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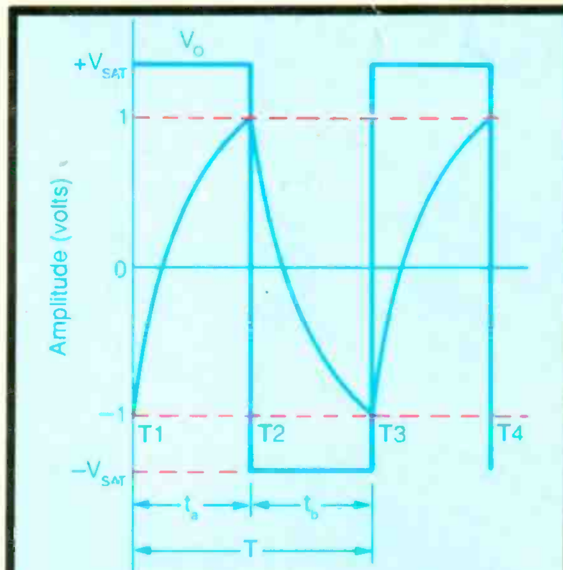
MODERN ELECTRONICS™

THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

AC LINE MONITOR

Warns When Volts & Frequency Are Beyond Preset Tolerances



Designing Square-Wave Generators (p. 32)

FONE MATE

Computerized Accessory Adds 6 Functions to Phone System

Also Featured:

- **Theory & Practice of Designing Square-Wave Generators**
- **Interfacing a VicModem to Any Computer RS-232 Serial Port**
- **High-Power Visible LEDs**

AC Line Monitor (p. 14)

Fone Mate Accessory (p. 22)

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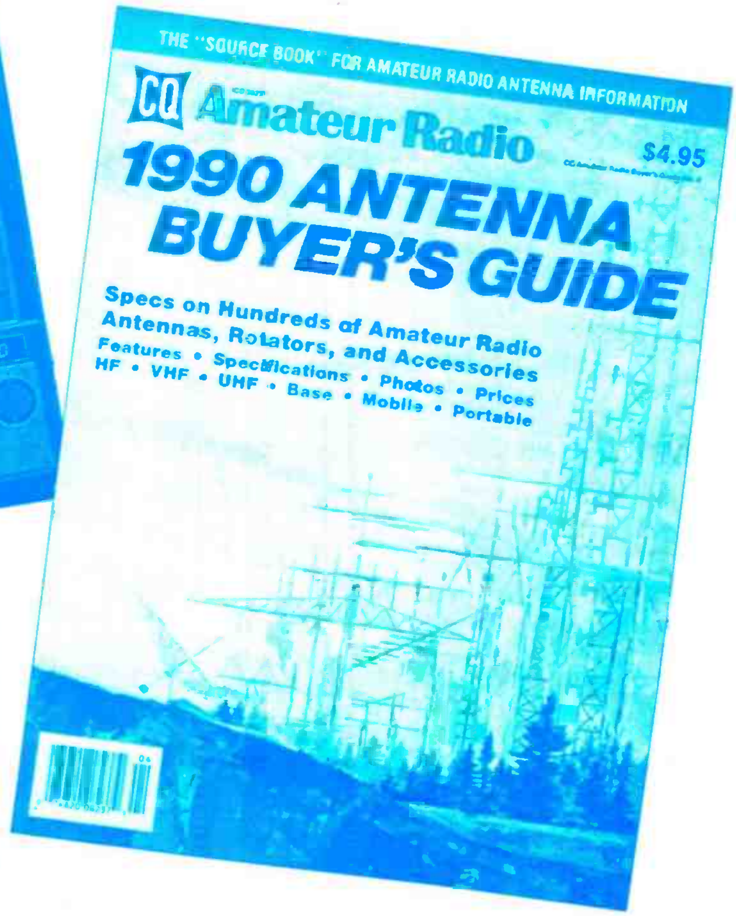

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MODERN ELECTRONICS

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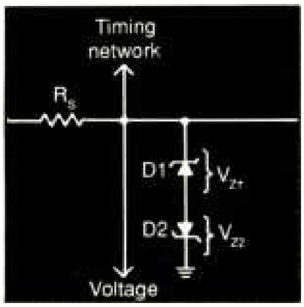
JULY 1990 VOLUME 7, NUMBER 7



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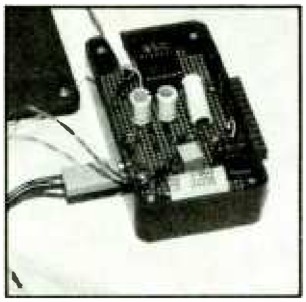

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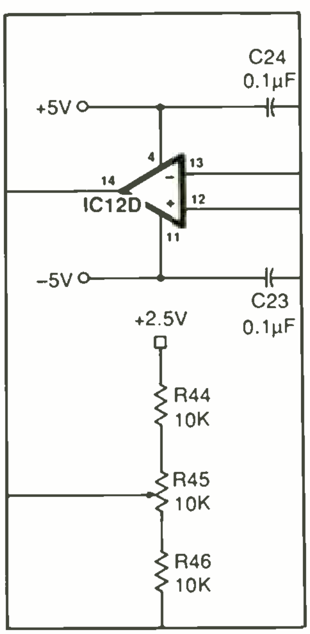

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EDITORIAL

On The Waning Edge

Some publications focus on the leading edge of technology, whether it's news or technical coverage. We touch on this, too, from time to time. But much of our editorial thrust uses an electronics platform on the *waning* edge of technology.

