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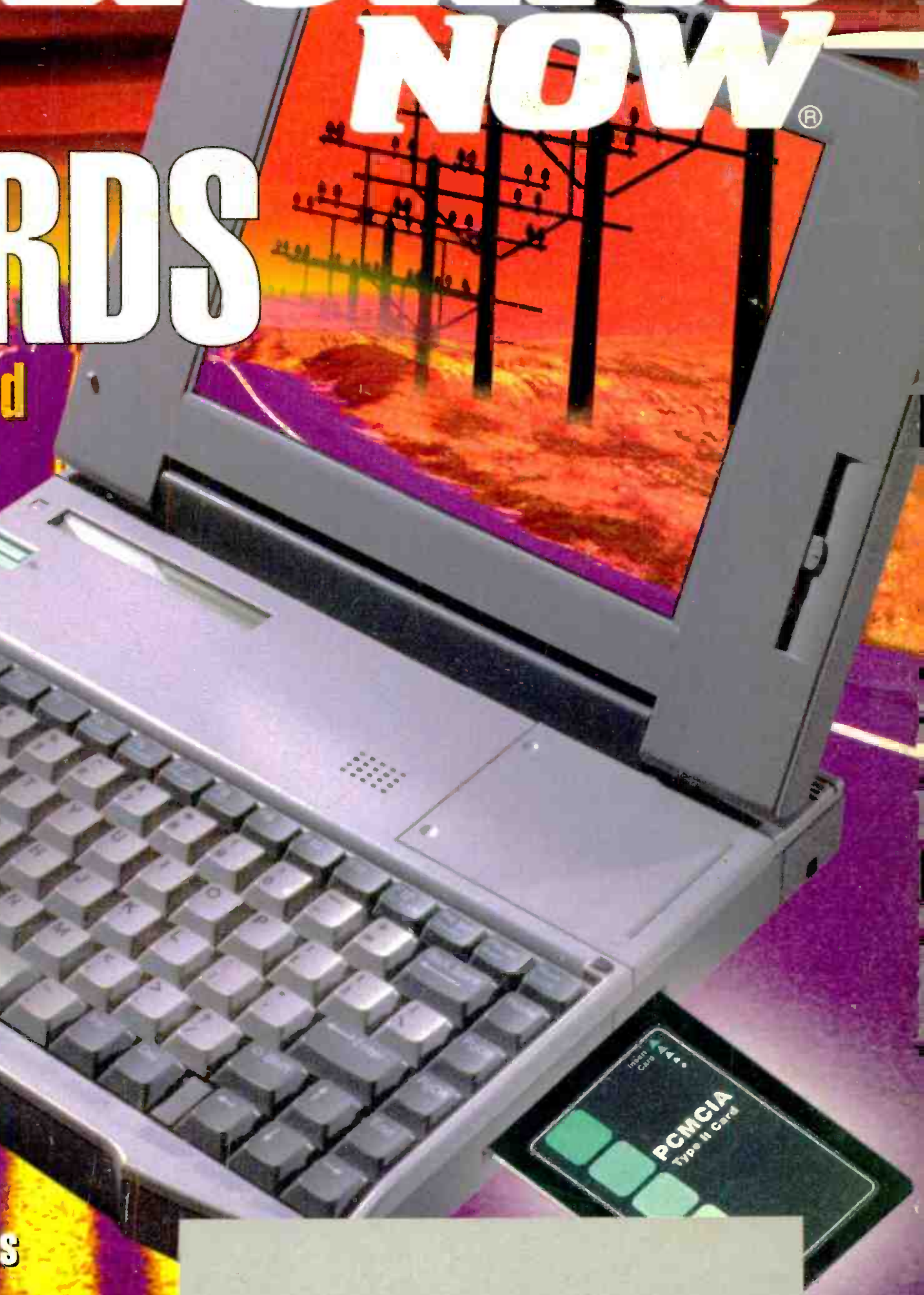

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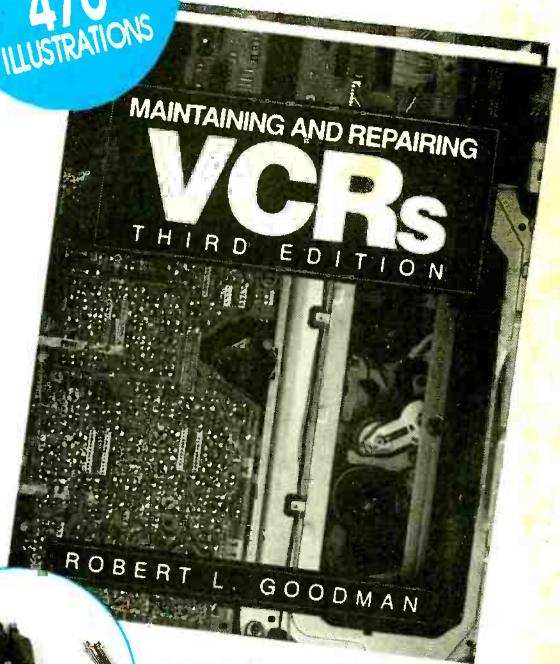

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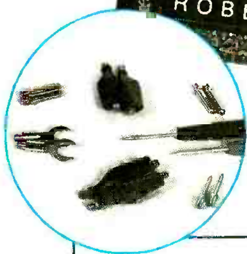

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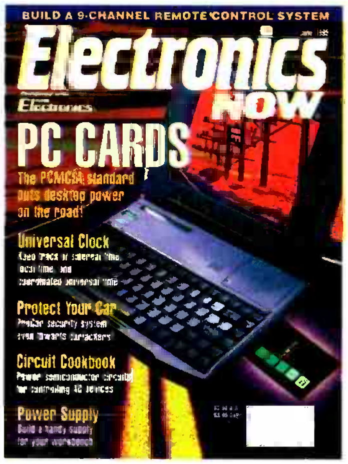

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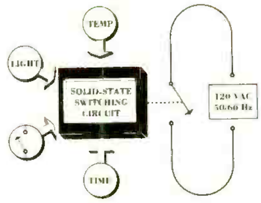

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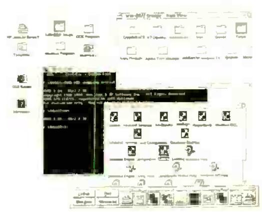

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WHAT'S NEWS

A review of the latest happenings in electronics.

Packaging improves new LEDs

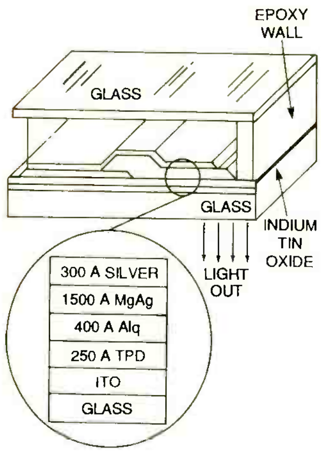
Princeton University scientists have demonstrated that the useful life of an organic light-emitting diode material can be extended greatly if the device is sealed in a glass enclosure filled with dry nitrogen. The life of an experimental LED device made from a material called Alq (hydroxyquinoline aluminum) was increased from the usual 400 hours to more than 1000 hours.

The scientists at the Advanced Technology Center see the packaging system as an important step toward the production of practical commercial Alq color displays.

Alq is of interest because it offers the efficiency and switching speed of such light-emitting diode materials as gallium arsenide (GaAs), gallium aluminum arsenide (GsAlAs), and gallium arsenide phosphide (GaAsP). Alq, a plastic-like substance, can be dissolved in solvent and applied to various substrates by different deposition methods, including spin coating. The material is seen as a prospective candidate for low-cost color display panels.

Researchers at AT&T, IBM, and Hewlett-Packard have also been working with Alq, and all have found that the material tends to break down while experimental devices were operating. The Princeton researchers believe the breakdown might be caused by water vapor in the air that reacts with the Alq. They believe the new packaging technique will overcome that particular drawback.

However, because Alq is a relatively new material, the Princeton scientists say they want to know more about its physical and chemical properties before they can be assured that commercial devices made from it will perform reliably. They report that the performance of experimental devices declined because of short-circuiting caused by conductive filaments that grow across the material when current is passed through it.



LEDs MADE FROM a material called Alq might make more efficient color displays possible.

Alq begins to develop gradually increasing "dark spots" where the material does not emit light. An interim solution to that problem was found by electrically overstressing the LED device to "burn out" the filaments.

Dual-layer compact discs

Sony Corp. and Philips Electronics demonstrated that 3M's dual-layer, single-sided compact discs can be produced at existing manufacturing facilities. The process was demonstrated to attendees at an international audio and video tape conference held last March in Rancho Mirage, Calif.

The dual-layer disks will be introduced in the 7.4-gigabyte disc players that Sony and Philips have proposed in their High-Density Multimedia CD specifications now being circulated for industry comment. The Philips/Sony specifications call for a dual-layer, single-sided disc that will provide up to 270 minutes or 4½ hours ofuninterrupted digital video, and the disk will be fully compatible with all existing CD formats.

The dual-layer demonstration disk was a standard-density disc with an extra layer of information on it. The prototype disc, which was manufactured by 3M, St. Paul, Minn. The disc, played on a slightly modified player, was able to go from track to track, and layer to layer, with ease.

According to Hoss Bozorgzad, a marketing executive at Philips, the dual-layer format will satisfy the vast requirements of the computer industry, business, and multimedia producers for more data storage in the same or smaller-size. Dr. Teruaki Aoki, a Sony Consumer Audio and Video Products vice president, declared that the dual-layer disc will be the most cost-effective format for movies and interactive multimedia programs in any combination the studios want.

The Philips/Sony High-Density Multimedia CD faces strong competition from the Toshiba/ Time Warner digital video disc (DVD) (see *Video News*, in *Electronics Now* , May and June 1995).

Low-power liquid-crystal display

Sharp Corp. has announced its development of an 8.4-inch, thin-film technology (TFT) liquid-crystal display that consumes less than 1 watt. The color display was developed in Sharp's ongoing program to reduce power requirements in notebook computers.The new display is expected to run for six hours, but the goal of Sharp and its Japanese competitors is eight hours on a single battery charge.

The new display panel includes a number of power-saving improvements. For example, a thinner 1⁄10-inch diameter fluorescent backlight and an improved polarizing plate save power. In addition, more highly integrated driver electronics run at 3.3 volts rather than 5 volts. Even the glass in the cover panel and substrate were thinned down to pass more light. As a side benefit, the

Continued on page 58

VIDEO NEWS

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

DAVID LACHENBRUCH

• **Another format war?** Sony and Philips have vowed to fight for their digital videodisc (DVD) system despite the bandwagon effect being enjoyed by the competing Toshiba-Time Warner system. Both systems use what resemble five-inch compact discs to provide up to 135 minutes of high-quality digital video, and the DVD is generally believed to be the successor to videotape for the viewing of prerecorded movies (*Electronics Now*, May 1995). The Sony-Philips system uses a single-sided disc 1.2 mm thick with a capacity of 3.7 gigabytes, as opposed to Toshiba-Time Warner's double-sided disc (actually two 0.6 mm discs laminated together), each side storing up to 5 gigabytes. Sony and Philips have successfully demonstrated a dual-layer recording system that doubles the playing time of their single-sided disc.

The latest hardware company to endorse the Toshiba-Time Warner approach is Zenith, which says it can have players on the market next year at under $500—the same price point mentioned by its competitors. Other hardware manufacturers backing Toshiba-Time Warner are Thomson (RCA and GE brand TVs), Matsushita (Panasonic and Quasar), Hitachi, Pioneer, JVC, and Denon. Those brands include manufacturers holding almost 50% of the U.S. TV market. In addition, some of the top movie studios have embraced Toshiba-Time Warner.

The two warring camps are embracing different strategies. While Toshiba-Time Warner is marshaling forces in the home-entertainment fields—both hardware and software companies—Sony and Philips are seeking to enlist the support of computer manufacturers to get momentum for their system, which they call HDCD (for High Density Compact Disc). Their strategy is to become the de facto replacement for the current CD-ROM and then move into the entertainment field. While Toshiba and Time Warner also have ambitions in the CD-ROM field, that is secondary to them after setting a de facto standard for entertainment first.

Sony and Philips say that the Toshiba-Time Warner claims are premature. They say that the $500 price point for a player can't be met unless hardware manufacturers are willing to subsidize programmers (Toshiba has an interest in Time Warner and Matsushita owns MCA-Universal), and that manufacture of the two-sided disc is beyond the current state of the art. Toshiba-Time Warner partisans reply that their system is proven and that Warner's CD plant has turned out some 100,000 sample discs already. They also argue that if the dual-layer disc is practical, they can adapt it to their system. They will laminate two dual-layer discs together and offer one disc that contains four movies.

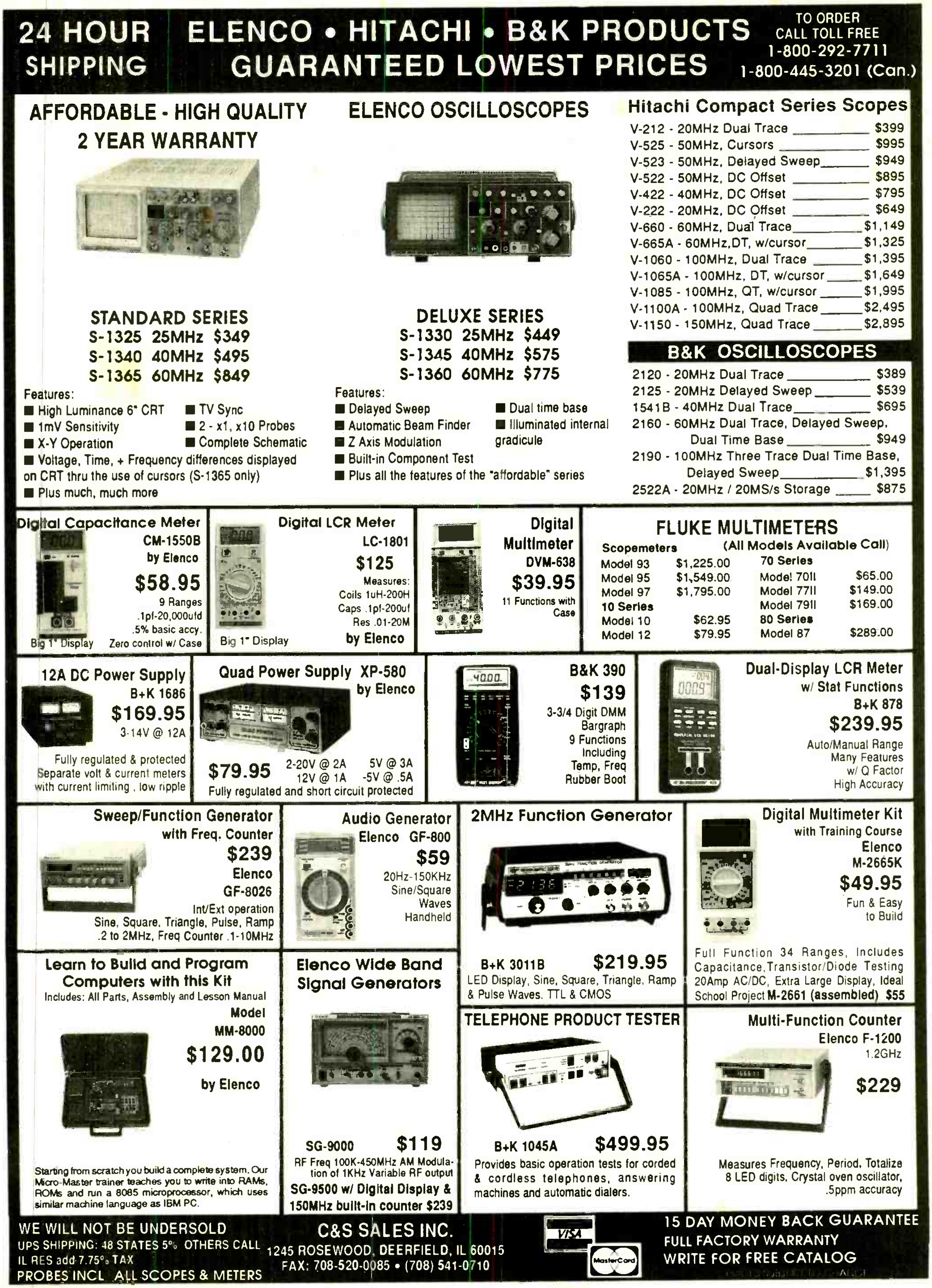
• **Digital videocassettes.** The excitement over the DVD has obscured the progress being made on the digital videocassette (DVC), a system agreed upon by 50 manufacturers as the digital successor to the home VCR for the high-definition age. The system uses tape ¼-inch wide in two different size cassettes—a DAT-size unit designed for camcorders and capable of recording an hour in NTSC or 30 minutes in HDTV, and a large cassette about the size of an audio cassette that will tape for 4½ hours in NTSC and half that in HDTV.

The first to introduce DVC recorders was Panasonic—but its initial offerings are for broadcast, not consumer, use. The convenient, lightweight format and its high-quality component-type recording system make it ideal for electronic newsgathering and electronic field production. However, the first Panasonic units, due late this year, will only be semicompatible with the upcoming consumer versions. That is, tapes made with the professional version won't be playable on consumer recorders, but consumer tapes can be played back on professional models.

• **New VHS technology.** Despite the potential market inroads of digital systems, there's still life left in the conventional VHS recorder. In fact, JVC—the inventor of VHS—has introduced a new head-drum system that increases the flexibility of the recorder and gives it many of the features of professional and broadcast recorders.

JVC's Dynamic Drum System (DDS), which soon will appear on other brands as well, makes possible virtually noiseless special effects, longer playing tapes, and "endless recordings" (due to its ability to play in both directions, reversing the tape at the end). Although not all features will be used in the first models, DDS can also accomplish smooth slow-motion (without the frame-by-frame jerkiness of today's models) and noiseless fast-forward or reverse, accompanied by intelligible sound for high-speed viewing. In addition, it will permit still-frame recording while the recorder is in the pause mode. The DDS feature will add about $100 to the price of a VCR.

• **More satellite receivers.** The Direct Satellite System (DSS) with its 18-inch dish antenna is continuing to make inroads on cable, with about a million installations in its first year. After a year of monopoly on receivers by RCA, Sony is now beginning to offer them as well, and Toshiba, Uniden, and Hughes Network Systems are waiting in the wings with licenses to produce receivers later. Competition for DSS is being provided by Primestar, a satellite system owned by major cable operators, with two more birds—known as Echostar and AlphaStar—scheduled for launch by this fall. Ω



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Q & A

Write to Q & A, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

HEADPHONE AMPLIFIER

I recently built a fairly high quality pre-amp and would like to add a headphone driver to it. I have experimented with op-amps such as the LM741 and LM386, but have found their sound quality less than satisfying. Could you provide a circuit that would function more to my liking?—Derek Au, North York, Ontario.

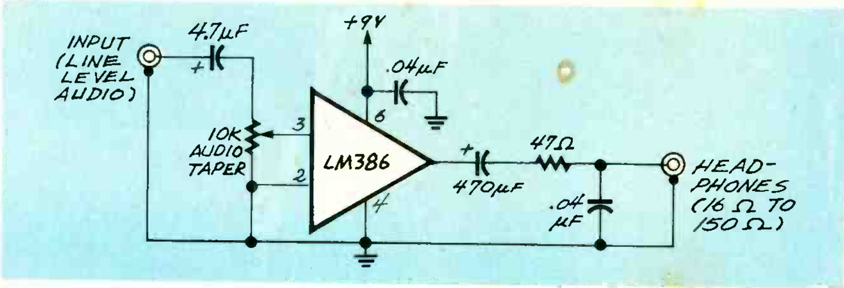

FIG. 1—LM386 HEADPHONE AMPLIFIER. Note the 47-ohm resistor that protects the headphones.

The 741 and similar op-amps can't deliver enough power to drive headphones well. Headphones typically require a drive power of at least 0.04 watt into an impedance of 16 to 150 ohms. That corresponds to an output current of 50 milliamperes RMS, too much for an op-amp.

You're on the right track using the LM386, which is designed to drive small speakers, but as you've discovered, the LM386 can be tricky to work with. The problem is high-frequency oscillation. The LM386 is apt to oscillate briefly at a frequency of 2 to 4 MHz during parts of the audio cycle. This causes distortion that could be severe or could be almost unnoticeable.

To prevent oscillation, build the LM386 circuit compactly on a printed circuit board (not a solderless breadboard) and include two 0.04-µF capacitors, one across the power supply leads and one across the headphone jack (see Fig. 1). Mount both capacitors as close to the LM386 as possible.

You can also take advantage of the fact that, unlike speakers, headphones are normally driven through a resistance. The 47-ohm resistor in Fig. 1 protects the headphones from overdrive, allows the LM386 to work at its optimal signal levels, and further reduces the risk of unwanted oscillation.

If this circuit won't give you enough amplitude for studio headphones, reduce or eliminate the 47-ohm resistor, or use an LM386N-4 (a special high-power LM386) and raise the supply voltage to 15 volts. Or use any speaker-level amplifier, taking the output through a 100-ohm, 1-watt resistor.

MICROCONTROLLER HELP

Where can I find a beginner's book or manual for the Zilog Z8681 microcontroller? I already have the Zilog microcontroller manual and need some basic explanation.—Olden Green, Decatur, GA.

Unfortunately, introductory guides do not exist for all kinds of microcontrollers. The Z8681 is part of the large Z8 family, and you might look for literature on other Z8's (unfortunately not the same as Z80's or Z8000's). If you have not already done so, you should learn the assembly language of a popular computer such as the IBM PC before tackling the assembly language of a microcontroller. Also, there is a lot of useful information—unfortunately not Z8-specific—in "The Art of Electronics", by Paul Horowitz and Winfield Hill, published by Cambridge University Press.

SWEEP ALIGNMENT—LOST ART?

What ever happened to tuning the AM/FM radio the old-fashioned way? Sweep alignment is no longer taught in technical schools. I've read service books from the library but have never done the procedure. Can you help me?—Neil W. Fisk, Edmonton, Alberta.

Good question! Like you, I've read about the procedure but never actually done it. Sweep alignment of a 10.7-MHz circuit requires a signal generator that rapidly sweeps back and forth from, say, 10.5 to 10.9 MHz, and an oscilloscope whose horizontal sweep is synchronized with the generator. Using this equipment, you can easily see the width of the band of frequencies getting through the IF, and you can tell if all frequencies within the band are being amplified equally.

I'm sure one reason the technique has died out is that the need for it has diminished. Older FM radios used Foster-Seeley discriminators that were quite picky about alignment; the newer quadrature detectors are less demanding. Also, FM stations have proliferated, so that weak-signal performance is no longer critical. Finally, the vacuum tubes in older radios and TVs contributed to the need for alignment in two ways: replacing a tube could throw the alignment off, and the heat from the tubes shifted the values of other components. In the early 1950s, it was common for a TV set to need some kind of repair every month or two; thank goodness we don't have to put up with that today.

VARIABLE DUTY CYCLES

I have been playing around with 555 and CMOS ICs trying to make a generator whose duty cycle (controlled by a potentiometer) can be varied fairly linearly from always off to always

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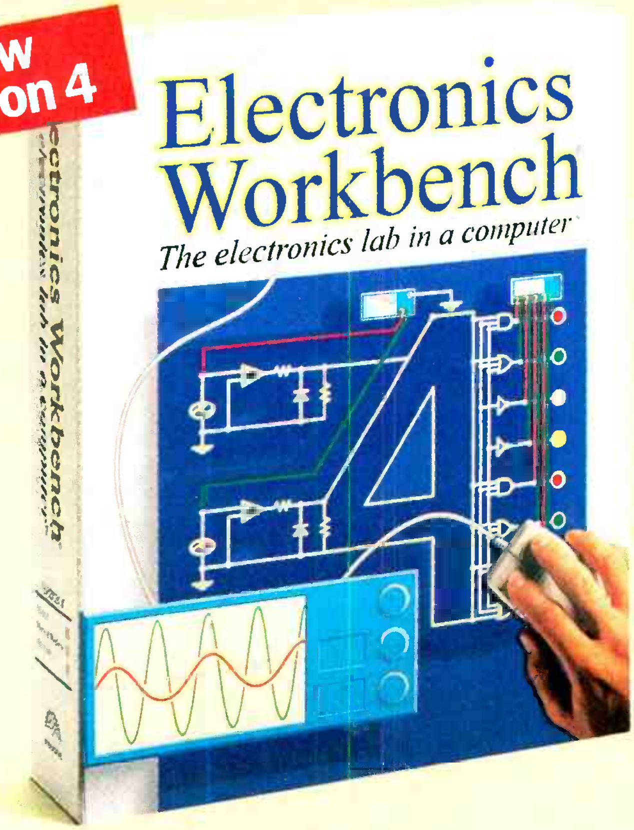

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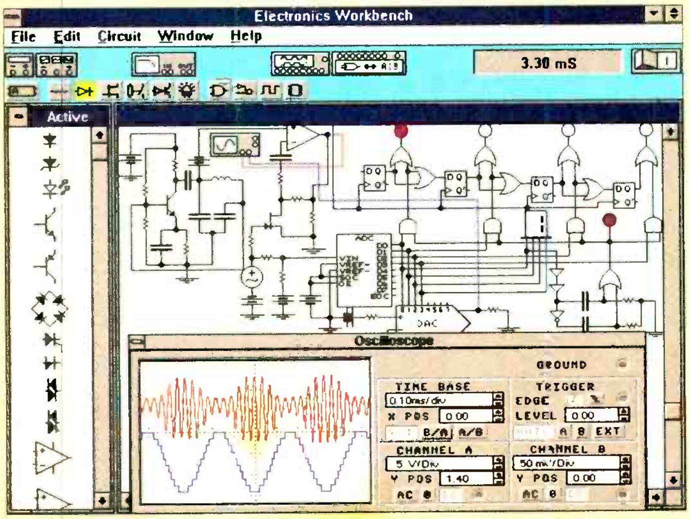

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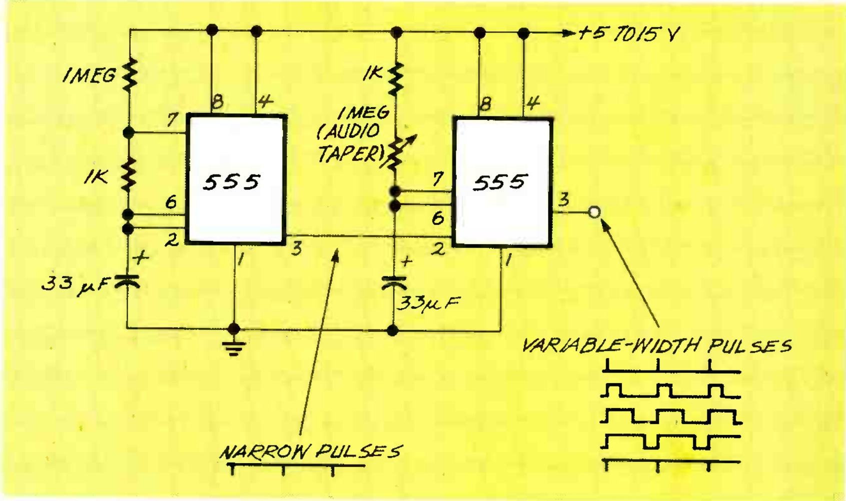

FIG. 2—A PAIR OF 555s gives pulses with adjustable duty cycle from 0.1 to 99.9%.

on, with the overall cycle always being about 30 seconds to a minute in length. How can I do this?—Jan Janowski, Skokie, IL.

That's hard to do with a single 555 timer, but relatively easy with two of them, as shown in Fig. 2. The duty cycle is the percentage of time that a squarewave is in the "high" or "positive" state. You want to vary the duty cycle without varying the frequency. The way to do it is to generate very brief pulses with one 555, then use a second 555 as a monostable multivibrator to lengthen the pulses the desired amount. (You can use a 556, which is two 555s in one package.)

In Fig. 2, the first 555 produces a very short negative-going pulse once every 30 seconds. The second 555 turns them into positive-going pulses whose length is controlled by the potentiometer. You can't quite get duty cycles of 0% or 100% (always off or always on), but you can easily go from 0.1% to 99.9%. Be sure the two 33-μF capacitors are well matched, and try out the potentiometer to see exactly what it does. As you turn up the resistance, the duty cycle will rise almost linearly from 0.1% to 99.9%, then suddenly jump back to 50% at a lower frequency when the period of the monostable IC becomes longer than that of the first oscillator.

CHEAPER MANUALS?

I do some part-time VCR repair. One of my biggest problems is getting schematics and service information. Generally I find that purchasing information from manufacturers or Sams is so expensive that, along with parts and labor, it is just too costly for me. Thanks.—Ray Andrew, Honeoye Falls, NY.

The high cost of manuals puts part-timers at a disadvantage. Most full-time repair shops spend $20 to $100 per month to receive Sams publications on subscription. As a result, these repair shops have relatively complete files covering all current equipment.

The rest of us have to order manuals piecemeal for $20 to $40 each, which more or less wipes out the profit from a repair job. (At least we're not fixing cameras; those manuals cost $75 or more!)

Unfortunately, I know of no inexpensive alternative. You can get old service manuals from shops that are going out of business; check the classified ads in several different magazines, including this one. But new service manuals are expensive.

Your best bet is to learn how to troubleshoot without a complete manual. After you've read several manuals, you'll find that a lot of features are about the same on all makes and models. This is especially true if you make an effort to understand the circuit rather than just checking off a list of voltage readings or following a flowchart. Also, the manuals for a manufacturer's most popular models will often shed a lot of light on other VCRs from the same maker.

Continued on page 29

TECHNOLOGY UPDATE

New device turns your car stereo into a CD player...*with no installation!*

Breakthrough adapter plugs in, instantly transmitting sound from your portable CD player to your car stereo.

by Walker B. Hindelang

Do you ever wish your car had some of the amenities of those expensive luxury cars? Be honest. While some of them are unnecessary (like miniature wipers on your headlights), there are others that we would all appreciate. If I could choose just one luxury-car option, it would have to be an in-dash CD player. But did you know there is an easier, less expensive way to get CD sound in your car? It's called Sound Feeder.

How does it work? Sound Feeder is a unique car CD adapter that allows you to play music from a portable CD or cassette player through your car's existing stereo speaker system. Sound Feeder contains a miniature FM modulator that broadcasts the audio signal from your CD player to a blank channel on your FM radio.

Take it anywhere. With Sound Feeder, you can use your existing portable CD player in your car. This eliminates the need for the purchase and installation of an expensive in-dash system. Plus, because it is portable, you can unplug it and take it with you when you leave your car; this reduces the risk of theft.

Sound Feeder also has an adapter that will supply most portable CD players with power. Because they needn't rely on batteries to operate, they will run longer and be more cost-efficient. Your car doesn't have to have a cassette deck—any AM/FM radio will do.

The first of its kind. The company that makes Sound Feeder, Arkon Resources, has a 10 year history of electronic innovation. They pioneered the consumer market for cordless headphones for use with TVs. Other innovations include camcorder battery chargers, compact video lights for camcorders, universal AC/DC chargers and battery dischargers. It's no surprise, then, that they have produced the first transmitter-type car CD adapter that provides stereo sound and voltage conversion technology. In addition, Sound Feeder meets FCC regulations.

Just plug it in. Playing a portable CD player in your car is simple. Just plug Sound Feeder into your cigarette lighter, connect the audio input wire to your portable CD or cassette player and set it to the desired FM station. You can enjoy the amplified stereo sound of your portable CD player without the dangerous or illegal use of headphones.

Sound Feeder is guaranteed to work with any car stereo—old or new, cassette deck or no. Simply put, if your car has an AM/FM radio, with Sound Feeder and your own portable CD player it can have CD sound!

Factory-direct savings. Because we're bringing this offer direct from the manufacturer, you save the cost of middlemen and retail mark-ups. For a limited time, you can buy Sound Feeder for just $39. How else can you get CD sound in your car for so little? In addition, if you act now, buying Sound Feeder qualifies you for a $10 discount on the soft-side carrying case!

The Sound Feeder advantage:

- **No installation.** *Forget about the hassle of installing an in-dash system—Sound Feeder simply plugs in!*
- **Theft-proof.** *Because you can easily disconnect your CD player and take it with you, there's nothing in your car to tempt a would-be thief.*
- **Universal.** *Sound Feeder will work with any AM/FM car stereo... even if you don't have a cassette deck!*
- **Convenience.** *Leave Sound Feeder plugged into your car and take your portable CD player with you.*
- **Value.** *You could pay up to $400 to purchase and install an in-dash CD player in your car. With Sound Feeder, you spend $39 and use your own portable CD player.*

Buy Sound Feeder and 25 CDs for the price of installing an in-dash system in your car!

Sound Feeder and its carrying case both fit discreetly into your car interior.

How does it work?

Sound Feeder contains a miniature FM modulator that broadcasts the signal from your CD player to a blank channel on your car stereo. It can also provide power to many models, preserving battery life.

Connect Sound Feeder's audio input cord to the headphone or line-out jack of your portable CD player. Set the FM Band selector switch on the Sound Feeder for the portion of the FM radio band you wish to access. Once set to the desired station, it's ready to play!

Try it risk-free. Sound Feeder is backed by Comtrad's exclusive risk-free home trial. Try it, and if you're not completely satisfied, return it within 30 days for a full "No Questions Asked" refund. The Sound Feeder unit is also backed by a one-year manufacturer's limited warranty. Most orders are processed within 72 hours and shipped via UPS.

Sound Feeder	$39	$6 S&H
Carrying case	~~$19~~	$4 S&H
Case when you buy Sound Feeder	$9	$4 S&H

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LETTERS

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

WWV RECEIVER UPDATE

I encountered a problem with the AGC amplifier (IC3, a Texas Instruments TL071 operational amplifier) specified in my "WWV Receiver" project (*Electronics Now*, March 1995). I had been operating the TL071 too close to its input common-mode voltage ratings. I built 10 receivers from one lot of TL071s and encountered no difficulties, but when I took parts from a different lot, none worked properly.

The fault symptoms are severe audio distortion of strong signals and the AGC voltage at pin 6 of IC3 is always less than 2 volts. Although I sent several customers a modification kit, that fix is inadequate in all instances, especially if the builder has installed a new battery with an output greater than 8.8 volts.

My recommendation is to replace the TL071 with a Harris CA3140E. This op-amp's input common-mode range is well within the values needed by the receiver. Those readers who built the receiver from the article should replace the TL071 with a CA3140E.

Readers who received my modification kit and installed it should restore the original resistor values, and substitute a CA3140E for the TL071. They should contact me as soon as possible for a free modification kit containing a CA3140E. Those readers who purchased completely assembled receivers from me containing a TL071 can return the receivers to me for a free, postage-paid upgrade.

NEIL HECKT
Almost All Digital Electronics
1412 Elm Street SE
Auburn, WA 98092

CSICOP RESPONSE

Benson Boss' recent letter (*Electronics Now*, January 1995) condemning the Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP) reveals that he didn't do his homework before picking up his pen.

The stated aims of CSICOP *do not* involve doing any research as a committee. However, many of the individuals on the Committee and/or its scientific consultants do and have done research on various paranormal phenomena. And they *do* investigate individual incidents.

As any reading of CSICOP's journal, *The Skeptical Inquirer*, will reveal, the Committee is not afraid to examine *any* claim of the paranormal. The physical evidence must be measurable by existing instruments.

Human testimony is fine for giving the scientists clues about what to investigate, but scientists can only test phenomena that they can measure. Evidently Mr. Boss is unfamiliar with the scientific method.

The committee has never implied that *no* reports are worth investigating. Unfortunately, it does not have the facilities or the personnel to investigate any more than a small percentage of the paranormal claims made.

If a phenomena is said to exist in the *natural* world, it should be subject to tests and the results should be explainable by science (at least hypothetically, if not yet practically).

Finally, CSICOP has never tried "to prevent the introduction of any fundamentally new ideas" anywhere. It does not get involved in political claims. However, CSICOP urges that new ideas in science and medicine be tested scientifically, as would any individual scientist.

GORDON STEIN, Ph.D.
Library Director, CSICOP
Buffalo, NY

A READER'S SUGGESTIONS

I just read and liked Ray Marston's article, "Active Audio Filters" (*Electronics Now*, March 1995) because it discusses circuits that I might find useful in the future. I found certain circuits to be of special interest—the tone control and equalizer circuits, and the constant volume amplifier.

It has been my experience that most circuits that include at least one operational amplifier usually need several of them, so that is why dual and quad op-amps are so useful. Mr. Marston typically calls out the classic 741 in his articles. However, the 1458 dual op-amp contains two 741 op-amps in an eight-pin DIP package. It is widely available because it is made by Exar, Harris, Motorola, National Semiconductor, Philips , SGS-Thomson, Texis Instruments, and others.

However, I prefer the 4558 low-noise dual op-amp offered by Exar, Motorola, Philips, Raytheon, and others. (It has about the same price and the same pinout.) I also favor the very-low-noise 5532 offered by Exar, Philips, Raytheon, and TI.

I also found "Prototyping Station," by Carl Berquist to be very useful because I favor construction articles that permit the builder to make changes to meet his own requirements.

I service electronic music equipment and I am often asked to make calls to service electronic organs. This means I need portable test equipment. I have built several circuits similar to the modules discussed in Mr. Berquist's article, but I put each one in a separate case so I could carry them around.

Unfortunately, I was unable to find a suitable commercial power supply so I built a regulated supply in a portable case that provides both fixed and variable voltages. I have been using a set of four potentiometers (the same values as those mentioned by Mr.Berquist) for years, but I installed them in a small project case.

I devised my own simple voltmeter module based on a No. 39-165 digital panel meter from Hosfelt Electronics. (Comparable insruments are available from other electronics mail-order houses.)

The DPM I selected offers maximum readings of 0.2 volt with an input impedance of more than 100

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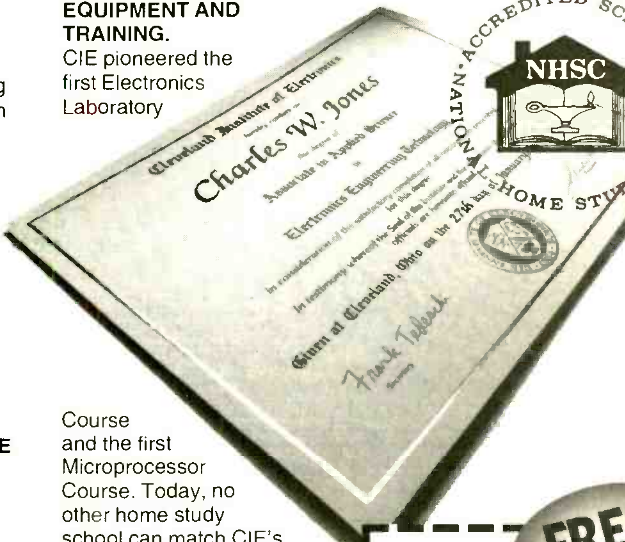

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megohms. A voltage divider made of a 1-megohm resistor and an 8.2-megohm resistor in series with a 1-megohm multiturn trimmer potentiometer gave me a 2.0-volt output with an input resistance of about 10 megohms.

I put my DPM in a project case with a five-position, two-pole switch. I then replaced the 1-megohm resistor with four 1% resistors to give ranges of 0.2, 2.0, 20, 200, and 2000 volts DC. The second pole of the switch sets the decimal point. One of the three terminals is grounded.

My DPM requires a 9- to 12-volt power supply that is isolated from the voltage inputs. The current drain of the DPM with its liquid crystal readout is so low that a 9-volt battery will give many hours of service. Moreover, the half-inch high digits on the DPM's LCD are larger than those on many digital multimeters.

I also built an audio amplifier based on a National Semiconductor LM3856, 5-watt power amplifier, similar to Mr. Berquist's, but in a project case for portability. I found that if more gain is needed from the amplifier, connecting a 10-µF capacitor to pins 1 and 8 (positive to pin 1) will increase the gain to about 200.

A 1200-ohm resistor in series with the capacitor gives a gain of about 50. If it is installed connect a 100µF bypass capacitor from pin 7 to ground (positive to pin 7). The LM386 specification sheet also shows a 0.047µF capacitor in series with a 10-ohm resistor from pin 5 to ground. A 9-volt battery for powering the LM386 will last a long time, but I would replace it with six AA cells.

Keep on publishing the good construction and technology articles!

BILL STILES, CET
Hillsboro, MO

BATTERY DRAIN ANSWERS

The answer to the question about why lead-acid batteries stored on bare concrete floors in garages or basements discharge ("Q&A," *Electronics Now*, April 1995) is due to condensation. You can see condensation on a mirror in a bathroom after you have taken a hot shower. The water vapor in the air condenses out as a liquid on the cool mirror surface.

Similarly, when an unsealed lead-acid automotive battery is stored on a cold concrete floor, the inner walls of the battery case are chilled. Water vapor trapped in the spaces above the electrolyte in each cell condenses out as water on those walls. When the water drains down the walls it dilutes the electrolyte in each cell. This starts a discharge cycle. That response is repeated again and again in a stored unsealed battery.

My father, a mechanic, told me not to store a battery on the concrete garage floor because it would be discharged. I thought I knew better from what I learned in a high school electronics class. So I charged a car battery and left it on the garage floor. When I came back a week later and checked it I found it was dead!

Realizing that my father might be right, I recharged the same battery and placed it on a wood platform. A week later the battery was still charged. My father knew this from experience even if he didn't know why it happened.

I made up my mind that some day I would find out why the battery had discharged. I have long since forgotten the source of my information. But I suspect that I learned about it some time during the past 20 years while working in the electronics field. I had occasion to be in substations that contained large arrays of batteries for backing up telecommunications equipment, and I think I might have learned about it there.

I know that solving the problem obsessed me for years, and I had asked literally hundreds of people before I got the right answer!

RICHARD A. KUNKEL
Huntsville, AL

On the subject of the discharge of lead-acid batteries stored on bare concrete floors, I'd like to say that all kinds of batteries lose output energy when cold. Energy content remains fixed because energy is conserved. But the conversion of chemical energy to electrical energy by means of a chemical reaction is impaired at low temperatures. Putting any object on a concrete floor is a good way to draw the heat out of it. (Think of it as a heatsink.)

Once the battery warms up, its output power will be restored. I have not observed that effect personally, but I have read about it often enough to believe that it is true.

JOHN N. POWER
Baltimore, MD

MONITOR SWITCHER DILEMMA

I am writing about the answer to a question concerning connecting or disconnecting computer monitors ("Q&A," April 1995 *Electronics Now*).

The answer said one can safely disconnect and connect monitors to and from computers while they are powered. I believe one should check with the computer manufacturer doing this.

I own a Gateway 2000 computer, and my owner's manual states that one must turn the monitor on before the computer, and turn the monitor off only after the computer is off. Because I was not happy about that instruction, I called Gateway 2000's help line twice and got the same answer twice.

The computer interrogates the monitor to determine what video mode it should be in, so the monitor must be turned on first so that routine can be carried out. I did not ask why the units must be turned off in the reverse order.

My Gateway 2000 manual contains a note warning against connecting or disconnecting any cables from the computer while it is turned on. Please qualify your answer or give me a more complete explanation if you could.

KENNETH E. STONE
Cherryvale, KS Ω

ITT Instruments' MX-200 Clamp-on Multimeter

Measure high current safely with the MX200 clamp-on multimeter.

Making high current measurements can be a danger to your health without the right test instrument and knowledge of how to do it correctly. High voltages at microampere levels can be tolerated if encountered accidentally, but even milliampere current can be lethal if it flows through your body. Simply walking across a carpet in a room with very low humidity can generate up to 35,000 volts, but the current will be so low that all you'll get when you touch a doorknob is a startling jolt. But, current is another matter.

In addition to safety consideration, current measurement, especially high current measurement, calls for special instruments. In many situations where only low current is present, it is not practical to break a conductor so the current will pass through a meter for measurement. It is usually out of the question when measuring amperes in power circuits.By contrast, you can measure voltage at all reasonable levels as long as you have access to circuit ground. All you need is a couple of insulated leads and a suitable voltmeter.

