logical reason for this to happen.—Larry Ball

We've heard the same thing and it doesn't make sense to us either. We know of no way that a concrete floor can discharge a battery. But if the battery cracks open, the acid will certainly damage the concrete.

VCR MODIFICATION
I want to use a VCR to record programs while on the road in my RV. I haven't been able to locate any 12-volt DC units (all I've found are video player-only units). Since all solid-state electronics operate on DC, why can't I modify a conventional AC-powered VCR?—William Rauch

Mainly because some of the voltages in a VCR are higher than 12 volts. To obtain them, you'd have to use a DC-to-DC converter, which is essentially an inverter followed by a rectifier. If you're going to do that, you might as well feed the VCR with 120 volts AC from a regular inverter, rather than building one.
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PCMCIA MODEMS. Motorola’s Transmission Products Division has introduced two series of credit-card-sized modems called Lifestyle and Power. The 14.4 PCMCIA modems conform to the standards of the Portable Computer Memory Card International Association (PCMCIA).

The Lifestyle data and fax modems are intended for laptop, notebook and palmtop personal computers with PCMCIA slots. The modems permit the sending and receiving of data and files over standard phone lines. They also permit connection for online services such as banking and shopping. The Lifestyle modems can be upgraded for use with cellular telephones.

By contrast, the Power data and fax modems for laptop, notebook and palmtop personal computers with PCMCIA slots are intended for use with cellular or traditional phones. The series permits the sending and receiving of faxes, email and the downloading of files anytime, anywhere in the world.

A Motorola MC2 flip cellular telephone is required for compatible cellular connectivity. The Power modems support Motorola’s proprietary EC2 (Enhanced Cellular Control) technology for improved cellular phone operation.

Both series of modems can be inserted in computers with PCMCIA Release 2.0 and higher, Type II slots. They are fully compatible with the installed base of CCITT Group III and EIA Class 1 modems. When used with Class 1 software, the modems can send and receive a document at 14,400, 12,000, 9600, 7200, 4800, or 2400 bits per second, assuring compatibility with most fax machines and modems.

The modems automatically adjust speed as needed. Both series of modems perform T.30 error correction for increased data reliability and fax cost reduction. Power reduction of 25 to 90% in standby modes over competitive modems is claimed.

The Lifestyle modem (pictured) is priced at $279.00, and the Power modem is priced at $390.00. The price for both modems includes Delrina WinFax/WinCom software, and one month of free service on America Online, CompuServe, Prodigy, and the Reuters Money Network.

Motorola Transmission Products Division
5000 Bradford Drive
Huntsville, AL 35805-1993
Phone: 800-365-6465
Fax: 508-261-1058

16-CHANNEL LOGIC ANALYZER. Hewlett-Packard’s HP 54620 16-channel logic analyzer can be coupled to an oscilloscope to permit quicker and easier troubleshooting of complex digital circuits. Priced in the same range as a 100-MHz delayed-sweep oscilloscope, it permits timing analysis across all of its 16 channels.

The logic analyzer was designed for those who routinely use an oscilloscope instead of a logic analyzer for testing and debugging. It features a simplified control panel and easier setup procedures to encourage its use. The HP 54620 has a 500-millisecond sampling speed and 20-screens/second display update rate. An autoscale feature lets users display active channels with the push of a button. All functions are accessible through multilayer menus.

The HP 54620A provides a front-panel trigger output to link the logic analyzer to an oscilloscope. This gives users a complete picture of circuit operation, with the logic analyzer providing signal relationship information while the oscilloscope displays related parametric waveform information.

With the HP 54620A linked to an oscilloscope, the triggering capability of the logic analyzer can capture elusive glitches so that the signal can be examined in detail. It offers simple edge triggering, pattern triggering qualified with an edge, or advanced triggering sequences for applications where simpler triggering methods won't isolate the event of interest.

HP 34810A BenchLink/Scope (version 1.2) software allows users to import logic-analyzer data into their own Windows applications.

The HP 54620A 16-channel logic analyzer is priced at $2995.00.
TekMeter™ can show you the answer before you even know the question.

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

It's easy. Just connect the probes. TekMeter finds the signal then makes the correct scope or DMM settings to display voltage, current or waveforms in the most meaningful way. What's more, your hands remain free to probe more accurately and safely. Especially in small places.

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

TekMeter is the answer you've been looking for. Contact your local authorized Tektronix distributor today, or call 800-426-2200, ext 299.

*Circulated retail price, model TMS 550 © Copyright 1994, Tektronix, Inc. All rights reserved. TekMeter, TekTools, and Tektronix are trademarks of Tektronix, Inc. DPW-284597

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SPECTRUM ANALYZER. The SA2600 spectrum analyzer from DKD Instruments can convert a personal computer into a spectrum analyzer/receiver. It covers the 100-kHz to 2.4-GHz frequency range and draws less than 12 watts at 12 volts. The SA2600 offers fully synthesized tuning with a crystal reference. Less than 2-Hz frequency resolution is provided by its direct digital synthesizer. Video and resolution bandwidth are programmable from 300 kHz to 500 Hz for making precise measurements.

CIRCLE 22 ON FREE INFORMATION CARD

With a spurious free dynamic range of 80 dB and the optional internal, programmable, 60-dB step attenuator, signals from −130 dBm to +20 dBm can be accurately measured. Internal gain compensation and power calibration give power accuracy to ±1.4 dB. In addition, wide and narrow FM demodulators provide audio for directed search and surveillance.

The software supports features such as overlays, trace math, marker functions, and auto logging and hard copy to a printer. The instrument's features include signal track, peak search, and delta marker. Maximum hold and spectrum averaging allow special measurements to be made.

The SA2600 spectrum analyzer has a base price of $4,995.00.

DKD Instruments
1406 Parkhurst
Sun Valley, CA 91065
Phone: 805-581-5771
Fax: 805-583-8270

SURFACE-MOUNT TOROIDS. The KM Series of toroidal inductors from Associated Components Technology is intended for surface-mounting on circuit boards. They are suitable for use in miniature high-frequency switching power supplies where energy storage and filter inductance are critical and noise-filtering ability is a desirable feature.

The toroids' molypermalloy powder cores makes them suitable as noise filters in situations where the inductors must withstand AC voltages as high as 100 to 220 volts without core saturation. The cores have a flat frequency response between DC and 1 MHz. Intended for unidirectional drive applications, the inductors can be placed in a circuit in either direction without concern about damaging them.

When used to store energy within the circuit, the toroids offer high capacity in a small volume. A 2-ampere toroid can store 8 microJoules, and a 0.25-ampere unit can handle up to 20 microJoules. The toroids occupy 0.40 by 0.38 inches of board space.

The inductance values of the toroids range from 10 to 250 microhenries (µH), and DC resistance is between 0.04 and 0.7 ohms. The safe operating temperature range for the toroids is from −55°C to +125°C.

CIRCLE 23 ON FREE INFORMATION CARD

The toroids are sold on tape reels in lots of 1000 on 13-inch diameter, 25-mm wide reels.

KM Series surface-mount toroids are priced at $1.60 each in quantities of 1000.

Associated Components Technology
1576 Trask Avenue
Garden Grove, CA 92643
Phone: 800-234-2645 and (714-636-2645 CA)
Fax: 714-636-8276

AMATEUR RADIO LINEAR MOSFET AMPLIFIER. The ALS600 amateur radio linear amplifier from Ameritron requires no tuning or warmup, so it is works as soon as it is turned on. It includes four Motorola TMOS radio-frequency power MOSFETs. A separate AC power supply (ALS-600PS) with cord can be plugged into the amplifier and the 120-volt AC outlet.

CIRCLE 24 ON FREE INFORMATION CARD

Rated for 600 watts PEP and 500 watts CW, the amplifier covers the 1.5- to 22-MHz band continuously. It includes a cooling fan and an illuminated cross-needle standing-wave ratio (SWR)/wattmeter. To safeguard the amplifier, both SWR and over-power protection are included to prevent damage to the amplifier if the wrong band is switched, the wrong antenna is connected, or the SWR on the transmission line is high. The amplifier is packaged in a case measuring 6 × 9½ × 12 inches and it weighs 12.5 pounds.

The ALS-600 amplifier with the ALS600PS power supply is priced at $1,299.00.

Ameritron
P.O. Box 494
Mississippi State, MS
Phone: 601-323-8211
Fax: 601-323-6555

INSULATED TOOL KIT. Jensen Tools has introduced a set of electrically insulated tools to protect users when working on live power circuits. Made in Germany, each tool has been individually tested to withstand 10,000 volts and is certified to protect the user at either 1000 volts AC or 1500 volts DC.

CIRCLE 25 ON FREE INFORMATION CARD

The tool set contains 11 vanadium steel tools: 7-inch side cutters; 8-inch long nose pliers; 6½-inch long nose pliers; 8-inch lineman's pliers; and seven assorted screwdrivers. Each tool has a permanently attached insulated sheath. All the tools are packaged in a handy zipper case.

The insulated tool kit (Jensen Part No. 194B675) is priced at $225.00.

Jensen Tools Inc.
7815 South 46th Street
Phoenix AZ 85044
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Continued on page 28
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CIRCLE 126 ON FREE INFORMATION CARD
Create Your Own Virtual Reality System; by Joseph R. Levy and Harley Bjelland. Windcrest /McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Phone: 800-233-1128; Fax 717-794-2103; Paper $32.95, Hard $44.95; 320 pages, 62 illustrations; includes disk.

Virtual reality (VR), now a common high-tech "buzz" word, refers to the combined computer and video technologies that place the observer in computer-generated situations for obtaining new and exciting visual experiences vicariously, training in the operation of moving vehicles, gaining insights into architectural structures, and yes, even—playing games.

This book by Levy and Bjelland provides an excellent introduction to the concepts of VR, yet it does not require that the reader have training and experience in the technologies discussed. Experiments in VR are now taking place in some of the most advanced research laboratories in the world. An accompanying disk will help the reader to grasp the fundamentals.

Included in the book are descriptions of consumer-grade VR hardware and software products now on the market. It gives prices along with the addresses, telephone and fax numbers of the suppliers. Chapters in the book explain how to build and install head-mounted displays, "data gloves," stereoscopic glasses, audio speakers, and other VR components.

The authors also explain how to play interactive VR games, generate real-time VR images, and carry out many different interesting VR experiments.

The book discusses the limitations and advantages of desktop VR systems. It also includes information on how to obtain free or low-cost VR demonstration disks and how to contact VR-related organizations and publications. Finally, the book looks beyond the existing equipment and technology to explore the future of VR and its applications in science, medicine, commerce, entertainment, and other human activities.

The PC Toolbox; Dynamic Learning Systems, P.O. Box 805, Marlboro, MA 01752, Phone: 508-366-9487; Fax: 508-899-9995; CompuServe: 73652,3205; start-up newsletter; one-year subscription (six issues), $39.00; two-year (12 issues), $69.00.

This newly announced newsletter is intended for personal computer users at all levels of experience, wherever they are. However, it is focused on the PC enthusiast who wants to optimize the operation of his PC and keep it functioning at top efficiency despite today's short life cycles of processors, software and peripherals.

The newsletter publisher expects both business and home PC users to benefit from the feature articles, regular columns, and practical tips for that can be applied immediately. He believes that the editorial coverage will help readers make more efficient use of their present hardware and software. Nevertheless, objective product reviews will offer the reader guidance in the purchase of replacement PCs, processors, circuit boards or software when updating is advisable.

The newsletter, supported by subscription only, will contain no advertisements. This will eliminate any possible conflict of interest. The introductory issue contains articles on optimizing conventional memory, installing CD-ROM drives, and master-
12 separate 48-volt power supplies with output power ratings from 10 to 480 watts. These products are packaged as modules, wall-outlet plug-in units, and in floor-mounted or rack-mounted cases. Many accept AC line power from 90 to 260 volts, 50 to 60 Hz.

The power supplies are intended for PBX consoles, data-interface systems, T-1 telephone and fiber-optic systems. Complete mechanical and electrical specifications and pricing is included. All models meet applicable UL, CSA, and European safety standards.

The Net After Dark; by Lamont Wood. John Wiley & Sons, Inc., Professional Reference and Trade Group, 605 third Avenue, New York, NY 10158-0012; Phone 1-800-CALL-WILEY; $16.95.

This book, subtitled “The Underground Guide to the Coolest, and the Newest, and the Most Bizarre Hangouts on the Internet, Compuserve, AOL, Delphi, and More,” was written to introduce readers to the recreational aspects of computer networking. It offers tips and "secret handshakes" to the unusual services and exchanges available on the various personal computer networks.

This entertaining book includes the on-line addresses to hundreds of unusual and perhaps even bizarre exchanges, including many local cult or special interest bulletin board services.

Computers in Science & Art Catalog. Media Magic, P.O. Box 598-PR, Nicasio, CA 94946; Phone: 415-662-2426; 132 pages; free.

This mail-order catalog lists more than 1000 products that provide information on the leading-edge of art, science, and technology. It is a valuable resource for determining what material is available for classroom and self-education in those fields.

The Microcontroller Idea Book: by Jan Axelson. Lakeview Research, 2209 Winnebago Street, Madison, WI 53704; Phone: 608-241-5824; $31.95 + $3.00 S&H; 277 pages.

This is a book of circuits and programs for applying the popular Intel 8052 BASIC microcontroller (MCU). The MCU, otherwise known as the single-chip computer, contains all the CPU functions of the microprocessor (MPU) as well as memory and I/O functions not found on the MPU chip. Although more limited in computational capability than the MPU, the MCU chip is ideal for repetitive control and data logging.

Axelson’s book contains complete circuit diagrams, parts lists, design theory, and construction tips for working with the 8052 BASIC. Its on-chip BASIC-82 programming language simplifies the task of writing applications software. Special commands store programs in EPROM or other nonvolatile memory.

In addition to its coverage of the basic circuits needed to complete any project, this book explains how to add keypads, switches, relays, displays, sensors, clock/calendars, motor controls, wireless links, and other input/output interfaces.

1995 Antique Supply Catalog. Antique Electronic Supply, 6221 South Maple Avenue, Tempe, AZ 85283; Phone: 602-820-5411; Fax: 800-706-6709; $2.00.

This is the 1995 edition of a catalog for antique radio and instrument collectors and the hobbyists and professionals who like to restore them—or perhaps even or build new ones from scratch. Newly expanded to 36 pages, the catalog lists more than 3000 different kinds of receiving, transmitting, audio, and industrial vacuum tubes.

In addition, the catalog lists capacitors and other electronic components suitable for use with AC line- and battery-powered receivers and instruments of the vacuum-tube era. Included is a list of 75 books devoted to the collection and restoration of vacuum-tube circuits.

Electronics For Your Future; by Daniel L. Metzger. Technology Training, Inc., 6969 Streamview Drive, Lambertville, MI 48144; Phone/Fax 313-854-3605; 300 pages; $35.00.

This basic textbook on electronics emphasizes brevity and reader friendliness. Each page is divided into six panels—like a comic book—with colorful sketches, icons, and diagrams to illustrate the basic concepts behind electronics.

Metzger’s book covers a wide range of subjects...
NEW PRODUCTS

continued from page 24

MULTIFUNCTION GENERATOR. Compuvideo has introduced the Series 7000 multifunction video, sync, and test pattern generators that meet NTSC or PAL transmission standards. Outputs include the S-VHS, composite, and component.

The six models in the series are intended for TV editing, production, post-production, and maintenance. The generators consist of four sections: 12 test patterns; six black-burst outputs; sync and subcarrier outputs; and an audio generator.

The pricing for Series 7000 multifunction generators is from $299.00 to $1199.00, depending on unit configuration. Compuvideo, Inc. 3861 Oceanview Avenue Brooklyn, NY 11224 Phone: 212-213-6818 Fax: 718-714-9873

CACHE DATA RAMS FOR PENTIUM, 486, AND POWERPC PROCESSORS. IC Works has introduced the W73B586B cache data RAM for Pentium and 486 microprocessors and the W73B601 cache data RAMs for PowerPC processors. Both offer access times from 9 to 12 nanoseconds, and they support burst sequence addressing at 66 MHz with a two-bit wrap-around counter.

The RAMs have 32-kilobit by 18-bit organizations, and they can be interfaced directly with an external cache controller and the CPU. The cache data RAMs ease the installation of cache memory in systems with microprocessors by meeting the processor's requirements for setup and hold time at 66 MHz. They will also support zero-wait state memory access and burst sequence addressing.

The W73B586B and W73B601 cache data RAMs, packaged in 52-pin plastic leadless chip carrier (PLCC) packages, are priced from $30.00 to $35.00 (based on speed) in quantities of thousands.

IC Works, Inc. 3725 North First Street San Jose, CA 95134-1700 Phone: 408-922-0202 Fax: 408-922-0833

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from diodes, transistors, power supplies and amplifiers to overviews of linear and digital integrated circuits. Each topic is covered on a single page or a pair of facing pages, and diagrams appear in the same panel that explains them. Each of the 24 chapters concludes with four pages of review and examples of circuits that have been analyzed. The book is suitable for self-study or as a text in formal training courses.

Serial EEPROM Handbook; Microchip Technology Inc., 3255 West Chandler Blvd., Chandler, AZ 85224-6199; Phone: 602-786-7200; Fax 602-899-9210; 480 pages; free from Microchip sales offices or distributors.

This handbook is the first reference published for engineers who use Microchip's serial EEPROMs. It includes 25 product specifications sheets, more than 12 applications notes, and nine qualification reports on the company's EEPROMs development tools. Included are data on the 64-kilobit serial EEPROM and the Total Endurance Disk.

CIRCLE 345 ON FREE INFORMATION CARD

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100-MHz, THREE-CHANNEL OSCILLOSCOPES. Leader Instruments has introduced two new analog oscilloscopes, the Models 8103 and 8104. Both of its new oscilloscopes have 100-MHz bandwidths, three channels, and the same basic operating characteristics.

Both oscilloscopes offer calibrated sweep with alternate sweep so that the main and delayed traces can be viewed simultaneously.

Six traces are displayed in an alternate sweep mode when three channels are active. The sum (or difference with channel 2 inverted) of channel 1 and 2 can also be displayed together with channels 1 to 3. This makes it possible to view eight traces.

The main time base ranges from 50 nanoseconds per division to 0.5 seconds per division in 22 steps. The times 10 magnifier increases the fastest sweep speed to 5 nanoseconds per division. A single sweep mode captures one-time events.