We're quite proud of this, too. The applications-oriented nature of *Modern Electronics* takes advantage of electronic components that are mostly readily available from a variety of sources and are modestly priced. In contrast, the leading edge relates to either devices that are still in the laboratory stage and, therefore, not accessible to most people or recently developed components that are quite costly in single or low-volume quantities. Moreover, some cannot even be purchased without a corporate purchase order for high quantities.

Consequently, the ubiquitous 555 integrated circuit or a 741 op amp or an 8088 CPU aren't at all beneath us. The circuit in which they are used plays the most important part, not the fact that they might take up a bit more real estate on a pc board or not operate quite as fast as a more sophisticated device can.

Interestingly, such electronic products have a life span that far exceeds what one might think. Decades, in fact. Even the military, where so many leading-edge research and developments head, make wide use of obsolete products. That is, obsolete in terms of incorporating them into the latest equipment.

This fact was underscored to me recently when I learned that a company, Lansdale Semiconductor (Tempe, AZ), started to market Intel's 8080 eight-bit microprocessor, joining other devices that are thought of as only a history-book part, to the military market. When you think about it, it makes sense. After all, there is much military equipment being used that came to life ten and more years ago. When a small circuit device that's no longer supported by a manufacturer breaks down it would be foolish to dump the whole machine. Clearly, there's a market for such useful devices, though they're no longer state-of-the-art ones. Lansdale Semi expects to do $10-million worth of business this year in just such old-design semiconductors.

The 8080 kicked off the personal computer revolution, of course, with the MITS Altair computer that I featured on a magazine's cover with plans inside on how to build it, cheap. The entire kit cost about the same as the single device was being sold for at the time: $365. Today, its price is around $4 in single quantities from mail-order supply houses.

The computer was the launching pad for many illustrious careers. Readers whose imaginations were sparked by it include: Bill Gates, who with Paul Allen developed Altair BASIC and went on to found Microsoft; Millard, who produced a virtual replica of the Altair under the name, IMSAI, when he couldn't get delivery of Altairs to meet his customers' needs, and then founded Computerland; Lee Felstenstein, who with Bob Marsh, created an all-in-one computer system called the Sol, and later designed the first transportable computer, disk drives and all, the Osborne; Steve Jobs and Wozniak, who used a less costly CPU, the 6502, to do their thing called an Apple computer; and so on.

This all brings to mind a day last weekend that I spent with another electronics/computer innovator, George Meyerle. Many years ago he had developed the first consumer audio graphic equalizer, a five-bander, which was published as a construction project. A giant company bought him out and he worked for them for a few years. When his contract period ended, he reappeared and asked, "What's new?" My technical editor, Les Solomon, took him for a walk a few blocks away from our New York offices to visit what was one of the first computer stores, in the back of Polk's Hobby Shop, and introduced him to its owner, Stan Veit, from whom he bought a Sol computer. Some time later, Stan joined my editorial staff and subsequently became editor and publisher of *Computer Shopper*, helping

(Continued on page 80)

LETTERS

Part Source Missing

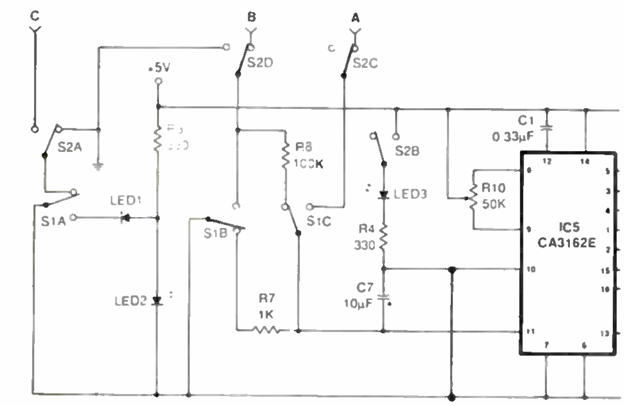
• The "Big Score" counter display featured in the March issue shows a bargraph-type display in the photos and references it in the text, but no part number was given in the Parts List of an otherwise excellent article. Please help.

William D. McMurray
Cary, NC

Just about any 10-element LED bargraph display that permits series connection of all elements, such as the Radio Shack Cat. No. 276-081 ($2.99), can be used. Alternatively, if you need longer segments than such displays provide, you can simply connect 10 discrete LEDs in series with each other for each segment, spacing them as needed.—Ed.

Switching Erratum

• There seems to be an error in the switching arrangement for the "Dual-Polarity Power Supply" in the March 1990 issue. With



S2A, *S2C* and *S2D* open with respect to the power supply as shown, there is no input. How can the circuit work?

Chuck Hall
Florence, MT

You're correct about the switching arrangement error. The correct configuration of the affected circuit portion is shown here.—Ed.

Adding ZIP

• I would like to commend you on a fine magazine. In the Parts List of "A precision Thermocouple Thermometer" (December 1989), was given the name and address of where one can send for a kit of parts. Unfortunately, the ZIP code was left out of the address. Could you please supply the missing ZIP code so that I can purchase this kit?

David R. Selinger
Regina, Saskatchewan, Canada

The full address is: Collins Aviation, 72 Long Point Dr., Brick, NJ 08723.—Ed.

Label Dilemma

• Your fine publication could stand one more innovation! More than a small irritant to me is the mailing label posted over pertinent information printed on the front cover of *Modern Electronics*. How about using easily removable labels?

J.D. Knight
Waterloo, IA

It's now being done.—Ed.

COUNTERFEIT NINTENDO CARTRIDGES. Nintendo of America Inc. implemented an international campaign against video rental and other retail outlets, distributors and importers who rent or sell counterfeit Nintendo video game cartridges for play on the Nintendo Entertainment System. A host of lawsuits have already been initiated. The most common type of counterfeit Nintendo cartridges are about half the size of legitimate cartridges and require an adapter for playing on the NES. Moreover, the cartridges contain multiple games, which legitimate ones don't.