In situations where current does pass through a conventional ammeter, the ammeter has a small internal resistance that could affect measurement accuracy. However, if that resistance is small compared to the resistance of the circuit under test, the effect will be minimal.

Special instruments are needed when measuring current from integral values up to 200 amperes. The clamp-on meter avoids both the insertion and internal resistance problems by measuring the fields associated with the current passing in the conductor. Moreover, it permits the measurement to be made safely.

The MX200 clamp-on

The MX200 from ITT Instruments (1500 East Ninth Street, P.O. Box 2767, Pomona, CA 91769, 714-469-2900) is a handheld, clamp-on multimeter that measures either direct or alternating current up to 200 amperes. It does this without the need to break the current circuit. In addition, the MX200 can measure most of the electrical variables associated with power plant installations.

The MX200 can measure DC and AC current to 200 amperes, DC and AC voltage to 750 volts, and true AC and DC power. (The AC values are true RMS.) It can also measure AC apparent power to 20 kVA, power factor and frequency to 1000 Hz.

Hall-effect sensors in the magnetic circuit provide accurate DC and AC current values. The measured value, together with the corresponding engineering unit being measured, is displayed on a 3½-digit, 2000-count liquid crystal display. True RMS measurement provides current, voltage, and power readings that are accurate (almost regardless of waveform shape) to a crest factor of 7.

An analog output of the measured current value is available for display on an oscilloscope, chart recorder, or other measuring instrument. Either true RMS or instantaneous waveform value can be selected for the analog output.

Autoranging is available on all measuring ranges. Symbols denoting AC or DC, low battery indication, and two ranges of surge current readings are displayed. Moreover, the instrument will switch off automatically if the instrument is left on and no measurements are being made. ITT Instruments declares that all of these features are possible because the latest internal CMOS microprocessor is included in the instrument.

Special features MX200

The characters on the liquid-crystal display are over a half inch high making the display easy to read even in subdued light. The automatic test and calibration procedures that take place during start up are displayed. The MX200 is powered by a nine-volt battery (included), and it is equipped with all necessary test leads. Battery life is given as 45 to 85 hours of continuous operation, depending on the range setting.

Current resolution is 10 milliamperes in the 20-ampere range and 100 milliamperes in the 200-milliampere range, and accuracy is 1 % of range. Voltage resolution is 100 millivolts in the 200-volt range and 1 volt in the 750-volt range. Accuracy is 0.5% of range. The frequency range of the voltage being measured is from DC and 15 Hz to 1000 Hz.

Active power can be measured in two ranges with autoranging: 2 kilowatts and 20 kilowatts with true RMS AC and DC. Resolution is 1 watt for the 2-kW range and 10 watts for the 20-kW range. Apparent power can be measured in two ranges: 2 kVA and 20 kVA, both true RMS. Power factor can also be determined. The MX200 measures frequency in two ranges: 5 to 200 Hz and 200 to 1000 Hz. An optional HX-3 PL adapter permits the clamp-on multimeter to measure power and power factor in three-phase systems.

The MX 200 has an insulation rating of 6 kV and it meets the class II safety requirements of VDE 0411. When measuring current flowing in a conductor that is not isolated the voltage between the conductor and ground must not exceed 100 volts RMS. The clamp-on multimeter is 10 inches long, 3½ inches wide, and 2½ inches deeps; it weighs slightly over a pound.The jaw opening will permit the measurement of circular cables up to 9/10 inch in diameter.

How to operate the MX200

The MX200 is turned on by pressing the ON keyswitch. During the first five seconds, the display shows CAL to indicate that the automatic zero calibration for all measuring ranges has been completed. A display of "0" after the CAL indicates that the instrument is ready to make measurements. During this five-second CAL period the instrument should be kept away from any current-carrying cables to assure measurement accuracy.

When the clamp-on meter is ready for use, depress and hold the keyswitch to take any of the electrical measurements. The keyswitch must be held down during all measurements. When the keyswitch is released, measurement during the normal operation mode is complete. The last measured value will be retained and displayed for about 30 seconds before the instrument will switch off, unless the switch is pressed again.

If a measurement is to be made over a longer time period, the MX200 can be put in the *continuous mode* so that the switch need not be held down. The instrument is turned on with momentary pressure on the keyswitch. During the calibration period, a CONT display flashes for about two seconds. If the ON keyswitch is depressed during that period, the display will stop blinking.

Now the keyswitch need not be held down, and the instrument is in the continuous mode. To return to the normal operation the keyswitch is depressed again until the CONT symbol disappears.

After high current has been measured or the instrument was overloaded, the display might not return to 00.0 amperes. If that occurs, it is recommended that the instrument be recalibrated by depressing and releasing the ON button twice in quick succession.

Current is always measured with the clamp-on jaw. Voltage, however, is measured at two input terminals located at the bottom of the meter where the two included safety test probes are plugged. The MX200's analog output is also available at these two jacks, although the signal can be accessed only with the special output leads supplied with the meter. Power measurements are made with the clamp-on jaw measuring current while the voltage is measured through the leads.

Who needs the MX200?

One does not normally think of a clamp-on multimeter as an integral part of the electronic technician's arsenal of tools. Indeed, many a technician might complete a career without ever making measurements of more than 10 amperes or so. However, the times are changing as electrical power technology merges with electronic technology. One can expect to see more applications for this class of instrument in electronics-related activities.

Keep in mind that people who test and maintain radio transmitters, radar, lasers, and other power-guzzling systems must be well acquainted with the skills and techniques for measuring heavy current. For those who routinely measure high current, power power factor, and related parameters, the $695 price for the MX200 can be considered an investment. It will pay off in the years of service from this rugged multimeter. The optional HX-3 PL three-phase adapter carries a price tag of $139. Ω

NEW PRODUCTS

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

GRAPHICAL MULTIMETERS. Fluke has introduced its new 860 series of Graphical Multimeters (GMM) that offer a combination of analog, digital, and graphical displays. The three handheld meters in the series feature selectable display modes that allow the viewing of waveforms for component testing, trend plotting, and logic analysis. The principal operating control on the instruments is a rotary switch.

CIRCLE 20 ON FREE INFORMATION CARD

Each meter offers several operating modes. In those modes the 860 meters are useful for troubleshooting various industrial, commercial and consumer electronic products, equipment, and systems as well as their components. Each multimeter has a 32,000-count (4.5 digit) resolution, a dual digital display and Fluke's analog NeedleGraph display.

The meter mode permits current, resistance, conductance, capacitance, frequency, duty cycle, pulse width, period, decibels, and AC and DC voltage to be measured directly. An AutoDiode feature built into the unit permits optional temperature and pressure measurement.

The waveform display mode provides a graphical display, similar to that of an oscilloscope, of noise, waveform distortion, and intermittent failures. The display capability (up to 1 MHz signal bandwidth) supplements the numeric display. The full automatic display setup automatically scales voltage, timebase, and triggering to simplify testing. Manual setup or external triggering are also available.

The TrendGraph mode plots high-resolution readings for up to 30 hours in intervals from 1 second to 15 minutes. This permits the detection of power sags or surges and droops. This feature collects and graphs desired information automatically.

The in-circuit component-test mode allows the viewing of component "signatures" without having to remove components from the circuit boards. Troubleshooting can be performed by comparing the signatures of known, functioning circuits with those of defective circuits. The components can be checked safely without powering the host equipment.

The logic-test mode offers a simple way to isolate digital failures. Logic transitions or state changes to 10 MHz are indicated, showing if a logic circuit is functioning properly. Activity frequencies and average DC voltage are also displayed.

The Model 863 has both meter and graphic capabilities including meter mode, waveform display, and TrendGraph mode. Its basic DC accuracy is 0.04%. The Model 865 offers the comprehensive meter and graphic capabilities of the Model 863, but also includes in-circuit component test and logic-test modes. Its basic DC accuracy is also 0.04%. The 856 has internal battery charging, a line-voltage adapter/battery charger, and liquid-crystal display backlighting.

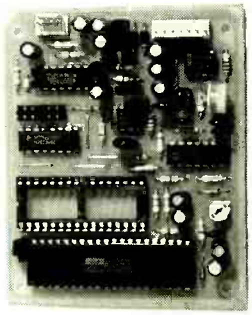
The Model 867 has all the features of the Model 865 and improved DC accuracy of 0.025%. It has an optically isolated RS-232C cable and is sold with software and a nickel-cadmium rechargeable battery pack.

The pricing of the 860 series is: Model 863—$795.00, Model 865—$995.00; and Model 867—$1295.00.

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

LOW-COST AUDIO BOARD. The QuikVoice DM1000LS audio board from Eletech is intended for talking displays and vending machines, public building announcement systems, industrial controls, and talking alarms. Self-contained, the board needs no external controller.

When activated by external contact closure or a motion sensor, it plays the message stored in its EPROM. A message of two minutes duration can be programmed into EPROMs with a separate development circuit.

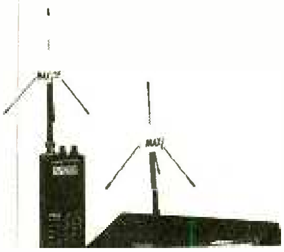

CIRCLE 21 ON FREE INFORMATION CARD

The board can be powered from a single 6- to 12-volt DC power supply. Audio output is up to 2 watts into a 4-ohm speaker. Standby current is 1 microampere in standby mode. The board measures 3.0 × 3.5 inches. It can be triggered by an optional infrared sensor unit.

The DM1000LS audio board, without EPROM, is priced at $30.00 in single quantities.

ELETECH ELECTRONICS
16019 Kaplan Avenue
Industry, CA 91744
Phone: 818-333-6394
Fax: 818-333-6494

GROUND PLANE ANTENNA. The improved MAX 800 ground plane antenna from Cellular Security Group now receives 800-MHz signals with the latest generation scanners. The new antenna weighs less than the earlier models and adaptors are no longer needed.



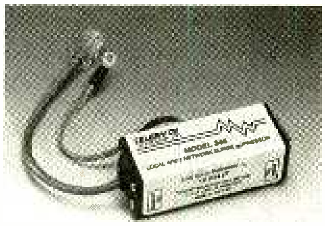
CIRCLE 22 ON FREE INFORMATION CARD

Two versions of the antenna are available. Both connect directly to the BNC fitting on either a handheld or a base station scanner. The antenna for handheld scanners is priced at $31.95, and the base station version is priced at $35.95.

CELLULAR SECURITY GROUP
4 Gerring Road
Gloucester, MA 01930
Phone: 508-281-8892
Fax: 800-487-7539

LAN SURGE PROTECTOR. The model 346 multistage surge protector from Telebyte Technology will protect 10BaseT Ethernet adaptor cards in local area networks (LANs) linked with twisted wires. It protects against damage from electrostatic discharge (ESD), transient pulses, and lightning strikes.

The surge protector will work at data rates as high as 20 megabytes per second. Response time is given as less than 1 nanosecond, and it will clamp at 7 volts peak. Its interface is compatible with



CIRCLE 23 ON FREE INFORMATION CARD

Ethernet, IEEE 802.3, (10BaseT) standards. Protection is provided for all four wires of the twisted-pair cable for 10BaseT LANs. It is packaged in a case measuring 1.25 × 1.25 × 3.2 inches.

The Model 346 10Base-T surge protector is priced at $65.00

TELEBYTE TECHNOLOGY, INC.
270 Pulaski Road
Greenlawn, NY 11740
Phone: 516-423-3232 or 800-835-3298
Fax: 516-385-8184

CLAMP-ON METERS. TheMX210 and MX215 portable, clamp-on multimeters from ITT Instruments can monitor inverter and frequency converter operation for economical operation. The MX210 is intended for inverters with a fundamental frequency up to 100 Hz and a switching frequency greater than 1 kHz. The MX215 is intended for for inverters with a fundamental frequency up to 500 Hz and a switching frequency greater than 5 kHz.

Both instruments, which include internal microprocessors, can measure true RMS current and voltage. They can also measure frequency as well as both apparent and active power without circuit interruption. A power-factor measurement can then be obtained to calculate phase shift compensation. An analog output permits

CIRCLE 24 ON FREE INFORMATION CARD

the recording or monitoring of the waveform on a chart recorder or oscilloscope.

Both meters can measure frequencies from 15 to 1000 Hz and AC or DC voltage to 750 volts RMS. They measure AC/DC current from 20 to 200 amperes, active power to 20 kilowatts, and apparent power to 20 kVA. An optional three-phase adapter module (HX-3PL) permits three-phase power measurement.

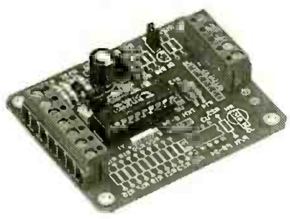
A squeeze-opening clamp admits cables with diameters up to about an inch (23 millimeters) and 20 mm × 10mm rectangular bars. Liquid crystal displays with half-inch high digits display all measurements, overload and incorrect input values, in addition to auto-test and calibration.

The MX210 and MX215 multimeters with 9-volt batteries and test leads are priced at $995.00. The optional three-phase adapter (HX-3PL) is priced at $139.00.

ITT POMONA INSTRUMENTS
1500 East Ninth Street
Pomona, CA 92766
Phone: 800-241-2060
Fax: 909-629-3317

SENSOR INTERFACE MODULE. The SI-01 sensor interface module from Blue Earth converts low-level signals from analog sensors to a digital format for direct reading by microcontrollers. The board includes a single-channel, 16-bit, delta-sigma analog-to-digital converter. Analog input signals can be 0 to 5 volts, with a maximum differential of 2.5 volts. The typical operating current (excluding sensors) is only 6 milliamperes.

Optional oscillator circuitry can be included that will permit the measurement of such variable capacitance-sensors as relative-humidity sensors. Compatibility with a wide range of sensors and microcontrollers is claimed. The board measures 2.25 × 2.75 inches.



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The SI-01 sensor interface board with documentation and software is priced at $59.95, and an optional oscillator (SI-01-C) is priced at $79.95.

BLUE EARTH RESEARCH
165 West Lind Court
Mankato, MN 56001
Phone: 507-387-4001
Fax: 507-387-4008
BBS: 507-387-4007

REMOTE CONTROL-PANEL TRANSCEIVER. The IC-Z1A handheld, dual-band (2-meter/70 centimeter) FM (F3E) transceiver from Icom has a removable remote-control unit that detaches from the main radio. This feature permits the radio to be operated with the main radio clipped to a belt or carried in a purse or briefcase.

The American version transmits at 144 to 148 Mhz in VHF and 440 to 450 Mhz in UHF. It receives at 136 to 174 MHz in VHF and at 400 to 470 MHz in UHF.

The remote control unit offers complete control of volumes, tuning, scan, and band selection. It also has an on/off and push-to-talk switch. The unit is equipped with an alligator lapel clip and the display is backlit for night operation. Tuning is over 5 to 50 kilohertz in increments. The dial select steps are 100 kHz or 1 MHz.

An alphanumeric display provides six characters for memory channel identification. The transceiver has a total of 104 memory channels. Of these, 92 are regular and 12 are scan edge for the display of frequency channel number and alpha name. An EEPROM prevents loss of memory data when the batteries are dead.

CIRCLE 26 ON FREE INFORMATION CARD

The alphanumeric display can be used to transmit up to six characters (with DTMF tones) as a message pager. Secret codes and acknowledgements can also be sent. Each band has its own tuning dial Full crossband duplex operation is offered. The keypad is backlit. Current drain is as low as 35 milliamperes when powered from a 700 milliampere/hour nickel-cadmium battery. It also accepts 4.5 to 16-volt external power. Versions suitable for operation in Europe and Asia are also available.

The IC-Z1A transceiver sells for $600.00.

ICOM AMERICA, INC.
2380 116th Avenue N.E.
Bellevue, WA 98004
Phone: 206-454-8155

SPREAD-SPECTRUM AMPLIFIERS. The HyperAmp 900 and 2400 series of remote bilateral power amplifiers from Hyperlink Technologies are for 900 MHz and 2.4 Ghz wireless networking equipment. They can increase the range of spread spectrum radios and wireless LAN adapters by placing the power right at the antenna where it is most effective.

The amplifiers are intended as a low-cost communications alternative to microwave and wired systems. They can be installed in such applications as campus and metropolitan area networks, remote T-1 bridges, remote control and telemetry, and wireless LAN bridges.

Each amplifier consists of a low-noise receive amplifier and a transmit power amplifier. Each HyperAmp is mounted at the antenna, and provides receive gain of 19 to 24 decibels. This gain compensates for feed-cable attenuation. A fast RF-sensing circuit switches the HyperAmp between transmit and receive modes in less than three microseconds.

HyperAmp amplifies in both transmit and receive modes, overcoming signal

CIRCLE 27 ON FREE INFORMATION CARD

losses in both directions. Antenna cable lengths up to 1000 feet are permitted with no loss in signal strength. The units are powered through the antenna feed cable, eliminating the need for additional power wiring. The aluminum amplifier enclosures can be fastened to antenna masts with U bolts.

HyperAmp 900 models cover a frequency range of 902 to 928 Mhz and have maximum outut ratings of 240 milliwatts to 10 watts. Receive gain is from from 19 to 22 decibels. HyperAmp 2400 models cover the 2400 to 2483 Mhz range and have maximum output ratings of 100 milliwatts to 10 watts. The receive gain for all 2400 models is 24 decibels. (Models that extend the range to 2500 Mhz are available.)

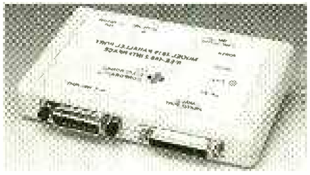
Some HyperAmps can be powered from 11- to 15-volts DC sources, making them suitable for battery, or solar cell operation in marine, or mobile stations.

HyperAmp prices range from $595.00 to $995.00

HYPERLINK TECHNOLOGIES, INC.
6600 West Rogers Circle, Suite 6
Boca Raton, FL 33487
Phone: 407-995-2256
Fax: 407-995-2432

IEEE-433.2/GPIB CONTROLLER FOR PORTABLE COMPUTERS. The Model 4818 IEEE-488.2 controller module from ICS Electronics permits any IBM-or compatible computer to control GPIB bus devices from its standard or enhanced parallel printer port.

When connected between the computers parallel port and printer, the 4818 monitors the output from the parallel port and automatically routes all GPIB commands from its IEEE-488 connector to the GPIB bus. Responses from the GPIB devices are sent back through the printer port to the computer.



CIRCLE 28 ON FREE INFORMATION CARD

All non-GPIB commands and data are passed to the printer or to any other parallel devices that are connected to the 4818's printer-output connector. The module is powered from the computer's auxiliary keyboard connector and does not require an external power supply.

Light-emitting diodes give a visual indication of the module's status. The module includes ICS's 488 driver libraries software and program examples. An interactive command line program allows the GPIB devices to be controlled from the keyboard.

The 4818 GPIB controller, including computer connection cables, adapters, software, and instruction manual, is $395.00

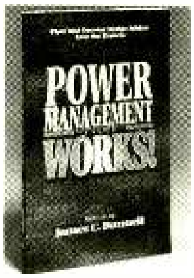
ICS ELECTRONICS CORPORATION
473 Los Coches Street
Milpitas, CA 95035-5422
Phone: 408-263-5500 Ω

NEW LITERATURE

Use The Free Information Card for fast response.

Power Management That Works!; by James C. Burnell. Annabooks, 11838 Bernardo Plaza Court, San Diego, CA 92128-2414; Phone: 619-673-0870 or 800-462-1042; Fax: 619-673-1432; $24.95.

This book presents simple, alternative power-management techniques intended for designers of portable, battery powered computers to help them obtain the highest performance from the computer while maximizing battery life.



CIRCLE 337 ON FREE INFORMATION CARD

This book will also be of interest to persons who do not design battery-powered computers and other handheld and portable electronics products who want to learn more about the latest concepts of power management for those products. It should also provide useful guidance to the features and specifications of the power supply that relate to power management when purchasing portable, battery-powered electronics.

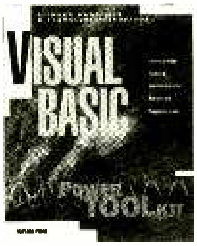
Burnell explains why the early methods of power management were doomed to failure because they relied on the user to make sophisticated decisions within the computer's BIOS setup routines. According to Burnell, even if the user knew enough to predict parameters for one application, those parameters would probably not be applicable in other related applications.

The author points out why some decisions should be made by the power-management software. One starts with default settings and modifies them according to the demands of specific applications. An alternate approach called *heuristic* power management is defined. It quickly adapts itself to new situations or changing requirements and is invisible to the computer user.

Visual Basic Power Toolkit; by Richard Mansfield and Evangelos Petroutsos. Ventana Press, P. O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $39.95, including CD-ROM disk.

This book is intended for advanced programmers, and it discusses the tools and techniques for getting the most out of Visual Basic. Hundreds of examples, images, sample routines, and step-by-step explanations illustrate the techniques presented in the book.

The CD-ROM included with the book contains all the program examples from the book, a selection of never-before-released utilities developed by the authors, sounds, animations, and images that make use of programs from the book. Also included are sample tools and demonstrations from selected third-party developers of Visual Basic applications.



CIRCLE 338 ON FREE INFORMATION CARD

The authors explain how programs are optimized for speed. You will learn how to enhance your applications with TV-like effects including wipes and animated transitions. You'll also learn how to manipulate color palettes and program sophisticated image processing. These include blurring, embossing, and solarizing.

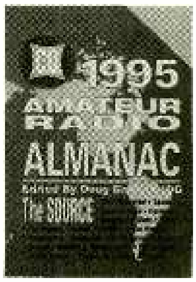
Other topics covered are how to master multimedia by adding voice, sound effects, music, animation, and video to programs without the need for specialized hardware or editing tools. You'll learn how to use Visual Basic with networks and how to design newsletters, brochures, and advertisements.

The book includes a complete discussion of Visual Basic's database and handling capabilities. It also offers a large collection of helpful API calls and hard-to-find tools.

1995 Amateur Radio Almanac; edited by Doug Grant, K1DG. CQ Communications, 76 North Broadway, Hicksville, NY 11801; Phone: 800-853-9797; Fax: 516-681-2926; $19.95.

This second 1995 edition of the almanac contains more than 500 pages of illustrations and text of interest to amateur radio operators. New and updated information includes propagation predications for 1995, the latest FCC Part 97 rules and regulations, FCC survey listings of RFI-proof telephones, and a comprehensive index of equipment reviews.

Grant has also included the revised U.S. amateur radio operator census and the questions in the FCC General Class question pool. Other topics covered are an expanded coverage of Internet computer services for amateurs, U.S. radio club listings, and IOTA program rules.



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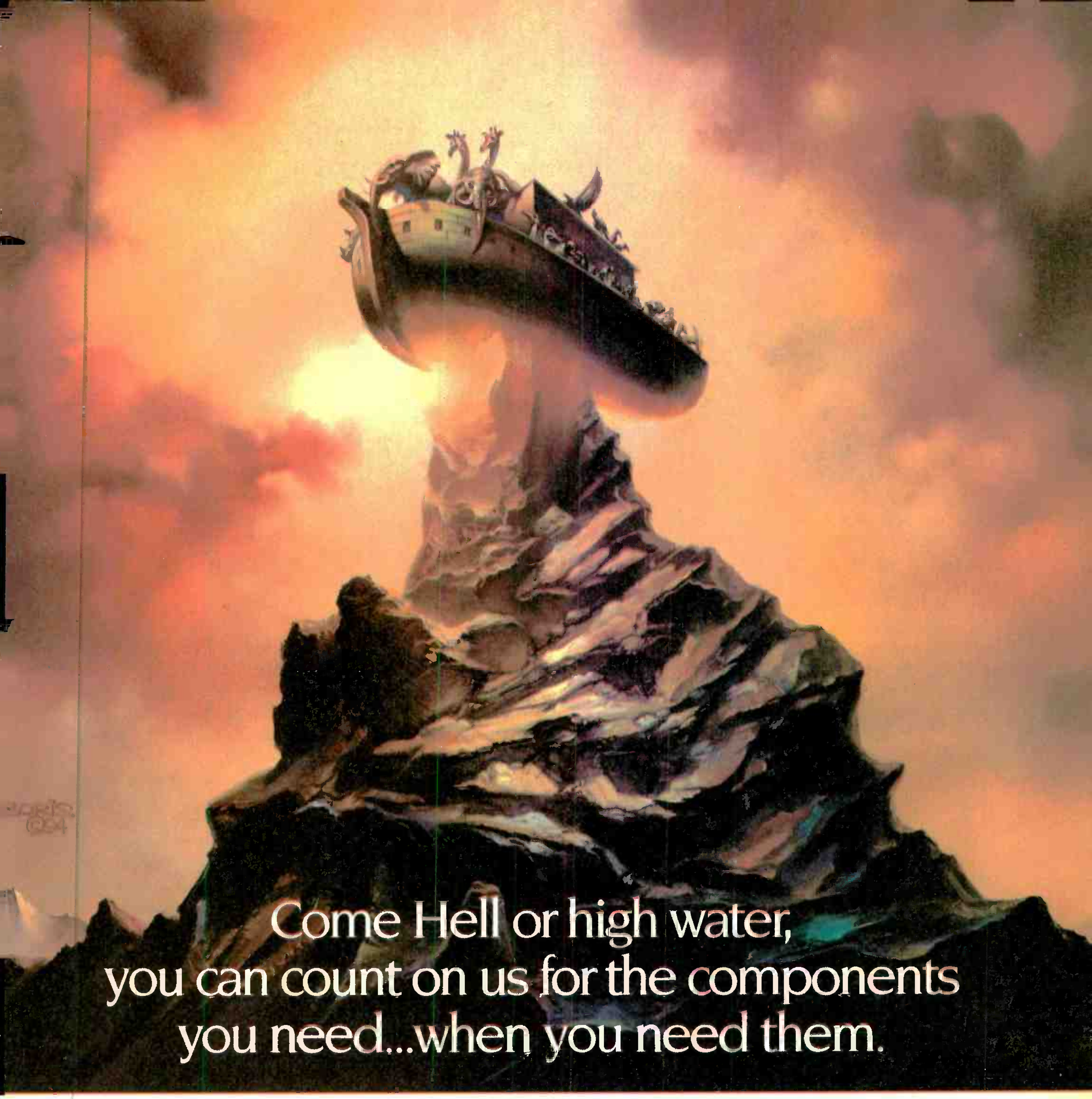
This edition has been published in a simplified format with somewhat larger type than the last edition. It reviews amateur radio around the world and amateur-radio history, lists famous amateurs, gives the background of awards. It identifies the world's biggest antennas, and gives the names and addresses of amateur radio equipment manufacturers and dealers.



NTE distributors will move heaven and earth to make sure you get the critical part you need. And if for some reason they don't have the exact resistor, capacitor, semiconductor, relay, or flyback transformer you're looking for, you won't have to wait 40 days and 40 nights. We'll drop ship it to your door the next day!

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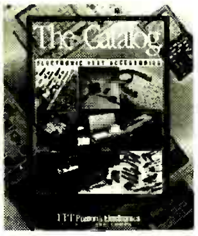
CIRCLE 71 ON FREE INFORMATION CARD

1995 Electronic Test Accessories Catalog. ITT Pomona Electronics, Customer Service, 1500 East Ninth Street, Pomona, CA 91766-3835; Phone: 909-469-2900; Fax: 909-629-3317; 172 pages: free.

The 1995 ITT Pomona catalog contains descriptions of more than 3800 products for test equipment offered by ITT Pomona.

A sampling of products described in the new catalog includes a new series of 30- to 450-MHz oscilloscope probes, which include a surface-mount (SMD) circuit, for testing advanced integrated circuits, IC test clips including those that are used for 240-pin microprocessors, a pocket-sized logic-scope probe, and ultra-thin micrograbbers for testing fine-pitch (0.25 mil) ICs.



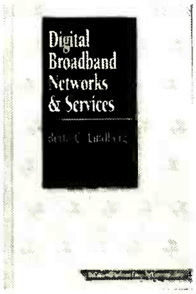
CIRCLE 340 ON FREE INFORMATION CARD

Other products listed and described in the new catalog are a programmable IC socket test adapter, high-voltage and plug-on specialty probes, and a line of products specially designed for electrostatic discharge (ESD) protection and servicing and testing products in ESD controlled rooms.

The catalog includes helpful selection guides and several short tutorials on such subjects as selecting the right oscilloscope probe for a particular job and extending digital multimeter capability

Digital Broadband Networks & Services; by Bertil C. Lindberg. McGraw-Hill Book Company, 11 West 19th Street, New York, NY 10011; Phone: 1-800-2-MCGRAW; $50.

Lindberg's book is a technical guide to digital broadband communications for telecommunications managers, equipment designers, and engineers. It includes a description of the present state of digital broadband technology and comments on its directions and applications for the technology.



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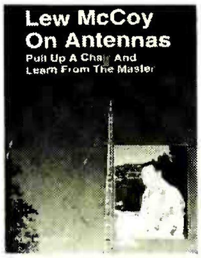
Among the topics discussed are the present and future services that can be provided by broadband networks and how those networks should be managed. The book reviews existing and future broadband interfaces between users and the networks. These include SMDS, B-ISDN, and ATM. The book also defines and explains "internetworking"—the interconnection of existing networks and methods for upgrading them to broadband communications.

Lew McCoy On Antennas: Pull Up A Chair And Learn From The Master; by Lew McCoy; W1ICP. CQ Communications, 76 North Broadway, Hicksville, NY 11801; Phone: 800-853-9797; Fax: 516-681-2926; $15.95.

This book summarizes the author's 40 years of experience with antennas for amateur radio and is based on his lectures and articles. McCoy reviews the basics of antennas by discussing such subjects as standing



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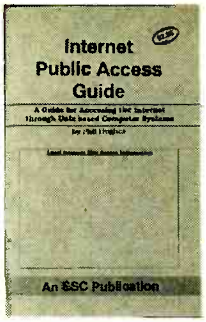
wave ratio (SWR), antenna gain (and line loss), and transmatches.

Included in the book are chapters devoted to wide variety of antennas from the simple dipole to complex multiband beam and quad antennas. The author has avoided the mathematical and theoretical approach to antennas found in many textbooks and engineering handbooks.

Internet Public Access Guide: A Guide for Accessing the Internet through Unix-based Computer Systems; by Phil Hughes. Specialized Systems Consultants, Inc. (SCS), P. O. Box 55549, Seattle, WA 98155; Phone: 206-527-3385; Fax: 206-527-2806; E-mail: sales$AKssc.com; $2.95 (quantity discounts available).

This booklet was written specifically for newcomers to the Internet, and it will help them get "on-line" quickly and painlessly and put the system to good use.

The booklet begins with an introduction to the Internet, including a definition of related terms. It goes on to describe basic Unix commands. Internet-specific

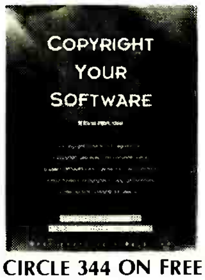


CIRCLE 343 ON FREE INFORMATION CARD

topics include electronic mail, Usenet news, remote system access, and information searching. The programs and capabilities covered include the *tin* and *trn* newsreaders, *ftp, telnet, archie, gopher, veronica,* WAIS, WWW, and much more.

Copyright Your Software; by Stephen Fishman. Nolo Press Self-Help Law Books and Software, 950 Parker Street, Berkeley, CA 94710; $39.95.

Fishman provides detailed information on how to obtain secure copyright protection for software that you develop. The author, an attorney, explains who owns a copyright—the developer, programmer, employee, or publisher—and



CIRCLE 344 ON FREE INFORMATION CARD

how and when software licenses are issued. Whether you want to protect a user interface, a computer database, or a multimedia project, you will learn what your copyright notice should say and how it should be stated. Ω

Q & A

continued from page 10

MOTOR NEEDED

Where can I get a type EM-51441 motor for a JVC record changer?—John H. Rodriguez, Weymouth, MA.

You can contact JVC at 107 Little Falls Road, Fairfield, NJ 07004, 1-800-882-2345. JVC parts are also available from E&K Parts, 2115 Westwood Boulevard, Los Angeles, California 90025, 1-800-826-0890.

THERMAL CUTOUT

I am trying to locate a small thermal cutout. When my rechargeable VCR battery failed, I opened it up and found ten Ni-Cd AA-size batteries, all of them fine, plus a thermal cut-out that had opened. Where can I get a replacement?—Dave Ching, Belmont, MA.

A thermal cutout, or thermal fuse, is a device that opens a circuit temporarily or permanently when it gets above a certain temperature. Thermal fuses are used in hair dryers and other appliances to prevent overheating. In a Ni-Cd battery pack, the thermal fuse prevents the whole thing from heating up and exploding if one of the cells short circuits or the charging current is excessive.

One place that offers thermal fuses is Radio Shack. Use the lowest-temperature version (128°C), since Ni-Cd cells aren't supposed to get very hot. Make connections to the leads by crimping rather than soldering, because a soldering iron can easily blow the thermal fuse. Also check your charger; it might have overheated your battery.

RADIO WAVE SOURCE

I am a 13-year-old electronics hobbyist working on a project to prove a fact about radio waves. I need a transmitter that can transmit to an AM receiver about a meter away, but I don't want to spend a lot of money for parts. Do you have any ideas?—J. Williams, Houstin, TX

To make AM (amplitude modulated) radio waves, you need three things: a radio-frequency (RF) oscillator, an audio signal, and a modulator to combine the two. Figure 5 shows how to do all of this with one CMOS chip, a 4049 hex inverter—and you don't even have to wind any coils.

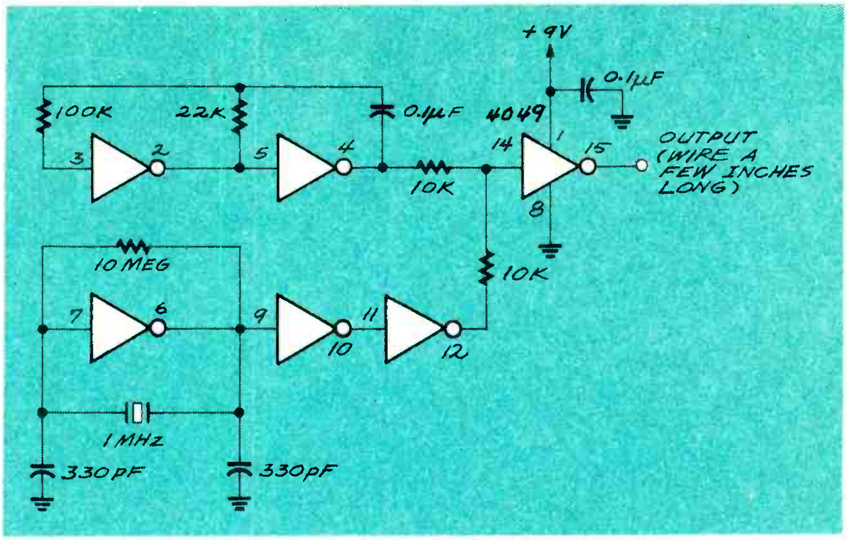


FIG. 5—TO MAKE AM RADIO WAVES, you need a radio-frequency (RF) You can do all of this with one 4049 hex inverter.

The 4049 contains six inverters, all of which can be used as amplifiers or oscillators. The RF oscillator in this circuit uses one inverter; its frequency is controlled by a 1-MHz (1000-kHz) microprocessor crystal, which should be the most expensive part (under $5). Two more inverters amplify its output. Meanwhile, the two inverters at the top left produce an audio tone, which is modulated onto the RF signal by the last inverter. You can tune this in as an audible whine at 1000 kHz on your AM dial. A few inches of wire attached to the output terminal should suffice as a transmitting antenna.

This circuit also has another use. It emits harmonics at all whole-number multiples of 1 MHz (i.e., 2 MHz, 3 MHz, etc., up to at least 10) and you can use it to check the dial calibration of a shortwave radio.

TV SCHEMATIC WANTED

I am trying to locate a schematic for a "Kawasho" color TV, model 3713. Where can I get one?—William V. Levine, Cranford, NJ.

Write to the manufacturer or importer, if you have his address; also, contact Howard W. Sams & Co. (Indianapolis, Indiana 46214; 1-800-428-7267). Sams publishes well-written service manuals for all types of consumer electronic equipment. Although the Sams catalog doesn't list Kawasho equipment, the company may well have some Kawasho material in its files.

AUDIO CHIP

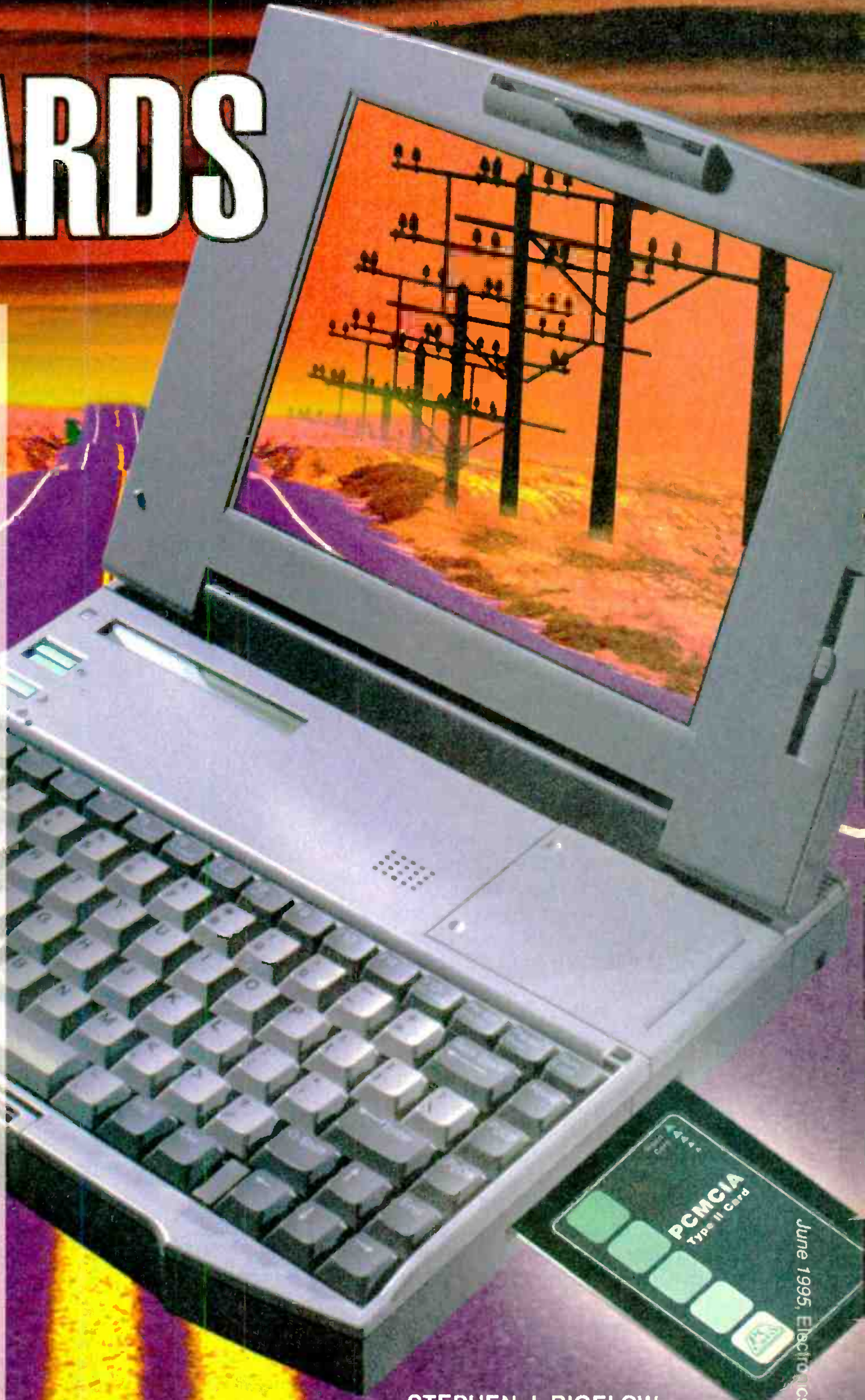
Is there some trick to the ISD1000A audio storage IC? I can't seem to get good audio quality. A couple of friends have also had the same trouble.—Kendall R. Simmons, St. Paul MN.

The ISD1000A audio recording/playback chip is a very handy way to record and play back up to 20 seconds of sound without tape. The recording isn't digital; instead, it's a series of analog samples recorded thousands of times per second. Although the sound recorded by the IC is never going to be studio quality, it should be acceptable for voice.

Working with any chip that handles microphone-level audio will require some precautions. Make sure the power supply connections to the chip are bypassed to ground with 0.05-μF capacitors. Build the circuit on a printed circuit board or perforated construction board. Don't use a solderless breadboard; solderless breadboards have too much stray capacitance. Also, use the weakest input signal that produces acceptable results. You can feed the chip with microphone-level audio from any source. Ω

The PC Card standard is changing the shape of mobile computing.

PC CARDS



STEPHEN J. BIGELOW

PERSONAL-COMPUTER (PC) DESIGNers are constantly striving for two things: compatibility and expandability. The PC industry could not have evolved as far and as fast as it has if it weren't for such industry-accepted standards as VGA video, the RS-232C serial port, and the IBM-PC expansion bus.

Compatibility is so important that even the newest Intel Pentium microprocessors are compatible with the 8086 processor that powered the first IBM PCs more than a decade ago. Expandability has allowed PC users to upgrade their computers to take advantage of new technology, and also to tailor their systems to their own unique needs.

Unfortunately, mobile computers—which include laptop, notebook, sub-notebook, and pen systems—have largely lacked the compatibility and expandability of desktop computer systems. Adding such simple items as modems, additional memory, or hard-disk drives has traditionally been a cumbersome and often expensive process for portable-computer owners.

The few add-on products that have been available for mobile computers have been proprietary to the particular manufacturer. For example, an internal modem for a Toshiba 4400SX notebook will work only with that computer. Furthermore, if you replace your mobile computer with a new one, any upgrade hardware that you bought for your original system will probably not be compatible with the new one.

Origins of PCMCIA

By the late 1980s, it became clear that a standard was needed to allow mobile computers to be upgraded rapidly and conveniently. Neil Chandra of Poquet Computer (now part of Fujitsu) took a vision originally conceived to provide memory for the handheld Poquet computer, and brought together industry leaders to forge a new standard.

In 1989 Chandra's brainchild, the Personal Computer Memory Card International Association (or PCMCIA), was formed as a standards body and trade association. The objective of the PCMCIA is simple—to provide universal, non-proprietary expansion capability for mobile computer systems. More than 475 organizations are now affiliated with the PCMCIA. In addition, the PCMCIA works closely with other major standards organizations such as the Japan Electronics Industry Development Association (JEIDA), the Electronics Industries Association (EIA), the Joint Electron Device Engineering Council (JEDEC), and the International Standards Organization (ISO).

The PC Card

Ultimately, the universal expansion standard envisioned by the PCMCIA has taken the form of a plug-in card, now called a PC Card, which is roughly the length and width of a credit card. (See Fig. 1.) This basic shape has remained virtually unchanged since the initial release of PCMCIA standards in September 1990.

The original PCMCIA specification defined an interface that was intended exclusively for memory cards such as DRAM, flash EEPROM, and ROM cards. However, becuase PCs are a lot more than memory, the original specification did not even come close to fulfilling the promise of universal expansion capability.

PCMCIA release 2.0 followed a year later in September 1991. Version 2.0 moved beyond the memory expansion offered by version 1.0 and incorporated input/output (I/O) capability and software support into the PC Card. It was this addition of I/O capability that PC Card technology finally began to attract serious attention from mobile computer manufacturers.

A standard for I/O functions allowed PC Card manufacturers to offer a wealth of other expansion products such as LAN cards, modems, and disk drives. Release 2.1 followed in July of 1993; it added software support for card operations to the specification.