Trigger capabilities include a time-saving automatic source selection coordinated with V-mode operation. Manual override allows the source to be selected from any of three channels and the power line.

The trigger modes include AUTO, NORMAL, and FIXED. Trigger coupling settings include dedicated horizontal and vertical TV sync separators for video observations.

The Model 8104 can make automatic cursor measurements of voltage, time, frequency, and phase, and it can display on-screen sensitivity, time-base, and delay-time setting messages.

The Model 8103 is priced at $1600.00 and the Model 8104 (pictured) is priced at $1900.00. Leader Instruments Corp. 380 Oser Avenue Hauppauge, NY 11788 Phone: 800-646-5104 (516-321-6900 in NY)
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HAVE YOU EVER BEEN IMPRESSED by a professional laser light show at a nightclub or a concert? Now you can impress all of your friends by creating your very own laser light show! This easy-to-build project works with any laser to create unlimited complex geometric patterns.

Safety Notice: The laser beam that is projected by this device is harmful if aimed directly into the human eye. Never look directly into the laser beam, nor aim the laser at anyone else. The unit should be used only by adults or with adult supervision. It is not a toy and must be used only in a safe and responsible manner.

When assembled, this laser product must conform to the safety regulations of the C.D.R.H. (Center for Devices and Radiological Health) of the Food and Drug Administration. The regulations classify lasers by power, mechanical requirements, and so on. (Detailed information on these requirements are available from the Center for Devices and Radiological Health, Office of Compliance, 2098 Gaither Road, Rockville, Maryland 20850.)

Mechanics and optics
The project consists of a base unit and a wire-linked remote control. The base unit houses the mirrors, motors, and motor-drive circuits, in addition to a solid-state laser assembly. The handheld remote unit contains an on/off switch and speed control circuits.

The light show project creates fascinating patterns by reflecting a laser beam from three "wobbly" mirrors. Each mirror adds a unique spiral pattern to the beam, and the patterns combine to create complex geometric shapes. Each mirror is mounted slightly off-axis on a small DC motor, and each motor is driven by a separate speed-control circuit. As the speed of each motor is adjusted, the size and shape of the spiral laser pattern is altered.

The circuit
Refer to the schematic of the laser light show in Fig. 1. An

Amaze your friends and family with the dazzling displays you can create with your own laser light show.

DAVID WILLIAMS
external DC power adapter plugs into connector J1 to power the circuit. Diode D10 provides reverse-polarity protection for the voltage regulator, IC4. The LM7808 voltage regulator and capacitor C15 convert the transformer voltage to a constant regulated +8 volts to power the rest of the circuit. This main power is fed to the handheld remote through an RJ-11 modular cable and jacks J2 and J3 and is switched on and off by S1. Light-emitting diode LED1 indicates when power is on.

On the handheld remote side, the LM7805 (IC3) regulates the 8-volts down to 5 volts to power the CD4011 quad NAND gate ICs. Although IC1 and IC2 would operate fine at 8-volts, powering them from the output of IC3 helps to isolate the oscillator circuits from the electrical noise produced by the DC motors. The remote section has three identical oscillator circuits that produce pulse-width modulated signals to control the speed of the DC motors in the base unit. Each oscillator consists of two NAND gates from a CD4011 (wired as inverters), and a 0.01-microfarad capacitor that determines the oscillation frequency.

Two signal diodes and a 500-kilocm potentiometer control the duty cycle, or on time of each pulse-width modulator. With the 3.3 megohm resistor in the circuit, the duty cycle can be varied from 0% to only about 20%. (Without the 3.3 megohm resistor, the potentiometer can vary this on time from 0% to 100%). The 0% to 20% duty-cycle gives a good speed range with the motors used in the author's prototype unit. You might have to experiment with the values of R8, R9, and R10 depending on the motors that you choose.

The three motor-control signals pass through connector J3 and a six-conductor modular cable to J2 on the base unit. In the base unit, each pulse-width modulated signal controls the motor speed by switching an IRF510 N-channel MOSFET transistor. The 100-ohm resistor and the 0.1µF capacitor filter noise in the cable and the 22-kilohm resistor connected to the gate of each MOSFET keeps

FIG. 1—SCHEMATIC OF THE LASER LIGHT SHOW. An external DC wall-outlet adapter powers the circuit at J1; the LM7808 voltage regulator produces a constant +8 volts to power the rest of the circuit.
Start by assembling the handheld remote unit. Figure 2 is the parts-placement diagram for that board. Use two 14-pin DIP sockets for IC1 and IC2. Mount the LED to the PC board with a ¾-inch plastic spacer. This will allow the LED to protrude through a hole in the plastic cover.

To connect the three potentiometers, cut nine 4-inch pieces of stranded hookup wire and solder the wires from the PC board to the potentiometers, as shown. Do the same for switch S1. Last, install IC1 and IC2 in their sockets, observing the proper orientation of pin 1.

Drill a row of three holes in the top of the case for the three potentiometers. Mount the PC board in the bottom half of the case with any suitable hardware. Determine where the LED will protrude through the top of the case, and drill a ¾-inch hole in that spot. Drill another ¾-inch hole for S1 in any open location on the cover. Test fit the case’s end panels, and cut an opening in one end to allow access to modular connector J3. Mount the three potentiometers and switch S1 on the case cover. Align the cover so that the LED fits through its hole, and secure the two halves of the enclosure together. Set the remote unit aside for now and begin assembling the base unit.

Refer to Fig. 3 for the parts-placement diagram of the base unit. When installing the electrolytic capacitors C11, C12, and C13, be sure to follow the proper polarity orientation. Jack J1 is a 2.1 millimeter power connector that attaches to the PC board and accepts power from a wall transformer. You can either install J1 or you can attach the wires from a DC-output wall-outlet adapter directly.

Install the three MOSFET transistors on the board. Be sure that the metal tabs are oriented as shown in Fig. 3 before soldering them in place. Note that MOSFET transistors are ESD-sensitive, so always take precautions to discharge static electricity from your body by touching grounded metal be-
FIG. 4—RIGHT-ANGLE ALUMINUM brackets. These are attached to the motors and can pivot on the base for alignment adjustments.

Before you handle them. Next install the voltage regulator IC4, observing the proper orientation of the metal tab. Solder six

PARTS LIST

All resistors are ½-watt, 5%.
R1—R3—100 ohms
R4—620 ohms
R5—R7—22,000 ohms
R8—R10—3.3 megohms
R11—R13—500,000 ohms, panel-mount potentiometer

Capacitors
C1—C3—0.01 µF, ceramic disk
C4—C9—0.1 µF, ceramic disk
C10—1 µF, 16 volts, tantalum electrolytic
C11—C13—220 µF, 16 volts, electrolytic

Semiconductors
IC1, IC2—CD4011 quad 2-input NAND gates
IC3—LM78L05, 5-volt regulator (TO-92 case), Motorola or equiv.
IC4—LM7808T, 8-volt regulator (TO-220 case), Motorola or equiv.
Q1—Q3—IRF510 N-channel MOSFET transistors, International Rectifier.

D1—D6—1N914 diode
D7—D10—1N4001 rectifier diode
LED1—red light emitting diode, T-1 ¾

Other components
J1—2.1 mm power jack
J2, J3—6-pin RJ-11 jacks
M1—M3—DC hobby motor
S1—SPST subminiature toggle switch, PC mount

Miscellaneous: 9-volt DC, 300 mA wall outlet adapter; plastic enclosures (remote, Serpac A-21; base unit, Serpac A-31); knobs for potentiometers; three aluminum motor brackets (see Fig. 4); three 1-inch diameter round plastic mirrors and three plastic mounting disks; two PC boards; two 14-pin IC sockets; 3-foot, 6-conductor modular cord; No. 24 gauge stranded wire; hardware; glue; solder.

Note: The following items are available from LNS Technologies, 20993 Foothill Blvd, Suite 307R, Hayward, CA 94541-1511, 1-800-886-7150:
- Complete kit of parts for the Laser Light Show (LSHOW-KIT) includes two PC boards, brackets, mirrors, enclosures, motors, and all components listed above (laser not included, see below)—$99.00
- Solid State Laser Kit (LASER-KIT)—$89.00
Add $5.00 S&H to all orders. California residents add local sales tax. MC/VISA orders accepted.

FIG. 5—IF YOU ARE MOUNTING THE BASE UNIT in a plastic enclosure, you will need an aluminum baseplate cut and drilled to these dimensions.
pieces of 6-inch long stranded hook-up wire to the board as shown for connecting the three DC motors later on.

**Final assembly**

The three motors and their mirrors must be mounted securely and aligned accurately to properly deflect the laser beam. The right-angle aluminum brackets shown in Fig. 4 attach to the motors and can pivot on the base for alignment adjustments. If you don’t purchase the kit for the laser show, you’ll have to fabricate these brackets yourself. If you are mounting the base unit in a plastic enclosure like the author’s prototype, you will also need the aluminum baseplate shown in Fig. 5. Otherwise, you can simply attach the three motor brackets to a wood base as long as you match the hole spacing to the base plate shown in Fig. 5.

You need three 1-inch diameter mirrors for your light show. Do not use glass mirrors. They are too fragile and can break or shatter and cause injury. At most plastic supply houses or hobby shops, you can purchase mirrors made of plastic. Ask the clerk to cut the material into 1-inch circles or carefully cut your own. You also need three 1-inch round disks to attach the mirrors to the motors. Here you can use wood or plastic. Whatever material you choose for the mirror mounts should be approximately ⅛-inch thick.

Before mounting the plastic mirrors to the disks, you must drill a hole in the center of each disk. The hole should be a bit smaller than the diameter of the motor shaft to make for a snug fit and it should be drilled at a very slight angle. The angled axis will give the mirror a slight wobble as it spins. A small amount of wobble is necessary for proper operation, but an excessive amount will prevent proper alignment.

Put together the motorized mirror assemblies by attaching the mirrors to the mirror mounts. Use quick-set epoxy, cyanoacrylate adhesive (super glue), or double-sided foam tape and make sure the reflective side faces away from the motor. Repeat the procedure for all three mirrors and mounts, and wait at least an hour for any adhesive to set.

Next attach an aluminum bracket to each of the motors, as shown in Fig. 6, with two No. 2 x 3/32 self-tapping screws. Press a mirror onto each motor shaft. The mounting disc should be pressed onto the shaft as far as possible without hitting the motor screws. If the mirrors spin freely, remove them and then reinstall them using a few drops of adhesive to permanently bond them to the

![Diagram](https://www.americanradiohistory.com)

**FIG. 6—AN ALUMINUM BRACKET** is attached to each motor with two No. 2 x 3/32 self-tapping screws. The mirror-mounting disk should be pressed onto the motor shaft as far as possible without contacting the screws.

![Diagram](https://www.americanradiohistory.com)

**FIG. 7—THE MOTOR ASSEMBLIES** can pivot on the baseplate to allow for alignment of the laser beam.
FIG. 8—LASER BASE UNIT. Any laser will work with the laser light show. The laser shown here is a solid-state unit from an available kit.

FIG. 9—THE REMOTE CONTROL UNIT lets you vary the speed of the three motors in the base unit individually.

motor shafts.

After everything has dried, carefully inspect each motor and mirror assembly. Make sure that the plastic mount, the mirror, and the motor are all firmly attached to each other. Any loose part could fly off and injure somebody. Make sure each mirror turns freely. Do not run the motors if anything is binding or rubbing. Correct any problems now.

Mount the motor assemblies on the baseplate as shown in Fig. 7 and partially tighten the mounting screws. A final alignment will be done later with the laser in place. Solder a pair of wires from the base-unit board to each motor (see Fig. 3). Before soldering, the leads can be trimmed in length to fit the case. It doesn't matter which wire goes to which terminal on each motor.

Any laser will work with the laser light show, as long as the device can be mounted so that the laser beam can be bounced off the mirrors as shown in Fig. 7. The author used a solid-state laser for which a kit is available (see the Parts List). That laser

Continued on page 54
IF YOU HAVE TOUCH-TONE TELEPHONE service, you can now put a call on hold from any phone in your house by plugging this simple device into any telephone jack. The universal hold circuit works with any phone that has a keypad with a # key. To put a call on hold, press the # key and hang the phone up. A timer extends the #-key function while you hang up phones that have a keypad built into the handset.

The universal hold circuit first detects the dual-tone, multifrequency (DTMF) signal that is generated when the # key is pressed. It then activates a circuit that partially loads the telephone line so that the central office thinks a phone is still off-hook even after it is hung up. The hold circuit remains active for five seconds after the # key is released, so the key does not have to be held down while the phone is being hung up. When any phone is again picked up, the hold function is canceled.

**How it works**

Figure 1 shows the schematic diagram of the universal hold circuit. The telephone line is connected to the hold components through bridge rectifier BR1 so that the input is not polarity sensitive. The positive side of the line is always connected to Zener diode D2, and the negative side of the line is always connected to IC2. The telephone line also connects to tone-decoder IC4 through C4 and T1. Power is supplied to the circuit by a 12-volt DC power adapter and by IC5, a 78L05 5-volt regulator, and is filtered by C2 and C3.

Optoisolator IC1 contains a silicon-controlled rectifier (SCR) that latches on after it’s turned on by current flowing through an optically coupled LED within the IC. The SCR continues to conduct even after the LED current is removed, providing that enough anode current is available to sustain it. When the SCR anode voltage is removed and conduction stops, it will not resume until the SCR is again triggered by the internal LED.

When all phones on the line are on-hook, the voltage across the telephone line is about 48 volts. When a phone is taken off-hook, it places a load on the line and a current of about 20 milliamps flows through the phone, which causes the line voltage to drop to about 3 to 8 volts, depending on the telephone. Current also flows through circuits at the central office, indicating that a phone has been picked up.

A call is put on hold when all phones are hung up and the SCR in IC1 is triggered on by circuits driving its LED. When the SCR conducts, current flows through BR1, D2, LED1, IC1, IC2 and back through BR1, placing a load on the line that keeps the central-office circuits active. A 15-volt drop across D2, a 2-volt drop across D1, a 1.5-volt drop across the LED in IC2, and about a 1.5-volt drop across the diodes in BR1 result in the normal 48-volt line voltage being clamped to about 20 volts. That allows line current to flow, but at a higher voltage than normal. The LED lights to indicate that a call is on hold. When a phone is picked up and the line voltage drops to 8 volts or less, there is no longer enough voltage to keep current flowing through D2, D1 IC1, IC2, and BR1, and the hold function is canceled.

The telephone line also connects through capacitor C4 and transformer T1 to capacitor C8, which couples the DTMF signal to the input of IC4, a Motorola MC145436 DTMF decoder used to detect the # key tone. Zener diode D6 clamps IC4’s input voltage to 9.1 volts to prevent damage from transients. The decoder has four outputs that produce a hexadecimal code corresponding to the tones it receives when a key is pressed (see Table 1). Notice that only when the # key is pressed will pins 13 and 14 both go high (logic “1”). That is convenient, as the circuit has to monitor only two outputs of IC4 to decode the # key.

Decoding the outputs of IC4 pins 13 and 14 is done by a logical and circuit consisting of two diodes, D4 and D5, whose cathodes must both be high for their anodes to be pulled high by R5. That discharges C1 through R4 into the positive
supply. When the # key is released, pins 13 and 14 go low again and a negative pulse is produced by C1 and R4 at the trigger input (pin 2) of 555 timer IC3. That starts IC3's timing cycle where pin 3 goes high for about five seconds. That drives current through R3 into the LED within IC1, latching the internal SCR. The five-second output from IC3 keeps current flowing long enough to hang up the phone. The 5-second duration is controlled by R7 and C7 and may be altered by changing the value of R7.

Optoisolator IC2 has a transistor output. After the # key is pressed and the phone is hung up, telephone line current flowing through the LED in IC2 turns its transistor on, which resets timer IC3.

The reset function removes current from the LED in IC1 and allows a hold to be canceled immediately after initiating it without having to wait for the five-second cycle to complete. The transistor within IC2 also performs a power-on reset by having its base coupled through C5 to the positive supply. When

FIG. 2—PARTS-PLACEMENT DIAGRAM. Leave LED1's leads long and bend them in an "S" shape so its position can be adjusted later to fit through a hole in the top of the case.
ALL PARTS LIST

All resistors are 1/4-watt, 5%, unless noted.
R1, R4—56,000 ohms
R2, R5—10,000 ohms
R3—56 ohms
R6, R7—1 megohm

Capacitors
C1, C3—0.1 μF, 50 volts, metal film
C2—1000 μF, 16 volts, electrolytic
C4—0.1 μF, 250 volts, polyester
C5—1 μF, 50 volts, electrolytic
C6, C8—0.01 μF, 50 volts, metal film
C7—4.7 μF, 35 volts, electrolytic

Semiconductors
IC1—H11C1 SCR optoisolator (Harris or equiv)
IC2—4N28 transistor optoisolator (Harris or equiv)
IC3—555 timer
IC4—MC145436 (Motorola or equiv) or CD2204 (Harris or equiv) DTMF decoder
IC5—78L05 voltage regulator
BR1—DF04 1-ampere, 400 volt, DIP bridge rectifier (Allied Electronics or equiv)
D1—not used
D2—1N4744 Zener diode, 15-volts, 1 watt
D3—D5—1N914 silicon diode
D6—1N4739 Zener diode, 9.1 volts, 1 watt
LED1—light-emitting diode, any color, T1-1/4

Other components
XTAL—3.579545 MHz crystal
T1—matching transformer, 600-ohm primary, 600-ohm secondary (Jameco P/N 105902)
PL1—RJ11 modular plug attached to telephone wire

Miscellaneous: three 6-pin IC sockets, one 8-pin IC socket, one 14-pin IC socket, 120-volt AC to 12-volt DC, 100 millamp, power adapter, 2- × 3- × 1-inch plastic project box (Jameco P/N 18921), two cable ties, PC board, wire, solder

Note: The following items are available from American Electromechanical Inc., 134 Van Voorhis Terrace, Wappingers Falls, NY 12590:
- Complete kit of parts including PC board and pre-drilled enclosure—$49.95
- Etched and drilled PC board only—$6.95
Check or money order, only. Add $4.00 shipping and handling. NY State residents must add sales tax

FIG. 3—THE COMPLETED PC BOARD. Point-to-point wiring will also work for this project.