ON-LINE INFO SERVICE EXPANDS. GE Information Services' GEnie on-line information service added an IBM product support roundtable for vendors of IBM PC and compatible software and support services. Each participating vendor will have a dedicated bulletin board area where messages will be posted covering news and rumors as well as tech questions and answers by all members. Each vendor will also have a software library for product announcements, technical and application notes and bug fixes, all of which will be available for downloading. For more information, call 1-800-638-9636.

INTELLECTUAL PROPERTY PRIMER. An easy-to-read 76-page guide to patent law is available free in celebration of the 200th anniversary of the U.S. Patent system by Brooks & Kushman, specialists in intellectual property law. It can benefit anyone involved in technology development, such as computer microcode, semiconductor chip design, etc. Call 313-358-4400.

COMPACT VHS CASSETTE UPS RECORDING TIME. Panasonic introduced a 30-minute Super VHS-Compact videotape for camcorder owners, which has 50% more recording time than most VHS-C videotapes. In extended-play mode, it can record for up to 1-1/2 hours.

FAVORITE PHOTOS ON COMPUTER SCREENS. Some company computer monitors picture their logo on the screen whenever the computer is idle. This idea has been extended by Integrated Concepts (139 Village Drive, Redding, CA 96001). Its software process let's you display any photo, whether it's your wife, children or whomever or whatever on a VGA monitor; color or black-and-white. To accomplish this, you send in your photo to the company, which digitally translates it onto a database, and sends you back a diskette and simple instructions for loading the program. It costs $19.95. ("Adult" stuff and copyrighted images without permission are not accepted.)

MAC PORTABLE COLOR SOLUTION. Aura Systems, Carlsbad, CA, has introduced a self-contained color video card for the Macintosh portable that connects externally to the computer's SCSI bus. It's reported that virtually any color monitor with a minimum resolution of 640 x 480 pixels, digital or analog signal type, can be used to substitute for the portable's LCD screen. The color device, called a ScuzzyGraph, uses an intelligent SCSI controller with two microprocessors, and is about the size of an external disk drive, so can be easily transported. Nothing has to be added to the Mac itself except for loading of a small INIT file. The color adapter can also be used with other monochrome MAC models, it's said. Prices start at $995.

For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.

Rugged, Water-Resistant Hand-Held DMM

A new hand-held digital multimeter designed to bear up to the rigors of field service and general industrial applications is available from B&K-Precision. Called the Survivor™, the Model 2860 offers drop (rated to survive a 5-ft. fall), water and overload resistance. It features an oversized

0.8" LCD display, fused overload protection and bright easy-to-see yellow safety case.

For quick circuit tests, an audible beeper indicates continuity. Easy to operate, the 2860 has a single function/range selector switch. Auto Power Off disables power to the meter after a preset period of time during which no measurements have been made to conserve battery power. Diode junctions are tested with a maximum current of 1.5 mA and maximum open-circuit potential of 3.2 volts. Results of such tests are indicated in the LCD display and by audible beep. A test-prod holder simplifies field tests by permitting the user to hold the meter and prod in one hand.

Technical specifications: dc measurement to 1,000 volts full-scale in dc with 0.5% accuracy and 2 amperes basic (20 amperes extended); ac measurement to 750 volts full-scale with accuracy of 1.25% from 40 to 500 Hz and 2 amperes basic (20 amperes extended); measurement to 20 megohms. $99.

CIRCLE NO. 126 ON FREE INFORMATION CARD

VHF Marine Transceiver

The Model MTX-101 from Radio Shack is for ship-to-ship and ship-to-shore (radiotelephone and Coast Guard) communication. This unit provides 54 transmit channels and 99 receive channels, including nine designated weather channels, and dual

output power settings. A 1-watt setting can be used for normal communication, while a 25-watt setting can be used for emergency and long-distance communication. The transceiver also provides communication on all international channels.

Among the features included in this transceiver are: frequency-synthesized PLL tuning circuitry; adjustable squelch control; emergency channel 16 button; large digital numeric display with dimmer; built-in 3" speaker; jack for adding an external speaker; and universal mounting bracket. $229.95.

CIRCLE NO. 127 ON FREE INFORMATION CARD

Hacker Protector

The Model 232MSD modem security device from B&B Electronics (Ottawa, IL) is designed to help protect

computers and private bulletin boards from hackers and computer viruses. It uses the call-back method that requires a user to have the proper password and also be located at the correct telephone number.

This device works with most stand-alone modems that are AT command set-compatible. When a caller reaches the protected system's modem, the MSD intercepts the call and asks for the password. Upon receipt of a valid password, the MSD waits for the caller to hang up and then calls the phone number stored in its memory tagged with the password. If someone else uses the password, he will be unable to use it because the calling phone will not have the correct number in memory.

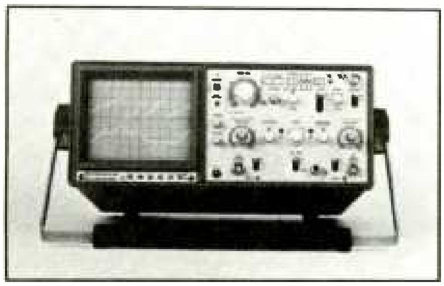
The 232SMD features: 50-number directory of password/number combinations; capability for the system manager to give a user password access without call-back; no blocking of calls originating at the protected computer; passwords and phone numbers stored in EEPROM for protection against loss due to power outage; locally accessible password/phone number editor; automatic baud-rate selection (110, 150, 300, 600, 1,200 and 2,400). Connection to and from the MSD is via cables terminated in DB-25 male connectors. $129.95.