The latest standard adopted by the PCMCIA is called the PC Card standard. The new standard includes such enhancements as 3.3-volt operation and a multiple-function specification that allows more than one application to be built on a single card.

Making it work

Of course, integrating a PC Card into a computer is not as easy as just wiring a connector to the PC's bus. A selection of system hardware and software is needed, as illustrated in Fig. 2. This multi-layered approach is typical of most PC peripherals—any device that is added to a PC, from a CD-ROM drive to a sound card, requires a similar integration of hardware and software.

At the foundation of PC Card architecture is the *hardware layer*, which represents the PC card, its connectors, and the circuitry required to interface the card to the PC's buses. In most cases, PC Card support can be added to a computer with one or two VLSI (Very Large Scale Integration) ICs and a bit of "glue" logic. You can see this hardware implemented for a desktop PC in the QuaTech Card Drive shown in Fig. 3.

The second layer is called the *socket-services* layer. Socket services act as a supplement for the computer's basic input/output system (BIOS) by providing the low-level software routines

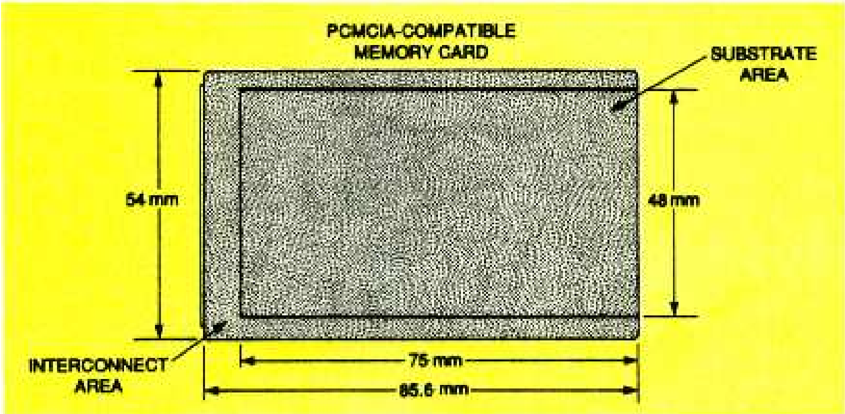


FIG. 1—PC-CARD DIMENSIONS. The interconnect area must be 3 millimeters thick.

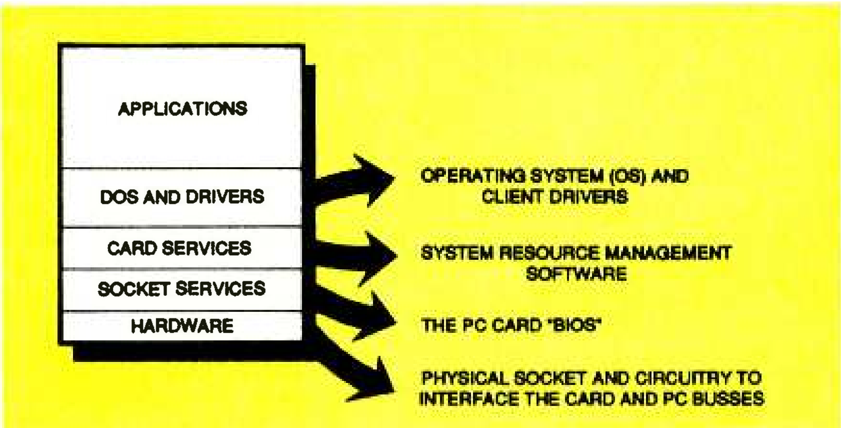


FIG. 2—PC CARD ARCHITECTURE. A collection of system hardware and software is required to integrate a PC Card into a PC.

PCMCIA GLOSSARY

AIMS—Auto indexing mass storage. A standard card interface for storing large amounts of data such as images, sound, or other multimedia files.

ATA—AT attachment. The interface and protocol used by IDE drives. The PCMCIA standard supports both solid-state and rotating-media drives.

Attribute memory—A small, separate memory space for holding the CIS data that describes the card's configuration.

CIS—Card information structure. A data structure in the attribute memory of every PC card. The CIS contains information about the card's formatting and data organization.

Card services—Software, usually in the form of drivers, that allocate and manage system resources for the card.

Client—Any application program or device driver that uses card or socket services.

Common memory—The bulk of memory available for files and program storage.

I/O card—A PC card that provides communication, mass-storage, or imaging capabilities.

I/O interface—An interface supporting both memory and I/O operations as defined in PCMCIA release 2.0. The interface is not active at power-up or reset, but it can be enabled.

Memory interface—The default interface available to a system after power-up or reset as defined by PCMCIA release 1.0.

OTP—One-time programmable. A type of memory that can be programmed once and cannot be altered or erased.

PCMCIA—Personal Computer Memory Card International Association. An international organization dedicated to developing PC Card standards.

Socket—The physical connection where the PC Card is inserted.

Socket services—PC Card BIOS software that provides a standard interface for manipulating PC Cards, sockets, and adapters. As with system BIOS, socket services hides hardware specifics from card drivers and applications.

Tuple—A data block in the CIS used to record specific information about the card's organization.

XIP—(Execute-in-place) a technique of executing code directly from the PC Card without first loading it into system memory.

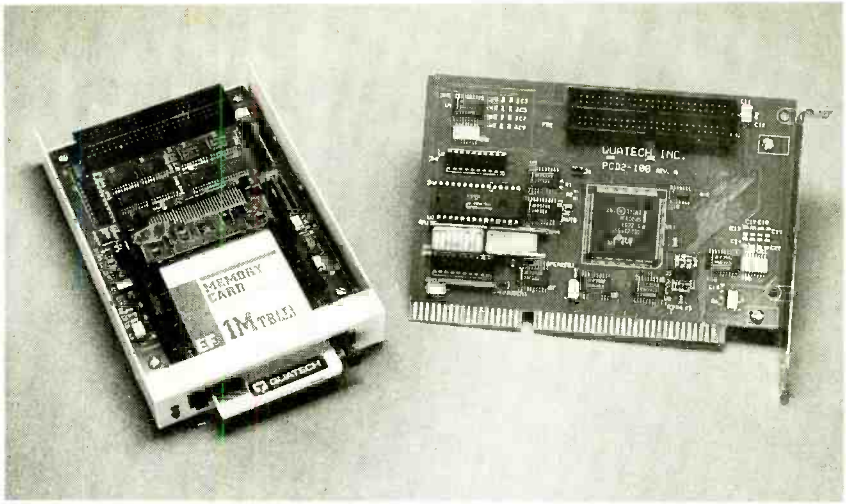


FIG. 3—THE QUATECH PCD2-F CARD DRIVE KIT adds PC-Card capability to desktop computers.

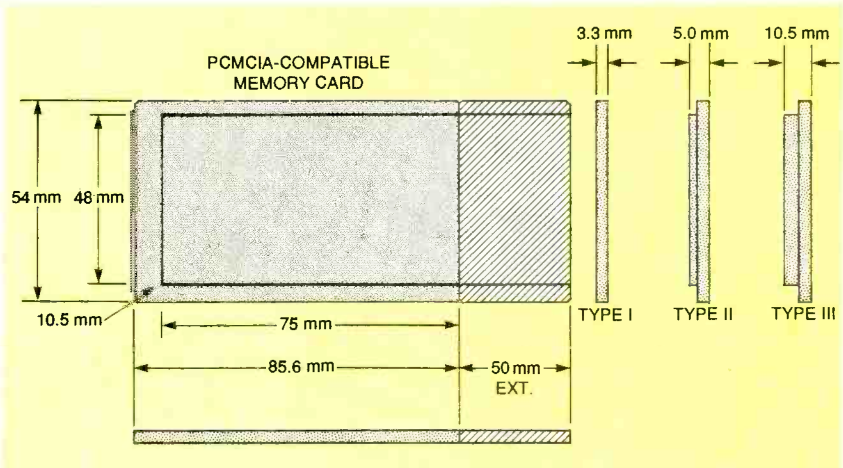


FIG. 4—A COMPARISON OF PC CARD THICKNESSES. Note that the connector area and the "mounting rails" maintain a 3.3 mm thickness.

that are required to access the card hardware. The socket-services software is always implemented as firmware, sometimes in the computer's BIOS (common in new BIOS versions). It can also be included in an expansion ROM contained on an adapter board (as in Fig. 3). Socket-services passes information to the computer, including the number of sockets in the system, and whether cards are inserted or removed.

The *card-services* layer forms the interface between the operating system and socket services. When socket services detects the presence of a card, card services allocates and manages the system resources (interrupts, DMA channels, and addressing) needed by the card(s). When a card is removed, card services frees those system resources again. It is this unique ability to find, use, and then free system resources that gives PC Cards their powerful I/O capability and "plug-and-play" flexibility.

Above card services are the *DOS layer* and *application* layer. Specialized (client) device drivers that are needed for particular cards (such as a hard-disk drive) are considered to be part of the DOS layer.

Card types

PCMCIA standards also define the physical dimensions for PC Cards. Three card types are defined: Type I, Type II, and Type III. Although the length and width of all cards are the same, their thicknesses vary, as shown in Fig. 4, to accommodate different applications. The Type I card is only 3.3 millimeters (mm) thick. Although that is too thin for some mechanical PC Card assemblies, it is ideal for most kinds of memory enhancements. Type II cards are 5.0 mm thick, which make them ideal for larger memory enhancements and most I/O cards. Note from Fig. 4 that despite thickness of the card, its edges and connector area (the interconnect area) are 3.3 mm thick. So, for example, although the Type III card is 10.5 mm thick—which is large enough to accommodate the components for a complete hard drive or radio communication device—its interconnect area is still 3.3 mm. This common thickness permits thinner cards to be inserted into thicker slots (but not vice versa).

Inside the card

The inside of a typical PC Card is not necessarily more complex than other electronic devices, but it is very compact. A PC Card consists of a metal shell that encases one or more PC boards. It might also contain such additional components as spacers, a write-protect switch, or one or more batteries. Figure 5 is a cutaway view of an ordinary memory card. The main PC board contains TSOP (thin, small-outline package) ICs which are surface-mounted on both sides of the board. The PC board is clamped within its shell with a series of non-conductive spacers.

One important consideration in memory card design is the control and suppression of electrostatic discharge (ESD). Static electricity must be prevented from reaching the card's PC board where IC damage can occur. Once a card is inserted into a system (as in Fig. 6), a discharge tab at the physical interface connector carries away any accumulation of charges to system ground. Until a card is inserted, its circuitry is protected from damage with a Faraday cage. The same technique helps anti-static bags to protect their contents.

The shell of most memory cards is either metal (such as stainless steel) or metalized plastic. Both shell halves are bonded together by a small spring. Any charge introduced on the card is quickly dispersed over the entire shell surface instead of being allowed to enter the card.

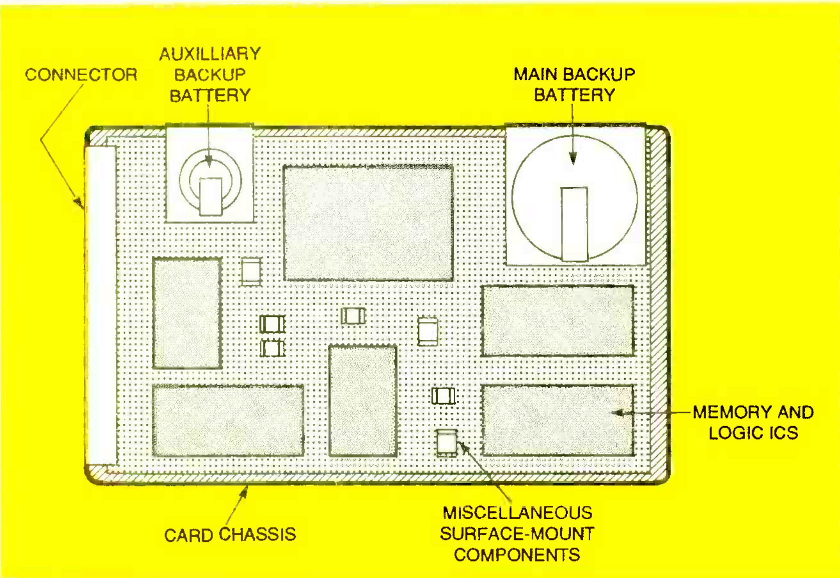


FIG. 5—EXPOSED VIEW of an ordinary memory card.

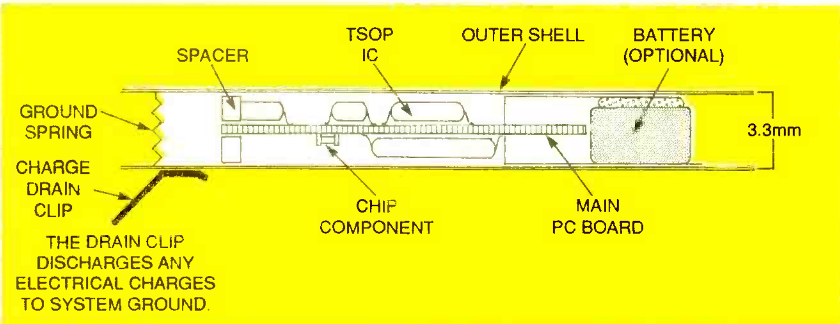


FIG. 6—CROSS-SECTION OF A PC CARD. The shell of the card forms a Farady cage around the electronics.

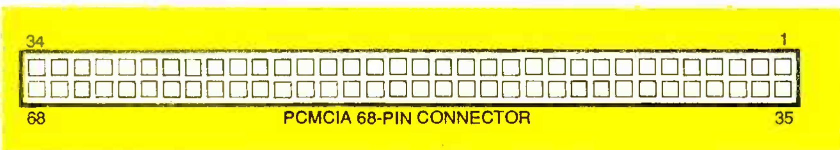


FIG. 7—PC-CARD PINOUTS. Table 1 lists the pin functions.

Connections

The standard PC Card is connected to a PC through a 68-pin header plug that is arranged in two rows of 34 pins as shown in Fig. 7. The PC's mating header contains several pins that are longer than the others—those are ground pins. They are longer so that any card that is inserted is connected to ground first; when the card is removed, ground will still be attached after the power pins have been disconnected. Good grounding helps to ensure the card's reliability. It also permits "hot swapping," which is the ability to insert and remove the card even when the computer is turned on.

Table 1 lists the assignment of each pin of the PC Card. There are basically four types of signals available at the interface: data, address, power (and ground), and control.

New card applications

New PC Cards that are being developed to the latest PCMCIA specification offer a series of compelling advantages for

TABLE 1—PC CARD PIN FUNCTIONS

Pin	Function	Pin	Function	Pin	Function	Pin	Function
1	Ground	18	Prog Voltage 1	35	Ground	52	Prog Voltage 2
2	D3	19	A16	36	Card Detect 1	53	A22
3	D4	20	A15	37	D11	54	A23
4	D5	21	A12	38	D12	55	A24
5	D6	22	A7	39	D13	56	A25
6	D7	23	A6	40	D14	57	reserved
7	Card Enable 1	24	A5	41	D15	58	Reset
8	A10	25	A4	42	Card Enable 2	59	Wait
9	Output Enable	26	A3	43	Refresh	60	reserved
10	A11	27	A2	44	reserved	61	Register Select
11	A9	28	A1	45	reserved	62	Batt Detect 2
12	A8	29	A0	46	A17	63	Batt Detect 1
13	A13	30	D0	47	A18	64	D8
14	A14	31	D1	48	A19	65	D9
15	Write/Program	32	D2	49	A20	66	D10
16	Ready/Busy	33	Write Protect	50	A21	67	Card Detect 2
17	+Vcc	34	Ground	51	+Vcc	68	Ground

mobile computer users. The I/O support allows virtually any computer peripheral to be incorporated into a PC card. Modems, network adapters, video-capture modules, audio cards, and hard drives are just some of the devices that PCMCIA standards now embrace.

PC Cards can be made to operate in a dual-voltage mode (either 5.0 volts or 3.3 volts) depending on the design of the mobile PC. Low-voltage compatibility saves power and extends battery life.

The programs and applications stored on PC Cards can now be executed in place—the contents of the card no longer have to be transferred to the computer's main memory. This execute-in-place (or XIP) technology reduces the demand for large amounts of on-board RAM.

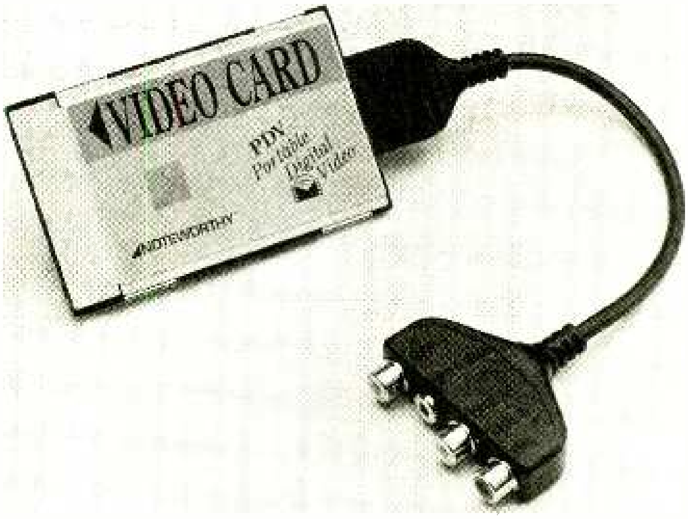


FIG. 9—A TOSHIBA NOTEWORTHY digital video PC Card can be used to capture video images.

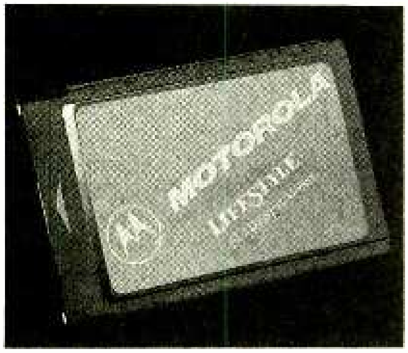


FIG. 8—THE MOTOROLA LIFESTYLE PC-Card data/fax modem can send and receive data at 14.4 kilobits per second.

The socket-services software defined by the new standard describes a BIOS-level interface that allows applications to access the card's hardware. The device drivers written to operate specific PC cards will run on any PC that supports socket services. Such compatibility was a problem in the past.

The card-services software automatically allocates system resources (i.e. memory and interrupts) when a PC Card is inserted into a system. This is called dynamic resource allocation. *Tuple information* contained in the card information structure (CIS) describes the characteristics and abilities of the card. In turn, the host system can automatically configure the card for proper operation. This type of operation is the earliest implementation of a "plug-and-play" architecture.

PC Card problems

Like all new PC technologies, however, the early implementations of PCMCIA were problematic. Before you decide to buy that next "PC Card-compatible" system, you should understand some of the factors that have contributed to PCMCIA's checkered reputation. When the PCMCIA issued release 1.0 in 1990, socket and card services did not exist—card makers had to supply their own specific drivers, which had to be tested for compatibility with each specific computer. If the host computer were updated or upgraded, the cards that worked on the older systems would probably not work on the newer ones. This resulted in compatibility problems.

Socket and card services were added in 1991 with PCMCIA release 2.0, but the release also brought I/O devices into the PC Card picture. Although this made PCMCIA much more versatile, it brought in a host of new problems. One is that most operating systems are designed to work with resources that are present when a system is booted. So even if you can insert and remove cards safely when the computer system is powered, the operating system might not be able to adjust the system resources properly when that is done. For many cards to work properly, they must be installed *before* the system boots.

Today, most PCMCIA cards work in most systems, and can be inserted and removed without rebooting—but there are no guarantees. The situation has gotten much better over the last year or so, but beware of older PCMCIA systems.

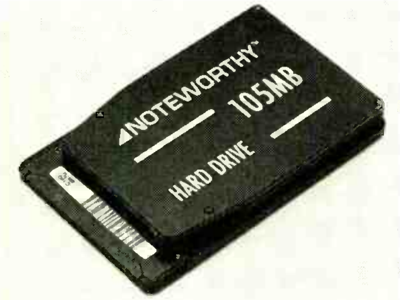


FIG. 10—A TOSHIBA NOTEWORTHY 105-megabyte hard drive packaged in a Type-3 format.

Today's cards

PC cards have come a long way since the early memory cards of 1990. Virtually any device that can be implemented on an expansion card can be fabricated as a PC Card.

Memory Cards—Memory expansion devices continue to be popular PC Card devices, not so much for added system memory, but for running built-in applications directly off the card.

Modem Cards—PCMCIA modems (such as the one shown in Fig. 8) are rapidly replacing proprietary modems as communication devices for portable computers. PCMCIA modems can match the speed and performance of stand-alone modems, and are even being equipped with cellular connections for true mobile operation.

LAN Cards—Connecting portable computers to local area networks is becoming more popular as businesses integrate their operations and add connections to such resources as the Internet.

Digital Video Cards—The soaring popularity of multimedia applications has dramatically increased the demand for video and still-frame capture products. PCMCIA technology allows video and audio capture capability in PC Card products (such as Fig. 9) for high-quality multimedia "on-the-road."

Hard Drive Cards—Until the advent of PCMCIA, it was virtually impossible to add a second hard drive to a portable PC. Fortunately, the PCMCIA standard, combined with the stunning advances in hard drive technology, allow substantial hard drive capacities in a Type III form factor (such as the 105-megabyte hard drive in Fig. 10).

Audio Cards—Games and music-composition software demands high-quality sound reproduction. PCMCIA audio cards provide SoundBlaster-compatibility, and output sound to external speakers. Even though the current trend is toward integrating sound systems and speakers right into the mobile PC, the sound PC Cards still have a place.

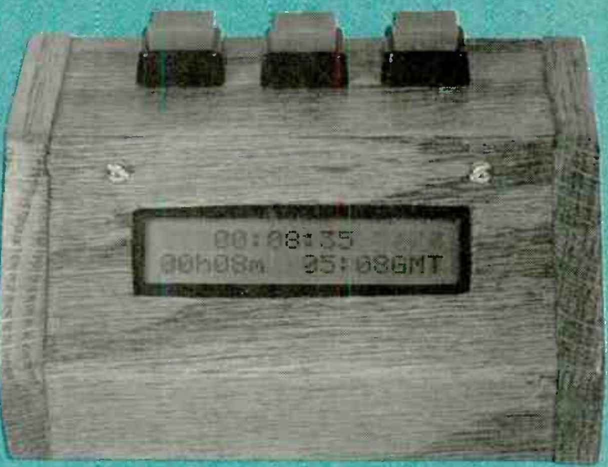
SCSI Adapter Cards—The Small Computer System Interface (SCSI) is a system-level interface scheme that allows a multitude of devices (including CD-ROM drives, scanners, and tape drives) to be connected to a system. A PCMCIA SCSI card opens a whole new level of compatibility for a mobile computer.

Floppy Drive Cards—The recent trend among sub-notebook and palmtop computers has been to forego the floppy drive in favor of a PCMCIA slot. However, PCMCIA floppy disk adapters such as the Accurite Technologies PassportCard (Fig. 11) bring a standard floppy drive to any mobile PC that lacks an internal floppy drive.

Although its beginnings have been a bit rocky, the development and broad adoption of PCMCIA standards has opened up tremendous possibilities for mobile PCs. Future PC Cards promise to provide even more capabilities. Ω

FIG. 11—THE ACCURITE TECHNOLOGIES PassportCard PCMCIA floppy disk adapter allows a floppy disk drive to be added to a portable computer with a PC Card slot.

UNIVERSAL CLOCK



Build the Universal Clock—three unique timepieces in one!

JAMES E. TARCHINSKI, N8PTG

ASTRONOMERS—BOTH professional and amateur–are just a little bit different from regular folks. For instance, they think nothing of traveling thousands of miles to view a five-minute event (such as a solar eclipse) and they often enjoy spending hours at a telescope, working by themselves under freezing conditions, at an altitude where the air is too thin to breath. Astronomers even use a different system of timekeeping!

The Universal Clock described in this article keeps track of time the same way astronomers do, in what is called sidereal time. (See the sidebar titled "Sidereal Time" for an explanation.)

In addition, the Universal Clock also simultaneously displays standard (local) time, as well as coordinated universal time (UCT) formally known as Greenwich Mean Time (GMT), which is often of interest to shortwave radio listeners and ham-radio operators.

The project is built around Motorola's 68HC705K1 microprocessor, with built-in RAM, ROM, and I/O, and an intelligent LCD display. Complete plans are presented, including a single-sided PC board layout. Programmed microcontrollers are available for less than $15 (see Parts List).

Circuit description

The complete schematic diagram of the Universal Clock appears in Fig 1. The circuit contains six major sections:

- Microprocessor
- LCD display
- Buzzer output
- Input switches
- 60-Hz time-base
- Power supply

The 68HC705 is an eight-bit microprocessor containing 32 bytes of RAM, 498 bytes of ROM, a single interrupt, and ten input/output (I/O) lines. The I/O lines are configured as one 8-bit port (Port A) and one 2-bit port (Port B).

Seven bits of Port A drive DISP1, an intelligent two-row by sixteen-column LCD display module. To conserve I/O lines, the LCD operates in its four-bit mode. Although that mode requires software overhead, it simplifies the hardware and reduces cost when compared to the four-bit mode.

The remaining bit of Port A (bit 1) controls a small piezoelectric buzzer, BZ1, which provides audible feedback whenever the user presses a switch. A 2N4403 transistor drives the buzzer to ensure that the microprocessor's current-sinking capabilities are not exceeded.

Port B is dedicated to reading inputs from the three switches (S1–S3). When no switch is pressed, resistors R5 and R6 pull both lines high. If the user presses S1, PB0 goes low. If the user presses S3, PB1 goes low. If the user presses S2, both PB0 and PB1 go low, thanks to the hard-wired OR circuit formed by diodes D2 and D3.

The microprocessor's clock is based on an RC network composed of R1 and C2. The circuit doesn't need a crystal, because it uses the 60-Hz power line as the timebase for the timekeeping function. The network consisting of capacitor C5 and C6, resistor R9, and diodes D3 and D4 clips and shapes the power-line signal, then delivers it to the microprocessor's interrupt input.

The power supply is a standard 7805-based design. Also note R2 and C1, which provide a reset pulse for the microprocessor, and jumper JU1 and resistor R8. The author used pins 1 and 2 of JU1 to supply interrupts from an external source during software development. You can install a shorting jumper between pins 2 and 3. In that case, you needn't install R8.

Software

The Universal Clock's software consists of three main sections, plus half-dozen or so utility routines. The software is available on the *Gernsback BBS* (516-293-2283, v.32, v.42bis), as a file called UCLOCK.ZIP. Although the listing is too large to print here, an explanation of how the different sections work is included.

Section one, the largest, drives the LCD. Because the LCD operates in four-bit mode, each byte of data must be broken down into two separate four-bit *nibbles* and sent to the LCD separately.

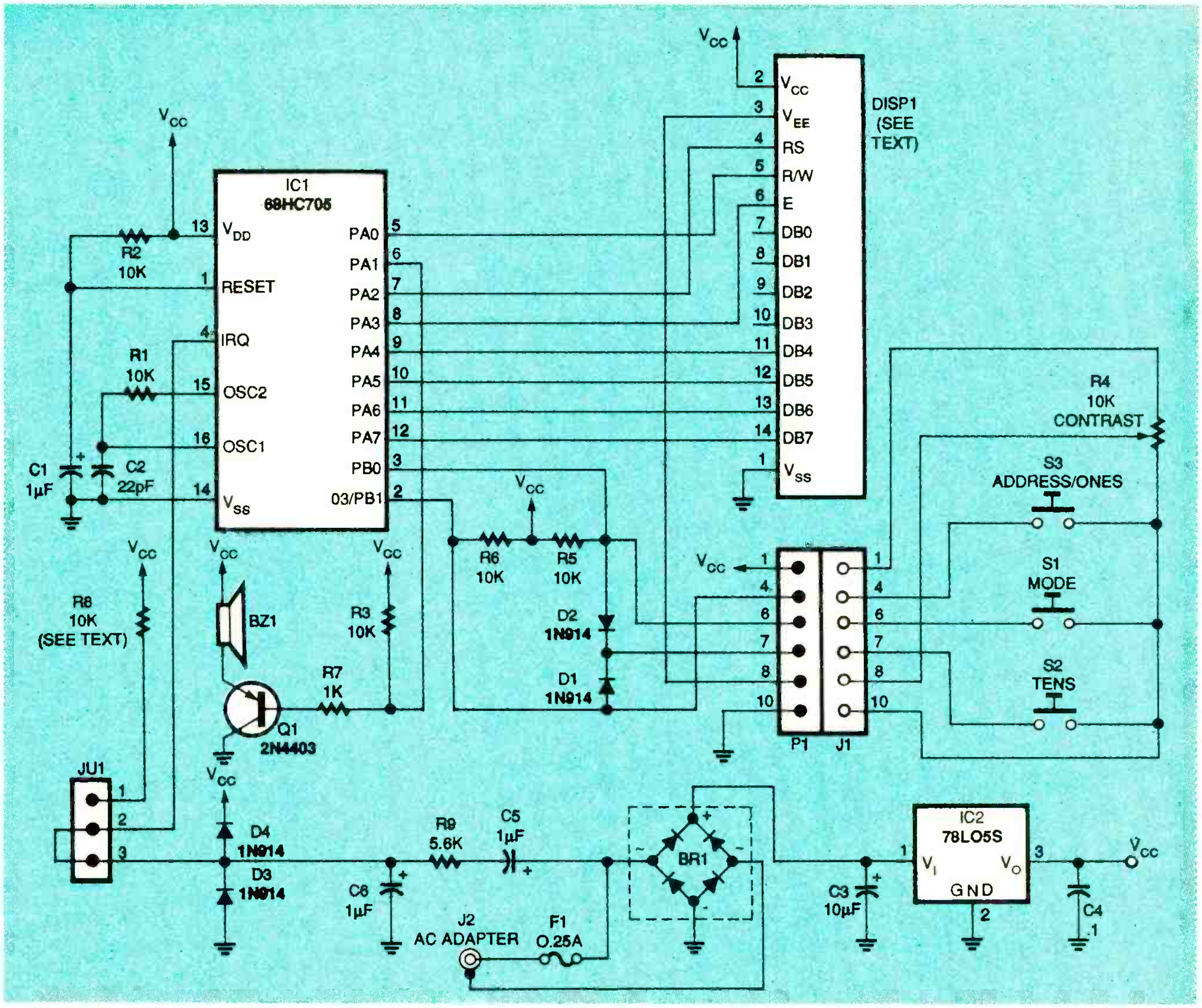


FIG. 1—MOTOROLA'S EVER-POPULAR 68HC705K1 forms the basis of this project. Note that all off-board components connect via J1 and J2.

Section two handles switch inputs. The routine monitors the switches constantly. When it detects a closure, it eliminates (via software) any key-bounce that may be present. Then, it transfers switch settings to the rest of the program.

Section three is the time-keeping function; it is the most interesting section of the program. Tracking standard time is simple. Every time the program sees 60 pulses (which we'll call "ticks") on the IRQ line, it increments the seconds counter by one. When the seconds counter reaches 60, the software increments the minute counter. When the minute counter reaches 60, the hour counter increments. When the hour counter reaches 24, all locations are reset to zero and the clock starts tracking a new day. Tracking UCT is simple as well—it's necessary only to add a constant to the current local time and possibly adjust for a new day.

Things get interesting when calculating sidereal time, which is shorter than a standard day. The difficulty is in tracking sidereal time smoothly. The easiest way would be to simply skip four minutes each day by resetting the sidereal counters to zero when the standard clock reached 23:56. Smoother operation might call for spreading those four minutes throughout the day.

The first thing to realize is that it is simpler to subtract ticks from a clock than to add them, because adding ticks requires that any rollovers that

PARTS LIST

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

R1–R3, R5, R6—10,000 ohms
R4—10,000 ohms, single-turn miniature potentiometer
R7—1000 ohms
R8—10,000 ohms (see text)
R9—5600 ohms

Capacitors

C1, C5, C6—1 µF, 10 volts, electrolytic
C2—22 pF, ceramic
C3—10 µF, 10 volts, electrolytic
C4—0.1 muF, ceramic

Semiconductors

IC1—Motorola 68HC705K1S microprocessor
IC2—78L05 +5V, 100mA regulator
BR1—DF06 1-amp bridge rectifier, or equivalent
Q1—2N4403 PNP transistor
D1–D4—1N914 diode

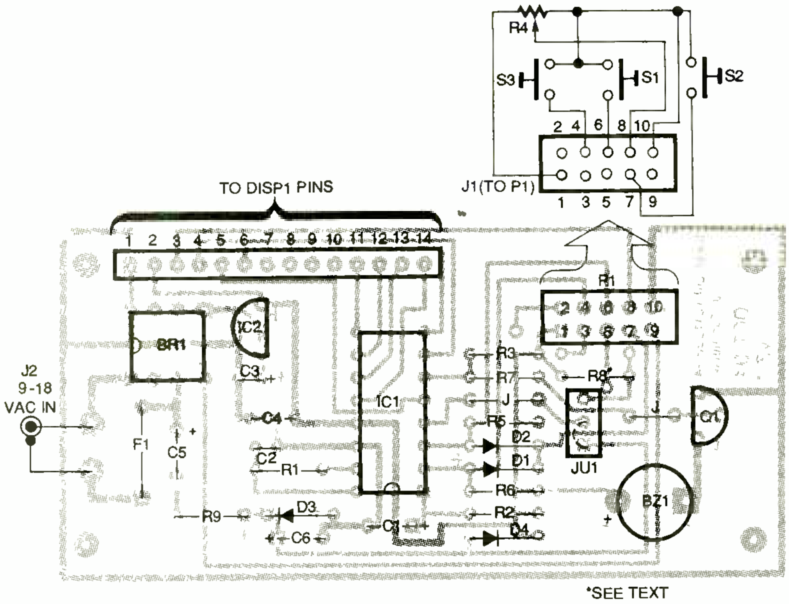
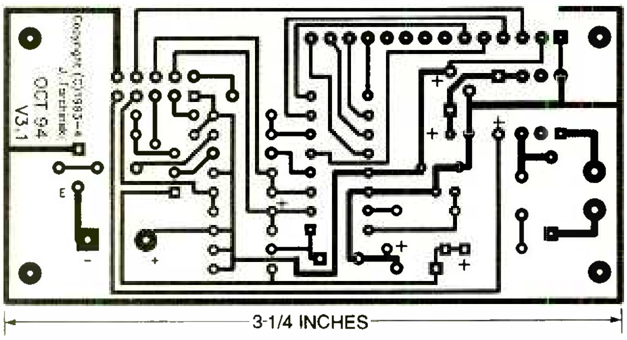


FIG. 2—PARTS-PLACEMENT DIAGRAM. Stuff the universal clock board as shown here.



FOIL PATTERN for the Universal Clock.

Other components

DISP1—Optrex DMC series, 16 × 2 liquid crystal display module (see text)
BZ1—9-volt piezoelectric buzzer (Radio Shack 273-074 or equivalent)
F1—0.25-ampere pico-fuse, PCB mounted
S1–S3—normally open pushbutton switch
P1—10-pin male connector, PCB mount
J1—10-pin female connector, ribbon-cable mount
J2—coaxial power jack (to match AC adapter)
JU1—optional jumper, see text
Miscellaneous: 9- to 18-volt AC power supply, wire, 14-pin 0.1" header socket, 16-pin DIP socket, enclosure, connection wire, 0.75-inch standoffs.

Note: The following items are available from Aurora Software, The Universal Clock, P.O. Box 080133, Rochester, MI 48309-0133
• Programmed 68HC05K1CP microprocessor—$12.78
• Software diskette containing S-record file of software for IC1 plus two programs to determine sidereal time (5.25"/360K format)—$4
• Software on 3.5"/1.44MEG disk—$6

All orders please add $2 S&H. Sorry, no orders can be accepted from residents of Michigan.
• An etched, drilled, and tinned PC board is available for $6.25 from Chelco Electronics, 61 Water Street, Mayville, NY 14757. NY residents must add 7% sales tax.

DETERMINING SIDEREAL TIME

There are two simple methods to determine the correct sidereal time: Ask someone who knows or figure it out yourself. If you don't have access to a computer, the first method is the way to go.

Using method 1, call your local planetarium or astronomical observatory and ask them what time it is on the sidereal clock. Be sure to enunciate the word sidereal clearly, otherwise you're like to get a puzzled response. You might even have to briefly explain what sidereal time is, because the person who answers the phone will probably not be a trained astronomer. With a simple explanation and a little help from the receptionist, you should end up with the correct sidereal time.

If you want a more accurate or repeatable method, you can use a computer program to calculate sidereal time. There are several very good commercial astronomy programs on the market, and most of them compute and display sidereal time. Unfortunately, however, these programs tend to be expensive.

There are also freeware and shareware programs that calculate sidereal time. Any sidereal time calculator needs to know two things: your local time and your longitude. These programs typically extract the time from your computer's system clock, so make sure it's set accurately. You'll also need to configure the program to the closest city with a known longitude.

Sidereal time calculators

Following are the names of one freeware and two shareware programs that calculate sidereal time for PC-compatible computers. All three programs are available from America Online, the author (see the Parts List), and as part of the ZIP file UCLOCK.ZIP on the Gernsback BBS (516-293-2283, v.32, v.42bis). Don't forget that if you find a shareware program to be useful, you should pay the requested registration fee directly to the author of the program.

Sky View for Windows, Version 1.00, $0, by Stephen M. Schimpf. Filename: SKYVIEW.ZIP.

Astronomy Clock for Windows, Version 1.10, $5, Pocket-Sized Software, 8547 E. Arapahoe Road, Suite J-147, Greenwood Village, CO 80112. Filename: ACLOCK.ZIP.

Celestial Clock for DOS, $10, GBox Software, 1350 Boone Ave, Golden Valley, MN 55427. Filename: CLOCK.ZIP.

We tested Sky View and Astronomy Clock, which agreed with each other closely. We did not test Celestial Clock, because the unregistered version does not allow you to set longitude for your location. Ω

happen further downstream must be checked for and corrected. So what is done in the Universal Clock is that a lot of ticks are added at a convenient point, and ticks are subse-

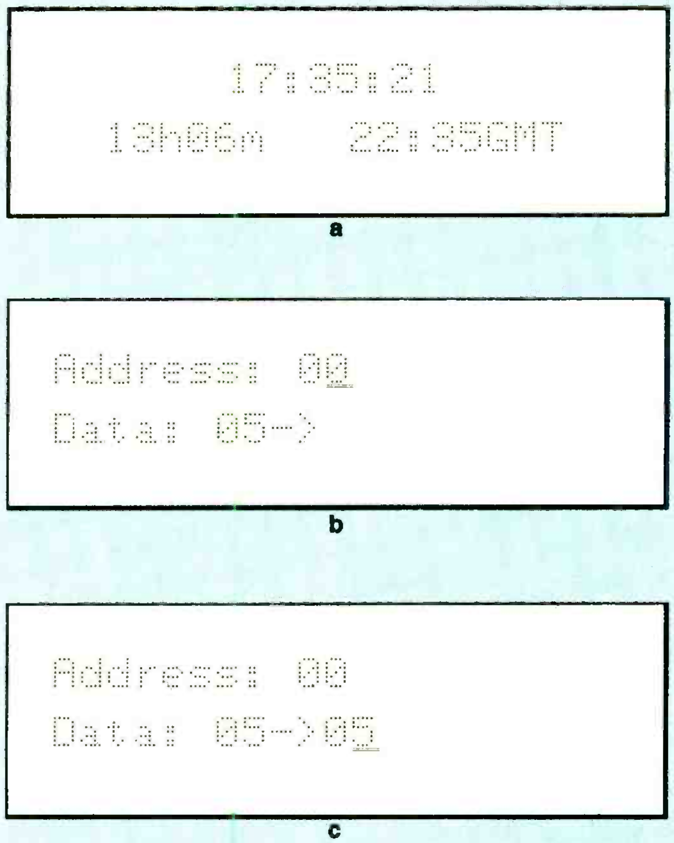


FIG. 3—DISPLAY MODES OF THE UNIVERSAL CLOCK: Time display (*a*), address selection (*b*), and data entry (*c*).

quently subtracted throughout the day to get back to the four-minute mark. Here's how it works:

First, the seconds counter of the sidereal time clock is incremented after only 59 ticks. Doing so causes the sidereal clock to run faster. But, unfortunately, it will run too fast—with no further corrections, the sidereal day would be 24 minutes shorter than a standard day.

The solution is to add 20 minutes to achieve the goal: −24 + 20 = 4. That's done by subtracting (from standard time) 50 ticks per minute, 18 ticks per hour, and 11 ticks per day. If you multiply it all out, you end up with a sidereal day that is about 3.94 minutes shorter than a standard day, and that's the answer we're looking for.

Assembly

The PC board is single-sided. All off-board components connect via P1/J1. Placing those components off-board allows the builder to choose components without matching precise

SIDEREAL TIME AND COORDINATED UNIVERSAL TIME

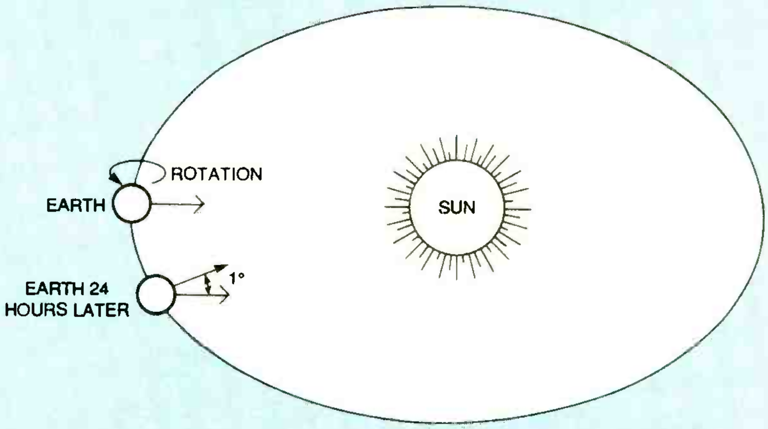
The familiar 24-hour clock is based on the amount of time it takes Earth to make one rotation, such that the sun is highest in the sky at the same time every day (i.e., high noon). Astronomers find it more convenient to use sidereal time, which is based on how long it takes Earth to make one rotation, such that a given star is highest in the sky at the same time every day. This means that an astronomer can go outside every night at midnight (sidereal time) and the same stars will be overhead. By the way, *sidereal* is pronounced sy-der-ee-uhl, with the accent on the second syllable.

A sidereal day is about four minutes shorter than a normal 24-hour day. The reason can be understood easily by examining the diagram shown here. As Earth rotates on its axis, it is also simultaneously traveling in a large ellipse around the sun. It is the combined effects of those two motions that cause sidereal and normal time to differ.

By definition, one day on Earth is the time it takes the planet to spin once on its axis relative to the sun, and one year is the time it takes to make one revolution around the sun (about 365.25 days). Because the two motions occur simultaneously, in the 24-hour period that the Earth spins it has also moved about 1/365.25 of the way around the sun. Therefore, the Earth must spin nearly one extra degree on its axis each day so that the same spot on Earth points directly at the sun. Mathematically, in 24 hours Earth rotates about 361 degrees. Twenty four hours is equal to 1,440 minutes, so:

1,440/361 = 3.98

It takes 3.98 minutes for Earth to rotate the extra degree. After one year, when Earth returns to the same position in its orbit, the two clocks again will be synchronized—briefly. Ω



DURING THE 24 HOURS it takes Earth to make one complete rotation, it has also moved through part of its orbit around the sun. Because of this, Earth must turn an extra degree on its axis to again be "pointed" directly at the sun. (This is not drawn to scale.)

mechanical dimensions, and it provides additional freedom in mounting the project in a case.

The foil pattern contains pads for several components that were used during prototyping, and for other parts that were found to be unnecessary for the final version of the project. Ignore any pads not used in the parts layout. Foil patterns are presented here; you could also use point-to-point or wirewrap construction techniques.