FIG. 4—THE BOARD FITS TIGHTLY in a 2- × 3- × 1-inch plastic case, and is held securely without any hardware.

POWER IS TURNED OFF. C5 discharges through D3.

Construction
Since this is a low-frequency circuit, parts layout and wiring are not at all critical. Parts tolerances are not critical, and equivalent types may be substituted.
The prototype was built on a small PC board for which we've provided a foil pattern. Point-to-point wiring will work just as well, however.

If the printed-circuit board is used, use Fig. 2 as a guide to install the parts. It's always best to use IC sockets for all ICs, although they aren't absolutely necessary.

When installing LED1, leave its leads long and bend them in an S shape so its position can be adjusted later on to fit through a hole in the top of the case. After all parts are installed, plug the ICs into their sockets. Keep in mind that IC4 is a CMOS device that is sensitive to ESD or electrostatic discharge. Figure 3 shows the completed PC board.
The author installed the board in a 2- × 3- × 1-inch plastic case (see Parts List), in which the board fits perfectly and is held securely without any hardware. You are free to use any case you like, but the installation details are up to you if you decide to go that route.

Place a nylon tie around the power leads and the telephone wire to act as strain relief, or tie knots in them to serve the same purpose. Cut and file slots in the edge of the case to pass the wires through and drill a hole in the top of the case directly above where the LED will be once the board is installed. Figure 4 shows how the board fits into

Continued on page 54
This article explains the design of a many different low-power electronic voltage converters. These circuits generate higher-value supply voltages from low-voltage DC sources and negative DC voltages from positive DC voltage sources. The circuits in this article include the popular 555 industry-standard timer IC and the Harris Semiconductor ICL7660 voltage converter IC, devices that simplify the design and construction of a variety of voltage converter circuits.

Low-voltage generation.

The easiest way to increase the voltage level of a DC source voltage or reverse its polarity is to apply that DC voltage to a free-running, squarewave generator whose output is fed to a multisection capacitor-diode voltage-multiplier network. Figure 1 shows block diagrams for positive and negative output voltage converters.

If a positive output voltage is desired, the multiplier must provide a noninverting response, as shown in Fig. 1-a. But if a negative output is required, the multiplier must function as an inverter, as shown in Fig. 1-b.

Voltage converters are based on a variety of multivibrator circuits. These converters can include free-running, squarewave-generating multivibrators based on bipolar or field-effect (FET) transistors or CMOS or TTL integrated circuits. In general, the squarewave generators should oscillate at frequencies between 1 kHz and 10 kHz so that the multiplier section can operate efficiently. This frequency range permits the use of multiplying capacitors with low values.

An easy way to build a voltage converter is to design it around an industry-standard 555 timer IC. (This versatile device and many practical circuits that include it were discussed in the November and December issues of *Electronics Now*, starting on pages 61 and 62, respectively.) The 555 can source or sink up to 200 milliamperes when set up as a free-running squarewave generator.

Figures 2, 3, 4, and 5 are voltage-converter circuits based on the 555. The 555 is configured...
CONVERTERS -conversion circuits from popular to work in your own circuit designs.

as a free-running astable multivibrator (squarewave generator) operating at about 3 kHz in all of these circuits. The 3-kHz frequency is determined by the values of resistors R1 and R2 in series with capacitor C2. Supply-line capacitor C1 prevents the 3-kHz output of the 555 from feeding back into the device, and capacitor C3 enhances circuit stability.

The circuit in Fig. 2 is a DC voltage-doubler that generates a DC output voltage with a value that is approximately twice that of the supply voltage. The 555's output is fed to a voltage-doubler network made up of capacitors C4 and C5 and diodes D1 and D2. The network produces the approximate two times supply voltage output when that output is unloaded.

The precise output value is:
\[ 2 \times V_{\text{peak}} - (V_{\text{fd1}} + V_{\text{fd2}}) \]
Where: \( V_{\text{peak}} \) is the peak output voltage of the squarewave generator \( V_{\text{fd1}} \) and \( V_{\text{fd2}} \) are the forward voltage drops (about 600 millivolts) of multiplier diodes D1 and D2.

The output voltage of the circuit decreases when the output is loaded.

The Fig. 2 voltage doubler circuit will work with any DC supply of 5 to 15 volts. Because of its voltage-doubling response, it can provide voltage outputs over a range of about 10 to 30 volts. Higher voltage can be obtained by adding more multiplier stages to the circuit.

The Fig. 3 DC voltage tripler circuit can provide output voltages from 15 to 45 volts. The Fig. 4 DC voltage quadrupler circuit can provide output voltages from 20 to 60 volts.

Figure 5 is the schematic for a DC negative-voltage generator, capable of producing an output voltage that is approximately equal in amplitude but opposite in polarity to that of the power supply. It also operates at 3 Hz, and it drives an output stage consisting of capacitors C4 and C5 and diodes D1 and D2. This circuit's split-supply output is useful for powering ICs that require both positive and negative power from a single-ended source.

High-voltage generation.

The generation of higher output voltages with voltage multipliers is usually cost-effective only when the values of the required voltages are less than six times the supply voltage. Where very large step-up ratios are required (e.g., hundreds of volts generated from a 12-volt supply), other circuit designs are recommended.

It is usually cost-effective to apply the output of the low-voltage oscillator or squarewave generator as the input to a suitable step-up voltage transformer. The required high AC output voltages appear across the transformer's secondary winding.

This AC voltage can easily be converted back to DC with a...
Figure 6 is a DC-to-DC converter circuit that can generate a 300-volt DC output from a 9-volt DC power source. In this circuit, transistor Q1 and its associated circuitry form a Hartley inductive-capacitive (LC) oscillator. The voltage on the primary winding that swings between zero and 9-volts is applied to 250-volt transformer T1. The inductance of the primary is the inductive element in the LC oscillator, which is tuned by capacitor C2.

The supply voltage is stepped up to about 350 volts peak at the secondary of T1. This output is half-wave rectified by diode D1, and it charges capacitor C3. Without a permanent load on C3, the capacitor can deliver a powerful but non-lethal electrical shock. With a permanent load, the output drops to about 300 volts at a load current of a few milliamperes.

The Fig. 7 circuit can either drive a neon lamp or generate a low-current DC voltage of up to several hundred volts from a 5- to 15-volt DC supply. The 555 is configured as a 3-kHz astable multivibrator whose square-wave output is fed to the input of transformer T1 through the resistor R3.

In this circuit, T1 is a small audio transformer with a turns ratio necessary to give the desired output voltage. In this circuit, a 10-volt supply and a transformer with a 1:20 turns ratio will give an unloaded DC output of 200 volts peak. This AC voltage can easily be converted to DC with a half-wave rec-

simple rectifier-filter network, if required. Figures 6, 7 and 8 show schematics for low-power, high-voltage generation circuits based on this principle. Figure 7 is a DC-to-DC converter circuit that can generate a 300-volt DC output from a 9-volt DC power source. In this circuit, transistor Q1 and its associated circuitry form a Hartley inductive-capacitive (LC) oscillator. The voltage on the primary winding that swings between zero and 9-volts is applied to 250-volt transformer T1. The inductance of the primary is the inductive element in the LC oscillator, which is tuned by capacitor C2.

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CMOS voltage converter

The Harris ICL7660 is a monolithic CMOS voltage converter that converts its supply voltage from positive to negative for an input range of +1.5 volts to +10 volts. This results in complementary output voltages of -1.5 volts to -10 volts. For example, if powered from a +5-volt source, the device will generate a -5-volt output.

The ICL7660 has a typical open-circuit voltage conversion efficiency of 99.9% and a typical power efficiency of 98%. When the output is loaded, the ICL7660 acts like a voltage source with an output impedance of about 70 ohms. It can supply maximum currents of about 500 microamperes.

Only two external capacitors are needed to perform the charge pump and charge reservoir functions. The ICL7660 can also be configured as a voltage doubler and will generate output voltages up to +18.6 volts with a +10-volt input.

The DC-to-AC inverter circuit in Fig. 8 will produce an AC output at line frequency and voltage. The 555 is configured as an astable multivibrator whose output frequency can be adjusted over a range of 50 to 60 Hz by trimmer potentiometer R5.

The output of the 555 is fed to the paired NPN and PNP bipolar transistors Q1 and Q2, and their output is fed into the low-voltage side of reverse-connected filament transformer T1. It has the necessary step-up turns ratio. Capacitor C4 and coil L1 filter the input to ensure that the transformer input is essentially a sinewave.

Figure 9 is the functional block diagram of the ICL7660.
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It contains an RC oscillator, divide-by-2 circuit, voltage-level translator, voltage regulator, four output power MOS switches, and an unusual logic network. The logic network senses the most negative voltage in the device and ensures that the output N-channel switch source-substrate junctions are not forward biased. This is intended to ensure latch-up-free operation.

The unloaded oscillator oscillates at a nominal frequency of 10 kHz when the input supply voltage is 5.0 volts. This frequency can be lowered by the addition of an external capacitor to the osc terminal, or the oscillator can be overdriven by an external clock.

The LV terminal can be tied to ground to bypass the internal series regulator and improve low voltage (LV) operation. At medium to high voltages (+3.5 to +10.0 volts), the LV pin is left floating to prevent device latchup.

The ICL7660 is available in eight-pin minidIP and small-outline IC (SOIC) packages as well as TO-99 cases. Figure 10 is the drawing of pin configurations for the eight-pin minidIP package, the least expensive version. Power dissipation of this package is 300 milliwatts. The ICL7660S, an enhanced direct replacement for the ICL7660, is now available and can be substituted if desired.

The operation of the ICL7660 is similar to that of the oscillator and voltage-multiplier shown in Fig. 2, but it performs that function more efficiently. As stated earlier, the use of conventional silicon multiplier diodes causes the circuit's unloaded output voltage to drop by about 1.2 volts—the sum of the forward voltage drops of the two diodes.

The ICL7660 eliminates the voltage drop by replacing the diodes with MOS power switches. These switches are driven by the logic network so that each switch automatically closes when it is forward biased and opens when it is reverse biased. This feature accounts for its high operating efficiency.

**Do's and don'ts**

The manufacturer recommends some Do's and Don'ts to assure reliable device operation:

1. Do not exceed the device's maximum supply voltage.
2. Do not connect any pins to voltages greater than +V or less than ground.
3. If the IC is operating in the power supply range of 1.5 to 3.5 volts, ground the LV-SX pin 6; at supply values greater than 3.5 volts, leave pin 6 open-circuited.
4. Do not short circuit the output to the +V supply for volt-

**Continued on page 62**
Customize analog meter faces with your PC and a laser printer.

Finding the right meter
The first step to successfully making a newly labeled meter is to start with the right meter. Although many meters can be found for very reasonable prices in the surplus market, not every meter is a candidate for a new scale. Several specifications, such as the full-scale current and the meter movement's resistance, are critical in determining whether a meter is a suitable choice.

To change the scale of a meter, the face must be accessible. Some inexpensive meter movements have cases that can't be opened, and these should be avoided. Generally the cover of a meter face can either be removed by simply prying it off, or by removing several small screws on the outside of the meter. The second task is to remove the meter face itself. Again, some inexpensive meters might have their faces mounted permanently, but the majority of meters have several small screws that hold the meter face in place. The ability to remove the meter face is essential.

Other things that must be known about the meter before it can be used in a circuit properly are its full-scale current and the resistance of its movement coil. For a new meter, these are easy to determine from the meter's specification sheet. Sometimes you will be lucky enough to find information printed on an old meter face that will help determine the full-scale reading.

If you know nothing about a meter's electrical specifications, they can be determined rather easily. Generally most meters have a full-scale current between 100 microamperes and 1 milliampere. Coil resistance generally varies between about 40 and 1000 ohms. The setup to measure full scale current and coil resistance is simple. The value of the power supply is not critical. A potentiometer between the supply and the unknown meter should be large enough to limit current to about 50 microamperes (about 200K). First set the potentiometer to its maximum value, turn on the power supply, then decrease the resistance until the meter reads full scale. Measure...
the voltage of the supply and the value of the variable resistance. The voltage divided by the resistance will then give you the current required to deflect the meter full scale.

Another potentiometer can determine the meter coil resistance. With the meter indicating full-scale current, place a 1K potentiometer across the meter and adjust until the meter reads exactly ½ scale. Remove this potentiometer and measure its value. This will be the value of the coil resistance of the meter. The meter in Fig. 1 had a full-scale current reading of 229 microamperes and a coil resistance of 819 ohms.

Making faces

A protractor is the best tool for measuring the total angle of movement of the meter needle, which generally runs from 90 to 120 degrees. Also measure the distance from the pivot point to the scale of the old meter face and the location of the face-plate mounting holes with respect to the pivot point. Those measurements will be input to the program that draws the new meter face.

The next step in putting a new face on your meter is to carefully remove the old meter face plate. After opening up the meter case it is usually just a matter of removing the small screws holding the face plate on. A set of jeweler’s screw drivers can sometimes be helpful for particularly small meters. Once the face plate is loose it can be removed by very carefully sliding it from under the needle of the meter. Be careful not to bend or bump the needle.

Using HPGL

HPGL is a graphics language of short, simple statements that allows lines, arcs, and text to be drawn. Originally developed for plotters, this language has been incorporated into many of today’s laser printers. By using just a few of the many HPGL statements, professional looking meter scales can be created with customized features.

The BASIC language can send HPGL commands to the printer for drawing the various features of the scale. Using a computer language to send the commands to the printer is helpful because many commands can be generated using program loops with an incrementing variable. This lets rather short programs generate many different individual graphic elements to compose the new meter face plate.

Listing 1 is the BASIC program that draws the meter face in Fig. 2. Only a few of the many HPGL commands are used in the program. Most are two-letter commands followed by arguments. In Listing 1 many of the arguments are calculated by the BASIC program. The program plots points on a graph that has
ANGLE
LPRINT
LPRINT "LB10"
LPRINT "LBVOLTAGE*;"
LPRINT "L04;"
LPRINT "SD1,21,2,1,4,10,7,4148;"
REM
FOR
LPRINT "PW.S;"
REM
NEXT
LPRINT "PA"
LPRINT "PD;"
LPRINT "PA"
LPRINT "PW S-;"
REM
FOR
LPRINT "LB15*
REM
NEXT
LPRINT "PA"
LPRINT "PU"
LPRINT "PD;"
LPRINT "PA"
LPRINT "PW-;"
REM
LPRINT "XORG 5IN(I - K); "
LPRINT "YORG 5IN(I - K); "
LPRINT "COS(( -ANGLE / 2) K) ; "
LPRINT "YORG + COS(I * K) + ORAD; "$;
LPRINT "YORG + COS(I * K) + ORAD; "$;
LPRINT "PA; XORG + SIN(I * K) - IIRAD; "; YORG + COS(I * K) + IIRAD: ";
LPRINT "PD;"
LPRINT "PA; XORG + SIN(I * K) - ORAD; "; YORG + COS(I * K) + ORAD; ";
LPRINT "PU;"
NEXT I
REM
LPRINT "SD1,21,2,1,4,10,7,4148;"
LPRINT "DT*,1"
LPRINT "L05;" LPRINT "LBVOLTAGE*;"
LPRINT "PA; XORG; " YORG + 900; " I"
LPRINT "L04;"
LPRINT "LABATTERY*;"
REM
LPRINT "PA; XORG; " YORG + 750; " I"
LPRINT "LBPVOLTAGE*;"
REM
REM - SET UP TO LABEL THE METER AND PRINT "BATTERY VOLTAGE"
LPRINT "L016;"
LPRINT "PA; XORG + SIN((-ANGLE / 2) * K) * IIRAD; "; YORG + COS((-ANGLE / 2) K) * IIRAD; ";
LPRINT "DI; \cos(\text{ANGLE / 2} \cdot K); "; \sin(\text{ANGLE / 2} \cdot K) ; " I"
LPRINT "LB10+;"
LPRINT "PA; XORG + SIN(\text{ANGLE / 2} \cdot K) * IIRAD; "; YORG + COS(\text{ANGLE / 2} \cdot K) * IIRAD; ";
LPRINT "DI; \cos((-ANGLE / 2) \cdot K); "; \sin((-ANGLE / 2) \cdot K) ; " I"
LPRINT "LB15+;"
REM
REM - PUT THE LOWER AND HIGH VALUE BELOW THE SCALE ARC
LPRINT "L016;"
LPRINT "PA; XORG + SIN((-ANGLE / 2) * K) * IIRAD; "; YORG + COS((-ANGLE / 2) K) * IIRAD; ";
LPRINT "DI; \cos(\text{ANGLE / 2} \cdot K); "; \sin(\text{ANGLE / 2} \cdot K) ; " I"
LPRINT "LB10+;"
REM
REM - PUT THE INTERMEDIATE VALUES ABOVE THE SCALE ARC
LPRINT "L016;"
LPRINT "PA; XORG + SIN(I * K) * ORAD; "; YORG + COS(I * K) + ORAD; ";
LPRINT "DI; \cos(-I * K); "; \sin(-I * K) ; " I"
LPRINT "LB15; INT(I / \text{ANGLE / MAJORDIV}) + 12.5) ; " I"
NEXT I
REM
REM - PUT IN THE LOCATION DOTS FOR THE MOUNTING HOLES
LPRINT "PA; XORG - 508; "; YORG; " I"
LPRINT "PD;"
LPRINT "PA; XORG + 508; "; YORG; " I"
LPRINT "PD;"
LPRINT "PU;"
REM
REM - RESET THE PRINTER
LPRINT CHR$(27); "@OA"
LPRINT CHR$(27); "E"  END

FIG. 2—THIS METER FACE is the result of the BASIC program in Listing 1.

1016 points (pixels) per inch in both the X and Y directions.

Here's a list of the commands that are used and short descriptions:
IN—Initialize
SP—Select Pen
PW—Set Pen Width
PA—Plot Absolute
AA—Arc Absolute
PU—Pen Up
PD—Pen Down
SD—Standard Font Definition
DT—Define Label Terminator
SS—Select Standard Font
LO—Label Origin
LB—Label

The syntax of those commands is explained in the technical reference section for the HPGL language in your printer manual. Since some commands take X and Y coordinate locations, some simple trigonometry is used to calculate the arguments from the index angle in the program of Listing 1.