CIRCLE NO. 128 ON FREE INFORMATION CARD

Low-Cost Digital Storage Scope

Hitachi's new Model VC-6023 two-channel digital storage oscilloscope is said to provide features and familiarity of lower-cost analog scopes with the power of digital instruments. It features 20-Ms/sec sampling, eight bits of resolution, a 20-MHz digital bandwidth and 2K of memory for single-shot and repetitive waveform acquisition.

Averaging can be performed 4, 16, 64 or 256 times to extract signals from noise. Roll-mode sampling permits observation of low-speed phenomena that appears as a moving dot on the CRT of a conventional oscilloscope. Other features include pretriggering, cursors, readout, digital signal processing, channel 1 output and save reference memory. Built into the VC-6023 is also an RS-232 interface for making HPGL four-color plots and waveform data transfer to a personal computer.



The scope has a 6" screen with internal graticule, 5-volt sensitivity and dc to 2 MHz frequency range. Also, an adjustable handle doubles as a tilt stand for benchtop use. It comes with two probes; measures 14.6 × 12.2" × 5.1" and weighs 17.6 lbs. $1,995.

CIRCLE NO. 129 ON FREE INFORMATION CARD

Computer Color Printer

Advanced features like Command-Vue II™ front-panel control, Color On Command™ for outputting up to seven colors and superior paper handling are available on the Citizen America Corp. Model 200GX nine-pin printer. Delivering 213 cps printing in high-speed draft mode at 10 cpi, the printer is speedy for an economy model. It provides near-letter-quality (NLQ) at 40 cps.

Command-Vue II provides plain-English front-panel control with a menu slide switch that permits selection from more than 25 printer functions, including color, pitch, five resident fonts and top-of-form adjust-

Auto-Scan Car Stereo

Using ID Logic™, Technics' new Model CQ-ID90 car stereo receiver automatically scans the airwaves to seek out music broadcasts while on the road. Stored inside the ID Logic unit is data for more than 4,500 AM and 4,900 FM stations from more than 5,100 U.S. cities. In addition to storing these frequencies, the ID Logic circuitry displays the call letters, city and state of origin and programming format for any tuned station. Hence, the user can tell the receiver to tune into rock, jazz, easy listening, country and western, classical or all-talk stations in any given location in the U.S.

With the touch of a directional button on the radio approximately every 60 miles, ID Logic automatically locks onto the six strongest stations in the preselected programming format. As travel continues, ID Logic continuously finds the strongest stations to keep an uninterrupted flow of music coming in. If the user wishes to change from one format to another, this can be done at the touch of a single button. To eliminate the clutter of all small stations that operate across the country, the ID Logic system stores only those stations that broadcast with 1,000 watts or more of power.

Stations can also be tuned manually by this car stereo/cassette player combination. Keeping in tune with the state of the art, the CQ-ID90 has a jack on its rear panel to accommodate a car CD player.

The DIN-size receiver features six regular and six ID Logic presets in AM and 12 regular and 12 ID Logic presets for FM. Included are a seek mode, preset scan mode and automatic store. Maximum output power is rated at 25 watts per channel. FM Optimizer and Noise Impulse Quieting functions are built in to assure a strong, crisp signal under varying reception conditions.

A full-logic cassette deck rounds out the CQ-ID90's features. This player features motorized loading and automatic door shutting. It also offers programmable Tape Program Search, Repeat mode and blank tape skipping. A double-cut, narrow-gap head is said to minimize tape wear. Finally, a key-off/pinch-roller-off function lifts the pinch rollers from the tape when the car's ignition is turned off with the cassette still inside the radio.

General features include separate treble and bass tone controls, a prefader to facilitate additional amplifiers, an attenuator, and a tri-color LCD display along the bottom of the radio that shows the three modes (Tuner, ID Logic and Cassette). A service-facility-installed replacement ROM chip updates the CQ-ID90 when radio stations change frequency, call letters and/or programming format. $799.

CIRCLE NO. 130 ON FREE INFORMATION CARD

ment. Paper parking permits switching between continuous-form and single-sheet paper. A convertible

push/pull tractor is complemented by rear and bottom paper-feed slots.

Micro-adjustable top-of-form feature permits precise adjustment of the first printing position as needed. Continuous paper tear-off automatically advances a form to the tear bar for easy removal and then returns to the top of the next form.

Available options include devices that enhance the paper-handling capabilities: automatic sheet feeder ($169) that feeds up to 110 sheets of letterhead and a manual feeder ($59) that complements paper parking. $299.

CIRCLE NO. 131 ON FREE INFORMATION CARD

Soldering Iron Tip Thermometer

The Hakko Model 191B temperature meter for soldering iron tips is easy to use. Touching a hot soldering iron tip to the sensor while applying constant pressure causes the thermometer to display the temperature of the tip on

a large LCD display panel. A K-type thermocouple sensor is used to measure temperatures from 0° to +1,200° F. Coated with a special metal alloy, the sensor resists corrosion and oxidation. This thermometer meets DOD-STD-2000 and Navy Specifications WS-6536E. It comes with a 9-volt battery and 10 sensors and measures 6.3″ × 3.1″ × 1.8″ and weighs just 7 ozs.

CIRCLE NO. 132 ON FREE INFORMATION CARD

Hand-Held DMMs

John Fluke's 80 Series hand-held DMMs provide the usual voltage-, current- and resistance-measuring capabilities and add frequency, duty cycle, simultaneous minimum/maximum/average recording, MIN MAX Alert™ and Input Alert™ functions. Automotive timing measurements are handled by frequency and duty cycle capabilities, and MIN/MAX/AVERAGE recording with selectable response time permits the meters to locate intermittent failures and interference in general applications.