With board in hand, assemble it, using Fig. 2 as a guide. Generally, you should install low-profile passive components first, followed by the active components, and finishing up with the integrated circuits. The ICs should be mounted in sockets when possible, both to protect against excessive heat during assembly, and to facilitate repair, if ever necessary. Do not install the LCD or microprocessor at this time. After stuffing the board, check it thoroughly for poor solder joints, solder bridges, missed joints, and missing components.

Testing

With the circuit completely wired except for the LCD or microprocessor, power it up by plugging in the AC adapter. Measure the voltages at the input and output of the 78L05. Readings should be above eight volts and exactly five volts, respectively. Also check IC1 pins 1 and 13, both of which should measure five volts to ground.

Two other simple tests can be performed. First, use a wire jumper to short pins 6 and 14 of IC1. That should cause the buzzer to sound. Second, press each of the switches in turn and make certain the appropriate pin of IC1 goes low. Pressing S1 or S2 should cause pin 3 to drop to zero volts, and pressing S2 or S3 should also cause pin 2 to go low.

If you have either an oscilloscope or a frequency counter, examine the signal at pin 4 of IC1. That is the real-time clock pulse used by the microprocessor to keep track of time. That signal should have a frequency of exactly 60.0 Hz, and an amplitude of less than 5.5 volts. If either condition is incorrect, do not install the 68HC705, or you might damage it. After all initial tests are completed successfully, remove power from the circuit and install the LCD.

Before installing the microprocessor, the control software must be programmed into its ROM. If you have a 68HC705 programmer, you can download UCLOCK.ZIP from the Gernsback BBS. The file contains an S-record hex dump of the software. Alternatively, see the Parts List for a source of programmed 68HC705s and floppy disks containing the object file along with several shareware sidereal time calculators.

Now when you plug in the AC adapter, the screen illustrated in Fig. 3-*a*. should appear. If not, first try varying potentiometer R4, which controls LCD contrast. With a low contrast ratio, the screen appears blank. When R4 is set properly, the user's local time appears on the upper line, with sidereal time and UCT on the left and right portions of the second line. By default, GMT is set to be five hours ahead of local time.

If all has gone well, you should

TABLE 1—UNIVERSAL CLOCK RAM ADDRESSES

Address	Name	Valid Range	Notes
0	GMTCF	0–23	Greenwich Mean Time correction factor: The number of hours that must be added to local time to obtain GMT. This equals:
			5 for Eastern time,
			6 for Central time,
			7 for Mountain time, and
			8 for Pacific time.
1	STICKS	0–58	Sidereal tick counter: This address up dates too fast to be changed by the user.
2	SSEC	0–59	Sidereal seconds counter.
3	SMIN	0–50	Sidereal minute counter.
4	SHRS	0–23	Sidereal hour counter.
5	TICKS	0–59	Standard time Tic counter. This address updates too fast to be changed by the user.
6	SEC	0–59	Standard second counter.
7	MIN	0–59	Standard minute counter.
8	HRS	0–23	Standard hour counter.

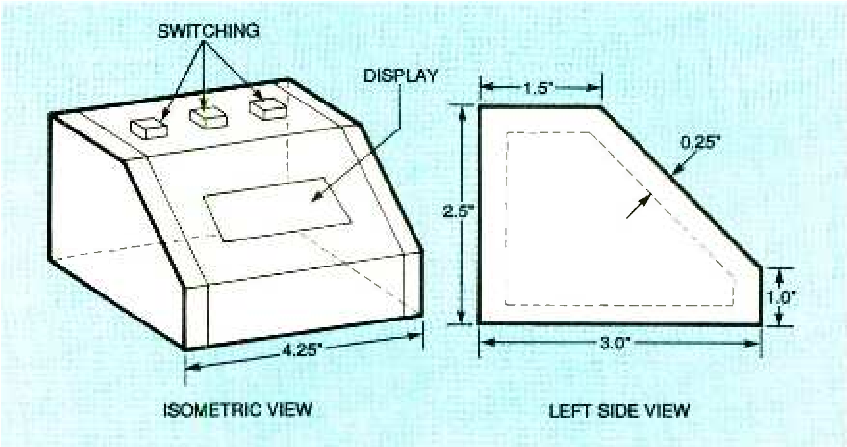
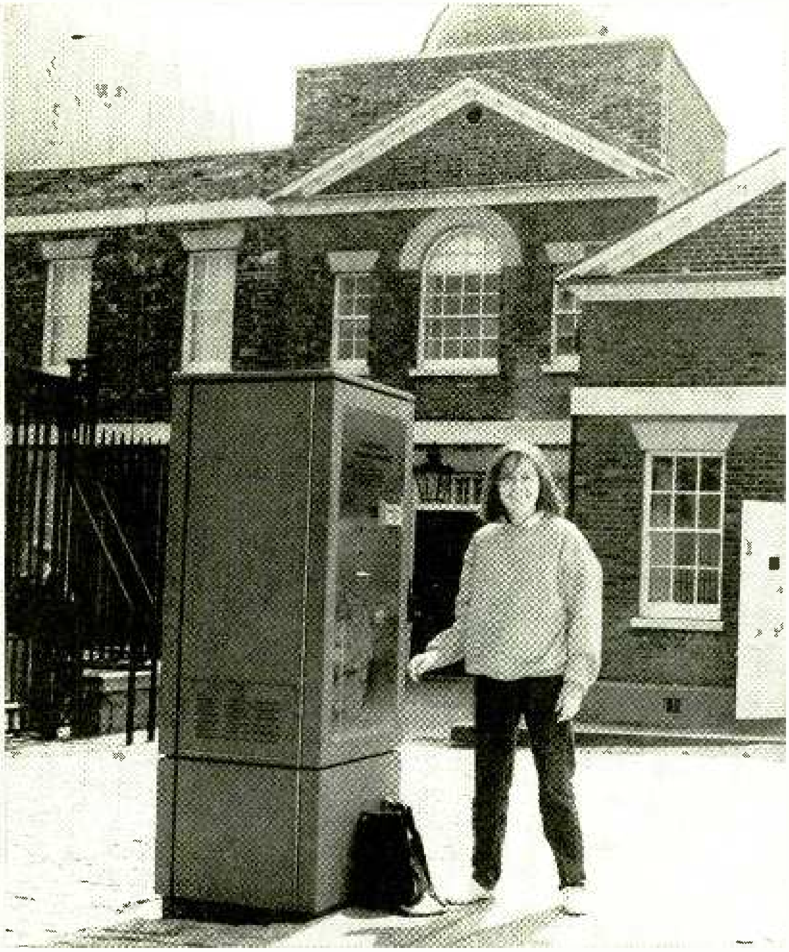


FIG. 4—CUSTOM ENCLOSURE for the Universal Clock. The slanted face makes it easy to view the LCD, while the top-mounted switches allow activation without the enclosure sliding all over the desk.



THE OLD ROYAL OBSERVATORY in Greenwich, England, which defines both time and the Prime Meridian for the planet Earth. Note that the author's wife is standing across the Prime Meridian, with one foot in the eastern hemisphere and the other in the western hemisphere.

GREENWICH MEAN TIME

Yet another system of time-keeping has been in effect since 1884. By international agreement, the transit telescope at the Old Royal Observatory in Greenwich, England, defines the Prime Meridian for the planet Earth. At the same time, the Old Royal Observatory was also given the distinction of being the standard reference for time.

Most announcements of international events, such as astronomical happenings or radio broadcasts, are given in terms of Greenwich Mean Time, now called coordinated universal time, or UCT. To determine when an event will take place in your local time zone all you need to do is add or subtract the appropriate number of hours from the UCT listing.

Time zones west of Greenwich lag UCT, while those east lead GMT. Los Angles, for example, is eight zones behind Greenwich, so when it is starting time (9:00 am) in LA, it is already quitting time (5:00 pm) in Greenwich. The Universal Clock contains one memory address that stores the difference between UCT and your local time.

Final exam

Just for fun, here's a little quiz to test your understanding of our discussion about time. What is the correct definition of a day? (a) The time it take the Earth to spin once on its axis. (b) Twenty-three hours and 56 minutes. (c) The length of time it takes for the same location on Earth to point at the sun on two successive occasions. (d) All of the above. The answer appears at the end of the main article. Ω

see the seconds counter incrementing in the local time portion of the display.

Setting and using the clock

This project has a slightly user-unfriendly method of setting time because in trying to hold down costs and cram everything into 500 bytes of ROM, some compromises had to be made. On the other hand, one person's user-unfriendly is another person's high-tech—so let's just consider ours a high-tech input method. Refer to Table 1 for the addresses of each value you need to set.

1. Press S1 to enter the set mode.

2. Press S3 to cycle through RAM addresses 0–8. The display appears as shown in Fig. 3-*b*.

3. Press S1 again; the display now appears as shown in 3-*c*.

4. Adjust the displayed value by pressing S2 to increment the tens place, and S3 the ones. Whenever the value exceeds 59, the display automatically rolls over to zero.

5. Press S1 when the desired value appears. That locks the displayed value into memory and returns the clock to the main display (Fig. 3-*a*).

To set the clock completely, you must loop through the three screens until all the required addresses have been set. Of course, setting your local time is easy. Setting the GMT offset is also easy. Setting sidereal time may be accomplished in several ways, as noted in the sidebar, "Determining Sidereal Time."

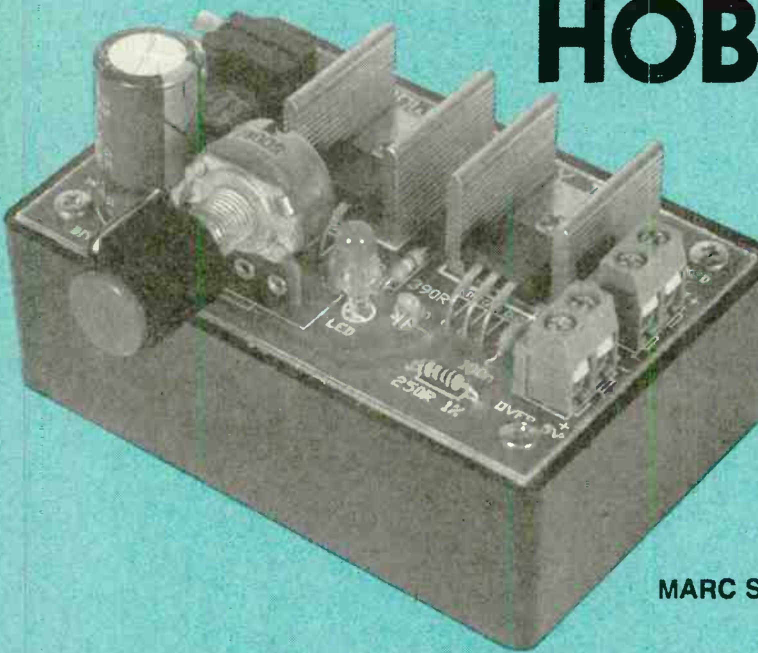
Enclosure

When it comes to packaging your Universal Clock, there are two options: buy or build. In making the decision, an important item for consideration is the LCD's viewing angle. Most LCD's have a fairly narrow range in which the viewing angle is acceptable. In general, it's best to view an LCD straight on. Doing so is difficult with a standard rectangular enclosure. If the LCD is mounted on the top face, you have to lean over the unit to see the display. Conversely, if it's mounted on the side, you have to bend your head down.

The prototype was housed in a custom enclosure built from a few pieces of wood. The plans

Continued on page 90

HANDY HOBBY POWER SUPPLY



Build this power supply that provides both fixed and variable DC outputs.

MARC SPIWAK

ALL ELECTRONIC CIRCUITS REQUIRE a power supply. The question facing any circuit designer, professional or hobbyist, is how to supply that power in the most economical way—either by battery or from the AC line. The decision, of course, will depend on what the circuit will be doing and how and where it will be run. It's never too soon to start thinking about the power supply once you have decided to build a circuit.

The tradeoffs between battery and AC line power are well known. To gain the freedom of a battery-powered circuit you have the choice of disposables or rechargeables. The disposables must be replaced frequently and are expensive; the rechargeables last longer but you face the chore of recharging them.

If you elect line power, the circuit will be tethered to the line cord. Of course you can buy any of the off-the-shelf AC-to-DC adapters that are rated for 1.5 to 12 or more volts DC in increments of a few volts. However, a better alternative is to build the universal supply described here. It has both fixed and variable voltage outputs to cover a wide DC range.

Dual-output supply

Figure 1 is the schematic for the power supply. The input voltage to the power supply at mini phono jack J1 must be from 7 to 20 volts AC or from 7 to 30 volts DC. You can use any transformer or AC-to-DC wall adapter that meets those input requirements.

The PC board for the power supply has space for both J1 and bare wire that serve as voltage inputs. Jack J1 is optional if you intend to connect the supply permanently to an AC-to-DC power adapter. If you think you might want to change the power source from time to time, install J1.

An AC input at J1 is rectified by bridge-rectifier BR1 while a DC input passes through half of the rectifier unmodified except that its value drops by the sum of two diode voltage drops. The bridge rectifier will not be needed if you intend to use a DC input. Nevertheless, you might want to install BR1 in the event that you decide you want it at some future time.

There are two MC7805 5-volt regulators in the circuit: IC1

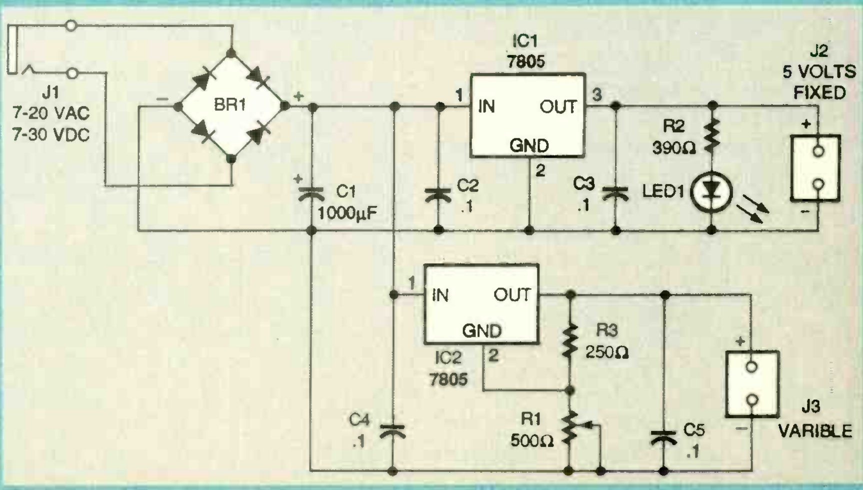


FIG. 1—DUAL-OUTPUT POWER SUPPLY. The input voltage at J1 must be from 7 to 20 volts AC or from 7 to 30 volts DC.

provides a fixed 5-volt DC output at J2, while IC2 has a variable DC output at J3. The variable output ranges from +5 volts DC to 2 volts less than the input voltage to the power supply. The output of the fixed regulator is made variable by varying the voltage at pin 2 with potentiometer R1. (Pin 2 is normally grounded to produce the fixed voltage output.)

Each voltage regulator can safely handle up to 1 ampere of current, provided that the transformer or power adapter can handle the demand and that the regulator is properly heatsinked. The voltage regulators must be heatsinked if more than a few milliamperes is to be drawn from the supply. Power-indicator LED1 is connected across the fixed 5-volt output, and it lights up whenever the supply is powered.

Building the supply

There are only a few components in this circuit, and it is simple enough to be made by point-to-point wiring on perforated construction board. Alternatively, you can make your own PC board from the foil pattern provided here. If you don't have all the parts needed in your own shop, and if you don't want to go to the trouble of making a PC board, you can buy the dual-output power supply as a kit from the source given in the Parts List. The kit includes a PC board and all the components except a power transformer.

Figure 2 is the parts placement diagram. The voltage regulators IC1 and IC2 are packaged in three-pin TO-220-style cases with built-in heatsink tabs. They can be mounted vertically if you do not want to install additional heatsinks.

However, the PC board was designed for surface mounting the voltage regulators flat down on the channel-shaped heatsinks. Both the tabs on the regulators and heatsinks are fastened to the PC board with screws and nuts. Notice that the holes in the PC board will permit the insertion of capacitors with different spacing between their leads.

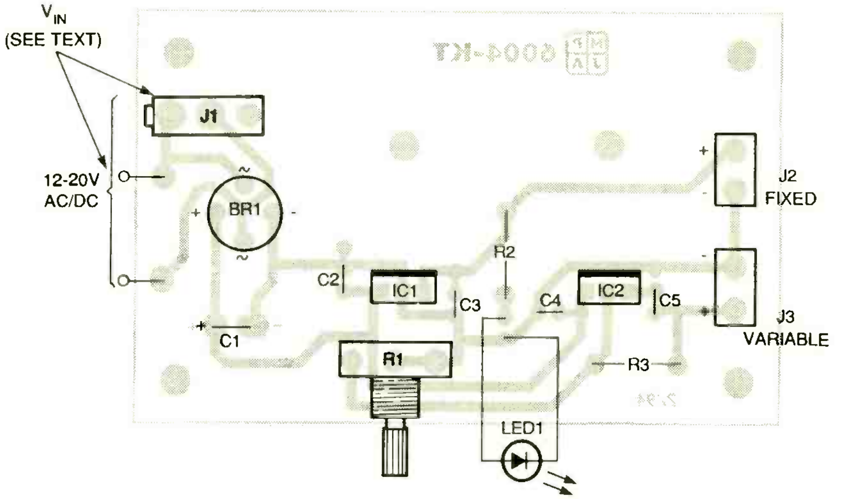
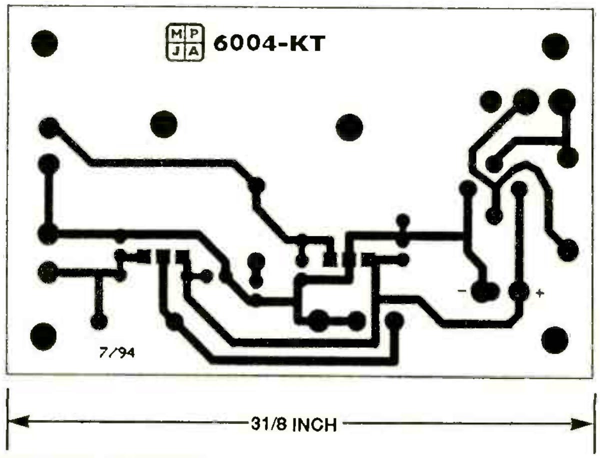


FIG. 2—PARTS-PLACEMENT DIAGRAM. The board can accommodate capacitors with different lead spacings.



POWER-SUPPLY FOIL PATTERN.

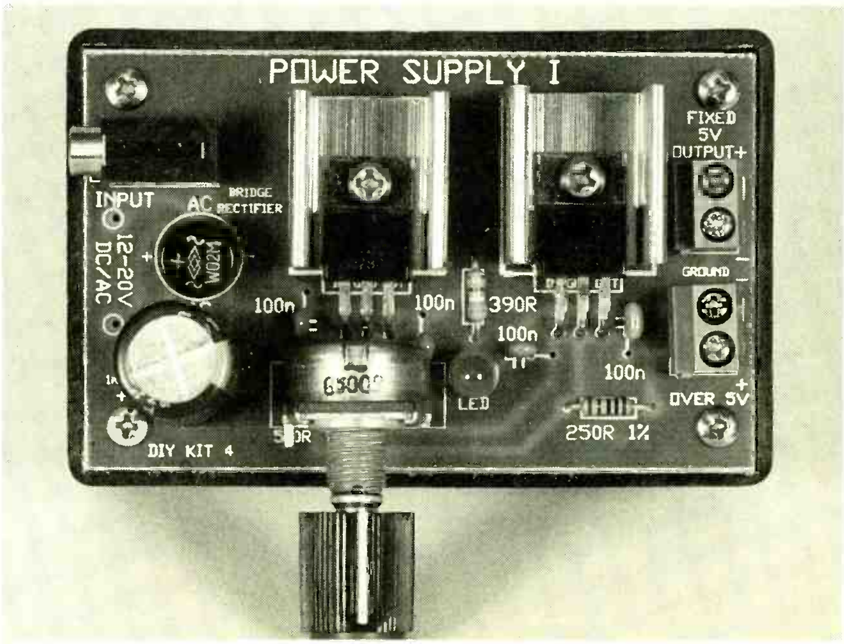


FIG. 3—FINISHED POWER SUPPLY built from the kit available from the source given in the Parts List.

PARTS LIST

Resistors
R1—500 ohms, ½-watt, potentiometer
R2—390 ohms, ¼-watt, 5%
R3—250 ohms, ½-watt, 1%

Capacitors
C1—1000 µF, 35 volts, aluminum electrolytic
C2–C5—0.1 µF, monolithic ceramic

Semiconductors
IC1, IC2—MC7805 5-volt regulator, 221 case, Motorola or equiv.
LED1—light-emitting diode, T-1¾ case, any color
BR1—bridge rectifier, 2 ampere, 200 PIV

Other Components
J1—⅛-inch mini phono jack, PC-mount (optional, see text)
J2, J3—double screw terminal (optional, see text)

Miscellaneous: 7 to 20-volt AC transformer and line cord or 7 to 30-volt AC-to-DC wall adapter; ⅛-inch mini phono plug (optional, see text); aluminum channel heatsinks for the 7805 regulators; four standoffs or project case; bolts, nuts, and lockwasher, and solder.

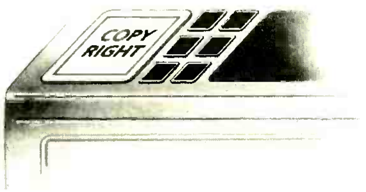
Note: A kit for the dual-output power supply (No. 6004-KT—it includes all parts except a transformer) is available for $18.95 plus $4.00 shipping and handling from Marlin P. Jones & Associates, Inc., P.O. Box 12685, Lake Park, FL 33403-0685
Phone: 407-848-8236
Fax: 407-844-8764.

The optional input jack J1 can be soldered to the indicated pads directly. If you install J1, terminate the leads from the transformer with a matching mini phono plug. The screw terminals at J2 and J3 are also optional. Solder the output leads directly to the board, or mount terminals that will allow quick connects and disconnects if you need them.

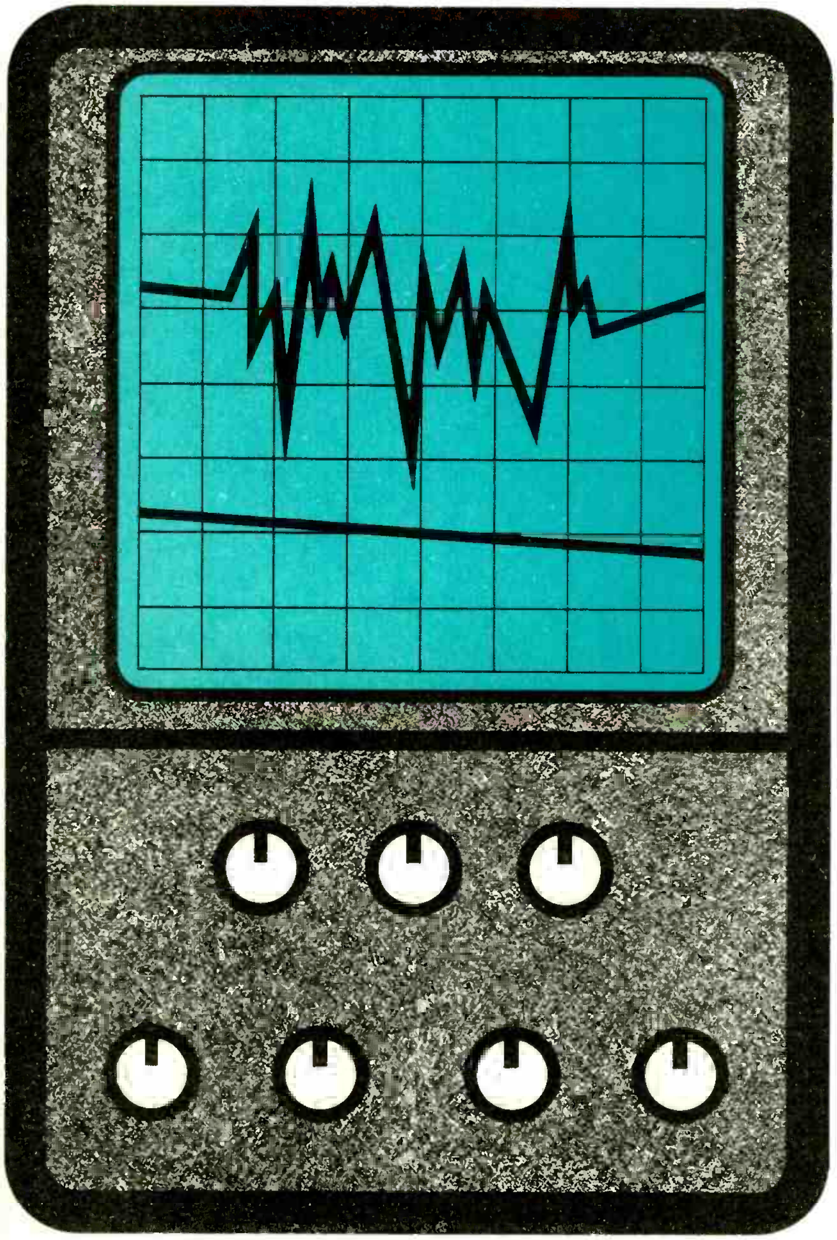
The finished PC board can be supported by four standoffs, one mounted on each corner. Alternatively, it can be installed on the top of the plastic project box. Figure 3 shows a completed power supply that was built from the kit listed in the Parts List.

When the circuit board is finished, inspect your soldering work for inadvertent solder bridges or cold solder joints, and make any needed corrections before you apply power. When power is applied, the LED should light, and the voltage at J2 should be a steady 5 volts. The voltage at J3 can be adjusted by R1, and it will range from 5 volts to 2 volts less than the input voltage.

The power supply is now ready for a permanent home inside your latest project. If you decide to use the dual-output power supply as a permanent part of another circuit, then you should not install any of the "unnecessary" parts such as the input and output jacks. This will save you time and money. On the other hand, it can become a handy power source right on your test bench. Because this dual-output power supply is so versatile, it could be the last power supply you'll ever have to build. Ω



DUAL-TRACE CONVERTER



Turn your single-trace oscilloscope into a dual-channel instrument for next to nothing in price.

GREGORY McINTIRE

A SINGLE-TRACE OSCILLOSCOPE can be a useful piece of test gear, and very inexpensive as well. However, there are many advantages to having an oscilloscope with dual-trace capability. It allows you, for example, to compare the phase of a signal at two different points in a circuit.

The converter described in this article allows any single-trace oscilloscope with an external input to be converted into a dual-trace unit.

Circuitry

The probe switching circuit is shown in Fig. 1. Two SPST reed relays, RY1 and RY2, switch the signal from two probes to a single scope input. Reed relays provide smooth and noise-free switching. The input side of each relay is connected to a scope probe, and the outputs of the relays are tied together and connected to the scope's single-channel input.

A 555 timer, IC1, is configured as a variable duty cycle, square wave oscillator. Potentiometer R1 varies the oscillator's duty cycle to compensate for response time variations that different relays might have.

The potentiometer is adjusted to give equal brightness to both of the signals being displayed on the oscilloscope. If the relays you choose work well with a 50 percent duty cycle, the potentiometer can be replaced with two fixed resistors wired in series with the junction between the two resistors connected to pin 2 of IC1.

With the parts values shown, the timer has an output frequency of about 30 hertz. Switch S1 allows independent viewing of each oscilloscope trace.

When S1 connects pin 3 of IC1 to the coil of RY2 and R4, both input traces will be displayed. When S1 connects +V to the coil of RY2 and R4, only channel B will be displayed. With the switch in the center-off position, only the channel-A signal is displayed.

Construction

The entire circuit can be built on small piece of perforated con-

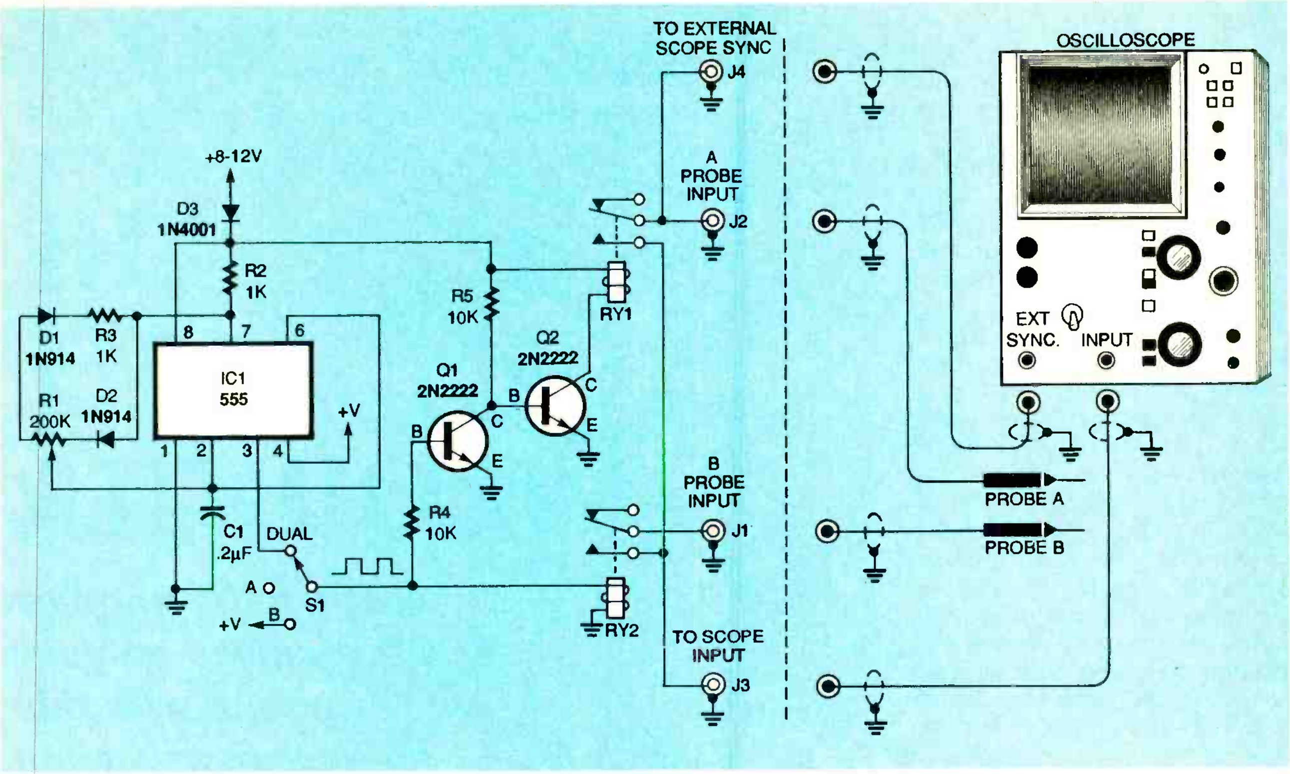


FIG. 1—THIS SIMPLE CIRCUIT lets single-trace oscilloscopes display two waveforms simultaneously.

struction board and mounted in a small box. The box should have two jacks on one side for the two scope probes and one jack on the other side for the connection to the scope input. It must also have a jack for connecting to the scope's external trigger (or external sync.) input. The trigger is connected to only one of the probe inputs so that the phase relationship between the two signals is accurately displayed.

The circuit's power supply can be any clean source of 8- to 12-volts of DC. When used with reed relays, the circuit's total current draw is only about 28 milliamps at 11.5 volts.

The circuit's ground should be kept separate from the oscilloscope probe grounds to help isolate the circuit from the scope and the signals being measured or displayed. This is accomplished by mounting the board in a *plastic* enclosure with the grounded side of the three jacks (two inputs and one output) tied together.

PARTS LIST

Resistors
R1—200,000 ohms, potentiometer (or two 100K fixed resistors, see text)
R2, R3—1000 ohms, ¼-watt, 5%
R4, R5—10,000 ohms, ¼-watt, 5%
Capacitors
C1—0.2 µF, ceramic
Semiconductors
IC1—555 timer
DI, D2—1N914 diode
D3—1N4001 diode
Q1, Q2—2N2222 NPN transistor
Other components
S1—SPDT switch with center-off
RY1, RY2—SPST reed relay; 12VDC, 11 mA, 1.05-kilohm coil (Radio Shack part number 275-233)
J1–J4—panel-mount BNC connector
Miscellaneous: Plastic case, 8- to 12-volt DC power supply, BNC connecting cables.

Operation

When using this device, be sure to set your scope's external sync selector to its external trigger position. Otherwise, both displays will still appear, but the scope will be triggering alternately off of both of them, and will not give a true representation of the phase difference (if any should exist) between the two signals.

Also, if your scope's input is set to AC, both traces will be centered on the same horizontal axis. If your oscilloscope is set to DC, any differences between the two signals' DC voltage reference levels will also be displayed.

Experimentation with this device will show that it might be difficult to display two low-frequency (under 500 Hz) signals simultaneously. There will also be some evidence of the relays switching, particularity when viewing signals under about 1000 hertz.

As the input signals to the oscilloscope become higher in frequency, the dual-trace display starts to become nearly indistinguishable from that of a true dual-trace scope. The circuit has operated successfully with input signals as high as 60 volts, but you should not use it for signals that are more than 100 volts with the specified relays, as they are rated for only 125 volts. Ω

HOWARD S. STERN

THE CALL COUNTER

Record the number of calls received on your phone with this inexpensive and simple circuit.

MANY ANSWERING MACHINES NOT only tell you that you have messages waiting, but also let you know how many. What they don't tell you, however, is the number of times people called and *didn't* leave a message. That is exactly what the call counter does; it counts the total number of calls, regardless of the number of times the phone rings, and regardless of whether or not a message is left.

Circuitry

The circuit is shown schematically in Fig. 1. The key to its operation is that it counts any string of rings as one call, regardless of duration. If someone hangs up after one ring or ten, the counter advances by one. Similarly, if someone reaches an answering machine and hangs up, or leaves a message, the counter still advances by one call.

A phone line's on-hook voltage is about 50 volts DC, and its off-hook voltage is about 5 volts DC. A ring signal is about 90 volts AC at 20 hertz. The voltage on the phone line also varies during conversation and dialing. For example, hanging up the receiver will generate a voltage spike, as will the pulses from a rotary or pulse dialing phone. The counter circuit must ignore these signals and react only to the 90 volts AC that comes in when the phone is ringing.

Because the counter circuit is isolated from the phone line, it needs its own power supply. With some phone systems, power can be provided by the yellow and black wires of the phone line, which typically are connected to a small transformer that provides about 8 volts AC. The bridge rectifier, D1–D4, voltage regulator IC1, and filter capacitor C1, convert that to 5 volts DC to power the circuit. If your phone line doesn't have active yellow and black wires, a 6.3-volt AC transformer must be connected to the inputs of the rectifier.

Timer IC2 is triggered by relay RY1, which has a coil voltage of about 48 volts. Because diode D5 is reverse-biased relative to the normal DC across the phone

Continued on page 72

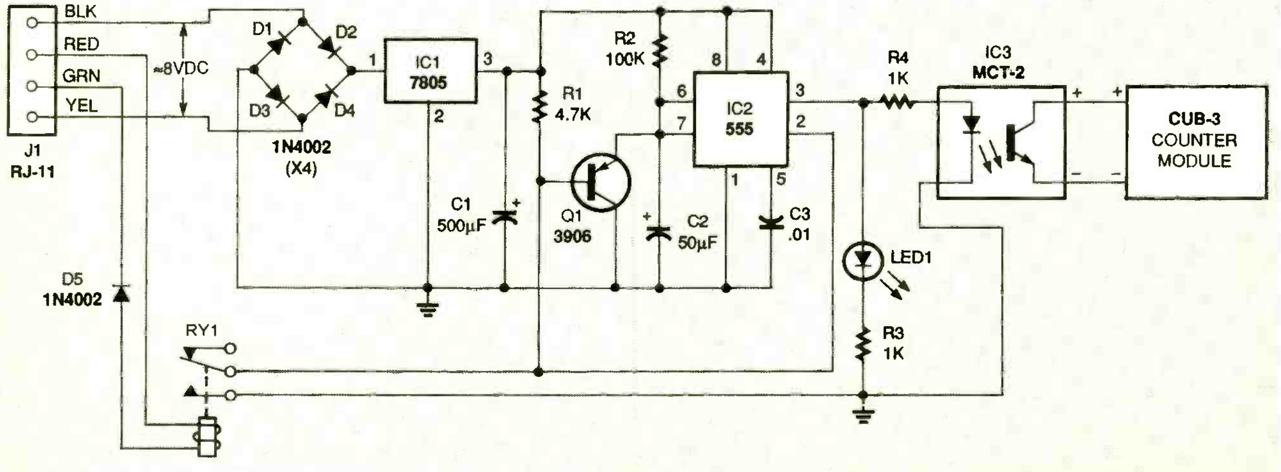
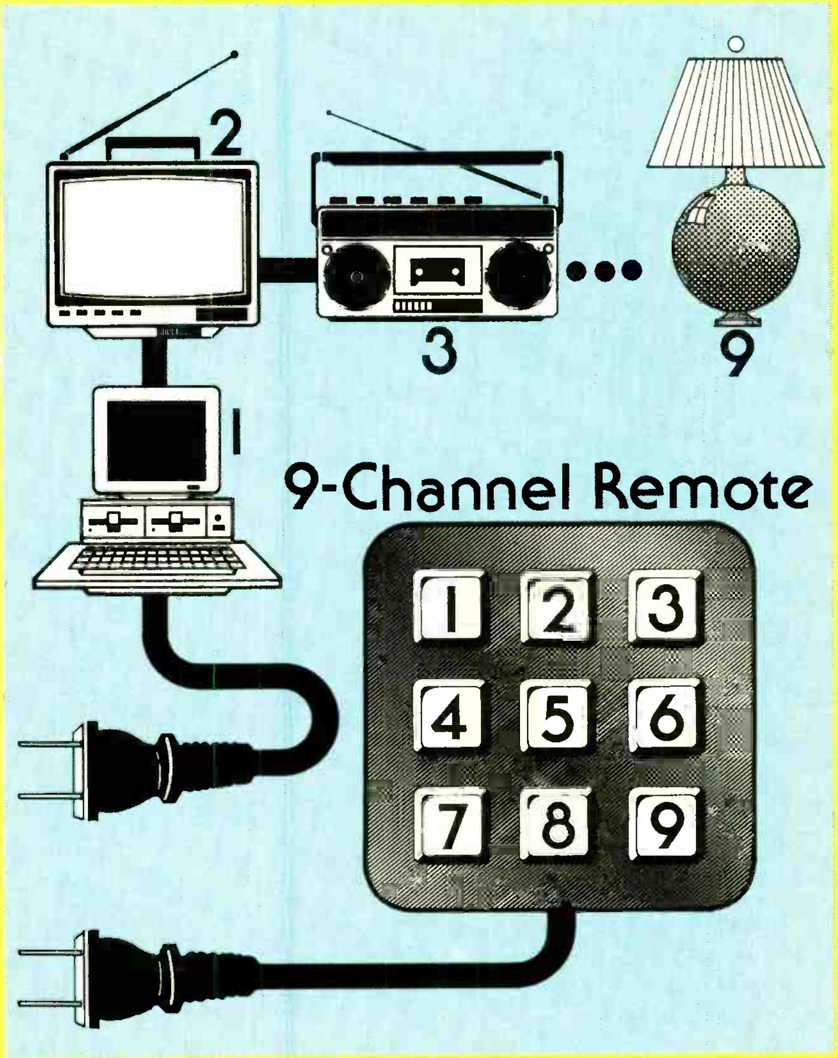


FIG. 1—THE CALL COUNTER counts the total number of calls received, regardless of the number of times the phone rings, and regardless of whether or not a message was left.

ANTHONY J. CARISTI

CARRIER-CURRENT REMOTE CONTROL



Control up to nine devices remotely with this versatile carrier-current circuit.

THIS WIRELESS REMOTE CONTROL system allows you to control up to nine electrical circuits (such as lights and appliances) with an RF carrier signal that is impressed upon and transmitted through your home's AC wiring. The transmission is called "carrier current" because the RF energy is not radiated, but conducted between transmitter and receiver by the AC wiring. Because no RF energy is radiated, no FCC license is required.

A typical remote control system will have one transmitter and several receivers. However, multiple transmitters can be used instead. Both transmitters and receivers can be placed anywhere within the home.

The transmitter and receiver are based on two Motorola application-specific integrated circuits (ASICs): an MC145026 remote-control encoder and an MC145028 remote-control decoder. Although the ICs can control as many as 19,683 channels using trinary (logic 1, logic 0, and open) data, the circuit described here has a simplified encoding scheme for the control of nine channels.

Both the transmitter and receiver are relatively simple, low-cost devices that operate directly from the AC power line. Power consumption is only 1 or 2 watts, allowing continuous standby operation with insignificant energy cost.

Although the receiver described here is a simple remote-control buzzer, any other kind of circuitry can be controlled as well. A typical receiver might operate as a simple on/off control unit or a momentary or timed-mode device. The extent of control circuitry is limited only by your imagination.

Fundamentals

The encoder IC encodes the inputs on its nine input lines and transmits the data in the form of a serial pulse train when it is enabled. To ensure reliability, the transmitter automatically transmits two complete code words containing the selected address data.

The decoder IC contains nine input pins that allow it to be user-programmed with a desired address. When the decoder detects incoming data, it checks the serial sequence to determine if it matches the preprogrammed code word.

If two identical transmitted words containing the correct address are received, the decoder will transmit a valid-transmission pulse. That pulse can then trigger auxiliary circuitry to provide the desired action.

Transmitter operation

Refer to the transmitter schematic diagram, Fig. 1. The power supply consists of a half-wave rectifier followed by voltage regulator IC1, which maintains a fixed 15-volt output. Most of the input power is consumed by power resistor R1. In-

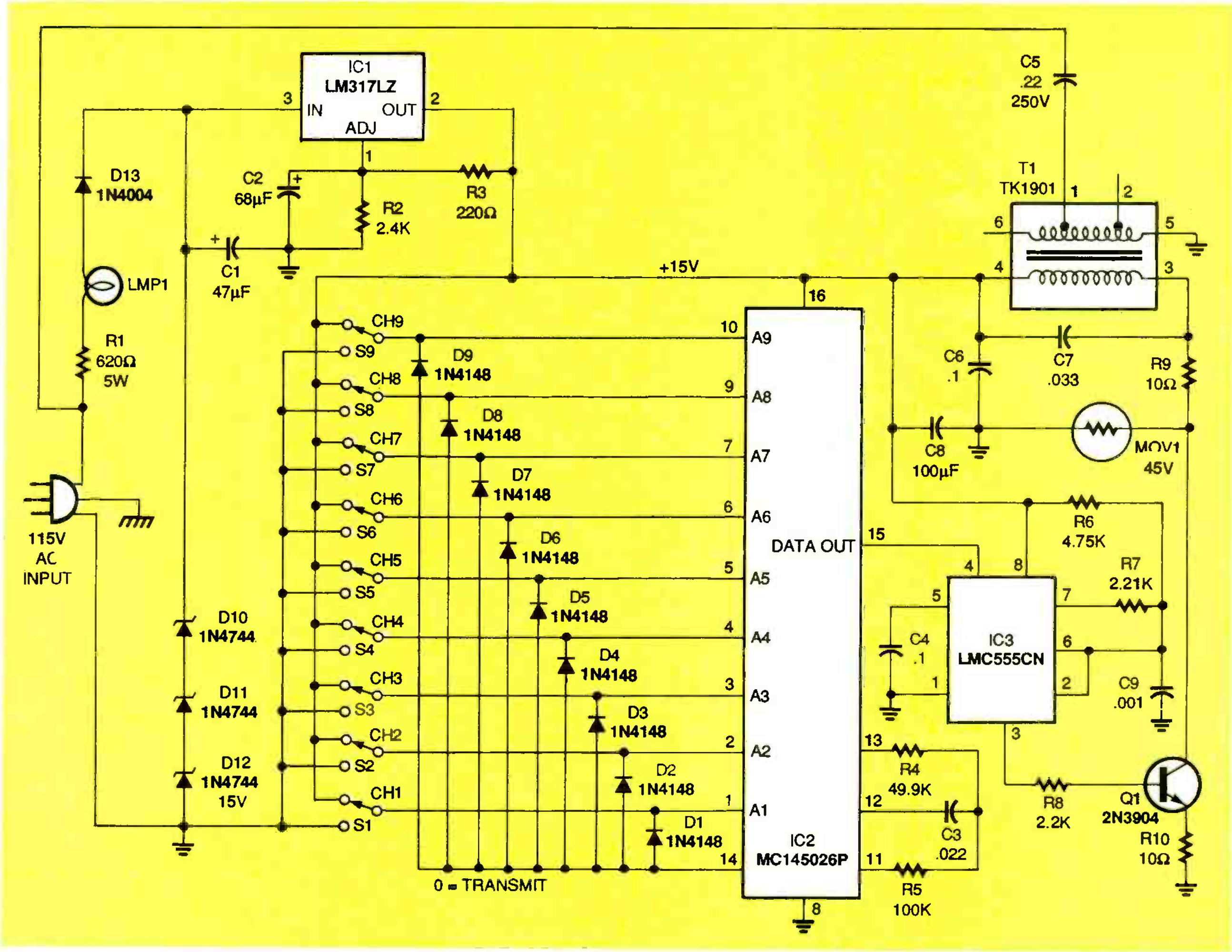


FIG. 1—TRANSMITTER SCHEMATIC DIAGRAM. Switches S1 through S9 activate the desired channel.

candescent lamp LMP1, connected in series with the input line, provides an additional voltage drop and also acts as a power-on indicator.