Developing your own meter face is a simple matter of running the program and printing the resulting graphics on the printer. You probably won't get it right the first time, but making modifications is easy. Writing the program in blocks that add a new graphic after each iteration works best. Printing locating marks on the new face for the mounting holes helps to align the new face properly on the old face plate.

Once everything looks the way you want it to on paper, print the results on a full-page laser label. It's best to apply the new label on the reverse side of the old face plate since it's usually a nice clean surface. Punch pinholes in the location marks to help locate them from the back side of the label. Peel off the backing of the new scale label and place the label face down. Then stick the face plate to the label, lining up the locator holes in the center of the face plate mounting holes. After applying the label use a modeling knife to trim the excess paper from around the meter face plate and mounting holes. Figure 3 shows the new label applied to the old meter.

Reassembly finishes the job. Carefully slide the face plate under the meter needle and replace the mounting screws. Next, replace the meter cover.

Creativity is the key to adding an exciting meter display to your next project. Expanded-scale voltmeters are an ideal application for this technique. Power supply current meters are also nice to have. This technique can also create non-linear meter scales such as decibel meters for audio or RF applications. Meter recycling can enhance your projects with just a small investment in time.

FIG. 3—HERE IS THE NEW LABEL pasted onto the surplus meter.
make sure that the mirror cannot accidentally hit the laser when it does turn. Loosen the bracket-to-base mounting screws and adjust the position of each motor so that the laser beam is reflected from the first mirror to the second mirror and then to the third mirror and out the side.

Next, fine tune the beam alignment by slowly turning each mirror by hand. As the mirror turns, the beam will be deflected. Adjust the position of each motor so that the deflected beam never leaves the surface of any mirror.

Adjust the last motor so that the laser beam will correctly exit through the hole in the enclosure cover when it is installed over the base.

Once everything is aligned, aim the laser light show at a blank wall or screen. As you vary the speed of each motors you'll see the endless variety of spiral forms that are created. If something was not assembled correctly, stop the motors before you try to adjust anything. When you are satisfied with the light show's alignment and operation, shut both the unit and the laser off and install the cover on the base unit.

This project should provide hours of fun and excitement. Everyone who sees it will want to take a turn at the remote control unit. Use your imagination in a dark room—with some background music and a little smoke you can create some truly sensational shows!

Alignment and operation

Do not attach the cover to the base unit until you have checked the operation of the motors and have finished the alignment of the mirrors. During check-out and alignment, follow all laser safety precautions and never let the beam shine into anyone's eyes. Wear eye protection when running the motors without the enclosure cover in place.

Connect the handheld remote to the base unit with a 6-conductor modular cord. Next, plug the wall outlet adapter into an outlet and into J1. The toggle switch on the remote turns the unit on and off, and the motors will spin with varying speeds as you adjust the three potentiometers.

With the laser device positioned as shown in Fig. 7, and without the motors running, apply power to the laser and make sure that the beam strikes the first mirror as shown, and the case.

Before closing up the case, connect the hold circuit to the telephone line and plug the wall transformer into an AC outlet. Pick a phone up, press the # key, and hang it up within five seconds; the LED should light. Pick a phone up and the LED should go out. Press the # key, wait about eight seconds, and hang the phone up; the LED should not light.

Operation

The power supply, DTMF decoder, and timing circuits are isolated from the telephone line by the optoisolators and transformer. The five-second timing cycle that starts after the # key is released gives ample time to hang up a phone with a keypad on the handset. If the keypad is on the telephone base, the # key can be pressed while the phone is hung up.

If the # key is pressed for reasons other than to place a call on hold, such as to signal the end of a number entry after using a fax-back service, the timing cycle will end after five seconds and will probably not be active when the phone is hung up. To be sure that the line is not on hold after using the # key, just pick the phone up and hang up again.

FIG. 10—THE LASER LIGHT SHOW consists of a wired remote control and the laser base unit that holds the rotating mirrors.
Have you ever been shocked by an excessive phone bill? If so, PhoneMeter's for you. This low-cost, "intelligent" device allows you to monitor the cost of your phone calls—as you make them. In addition, it also provides useful clock and alarm functions.

During its operation, PhoneMeter displays, on a four-digit LED display, the minute-by-minute charge of each phone call as it accrues. And when a phone conversation is not taking place, the LED display gives the present time. You can review and update the alarm time as needed.

The PhoneMeter works by maintaining a list of as many as 150 telephone numbers, each with an associated per-minute cost. A default rate allows you to estimate the cost of calls to non-listed numbers. Alternatively, the default rate can be set to a value of one to display the time in minutes of each call.

Other features include:

- After the unit is calibrated, all setup is done with the telephone keypad. You'll need a Touch-Tone—not a pulse—phone with this project.
- You can disable and reset the phone cost summing function as desired.
- You can increase or decrease all rates by a specific value (measured in cents).
- Per-minute cost varies according to the telephone rate schedule. Calls between 8 AM and 5 PM Monday through Fri-
day are charged the full rate. After 5 PM, calls are discounted 30%, and after 11 PM, 50%. Calls are also discounted 50% on weekends. Of course, you can adjust those values to match the values charged by your local phone company.

The PhoneMeter begins timing from the moment the call begins ringing on the receiving end. The display is updated on a one-minute basis: charges are not displayed for calls shorter than one minute.

Dual-tone multiple frequency (DTMF) decoders in conjunction with an 8085A microprocessor provide the required “smarts.” Setup and calibration are simple, and although there isn’t room to print it here, complete assembly-language source code is available from the Gernsback BBS (516-293-2283, V32, V.42bis); look for file PHONMET.ZIP. The file also contains an object-code file suitable for most EPROM programmers.

How to use it

PhoneMeter has three modes of operation: normal, function, and data. Normal mode displays time and ongoing call charges. Function mode allows you to enter times and default values. Data mode allows you to enter telephone number and rate data. Enter data mode by pressing the asterisk key ("*"), and enter function mode by pressing the pound key ("#").

On entering function mode, the display reads “E000.” To aid data entry, the display always shows the last digit entered in the right position, and the total number of keys pressed in the left two positions. Enter time in a 24-hour format. Most-significant digit first, and include leading zeros. Table 1 lists the available functions.

On entering data mode, the display reads “E000.” To aid data entry, the display always shows the last digit entered in the right position, and the total number of keys pressed in the left two positions.

Enter each phone number as you would dial it. After entering the complete telephone number, press the pound key, then enter the two-digit base rate associated with that number, using a leading zero, if necessary. After the two cost digits have been entered, the display shows “E000” to indicate that the

<table>
<thead>
<tr>
<th>Key</th>
<th>Function</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>#0</td>
<td>Disable cost monitoring function</td>
<td>Meter functions only as a clock and alarm</td>
<td>For Wednesday, 9:14 AM, enter 09143</td>
</tr>
<tr>
<td>#1</td>
<td>Enable cost display</td>
<td>Meter displays time and cost information</td>
<td>For 9:34 PM, enter 2134; for 8:56 AM, enter 0856</td>
</tr>
<tr>
<td>#2</td>
<td>Enter current time and day</td>
<td>Time in 24-hour format, including leading zeros if necessary. Day numbering: Mon = 1, Tue = 2, Wed = 3, Thu = 4, Fri = 5, Sat = 6, Sun = 7</td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td>Set alarm time</td>
<td>Time in 24 hour format, including leading zeros if necessary</td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>Display alarm time</td>
<td>Display alarm time in 24 hour format as long as “4” key is pressed</td>
<td></td>
</tr>
<tr>
<td>#5</td>
<td>Enter default cost</td>
<td>Cost per minute, two digits</td>
<td></td>
</tr>
<tr>
<td>#6</td>
<td>Increase all rates</td>
<td>Increase or decrease the cost of all telephone numbers by the specified amount. Enter two digits including leading zeros if necessary. Default rate not affected. Decrease by entering tens complement</td>
<td></td>
</tr>
<tr>
<td>#7</td>
<td>Reset database</td>
<td>Erase all phone numbers in memory</td>
<td></td>
</tr>
</tbody>
</table>

FIG. 1—STANDARD TELEPHONE keypad: A connection at any junction produces the two tones associated with the corresponding row and column.

FIG. 2—STANDARD TELEPHONE voltages: When on-hook, voltage is at least –36 volts. When it is off-hook, voltage rises to about –5 volts. The “click” is caused by a temporary transition to 0 volts when the phone initially goes off-hook.
How it works

To understand how the PhoneMeter works, it's necessary to review some background on telephone line operation.

A standard phone cable has four wires: red, green, black, and yellow. Voice communication occurs on the red and green wires, yellow is for the ringer, and black is the common connection. The phone meter uses only the red and green wires, with the green wire connected to circuit ground.

Modern telephones use a dual tone multiple-frequency signaling scheme to generate unique frequency-pair combinations for each element of a 4 × 3 array of keys, as shown in Fig. 1. Whenever a key is pressed, the DTMF circuitry generates the pair of tones represented by the row and column headings of that element of the matrix. For example, pressing the "4" key causes 770- and 1209-Hz tones to be generated.

Now consider the signaling voltages. When the phone is on-hook (not in use), the voltage on the red wire is −36 volts or less. When the phone is off-hook (in use), that value drops to about −5 volts. The click heard when the phone initially goes off-hook occurs because of a momentary 0-volt signal, as shown in Fig. 2.

Voice-signal amplitude varies in proportion to sound strength. It can reach 4 volts peak-to-peak when someone yells into the phone. Synthesized DTMF tones typically have values of approximately 4 volts p-p.

With that background in mind, look at the circuit. First look at the analog portion of the circuit, which includes the tele-
SOFTWARE

There is insufficient space to print the entire 8085A assembly-language source code, so a brief overview of the software will be provided. It consists of a start-up process, a main program loop, an interrupt-service routine for handling the real-time clock, various utility functions, and variables. Table 3 describes key variables, and Table 4 describes major subroutines.

Program Initialization. At power-up, the microprocessor begins execution at address 0000. That address contains a jump to the initialization routine, which sets up the stack (at RAM address 47FFH), enables interrupt 5.5 (for the real-time clock), and performs other initialization chores.

Real-time Clock Interrupt. The multivibrator circuit generates a 70-µs pulse at a 60-Hz rate. Each pulse triggers the microprocessor's RST 5.5 interrupt, which in turn calls the clock routine. The clock increments a set of time-keeping counters (seconds, minutes, hour, day).

Main Loop. The main program loop displays present time and checks whether the alarm should be turned on or off. It then checks to see whether the phone is on-or off-hook. If the phone is off-hook, the program then determines whether a key has been pressed. If the "#" or "*" keys were pressed, the software jumps to the appropriate function code loop. If the phone remains off-hook for 60 seconds and no function keys are pressed, the program goes into the charge recording mode, in which rates are summed, discounts applied, and the results displayed.

Table 3—Key Program Variables

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARMIN AND ALARHR</td>
<td>Alarm time setting</td>
</tr>
<tr>
<td>COUNT</td>
<td>Tracks number of keys pressed</td>
</tr>
<tr>
<td>COUNT-SEC</td>
<td>Number of seconds since phone went off hook. If greater than 20, further key receipt inhibited.</td>
</tr>
<tr>
<td>COST</td>
<td>Base rate value associated with current phone number, or default value if not match.</td>
</tr>
<tr>
<td>COST-ACCUM</td>
<td>Accumulated by-minute cost of current call.</td>
</tr>
<tr>
<td>DATA</td>
<td>Start of telephone number and base rate cost data list.</td>
</tr>
<tr>
<td>DATA-END</td>
<td>One byte beyond telephone data.</td>
</tr>
<tr>
<td>DAY</td>
<td>Current day of week (Monday=0, Tuesday=1,..., Sunday=6)</td>
</tr>
<tr>
<td>DATA--AT</td>
<td>Address of current field in DATA.</td>
</tr>
<tr>
<td>DEFAULT</td>
<td>Pointer to address that contains default rate, in high, low order.</td>
</tr>
<tr>
<td>DGO-DIG12</td>
<td>Address of current display data.</td>
</tr>
<tr>
<td>DISPLAY-SW</td>
<td>If 1, displays ongoing cost; if 0, does not.</td>
</tr>
<tr>
<td>HOUR</td>
<td>Current hour.</td>
</tr>
<tr>
<td>NINFSEC and INITMIN</td>
<td>Time of most recent key press.</td>
</tr>
<tr>
<td>KDIG0-KDIG12</td>
<td>Keypad buffer.</td>
</tr>
<tr>
<td>KEY</td>
<td>Last key pressed. Contains 8 bits if decode error. FFH if no key pressed and phone off-hook, or FFH if phone on-hook.</td>
</tr>
<tr>
<td>MIN</td>
<td>Current minute.</td>
</tr>
<tr>
<td>SEC</td>
<td>Current second.</td>
</tr>
<tr>
<td>SIXSEC</td>
<td>Counts 160 second interrupts from real-time clock.</td>
</tr>
</tbody>
</table>

Table 4—Major Subroutines

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLONOFF</td>
<td>Turns control by writing 1 to bit 0 of Port C.</td>
</tr>
<tr>
<td>COLONON</td>
<td>Turns control by writing 0 to bit 0 of Port C.</td>
</tr>
<tr>
<td>CONNECTED</td>
<td>Inhibits key detection. Called after connect click detected.</td>
</tr>
<tr>
<td>COST-OUT</td>
<td>Sums next cost increment into cost-accumulation register.</td>
</tr>
<tr>
<td>DISPLAY-DE</td>
<td>Displays low-order nibble of E register on digit 3, high-order nibble on digit 2, low-order nibble of D register on digit 1, and high-order nibble on digit 0.</td>
</tr>
<tr>
<td>DISPLAY</td>
<td>Display values stored in DIG0-DIG3.</td>
</tr>
<tr>
<td>DIV</td>
<td>Divides BCD value in A register by BCD value in D register. Result goes to E and remainder to B. D is first converted to tens complement. Division then performed by multiple addition of tens complements.</td>
</tr>
<tr>
<td>FCDSCD</td>
<td>Disenables display of phone costs.</td>
</tr>
<tr>
<td>FCENC</td>
<td>Enables display of phone costs.</td>
</tr>
<tr>
<td>GET-COST</td>
<td>Searches phone data to find match between values in KDIG0-KDIG12. If match, low-order nibbles of next two addresses combined and saved at address specified by COST. If no match, address DEFAULT saved at all address specified by COST.</td>
</tr>
<tr>
<td>GET-KEY</td>
<td>Buffers keypresses into phone keyboard buffer.</td>
</tr>
<tr>
<td>INIT</td>
<td>Configures 8255 to make ports A and C outputs, Port B input. Initializes data and display.</td>
</tr>
<tr>
<td>KEYSAV</td>
<td>Saves each key in key buffer, displays last key entered in display digit 3, displays keystroke count in digits 0 and 1.</td>
</tr>
<tr>
<td>PHBL2A</td>
<td>Determines cost of next minute, adds to current cost, displays.</td>
</tr>
<tr>
<td>PMOFF</td>
<td>Turns PM indicator off.</td>
</tr>
<tr>
<td>PMON</td>
<td>Turns PM indicator on.</td>
</tr>
<tr>
<td>WAITKEY</td>
<td>Calls GET—KEY until phone is off-hook and no key is pressed.</td>
</tr>
<tr>
<td>ZERO-DIG</td>
<td>Loads zeros in DIG0-DIG3.</td>
</tr>
<tr>
<td>ZERO-KDIG</td>
<td>Loads zeros in KDIG0-KDIG12.</td>
</tr>
</tbody>
</table>

The telephone interface

The telephone-line interface consists of a 741 op-amp, seven LM567 tone decoders, and two 2N5951 N-channel JFETs, as shown in Fig. 3. The op-amp input and output both are AC coupled. The op-amp has a gain of one; potentiometer R7 adjusts the input signal so that a 1.75-volt p-p signal drives the tone decoders.

Obtaining class A output (an unclipped signal) from the op-amp requires biasing the non-inverting input of the amplifier to 2.5 volts, midway between the +5-volt supply and ground. The bias voltage is generated by the voltage divider consisting of R10 and R11.

Each tone decoder responds to one of the seven required DTMF signals (H1—H3, L1—L4). The output of a given tone decoder goes to logic low whenever it detects the presence of the desired frequency. That frequency depends on the value of the resistor connected between pins 5 and 6 of the IC, and on the capacitor connected between pin 6 and ground. The center frequency of the tone decoder is determined by the frequency equation:

$$F_o = \frac{1}{1.1 \text{RC}}$$

For some frequencies, fixed RC combinations give the desired results. The generation of other tones such as 697, 770, 941, and 1747 Hz, requires variable resistors.

The JFETs provide on-hook and click detection. When the phone is on-hook, the red-wire voltage varies from -36 to -50 volts. On-hook detection requires that the gate of Q1 be biased to +5 volts. That is accomplished via 150-kilohm resistor R1. The biasing ar-
rangement lets the JFET begin conducting when the red-wire voltage is greater than -9 volts (i.e., between -9 and 0 volts).

Click detection is accomplished in a similar manner, except that the JFET (Q2) has no positive bias, so it does not begin conducting until voltage approaches 0. The -5-volt level that is present when the phone is off-hook suffices to keep the JFET off. The click detection output drives the serial input data (SID) input of the 805A. The serial input data input functions as a one-bit port on the microprocessor.

**Microprocessor and company**

The “brain” of the project consists of an Intel 8085A microprocessor. 2 kilobytes of 8-bit RAM, an 8-kilobyte EPROM, an address latch, and a 4-to-10 line decoder, as shown in Fig. 4. One unusual feature of the circuit is that part of what is normally RAM address space, rather than the separate I/O space, is used for addressing its I/O devices. This permits the use of non-Intel bus-compatible peripherals.

The microprocessor runs at a clock rate of about 1 MHz, as supplied by a 20 pF capacitor (C26) and a 10-kilohm resistor (R40). Crystal control is not required because the 60-Hz AC power line provides suitable accuracy for time-keeping.

The 8085A multiplexes the data bus with the low-order address lines. Hence IC10 latches the low-order address lines for addressing RAM and ROM. Latching occurs when the microprocessor's address latch enable (ALE) line goes high. At that point, the low-order address lines are available at the outputs of IC10.

The 74LS42 (IC11) decodes the upper nibble of the address bus to provide 10 unique 4-kilobyte regions of address space; of those the circuit uses three. The EPROM begins at address 0000H, the 8255 programmable peripheral interface (PPI) discussed next begins at 2000H, and the RAM begins at 4000H. Because the address space is not fully decoded, only half the EPROM is accessible, half the RAM's address block is wasted, and the PPI uses only four of the 4096 available slots. The circuit has no need for additional address space.