High accuracy, the ability to measure capacitance and a user-selectable back-lit 4½-digit (20,000-count) display in the Fluke 87 make this an ideal meter for use in electronics testing. (The display in the Fluke 85 and 83 has 3¾ digits, for a 4,000 count.) This true-rms meter features a Peak MIN MAX recording mode that captures transient events to 1 ms or sinewave plus or minus peaks to 400 Hz. Other features include a relative (zero) mode and Touch Hold® capability that generates a beep when it senses a stable reading and locks it in the display for viewing after removal of the test leads.

Input Alert warns the user when the leads are connected to the current jack in the voltage or resistance function to prevent blown fuses due to operator error. The analog display, updated 40 times per second, is a high-resolution pointer on the Fluke 87 and a bargraph with zoom mode on the Fluke 83 and 85.

Specified ac voltage response is to 5 kHz for the Fluke 83 and 20 kHz for the Fluke 85 and 87, and dc accuracy is rated at 0.03% for the Fluke 83 and 0.01% for the Fluke 85 and 87. All models are protected to 1,000 volts on the resistance and diode-test functions. All feature emi shielding and are packaged in splash- and dust-proof cases with protective holsters that include a unique flexible rubber stand that allows hanging from doors or pipes. $289, Fluke 87; $239, Fluke 85; $199, Fluke 83.

CIRCLE NO. 133 ON FREE INFORMATION CARD

100-Channel Programmable Hand-Held Receiver

Ace Communications' new Model MVT-5000 multi-band radio receiver offers 100-channel coverage with continuous frequency coverage from 25 to 550 MHz and 800 to 1,300 MHz in a compact hand-held unit. The frequency coverage permits reception of civil and military aviation bands plus all public service bands. AM or narrow-band FM mode is selectable at any frequency.

Twenty front-panel keys permit programming of 100 total scan memory channels. Pairs of upper and lower limits for bands can be searched and be stored in 10 separate search memory locations. All information is stored in RAM that is backed up by its own separate long-life lithium battery. Other features include: selectable single channel priority, key-

board lockout, BNC antenna connector, and display backlight for night use. An LCD display window provides 22 separate prompting annunciators. An energy-saving sleep mode is provided for shutting down, via an internal computer chip, all operating circuits and displaying "sleep" on the display, powering up only periodically to check for active transmissions.

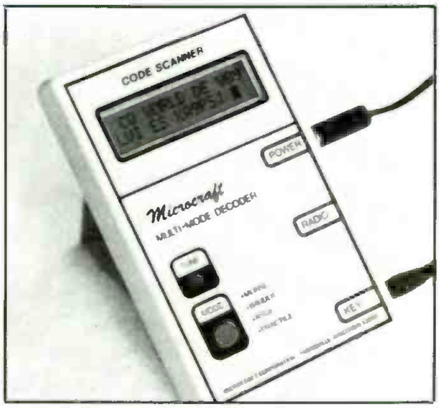
Sensitivity is rated at better than 0.4 microvolt at 12 dB SINAD in narrow-band FM mode and 1.0 microvolt at 10 dB S/N in AM mode.

Included with the radio are a 117-volt ac adapter/battery charger that is fused for dc operation from a vehicle's cigarette-lighter receptacle, a telescoping antenna, carrying case and rechargeable AA cells. The receiver measures 7"H × 2½"W × 1½"D and weighs just 13 ounces. $499.

CIRCLE NO. 134 ON FREE INFORMATION CARD

Multi-Mode Decoder

Microcraft Corp. (Thiensville, WI) has a new 2-line, 32-character multimode decoder that copies Morse, Baudot and ASCII codes from radio transmissions. The Code Scanner features a built-in code practice oscillator for hand-key readout to the display, built-in speaker, analog and digital filtering with – 16-dB agc and



a special practice mode for learning Morse characters.

Measuring just 5¾" × 3½", Code Scanner can be placed almost anywhere within reach on the user's station table. It operates from 12 volts dc or 117 volts ac, the latter through an adapter provided with the unit. Hookup is easily accomplished to the speaker terminals or headphones jack of the receiver or transceiver with which Code Scanner is used.

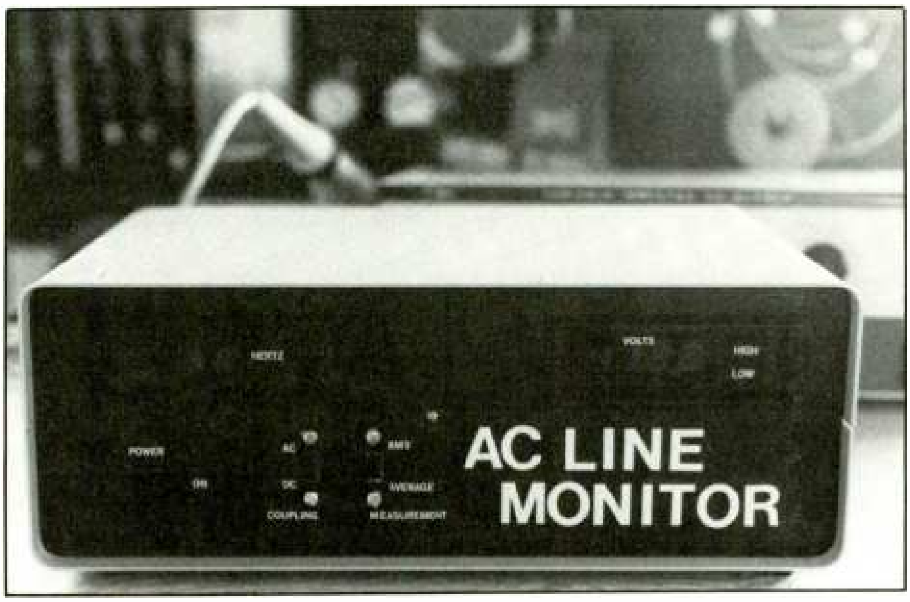
Code Scanner has two optimized Morse ranges. It features automatic speed tracking between 3 and 70 wpm; Morse alphabet in practice mode; and tuning LED. $189 + $5 P&H.