Three 15-volt Zener diodes (D10, D11, and D12) ensure that the voltage input to IC1 does not exceed its rated maximum allowable input. Three diodes provide sufficient power-handling capability. A fixed voltage divider composed of R2 and R3 sets the regulated output voltage of IC1 to 15 volts.

The heart of the transmitter is IC2, a Motorola MC145026P remote-control encoder. This chip contains all the necessary circuitry, with the exception of the timing components R4, R5, and C3, to generate a two-word pulse train containing the encoded information in accordance with the logic states of address inputs A1 through A9.

When the transmit enable (TE) input, IC2 pin 14, is forced to logic 0 by any of the transmit switches, the chip will transmit its coded sequence. If the TE terminal is held at logic zero, the encoder will continuously send the coded pulse train.

A different arrangement of channel transmit switches would allow the encoder to generate up to 19,683 different code sequences, as discussed earlier. Only nine unique code sequences are produced by this project, which is configured to take only one of the address inputs low while the remaining eight inputs are held high. (None should be left floating.) This is accomplished by nine single-pole, double-throw momentary switches (S1–S9) and nine switching diodes (D1–D9). When any one of the transmit switches is closed, the switching diode associated with the selected channel forces the TE input low, causing the encoder to send its word sequence.

A CMOS timer, IC3, is in an astable mode with a duty cycle close to 50%. The frequency of oscillation is determined by timing components R6, R7, and C9, and is set to about 125 kilohertz. IC3 oscillates only when its enable input, pin 4, is at a logic 1. Since this terminal is driven by the pulse train output of IC2, the RF carrier output frequency of IC3 is pulse modulated in accordance with the encoding of the selected remote-control channel.

The output of IC3, bursts of 125-kHz pulses, drives the base of Q1. The collector of Q1 feeds a matching transformer that converts the relatively high output impedance of Q1 to the low impedance presented by the AC power line. Capacitor C5 couples the output signal of T1's secondary to the AC line where it will travel throughout the 60-hertz AC wiring. The RF energy impressed upon the AC line is very small, but of sufficient magnitude to be detected by each of the remotely located receivers. Surge suppresser MOV1 protects the circuit from high-voltage transients that might appear across the AC power line.

Receiver operation

Refer to the receiver's schematic diagram, Fig. 2. A half-wave rectifier and Zener-diode regulator provide 15 volts DC to power the circuit. Resistor R12 drops the relatively high AC line voltage and limits the current through D15.

An RC network composed of R13 and C11 couple the low-power RF signal appearing across the power line to parallel-tuned circuit C12-L1. The resonant frequency of the tuned circuit (125 kHz) allows the RF signal to be coupled to the base of Q2 while attenuating all other frequencies. Transistor Q2 operates as a common-emitter amplifier, providing a very high gain to the RF signal appearing across the tuned circuit. The output of this stage is coupled to Q3 through C14.

Transistor Q3 is a detector whose base is driven by the RF signal. When Q3 is saturated, the voltage across R18 approaches 15 volts. Capacitor C15 provides sufficient filtering of the 125-kHz pulses to cause the waveform across R18 to assume the shape of the original modulating pulses generated by the transmitter encoder. The output of Q3 is fed through two NOR gates (IC4-a and IC4-b) connected as inverters to provide a clean digital pulse train to drive the decoder's serial data input.

Decoder IC5 contains nine address inputs, A1–A9, that are preprogrammed with binary data. Grounding any one of the address inputs sets the receiver to that channel. In this project, only one input is grounded, while the remaining eight are held high. The digital pulse train detected by the receiver is fed to the data input terminal (pin 9) of IC5. If the address contained in the data is equal to the preprogrammed address of the decoder, an output pulse is generated at pin 11. To ensure the transmission integrity, two identical transmitted words containing the correct address must be received consecutively before a valid transmission signal is issued.

The trailing edge of the positive-going output pulse at pin 11 of IC5 triggers a 555 timer (IC6) connected in a monostable configuration. The 1½-second long output pulse from IC6 drives piezoelectric buzzer BZ1 to indicate that a valid transmission has been received.

The valid transmission pulse output of IC5 or the output pulse from IC6 can trigger the auxiliary circuitry to provide the desired response on the external device which is under remote control.

Construction

Both transmitter and receiver are constructed on single-sided PC boards. Foil patterns are provided if you want to make your own boards. Point-to-point wiring is acceptable if good construction techniques are used. Follow the parts-placement diagrams for the transmitter and receiver boards in Figs. 3 and 4, respectively. Note that the timing and tuned-circuit components must be temperature-stable; use only the components specified in the Parts List.

Install all integrated circuits, except IC1, in sockets. Be careful when installing polarized components such as ICs, di-

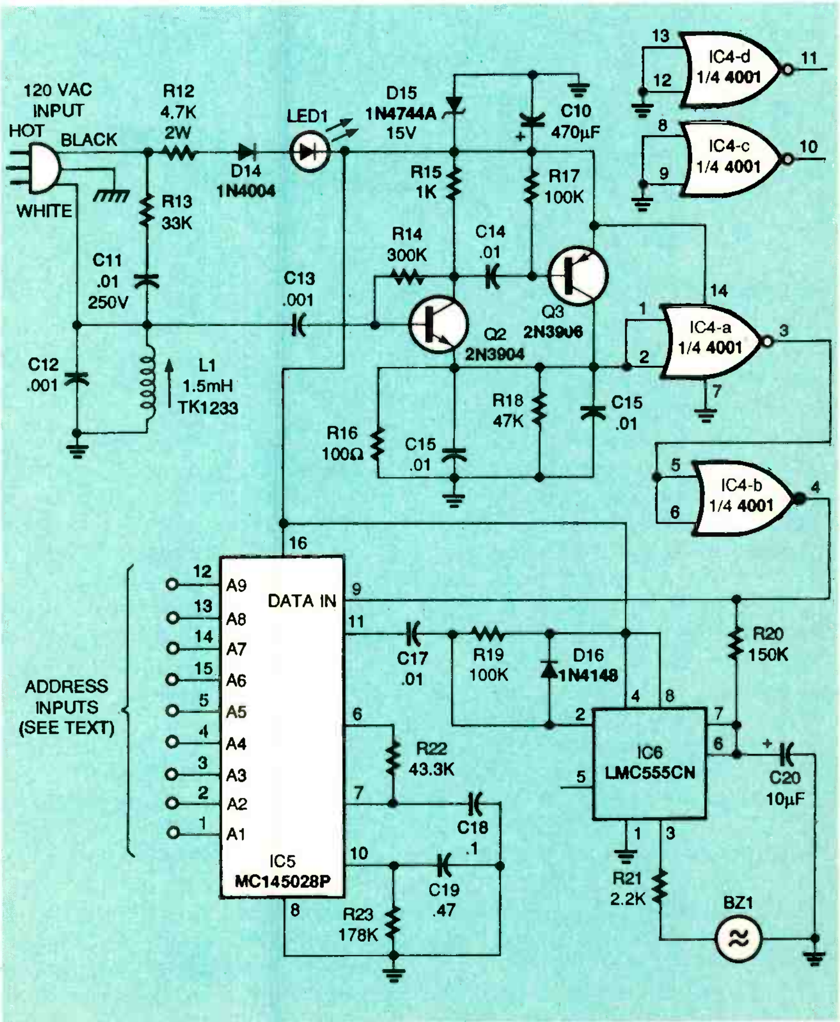


FIG. 2—RECEIVER SCHEMATIC DIAGRAM. Grounding one of IC5's address inputs, while keeping all others high, sets the receiver to that channel number.

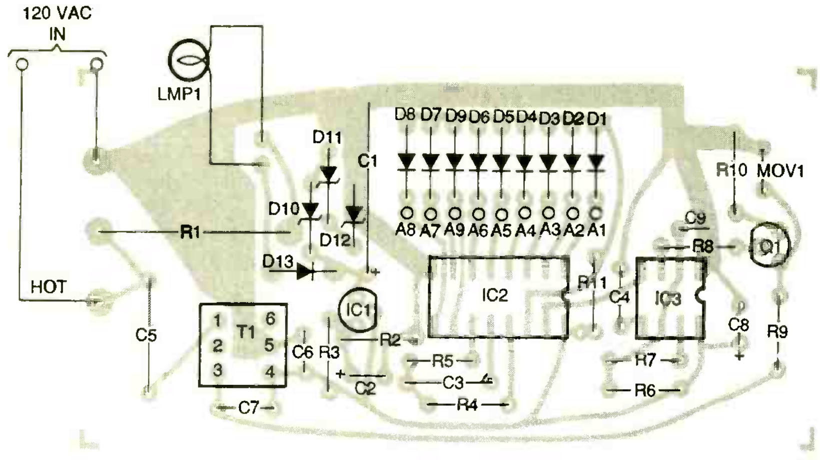
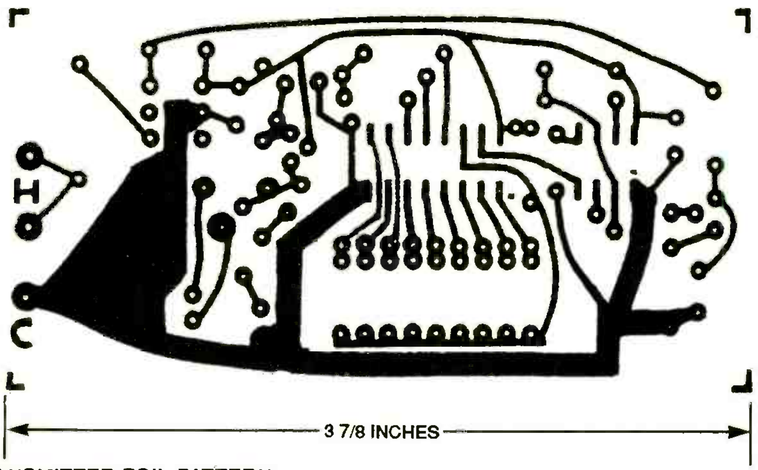


FIG. 3—**PARTS-PLACEMENT DIAGRAM** for the transmitter.



TRANSMITTER FOIL PATTERN.

odes, and electrolytic capacitors. It is also important that transformer T1 be placed correctly into the circuit.

The transmitter can control up to nine receivers, with one control switch (S1–S9) for each channel. If not all channels are to be used, you can leave out the unnecessary switches, in which case the inputs must be tied to +15 volts.

Because of the transmitter's very low power consumption, a power-on switch is optional. If desired, a double-pole double-throw switch can be substituted for each of the channel-control switches, with the extra pole wired to apply line power to the circuit only when needed. This option is illustrated in Fig. 5.

Power indicator LMP1 should be mounted on the front panel of the transmitter. This is easily accomplished by drilling a hole and securing the lamp to the panel with a small amount of epoxy.

As with the transmitter, the power-on indicator LED should be mounted to the front panel of the receiver to provide visual indication that the receiver is powered and operational. The extremely low power draw of the receiver eliminates the need for a power on-off switch in the circuit, but one may be added if desired.

Because this project is powered directly from the 60-hertz AC line without the use of an isolation transformer, proper safety precautions must be observed. A grounded line cord must be installed on both transmitter and receiver. Additionally, you must verify the polarity of the house wiring where the system is to be installed to make sure that it is correct. That can be done with an AC voltmeter set to read at least 150 volts AC, or a neon test light.

The AC wiring to any 120-volt receptacle should contain two conductors, plus a third conductive path (via a third wire or the BX cable's metallic sheath) to earth ground. One of the current-carrying wires is known as the "hot" lead, and this wire should be black. The other wire is known as the "cold," or neutral lead, and this wire should be white. Without removing the cover plate of the receptacle, verify that the polarity of the receptacle is correct by touching the common test lead of the voltmeter to the screw that holds the cover plate in place (this

TRANSMITTER PARTS

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

R1—620 ohms, 5 watt wirewound resistor
R2—2400 ohms
R3—220 ohms
R4—49,900 ohms, 1%, metal film
R5—100,000 ohms, 1%, metal film
R6—4750 ohms, 1%, metal film
R7—2210 ohms, 1%, metal film
R8—2200 ohms
R9, R10—10 ohms
R11—10,000 ohms

Capacitors

C1—47 µF, 63 volts, electrolytic
C2—68 µF, 10 volts, electrolytic
C3—0.022 µF, 50 volts, 2% polypropylene
C4, C6—0.1 µF, 50 volts, ceramic disc
C5—0.22 µF, 250 volts, metal film
C7—0.033 µF, 50 volts, 2% polypropylene
C8—100 µF, 16 volts, electrolytic
C9—0.001 µF, 50 volts, 2% polypropylene

Semiconductors

IC1—LM317LZ adjustable voltage regulator
IC2—MC145026P encoder (Motorola)
IC3—LMC555CN CMOS timer
D1–D9—1N4148 diode
D10–D12—1N4744A 15-volt, 1-watt Zener diode
D13—1N4004 diode
Q1—2N3904 NPN transistor

Other components

LMP1—14 volt, 0.08-ampere incandescent lamp
S1–S9—SPST momentary slide or toggle switch (see text)
T1—49.1 µH, 125 kHz output transformer (Toko No. 719VXA-T1060YUK, Digi-Key No. TK1901-ND)
MOV1—45-volt metal-oxide varistor (Panasonic ERZ-C05DK560 or equivalent)

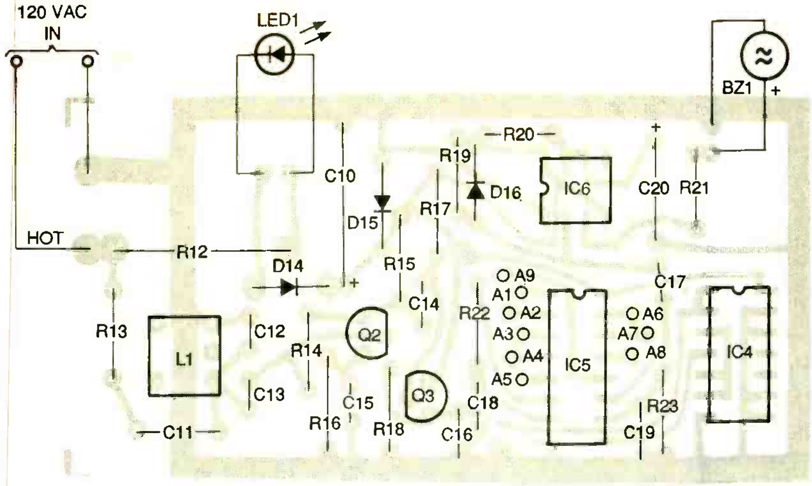
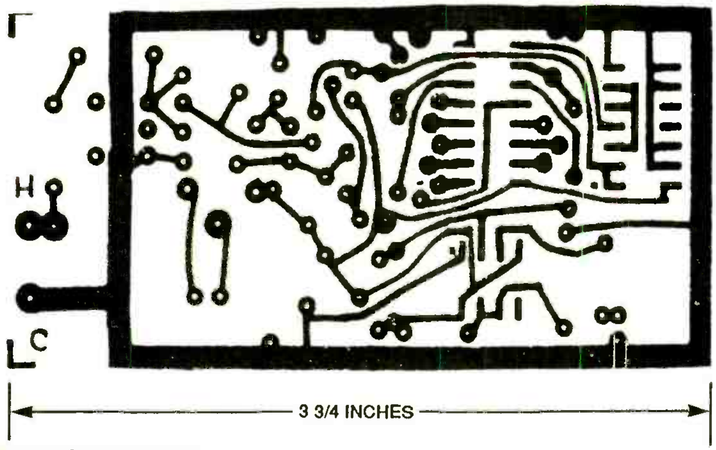


FIG. 4—PARTS-PLACEMENT DIAGRAM for the receiver.



RECEIVER FOIL PATTERN.

should be earth ground), and carefully insert the other test lead into each of the receptacle's slots. The narrow slot should be connected to the hot (black) wire, and should indicate a reading of about 120 volts AC—or it should light the test lamp. The wide slot should be connected to the neutral (white) wire of the AC line, and should give a reading of zero on the voltmeter—or it should not illuminate the test lamp. Be sure to check all AC receptacles that will be used with this system for proper polarity and ground

If you do not obtain the correct polarity readings of your AC receptacles as described, the wiring is in violation of electrical codes and should be corrected by a licensed electrician. Do not install the remote-control system until the electrical violation is corrected. Make sure that the line cords you install conform to local electrical codes as well. Once the polarity of the line cords has been determined, wire them into the transmitter and receiver. Connect the neutral (white) lead to circuit ground (the negative side of C1 in the transmitter and the negative side of C10 in the receiver). Connect the hot lead of the transmitter line cord to R1 and the hot lead of the receiver's line cord to R12.

If you install the receiver and/or transmitter in a metal enclosure, connect the ground lead of the line cord to it with a good, solid connection. If you enclose the transmitter in a plastic case, tape the ground lead out of the way so that it can't cause a short circuit. If you enclose the receiver in a plastic case, connect the ground wire of the line cord to the ground of the circuitry you are attaching to it.

RECEIVER PARTS

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

R12—4700 ohms, 2-watt metal-oxide
R13—33,000 ohms
R14—300,000 ohms
R15—1000 ohms
R16—100 ohms
R17, R19—100,000 ohms
R18—47,000 ohms
R20—150,000 ohms
R21—2200 ohms
R22—4330 ohms, 1% metal film
R23—178,000 ohms, 1% metal film

Capacitors

C10—470 µF 16 volt electrolytic
C11—0.01 µF, 250 volt metal film
C12—0.001 µF, 50 volts, 2% polypropylene
C13—0.001 µF, 50 volt ceramic disc
C14, C15, C17—0.01 µF, 50 volts, ceramic disc
C16—0.0047 µF, 50 volts, ceramic disc
C18—0.1 µF 50 volts, 2% polyproplyene
C19—0.47 µF, 50 volts, 2% polyproplyene
C20—10 µF, 16 volts, electrolytic

Semiconductors

IC4—CD4001BE quad 2-input NOR gate
IC5—MC145028P decoder (Motorola)
IC6—LMC555CN CMOS timer
D14—1N4004 diode
D15—1N4744A 15-volt, 1-watt Zener diode
D16—1N4148 diode
Q2—2N3904 NPN transistor
Q3—2N3906 PNP transistor
LED1—Light emitting diode, any color

Other components

BZ1—3-volt DC piezo buzzer
L1—1.5 mH coil (Toko No. RUNS-T1029Z, Digi-Key No. TK1233)

Miscellaneous: Enclosures, IC sockets, grounded line cords, wire, solder

Note: The following items are available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463:

- **Transmitter PC board—$12.95**
- **Receiver PC board—$12.95**
- **IC2—$8.75**
- **IC5—$8.75**
- **T1—$7.75**
- **L1—$6.75**
- **LMP1—$2.50**

Please add $5.00 S&H.

Transmitter checkout

The checkout of the project requires a digital multimeter or VOM. An oscilloscope is not necessary, but may come in handy. Remove all socketed ICs from the transmitter and receiver before proceeding.

To check the transmitter, ap-

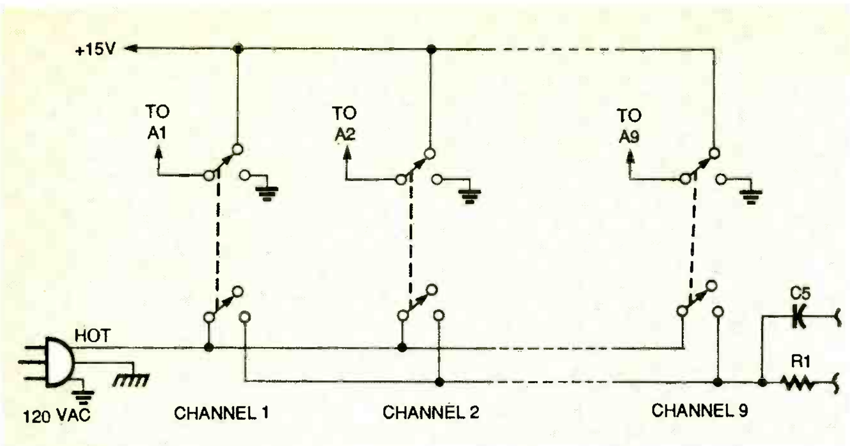


FIG. 5—A TRANSMITTER POWER SWITCH is optional. Double-pole double-throw switches can be substituted for the channel-control switches, with the extra pole wired to apply line power to the circuit only when needed.

ply AC power to it; the power-indicator lamp should glow. Measure the DC voltage across C1; a normal reading is about 42.5 to 47.5 volts DC. Also check the output of the regulator (pin 2) for 14.24 to 15.75 volts DC.

With power removed from the circuit, measure the resistance between the +15-volt bus and ground; normal indication is about 2.6 kilohms. If anything does not check out, do not proceed until the fault is found and corrected.

With power disconnected from the transmitter, carefully insert IC2 and IC3 into their sockets and apply power to the circuit. While observing the indicator lamp, push and hold any of the channel selector switches and verify that the lamp "pulses" in intensity at a rate of about 5 times a second. This indicates that the encoder is operational and is driving IC3 and transistor Q1.

You can connect an oscilloscope to verify that bursts of 125-kilohertz pulses, at about 3 volts peak-to-peak, are present at pin 1 of transformer T1. Adjust the tuning slugs of T1 with an insulated tool to attain RF pulses of maximum amplitude at pin 1 of T1.

Verify the proper operation of IC2 by examining the output pulse train at pin 15 while holding a transmit switch in the on position. A normal indication at that output will be a series of pulses at about 15 volts peak amplitude. Check pin 14 of IC1 to verify that the logic level at this terminal reaches about 0.7 volt when any transmit switch is actuated.

Verify the operation of IC3 by examining the output at pin 3. A normal indication at that output is bursts of 15-volt, 125-kilohertz pulses.

The waveform at the collector of transistor Q1 should be 125-kilohertz pulses at about 35 volts peak-to-peak.

Now put the transmitter aside and proceed with the receiver checkout.

Receiver checkout

With all ICs removed from their sockets, apply power to the receiver; the LED should illuminate. Measure the voltage across C10; it should be about 15 volts DC. Disconnect power from the circuit and measure the resistance between the +15 volt bus and ground; you should measure approximately 50 kilohms or more.

Insert all ICs into their sockets. Set the transmitter nearby to operate continuously with the chosen channel. Adjust L1 by observing the waveform at the collector of Q2 with an oscilloscope, while setting the tuning slug for maximum amplitude; a normal indication is 125-kilohertz pulses at 5 volts peak-to-peak. Check the output of Q3 for a pulse train at about 15 volts peak amplitude.

Verify operation of the receiver by momentarily actuating the correct transmit channel switch, and holding it on for approximately a ½ second to allow the transmitter to output at least two complete pulse trains. When the transmit switch is released, the piezo buzzer should sound for about a second or so.

If the receiver is operating as described, it may be placed in a remote location and operated to verify that it receives and detects the transmitted pulse train from the transmitter. If the receiver does not respond to the transmit signal, make sure that the correct channel has been actuated. Try all transmit channels to see if one of the other channels will actuate the receiver.

Verify the operation of decoder IC5 by checking the serial data input terminal (pin 9) for the 15-volt pulse train as detected by Q3. The valid transmission output terminal (pin 11) should go high as long as the correct transmit channel switch is held on. Check the logic levels at the address inputs of IC5; all inputs should be at about +15 volts DC except the selected input which should be grounded.

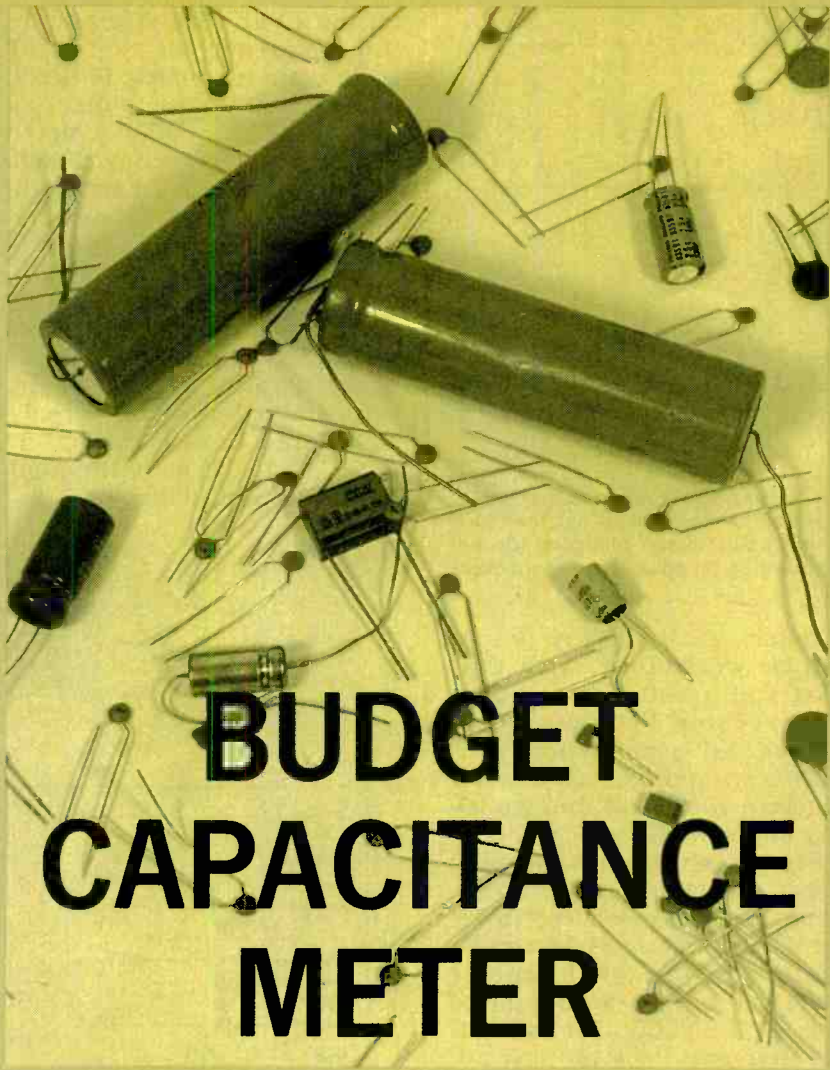
If the valid transmission output of IC5 (pin 11) is working, IC6 should be triggered when the transmit switch is released. That causes pin 3 of IC6 to go to about 15 volts, and turn on the buzzer.

Using the system

The transmitter is placed at any desired control location and plugged into a nearby AC receptacle. When it is desired to transmit a control signal, the appropriate transmit switch is actuated for at least a ½ second to transmit two complete pulse trains. The selected receiver will then respond.

The receiver, as described, is designed as a simple remote-actuated buzzer. One application for this would be a wireless doorbell system that requires no modifications. However, the circuit can be modified for many applications. For example, the pulse output of IC6 can operate a relay which then can control other devices. Ω

W. E. BABCOCK



BUDGET CAPACITANCE METER

Build a direct-reading capacitance meter.

MOST ELECTRONICS EXPERIMENTERS accumulate, among other things, a large number of capacitors whose values are unknown. The color-coded markings might be worn off, or maybe the true color of the dots or stripes cannot be determined for sure—after a few years knocking around in the junk box the yellows, browns, and reds quite often seem to degrade to some common, indistinguishable color. The electrolyte in electrolytic capacitors often dries out and the capacitance values drop drastically below those printed on the cases. This article describes a simple capacitance meter that you can build to help determine the values of all of your capacitors.

The capacitance meter works by measuring a capacitor's charging current. To understand its operation, take a look at the simplified circuit in Fig. 1-*a*. If the output of the generator is at the +E level, diode D2 will be reverse-biased. In that case, the generator can be replaced by a battery as in the equivalent circuit of Fig. 1-*b*. Capacitor C_X will then charge and will assume the voltage +E, assuming there's no voltage drop in D1 or the meter.

The result is that current flows through the meter while C_X is charging. When the generator output drops to zero the generator can be replaced by a short circuit and the equivalent circuit is shown in Fig. 1-*c*. If the output of the generator is a single pulse, then the meter will deflect upward momentarily and then drop back to zero. However, if the output of the generator is a continuous train of pulses, the meter will show a steady reading.

The charge on the capacitor (Q) is equal to its capacitance divided by the voltage across it. The formula is Q = CV. If the capacitor is charged or discharged over a given time period, both sides of that equation can be divided by the time (t), yielding the formula Q/t = CV/t. However, current is the rate of change of charge, or I = Q/t, and 1/t is the frequency (*f*). Therefore, the formula can be rewritten as I = CV*f*.

The meter's sensitivity, the desired capacitance measurement range, the supply voltage, and the operating frequency all affect the capacitance meter's design. For example, if a 6-volt supply were used with a 1-milliampere meter movement and a full-scale reading of 10 picofarads were desired, the required operating frequency would be approximately 16.7 megahertz. That would preclude a design based on the popular 555 timer. Even if the supply voltage were to be doubled, the required operating frequency would be over 8 megahertz, still well over the capability of the 555.

If a lower operating frequency is desired, it is not practical to use a 1-milliampere meter movement in the capacitance meter. Even if a more sensitive 200-microampere meter movement were substituted, the circuit would still require an operating frequency outside the capability of a standard, bipolar 555 timer. However, the CMOS TLC555, manufactured by Texas Instruments, has a maximum frequency of 2.1 megahertz, and by choosing scale ranges and the supply voltage

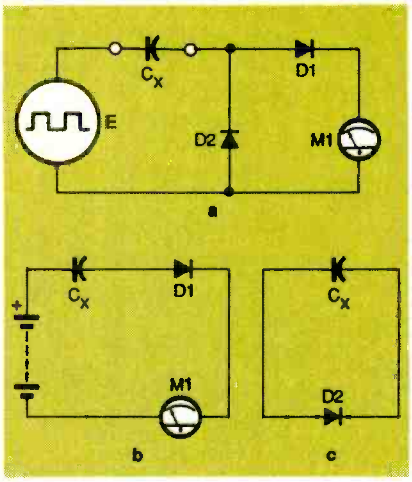


FIG. 1—BASIC CIRCUIT of a direct-reading capacitance meter (*a*), and the equivalent circuits when charging (*b*) and discharging (*c*) an unknown capacitor.

carefully, a satisfactory design can be worked out with that part and a 200-microampere meter. Table 1 shows meter ranges, full-scale meter readings, and approximate operating frequencies assuming a 10-volt supply.

Figure 2 shows the schematic of the capacitance meter incorporating the scales given in Table 1. Each range is a convenient multiple of the meter scale. The author decided not to operate the TLC555 at its highest frequency to avoid any potential problems at the upper limit. To minimize low-frequency meter-needle fluctuations on the two highest capacitance ranges, the author designed the circuit with a full-scale meter current of 2 milliamperes. That made it possible to increase the operating frequency for those ranges by a factor of 10. Even so, the operating frequency for the 20-microfarad range is only 10 hertz.

A single potentiometer (R10) calibrates both the 0.2- and 2-µF ranges. The 250 kilohm potentiometer is adjusted with the range switch S1 in the 0.2-µF position. Then, with S1 in the 2-µF position, the 25-ohm potentiometer shunting the meter (R17) is adjusted to obtain the proper reading. Once that is done, the meter's full-scale deflection will be approximately 2 milliamperes, which is also the proper current range for the 20-µF scale. The operating frequency for the 20-µF scale is approximately 10 hertz, which is fairly close to the resonant frequency of the meter. The meter is damped by a 6600 µF capacitance on the two highest ranges to prevent low-frequency meter-needle fluctuations.

The operating frequency for each range must remain constant if the accuracy of capacitance reading is to be maintained over long time periods. The three timing capacitors (C1–C3) should be of the highest stability available.

Any capacitance coupling between the C_X terminals and between the leads going to these terminals will produce a residual capacitance reading. This residual reading can increase the measured value of very low-value capacitors by a considerable amount. Therefore, a grounded piece of aluminum is located on the rear surface of the panel on which the C_X terminals are mounted to minimize coupling between the terminals, and the two wires going to the terminals are kept separated from each other and from other wires in the circuit.

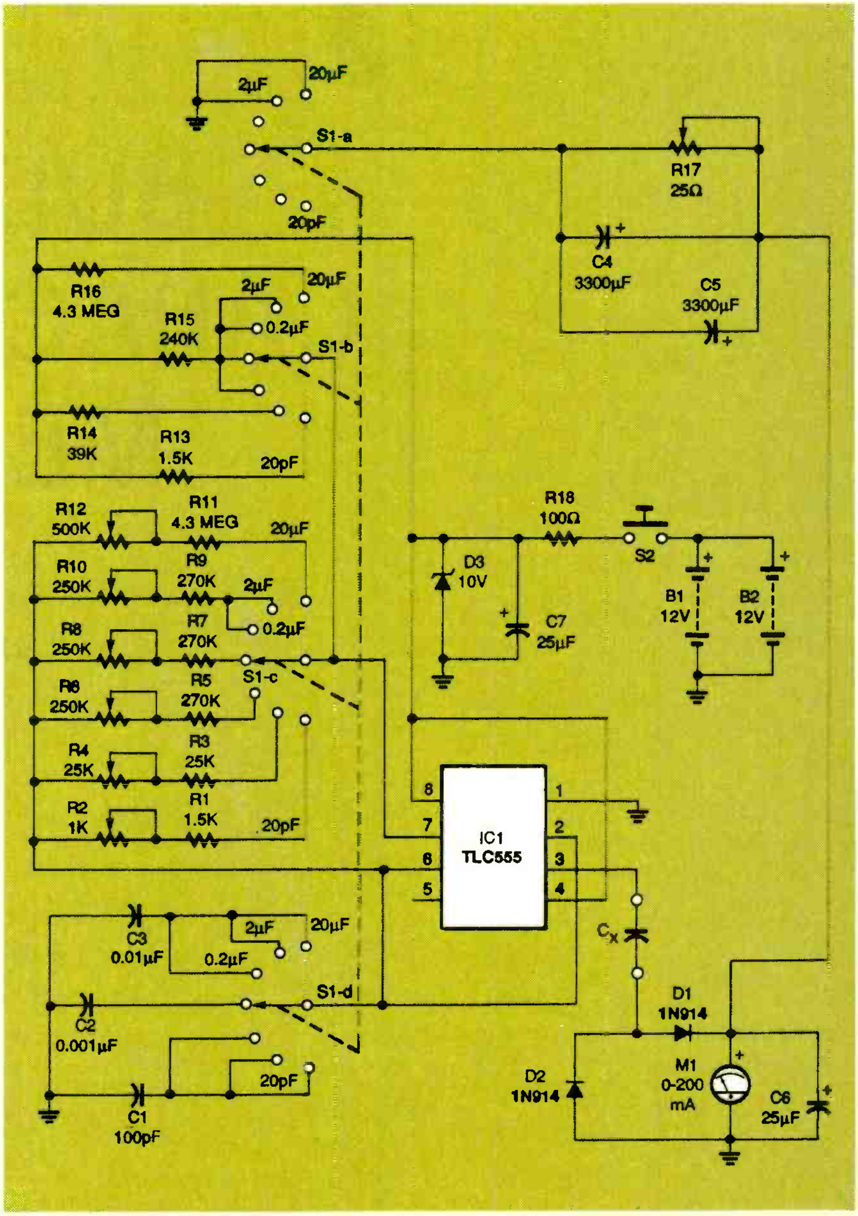


FIG. 2—CAPACITANCE METER SCHEMATIC. The circuit is centered around a TLC555 timer, one that can operate at frequencies up to 2.1 megahertz.

TABLE 1—CURRENT AND OPERATING FREQUENCY

Full-Scale Range	Full-Scale Current	Operating Frequency
20 pF	200 μA	1 MHz
200 pF	200 μA	100 kHz
0.002 μF	200 μA	10 kHz
0.02 μF	200 μA	1 kHz
0.2 μF	200 μA	100 Hz
2 μF	2 mA	100 Hz
20 μF	2 mA	10 Hz

The residual capacitance reading is less than 0.2 picofarads, which should be subtracted from all readings taken on the 20-picofarad scale. The residual capacitance reading can be neglected for ranges that are above 20 picofarads.

Two 12-volt GP23A alkaline cells in parallel power the circuit. Two batteries in parallel are required to supply the 20 milliamperes current required by the circuit. N-cell battery holders work fine as holders for the GP23A batteries. If GP23A batteries are not available, two standard 9-volt batteries connected in series can be used, but the resistor in series with batteries (R18) should be increased to 390 ohms. To prevent unnecessary current drain on the batteries, a pushbutton switch (S2) momentarily applies power to the circuit only while a test is being performed. That extends battery life to near shelf life since the meter will normally be used only for short periods of time.

Construction

The author mounted all circuit components, with the exception of the range switch and off/on switch, on a scrap piece of Formica laminate, a good low-cost substitute for phenolic perforated construction board. Mounting holes for the components were drilled in the board, and components were wired point-to-point on the back side.

Figure 3 shows the completed circuit board, housed in a 3¼- × 6¼- × 2-inch bakelite meter case. Labels for the various ranges were scratched into the bakelite panel with a scribing tool. The scratches were then filled in with white paint. Figure 4 shows the modified meter case.

PARTS LIST

All resistors are ¼-watt, 5%, unless noted.
R1, R13—1500 ohms
R2—1000 ohms, linear taper potentiometer
R3—25,000 ohms
R4—25,000 ohms, linear taper potentiometer
R5—270,000 ohms
R6—250,000 ohms linear taper potentiometer
R7—270,000 ohms
R8—250,000 ohms, linear taper potentiometer
R9—270 ohms
R10—250,000 ohms, linear taper potentiometer
R11, R16—4.3 megohms
R12—500,000 ohms, linear taper potentiometer
R14—39,000 ohms
R15—240 ohms
R17—25 ohms, potentiometer
R18—100 ohms, ½-watt
Capacitors
C1—100 pF, metal film
C2—0.001 μF, metal film
C3—0.01 μF, metal film
C4, C5—3300 μF, 16 volts, electrolytic
C6, C7—25 μF, 16 volts, electrolytic
Semiconductors
IC1—TLC555 timer, Texas Instruments or equivalent
D1, D2—1N914 diode
D3—10-volt Zener diode
Other components
S1—4-pole, 7-position, non-shorting rotary switch
S2—Normally-open SPST pushbutton switch
M1—200 microampere meter movement
B1, B2—GP23 12-volt alkaline battery (or other suitable supply, see text)
Miscellaneous: Two N-cell battery holders, construction board, meter case, wire, solder.

Calibration

Capacitors with known accurate values covering the meter's complete range are necessary to calibrate the capacitance meter. Initial calibration was accomplished by measuring a large number of capacitors covering the complete range and adjusting the appropriate calibrating resistors for each scale to obtain the closest possible agreement with the nominal values across the entire range.

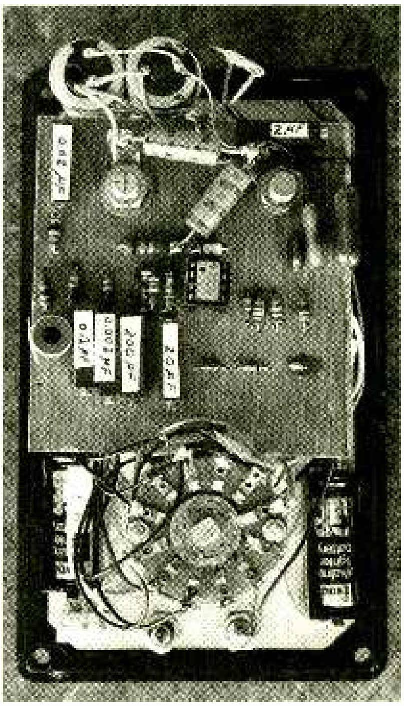


FIG. 3—ALL COMPONENTS, with the exception of the range switch and off/on switch, were mounted on a scrap piece of Formica as a substitute for phenolic perforated construction board. Point-to-point wiring is made on the back side.

Since many capacitors have poor tolerances, some of the meter readings deviate several percent from their nominal values. After completing the calibration as just described, a group of 1-percent tolerance capacitors was first read on the meter without recalibrating, and the maximum deviation from the nominal value was found to be about 11 percent. The meter was then recalibrated

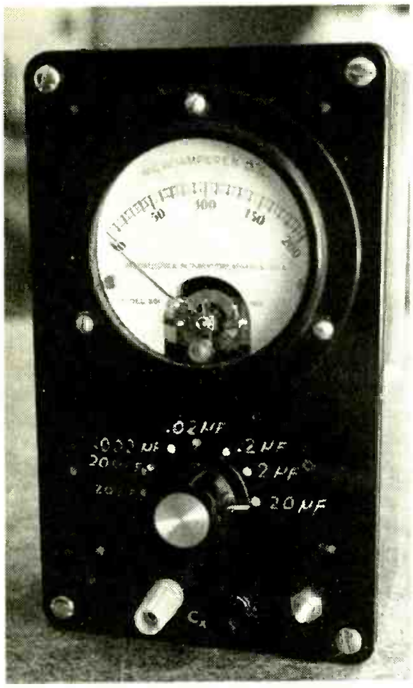


FIG. 4—THE BOARD IS HOUSED in a bakelite meter case. Labels are scratched into the bakelite panel, and the scratches are filled in with white paint.

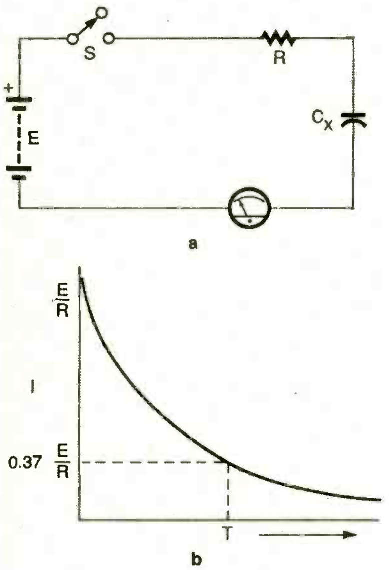


FIG. 5—VALUES FOR LARGE electrolytic capacitors can be obtained by observing the charging characteristic of the capacitor when it is connected to a voltage source through a series resistor (*a*). If the capacitance is unknown, but R and E are known, then C = T/R where T is the time when I = $0.37 \times I_{INITIAL}$.

using one-percent capacitors with values near midscale for each range.