**I/O control**

When the microprocessor accesses memory addresses 2000–2003H, it is addressing the 8255 PPI, as shown in Fig. 5. The PPI has three eight-bit ports, A, B, and C, which are addressed at 2000–2002H, respectively. Location 2003H is the PPI's control register; it determines the operating modes of the three ports.

Port A provides address and

---

**FIG. 4—THE MICROPROCESSOR AND MEMORY INTERFACE** appears here. Decoder IC11 breaks the address space down into ten 4-kilobyte blocks; in this circuit, the 8255 is memory-mapped.
data information for LED decoder/driver IC15. Three address bits allow each of the four LED digits to be addressed separately. The PPI provides those three bits via the low three bits of Port A. The four high bits of Port A provide the values that the LED digits display.

Port B accepts the inputs from the analog circuitry. The seven tone decoders drive bits 0–6 of port B: the on-hook detector (Q1) drives bit 7. When the phone is on-hook, all Port B inputs are high.

By setting bit 7 of the command register (address 2003H) to 0, each bit of port C can be individually set or reset. One bit of Port C provides the write function that latches data into LED driver (IC15). Several other bits control auxiliary display functions and the alarm driver (Q3). Table 2 shows several sample values and the corresponding actions taken by the circuit.

The LED display is a four-digit, common-anode type, with colon and PM indicator. The display driver interprets digits numbered 0 to 3 from left to right.

The last section of hardware that will be discussed is the real-time clock. The clock circuit appears in Fig. 6, along with the power supply via a clipping network, the 60-Hz power line drives a pair of 74123 monostable multivibrators arranged to generate a 70-microsecond pulse. That pulse, in turn, directly feeds a hardware interrupt (RST 5.5) that is on the microprocessor.
Construction and setup

The author wired the prototype point-to-point, as shown in Fig. 7. A 4.5 × 5-inch piece of perforated construction board was big enough to mount most of the electronics. In the photo you can see several empty IC sockets. During development, those held a UART (universal asynchronous receiver transmitter), a baud-rate generator, and a direct memory access port (DMA), to download test programs into RAM. Several other components are not mounted on the main board. The exceptions include the LED display, the alarm buzzer, a duplex phone jack, the power transformer, the voltage regulator, the power supply and time-base circuit. The author built the time-based circuit on a separate piece of perforated circuit board. All components fit into a small “U”-shaped aluminum case measuring 5-½ × 5-½ × 2½ inches. The author mounted the power supply board, the LM309, and the alarm to the base of the case. The alarm switch, phone jack, and transformer are mounted on the rear, and the LED display on the front wall of the case. Three 1%-inch high standoffs hold the perforated board above the case-mounted components.

When building the circuit, observe all device polarities, and try not to form any solder bridges or open-circuits. Setup calls for tuning the four tone decoders (IC2, IC3, IC5, and IC8), and verifying that each responds to the correct telephone keys. A convenient method of tuning the decoders is to dial your own number. During the busy signal, you can freely press keys and measure outputs without inadvertently dialing an undesired number.

Tune each of the variable tone decoders by pressing the corresponding telephone key and varying the associated potentiometer while monitoring pin 8 of the tone-decoder IC. The voltage at that pin will drop to zero when the keypad signal matches the tuned frequency.

After tuning all adjustable decoders, as a precaution, go back and monitor the output of each decoder while sequentially pressing all telephone keys. Be sure that output goes to logic low only when the associated key is pressed. There should be no spurious oscillation. The decoders are very sensitive to small changes in tuning resistance, but after correct adjustment, they remain stable.

![FIG. 7—THE AUTHOR'S PROTOTYPE fit in a case measuring approximately 5.5 × 5.125 × 2.875 inches.](image-url)
VCR CROSS REFERENCE

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VOLTAGE CONVERTERS

continued from page 50

ages above 5.5 volts for extended periods.
5. When installing polarized capacitors, connect the positive lead of the capacitor to the CAP+ pin 2 and the negative lead to the CAP- pin 4 of the ICL7660. Connect the positive terminal of capacitors to VOUT pin 5 to ground.
6. Be sure that pin 5 does not swing more positive than GND pin 3 to prevent latchup.
7. If the supply voltage is greater than 6.5 volts, put a protective diode in series with pin 5.

Practical ICL7660 Circuits.
The most popular application for the ICL7660 is as a negative voltage converter. Figures 11, 12, and 13 are three basic negative converter circuits. In each circuit, capacitors C1 and C2 are multiplier capacitors with a value of 10 microfarads.

The negative voltage converter circuit in Fig. 11 is designed to be powered from a 1.5- to 3.5-volt supply, and it requires only two external electrolytic capacitors, C1 and C2. The circuit in Fig. 12 is similar, but it is designed to be powered in the 3.5- to 6.5-volt range and its LV pin 6 grounded.

The negative voltage converter circuit in Fig. 13 is designed for a 6.5- to 10-volt supply. Diode D1 is in series with +VOUT pin 5 to protect the IC from excessive reverse biasing by C2 when the power supply is removed. Diode D1, which should be a Schottky diode, reduces the available output voltage by Vth.

Up to ten cascading ICL7660s will give increased output voltage. For example, if three ICs are cascaded, their final output voltage will be ~3 volts. Figure 14 shows how to make the connections for cascading two of these stages. Connect all additional stages in the same way as shown in the schematic.

Output frequency change

In some applications there might be a reason for reducing the operating frequency of the IC's RC oscillator. This can be done by inserting an external oscillator capacitor Cosc between osc pin 7 and +Vpin 8, as shown in Fig. 15.

The relationship between the value of Cosc in picofarads and the oscillator frequency fosc is shown in Fig. 16. For example, a Cosc of 100 pF reduces the operating frequency by a factor of ten, from 10 kHz to 1 kHz.

However, it will be necessary to alter the values of capacitors C1 and C2 to compensate for this 10 to 1 reduction of frequency if circuit efficiency is to be kept high. Increase the values of C1 and C2 (both 10 microfarads) by the inverse of the reduction function. For example, if the oscillator frequency is to be 1 kHz, both C1 and C2 should have values of about 100 microfarads.

Oscillator frequency can also be reduced by connecting osc pin 7 as shown in Fig. 17 so that an external clock input overrides the internal oscillator. Feed the clock signal to pin 7 through 1-kilohm series resistor R1. The clock signal should switch fully between the two power supply voltages. The CMOS NAND gate is connected as an inverting buffer stage to ensure reliable switching between those values.

The ICL7660 can also be a positive voltage multiplier. It can produce a positive output voltage that is nearly double the initial supply voltage value when set up as shown in Fig. 18. The oscillator output signal at CAP+ pin 2 drives a capacitor-diode voltage-doubler network. It is the same network as the one shown in Fig. 2.

The two diodes, D1 and D2, reduce the available output voltage by an amount equal to their combined forward voltage drops. Consequently, both D1 and D2 should be low-loss germanium diodes.

Figure 19 shows how the circuits of Figs. 12, 13, and 18 can be combined to form a positive voltage multiplier and negative voltage converter that provides dual output voltages. Each voltage source has an output impedance of about 100 ohms. 
A HIGH-TECH CAREER FOR THE '90s

Your skills as an electronics technician can give you a never-ending source of job opportunities.

RONALD A. REIS

BILL HANSEN COULDN'T HAVE BEEN happier, as well as being surprised. At 28, and only three years out of a two-year technical college in Los Angeles, he had just landed a lucrative electronics technician's position at Advanced Electronics, Inc., winning out over a dozen other candidates. "Why me," he wondered out loud? "Why was I the chosen one?"

John Parry, one of the twelve applicants who didn't make it, was speculating, too. With 18 years of experience as an electronics technician, the last 12 working for Hughes Aircraft Co. as a high-frequency antenna specialist, "Surely I should have had the edge for that job," he mused.

Why had Bill succeeded where John and the other applicants failed? Because, as we shall see later, Bill possessed what it takes to make it as an electronics technician in the 1990s. He had the knowledge, the skills, and, most important, the attitude required for success. Unfortunately, many of "yesterday's" highly specialized electronics technicians do not.

This article will update you on what it means to be—and what it takes to become—a professional electronics technician in the 1990s. Are you a hobbyist or experimenter thinking about parlaying your interest in electronics to the career level? Or perhaps you're a seasoned electronics technician who wants to keep up on how your profession is changing and what you can do to broaden your opportunities?

The times, they are a-changing

Global competition and major transformations in the electronics industry are combining to inject significant change into the career of the electronics technician. Automation, fierce business competition, and corporate downsizing are the principal causes of that change. They make the immediate post World War II era of job stability, predictability, and specialization in all fields seem a dim memory.

At the same time, the electronics industry is seeing enormous increases in the demand for electronic products and services, unparalleled technological innovation resulting in a continuous flood of new high-tech products, and a downward pricing spiral that makes such products affordable.

Together, these influences are expanding the role of today's electronics technician. At a time when it is often cheaper to replace than to repair electronic products, technicians have seen their activities extend outward from component replacement to systems maintenance. As a consequence of these new challenges, new opportunities are opening up to the astute and enterprising electronics technician who is ready to take charge of his or her career.

Replacement to maintenance

Before electronic products, especially in the consumer field, became relatively inexpensive to produce, and back when their costs were high and their reliability low, technicians spent most of their time repairing equipment. The typical technician would troubleshoot down to the component level. He, and it was almost certainly a he, would spread out a schematic drawing, grab a few instruments (meter, generator, scope), and search for a faulty diode, transistor, or SCR. Once discovered, he would remove the defective component and replace it with a good one.

This is still done today, especially for expensive products. One rarely tosses out a $500 motherboard from a big-screen television, and it is often cheaper to replace than to repair.
TV set. Yet, for some time now, troubleshooting has retreated from component-level to board- and modular-level. This is especially true for field technicians who must get a customer's product up and running as quickly as possible. As a consequence, technicians are required to understand product and process operation at a higher level. The technician must survey the entire operation, be it that of a VCR or a sophisticated industrial control process.

To be sure, today's electronics technician is still likely to fall into one of the traditional 10 subfields shown in Fig. 1. But within a given field, he or she must think at the systems level.

For example, Byron Munoz works as a microcomputer technician for TEAM LA. He is responsible for restoring and installing personal computers in non-profit agencies throughout the city. "When I first got here," he said, "I thought I would be concentrating on what's in the box (computer). Actually, I've become what is known as a systems analyst. Working with both hardware and software, I must constantly take a systems approach, where I tie everything together. With local area networks and all manner of data communications exploding like crazy, the 'system' keeps getting bigger."

Or, take Norm West, working at the Los Angeles Times Olympic printing plant. "I'm what they call an 'electrotech,' although I was trained many years ago as an electronics technician. Now I'm responsible for maintenance on the complete system, a system that off-loads one-ton rolls of newsprint from railroad boxcars at one end and sends a finished product out as a printed, stuffed, and folded newspaper at the other. I have to keep the entire process (system) in mind all the time."

In the job-subfield wheel in Fig. 1, notice that the spokes unite at a center hub; the various subdivisions in electronics are not islands unto themselves. Increasingly, electronics technicians are crossing into allied fields as they take the systems approach to even higher levels of integration.

**Beyond product repair**

Electronics technicians are also becoming more involved in the entire product cycle, beginning with product design and culminating in customer service (see Fig. 2).

True, electronics technicians have always found themselves fabricating engineering prototypes, "tweaking" production lines, and performing product tests (stages 2 and 3). And, of course, their strengths are the installation, maintenance, and troubleshooting of electronic devices and systems (stages 4 and 5). But today, new opportunities are emerging for the technician at the product-design stage, too. You don't have to be a graduate electrical engineer with a B.S.E.E. (bachelor of science in electrical engineering) to do design work. Electronics technicians, with their hands-on product familiarity, can often contribute to circuit modification, packaging, and production facilities layout.
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- Internal fax modem
- Windows 95 — the very latest version of this popular graphical interface
Another design area open to the technician is printed circuit board design and artwork generation. Traditionally, individuals working in this field have been drawn from the drafting profession. However, such designers often lack an in-depth background in electronics. Take an electronics technician, though, and give him or her CAD (computer-aided design) training, and you have what many consider to be the winning combination of skills necessary to design printed circuit boards.

Though design possibilities are opening up for electronics technicians, it is at the end of the product cycle, in customer service, where the greatest opportunities for technicians are rapidly emerging. As anyone in the personal-computer field can tell you, customer service is the fastest growing—and most demanding—part of the business. Customer service isn't just troubleshooting customer problems over the telephone. Specifically, there are growing opportunities for technicians in the three related “Ts”: technical writing, technical training, and technical sales.

The three T's
Technical writers, who document product repair, operation, and assembly procedures in data sheets, pamphlets, manuals, and even books, are in strong demand—especially for writers with a technical background. Traditionally, technical writers have emerged from the ranks of college English majors. While their writing skills are fine, these individuals often lack the technical savvy that would heighten their effectiveness. “What is desperately needed,” according to John Giesler, documentation manager at Transaction Technology Incorporate, in Santa Monica, California, “is a person with a capital T. In other words, someone with strong technical skills first and writing ability second. We'll settle for the lower case w. With enough exposure and encouragement, a good technical writer will surface.”

If you have a proclivity for writing, why not consider technical writing as a adjunct to your work as an electronics technician? One way to get started is by freelancing. Just let the word out that you're interested. You'll be surprised at the number of small companies, and even giant corporations, that will give you an assignment. That's exactly how I got started, writing two-sheet assembly manuals for an electronic kit company, part-time.

Technical trainers, those that explain to customers the operation and maintenance of electronic equipment, or put on in-house or vendor seminars, are also in high demand. Again, a strong technical background is the first priority. As a technician, you'll already have that. Can you also teach or explain things to others? If you itch to get in front of a class or a company-sponsored training seminar, it's never too late to consider becoming a technical trainer.

To develop the skills necessary to teach, first watch others in action. The next time you are in a college class or are receiving training from a product vendor, observe the instructor's style and techniques closely. To get started yourself, volunteer to tutor other students or take new technicians under your wing. Any direct contact with customers, providing customer support, is invaluable experience. Soon enough you'll be ready to work as a valued technical trainer.

If you are an electronics technician who is often in contact with customers, what you say and do can have a significant impact on company sales. Why not expand such experiences into full-time technical sales? As with technical writing and technical training, the key is to first possess technical expertise. There is no way anyone can sell today's complex electronic equipment by bluffing the technical details. Potential customers won't stand for it. If you're already technically strong and have the personality and drive to sell, here, again, is an allied field that will allow you to go beyond the strictly technical and expand your career opportunities.

To get started, start selling. When out in the field, you might suggest that users purchase various equipment upgrades.
your company is offering. If you are successful in convincing them to buy, your boss will notice. Soon you'll have the opportunity to sell all the time.

**Demand and compensation**

Today’s electronics technicians are finding renewed job strength and opportunity by moving from the more narrow focus on product repair to systems maintenance. Furthermore, they are finding openings in allied fields of design and technical writing, training, and sales. But what, in this challenging job market, is the demand for these skilled and knowledgeable individuals?

And what kind of salary can they expect to earn?

According to Robert B. Reich, U.S. labor secretary, the demand is strong: “The cause for real optimism,” he declared recently, “lies in a trend just emerging from the occupational statistics. Look closely and you'll find a growing demand for technicians—people with the skills to test, repair, upgrade, and sell complex products. The Bureau of Labor Statistics predicts that these jobs will increase 37% from 1990 to 2005.”

Of course, with regard to job demand, much depends on where you are located. Things are still pretty tight in Los Angeles, but they are booming in Salt Lake City and Tucson.

What about compensation? As shown in Fig. 3, it depends to some extent on what subfield you’re in (see Fig. 1). It also depends on whether you’re at the job entry level (for example, field service trainee), or at the higher job levels well beyond that of the traditional electronics technician (director of technical services, for instance). As seen in the graph, salaries within the medical-equipment sector tend to be highest at the lower job levels. Salaries within the communications equipment sector are among the lowest at lower job levels and highest at the higher job levels. The average annual salary for an electronics

**TECHNICAL SUPPORT COURSES**
- Math for Electronics
- Technical Report Writing
- Physics for Electronics
- Computer Usage
- Drafting for Electronics

**CORE COURSES**
- Survey of Electronics Technology
- Fundamentals of DC/AC
- Introduction to Electronics: Devices and Circuits
- Digital Electronics

**ADVANCED COURSES IN ELECTRONICS**

**ELECTRONICS COMMUNICATIONS**
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- Microwave
- Digital

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- Advanced Digital
- Microprocessors
- Computer Systems
- Networks

**BIOMEDICAL ELECTRONICS**

**AVIONICS**

**INDUSTRIAL ELECTRONICS**
- Robotics
- Industrial Controls
- PLCs

**CONSUMER ELECTRONICS**
- Radio
- TV
- VCR
- Stereo
- CD Player
- Telephone
- Camcorders

**ASSOCIATE DEGREE**

**FIG. 4—A TYPICAL ASSOCIATE DEGREE PROGRAM** will not only contain core courses in electronics, but technical support and general education courses as well.
technician, according to 1990 Department of Labor figures, is $23,028. The minimum is $14,244, while the maximum is $39,180. Figures for 1995 are estimated to be approximately 17% higher in all three categories.

**Becoming a 1990's technician**

To become an electronics technician you will need formal training and education. While some old timers will tell you they learned everything on the job, today a certificate (not to be confused with certification, which will be discussed shortly) or a two-year associate degree is the recognized “ticket” to an entry-level position.

Certificate programs are offered by correspondence schools, trade, vocational, or technical schools, and many community colleges. They are designed to recognize a student’s satisfactory completion of an organized program of vocational study. Certificate programs for technicians can take from a few months to 1 or 2 years to complete, depending upon the course of study and type of institution offering the program.

One problem with certificate programs is that courses required to earn the certificate are almost entirely in the major field of study. This is fine for a short-term, focused program, such as one for CAD expertise or quality assurance testing. In a broader sense, however, certificate programs are inconsistent with the kind of training you’ll need to become today’s electronics technician. If you choose the certificate route, try to supplement your technical education with various courses in English, psychology, speech, and technical writing.