CIRCLE NO. 135 ON FREE INFORMATION CARD

AC Line Monitor

A sophisticated device alerts you when ac line voltage and frequency conditions are detrimental to the health of your computer and other sensitive electrical equipment

By Thomas R. Fox



The quality of power available at a typical ac outlet is far from ideal for computers and other sensitive electronic equipment. Though the waveform on the ac line is rated to be at 117 volts ac rms at 60 Hz, a multitude of periodic effects can raise and lower the actual voltage and cause the frequency to deviate from the ideal.

Typically, there may appear on the ac line thousands of short-duration high-voltage spikes, hundreds of long-duration voltage sags and even several complete blackouts in any given year. None of these is beneficial to computers and other sensitive equipment, and a few are actually capable of physically damaging this equipment.

The AC Line Monitor described here will not correct problems on the ac line, but it will allow you to determine if a problem exists by visually and audibly alerting you to conditions that fall outside set limits for amplitude and frequency of the voltage at an ac outlet. With this Monitor, you can even sometimes predict the onset of a potentially damaging condition so that you can power down in an orderly manner before the condition becomes full-blown.

Our AC Line Monitor constantly samples the condition of the ac line into which it is plugged. It provides numeric display of true rms or average ac line voltage. Warning LEDs and a piezoelectric buzzer alert you when the voltage rises above or drops below preset levels. The LEDs light and buzzer sounds when the Monitor detects brief voltage sags and drops that would normally go unnoticed.

Problems Defined

According to expert Mark Waller, author of several books on the subject, " . . . the quality of [ac-line] power has steadily decreased over the last 10 years and as often as twice a day, one may experience an electrical disturbance that falls outside a typical computer's acceptable limits." Emerson Computer Power adds that a typical computer site experiences about 2,000 high-voltage spikes and surges, more than 500 voltage sags and about seven complete blackouts in a year!

Ideally, an ac outlet should provide 117 volts rms ac at a frequency of 60 Hz. While frequency is usually held to within ±0.01 Hz, average voltage often varies from 120 volts down to about 105 volts—and even less. Harmful high voltages usually last for only short periods of time, about 1 second or less. However, potentials of less than 105 volts are often persistent and are normally caused by inadequacies in the wiring in a home, apartment or commercial building.

Relatively long-term voltage sags are not normally the fault of the local utility power company. However, the utility company can be the cause of such a situation during planned brownouts and peak-usage periods, such as during a hot spell when heavy use of air conditioning strains the company's ability to deliver adequate power.

While the ac-line rms potential

rarely exceeds a steady 117 volts, voltage spikes with amplitudes that are 5 to 10 times this level sometimes occur and can wreak havoc on unprotected electronic equipment. Causes for spiking are many, including lightning strikes, failure of utility company equipment, switching on and off heavy-duty motors, etc. Such spikes usually last only microseconds. Thus, a good surge protector can generally handle these short-duration spikes and provide adequate protection for sensitive equipment.

Voltage surges are potentially more damaging and dangerous because they last for much longer periods of time. Few surge protectors can provide complete protection against the worst of these power-line problems.

Surges are caused by much the same conditions responsible for high-voltage spikes. Some of the worst surges are the result of a high-voltage distribution conductor falling on a 240-volt customer line. Super surges that result from this can "fry" any electronic equipment connected to the line through no surge protector or an inadequately designed one. Although a super surge protector may self-destruct during such a hazardous condition, it often protects the equipment it was there to prevent from coming to harm.

Another problem, especially for computer users, are 0.5- to 2-second blackouts that occur randomly and with increasing frequency throughout a given year. If you are working on a lengthy report, writing a long letter, etc., and have not recently saved your work, even this short an interruption in ac line power will wipe out all your work since the last time you saved your work.

Still another problem is low ac-line voltage. Most electric motors are less efficient at reduced voltage. This inefficiency makes itself apparent as heating of the motor that, under certain conditions, can permanently damage the motor.

Though the AC Line Monitor described here will not correct problems encountered on an ac line, it will alert you to an out-of-tolerance condition so that you can decide if a problem is serious enough to take remedial action. By keeping a watchful eye on the Monitor, it is sometimes possible to predict the onset of a problem on the ac line and save files to disk and power down in an orderly manner computers and other sensitive equipment.

This project is especially useful (actually, practically indispensable) when utility company ac power fails and you are running on back-up power from a generator, standby power system (SPS) or full-blown uninterruptible power system (UPS).