Practical considerations limit the maximum scale range to 20 microfarads. To add another range covering 200 microfarads would require an operating frequency of 1 hertz or a maximum current range of 4 milliamperes. However, reasonably accurate values for large value electrolytic capacitors can be obtained by observing the charging characteristic of the capacitor when the electrolytic is connected to a voltage source through a series resistor as shown in Fig. 5.

The time constant (T) in seconds of the circuit of Fig. 5-*a* is given by the formula T = RC, where R is the resistance in ohms and C is the capacitance in farads (or megohms and microfarads). As shown in Fig. 5-*b*, at time t = 0 the capacitor will be a short circuit and the current through the resistor will be E/R. The current through the resistor will decay exponentially and, at t = T, will be equal to 37 percent of the initial current. If the capacitance is unknown, but R and E are known, then C = T/R where T is the time when I = $0.37 \times I_{INITIAL}$.

The procedure for determining an unknown capacitance is as follows:

Choose a value of resistance that will produce a convenient value of initial current. For example, if E = 10 volts, a resistance (R) of 50,000 ohms will produce an initial current reading of 200 microamperes, and 37 percent of that value is 74 microamperes. If the current drops to 74 microamperes in 10 seconds, then C = 10/50,000, which equals 0.0002 farads or 200 microfarads.

The initial current should always be the calculated value. The inertia of the meter movement may prevent the needle from accurately indicating the initial current.

The value chosen for R should always be sufficient to produce an RC time constant (T) of at least 10 seconds. Theoretically, shorter time constants could be used, but in such cases the current would drop so rapidly it would be difficult to obtain an accurate value for the time when it reached 37 percent of its initial value. Ω

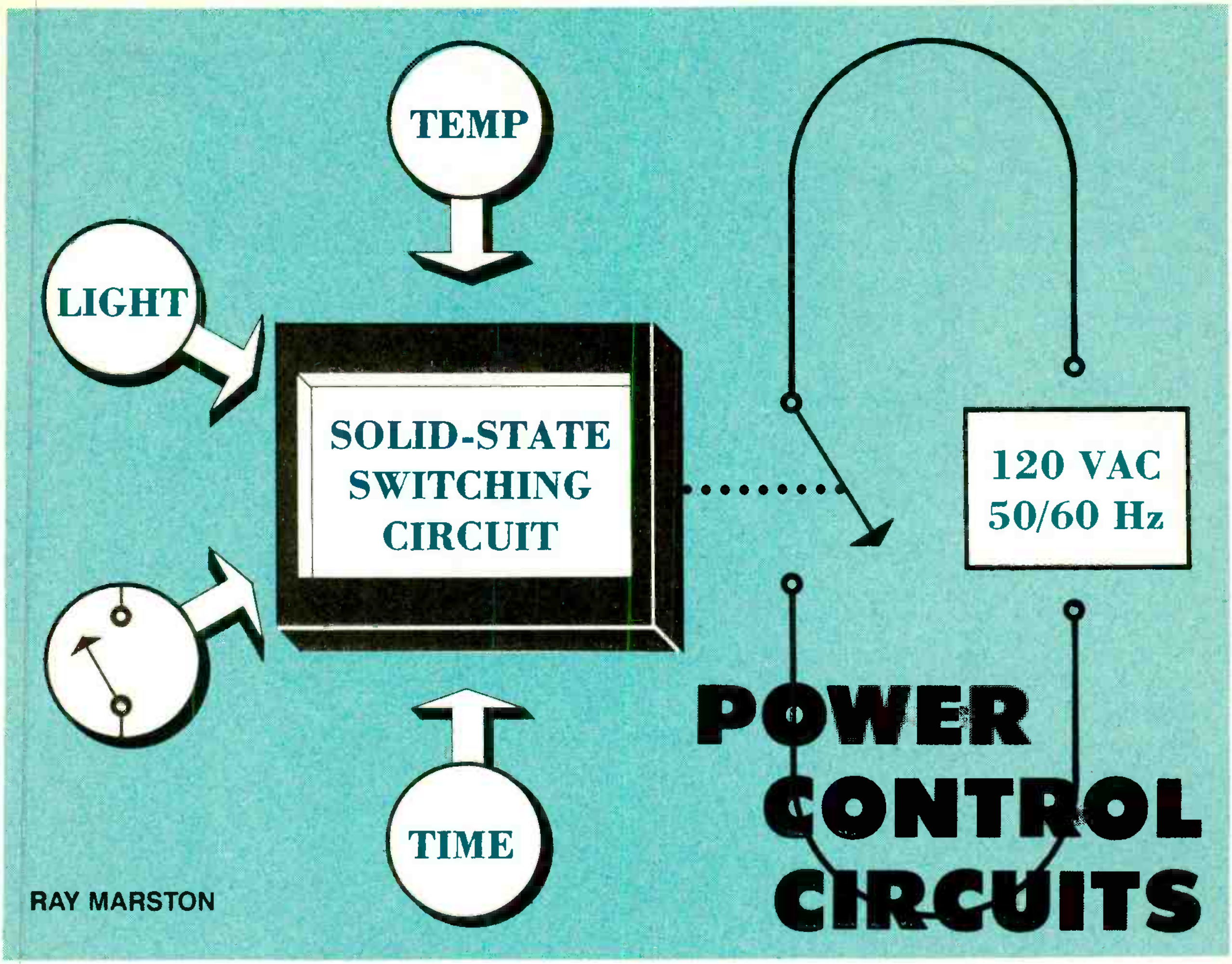
WHAT'S NEWS

continued from page 4

complete module weighs less than its 8.4-inch predecessors.

So far, Toshiba has demonstrated a 9.5-inch VGA TFT prototype that consumes 2 watts and NEC has announced that it plans to introduce a 10-inch LCD that draws 1.5 watts. The present generation of color TFT displays will run down rechargeable nickel-metal hydride (Ni-MH) batteries in the small computers in about two hours. Unfortunately the trend toward larger 10-inch panels will only aggravate the problem because of the general rule that power consumption is proportional to panel area.

A Sharp spokesperson said that high production will begin on the improved displays this year and when they reach volume levels, they will be priced lower than the existing 8.4-inch displays. The company also expects to sample a 10.4-inch model later this year. Ω



POWER CONTROL CIRCUITS

RAY MARSTON

Learn to apply power semiconductors in practical power control circuits and control appliances, motors, and relays.

SOLID-STATE ELECTRONIC CONTROL circuits stand between you and the AC power line in appliances from washing machines to air conditioners. You'll also find them in light-switching circuits, power tools, and all manner of industrial equipment.

AC-powered equipment with electronic controls can be switched on and off by sensors that respond to changes in temperature, light level, pressure, air flow, liquid level, and other physical variables.

The low cost and ready availability of solid-state electronics has made switching the AC line convenient and economical. The miniature circuitry occupies very little space within the host appliance or product, and it consumes very little power on its own.

An article in last month's *Electronics Now* discussed power semiconductor devices—how they work, how they are made, how they are packaged, and their applications.

This artice will continue the "power control" theme by introducing a selection of practical, basic, ON/OFF AC power switching circuits.

Sync vs. async switching

Triacs are solid-state bidirectional thyristors that can operate in the 120-volt or 240-volt AC line and switch either polarity. A triac can be triggered (turned on and latched) either synchronously or asynchronously with the AC line. However, the triac will be turned off automatically at the end of each AC half-cycle (180 electrical degrees) as its terminal current falls below the device's *minimum holding* value. Asynchronous circuits can generate significant radio-frequency interference (RFI), particularly at initial turn-on

Synchronous circuits, which will be covered *always* turn on at the same point in each AC half-cycle (usually just after the zero-crossing point) and generate minimal RFI.

All of the circuits in this article perform asynchronous power switching. Figures 1 to 8 show a variety of asynchronous triac power-switching circuits that perform basic ON/OFF AC-line switching.

Triac switching circuits

Figure 1 is the schematic for a simple AC power switch that includes a triac. This circuit can switch AC power to lamps, heaters, motors, or many different

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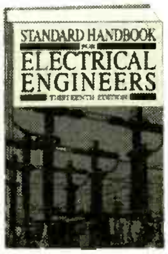

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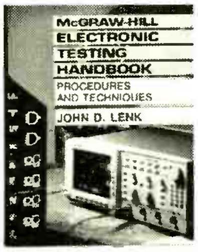

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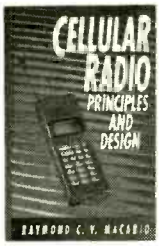

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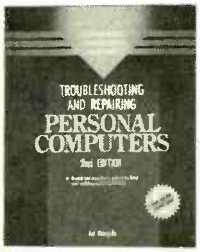

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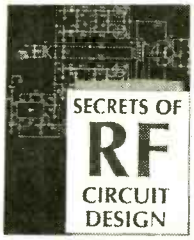

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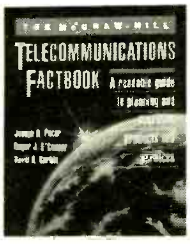

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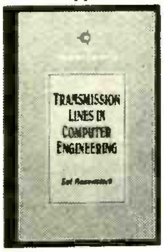

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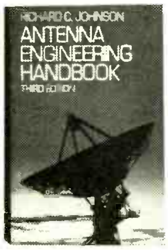

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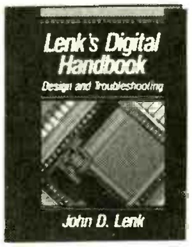

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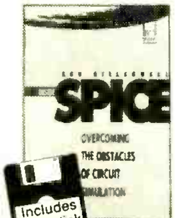

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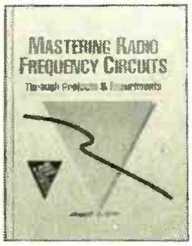

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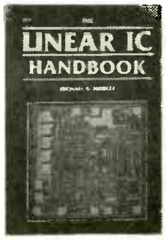

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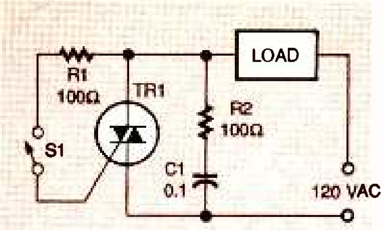


FIG. 1—SIMPLE AC POWER SWITCHING circuit with a triac that can be triggered from the AC line.

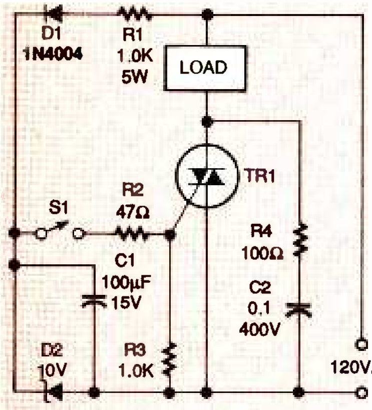


FIG. 2—AC POWER SWITCH whose triac can be triggered with line-derived DC.

kinds of appliances and machines. However, the triac for this circuit must be selected with the necessary rating to switch AC power safely for your intended application. *Caution:* The components for all of the schematics in this article have been selected for switching *only* 120-volt, 50/60 Hz AC.

In Fig. 1, the triac is off and acts like an open switch when S1 is open. However, it acts like a closed switch that is gated on from the AC line through the load and R1 shortly after the start of each AC half-cycle, when S1 is closed. The triac's main terminal voltage drops to only a few hundred millivolts when the triac turns on, so R1 and S1 consume very little current.

Keep in mind that the triac's threshold is *not* synchronized to the AC line when S1 is initially closed, but it becomes synchronized on all subsequent half-cycles. Resistor R1 and capacitor C1 form a *snubber* network that (as was described last month) suppresses voltage spikes that occur when inductive loads are switched and current and voltage are out-of-phase. Snubber networks are included in all of the triac circuits presented in this article.

Figure 2 shows how the triac functions as a power switch that can be triggered by the AC line-derived DC supply. Capacitor C1 is charged to + 10 volts on each positive line half-cycle through resistor R1 and Zener diode D1. The charge on C1 triggers the triac when S1 is closed. Notice that resistor R1 is subjected to close to the full AC line voltage at all times. Consequently, it must have a high power rating (5 watts here).

Caution: All parts of this circuit are "live" so the circuit poses a life-threatening electrical-shock hazard. Moreover, this circuit is difficult to interface with external control circuitry because it does not include an isolator or matching device.

Isolated input control

Figure 3 shows how the circuit in Fig. 2 can be modified so that it can easily be interfaced to external control circuitry. Here, switch S1 is replaced by bipolar junction transistor Q1, which is driven by the output stage of an optocoupler (or optoisolator) IC1. It consists of an infrared light-emitting diode (IRED) optically coupled to a phototransistor. Any of a number of industry-standard transistor-output optoisolators will work here.

These include the TIL111, TIL 112, 4N27, and 4N28. The optocoupler can be driven from a 5-volt or greater DC supply through resistor R1. The triac turns on only when the input circuit supply is connected to the 5-volt or greater power source by switch S1.

As was pointed out in last month's article, optocouplers

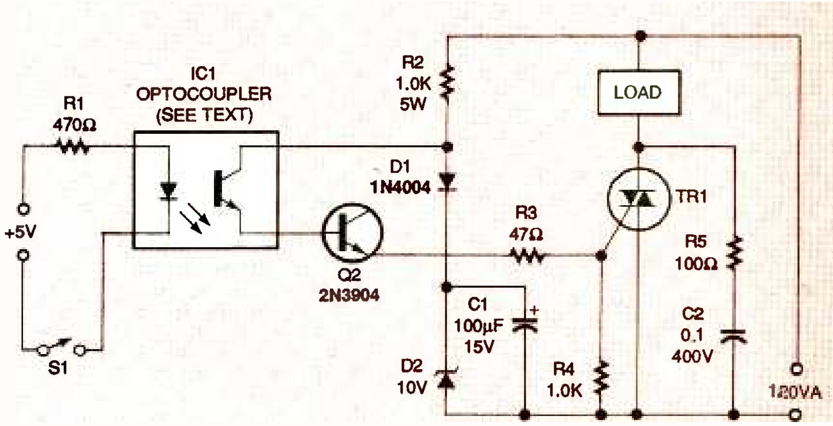


FIG. 3—OPTICALLY COUPLED AC power switch with a triac that can be triggered by DC input.

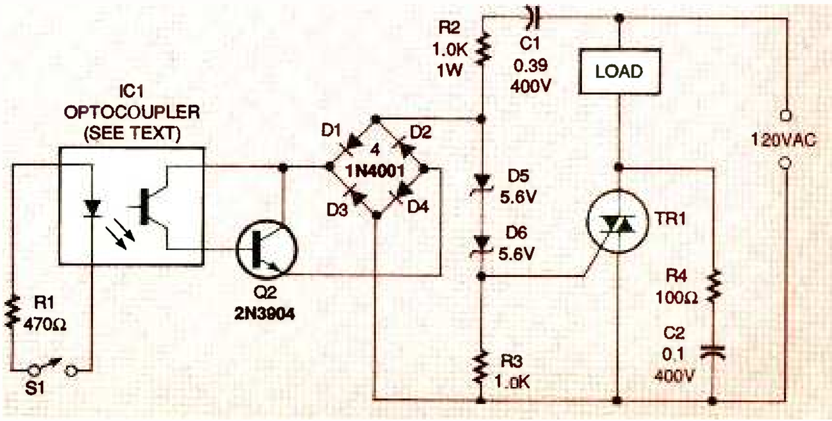


FIG. 4—OPTICALLY COUPLED AC power switch with a triac that can be triggered by AC input.

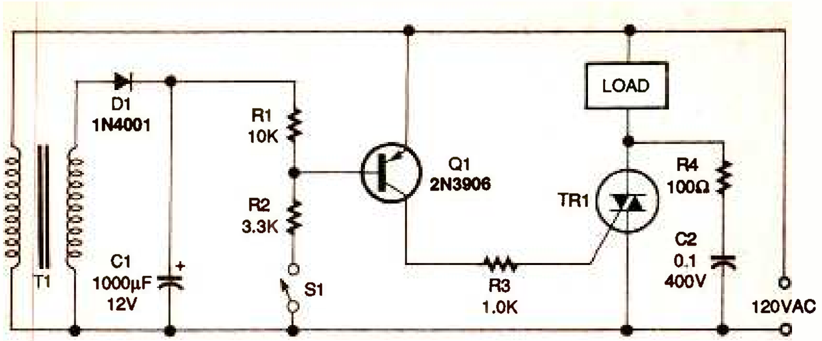


FIG. 5—AC POWER SWITCH with transistor-aided DC triggering and transformer isolation

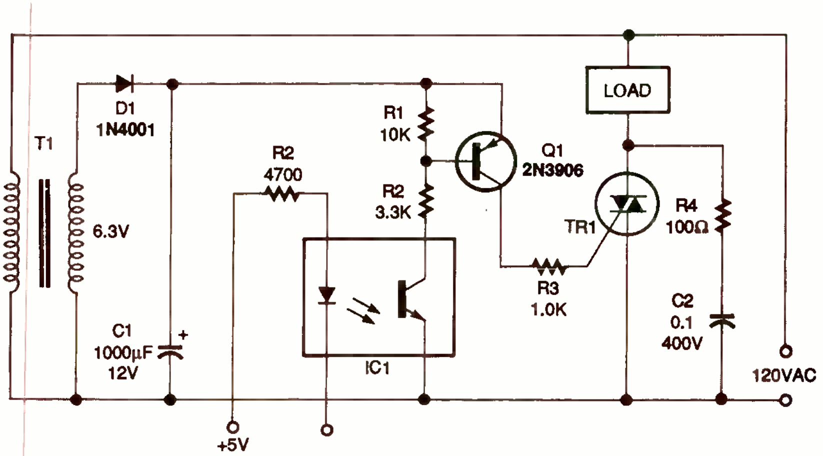


FIG. 6—OPTOISOLATED-INPUT AC power switch with DC triggering and transformer isolation.

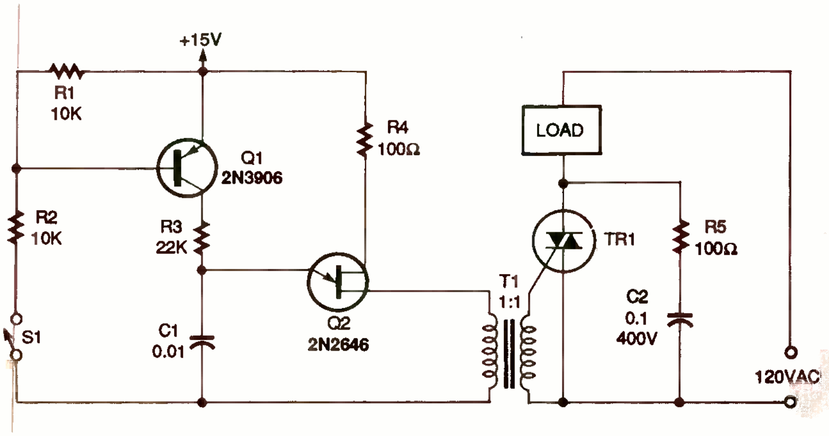


FIG. 7—TRANSFORMER ISOLATED AND COUPLED triac AC power switch with a unijunction transistor

have typical isolation ratings (V_{ISO}) of 5000 volts AC, and some have ratings as high as 7500 volts AC. This means that the input circuit (think of it as the "coil" circuit of an electromechanical relay) is fully isolated from the AC line-driven triac output circuit (think of it as the "contact" circuit of an EM relay).

This basic circuit can be designed to give any desired form of automatic "remote" triac switching by replacing S1 with a suitable electronic sensor.

Figure 4 is a variation of the Fig. 3 circuit. In this schematic, the triac is AC triggered on each line half-cycle through capacitor C1 and resistor R1 in series and back-to-back Zener diodes D5 and D6. The AC line impedance of C1 determines the magnitude of the triac gate current, but C1's power dissipation is near zero.

The bridge rectifier consisting of D1, D2, D3, and D4 is connected across the series network of Zener diodes D5 , D6 and R3, which is loaded by transistor Q1. When transistor Q1 is off, the bridge is effectively open, and triac TR1 turns on shortly after the start of each AC half-cycle.

When transistor Q1 is conducting, a near short-circuit appears across D5, D6, and R3, inhibiting the Triac gate circuit, and triac TR1 is off. Transistor Q1 is actually driven by the optocoupler from the isolated external input circuit, so the triac is normally on, but it turns off when S1 is closed.

DC triggering

Figures 5 and 6 show several ways to trigger a triac power switch with a transformer-derived DC power supply and a transistor-aided switch. In the Fig. 5 circuit, the transistor and the triac are both driven on when S1 is closed, and they are off when S1 is open.

Switch S1 in Fig. 5 can be be replaced by a sensitive switch that will respond to physical changes. For example, a thermistor can trigger the circuit if the ambient temperature falls below a specified set point. Similarly, a photoconductive cell can respond to changes in light level, a pressure sensor to changes in air or liquid pressure, and a flowmeter to changes in a liquid or air flow rate. Notice, however, that the Fig. 5 circuit is "live" and presents a shock hazard.

Figure 6 shows how the Fig. 5 circuit can be modified for control by an optocoupler. This will permit it to be activated by fully isolated external circuit.

Unijunction triggering

Figures 7 and 8 show several alternative ways to trigger a triac from a fully isolated external circuit. In these two circuits the triggering action is obtained from a unijunction transistor

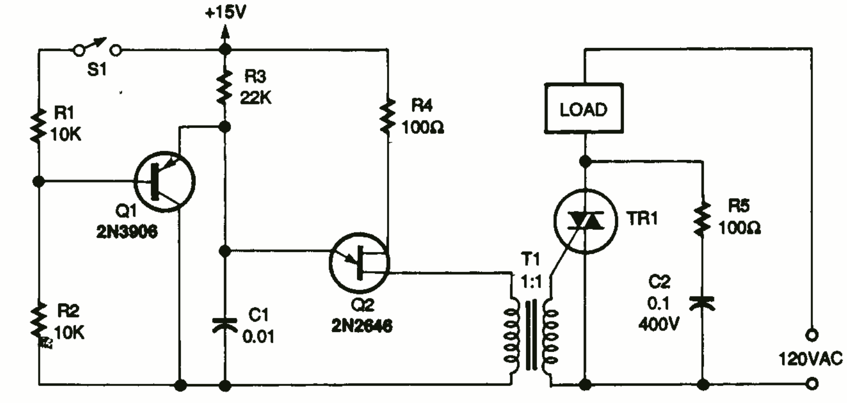


FIG. 8—TRANSFORMER-ISOLATED AND COUPLED triac AC power switch with a unijunction transistor.

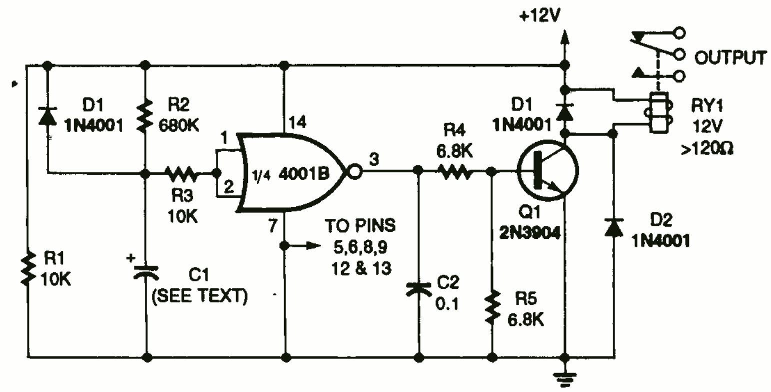


FIG. 9—AUTOMATIC TURN-OFF relay switching circuit.

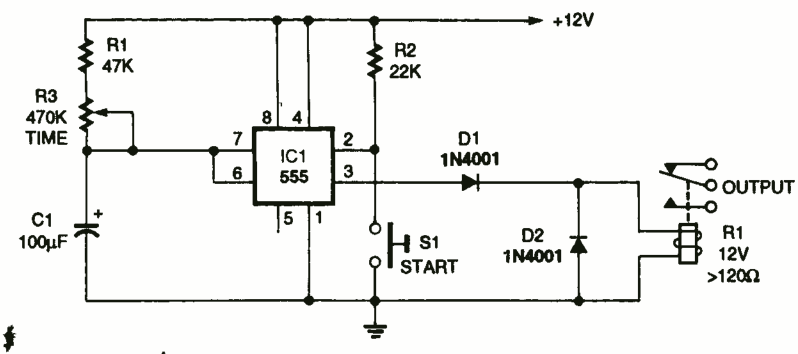
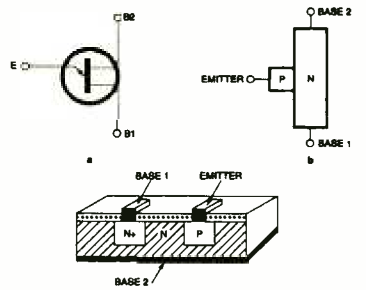


FIG. 10—SIMPLE 6 TO 60-SECOND timer circuit.

What Is A Unijunction Transistor?

A *Unijunction transistor* (UJT) is a three-terminal silicon transistor with a single PN junction. Its input terminal is called the *emitter* and its two other terminals are called called base 1 and base 2. The important characteristic of the UJT is its *negative resistance* that occurs when the emitter is properly biased. It is this characteristic that makes it useful in pulse formation, timing, triggering, and various sensing applications.

The emitter of the N-channel UJT is connected to the P-type region of the PN junction and base terminals 1 and 2 are connected to the N-type region. The N-type region is lightly doped, giving it a high resistance in the absence of a positive emitter bias.



SCHEMATIC FOR AN N-channel UJT (a), functional diagram (b), and section view of a modern UJT made by the diffusion process(c).

If the emitter is grounded, the PN junction is reverse biased, and a small emitter reverse current flows. However, with a positive bias on the emitter, current flows from the emitter into the N-type region, causing the resistance of that region to decrease, resulting in more forward current. The device continues to conduct until the input is open-circuited or the emitter current is significantly reduced.

The arrowhead points in the direction of conventional current for a forward-biased N-channel UJT (from the P-type emitter to the N-type region). There is also a P-channel UJT whose schematic symbol is identified by the arrowhead directed outward.

(UJT) configured in a pulse-generating relaxation oscillator.

In these two circuits, the triggering action is obtained from the oscillator circuit that includes UJT Q2. It operates at a frequency of several kHz, and its output pulses are fed to the gate of triac TR1 through pulse transformer T1, which provides the desired isolation.

Because of the UJT oscillators's fairly high operating frequency, the triac is triggered on within a few electrical degrees of the start of each AC half-cycle when the oscillator is on.

(For more on the UJT refer to the sidebar "What is a Unijunction Transistor?").

The UJT Q2 forms a relaxation oscillator when resistor R3 is placed between its emitter and base B2 where positive voltage is applied and a capacitor C1 is placed between the emitter and the base B1. When the capacitor voltage reaches a specified level, the UJT conducts and rapidly discharges the capacitor. The time for the capacitor to discharge can be calculated, and the frequency of the sawtooth is approximately 1/time.

In the Fig. 7 circuit, Q1 is in series with the UJT's main tim-

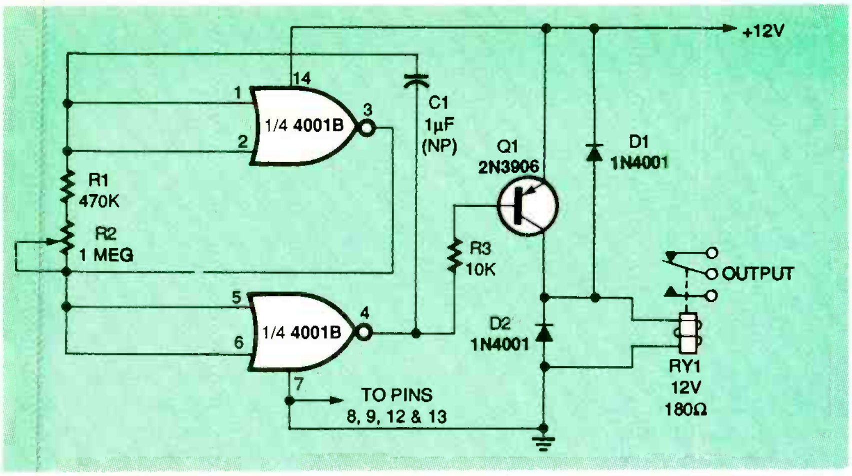


FIG. 11—RELAY PULSER circuit.

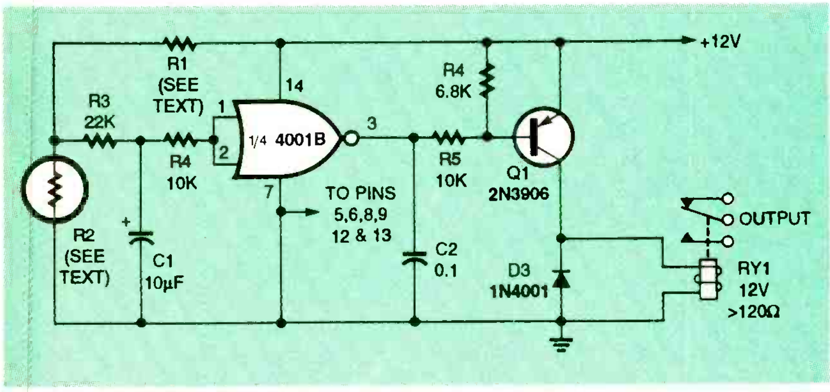


FIG. 12—LIGHT ACTIVATED RELAY switching circuit with transient suppression.

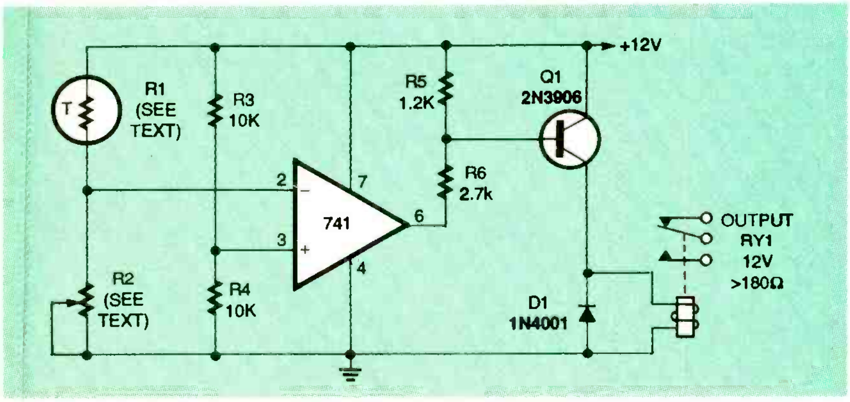


FIG. 13—PRECISION OVERTEMPERATURE relay switching circuit.

ing resistor R3, so the UJT and triac turn on only when S1 is closed.

In the Fig. 8 circuit, Q1 is in parallel with the UJT's main timing capacitor C1, so the UJT and triac turn on only when S1 is open. In both of these circuits, S1 can be replaced by a sensor or transducer to give some kind of automatic power-switching action as described earlier.

Automatic control

The triac circuits in Figs. 3 to 8 can be modified to provide automatic switching in response to a change in a physical variable such as temperature, time or light intensity. These changes can be translated into signals that turn the triac circuits on or off.

Figures 9 to 13 show some examples of automatic control circuits. All of these circuits have electromechanical relay outputs, enabling them to switch AC or DC power directly. Nevertheless, each circuit can be modified to drive a triac.

Time control

The most popular automatic control circuits respond to time delays. Figures 9 to 11 show circuits that offer a simple "timer" response. In this response, the relay turns on as soon as the circuit is activated, but then it turns off again automatically after a preset period.

The automatic turn-off switching circuit Fig. 9 works as follows: The NOR gate (one-fourth of an industry standard 4001B quad, two-input CMOS NOR gate IC) acts as a digital logic inverter. Its output is sent to the relay coil through NPN bipolar junction transistor Q1, and its output is obtained from the junction of the time-controlled voltage divider formed by resistor R2 and capacitor C1.

When power is first applied to the circuit, C1 is fully discharged. As a result, the inverter input is grounded and its output is at the full positive-supply voltage. Consequently, transistor Q1 and relay RY1 are driven on.

As soon as power is applied, C1 charges through resistor R2, and a rising exponential voltage appears at the inverter input. After a time delay determined by the R2-C1 time constant, this voltage rises to the threshold value of the CMOS inverter stage. As a result, the inverter gate output swings to logic low and switches Q1 and the relay off, completing the action. Diode D1 and resistor R1 ensure that C1 discharges rapidly as soon as power is removed from the circuit, giving the circuit a rapid reset feature.

The circuit in Fig. 9 has a time delay of about 0.5 second per microfarad of C1 value. This relationship permits the circuit to be designed for delays up to several minutes with the proper C1 value. If required, the delay can be made variable by replacing resistor R2 with a fixed resistor and a potentiometer in series.

This circuit offers only mid-range timing accuracy. However, greater accuracy can be obtained with a circuit that has an industry-standard 555 timer IC as its basic timing element. For example, consider the simple 6- to 60-second timer circuit (For more information on the 555 timer IC, refer to *Radio-Electronics*, September, October, November, and December, pages, 58, 69, 61, and 62, respectively.)

In the Fig. 10 circuit, a timing cycle is started when the START momentary switch S1 is closed. The contacts for relay RY1 close immediately, and capacitor C1 begins to charge towards the positive supply voltage through resistor R1 and potentiometer R3 until, after a delay determined by the potentiometer R3 setting, C1 rises to two-thirds of the supply voltage. At that time, the IC1 gate changes state and the relay turns off. The timing cycle is then complete.

The circuit in Fig. 11 is a simple relay pulse circuit that repeatedly switches relay RY1 on and off at a rate variable by adjusting potentiometer R2 between 26 and 80 cycles per minute through NPN transistor Q1. An astable multivibrator is formed by resistor R1, potentiometer R2 and the two 4001B NOR gates.

Heat/light control

Figures 12 and 13 are circuits that will activate a relay in response to variations in light or temperature levels. The circuit in Fig. 12 circuit acts as a *dark-activated* switch that closes the relay only when light intensity falls below a preset level. Potentiometer R1 and light-activated photoconductive cell R2 form a light-sensitive voltage divider.

Photoconductive cells are also known as light-dependent resistors, light-sensitive resistors, or photoresistors. In Fig. 12, the output of the photoconductive cell is filtered to suppress transients by the network consisting of R3 and C1 and fed to the input of the 4001B NOR gate. It functions as a logic inverter to close the relay contacts through transistor Q1.

Under bright light conditions, the resistance of the photoconductive cell is low, so the inverter input is logic low, its output is logic high, and both transistor Q1 and relay RY1 are off. Under dark conditions, the photoconductive cell R2 has a high resistance. As a result, the inverter gate input is high, its output is low, transistor Q1 is on and the contacts of relay RY1 are closed.

The precise illumination threshold level of the circuit can be varied by potentiometer R1. The photoconductive cell in this circuit can be any with a cadmium-sulfide resistive element whose resistance value is between 2 kilohms and 2 megohms at the desired illumination threshold level. In addition, the adjusted resistive value of potentiometer R2 should balance that of the photoconductive cell. (For more information on photoconductive cells, refer to the July 1992 *Radio-Electronics*, Page 63.)

Figure 13 is a schematic for a precision over-temperature relay switching circuit that turns a relay on when ambient temperature exceeds a preset level. In this circuit, a 741 operational amplifier IC1 and a PNP transistor Q1 are connected as a relay-driving precision voltage comparator.

The noninverting input is taken from the voltage divider formed by the junction of resistors R3 and R4, and the inverting input is taken from the temperature-sensitive voltage divider formed by thermistor R1 and potentiometer R2.

The thermistor for this circuit can be any resistive element with a negative-temperature-coefficient (NTC) that has a resistance value between 1 kilohm and 20 kilohms at the desired threshold. The resistance of potentiometer R2 should equal this value at the same temperature. This circuit can also be modified to act as a under-temperature switch by exchanging the positions of thermistor R1 and potentiometer R2. (For further information on thermistors, refer to *Radio-Electronics* March 1992, page 52.) Ω

The ProCar Security System

This is the fourth part of a series of articles about building ProCar, an automobile alarm, anti-theft, and anti-carjacking system.

DAVID T. MIGA

THE THIRD PART OF THIS ARTICLE (*Electronics Now*, May 1995, page 71) explained the formation of the wiring harnesses and the installation of the Logic and Power Modules in the car. It also explained how and where to make all connections to sensors, switches, actuators and other functions both under the dashboard and in the engine compartment. The installation of ProCar's optional Remote Radio Frequency Receiver was also explained.

This fourth and last installment includes the 29-step test and checkout procedure to verify that ProCar is operational and an "instruction manual" for your reference. It is recommended that a copy be kept in your car at all times.

It will prove useful as a reference when teaching the operation of the ProCar system to authorized drivers. It will also serve as refresher course and help you to take full advantages of ProCar's features.

Test and checkout

The following 29 tests will check every ProCar circuit. If any circuit fails a test, examine the related circuit board to verify that the components specified were installed as such with their correct orientation and polarity.

Examine all solder joints to verify that there are no inadvertent solder bridges or high-resistance cold (dull gray, angular) solder joints.

1—Verify that the Logic Module door polarity headers are set for the polarity of the host automobile.

2—After applying power to the ProCar system, hold the secret switch for 3 seconds to clear the system.

3—Close the doors, hood and trunk and then open and close the driver's side door. Verify that the LED indicator remains green for 15 seconds before switching to orange and the system- activation announcement is heard. After another 15-second delay, the LED indicator should turn red, and all door locks should lock (assuming that locking relays are all installed).

4—Verify the operation of the shock sensor by striking the car's front or rear bumper with a suitably padded weight. The internal and external sirens should sound, and the lights should flash. Disarm the system by depressing the remote button No. 2 for 3 seconds. The driver's-side door lock should unlock only (if the locking relay option is installed and the ProCar system should announce "system reset."

5—Open, then close the driver's-side door to restart the arming process, but reopen any door within 10 seconds. The system should not arm, and the LED indicator should remain green. This test checks the "arm" delay circuit to verify that there is a package loading delay. After 30 seconds, close the door and the system should arm fully within 30 seconds.

6—Start a 60-second timer. Open, then close the passenger-side door. The sirens and lights should be activated. Then reset within 60 seconds.

Warning: *Wear a headset to protect your ears from the loud siren noise before conducting step 7.*

7—Open the driver's-side door, enter the car, and close the door. The sirens and lights should *not* activate, and the system should announce that it is active. After 10 seconds, the sirens should activate. Attempt to start the engine. The car should *not* start.

8—With the ignition still on, depress and hold the secret switch for 3 seconds. ProCar should reset.

9—Get out of the car and close the door to allow ProCar to rearm.

10—After ProCar is fully armed, open the driver's-side door, enter, and close the door. Within 10 seconds turn the ignition key on and start the car. ProCar should announce "system reset" and the car should start.

11—Turn off the engine and close the car doors. Before ProCar rearms, press and hold the remote No. 2 button for 3 seconds, and the green LED in the indicator should go out. Push the remote No. 1 button once for panic/forced rearm, then push the No. 1 button again. With the first push, the outside siren and lights should activate, the red LED should light, and ProCar should announce its activation. Following the second push, the sirens and lights should turn off, but ProCar should remain armed.

12—If your car has factory-installed keyless entry, examine it to verify that ProCar disarms when the driver's-side door is unlocked. Alternatively, disarm ProCar with the ignition key or the ProCar remote.

13—Enter the car, close the door, and start the engine. While the engine is running, open the passenger-side door and close it; the LED indicator should remain off.

14—Open and close the driver's-side door. The LED indicator should show green for 15 seconds, then the warning announcement should be heard when the indicator LED shows orange.

15—Cycle the ignition key off and on several times to simulate a carjacker trying to disarm the system. The system should ignore this and the engine should shut down.

16—Turn the ignition key off and get out of the car. Within 15 seconds, ProCar should sound all alarms again for 45 seconds.

17—After ProCar resets the sirens and lights, enter the vehicle and try to start it normally. The car should *not* start. The system should have reset for high security (owner identification required).

18—Identify yourself with the secret switch, and ProCar should reset and allow the engine to be started.

19—With the ignition on, tap the secret switch three times. The only response should be the normal function of the secret switch.

20—With the ignition on, press the secret switch four times within three seconds for the high security test. ProCar should announce "high security" within 4 seconds.

21—Turn the ignition off and get out of the car. Allow the system to arm.

22—Enter the car and attempt to start the engine. ProCar should announce that the system is active, and the engine should not start. Reset the system with your secret switch.

23—With the ignition switch on, press the secret switch five times for valet. Then open and close the driver's-side door to simulate a change of drivers. Wait 45 seconds. The green LED in the indicator should light, but the anti-carjack circuit should not be activated.

24—Turn the ignition switch off and get out of the car. ProCar should automatically rearm itself within 25 seconds.

25—After ProCar is fully

armed, enter the car and start it. The car should operate normally.

26—With the ignition switch on, press the secret switch five times for disarm, and verify that ProCar announces "system disarmed for service." Turn off the ignition switch and get out of the car.

27—The system should start to arm until the orange LED in the indicator lights. There should be no announcements, and the LED indicator should remain orange.

28—Open the driver's-side door, turn on the ignition switch, and ProCar should announce that it is fully disarmed.

29—Reset ProCar with the secret switch. With the ignition switch still on, press the secret switch seven or more times to check the panic mode, then reset the system.

If the ProCar system performs correctly during these 29 test steps, all circuits are operating normally.

Operation manual

Keep a copy of this information in your car. If any unauthorized person takes the car following an actual or implied bodily threat, do not resist. Get out of the car as quickly as possible and escape as rapidly as possible in a direction opposite that in which the car is directed. Look for a safe location such as a store, filling station, or nearby home and call the police immediately .

Secret identification signal

Restrict knowledge of the assigned secret signal to the installer and owner. This switch is the means for selecting all of ProCar's features. Whenever ProCar requests owner identification verification, respond either with the secret signal or with the No. 2 button on the remote control.

Automatic self-arming

After parking the car and turning off the engine, you can remain in the car indefinitely. However, when you leave, ProCar accepts the signal from the closing of the driver's-side door to start arming. Its response to this signal will be the green light of the LED indicator.

If you want to load or unload packages from the trunk or through any door by first opening any door or trunk, the arming procedure is temporarily halted. The indicator will remain green until loading or unloading is complete.

After all the doors, hood and trunk are closed for at least 15 seconds, ProCar's motion sensor detects that all motion has stopped. The indicator LED will flash orange, and ProCar 1 will announce that it is arming. After 15 seconds of flashing orange, the indicator will flash red and the system will be fully armed. The engine will then be cut off, and the doors will lock (if the optional auto-locking system is installed).

If the outside of the vehicle is struck, or if any passenger door, the hood, or trunk is opened, the internal and external sirens and the lights flasher will operate for one minute and reset. If any entry point is left open, the one minute timer is bypassed and the sirens and lights will operate continuously.

Disarming in standard security

ProCar normally returns to the standard security mode, allowing the driver to disarm the system with the ignition key.

After unlocking and opening the door, ProCar will warn audibly that it is active and flash its orange LED indicator. Close the door, turn the ignition key on, and start the car. The ignition must be turned on within 15 seconds. ProCar will announce that it is reset and the car can then be driven.

However, if you want to load or unload objects from the car, switch the ignition key on briefly to disarm ProCar before loading or unloading objects. There is no limit on the time for doing that as long as either one door or the trunk lid remains open, or the motion sensor detects motion. After completing loading and unloading, get in the car, close the door, turn the ignition on, start the car and drive it away.

Note: If ProCar is not disarmed within 15 seconds with the ignition key, the system will lock out the key disarm feature and require owner identification with the secret signal to disarm the system.

High-security disarm

This feature locks out the ignition key disarm so that the owner must identify himself or herself each time before the car can be started. To set ProCar for the high-security mode whenever the car is being driven, press the secret button four times within three seconds.