You won’t have to go searching for such courses when seeking a 2-year associate degree, be it at a public community college or proprietary technical institute, such as Cleveland Institute of Electronics, Grantham College of Engineering, ICS Computer training, ITT, and NRI schools. A typical associate degree program will not only contain core courses in electronics, but technical-support and general education courses as well (see Fig. 4).

Your core program usually begins with a survey course designed to get you excited about the field of electronics. From there it’s on to the fundamentals of DC and AC circuits, or basic electricity. Then you’ll take a course on devices and circuits, or basic electronics. A digital electronics course is also part of most core curriculums.

At some institutions, such as ITT, you will not be able to choose a second year advanced course sequence for specialization. At ITT, every student takes every course, core and advanced. It is a program that produces generalists. At most community colleges, though, some form of specialization is encouraged. As shown in Fig. 4, various sub-specialties, paralleling the subfields shown in the wheel of Fig. 1, are offered. Of course, no one institution will offer all subfields. Check your local institution to see what sub-disciplines, if any, are emphasized.

As mentioned a moment ago, an array of technical support courses will also be part of any 2-year curriculum. Not only do these courses “support” your work in electronics, they “supplement” it. They will round out your technical training as an electronics technician.

Rounding out your education will be the function of your general education courses. Don’t fight against these courses, embrace them. A class or two in language and psychology or in the behavioral sciences will mark you as an educated electronics technician.

Beyond formal education at a technical school or community college, you should consider electronics certification. The purpose of such certification is to distinguish the highly skilled and knowledgeable technicians from those with less experience. Many employers encourage—and some require—their technical employees to be certified.

There are a number of private-sector certification organizations, two of which are prominent. Both the International Society of Certified Electronics Technicians (ISCET) and the Electronic Technician Association (ETA) offer certified electronics technician (C.E.T and CET, respectively) certificates. The ISCET even offers two levels of certification: Associate Level and Journeyman Level. The Associate Level is designed for electronics technicians with less than 4 years experience and students studying electronics. Think of what having that Associate Level Certificate as a student would mean on your resume? Bill Hansen did.

Bill’s first, entry-level position, straight out of college, was at Micree Corporation, an electronic contract manufacturing firm in Torrance, California. He started as a test technician. But rather than just do “his job,” Bill made it a point to investigate what others were doing as well.

At the time, Micree was installing a new surface-mount technology (SMT) production line. Bill let it be known that he wanted to be involved with this new packaging technology. When an opening came up, he jumped at it.

On the SMT line, Bill learned all aspects of SMT production, from PC board inspection to final test. Since Micree assembles boards for clients under contract, Bill found himself interacting with customers and explaining to them the new technology. Soon he was representing the company at trade shows and conventions. Eventually, Bill even gave seminars on surface-mount technology and wrote a paper on SMT solder-paste applications.

**FURTHER READING**

For a more in-depth discussion of what it means to be and what it takes to become an electronics technician, you might want to pick up a copy of the author’s book, *Becoming an Electronics Technician: Securing Your High-Tech Future*, Prentice Hall Publishing, Inc., 445 Hutchinson Ave., Columbus, Ohio, 43235. Also contact ISCET, 2708 West Berry St., Ft. Worth, TX 76118, and ETA, 602 N. Jackson St., Greenacres, IN 46175.
OFF-LINE REGULATORS

These off-line voltage regulators produce adjustable DC outputs of 8 to 12 volts at as much as 100 milliamperes.

J. DANIEL CONNELL

5 volts DC. A conventional 5-volt, 100-milliampere linear DC supply typically occupies about 18 square inches of board space.

Linear power supplies occupy larger board areas because they include bulky 50/60-Hz transformers and large aluminum electrolytic capacitors. By eliminating those components, both weight and space can be saved. Moreover, the possibility of damage to the circuit by chemical leakage from large electrolytic capacitors has been eliminated.

If the proper safety precautions about isolation from the 120-volt AC line are observed, off-line power supplies can be economical and space- and weight-saving power sources, and might be perfect for your next circuit design.

LR6 linear regulators

The key components in the off-line regulator supplies explained in this article are monolithic members of the LR6 family of high-input voltage, low-output current linear regulators from Supertex. One version is a three-terminal, fixed output device that can be purchased in TO-92 plastic, TO-220 plastic, or SOT-89 plastic packages. Adjustable voltage versions of these regulators are available in eight-pin plastic DIP and small-outline IC (SOIC) packages.

The three-terminal fixed regulators permit input voltages up to 450 volts AC, and they have fixed 10-volt DC outputs. The adjustable voltage regulators in eight-pin DIPs have outputs that can be trimmed over the range of 8 to 12 volts DC. Moreover, their output current can be increased with an external depletion-mode MOSFET.

The circuits in this article are based on two versions of the LR6 regulator—LR645N4 and LR645N3. The LR645N4, an adjustable eight-pin DIP, was selected for its higher power rating and ability to control higher current than some of the other LR6 devices. The LR645N3, in a TO-92 package, serves as a preregulator stage in the second circuit that will be discussed here, a precision voltage source. Table 1 summarizes
the leading features of LR6 regulators.

**LR6 applications**

Off-line linear regulator circuits are suitable for many different applications. Some examples of them are:
- Low- to moderate-power off-line DC regulation.
- Regulators for noisy inputs.
- Proximity-controlled switches and alarms.
- Start-up circuits in switch-mode power supplies (SMPS).
- Power supplies for double-insulated products such as consumer entertainment products or power tools.

**How the LR6 works**

Figure 1 is a functional diagram for all LR6 series linear regulator ICs. They all include a comparator to control a field-effect transistor (FET). Input voltage is applied directly to the FET. A reference voltage is set by the Zener diode and it's associated resistor. The Zener voltage is applied to the noninverting terminal of the device's internal comparator.

Another voltage, derived from the ratio of the two internal trim resistors, is applied to the inverting terminal of the internal operational amplifier. The noninverting terminal always has the same potential, regardless of input or output voltage. Because the voltage at the inverting input will change in proportion to the source applied, the output of the comparator will swing between the input voltage (V_in) and ground.

That output then commands the FET to supply more or less current, causing the variation in the output voltage (V_out).

**Adjustable supply**

The ability to trim the output voltage of some LR6 linear regulators is useful for powering circuits or devices with unusual voltage requirements. By connecting a pair of selected resistors between V_out, trim, and the ground pins of the LR6, any voltage between 8 and 12 volts DC can be obtained at the output terminals.

Figure 3 is a graph of typical output-voltage vs. resistor ratio. The ratio of the resistors determines the output voltage. The best value for R1 plus R2 is 250 kilohms, although the data sheet allows values between 200 and 300 kilohms. The 250-kilohm value minimizes loading, permitting the circuit to provide more accurate output voltage. The power supplies described here do not have trimmed input, although they could be trimmed.

After building an off-line regulator, you might want to modify it to include a trimmed input. (The printed circuit board shown in this article has provision for mounting resistors R1 and R2.) Figure 4 shows a typical adjustable voltage circuit.

**Warning:** There is no AC isolation at the final 5-volt DC regulated outputs of the circuits described here. Potentially lethal voltages are present on off-line regulators when they are operated from 120-volt, 50/60-Hz line voltage.

Provide adequate protection from line voltage when adjusting the regulator for powering a device. A discussion of how to provide adequate protection when working on or with off-line voltage regulators is beyond the scope of this article and is the responsibility of the builder/user.

It is strongly recommended that the builder/user become familiar with safe AC isolation practices and the principles of double-insulated electrically-powered devices, circuits, and appliances.

Devices or appliances with double-insulation will have a metal chassis or frame connected to an electrical ground installed in an insulating plastic enclosure that has no ex-
posed metal parts that could be touched or contacted by the user. Double insulation construction is commonly found in television receivers, computer monitors, power tools, and appliances that are powered directly from the AC line.

**Adjustable voltage regulator**

The schematic Fig. 5 shows the adjustable off-line regulator, the first of the two discussed here. An input from 12 to 120 volts AC is applied to pins 7 and 8 of the eight-pin circuit-board-mounted header J1. Although the LR645N4 (IC1) can accept voltages up to 450 volts, the input of this circuit is limited by the 200 PIV (peak inverse voltage) rating of the bridge rectifier BR1. The full-wave rectified input is applied to the 1 µF filter capacitor C1.

The filtered 150 volts DC is applied directly to pin 1 of IC1. Filter capacitance is unusually low because IC1 has a ripple rejection ratio (V_{IN}/V_{OUT}) of 60 dB at 120 Hz with no load.

The filtered input DC is also applied to pin 2 of N-channel, depletion-mode MOSFET Q1, also made by Supertex. It was designed to be compatible with LR6 linear regulators. MOSFET Q1 conducts up to 100 milliamperes from the high-voltage source through the gate control line of the IC1, thus bypassing it. The combined regulated voltage and current source from Q1 and IC1 is then filtered through capacitor C2 to stabilize the regulated output.

The regulated output of IC1 is applied to the LM340 (7805) voltage regulator (IC2) that regulates the output voltage of the combination of IC1 and Q1 to a logic-compatible 5-volts DC. The total available current at the 5-volt DC output is 100 milliamperes, more than adequate current for most logic circuitry. The 5-volt DC is also filtered by 10 µF tantalum capacitor C3 for additional circuit stability under full current load.

**Building the first regulator**

The discussion of construction practice and precau-

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*Continued on page 87*
Countersurveillance

Never before has so much professional information on the art of detecting and eliminating electronic snooping devices—and how to defend against experienced information thieves—been placed in one VHS video. If you are a Fortune 500 CEO, an executive in any hi-tech industry, or a novice seeking entry into an honorable, rewarding field of work in countersurveillance, you must view this video presentation again and again.

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Foiling Information Thieves

Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted

The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug places the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snooper that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily. This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

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To obtain the professional contained in the video VHS cassette, you would attend a professional seminar costing $350–750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view Countersurveillance Techniques at home and take refresher views often. To obtain your copy, complete the coupon or call.

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what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

The open taps from where the information pours out may be from FAX’s, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user’s understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

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My incoming letters tell me that some readers ought to get back to the fundamentals of efficiency and economics before they write me letters—either to praise or condemn me. Several recent letters gave me the idea that the time was right to do a little review of those subjects for those who never studied them—or those who have forgotten what they once knew about them.

**Efficiency and economics**

"Efficiency, otherwise known as "bang-for-the-buck," is simply how much of something you get back compared to what you put in. This can be stated in terms of power, dollars, or other variables. However, physical systems never return more than is put into them.

Paradoxically, an enterprise or a technical venture might have an apparent efficiency well above 100%. That's the case if the rearrangement of the financial and material investments and the personal value added of the entrepreneur or management causes the perceived value of the products shipped (or services provided) to exceed the value of materials, time, overhead, and sweat equity that went into them.

Engineering economics is simply the study of finding out exactly what the bang for the buck is. If you get more than one buck back, you have a profit or will be a winner. On the other hand, if you get less than a buck back, you probably should have been doing something else.

Efficiency and engineering economics explains why solar cells that are only 6% efficient are useless electric power generators at any price—even if free! Those same principles explain why thermoelectric coolers simply don't work at power levels beyond about eight watts. They also tell us why solar space heating is impractical in much of a state like Arizona.

**Zoom in on details**

Suppose you want to start a technical venture. The first thing you do is borrow $1000 for tools and materials. Today, the true time value of money of those dollars will be somewhat around 10%. Thus, just to break even, your venture must generate more than $100 per year—and do it forever!

But your tools and materials won't last forever. If they last only for ten years, your venture must generate more than $270 per year to amortize your initial expense and the time value of money over its effective life. With a five-year lifetime, your venture must generate more than $329 per year just to break even!

**Just try to break even**

If your total costs are less than your returns, you will have an economic loss. The total costs must include all parts, labor, overhead, and the time value of your money. Add to that the cost of a lot of intangibles. Even this makes no mention of taxes and inflation. Paying cash will not make much difference because there are many other things you ought to be doing with that money to give you better returns.

Sadly, any "hacker economy" that substitutes time and energy for cash will only shift the viability of the breakeven points. But this shift is likely to be a lot less than you might first guess, even when you factor in entertainment, ego, and enjoyment. A hacker economy in no way gets around the fundamentals of engineering economics. Moreover,
there are likely to be both subtle and obvious subsidies involved.

Consider some examples of really bad engineering economics. The amount of electricity per unit area that a six-percent efficient solar cell produces can’t ever pay for all the expenses of the power station installation, interest, land, and operating expenses. The energy recovered is simply inadequate. The longer you run the station, the more it will cost you!

Their lack of reliability makes amorphous solar cells dismally poor performers. Their low level of efficiency holds them perilously close to the economic breakeven point. This is also the reason why commercial solar electric power plants are being dismembered and their components are being sold to hackers at yard sales. There’s a lot more profit to be made selling junk than there is in selling solar power.

In the Arizona desert, for example, there are too few winter degree-days to make solar space heating economical. It’s hard for solar space heating to compete with $10 worth of propane or a few branches of mesquite tree.

Thermoelectric coolers are so grossly inefficient that its heatsink typically has to handle six or more times its cooling power. At high power, the heat rise across the heatsink exceeds the cooling drop provided by the Peltier modules.

Million dollar ideas
Why does patenting your million dollar idea make no sense? The answer is simply because you will never earn enough profit from a million-dollar idea to begin to cover the costs of obtaining the patent and successfully defending it in court from challenges and copy cats. Your breakeven point is approximately $12 million in gross sales. At that level, its a matter of chance whether a patent is or is not worth all of the struggle it takes to make it profitable. There is a discussion of this subject in my WHEN2PAT.PS on GENie PSRT.

Is there any time when efficiency and engineering economics are not of crucial importance? Only if nobody else can come up with a good answer to “Uh... compared to what?” For example, inefficient solar cells are wonderful for calculators but useless as economical power generators.

Peltier thermoelectric circuits are great for cooling microscope slides or infrared detectors, but they are worthless for making ice. Water heated by solar power is great in the Arizona desert, but solar space heating does not cut it in that desert climate.

Wavelet update
There has been a lot of interest expressed in wavelets recently. These can be a superior performing replacement for the older Fourier analysis techniques related to time and frequency. Wavelet concepts apply to everything from video compression schemes to human vision and seismography. The field is maturing and there are now dozens of books available on the subject.
I have listed several of the more popular books in my resource sidebar.

In my view, the best tutorial paper on wavelets was written by Rioul and Vetterli in the IEEE Signal Processing Magazine, Volume 8, Number 4, October 1991 on pages 14 to 38. Also review the December 1993 issue of IEEE’s Transactions on Signal Processing. Be aware that these are two different IEEE publications. For your information, there is wavelet shareware on GENie PSRT File No. 365.

Hot new FM tuner
In past Hardware Hacker articles and reprints, I have discussed ultrafringe frequency-modulation reception as well as new FM RBDS data services. The folks at Denon were kind enough to loan me one of their superb new TU-650-RD FM tuners. It has a list price of $375 but is available on the street for about $299.

RBDS is a 1200-bit-per-second (bps) data subcarrier service. I gave some information on it as HACK73.PS on GENie PSRT along with some do-it-yourself circuits. The most common application for RBDS today is for the display of station call letters and station format on receivers.

However, RBDS is also used for traffic, weather, and emergency alerts on radio and broadcasting differential Global Positioning System (GPS) position corrections for vehicles, services, and individuals requiring more accurate position information than is available from the commercial-grade signals available to ordinary citizens directly from the satellites.

Unfortunately, most FM stations have not yet adopted RBDS services, although they are all provided inexpensively. The latest Radio World listing shows that only about 220 stations have adopted it.

In addition to showing the station call letters, the Denon receiver lets you search format. For example, you can ask it to scan only for classic rock. There are now only a few stations in Arizona offering RBDS, but the reception on several is excellent. However, most provide only the format and call letters.

This is an example of a typical chicken-and-egg problem. Listeners don’t want RBDS if only a few stations have it, and the stations do not want to spend money on a service if nobody is using it. Nevertheless, the benefits are there, especially for car radios.
Scottsdale, Arizona's KSLX (100.7 MHz), Kingman, Arizona's KZZZ (94.7 MHz), and Cottonwood, Arizona's KZGL (95.9 MHz) broadcast the differential GPS corrections. These can upgrade the listener's position accuracy to within several feet of true position.

The theory behind differential GPS is that the radio transmitting station has a known and fixed location. At ranges of several dozen miles, the errors in radio station position will be about the same as the error in your handheld GPS receiver. You just subtract these two values to increase the accuracy of your position data.

More information on differential GPS is given in GPS World. Two principal information sources for RBDS are Differential Corrections Inc. and Coupon Radio.

The Denon receiver would have to be modified slightly to receive GPS signals. This is a custom and encrypted fee-based commercial service. Several unique features make Denon's TU-650-RD receiver good for ultra-fringe reception: A fully shielded high-performance front-end design and an optional narrow-band IF filter that blocks most co-channel interference. Yes, you can still receive stereo and RBDS in the narrow mode.

Figure 1 shows my test setup for receiving ultra-fringe FM and RBDS. I mounted a Winegard CA-6060 Yagi antenna high on my roof and pointed it due west. A ten-decibel Radio Shack 15-1117 amplifier is in the transmission line between the antenna and a grounded lightning/static blocker.

A 75-ohm coaxial cable couples the blocker to a line splitter/two-set coupler in my living room. One line drives the Denon TU-650-RD, and the other line drives my second lower quality receiver.

What about performance? First and foremost, FM station KDKB comes in like a champ. You can practically arc weld with the power of its signal! That's all that really matters to me. There are about 40 FM station signals of listenable quality available to me at an average distance of over 105 miles from my antenna.

The Denon's IF filter is incredible. The weak Tucson, Arizona station KXCI broadcasting at 91.3 MHz is easily separated from the much stronger signal from the Phoenix station KJZZ broadcasting at 91.5 MHz. Try out the bandpass filter. If the station changes, or noise increases, you have co-channel problems. However, keep in mind that any weak signal might be received.
better without the filter. In general, the filter makes a difference only for a few stations.

Does it make sense to add a lower quality booster at the antenna ahead of a high-performance receiver? A modest 10-dB boost at the antenna gives the antenna a fixed impedance to work into and compensates for both line and distribution losses. The slightly higher signal level is enough to override the "no stereo on weak signal" feature. This permits manual switching rather than having to depend on the factory setting. Mono is cleaner for marginal signals.