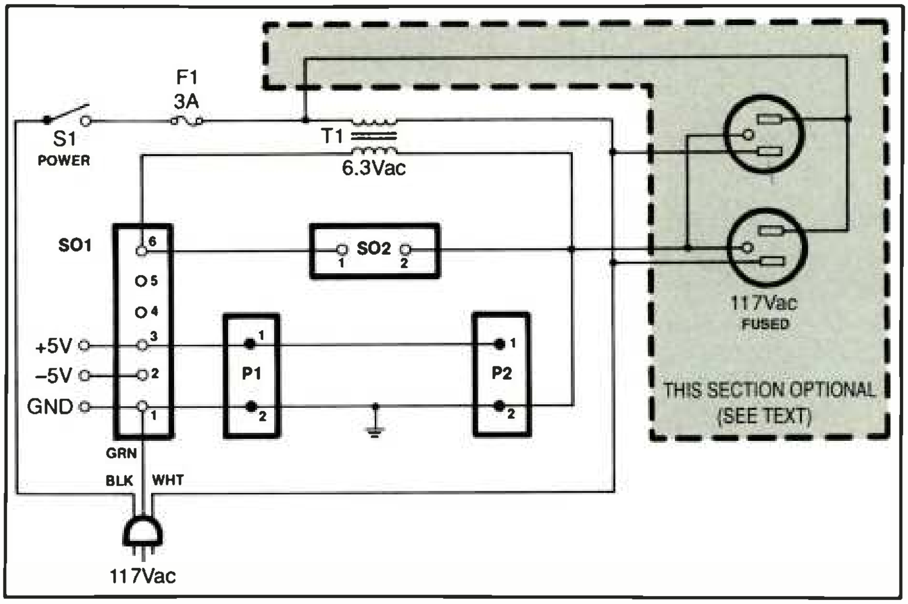


Fig. 1. Wiring diagram for power transformer and ac signal/dc power distribution to rest of project. Power supply can be built from scratch, or a ready-to-use power-supply module can be wired into circuit as shown. Ac receptacles shown at right are optional.

About the Circuit

This AC Line Monitor has a two-digit crystal-controlled frequency counter with separate overrange indication. This counter is especially important if you are using a back-up power system. Quality rather than quantity of power is sometimes more important. With this project, you can estimate the quality of the back-up system by monitoring the frequency and switching the measurement mode between rms and average. If the waveform is not a perfect sinusoid, the rms and average voltages should differ by more than 0.5 volt. The greater the voltage difference, the more the waveform differs from a true sinusoid. (When the project is set to indicate average ac voltage, the display actually shows 1.11 times the average voltage. For a perfect sinusoid waveform, this is the same as rms voltage.)

This is a fairly complex project. Therefore, to adequately describe how it works, the circuitry for it is broken down here into a series of function sections.

Input to the frequency-counter section comes from the circuit shown in Fig. 1. This input consists of the 6.3 volts at the secondary of power transformer *T1* and is applied to the bridge rectifier consisting of *D1* through *D4*, shown at the top of Fig. 2. This produces a train of positive

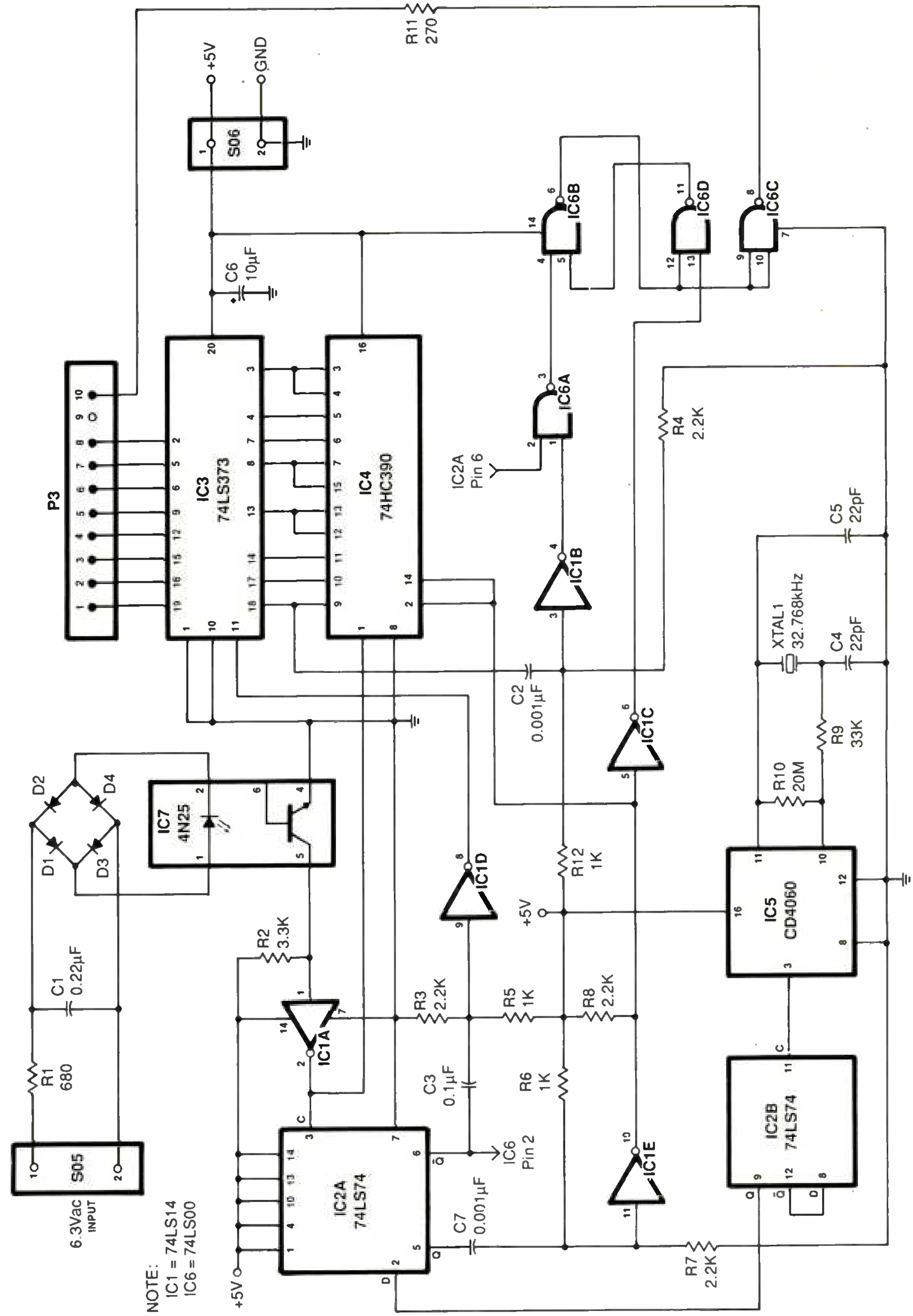


Fig. 2. Schematic diagram of line frequency-counting section of project.