ProCar will announce audibly that high security has been selected. To clear this selection, depress the secret switch for 3 seconds.

When entering the car, ProCar will announce that the system is active. Close the door, turn on the ignition, and key in the secret signal. ProCar will announce "system reset,"and turn off the indicator. The system will return to standard security after system reset. The high security mode can be selected whenever the driver believes it is needed.

Keyless entry/external disarm

If the car has a factory-installed keyless-entry system, the external disarm option can be selected. This feature permits ProCar to be disarmed from the outside with the digital entry keys. ProCar can be integrated with the OEM keyless entry while adding the protected valet, anti-carjack, and panic features.

If the high security mode is set, anyone knowing the keyless-entry code can unlock and open the doors, but that person will not be able to disarm ProCar. The system will allow entry, but all sirens and lights will be activated if the secret signal is not given within 15 seconds.

If the high-security mode is set, when the owner keys in the code to permit entry to the vehicle and then turns on the ignition switch, the multicolor LED indicator will remain green to remind the owner to key in the secret signal before starting the car. The indicator light will turn off, indicating ProCar has recognized the owner.

Note: ProCar resets to standard security when you give it the secret signal to identify yourself. High security must be selected each time before leaving the car if this feature is desired. Normally, this feature is set only when driving in a high-risk area, or if the owner does not want anyone but the owner with the car keys to drive the car.

Entry warning indicator

If unauthorized car entry has been made through the driver's-side door while ProCar is armed, the indicator will flash orange instead of red.

Malfunction indicator

If the indicator remains green and the system does not arm, the input sensor has a fault such as an improperly adjusted pin switch or motion sensor.

Anti-carjack

ProCar monitors the closed condition of all doors when the car is being driven. All passengers can enter or exit, or the trunk or hood can be opened while the owner/driver remains in the car with the engine running without causing ProCar to respond. However, if the driver's-side door is opened while the engine is running, a signal will be sent to ProCar to alert it for an unauthorized driver.

If the car is carjacked with the owner present, it is assumed that the owner (and any passengers) will seek help and escape as rapidly as possible to a safe location where help can be sought.

The hijacker will be able to drive the car with no interference for 15 seconds after the driver's-side door has been closed. ProCar will light the green indicator for 15 seconds, but will respond in no other way.

If the owner's secret signal has not been entered within 15 seconds, ProCar will flash the orange indicator and announce that the vehicle will be disabled in 10 seconds. If the driver still has not been recognized by ProCar, the engine will be shut down (or loose power and run erratically, depending on selection) after 10 seconds. Simultaneously, the external and internal sirens will activate, and the outside lights will flash.

The siren will continue to sound and the lights will remain on until the carjacker leaves; then it will reset. If the carjacker leaves the door open, the sirens and lights will remain activated to draw as much attention as possible to it.

When the anti-carjacking circuit activates, ProCar locks out the ignition key reset feature, even if ProCar has been set for standard security.

When the car owner is assured that the carjacker has fled the car and determines that it is safe to return to the car, he or she can indicate the return of the authorized driver when the ignition key is turned on and the secret signal is entered. (This assumes that either the owner has a duplicate key or the remote transmitter or the thief left the key in the ignition switch.)

It is expected that the car owner will exercise proper precautions in car retrieval to avoid encouraging the car thief to return. It is probable that the car, even if driven off at high speed will be no further than a quarter mile away.

Valet parking

The ProCar system will protect the car even when the owner or authorized driver gives the keys to a parking lot or garage attendant. It is expected that the attendant will get in the car while the engine is running. However, unless the proper signal is entered in ProCar prior to this authorized driving, it will appear to the system as an attempted carjacking.

Upon arriving at the intended destination, the owner keys the secret switch five times within three seconds. The system will announce the selection. The car can be left in the possession of the attendant for parking, but the engine must be running to make this choice.

Twenty seconds after the car is parked, ProCar will automatically reset to the standard security mode. When the attendant returns to the car with the keys, the attendant can enter and start the car, and the system will allow the attendant to drive the back to the owner's waiting location.

The attendant should be warned that he or she will hear a voice announcement. When the owner re-enters the car, the secret code signal must be entered into ProCar indicating that it is now in the possession of the authorized driver.

System service disarm

If the car is taken to be serviced, disarm ProCar so that the system will not shut down the engine. With the ignition switch on, tap the secret switch six times. ProCar will announce that it is fully disarmed. Fifteen seconds after the driver leaves the vehicle, the LED indicator will flash orange and continue flashing. Whenever the ignition switch is turned on, ProCar will remind the driver that it is disarmed. Reset the system by turning on the ignition switch and entering the secret code.

Panic mode

The outside siren and light flasher can be activated without activating the inside siren and shutting off the engine. With the ignition switch on, key the secret switch seven or more times. ProCar will remain in the panic mode, whether the ignition switch is on or off, with no time limit. The panic mode can only be disabled with the ignition switch on while the secret code signal is entered.

Fuel stop

When refueling the car, turn off the engine, remove the key and keep the domelight on by holding the door open slightly. Alternatively, turn on the domelight switch. This will neutralize ProCar if you get out to refuel the car.

Alternatively, press remote button No. 2 to inhibit ProCar from rearming after you leave the vehicle and close the door. This way the car will be protected if you must get out of it to pay for fuel in the filling station operator's booth.

If you normally leave the engine running, invoke the valet mode so that ProCar does not shut down the engine, and then lock the doors. However, the car will be vulnerable to theft and it can be driven away.

Four-function remote

System reset or system re-arm can be activated with a remote control. Panic, and Insta-stop functions can be activated from outside the car.

Do not attach your remote control to a keychain, lanyard or other restraining cord. Keep it separate in a pocket, purse or a safe place on your person while driving. This precaution is important for cars with automatic door-locking, if the key is accidentally left in the ignition switch.

To disarm ProCar, aim the remote control directly at the car and depress button No. 2 for 3 seconds. ProCar will announce "system reset." Get in the car, close the door, start it up and drive off. If you have the auto-unlock feature, ProCar will unlock the doors as it resets.

If ProCar is set for high security, disarming the system with the remote control will cause ProCar to announce that it is set for high security. After entering the car, key in the secret code for ProCar "recognition."

TOTAL CAR SECURITY can be as close as your remote. Don't attach the remote to your key chain.

If ProCar is disarmed to retrieve something from the trunk, after the trunk lid is closed, the system can be re-armed with the remote control without having to open and close the driver's-side door. Touch button No. 1, wait 1 second, and touch button No. 1 again. The lights will flash and the siren will sound to verify. If the automatic door lock option is installed, the doors will lock automatically within 15 seconds of door closure.

The Panic and Insta-stop functions are activated together with button No. 1. If the car is parked with ProCar armed, push button No. 1 once to activate the lights and siren, and push button No. 1 a second time to turn off the *Panic* mode.

If someone who knows the secret code drives away with the car, he or she can be stopped with the remote control by activating the *Panic/Insta-stop* function.

To do that, push button No. 1 only once. ProCar will lock out any attempt to disarm it. The secret signal switch inside the car will be locked out. When button No. 1 is pushed, the ProCar indicator will flash red and warn the driver that the engine will be shut down in 10 seconds and it will activate the car's outside siren and lights immediately.

If the driver ignores the warning, the ProCar system will activate the inside siren after 10 seconds and shut down the engine. The *Panic* and *Insta-stop* modes are reset by pushing button No. 1 once again. The driver must then allow ProCar to "recognize" him or her by depressing button No. 2 for 3-seconds.

Fault finding

The immediate activation of sirens and lights after the system arms itself indicates that a perimeter or motion sensor is faulty. However, if the system never arms, and the indicator LED remains green, a switch or motion sensor probably has a short circuit. Ω

CALL COUNTER

continued from page 48

line, it will pass only partially rectified AC. When the phone rings, D5 passes a partially rectified 90 volts, which is enough to energize the relay. Actually, the relay will chatter at about 20 hertz during a ring signal since the rectified voltage is not pure DC. This generates a rapid string of pulses to trigger the timer. But because the timer operates in a retriggerable mode, its output remains high for the duration of the rings.

The NE555 timer (IC2) is wired in a retriggerable, monostable configuration. The output stays high for a length of time determined by the time constant, $1.1 \times R2 \times C2$, which works out to about 5.5 seconds—that's longer than the time between trigger pulses produced by the ringing phone. Since the timer is retriggered with each ring signal, its output will remain high for about 5.5 seconds after the phone stops ringing. The counter will advance by one count whenever the output goes high.

Indicator LED1 shows when the phone is ringing and when the output of the timer is high. The high output activates optoisolator IC3, and advances the counter by one. Alternatively, a small relay could be used to advance the counter. The counter can be any digital or electromechanical counter whose operation is not affected by the duration of the trigger signal. The prototype uses a small, self-contained LCD counter module, model CUB-3 from Red Lion Controls.

PARTS LIST

All resistors are ½ watt, 5%.
R1—4700 ohms
R2—100,000 ohms
R3, R4—1000 ohms
Capacitors
C1—500 µF, 10 volts, electrolytic
C2—50 µF, 10 volts, electrolytic
C3—0.01 µF, 10 volts, ceramic
Semiconductors
D1–D5—1N4002 diode
LED1—light-emitting diode, any color
Q1—2N3906 PNP transistor
IC1—7805 5-volt regulator
IC2—NE555 timer
IC3—MCT-2 optoisolator (or equivalent)
Other components
RY1—SPST, N.O. relay, 48V coil
Miscellaneous: CUB-3 counter module (Red Lion Controls, York, PA), project case, perforated construction board, modular phone cord.

Construction

The prototype was built using point-to-point wiring on a perforated construction board. The circuit board was enclosed in a small metal case with the LCD readout and indicator LED on the front panel.

The device connects to the phone line with a modular phone plug. Just be sure to identify the positive side of the phone line, usually the green (tip) wire, and make sure it is connected to the cathode of D5. Ω

HARDWARE HACKER

Acoustic cancellations, chip adapter resources, PIC microprocessor fundamentals, fast and easy SM removal, and essential hacker nutrients.

DON LANCASTER

Several helpline callers have asked me about acoustic cancellation. These are schemes to null out existing noises by generating new ones precisely 180° out of phase. Well, the bottom line is: It doesn't work except in very special and very restricted circumstances.

If you have a confined area that is much smaller than the audio wavelengths, and when all of the acoustics are fully controllable and precisely known in that area, then sometimes a rather modest reduction in noise can be achieved—and mostly at very low frequencies, otherwise, forget it.

For instance, it is feasible to use small headphones to achieve limited cancellation inside the headphones themselves. But a total cancellation in an open room is impossible. It is feasible to reduce air conditioning noise somewhat within a long duct, but getting rid of all furnace noise completely is absurd. It is feasible to reduce the noise inside a special "active" car muffler, but getting rid of all engine noise is impossible. I'll try to work up some more technical information on this as we go along.

Even if you were to cancel the fundamental frequency, you couldn't remove all the harmonics unless the waveforms were *precisely* matched and you have very good transducers. So, the *perceived* noise reduction will usually be even worse than the actual one.

PIC chips

Since they clearly have become *the* hacker component of the decade, we might take a closer look at the PIC—a series of speedy, low-power, and very low-cost microcontrollers. *Microchip Technology* is the source for these devices.

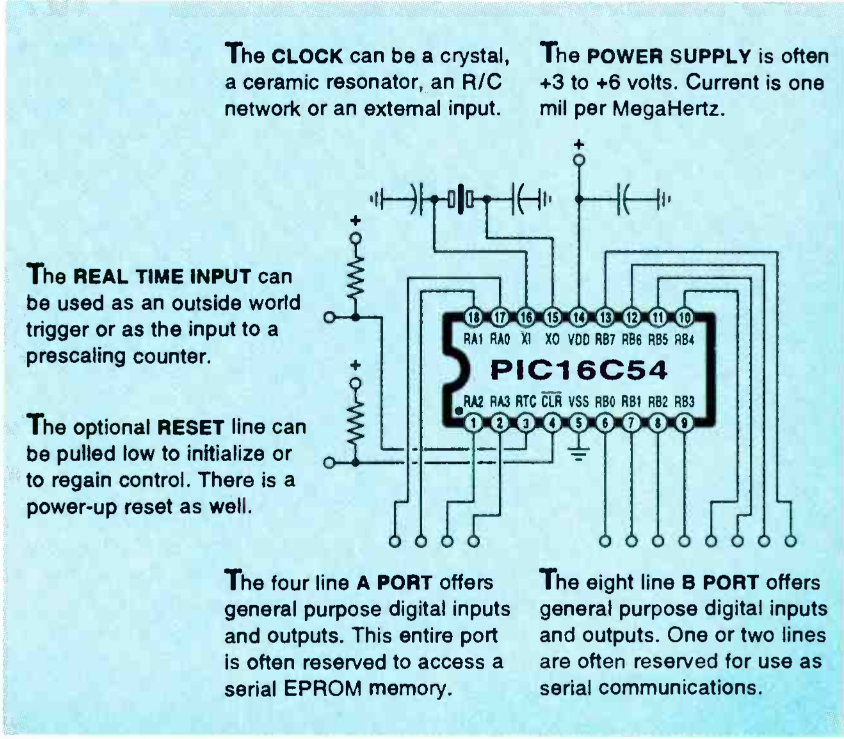


FIG. 1—THE PIC MICROCONTROLLER is well on its way to becoming the chip of the decade. Here is how to connect one.

PIC's are *much* easier to use than a 555 timer. So, there is absolutely no excuse whatsoever to continue using any outdated bits-and-pieces design unless you purposely want to waste time and money.

PIC's are radically different from older microprocessors. And they are better for low end uses. So, let's think of these instead as *universal custom integrated circuits*.

Typical PIC chips contain internal EPROM memory. Once it has been programmed, the PIC remembers the instructions and operates just like any other application-specific integrated circuit.

Certain PICs can be erased by shining UV light through a package window. Other PICs—less expensive and packaged in an opaque package—can be programmed only once.

Normally, the erasable version is used during a circuit's design stage. It is replaced with the one-time-programmable devices for production. For really big time production, even cheaper factory preprogrammed chips are sold.

The popular PIC16C54 is shown in Fig. 1. The chip is available in several 18-pin packages of different sizes and similar pinouts. Supply voltage can range over a +3 to +6 volt DC range. The supply current is typically one milliampere per clocking megahertz (four milliamperes at four megahertz), dropping down to microamps in a sleep mode.

A crystal is connected to two pins to form a system clock. The device can run at clock speeds as high as 20 MHz when powered from a five-volt supply. That drops to 4 MHz at three volts. A special -LP version is also available, intended for 32-kHz use with a supply voltage as low as 2.5 volts. This micropower gem needs only 15 *microamperes* of current to operate.

The obvious crystal choice for most applications is a 3.58-MHz colorburst crystal. You also have the option of using an external clock, a ceramic resonator, or even a resistor and capacitor network.

PIC instructions run at *one-fourth* the clock frequency. A 20-MHz clock executes 200-nanosecond instructions. There are twelve I/O pins. You can define any of them as an input or an output, even on the fly.

Now, all this PIC chip really does is accept the ones and zeros on your input I/O lines and generate new ones and zeros for the output lines. But that's all that *any* microprocessor is ever able to do. The selection of *which* ones and zeros are output will be determined by the program.

This leaves us with two pins. One is an optional active-low reset pin that lets the microprocessor start off on the right foot or synchronize to outside events. It also lets you regain lost control. The PIC microcontrollers also feature an automatic internal reset function provided that you apply the supply voltage quickly. The final pin can be used to wake up a PIC when in its sleep mode or might be used as an external event counter.

PIC architecture

The internal PIC arrangement is radically different than older microprocessors. The PIC is based on *Harvard* architecture where instructions are typically held separate from data. This uses fewer and longer instructions to pick up more speed.

The PIC is a RISC (reduced instruction set computing) microcontroller. Instead of providing scads of fancy operating modes, there are only a few rather simple commands. But these are much faster and easier to understand than the commands on older CISC (complex instruction set computing) computers.

Figure 2 illustrates PIC memory management. There is one program memory of 512 bytes. Unlike typical microcontrollers, the program instructions are *twelve* bits wide, so each instruction is only a single word.

Like other microcontrollers, a PIC *executes* a program by starting at some point in program memory and retrieving an *instruction* or an *opcode*. This opcode then handles some task, and the PIC then usually moves up to the next location and gets another instruction. The new instruction does something else useful. This process goes on indefinitely.

Things get interesting when you *interfere* with that sequential stepping. An instruction might tell the PIC to skip the next instruction, which provides a *branch* that lets the program do two different things. Or an instruction might tell the microcontroller to *jump* to a different location. This is one method to loop or repeat. You can also trick a PIC's program counter to go somewhere else. This is called a *calculated jump*.

Finally, there are times where you might want the microcontroller to move to a special code area to do something, and then pick up exactly where it left off. This is called a *subroutine*. Subroutines are accessed with a *jump to subroutine* instruction. The final opcode in any subroutine usually is a *return from subroutine* instruction.

Subroutines are useful programming constructs. They can shorten the length of a program by being reused several places. Subroutines can neaten code and make it easier to understand if they are arranged logically.

When a subroutine is used, the PIC has to remember where "back"

NAMES AND NUMBERS

Armour Products
PO Box 128
Wyckoff NJ 07481
(201) 847-0404

ARRL Handbook
225 Main St
Newington CT 06111
(203) 666-1541

AST Servo Systems
115 Main Rd Box 97
Montville NJ 07045
(201) 335-1007

Books Americana
PO Box 2326
Florence AL 35630
(205) 757-9966

ChipQuik
3 Second Street
Framingham MA 01701
(800) 836-CHIP

Cryptosystems Journal
485 Middle Holland Rd
Holland PA 18966
(215) 579-9888

Scott Edwards Electronics
964 Cactus Wren Lane
Sierra Vista AZ 85635
(520) 459-4802

Feed Point
NTMS % Wes Atchison
Rt 4 Box 565
Sanger TX 76266

Filtercrest
100 Carol Place
Moonachie NJ 07074
(201) 807-0809

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

Hand Papermaking
PO Box 77027
Washington DC 20013

Microchip Technology
2355 W Chandler Blvd
Chandler AZ 85224
(602) 963-7373

Mo Hotta Mo Betta
PO Box 4136
San Luis Obispo CA 93403
(800) 462-3220

NEXT Generation
1350 Old Bayshore Hwy #210
Burlingame CA 94010
(415) 696-1661

Parallax
3805 Atherton Rd, #102
Rocklin CA 95765
(916) 624-8333

Radar Sales
5485 Pineview Lane
Plymouth MN 55442
(612) 557-6654

Small Parts
PO Box 4650
Miami Lakes FL 33014
(800) 220-4242

Synergetics
Box 809
Thatcher AZ 85552
(520) 428-4073

Telecom Library
12 West 21st St
New York, NY 10010
(800) LIBRARY

Vaughn Duplication Services
4141 E Raymond Ste G
Phoenix AZ 85040
(602) 437-5344

is. A special *stack* keeps track of the return address. A *stack pointer* remembers where it is in the stack. Subroutines can be *nested* two-deep. Thus a program can call a subroutine which might call another subroutine.

All of the instructions in a PIC are normally locked in at programming time. They can't usually be changed during run time. The PIC has RAM memory of 32 bytes that can be grouped into *dedicated* and *general purpose* bytes called *registers*.

The seven dedicated registers will always do one specific task, such as serving as a "W" accumulator, as a program counter, an I/O data port, a status register, a timer control, and an indirect pointer. The remaining 26 general-purpose registers are yours to do anything you like with. Typical uses are for pointers, counters, addresses, and intermediate results.

There is a provision for both *direct* and *indirect* addressing modes. The direct addressing always goes where you tell it. Indirect addressing goes to a *calculated* location. For example, addressing RAM location $00 will instead go to the register whose value is stashed in an indirect pointer.

Outside of these few working RAM registers, there is no large read-write memory area in a PIC such as you'd want for storing data, ASCII text, musical notes, or whatever. There is also no means to directly address any external memory. The PIC handles external data storage by sending or receiving *sequential* information, routed by way of one or more I/O pins. The usual external memory is a serial EEPROM available with 128K bits and more.

As with any serial system, it takes a while to completely read or write a memory byte. But the PIC clock can be fast. Besides, all instructions execute quickly. Thus, a serial memory device should be fast enough for most real-world uses. Serial EEPROM memory prices start at a dollar. Some are designed from the ground up for PIC interface. Others are easily adapted.

PICs can communicate with another PIC or a host microcontroller serially. One I/O pin can be set aside for each communication channel.

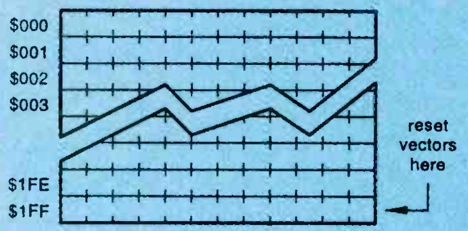
At first glance, PIC resources seem appallingly limited. But with creative programming, they can end up being far more than what you'll need for a surprisingly diverse variety of low-end applications. Several months ago, we saw how a PIC can generate high-quality sinewaves with a mere *six* instructions. There are also fancier PIC devices available that have more RAM and more program memory.

By far the simplest way around perceived PIC limitations is to use

The **PROGRAM MEMORY** consists of one or more 512 byte banks of 12-bit words. Regardless of whether it is actually ROM, EPROM, or OTP EPROM, the program memory is read-only at run time.

Reset jumps you to the highest location in program memory. Which often holds a jump to your actual program start. Unless told otherwise, program steps will be executed in increasing sequential order.

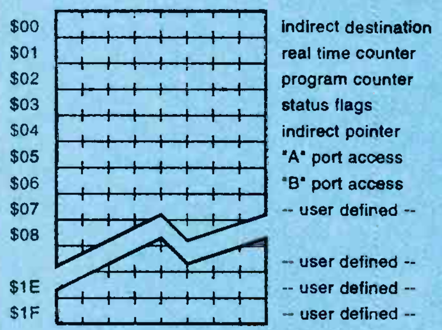
A limited amount of read-only data can be placed in the program memory. Data transfer can be done using the RETLW opcode...



The **SCRATCHPAD RAM** consists of 32 or more 8-bit bytes of read-write memory.

The first seven locations are dedicated special purpose registers handling the functions shown. The remaining locations are general purpose registers that are yours for any use you want.

If an opcode calls for register $00, an indirect access to the register number stashed in the FSR file select register gets done instead...



There is no direct addressing provision for **EXTERNAL MEMORY**. Instead, one or more port lines are used to access a serial EEPROM storage device.

Here is a typical four-wire external memory lashup. It makes use of a sneaky "logic power" stunt to dramatically cut the long term power consumption...

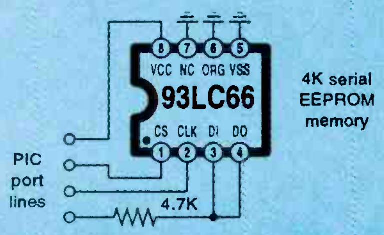


FIG. 2—PIC MEMORY MANAGEMENT. With the "Harvard" architecture, program and data are pretty much kept apart. External memory is accessed serially.

lots of them. Since they are so simple and cheap, it often pays to use one PIC for serial communication, a second for video interface, a third for data management, and a fourth for a keyboard or LCD display panel. This is distributed processing at its best.

PIC instruction set

The key secret to understanding a microcomputer is to carefully study the instruction set. You then use each instruction in as many different ways as you possibly can. An instruction is just a command that does something. That can be a *move*, an *add*, a *test*, or a *change*. By combining many instructions creatively, you can upgrade moves, adds, tests, and changes into just about any computer task.

There are only 33 PIC opcodes. They are amazingly powerful and easy to use. Unlike other microcontrollers, all opcodes need only one byte. Most of them can execute in a one clock cycle. Figures 3 and 4 summarize the PIC instruction set.

Let's start with the commands that can alter program flow. Each successively higher opcode should normally be executed in order unless you interfere with the program flow. Such interference, of course, is what microcomputing is all about, and where the fun begins.

A GOTO unconditionally moves program execution somewhere else. The CALL command moves execution to a subroutine with the intent of returning just past where it left off. Subroutines are usually exited with the RETLW instruction. RETLW also offers an ultra sneaky use: On return, the eight lower bits of this instruction are loaded into the accumulator. This stores read-only data in the program side of the PIC memory.

Four testing instructions are able to *conditionally* skip an instruction. These let the PIC *branch* to different points in the program. BTFSC tests a bit in a register and skips if that bit is a zero. BTFSS tests a bit in a register and skips if that bit is a one. DECFZ decrements any register and skips on any zero result. INCFZ increments a register and skips on a zero result. Finally, you have the option of forcing the PIC to move execution to a *calculated* location in the program by storing an address in the program counter.

The no-operation instruction NOP wastes an instruction to make room for a later feature, to provide a time delay, or provide a debugging aid. So much for commands that alter program flow. Now, let's look at commands that *move* data.

You can clear any register to all zeros by using a CLRF. CLRW clears the accumulator or "W" register. To fill W with a constant, use MOVLW. To move *from* any register *to* the accumulator, use *MOVF*. To move *from* the accumulator *to* a reg-

IC ADAPTOR RESOURCES

Advanced Interconnections
5 Energy Way
West Warwick RI 02893
(401) 823-5000

Aries Electronics
PO Box 130
Frenchtown NJ 08825
(908) 966-6841

EDI Corporation
PO Box 366
Patterson CA 95363
(209) 892-3270

Emulation Technology
2344 Walsh Avenue Bldg F
Santa Clara CA 95051
(408) 982-0660

Ironwood Electronics
PO Box 221151
St Paul MN 55121
(612) 431-7025

ITT Pomona
1500 E Nonth Street
Pomona CA 91769
(909) 469-2900

Keystone Electronics Corp
31-07 20th Rd
Astoria NY 11105
(718) 956-8900

McKenzie Technology
910 Page Avenue
Fremont CA 94538
(510) 651-2700

Meritec
1359 W Jackson Street
Painesville OH 44077
(216) 354-3148

Mill-Max
190 Pine Hollow Road
Oyster Bay NY 11771
(516) 922-6000

Vector Electronic Co
12460 Gladstone Ave
Sylmar CA 91342
(818) 365-9661

Vero
1000 Sherman Ave
Hamden CT 06514
(203) 288-8001

ister, you use MOVWF instead.

There are some commands that can *change* the contents of any register. COMF complements, changing each one to a zero and vice versa. DECF decrements any register, by subtracting a one. Decrementing any $00 underflows to $FF. Similarly, INCF can increment any register, adding one to its contents. Incrementing any register at $FF will cause it to overflow to $00.

BCF clears selected register bits to zero. A BSF sets selected bits to one. RLF rotates the bits in any register to the left, going through the carry bit in the status register in the process. RRF rotates bits to the right, also going through the carry bit. Finally, SWAPF *interchanges* upper and lower four bit nibbles in any register.

Next, let's look at commands that take something from somewhere, do something with it, and then move it somewhere else. ADDWF adds the accumulator contents to a register and SUBWF for subtraction using two's complement arithmetic. Very handily, these are both *dual mode* instructions. You have a choice of putting your answer back into your accumulator *or* source register.

The *logic* instructions are also dual mode. IORWF will bit-by-bit OR the accumulator against any register. The OR function forces *ones* into a word. ANDWF will AND the accumulator against a register. AND logic forces *zeros* into a word. You can use XORWF to bit-by-bit exclusive-OR (XOR) the accumulator against a register. XOR forces *changes*. You can also perform logic with an immediate value worked against the accumulator using ANDLW, IORLW, or XORLW.

SLEEP puts the chip in a powerdown mode. It stays there until your choice of (A) an external reset event, (B) an internal watchdog timer overflowing, or (C) by using the RTCC pin as an external hardware reset.

The TRIS command can be used to teach the port bit lines whether they are inputs or outputs. Bits internal to this opcode decide whether you are teaching the four port A lines, or the eight port B lines.

The watchdog timer is cleared with a CLRWDT command. And last but not least, the OPTION command presets how your watchdog timer will behave. It lets you pick an internal clock or an external clock tripping on either selected edge. A divider can be placed *before* or *after* the timer with ratios of 1 through 256.

Among other uses, the watchdog lets you "wake up" your PIC every 18 milliseconds up to every 2.5 seconds. That extends battery life for "check it every now and then" uses.

A *status register* works along with the opcodes. Various bits keep track of zero results, byte and word carries or borrows, power, and timeout. Three remaining bits are yours for any use you like. They make handy program flags.

PIC programming can be done by routing instructions to the I/O lines and suitably controlling the reset and RTCC pins. The use of a commercial programmer is a must.

We saw a list of programmers and PIC support services last month. As before, you start with the *Microchip Data Book* and the *PIC Applications Manual* from *Microchip Technology*. Then a BASIC Stamp from *Parallax* and the *Scott Edwards* tools.

Chip adapters

Those tiny new surface-mount IC packages do tend to reduce the need for plated through holes on circuit boards. But they are also small and hard to work with, especially for the initial design and debug stage.

Chip Adapters are one workaround. These are small socket-plug setups that step the tiny pins up to older and larger standards where they are easier to deal with. The good news is that the adapters are now readily available. The bad is that they might cost more than the chip components do—a ten dollar horse and a forty dollar saddle.

I've gathered together several of the main players offering these test and debugging adapters as this month's resource sidebar.

Instructions that alter your **PROGRAM FLOW**...

(RESET) –	Moves you to the highest location in memory. A **GOTO** usually resides here, jumping you to your real program start.
GOTO –	Moves you unconditionally to the location in your program addressed by the instruction's nine lower bits.
CALL –	Jumps you to a subroutine with the intent of returning. Subroutine address is set by the instruction's eight lower bits.
RETLW –	Returns from subroutine to location in stack. Also loads the accumulator with the instruction's eight lower bits.
BTFSC –	Tests a specified bit in a specified register and skips the next instruction if that bit is a zero.
BTFSS –	Tests a specified bit in a specified register and skips the next instruction if that bit is a one.
DECFZ –	Decrements a specified register and skips the next instruction if the register contents become a zero. "d" bit picks destination.
INCFZ –	Increments a specified register and skips the next instruction if the register contents become a one. "d" bit picks destination.
(ANY) –	Any other instruction that alters the program counter register will move you to a calculated location in your program.

Instruction that **DOES NOTHING**...

NOP –	Goes on to the next instruction. Used for debugging, time delay, or to reserve room for future options.

Instructions which will **CHANGE REGISTERS**...

COMF –	Complements the contents of a selected register, changing all ones into zeros and vice versa. "d" bit sets destination.
DECF –	Will subtract one from the contents of a selected register. Decrementing $00 produces an $FF. Also see **DECFZ**.
INCF –	Adds one to the contents of a selected register. Incrementing $FF produces an $00. Also see **INCFZ**.
BCF –	Clears selected bit in selected register to zero.
BSF –	Sets selected bit in selected register to one.
RLF –	Rotates the bits in a selected register one to the left, going through carry. "d" bit sets register or accumulator destination.
RRF –	Rotates the bits in a selected register one to the right, going through carry. "d" bit sets register or accumulator destination.
SWAPF –	Exchanges upper and lower 4-bit nibbles of selected register. The "d" bit sets register or accumulator destination.

FIG. 3—THE PIC INSTRUCTION SET. All are single byte instructions; most execute in a single clock cycle.

NEED HELP?

Phone or write all your Tech Musings questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(520) 428-4073

For fast PSRT access, modem (800) 638-8369. On prompt, type JOINGENIE. When asked for the keycode, enter DMD524.

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

SMD removal

Removing tiny multi-pin surface-mount parts from a circuit board can be a real difficulty. But there is a stunning new solution—one that I really like because it turns engineering on its ear. Every once in a while, it pays to try to do the *exact opposite* of what everybody else is up to. For instance, when any metallurgist designs an alloy, he almost always tries to *maximize* its strength. After all, what use would a *minimum* strength alloy be?

Just this: Replace all the solder on your SM. board with a minimum strength alloy, one that is so utterly wimpy that you can pop the chips right off it! The system is called the *ChipQuik SM. Removal Kit*. Each kit is good for eight to ten multi-pin chips. The product costs $13 in quantity. A free video is offered.

The system is amazingly simple to use: You first apply liquid flux. Then you melt a special Chip Quick alloy *into* all your existing solder joints. The alloy interacts with the

Instructions that are able to **MOVE DATA...**

CLRF –	Clears a specified register to all zeros. If an internal "d" bit in the instruction is set, also clears the accumulator to zero.
CLRW –	Clears the accumulator to all zeros.
MOVLW –	Fills the accumulator with an immediate constant value set by the instruction's eight lower bits.
MOVF –	Moves a copy of selected register contents into the accumulator.
MOVWF –	Moves a copy of accumulator contents into a selected register.

Instructions that do **ARITHMETIC...**

ADDWF –	Adds the contents of the accumulator to the selected register. The "d" bit selects register or accumulator destination.
SUBWF –	Subtracts the contents of the accumulator from the selected register by 2's complement arithmetic. "d" bit destination.

Instructions that perform **LOGIC...**

ANDWF –	Bit-by-bit AND's the accumulator against a selected register. The "d" bit selects register or accumulator destination.
IORWF –	Bit-by-bit OR's the accumulator against a selected register. The "d" bit selects register or accumulator destination.
XORWF –	Bit-by-bit XOR's the accumulator against a selected register. The "d" bit selects register or accumulator destination.
ANDLW –	Bit-by-bit AND's the accumulator against an immediate mask set by the lower eight instruction bits. Result to accumulator.
IORLW –	Bit-by-bit OR's the accumulator against an immediate mask set by the lower eight instruction bits. Result to accumulator.
XORLW –	Bit-by-bit XOR's the accumulator against an immediate mask set by the lower eight instruction bits. Result to accumulator.

Instructions that handle **INTERNAL CONTROL...**

TRIS –	Accumulator pattern teaches port lines whether they are inputs or outputs. Port selected by bits internal to the command.
SLEEP –	Puts chip in low power mode. Wakeup by way of reset, watchdog timer, or external real time input.
CLRWDT –	Resets the watchdog timer to zero. Also resets prescaler and status bits TO and PD.
OPTION –	Accumulator pattern teaches option register prescaler ratio, real time clock edge, and counter clock source.

FIG. 4—THE PIC INSTRUCTION SET, continued.

solder and produces a *zero strength* joint. You then pop the chip off the board with a dental pick. Finally, you use desoldering braid to clean up the board.

New tech lit

Everybody knows about the *ARRL Handbook for Radio Amateurs*. Well it has just been reissued in its new and expanded *seventy-second* edition! Needless to say, this book is an essential text for *all* of you technical and hardware-hacker types. Especially for beginner fundamentals.

But lesser known are the dozens of wireless, high frequency, television, microwave, and antenna publications from the same source. The ARRL lists them in a free catalog that's available.

Books on computer telephony are covered in depth by *Telecom Books*.

Toni Patti has just issued Volume III of his *CryptoSystems Journal* on amateur cryptography and related items such as fractals and chaos. It costs $45 including a PC software diskette.

Next Generation is a unique video gaming magazine. It includes well done reviews on entertainment software for CD-ROM, Sega, Nintendo, Jaguar, Arcade, and on-line systems for $29 per year. *Feed Point* is a ham microwave newsletter. And *Hand Papermaking* is an interesting craft publication.

A free slide chart on international television standards is provided by *Vaughn Duplication Services*.

Free industrial foam samples are offered by *Filtercrest*. Glass etching supplies are available from *Armour Products*. Sports radars (both new and recycled police units) are sold by *Radar Sales*. Heavy iron is offered by *AST Servo Systems* in its new and free catalog.

Small Parts has just released a brand new free catalog #16. It is *the* place to go for robotics or nearly anything else your hardware store has never even heard of.

Essential hacker nutrients are now stocked in depth by *Mo Hotta Mo Betta*. Its free catalog is a must. Uh, better use *extreme* caution when trying *Scotch Bonnets*. These are *strictly* for professional use only. Make sure you have your necessary state hazardous-materials permits before you start.

The *Collector's Guide to Personal Computers* is a Tom Haddock book on collecting personal computers. It gives product histories, technical details, and current market values. It costs $15 from *Books Americana*.

I still have a few classic Apples left at prices far below the values listed in Haddock's book, along with bunches of obscure cards—even impossible-to-get Integer BASIC ones. Call for a list.

I've also once again expanded my *Book-on-demand publishing kit* with lots of new and updated information. These days, you can easily produce superb quality books or technical information cheaply and quickly. This kit has all of the startup information needed. Additional book-on-demand support is in my *GEnie* PSRT RoundTable. Ten free trial hours are available per the *Need Help?* box. Ω

Taming the Deafening Decibels: The Potential for Ear Damage at School Dances

LARRY KLEIN

In my July 1994 column, I wrote about my adventures in trying to get the volume levels turned down at our town's middle-school student disco dances. It all started when my son called to ask to be rescued from his first dance because he found the music to be painfully loud. My wife, who went to get him, told me that Nathaniel was right—the sound level was very high when the DJ was in action, which was most of the time. I decided I would check out the scene, so I took one of my calibrated sound-pressure level meters, and dropped in at the school cafeteria, where the dance was being held.

I took several measurements about five feet directly in front of the DJ's speakers and from other parts of the room; the sound level was typically about 110 dB most of the time over the whole room where the kids were clustered! Appalled at the potential for hearing damage, I vowed to do something about the situation.

I spoke to the school principal about my findings, and he arranged for me to give a presentation before a small group that included the principal, PTSA officers, the teacher in charge of the dance, and other interested parties. I thought I came well prepared, but the meeting didn't go quite as I had hoped. Most of the committee seemed to think that I was simply another over-concerned, if not hysterical, parent riding a hobby-horse on a trivial issue.

However, I did get the okay to bring my SPL meter to two subsequent dances, and to report back with my findings. I also proposed that I prepare an informal educational "white paper" on the sound-level/hearing risk problem for the further edification of all parties involved. That idea, at least, was greeted with what seemed to be a modicum of enthusiasm.

TABLE 1
MAXIMUM ALLOWABLE OSHA LEVELS

Exposure Time (hours)	Maximum Level (dB)
8	90
4	95
2	100
1	105
0.5	110

In an effort to make my paper as comprehensible as possible, I used the easy-to-read and flexible Q-and-A format. I tried to organize the Q's in a logical sequence, but the complexity of the subject obviously works against complete linearity. Apart from its hopefully positive effect in my home town, I thought it would be a good idea to turn my "white paper" into an *Audio Update* column that other parents might find helpful in taming the deafening decibels in their own locality. I hope it works for you if you have a similar problem—or perhaps calls to your attention the fact that a problem exists.

Q. Why do you believe there is a problem of excessive sound levels at student dances?

As stated above, I measured well over 100-decibels (dB) sound-pressure level (SPL) in various areas of the cafeteria in which our dances were being held. Although there are no local regulations—at least in our town—dealing with recreational noise, there is a federal law, the Occupational Safety and Health Act (OSHA), that mandates the legal maximum noise in SPL to which employees may be subjected. (See Fig. 1.)

Q. Will one or two exposures to very loud sounds cause injury?

Not likely, unless the sound is in the decibel range (150 dB) of close-up gunshots. But it's important to realize that ear damage from high sound levels is cumulative over time, in much the same way as ultraviolet radiation or lead poisoning. A single exposure is not likely to cause injury, but frequent exposure to high sound levels will, in time, cause measurable, cumulative auditory damage. This could lead to significant hearing loss in later years. The OSHA rules, therefore, state the maximum average sound-pressure levels that may be "safely" present for a given time period. Note that for every increase of 5 dB, the allowable exposure time is halved. Keep in mind that I measured 110 dB at our school dances.

Q. Exactly what is meant by the term "safely?"

Experience has shown that some hearing loss will occur over time in 20 to 25% of workers regularly exposed to the legally allowed limit of 90 dB SPL for eight hours. That appears to be acceptable to the government, industry, and hearing-aid manufacturers. European industrial nations have the more stringent International Standards Organization (ISO) criteria, which halves the permissible exposure time with every 3-dB increase in sound levels. The U.S. Environmental Protection Agency (EPA) also finds the OSHA sanctioned level too lax, and would recommend that the maximum allowed SPLs be 5% lower.

Let me stress once again that the damage is cumulative, and that hearing loss might not begin to show up until late adolescence or much later, depending upon the totality of noise exposure and the individual's sensitivity to exposure. Environmental noise, live concerts or dances, car stereos, and particularly headphone stereo cassette players all contribute to the cumulative total noise exposure.

Q. Is there any way of knowing when sound is loud enough to cause injury to people?

Aside from making objective measurements with instruments designed to measure sound intensity, there are some significant subjective physiological effects. If anyone leaves a sound-intensive environment with ringing or a feeling of stuffiness in one or both ears, then his/her ears have suffered some degree of overstress. Repeated exposure could also cause low levels of damage without any obvious immediate symptoms. The stuffiness is a common physiological reaction to sustained high sound levels and is accompanied by a temporary threshold shift (TTS)—in other words, a hearing loss. One study reported in the "Canadian Family Physician" found a TTS of 10 dB among 76% of its test participants attending a rock concert. The hearing loss was still present 40 to 60 minutes later. A 10-dB loss approximates a 50% reduction in the loudness of sounds. Although the loss was temporary, it contributes to a possible permanent threshold shift.

Q. How do decibels relate to sound level?

Decibel is a technical term used in many areas of electronics and in acoustics. Sound intensity, which is the topic that concerns us here, is usually measured in dB. The human ear's response to sound level is roughly logarithmic (based on powers of 10), and the decibel scale reflects that fact. An increase in level of 3 dB doubles the sound intensity, but an increase of about 10 dB is required before the sound is perceived to be twice as loud. Therefore, a small increase in decibels represents a great increase in intensity. For example, while 10 dB is 10 times more intense than one dB, 20 dB is 100 times more intense (10 × 10, rather than 10 + 10), 30 dB is 1000 times more intense (10 × 10 × 10), and so on. The sound intensity multiplies by 10 with every 10-dB increase. The reason for this scale is simply that the human ear is sensitive over such a wide range of acoustic energy that the numbers involved had to be compressed for convenience. The dB scale converts a range of one million into 120 dB.

To provide an approximate reference, the approximate or average levels of common sounds are shown in Fig. 2.

Q. Fig. 2 shows that classical music can become quite loud also. Why isn't it as dangerous to human hearing as rock music or disco sound?

If you were to compare rock and classical music with test instruments such as a sound-pressure meter and a real-time spectrum analyzer, you would find that rock music and disco sound typically have a continuously high level and more energy at both high and low frequencies. Classical orchestral music can have its loud moments, but they are seldom sustained for any length of time. Human ears have a chance to rest and recover. There is also less high- and low-frequency energy. Exceptions to this generalization are the works of some modern classical composers who work with electronic synthesizers that are as capable of blasting your ears as the best of the heavy-metal freaks.

Q. Why do DJs tend to play music so loudly?

Mostly in response to their public's demand. The louder the music (particularly the bass line), the greater the visceral impact and the sensory saturation. As a background for those who have not been at school dances, the sound levels heard and the impact felt are exaggerated versions of the kind of sound occasionally heard from high-volume car stereos touring the streets of our cities. Also, DJs (and rock musicians) tend to play even louder than needed to attain the desired effects because they have already been somewhat deafened and have to operate at high levels for the music to sound as loud to

Continued on page 90

TABLE 2—DECIBEL LEVELS OF SOME COMMON SOUNDS

Sound Pressure (dB)	Sound Source
130	Jack Hammer (at 5 feet)
120	Discomfort/Pain Threshold Loud Rock or Disco Music
110	Riveter Heavy Truck (at 50 feet)
100	Very Loud Classical Music
90	Heavy Street Traffic (at 5 feet)
80	Loud Singing Heavy Traffic (at 40 feet)
70	Fairly Loud Speech (at 3 feet) Department Store/Noisy Office
60	Background Music Average Office Quiet Residential Street
50	Light Traffic Average Residence
40	Very Low Radio at Home Very Soft Music
30	Country House Quiet Auditorium
20	Faint Whisper (at 5 feet)
10	Leaves Rustling Anechoic Chamber
0	Threshold of Audibility

Note: Sound-pressure level varies with distance from source.