However, any preamplifier also adds to cross-modulation and can cause overloading. This is only observable at a half channel away from a nearby station. If you use a preamplifier, be sure to get an in-line coaxial version that is totally shielded. It will provide only the bare minimum gain needed. Does a fixed antenna make sense? Yes, it is cheaper and more rugged.

But Bee can't receive her classic Tucson, Arizona, FM station KUAT very well despite the strong signal on the car radio in the driveway. Some experiments with an unboosted, inexpensive fringe Radio Shack 15-1636 FM antenna surprised me. Many FM stations seem to use vertical or circular polarization. Their apparent objective is to improve nearby automobile reception at the cost of distant coverage. Our reception of station KUAT improved dramatically here in Thatcher when I flipped the Yagi antenna to its vertical position.

The ultimate solution seems to lie in raising antenna height. I can take a $4 pocket FM receiver to the top of the two-mile high mountain in my front yard and tune it to 93.3 MHz. By pointing the whip antenna in one of three directions, I can receive KDKB in Phoenix, KKOB in Albuquerque, New Mexico, or a Mexican station from the south.

Tuning gradations on the Denon TU-650-RD are at 100-kHz intervals, giving one stop between channels. This can reduce co-channel interference, and it can be useful for receiving some homebrew wireless broadcaster who is off frequency. It also helps to receive the audio from TV channel 6 near 87.8 MHz.

However, there is a strange restriction here: this tuner is so hot that I must activate the internal RF attenuator to prevent an overload on cable systems. For some reason, this can only be done from the remote. I suspect this might have been an afterthought before the receiver design was completed.

Because there is a microcontroller chip inside, the tuner has many unusual features. For example, you can manually store any non-RBDS station call letters and format or store other messages of 13 or fewer characters. You can also scan for all of the classic rock stations, all the news stations, or any of 20 other formats. Because it has no keyboard, selection of 66 characters is made with a single up/down button.

There are 30 station presets. These are "intelligent" enough to remember the RBDS or manually entered data, AM vs. FM, the RF attenuator setting, and the filter bandwidth. The tuner has a panel light dimmer. All presets are saved when the power is shut off, and power consumption is only 12 watts. Because it is a component tuner, an external stereo amplifier is required.

However, I'd like to see a "raw" RBDS output jack on the tuner. Other improvements I'd like to see are a monthly updated plug-in card, chip, or modem line that stores all of the stations in North America with all of their formats and their operating hours. This would come in handy on long auto trips.

More magic waveforms

High power sinewaves have become a hot hardware hacker topic. They have applications in car battery power inverters, uninterruptible (UPS) computer power supplies, telephone ringers, electric-powered automobiles, power-line conditioning, and variable-speed induction motor drives.

Most of these applications require well formed sine wave outputs. Square or other sloppy waveforms could cause circuit inefficiencies, heating, resonances, cogging, or severe audio whine.

Analog solutions based on power
amplifiers will not hack it because of their poor efficiency. A microcontroller-oriented digital solution is the only method to use these days, especially if stability, wide range, easily adjusted voltage, or a constant speed are requirements. Thus the trick is to find a "magic" single train of fixed amplitude ones and zeros that can imitate a respectable variable-voltage sinewave. You could pick an RZ, ternary, or pulse-width modulation (PWM) scheme that has states of +1, 0 and -1.

Figure 2 shows a "magic" 30-bit waveform for power sinewaves. When one examines all possible binary sequences for 36 or less bits per word, there is no other code that even comes close. The "top" half of the waveform is 0010111111110101. The "bottom" half is repeated with -1 values. Notice that the top-to-bottom are mirrored but not the right-to-left. This produces the 30-bit word or a 1800-Hz clock for 60-Hz line power. The 30-bit length nicely taps out by tens for three-phase power.

This elegantly simple "magic" word has a zero DC term. It has zero second, third, fourth, fifth, sixth, eighth, ninth, and tenth harmonics. The peak fundamental is about five percent above the "1" value for well behaved switching currents. The seventh harmonic ends up at about 11.8 % amplitude. This translates to 1.39 % power.

However, there are a few caveats. There is no way to get all those fancy square corners with nothing but a fundamental sinewave and a weak seventh harmonic.

As a result, all the 11, 13, 17, and 19 harmonics are gruesome, but they are no worse than the third in any squarewave. They end up in the mid-audio range with 60-Hz power. But these are usually easy to filter out.

The winding inductance of a motor acts as a low-pass filter. Nevertheless, some low-pass filtering will definitely be needed, and one must watch for system resonances.

Notice that the "-1" state can be a reversed current. With a bridge driver, only a single supply is needed to supply current in both directions. Another option is to use a pair of oppositely phased...
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windings.

Details vary with use.

The general purpose PostScript computer language is the quick and fun way to analyze waveforms interactively. I have written a new FOURIER.PS tutorial exploration utility and a ZEROHARM.PS code finder to GENie PSRT. I am now evaluating 210-bit words using nothing more than PostScript. One interesting 210-bit example is shown in Fig. 3. Its first nasty harmonic is its seventeenth.

A library of low harmonic codes with listings of different fundamental amplitudes can provide background on variable output voltage from a fixed supply. Call me for details.

At longer bit lengths, you must think smarter rather than harder to get useful answers in a hurry. But PostScript explores any high-bit count words with aplomb. The secret to its efficient operation is to represent words by ones and zeros in a string and then manipulate the strings. I'd like to thank mathematician Jim Fitzsimons for his help on this subject.

New tech lit

Three new data books are available: Crystal Semiconductor is offering its new Audio Databook on digital audio products with particular attention given to low-distortion, delta-sigma analog-to-digital converters; Dallas Semiconductor is offering a System Extension Data Book that includes data on digital potentiometers and electronic thermostats; and National Semiconductor is offering a Power IC's Databook full of information on linear and switching regulators, motion controls, and power drivers. This should be of interest to readers.

The November 24, 1994 issue of Science proves something that has been obvious to me for some time. It pointed out that 97 percent of so-called "junk" DNA is really a sophisticated computer language! At the very least, the DNA passes all of the

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<td></td>
<td>11th Harmonic: 0.0108</td>
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FIG. 3—AN EVEN MORE MAGIC power sinewave with 210 bits.
tests that have been applied to human and computer languages. The details on this finding are found on page 1320.

If you want to make a real quick buck on this concept, just publish the pocket reference card for the DNA language. Then maybe you can show us how to access a utility subroutine or two.

At last long, the Millenium Whole Earth Catalog is being shipped. It is a “must have” essential resource on access to tools. Don’t miss this resource.

I’ve just reissued my classic Active Filter Cookbook and have a lot of autographed copies on hand. Moreover, I still have scads of classic Apple computers, monitors, cards, and drives on hand. They are cheap enough to be put together as programmable controllers. I also have rare and collectible Apple III’s. Write, call, or E-mail me for details.

I want to remind you that unique downloads, “freebie” insider secrets, catalogs, and technical help are available to GENie subscribers on my PSRT. How about a ten-hour free trial per the Need Help? box. As usual, I’ve mentioned most of these resources in the Names & Numbers or Wavelets sidebars. Be sure to check the sidebars for information first before you call our no-charge technical helpline. Let’s hear from you.

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I'm departing from my usual column format to share with you a gadget that I built to alleviate a personal problem I had with shielded connecting cables. The problem, of course, is that they don't always stay that way—shielded and connected, that is. Remember the last time you spent a frustrating half hour or so trying to track down the specific shielded cable that was causing the intermittent hum or signal loss in a system—and which seemed to fix itself every time you touched or switched anything? (Defective cables sometimes short circuit or open up seemingly at random due to vibration, contact oxidation, and bad solder connections.)

The only sure way to test for an intermittent cable is to plug it in, put a signal through it, and try to provoke the problem. A standard ohmmeter isn't very helpful unless the cable is permanently shorted or open—assuming you're not an octopus, it's difficult to hold the test probes firmly on the plug elements while simultaneously flexing the cable in an effort to make it misbehave.

The audio/video cable tester tests cables in the same way they are used: plugged in and with a voltage going through them. And since they are plugged in, you can flex them vigorously while keeping an open ear on the built-in buzzer—which responds faster and more definitely than an ohmmeter. The inexpensive, easy-to-build, battery-powered cable tester will make a welcome addition to any electronics toolbox or test bench.

**Construction**

The parts layout is not critical, and the tester can be built into any convenient box. However, I suggest that you use a plastic case (such as the one specified in the Parts List) since the normally grounded sections of the test jacks do not all connect to a common ground. The circuit is embarrassingly simple and would make a good practical first project for a beginner. In fact, I'm considering using it for just that purpose in a basic electronics course I'm conducting for our local middle-school students.

Referring to the schematic in Fig. 1, the "B" jacks (J3 and J4) are shorted to themselves and to each other—this is not a schematic error.

The ¼-inch spacing between the fuse-test screw heads will accommodate type 3AG and smaller fuses. Unlike the phono jacks (J1, J3), some F-connector jacks (J2, J4) do not come with grounding lugs, so before installation, a loop of thin, bare wire must be placed under each mounting nut to serve as a ground soldering point. Each pair of phono and F-connector jacks is wired in parallel. Of course, other jacks such as BNC, phone, etc., that you encounter in your work can be installed in the tester and wired in parallel with the existing jacks. The connection between J3 and J4 allows cables with a phono plug on one end and an F connector on the other to be tested for continuity.

Proper polarity must be observed in wiring the piezoelectric buzzer (BZ1); its terminals are marked appropriately. The buzzer is mounted in a ¼-inch hole cut in the front panel and fixed in place with a couple of drops of hot-melt glue. (Although the Japanese call anything that generates a sound a "buzzer," BZ1's generated tone is around 3 kHz and fairly pure.)

The optional test probe shown in the photo is made up of a 2-foot shielded phono lead with an RCA-plug on one end and a test probe and ground clip on the other. The lead's inner conductor is soldered to the probe tip, and the shielding braid is twisted, brought out through the rear of the probe, and soldered to a foot or so of flexible lead with an insulated alligator tip installed on its end.

**Using the tester**

The short test should always be made first. Plug either end of the cable under test into the appropriate phono or F-connector "A" jack. Only one end of the cable need be plugged in for a complete short test; the other end is left free. If the buzzer sounds, there is a short circuit somewhere in the cable. If nothing is heard, test for an intermittent short by flexing the cable several times, particularly in the plug area of both the free and plugged-in ends.

The continuity test will indicate an open circuit in the inner signal-carry-
What Do These Prestigious Companies Have In Common?

Leadership in electronics is not just a matter of designing products better and manufacturing them better, but also of marketing them better. And the sponsors of this message understand that better service to customers requires effectively involving distributors as part of their marketing teams.

Distributor involvement means lower prices, quicker deliveries, better service over-all. The Buyer wins...the Seller wins.

Distributors help achieve marketing leadership. So does the manufacturer's involvement in the Components Group of the Electronic Industries Association. EIA fosters better industry relations, coherent industry standards, and the sharing of ideas, which helps one another and serves customers better.

In choosing your component supplier, look for the marks of leadership--

availability through distribution membership in EIA.

Electronics Now, April 1995

84

www.americanradiohistory.com
Every spring, millions of colorful songbirds migrate north from the rain forest. They winter in the rain forests of Central and South America, then fly north to summer in our neighborhoods and yards. That may end if rain forest destruction is allowed to continue. Rain forests are being destroyed at an alarming rate... an area the size of 10 city blocks is wiped out each minute. That's bad news for the planet. Because one out of three bird species nests in the rain forest.

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To contribute to Rain Forest Rescue, call 1-800-222-5312

The National Arbor Day Foundation

ANCYONE CAN AFFORD to build this simple cable tester.

The fuse test is simplicity itself. A good fuse touched across the screw-head Fuse Test terminals "C" will produce a tone; a bad fuse won't. You can also check whether the tester's battery is good by using a coin or paper clip across theFuse Test terminals on the bottom of the unit.

The continuity test probe is plugged into an "A" jack. When the circuit under test has continuity, the tone sounds. The lower the resistance, the louder the tone. The tone will sound (albeit weakly) for resistances up to about 50,000 ohms. You'll find the test probe handy for quick continuity checks of household fuses, electric light bulbs, appliances, and more.

I must admit to a slight embarrassment at the simplicity of the tester's circuit. But just because life has gotten more complicated over the years, there is no reason for our test instruments to go the same route.
Introduction

All of the projects are: 555 oscillators, saw wave and function generators, CMOS oscillators, voltage-controlled and RF oscillators, (555, TTL and CMOS) monostables, precision long timers, power supply and regulator circuits and many other useful circuits. (See BP323 at right)

BP106—Modern Op-Amp Projects...$5.75. Various projects that make use of operational amplifiers available to hobbyists. Text includes low-noise, low-distortion, ultra-high input impedance, low-slew rate and high current types.

BP229—Public Address Loudspeaker Systems...$6.95. Covers the moving-col loudspeaker, the basic requirements of a PA system, sound patterns, line-source, horn loudspeakers, low-impedance matching and much more.

BP301—Antennas for VHF and UHF...$6.95. From installing a TV or FM antenna to setting up a multi-antenna array for shortwave listening or amateur radio, this book explains the essential basics of antenna operation and installation. The text describes in easy-to-understand terms the necessary information about how antennas work, the advantages of different types, and how to get the best performance.

BP109—The Art of Programming the Atari...$5.95. Written especially for musicians, the book explains all current popular forms of synthesis, covering L.A., additive, phase distortion, FM and sampling. The theoretical side of synthesis is treated in an easy to understand way; the technical information being restricted to what you need to know to use your instrument effectively. Ideal for beginners and musicians.

BP310—Acoustic Feedback—How to Avoid It...$6.25. Feedback is the bane of all shortwave receivers which should have levels of performance at least equal to that of commercially built sets of similar complexity. Also included are a number of add-on circuits, such as, Q-multiplier, S-meter, noise limiter, etc., which can be used to aid and improve the listener's shortwave reception.

BP311—Circuit-Source Book 1...$5.50. A collection of over 150 analog-signal circuits on audio signal and power amplifiers, DC amplifiers, signal filters (high-pass, low-pass, band-pass and notch), tone controls, voltage-controlled amplifiers and filters, triggers and voltage comparators, gates and electronic switching, bar graphs, mixers, phase shifters, sensor, digital circuits, etc. (See BP322 at right)

BP221—Circuit-Source Book 2...$5.50. Contains over 170 circuits on signal generation, power supplies and digital electronics. A continuation of BP311. Topics are: 555 oscillators, saw wave and function generators, CMOS oscillators, voltage-controlled and RF oscillators, (555, TTL and CMOS) monostables, precision long timers, power supply and regulator circuits and many other useful circuits. (See BP323 at left.)
solder to improve solder "wetting" to component leads and prevent corrosion of exposed copper traces.

Take precautions to prevent damage to semiconductor devices from electrostatic discharge (ESD) when handling them. Handle those parts on a conductive surface, and attach a grounded wrist strap to your wrist. Do all soldering with a 20 to 40-watt, grounded-tip soldering iron.

Refer to the parts placement diagram Fig. 6. Begin circuit board assembly by inserting and soldering bridge rectifier BR1, observing the correct pin orientation. Then insert and solder swamping diode D1, observing its correct cathode location. Next, install and solder an eight-pin DIP socket for IC1 (LR645N4), observing the correct pin locations.

Locate a square mica electrical insulator on the drilled hole for mounting the LM7805 voltage regulator IC2 and fasten the heatsink tab of its TO-220 package with a screw through the insulator and circuit board and a lockwasher and nut. Solder the three pins. It is recommended that a heatsink be placed on IC2 when the total current drawn exceeds 30 milliampere.

**Caution:** MOSFET Q1 must be insulated from the copper-foil traces and external heatsink because up to 170 volts will be present on Q1 when it's powered from the 120-volt line.

Position the external heatsink (rated at 8.3° C/watt) on the circuit board at the location for MOSFET Q1, place a square mica (polyester) insulator on the heatsink and fasten the TO-220 heatsink tab of Q1 with a screw though the tab, insulator, external heatsink and circuit board with a screw, lockwasher and nut. Solder the three pins.

After installing Q1 and IC2, verify that there is no electrical continuity between the mounting tab with a digital multimeter. **Caution:** If you do not electrically isolate Q1 from IC2 the supply will be destroyed!

Insert and solder the electrolytic capacitors C2 and C4, after verifying that their polarity and pin orientation are correct. Then insert and solder film capacitor C1 and ceramic disc capacitor C4. Insert and solder the eight-pin in-line header J1.

Insert and solder the two separate clips for the fast-blow, ¼-ampere fuse F1. Insert IC1 in its socket.

**Power-up and check-out**

**Warning:** If you do not obtain the correct voltage readings as specified, disconnect AC power to the off-line regulator immediately. Failure to do so promptly could result in injury to you and destruction of the circuit. Troubleshoot and make all needed repairs before reapplying AC power. Do not use a reversible line cord or a line cord whose ground pin has been removed because of their potential shock hazard.

Connect a polarized AC line cord and at pins 7 and 8 of the board mounted header J1. (An optional DPDT switch S1 can be inserted as shown in Fig. 5. Ver-
PARTS LIST

Voltage regulator, 8 to 12 volts. (See Fig. 5)

Capacitors
C1—μF, 250 volts
C2—47μF, 35 volts
C3—10μF, 35 volts
C4—0.01μF, 500 volts

Semiconductors
BR1—bridge rectifier, 1 amp, 200 PIV, DIP style
D1—1N4003 silicon diode, 200 PIV
IC1—LR645N4 linear regulator, DIP, Supertex
IC2—LM340T5 (7805) 5-volt, TO-220, National Semiconductor or equiv.
Q1—D2540N5, MOSFET, TO-220, Supertex

Other components
J1—header, vertical, 8-pin, single row, 0.10-inch centers, AMP or equiv.
S1—switch, DPDT, (optional) 125 VAC, 10amps
T1—transformer 120 VAC to 24 VAC, standard, 25.2 center tap secondary, 450 mA
F1—fuse, 1/4 amp, fast-acting

Precision voltage regulator (See Fig. 7)

Capacitors
C1—μF, 250 volts
C2—0.01μF, 35 volts

Semiconductors
D1—1N4003 silicon diode, 200 PIV
IC1—LR645N3 linear regulator, TO-92 plastic, Supertex
IC2—OM7805AIH precision voltage regulator, Omni or equiv.