DRAWING BOARD

Here's the keyboard section of the all-electronic audio router.

ROBERT GROSSBLATT

If you've been reading my articles for any length of time, you should realize that every one of my designs goes through exactly the same sequence of stages. I put a lot of thought into the diagrams I drew last time, and a lot of bench time goes into translating those diagrams into working circuits. Although nothing is written—or wired—in stone, the first working circuit is usually pretty close to the original drawings. This is how to produce prototypes.

As you go through the process of creating the prototype, a lot of new ideas will occur to you about how the design can be made better, faster, smaller, and so on. But these new ideas should not be acted upon until you have a working circuit on your bench.

A perfect example of what I'm talking about is the project I'm working on now—the all-electronic audio router. Although I haven't made one exactly like it before, its basic elements are things I've done many times before. The first part of the design is the keyboard. Its details are shown in Fig. 1. There are two basic parts to the circuit: the keyboard encoder made from a CD4017B CMOS counter/divider and the clock made from a pair of CD4011B NAND gates.

The clock circuit is a gated oscillator whose component values were chosen to produce a 10-kHz square wave. The clock runs when pin 2 of IC1-a is logic high, and it stops when pin 2 is logic low. When the clock is running, the outputs of the 4017 keyboard encoder will go high sequentially.

The reset control (IC2 pin 15) is connected to pin 11, the last output of the 4017. When that output is selected, the 4017 resets itself and starts over again with the first output. The reset pin could have been grounded permanently, but I connected it to pin 11 of the 4017 to remind me that there are times when the 4017 should not count through a full sequence.

The final circuit will be able to select from eight inputs, so I need eight 4017 outputs—one for each selected input. As shown in the schematic, however, I'm using nine of the outputs. The reason for this will become clear as I go through the keyboard operation.

The nine outputs of the 4017 are connected to the keyboard switches through diodes D1 to D9. Those diodes prevent a logic high on one line from feeding back to the low lines. Although only one keyboard switch is supposed to be pressed at a time, I must guard against mistakes. Just as when typing on a keyboard, sometimes the wrong key is pressed and sometimes more than one key can be pressed at a time. The diodes are an inexpensive way to ensure that fat fingers only cause mistakes, and not smoked silicon.

The logic high that results from pressing a key is fed to the 4017's

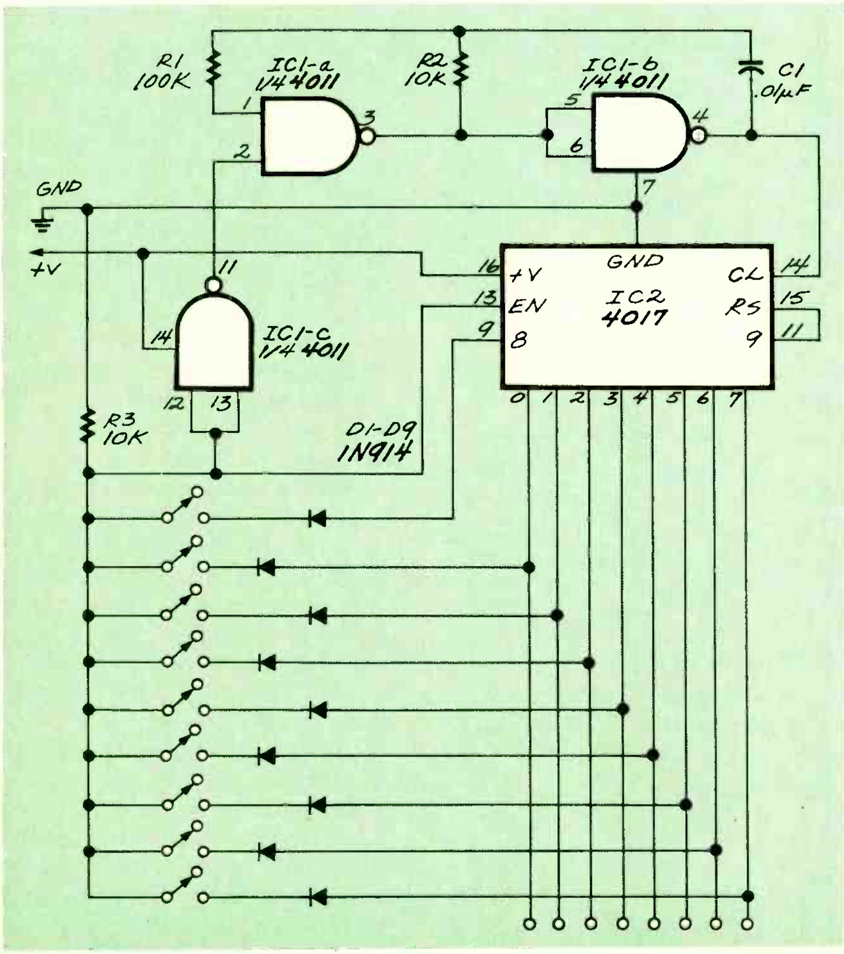


FIG. 1—THE FIRST PART of the all-electronic audio router design is the keyboard. It consists of an encoder made from a CD4017B CMOS counter/divider and a clock made from a pair of CD4011B NAND gates.

enable input pin 13 and through inverter IC1-c to the gate control of the oscillator. As long as a keyboard switch is held down, the selected 4017 output remains high. When the key is released, the oscillator starts, and the 4017 outputs start sequencing high again.

I also need a way to clear the input if I make a mistake. That's why I'm using nine of the 4017 outputs. Note that the ninth output doesn't go anywhere. When this key is pressed, the other outputs are all logic low so I can use this to clear the input selection. Also note that the common side of the switches is held low by resistor R3. Without that, the input of IC1-d would float.

There's nothing critical about the keyboard section of the circuit, but if it doesn't work properly, the rest of the circuit isn't going to work either. Build the keyboard first, and make sure it works correctly before continuing with the project. If you are having trouble getting the keyboard to work, replace C1 with a 10µF capacitor to slow the clock down. Then, with a multimeter, logic probe, or even a simple LED and current-limiting resistor, check to see if the 4017 counter/divider is operating correctly.

When the keyboard is working properly, proceed with the circuitry that stores the column information for the router. Because the keyboard line remains high only as long as a key is pressed, I need some way to store that logic state. I have eight possible inputs (remember

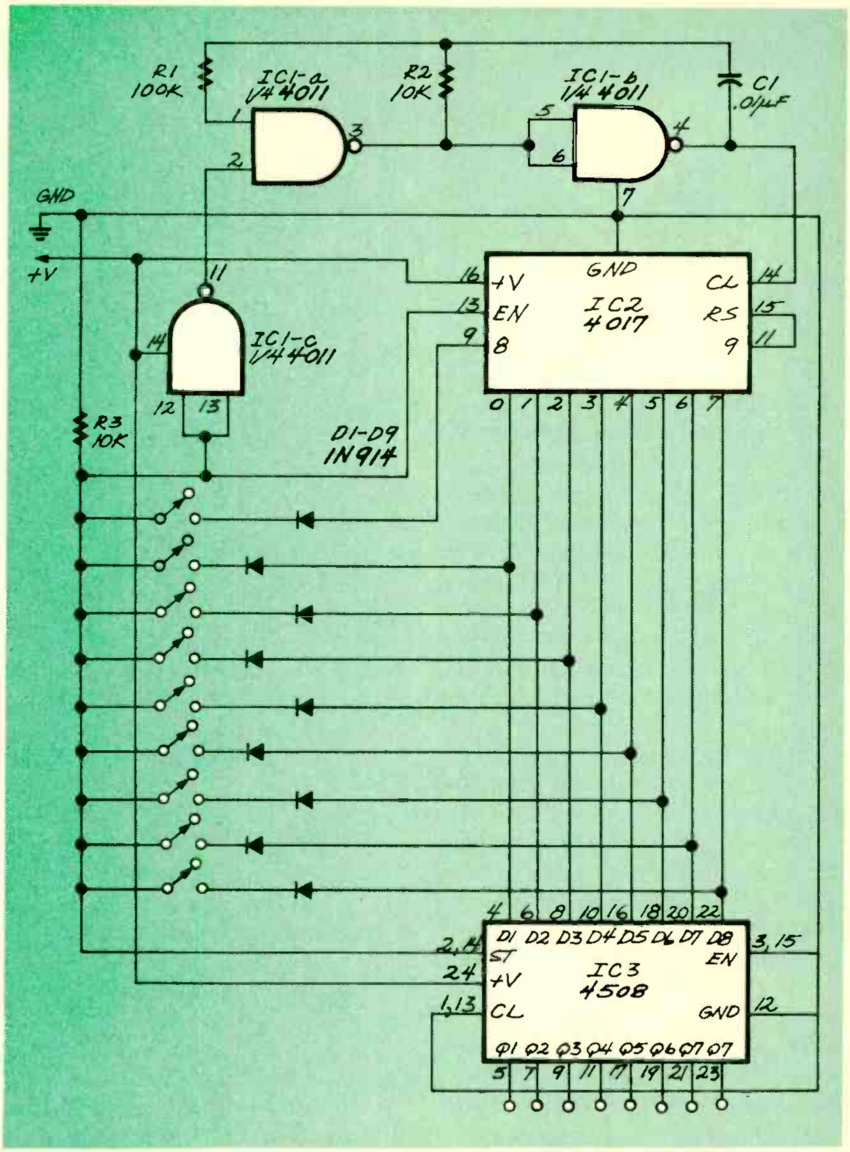


FIG. 3—THE OUTPUT OF THE CD4017B feeds the inputs of the CD4508B. Every time a key is pressed, the state of the eight 4017 output lines will be latched in by the 4508.

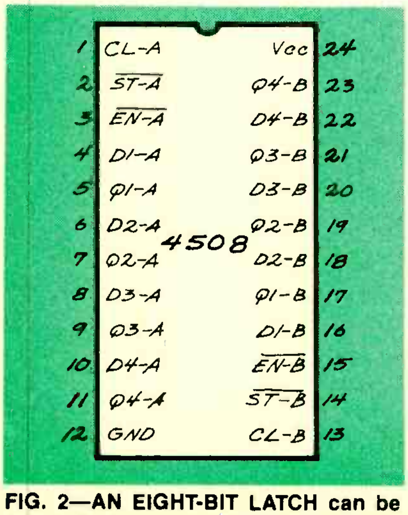


FIG. 2—AN EIGHT-BIT LATCH can be formed by tying together the two control pins of a CD4508B dual four-bit latch.

that the ninth output of the 4017 is for the clear line), so I need to design a circuit that can store an eight-bit word.

The simplest solution is with a 4508 dual 4-bit latch whose pinout diagram is shown in Fig. 2. By tying the control pins of each half of the latch together, I can use it as a single eight-bit latch.

The STORE lines (pins 2 and 4) control the IC's inputs; when they are high, the input data is transferred to the internal latches, and when they're low, the data is ignored.

When brought high, the CLEAR lines (pins 1 and 13) will store zeros in the latch. When the ENABLE lines (pins 3 and 15) are high, the latch outputs will be three-stated. The three-stated, or high-impedance output capability is useful at times but I won't need it in this circuit because it doesn't use a common data bus. As a result, there's no possibility of bus contention and all of the outputs can be left permanently enabled.

Figure 3 shows the 4508 added to the circuit. The 4017 outputs feed the inputs of the 4508. Because the 4508 latches data on the rising edges of of the signals at its STORE inputs, I have connected those lines to the "any key pressed" common side of the switches. Every time I press a key, the state of the eight 4017 output lines will be latched in by the 4508 and transferred to its output pins. Ω

COMPUTER CONNECTIONS

Windows and Warp, Delphi, and the P6.

JEFF HOLTZMAN

When it comes to new operating systems, there is usually good news and bad news. Microsoft's Windows 95 and IBM's OS/2 Warp Version 3.0 maintain the tradition. Both are 32-bit protected-mode, preemptive multitasking operating systems. And both claim to be capable of running any DOS/Windows software worth running, and without requiring a P6 microprocessor to do so. Both claim advanced ease of installation and advanced ease of use. Of course Warp, illustrated in Fig. 1, is here now, and Windows 95 is still targeted for an August release.

I had trouble installing Windows 95 Beta 2 on a really esoteric machine, an IBM PS/2 Model 70; but no trouble at all on a home-brew DX/2-50 clone. On the other hand, I had trouble installing Warp on an off-the-shelf Pentium 90 system made by Micron Technologies, but none at all on the home-brew clone.

Application compatibility for Windows 95 was better than for Warp. For example, I had no trouble running Crosstalk for Windows and a DOS version of ProComm under Windows 95, but I had lots of trouble with both under Warp. Under Warp, Crosstalk could dial out and I could log in to online services, but I could not transfer files. With ProComm, the modems would connect, but then I couldn't even log in. I used the identical setup files and login scripts as I normally use without problem running Windows for WorkGroups 3.11.

Other Windows applications including Visio 3.0, askSam 2.0, and multiple DOS utilities and applications ran just fine under both environments.

Warp's user interface is enigmatic. Parts of it are infinitely more elegant than those of either Windows 3.1 or Windows 95. For example, Warp's user interface is explicitly defined and designed as

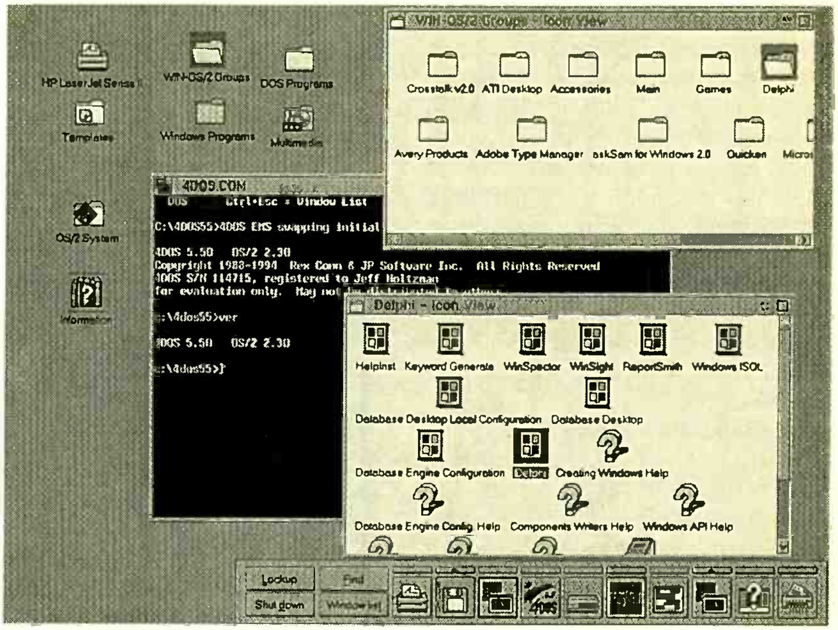


FIG. 1—IBM'S OS/2 WARP VERSION 3.0 does a good job of simultaneously running OS2, Windows 3.x, and DOS applications.

object-oriented. For example (and this is an improvement over OS/2 2.x), you can apply a group of settings to a folder and have all subordinate folders and files take on those characteristics simultaneously.

Warp's new Task Bar, which is actually a launch bar, is nicely done. You can drag and drop icons to it, and even create groups of icons in pop-out "drawers." Windows 95 by contrast has a Task Bar that gives push-button access to currently active tasks, but it has no built-in launch bar. Both operating systems allow random placement of icons representing programs and data files directly on the desktop.

IBM pitches Warp as an integrating platform capable of running anything. But it does so using two very different user interface conventions: Windows and OS/2. People who find Windows confusing will get a further dose of confusion by having to learn the second user interface. On the other hand, if you do want to run Windows applications under Warp, you can do so without noticeable performance penalty. A large application like Word for Windows Version 6.0c can be loaded about as fast under Warp, Windows 95, and Windows 3.1.

I really like the way Warp's desktop works, but it still has a clunky, awkward, inelegant feel that IBM hasn't managed to shake. I'm talking about subtle things—for example, the feel of the mouse pointer as it moves across the screen, the way icons line up, and the fonts and colors used. They don't impact overall functionality, but they do impact my impressions. It would be like delivering a Rolls-Royce to a customer in basic operating condition, but needing a tune-up. Even in its beta state, Windows 95 by contrast has a snappy, finished feel.

Windows 95 has a new user interface as well. The company has released a study, purportedly by an independent firm, that shows a definite improvement in ease of learning for new users over Windows 3.1. The Windows 95 user interface is similar to that of Warp, but it is more like Windows 3.1. The transition should be easier, but probably still somewhat traumatic for non-technical users.

Both Warp and Windows 95 have boot-management features. With Warp, you can press Alt-F1 during the initial boot sequence and force the operating system to revert to a least-common-denominator set of device drivers. One really nice feature is Warp's setup archiver, which allows you to archive a set of setup parameters, including boot files. Subsequently you can at any time resurrect a configuration and boot the computer from it. Warp also has built-in dual-boot and multi-boot options, which allow multiple operating systems to be booted from one hard disk. Windows 95's boot features are not currently as extensive, but they are nonetheless useful. Windows 95 needs a multi-operating system boot manager.

With Warp, IBM is trying to adopt a hip new attitude. And Warp is a pretty hip product. But it's not Windows. And that may be the biggest strike against it. In a non-Windows world, Warp would be more than good enough. However, in this Windows world, it might not be enough no matter how good it is.

Delphi

Since last month's discussion about Borland, I have obtained a late beta copy of Delphi, Borland's answer to Microsoft's Visual Basic. Delphi is Borland's ace in the hole in the company's struggle for survival. Delphi simply must succeed, if Borland is to be more than just another back-alley vendor of programming tools. Delphi is in fact extremely impressive—but, like most Version 1.0 products, not without fault.

A product like either Delphi or Visual Basic is not so much a tool as a toolbox. In that regard, Delphi is far superior to Visual Basic. If Visual Basic is a 179-piece socket wrench set, Delphi is a 437-piece set of everything you need to outfit your workshop, including the "meta" tools required to build your own tools.

Delphi's development environment is much more refined than Visual Basic's. Components (what Visual Basic calls VBXs) are organized by type, using the popular tabbed divider metaphor, and Delphi includes many more components than Visual Basic Pro 3.0. For example, Delphi includes components for directly implementing tabbed notebooks, toolbars, and status bars, all of which must be kludged in Visual Basic, or built or purchased separately as VBXs. In fact, much of Delphi is written in Delphi.

Delphi also includes a built-in single-user project-management system, which can be upgraded for multi-user network use. In addition, Delphi has a full-featured source-level debugger, as well as lots of thoughtful extras, including a bitmap editor for icons, cursors, etc.; an alignment tool for lining up on-screen components; and extensive right-button support.

Architecturally, Delphi is very object-oriented, with full support for inheritance, encapsulation, and polymorphism. Visual Basic has a few object-oriented features, but they amount to a thin veneer over a non object-oriented core. Delphi supports its object-oriented structure with a powerful class/object browser that can display the hierarchical relations of objects and their methods, properties, and interfaces.

I created a simple "Hello World" application that simply allows the user to click an OK button to terminate the program. Delphi compiled an executable file with a size of 195 kilobytes, which seems to be an awful lot of baggage. Windows applications like the File Manager, Paintbrush, and even Solitaire all come in at less than 195K. Visual Basic, by contrast, compiles a similar program to a much smaller executable (6 kilobytes), but Visual Basic also requires the presence of a 350-kilobyte run-time DLL.

That brings up an extremely important point, one with both philosophical and practical implications: Reuse. Visual Basic's practice of storing VBXs externally has several very important advantages. If a bug is found in a VBX, the VBX can be enhanced or fixed, and all applications dependent on it will automatically receive the enhancements and fixes.

By contrast, with Delphi's bound-in approach, not only the component, but also any applications dependent on it would have to be recompiled. Another point is that regardless of how many applications use a VBX, only one copy of the VBX occupies disk space. However, every instance of a Delphi component uses disk space.

On the other hand, version control with VBX's is a problem. Assume that a user installs an application that uses version two of some VBX. Later the user installs some other application that happens to use version one of the same VBX.

What typically happens is that the setup routine blithely overwrites the newer VBX with the older VBX, so the user is out of luck next time he or she tries to run the version-two-based application. With bound-in components, as Delphi supplies, that couldn't happen.

The long-term solution is an operating system that knows about objects and dependencies on them. But we're a long way from that kind of intelligence. For now, I have to side with the Delphi approach, because disk storage has gotten awful cheap lately.

Delphi's biggest problem is its convoluted means of setting up access to a database, especially when compared with the visual query builders in Microsoft Access and Intersolv/Q+E's Multilink VB. The methods used by those tools are much more straightforward and intuitive than Delphi's. This is one area I'd consider a must-have for version two.

Delphi is pretty well documented, and it includes on-line tutorials that introduce you to the environment by having you build several simple applications. Delphi also includes several more extensive sample applications, as well as source to its libraries.

Delphi is simpler to learn than C++, but not as simple as Visual Basic. On the other hand, it provides a much richer environment than Visual Basic for software development, and it produces better performing applications.

Move over Visual Basic; Delphi has come to town, and it's the Windows programming environment to beat—at least until Microsoft ships Version 4 of Visual Basic.

Next-generation CPU

Now that 100-MHz Pentium systems sell for under $2000, there's only one thing to worry about: Intel's newest CPU, the as-yet unnamed P6.

Last winter, Intel started shipping sample quantities of the P6. In addition, the company revealed basic facts and figures about the P6 and its architecture.

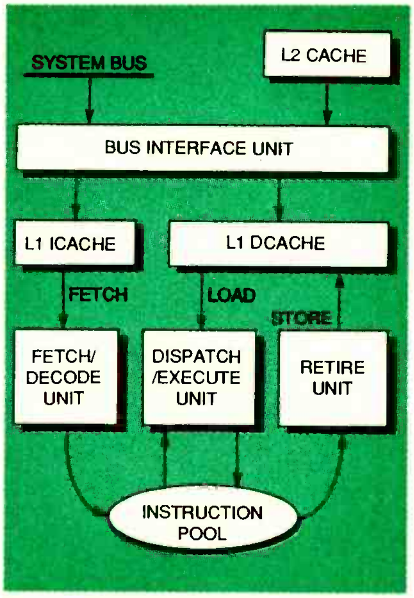


FIG. 2—DYNAMIC EXECUTION forms the core of Intel's new P6 CPU. Intel targets a 2× speed improvement over an equivalent-speed Pentium.

Features of note include a 133-MHz clock speed, an external bus running at ½, ⅓, or ¼ the clock speed, 2.9-volt operation, 0.6 μ process width, and a two-level cache design. The Level 1 cache is a dual 8K/8K instruction/data cache, and the Level 2 cache contains 256 kilobytes of RAM.

The P6 attains approximately twice the performance of an equivalent speed Pentium by means of three basic techniques (branch prediction, data-flow analysis, and speculative execution) that in combination Intel calls *dynamic execution*.

Intel claims that dynamic execution represents as much a jump over superscalar (multiple execution units) architecture as superscalar did over the single execution unit architectures associated with the 386 and prior Intel CPUs.

Figure 2 shows the principle of dynamic execution. The Instruction Pool contains a group of instructions that may be executed. The Fetch/Decode unit feeds the Instruction Pool from the Level 1 instruction cache (ICache), if possible. If not, the Bus Interface Unit supplies an instruction from the Level 2 cache, or failing that, from main memory.

After execution, the instruction returns to the Instruction Pool, from where a Retire Unit disposes of it, and if necessary stores results in the Level 1 data cache (DCache), where it may be propagated to system memory at some other convenient time.

Expect to see systems built around the P6 available at retail during the second half of this year.

Being Digital

Being Digital is the title of a new book by Nicholas Negroponte. Negroponte is head of MIT's Media Lab, and has long been associated with multimedia computing and the convergence that is taking place among the computer, communications, publishing, and entertainment industries.

Negroponte has an aversion to reading, as he is dyslexic. But he is an engaging writer, and *Being Digital* is an engaging book for the right reader.

It's not a deeply technical book; you won't learn about motion-video compression algorithms or anything of the sort. What's good about the book is Negroponte's way of highlighting the important issues surrounding the digital revolution.

I can see several groups of people that this book would probably appeal to: 1) older readers unfamiliar with the scope and depth of the revolution, 2) younger readers who don't understand that the world was *not* created yesterday complete with a computer on every desk, and 3) highly technical readers who in their focus on technical issues tend to miss the social importance of what's going on.

As always, comments are welcome: jkh@acm.org. Ω

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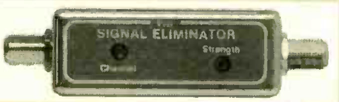

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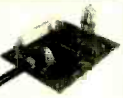

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- Receiver/transmitter range: 100 ft.

117647:

- 2 channel transmitter
- Key ring housing
- Power supply: 12V battery type V23GA
- Wt.: 0.36 lbs.

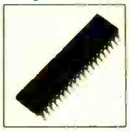
117655

117655: • 1 channel receiver

- Relay output 10A toggle or pulse contact
- LED indicator • Separate output to switch car alarm on or off
- Power supply: 18 VCT transformer (P/N 105531) or Power Source
- PCB dimensions: 3.64"L x 3.04"W x 1.0"H
- Weight: 0.49 lbs.

Part No.	Description	1-9	10-24
117647	Transmitter	$29.95	$26.95
117655	Receiver	39.95	35.95

Digitalker™ DT1050 Voice Synthesizer Chip Set



- Language translations
- Telecommunications
- Teaching aids
- Automotive • Clocks

Chip Set encoded with 137 separate and useful words. The words have been assigned discrete addresses, making it possible to output single words, phrases or sentences. Includes: • MM54104N (40-pin) speech processor chip • 74LS04 • MM52164SSR1 (24-pin) and MM52164SSR2 (24-pin) speech ROMs • Master Word List

Part No.	Description	1-9	10-24
16491	Digitalker™ (4 Chips)	$39.95	$37.95

Jameco Analog Display Soldering Station

- Electronic temperature control
- Zero-Voltage thyristor switching protects voltage and current sensitive devices
- Power-on and Heater-on LED indicators
- Power consumption: 60 watts
- Includes one 35115, 1/16" tip
- Size: 4.25"W x 6"D x 3.38"H
- Weight: 4.2 lbs. • UL listed

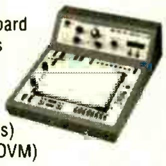
Part No.	Description	Price
114569	Analog Display Station	$79.95

3 1/2 Digit Pocket Multimeter

- Measures: AC/DC voltage, DC current, HFE and resistance
- DC Voltage: 200mV, 2V, 20V, 200V, 1000V
- AC Voltage: 200V, 750V
- Resistance: 200Ω, 2 KΩ, 20 KΩ, 200 KΩ, 2M
- DC Current: 200 mA , 2mA, 20mA, 200mA, 10A
- Diode Test • Transistor HFE
- Removable test leads
- Size: 2.62"W X 1"D X 4.75"H
- Weight: 0.5 lbs. • One-year warranty

Part No.	Description	1-9	10-99
119212	Digital multimeter	$19.95	$17.95

Jameco Digital Lab



Includes:

- Solderless Breadboard
- DC Power Supplies
- Two 7-Segment Displays
- Function Generator (5 ranges)
- Digital Voltmeter (DVM) 4 ranges
- Size: 10.625"W x 13.25"D x 5"H (w/ back panel)
- One-year warranty • Weight: 8.5 lbs.

Part No.	Description	1-4	5-9
75838	Digital Lab	$299.95	$269.95

286 12MHz Bare-bones System

Includes motherboard, computer case, power supply & keyboard

- Intel 286 12MHz CPU
- 1MB RAM
- 1.2MB (5.25") floppy disk drive
- IDE hard/floppy controller
- Five expansion slots
- Two serial & one parallel ports

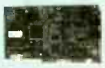
Part No.	Description	Price
115705	286 12MHz	$169.95

40 Piece Tool Kit

- IC extractor
- IC inserter with pin straightener
- Extra long 3-claw parts holder
- Slotted and Phillips screwdriver bits
- Metric nutdriver sockets (6mm-12mm)
- S.A.E. nutdriver sockets (3/16"-1/2")
- Reversible torque screwdriver bits (T10-T25)
- Potentiometer alignment tools
- Adapter bit for sockets • Wire cutters & stripper
- Pocket clip screwdriver • Zipper vinyl case
- Weight: 1.8 lbs. • Size: 9.5"L x 6.8"W x 1.38"H

Part No.	Description	Price
119183	40 Piece Tool Kit	SALE $14.95

Hyundai 2400bps Modems



- PC/XT/AT and compatible computers
- 8-bit card
- Hayes compatible
- CCIT V.22/V.22 bis & Bell 103/212A compatible
- Includes communication software

Part No.	Description	Price
106569	Internal 2400 Baud	$17.95
106577	External 2400 Baud	22.95

7400 Integrated Circuits

Part No.	Product No.	1-9	10-99	100+
48979	7400	$.29	$.25	$.22
49015	7402	.29	.25	.22
49040	7404	.35	.29	.25
49091	7406	.35	.29	.25
49120	7407	.35	.29	.25
49146	7408	.35	.29	.25
49437	7414	.39	.35	.29
50235	7432	.49	.45	.39
50420	7447	1.29	1.19	.99
50551	7474	.29	.25	.22
50577	7475	.39	.35	.29
50593	7476	.45	.39	.35
50665	7486	.39	.35	.29
50681	7489	2.69	2.49	2.29
50690	7490	.69	.59	.53
49293	74116	SALE	.99	.89
49322	74121	.89	.79	.69

CD4000 Integrated Circuits

Part No.	Product No.	1-9	10-99	100+
12562	CD4001	$.29	$.25	$.22
12634	CD4011	.29	.25	.22
12677	CD4013	.29	.25	.22
12722	CD4016	.35	.29	.25
12749	CD4017	.49	.45	.39
12950	CD4040	.49	.45	.39
13055	CD4049	.29	.25	.22
13098	CD4051	.59	.49	.45
13127	CD4053	.49	.45	.39
13186	CD4066	.35	.29	.25
13231	CD4069	.29	.25	.22
13274	CD4071	.29	.25	.22
13354	CD4081	.29	.25	.22
13400	CD4093	.35	.29	.25

Jameco ABS Speedy Boxes

SALE

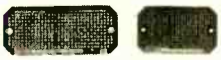
Will not crack or split when drilled or punched. PCB mounting slots on all four sides and the lid has a lip for precision fit. Complete with four screws and lid. Color: black

Part No.	Inside Dimens. (LxWxH)	1-9	10-99
18921	3.125" x 2.0" x 0.875"	SALE	$1.95
18913	4.875" x 2.5" x 1.5"	2.49	2.25
18892	6.0" x 3.5" x 1.875"	SALE	2.25
18905	7.5" x 4.25" x 2.25"	3.49	2.95

Jameco Prototype Builder Boards:

The Jameco Prototype Boards are designed to fit into ABS Speedy Boxes. These pre-cut boards will allow the builder an immediate start on prototyping circuits. Each board has 2 or 4 mounting holes. Drilled holes: .040" dia. on .080" square pad on .10" x .10" spacing. Solder mask.

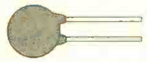
SALE



Part No.	Size (L x W)	Fits	1-9	10-99
105099	2.70" x 1.60"	18921	SALE	$2.95
105128	4.40" x 2.00"	18913	SALE	4.95
105152	5.50" x 3.10"	18892	SALE	5.95
105161	7.00" x 3.60"	18905	SALE	7.95
106551	Circuit Brd.Hdwr.(4 sets)		1.19	.99

Call for complete line of boxes & PC Boards!

Capacitors



Silver Mica, Radial and Axial Electrolytic Capacitors also available.

SALE

Ceramic Disc (± 20%) 50V

Part No.	Capacitance	Voltage	1	10	100	1000
15405	22pf	50v	$.10	$.05	$.03	.028
15341	100pf	50v	.10	.05	.04	.028
15190	.001µf	50v	.10	.05	.03	.028
15229	.01µf	50v	SALE		.05	.045
15253	.047µf	50v	.12	.07	.05	.045
15270	.1µ	50v	.15	.12	.07	.06

Mylar (± 10%) 100V

Part No.	Capacitance	Voltage	1	10	100	1000
26884	.01µf	100v	$.11	$.09	$.06	$.05
26921	.033µf	100v	.12	.10	.09	.065
26956	.1µf	100v	.19	.15	.12	.10
26972	.22µf	100v	.23	.19	.16	.11
26999	.47µf	100v	.29	.25	.22	.19
27001	1µf	100v	SALE		.35	.27

Dipped Tantalum (± 10%) 35V

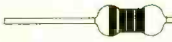
Part No.	Capacitance	Voltage	1	10	100	1000
33486	.1µf	35v	SALE		$.11	$.10
33662	1µf	35v	.21	.17	.13	.11
33734	2.2µf	35v	.25	.23	.17	.15
33806	4.7µf	35v	.39	.35	.26	.21
33689	10µf	35v	.65	.55	.49	.39
33822	47µf	25v	1.75	1.55	1.39	1.25

Monolithic (± 20%) 50V

Part No.	Capacitance	Voltage	1	10	100	1000
25523	.1µf	50v	$.19	$.15	$.11	$.09
25507	.01µf	50v	.15	.12	.09	.065
81525	100pf	50v	SALE		.09	.065
25558	.47µf	50v	.23	.19	.15	.12
25540	.22µf	50v	SALE		.15	.12

Carbon Film 1/4 Watt 5% Resistor Assortments

SALE



Part No.	Description	Price
10719	5 each 70 values	SALE $8.95
10663	100 each (27 values)	SALE 19.95

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CIRCLE 114 ON FREE INFORMATION CARD

UNIVERSAL CLOCK

continued from page 42

are given in Fig. 4. The nice thing about the wood enclosure is that the LCD mounts on a 45°ree angle for proper viewing, and the pushbutton switches are easily accessible.

The two side panels were fabricated from ¾ inch solid oak, and the other panels from ¼ inch oak-laminated plywood. All five sides of the end pieces were notched (dadoed) by ¼ inch to hide the rough ends, while simultaneously providing enough surface area for gluing.

To further improve LCD viewing, a one-inch groove was dadoed in the back side of the 45° face plate. The dado runs the entire width of the piece and reduces the wood's thickness to ⅛ inch. The dado allows the LCD to mount almost flush with the surface of the face plate.

The answer to the question posed in the sidebar, on page 42 is: (c). Many reference works oversimplify their descriptions, and give (a) as a correct definition. Close, but no cigar. Ω

AUDIO UPDATE

continued from page 81

them as they think it should. I also suspect that the volume level of the music tends to creep up slowly during a disco evening because the DJ and his audience start to suffer from temporary threshold shift.

Q. Are some types of music and noise more dangerous to our hearing than others?

Yes. The least dangerous are the intermittent sounds of various frequencies at a level well below 90 dB. Those are the sounds that surround us every day. More dangerous would be loud, intermittent noises of a limited frequency bandwidth, such as those that might be encountered on factory floors. Most dangerous would be very loud continuous sound levels over a very wide band of frequencies—such as are heard with the playing of rock music and most disco music. Ω

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TECHNOLOGY UPDATE

Put the remote back into your remote control!

Amazing new device attaches to your existing remote control giving it the power to transmit anywhere, even through walls!

By Charles Anton

It's Thursday evening and you have dinner guests. The kids are watching TV but it's too loud. Without embarrassing yourself or the kids by yelling to turn it down, you pick up your remote with Leapfrog long range power and turn it down without a hassle.

Until now remote control has never been very "remote." Even with the best equipment you had to be right in front of your stereo, TV, VCR, etc. to make it work. Now you can operate your entire entertainment system from anywhere in your home with Leapfrog, the next generation in remote systems.

How "remote" is it? Imagine yourself at home enjoying a relaxing evening of movies on your VCR. You decide to stop the movie so you can get yourself a snack. You aim the remote and click, but nothing happens! You grow more and more irritated, and finally have to stand right in front of the VCR before you can get it to stop the movie. You find yourself wondering why they call it a "remote" in the first place.

Why all the hassle? Typical remotes use infrared technology. In order for the process to work, the remote must be in direct line-of-sight with the audio-visual equipment. The equipment must "see" the signal.

Radio revolution. The Leapfrog transmitter never needs to be perfectly "lined-up" with the TV, etc. Why? Because the transmitter doesn't rely on an infrared signal. You can even point it in the wrong direction and it still works. Leapfrog overcomes all the headaches of obsolete remote controls through the use of radio waves.

Radio waves work anywhere within a 150 foot range. The signals pass through walls, doors, ceilings and floors, letting you control your equipment from any room of your home. You cannot aim and miss.

How does Leapfrog work?

Leapfrog converts your infrared remote signal to radio frequency. Radio frequencies enable the signals to pass through walls and other obstacles. It also allows signals to transmit up to 150 feet without staying in line-of-sight with your equipment. Leapfrog then re-transmits the signal to the receiver, which forwards it to your audio-visual equipment.

Leapfrog installs in minutes. The transmitter attaches to your current remote. Plug the receiver into any outlet and place it in line with your audio-visual equipment.

Leapfrog sends radio signals which pass through any non-metal obstacle, giving you complete control of your personal electronics system.

Infrared to radio. The Leapfrog transmitter, which attaches to your existing remote control, sends radio signals to the Leapfrog receiver. This receiver then transmits the signal to your audio-visual equipment with infrared technology.

Versatile uses. This amazing new remote control modifier works with any infrared remote. Just imagine the convenience of controlling your VCR, TV, stereo, cable converter box, speakers in multiple rooms, or any other audio-visual system throughout your home.

Leapfrog is also ideal for use with universal remotes. Control it all with just one remote.

Talented remote. The Leapfrog is not another hand-held remote control. This powerful innovation actually modifies your current remote, thus enhancing its value. You can control your stereo, your VCR, your TV, etc. from anywhere. From across the room or from across the house.

You can even use Leapfrog from outside. This is a fantastic feature to have when you're out by the pool, on your patio, or in your garage.

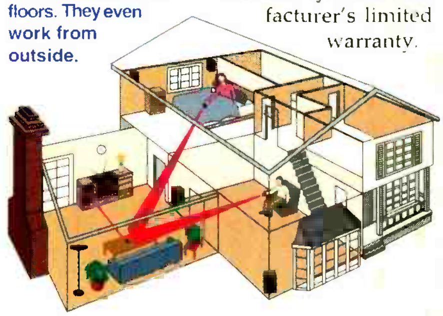
Factory direct. You would expect an innovative device like this to cost several hundred dollars. That might be the case if we sold only through exclusive high-end audio-visual dealers. But we bring the good news straight to you. You save money with factory direct prices.

Why Leapfrog beats infrared

- **Range.** You can control electronics from up to 150 feet away.
- **Aim.** You can't miss. Point your remote in the wrong direction and it'll still work.
- **Value.** It lets you get the most out of your audio-visual equipment by making use of it throughout your home.
- **Flexibility.** Because it sends signals through barriers, it lets you store your equipment behind cabinet doors.

Try it risk free. We are so confident that you will love Leapfrog that we've backed it up with our "No Questions Asked" 30 day money-back guarantee. If you are not completely satisfied for any reason, just return it for a full refund. Plus, it comes with a full one year manufacturer's limited warranty.

Leapfrog transmits signals in a range of up to 150 feet. Signals actually pass through walls, ceilings and floors. They even work from outside.



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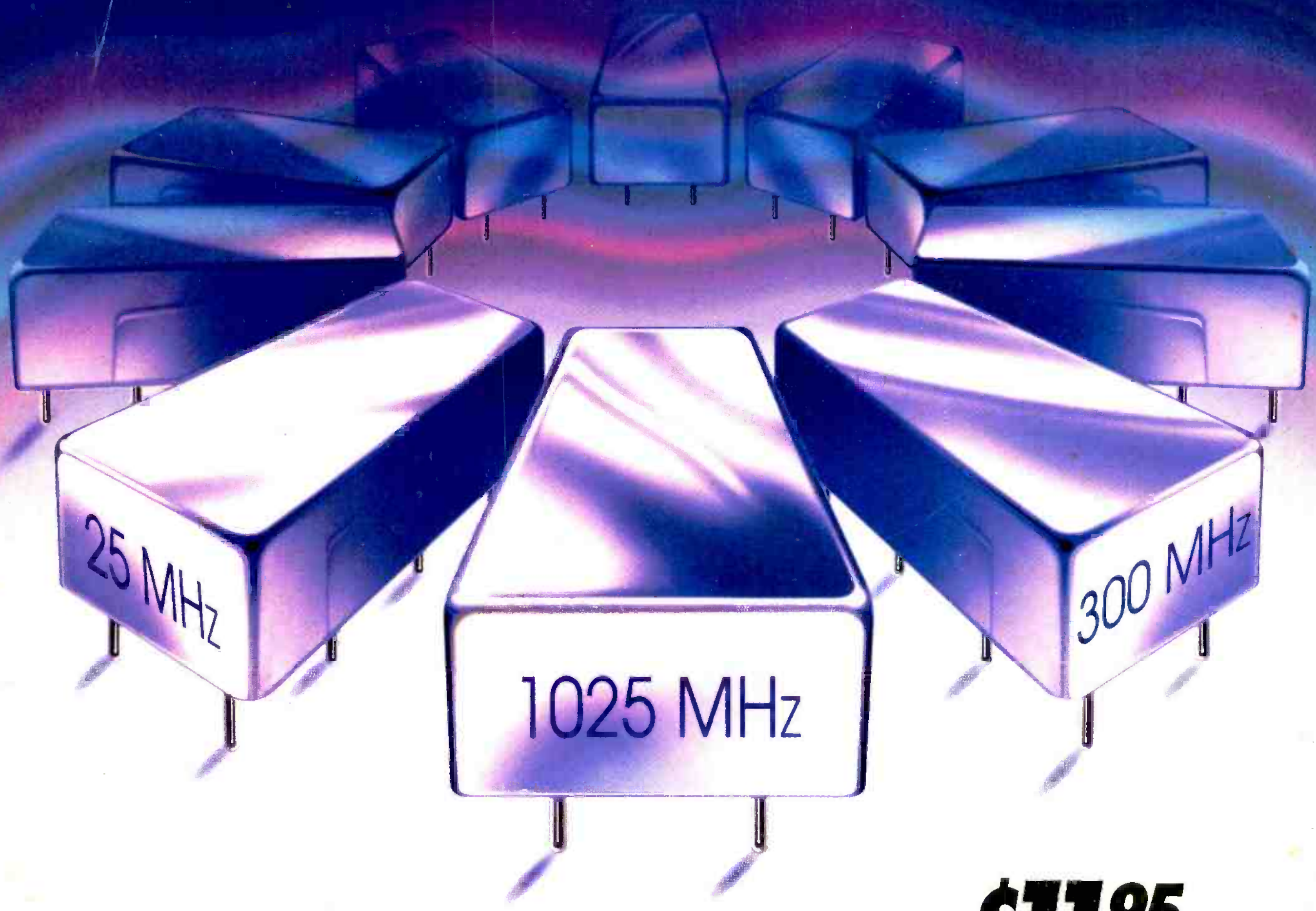

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K-POS2 $79.95(contains 1ea. all models except POS-75,-150,-300).

Model No.	Freq. Range (MHz) Min.	Phase Noise (dBc/Hz) SSB @10kHz Typ.	Harmonics (dBc) Typ.	Power 12V DC Current mA	Price (Qty.5-49) $ ea.
POS-50	25-50	-110	-19	17	11.95
POS-75	37.5-75	-110	-27	17	11.95
POS-100	50-100	-107	-23	18	11.95
POS-150	75-150	-103	-23	18	11.95
POS-200	100-200	-102	-24	18	11.95
POS-300	150-280	-100	-30	18	13.95
POS-400	200-380	-98	-28	18	13.95
POS-535	300-525	-93	-26	18	13.95
POS-765	485-765	-85	-21	22	14.95
POS-1025	685-1025	-84	-23	22	16.95

Notes: Tuning voltage 1 to 16V required to cover freq. range.
Operating temperature range: - 55°C to +85°C.

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