Miscellaneous: circuit board; project enclosure (optional, see text); heat sink (Thermalloy No. 7020 or equiv.): mica or fiberglass insulators for semiconductors; 120-volt AC polarized line cord with 3-pin plug; PC-mount fuse clips, nuts, bolts and lockwashers, solder. Note: Sample LR6 linear regulators and MOSFETs, data sheets, application notes, and information can be obtained from Supertex, Inc., 1350 Bordeaux Drive, Sunnyvale, CA 94089

Identify that the AC “hot” side is connected to Pin-8. With an isolation transformer between the AC line and the plug, power-up the assembly.

The article “Build An Isolation Transformer” by Doyle Whisenant, January 1995 Electronics Now, page 62, explains how to build an isolation transformer that meets all the requirements for testing off-line voltage regulators.

If you do not have a 120-volt AC to 120-volt AC isolation transformer, locate one that has a 120-volt AC primary and a minimum 24-volt AC secondary rated for 300 milliamperes. The transformer specified in the parts list can be purchased from electronics parts distributors or retail stores. Apply the AC to the polarized plug as shown in Fig. 5.

Carefully measure and verify the voltages with a DC voltmeter referenced to pin 2 of bridge BR1 at the following points with a 120-volt- to-120-volt isolation transformer in place:

- Approximately 150 volts DC at pin 1 of BR1
- 9 to 10 volts DC at pin 4 of IC1
- Approximately 5 volts DC at pin 3 of IC2

With a 120-volt-to-24-volt AC transformer the voltage at pin 1 of BR1 should be approximately 30 volts DC. The voltages measured at pin 4 of IC1 and pin 3 of IC2 should be the same as those measured with the 120-volt-to-24-volt transformer.

If all voltage measurements are correct, disconnect the AC power, and allow adequate time for C1 to self-discharge. If you are unable to obtain the correct voltages, remove the input AC and examine the circuit board for improperly located or soldered components and make any corrections necessary.

Regulating the output

MOSFET Q1 (D2540N5) is rated for 15 watts. The input to Q1 at 120 volts, 60 Hz AC is about 150 volts DC. The output of Q1 should be between 9 and 10 volts DC. Therefore, by applying the values given, the power drop across Q1 can be calculated for any current drain when 120-volt AC line power is applied. The power dissipated by Q1 at 100 milliamperes is determined as follows:

\[ P_D = (V_{IN} - V_{OUT}) \times I \]

Where: \( P_D \) equals power dissipated, voltage is in volts DC, and current is in milliamperes

This represents the worst case situation for the regulator. If a lower voltage were applied (i.e., 24 volts AC) the result would be a lower power dissipation across Q1:

\[ P_D = (30 - 9) \times (100) \]

\[ P_D = 2.1 \text{ watts} \]

The author tested MOSFET Q1 to verify its ability to operate to 100 milliamperes with an input voltage of 150 volts DC. This was done by placing a 50-ohm, 1-watt resistor across the 5-volt DC output and operating the regulator for one hour. The regulator functioned satisfactorily.

However, if the regulator is to operate under continuous full load current, it is recommended that the regulator be placed in an aluminum case with wall thickness of at least 0.090-inch with a solid, surface of less than 8 square inches. Heat sink MOSFET Q1 to the enclosure wall.

The metal enclosure must permit constant air exchange for ventilation and be grounded to the ground line of the three-prong power plug, as shown in Fig. 5. Consider improving the air circulation with a miniature molded cooling fan rated for at least 30 cubic feet per minute (cfm).

The final output of the regulator under no load was 4.96 volts DC. Under full load conditions (100 milliamperes) and after 1 hour of operation, the output was 4.83 volts DC. A 50.4-ohm load resistor was installed in the circuit.

Precision regulator

Refer to the schematic for the precision regulator. Fig. 7. The AC input is applied directly to diode D1. The half-wave rectified DC is then applied directly to filter capacitor C1 and then to the three-terminal LR645N3 fixed regulator IC1.

The 10-volt DC output of IC1 appears across stabilization capacitor C2. The 10-volt DC is then applied to the post-regulator IC. An Omni OM7805AIH precision regulator that will provide 5-volt DC output ±0.05 volts DC.

This circuit is useful for mak-
Thomson says it has back orders for 400,000 receivers. At that point, Sony becomes the second brand to offer receivers, and Thomson expects a shortage of receivers to last until them. After Sony, the second licensee, enters the field, Thomson concedes that the product will be subject to an "aggressive price curve."

The success of DSS has surprised some critics, because it competes directly with cable, which doesn't require the basic equipment investment. It was expected to succeed in areas without cable service. But in many areas where cable is available, cable subscribers are using the service as a substitute, praising the clarity of its digitally transmitted image and the service's ability to free them from the woes of dealing with their current cable companies. The DSS system delivers the same programming as cable, and it has a higher channel capacity than most cable systems. It also offers a near video-on-demand service for movies, as well as 28 channels of digital audio. However, although DSS carries the national feeds of ABC, CBS, NBC, and Fox, it doesn't necessarily carry the broadcasts of local affiliates or independents. So to have complete reception, viewers must have either a regular broadcast antenna or basic cable service in addition to DSS.

The DSS system currently is receiving 175 channels from two satellites, with a third bird scheduled for launch later this year. The system is being upgraded to MPEG-2 specifications this year, with Dolby AC-3 audio to be added as well. When Sony starts to offer competition, Thomson is expected to bring out new models—presumably under its ProScan and GE brands, as well as RCA—including at least one TV model with DSS built in.

Cable TV interests, eying the competition, have also fielded their own satellite system. Originally aimed at areas without cable service, the Primestar system is available nationwide. It employs medium-power satellites and 39-inch satellite dishes. At first the service was offered only by cable operators, but a retail effort is now being mounted as well.

**Commercial-killing VCR.**

Coming this spring: A VCR that really kills commercials. RCA has become the first licensee to build a unique system into VCRs that censors commercials. When the recordor makes a tape from a broadcast or cable program, it automatically rewrites it to the beginning and fast forwards to the start of the first commercial break (whose location has been memorized on the VCR's tape counter based on visual and audio cues). The VCR then encodes commercial-start and -end signals on the tape's control track. It continues to seek out and mark recorded commercials to the end of the tape, and then rewrites. On playback, the VCR goes into the forward search mode during the commercials, while a blue field masks the picture. The end signal puts the VCR back in the play mode. Thus, instead of a commercial, the viewer sees a blank blue screen for a maximum of 30 seconds, according to Arthur D. Little Enterprises, which developed the system.

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**VIDEO NEWS**

continued from page 6

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Windows. Can’t live with it, can’t live without it. But what is it? What is its relationship to DOS? Is it an operating system, as Microsoft has in recent years started to claim? Or is it simply an oversized branch grafted onto that spindly old twig, DOS?

And what about DOS, the 16-bit hanger-on in the emerging 32-bit world? Will Windows 95 really and truly and finally put DOS out of its misery—and ours?

A new book, Unauthorized Windows 95 (UAW95), by Andrew Schulman provides the definitive answers to all those questions. The book is difficult to understand. It assumes the reader has knowledge about Intel CPU architecture, DOS interrupt services, other DOS internals—oh yes, and equal understanding of the Windows architecture and programming model.

Shulman provides cursory coverage of some background material, but if you don’t know what INT 21h is, or the various Intel CPU modes, this difficult book will be impenetrable.

The author, Andrew Schulman, is one of just a few recognized, independent (of Microsoft) DOS/Windows gurus. Schulman appeared as an expert witness in the Stac vs. Microsoft case. He has written other books on undocumented features of DOS and Windows. And he edits a column called the “Undocumented Corner” for a first-rate programmer’s magazine called Dr. Dobbs Journal. Schulman knows his stuff. In fact, the January 1995 issue of Dr. Dobbs published a highly condensed summary of Schulman’s argument by Schulman himself (p. 127f).

In the 600-page book, Schulman spells out in excruciating detail his vision of what constitutes DOS, what constitutes Windows, the relationship between the two, and how he arrived at the picture. I can’t hope to do justice to UAW95 here. Nonetheless, I am going to devote this column to it. In so doing, I hope either to convince you of the merit of Schulman’s argument, or to inspire you to read his book and decide for yourself.

What I will do is threefold: 1) Discuss his methodology, the kinds of thinking he does to arrive at his conclusions, although not the thoughts themselves, as they depend on highly technical and lengthy chains of logic; 2) Summarize the DOS/Windows picture that arises; and 3) Discuss the importance of his findings. For details, see the book.

By the way, there are actually two versions of the book. The one subtitled “Developers Resource Kit” comes with a floppy disk containing source and executable code for most of the monitoring programs in the book. It also contains a so-so CD full of trial and demo versions of various programming tools.

**Methodology**

Schulman’s typical tactic is to write a program (in C, assembler, or both), “hook” it into the DOS interrupt-handling structure. He then monitors the output it produces in various environments, including both the unreleased Windows 95 (formerly known as Chicago), and several prior versions of Windows, including 3.0, 3.1, and 3.11 (Windows for WorkGroups). He also discusses how some architectural features date, in embryonic form, all the way back to Windows/386.

**Will the real OS stand up?**

Until publication of UAW95, most people, if they thought about it at all, considered DOS to be the operating system with Windows merely an application that ran on top of it. Looking a little closer, many said that DOS handled disk and file I/O, whereas Windows handled video, memory, and just about everything else.

UAW95 paints a totally different, yet highly compelling picture. This picture directly and deliberately...
contradicts the picture painted by both Microsoft and the computer press, which usually bases its descriptions on uncritical adoption of the Microsoft party line. There are two critical points to comprehend about the controversy:

- DOS is alive and well, and
- Windows is a real operating system.

**DOS is not dead**

First, contrary to what Microsoft and nearly everyone else is saying, DOS is not dead. The two system files (IO.SYS and MSDOS.SYS) that contain DOS have been combined and renamed (WINBOOT.SYS). This new system file has been given the ability to launch Windows automatically, so that under normal conditions, the user never sees a DOS prompt during a boot. However, it's easy to circumvent the auto-boot-to-Windows feature, and boot directly to a command line. Just add a PAUSE statement to the end of your AUTOEXEC.BAT, and when it prompts you to press a key, press Ctrl-C. You'll end up at the DOS 7/Windows 4.0 command line.

Of course, the presence or absence of a command-line interface does not, in and of itself, mean that DOS is either present or absent. However, it is a visible indication that things are changing. Less visible, but more relevant, are hundreds of DOS Application Program Interface (API) calls. Of course, they're still there; the question is whether Windows or DOS is what's on the other side of the "I" in that API. As we learn from UAW'95, however, it's not a question of DOS or Windows; it's a question of both. The real questions are: which calls are handled by Windows, which by DOS? how does DOS handle them, and just what is DOS.

If Windows itself handled all those calls (as NT does), it would be fair to say that DOS was gone. But Shulman demonstrates conclusively that DOS still handles numerous calls, and for reasons of compatibility, that is a good feature of DOS.

**Windows is the OS**

Second, Windows really is the operating system; DOS plays only a subservient role, one that has been in steady decline since the 386 Enhanced Mode was introduced with Windows 3.0. To be more specific, a component of Windows called the Virtual Machine Monitor (VMM) is what assumes the lowest level of control over all system resources. In Schulman's words (p. 82), "VMM is the Windows operating system."

As shown in Fig. 1, the VMM is a piece of code that runs in Ring 0 of the microprocessor's protected mode. Recall that 386 and later Intel CPUs have three modes: Real, Protected, and V66. Real mode is what the original 8088/8086 CPUs ran. Real mode allows access to 1 MB of memory. Protected mode, introduced with the 286, has access to more memory (16 MB on the 286: 4 GB on most later CPUs), has a different mechanism for accessing memory, and provides a much more sophisticated means of controlling what happens when interrupts occur, illegal opcodes are encountered, and I/O ports and memory are accessed. V66 mode is a form of protected mode that provides the same 1 MB address space as the original 8088, but with the advantage of full protected-mode control over interrupts, I/O ports, illegal opcodes, and memory.

Schulman shows how, under several versions of Windows, you can create simple batch files to run the VMM all by itself to get an "extended" version of character-mode DOS that allows direct access to many, many megabytes of memory, all through standard DOS API calls that under normal circumstances can never provide more than about 600K of memory.

Another interesting characteristic of the V66 mode is that under control of a proper multitasking operating system, multiple V66 machines can be active simultaneously, along with one system-level control program. This is, in fact, how Windows (and OS/2 for that matter) runs DOS and Windows programs. Under Windows' Enhanced Mode, you can start one or several DOS boxes simultaneously. Each is a separate V66 process. In addition, both the Windows GUI—what we normally think of as Windows—and all Windows applications run in another V66 process, the System VM (Virtual Machine). The System VM and all DOS VMs run at CPU Ring 3. The fact that all Windows programs run in the same process means that there is less protection among them; any one that crashed could take them all down. NT runs all GUI tasks as separate processes, thus providing better overall protection, but at the cost of performance.

The Ring 0 VMM controls all access to memory, I/O ports, and interrupts—both hardware and software. The VMM's control over software interrupts is what allows it to grab control from DOS and selectively perform various tasks itself, or pass them on to DOS to perform. The mechanism is based on software components called Virtual Device Drivers (VxDs), which are, in Shulman's words, "the TSRs of the 90's."

Even when the VMM passes a task on to DOS, DOS does not execute it in the microprocessor's real mode, but rather in a protected VM. There can thus be very complex sequences of events when a nominal DOS call is made by either a DOS or a Windows program. However, tracing even a single example of that kind of event chain far exceeds available space.

Nonetheless, I can provide a flavor of how it works. For example, a DOS character-mode application could issue a call that is serviced by underlying Ring 0 Win95 code running in 32-bit protected mode. Conversely, a Windows program could issue a DOS call that is serviced by plain old DOS running in a 640K VM. In fact, a given call could bounce back and forth several times between one or more VMs and the full 32-bit protected mode VMM. Further, it is even possible for that ultra-protected Ring 0 code to execute DOS VM code. In fact, all three kinds of events happen all the time while Win95 is running.

**Whither DOS?**

The bottom line here is that DOS is not dead. Its role has progressively diminished, but even in Windows 95, which supposedly does away with DOS, numerous
DOS calls are still executed by DOS running in a protected 386 VM. Windows 95 and Enhanced Mode Windows (all versions) are true 32-bit operating systems and have been so since Windows 3.0 was released in May of 1990.

Microsoft would like people to believe that DOS is dead. DOS rightly scares people who have no interest in learning about installing peripherals or managing memory. Corporate information departments expend all sorts of resources resolving DOS compatibility problems. Hence Microsoft has a vested interest in making it seem as if DOS were gone.

One key component of the W95 architecture is called "Plug 'n' Play." PnP is suppose to provide Macintosh-like ease in system reconfiguration. Just insert or remove a peripheral, reboot, and the system makes any required adjustments. That's the goal, anyway. Attaining that goal, however, will be difficult, because of the huge number of existing PCs and peripherals. It is a certainty that compatibility problems will not go away when W95 is finally released (latest estimate is now August of this year). The only question is whether PnP on new systems will really work as advertised. Meanwhile, don't plan on losing your knowledge of the PC/DOS system architecture.

Ramifications

Shulman makes a number of compelling points. I'll let him speak for himself on one of particular interest: "Windows supports general-purpose non-Microsoft applications in the same way that a rope can be said to support someone who will soon be hanged. Your product may be a Microsoft DLL just waiting to happen." (p. 11)

Second, and related, is the idea, discussed here many times in the past, that the operating system is gradually growing to encompass nearly every software component of value. Extending the concept, Shulman quotes an unnamed source who asserts that "Microsoft Office is the operating system, and Visual Basic the API."

Lotus who? Borland who? Novell who?

The Pentium bug

With the attention given to Intel by the nontechnical media, it's unlikely that anyone could have missed hearing about the infamous Intel division error. Just in case, I've assembled a file of information and test programs; see PENT—BUG ZIP on the BBS (516-293-2283, v.32, v.42bis).

On a related note, you've probably seen Intel's Nine Lives advertisement in which there are three groups of nine cats. That first group is labeled "386," and all nine cats are covered by big red X's. The second group is labeled "486," and seven of the cats are crossed off. The third is labeled Pentium, and prior to discovery of the bug, none were crossed off. My question is: how many lives did this cost the Pentium? To help ensure truth in advertising, contact Intel's marketing department with the correct number of X's.

Comments to jkh@acm.org.

WHAT'S NEWS

continued from page 4

radio stations for a "financial freefall." The organization, which serves and represents America's radio and TV stations and all the major broadcast networks, contends that a satellite radio service would chase away national advertising dollars and dilute local audiences, threatening the profitability of the local radio stations.

The NAB is pressing the FCC to adopt an overall policy for digital radio service before considering individual applications for a narrower digital service such as satellite radio. A digital radio service that operates within the AM and FM bands is expected to be demonstrated to the public at the 1995 NAB convention in April.

Maxim and Tektronix form new company

Maxim Integrated Products, Inc. and Tektronix Inc. have formed Maxtek Components Corporation, to develop and manufacture custom, high-frequency multichip modules (MCMs) and hybrids. Maxtek is ISO 9001 certified, employs more than 200 people, and has dozens of engineers working with client MCM and hybrid designs.

Multichip modules are individual electronic packages that contain multiple ICs and passive devices. Hybrid circuits usually contain discrete devices. Both contain devices in packaged or die form, bonded to a ceramic substrate or printed circuit board. The circuits function as RF power amplifiers and front ends for wireless communications, active filters, fiber-optic drivers and receivers, analog-to-digital converters, and ATE components such as pin drivers and attenuators.

Formed last summer, Maxtek is the descendent of the Tektronix MCM and hybrid facility, which produced more than eight million devices since it opened in the early 1970s. The MCM-and-hybrid facility developed unique capabilities to meet the needs of Tektronix, a manufacturer of measurement equipment, color printers, video systems, and network display products.

One Tektronix need is "active trim," the process of using lasers to change timing parameters, on a device while it is running. Maxim, a developer in the development of analog ICs for data-acquisition and control systems as well as for high-frequency semi-custom arrays and full custom designs, brings a worldwide sales and marketing presence to the new company.

Maxtek's expansion targets the military/aerospace, ATE, communications, data-acquisition, and OEM markets. Maxtek's engineers help circuit designers integrate complex analog/mixed signal functions with multiple ICs into single device packages, said Peter Guest, president of the company.

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