half-sine waves with a repetition rate of 120 Hz (twice that of the ac-line frequency fed to the Fig. 1 circuit).

The pulse train developed by the bridge rectifier drives the internal LED of optical isolator *IC7* through current-limiting resistor *R1*. The output at pin 5 of *IC7* is passed through Schmitt-trigger inverter *IC1A*, which converts the rounded waveform into a train of square waves with rapid rise and fall times.

D-type flip-flop *IC2A* receives the output from *IC1A* at CLOCK input pin 3. It synchronizes the pulse train (of uncertain frequency) with the 0.5-second crystal-controlled timing pulses delivered to pin 3 by *IC2B*.

Dual decade counter *IC4* has a wave-shaped pulse train (also of uncertain frequency) applied to its pin 1 input from the pin 2 output of *IC1A*. Octal D-type latch *IC3* temporarily holds the data delivered to it from *IC4*. Control signals for *IC3* and *IC4* are provided by *IC2A*.

To initiate operation, a short positive-going pulse is applied to the CLEAR input at pins 2 and 14 of *IC4*. This clears all eight flip-flops inside *IC4* and permits counting to start from zero. Exactly 0.5 second later, another positive-going pulse is applied to the ENABLE input to latch the *IC4* value at this instant.

As shown, plug *P3* connects the outputs of *IC3* to seven-segment decoder/drivers *IC8* and *IC9* located in the display section of the project, shown in Fig. 3. (For the following discussion, refer to both Fig. 2 and Fig. 3.) Because the data has been latched inside *IC3*, the information is invisible in displays *DISP1* and *DISP2*, even though *IC4* continues to count. The decade counters inside *IC4* are cleared in 0.5 second to start the cycle again for a new reading.

Overrange detection for this circuit is accomplished with a simple RS flip-flop made up of NAND gates *IC6B* and *IC6D*. The output of this arrangement, at pin 6 of *IC6B* is buffered by *IC6C* and then delivered to

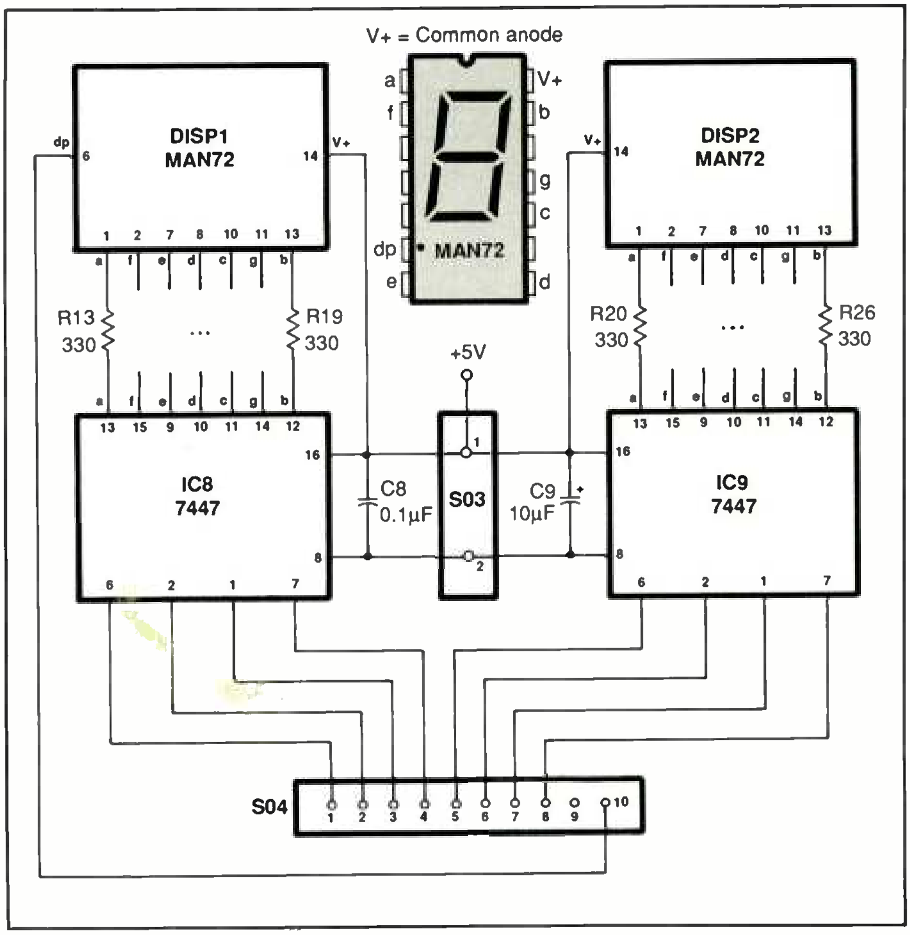


Fig. 3. Schematic diagram of display portion of frequency counting section.

the left-hand decimal point in the display through pin 10 of *P2*.

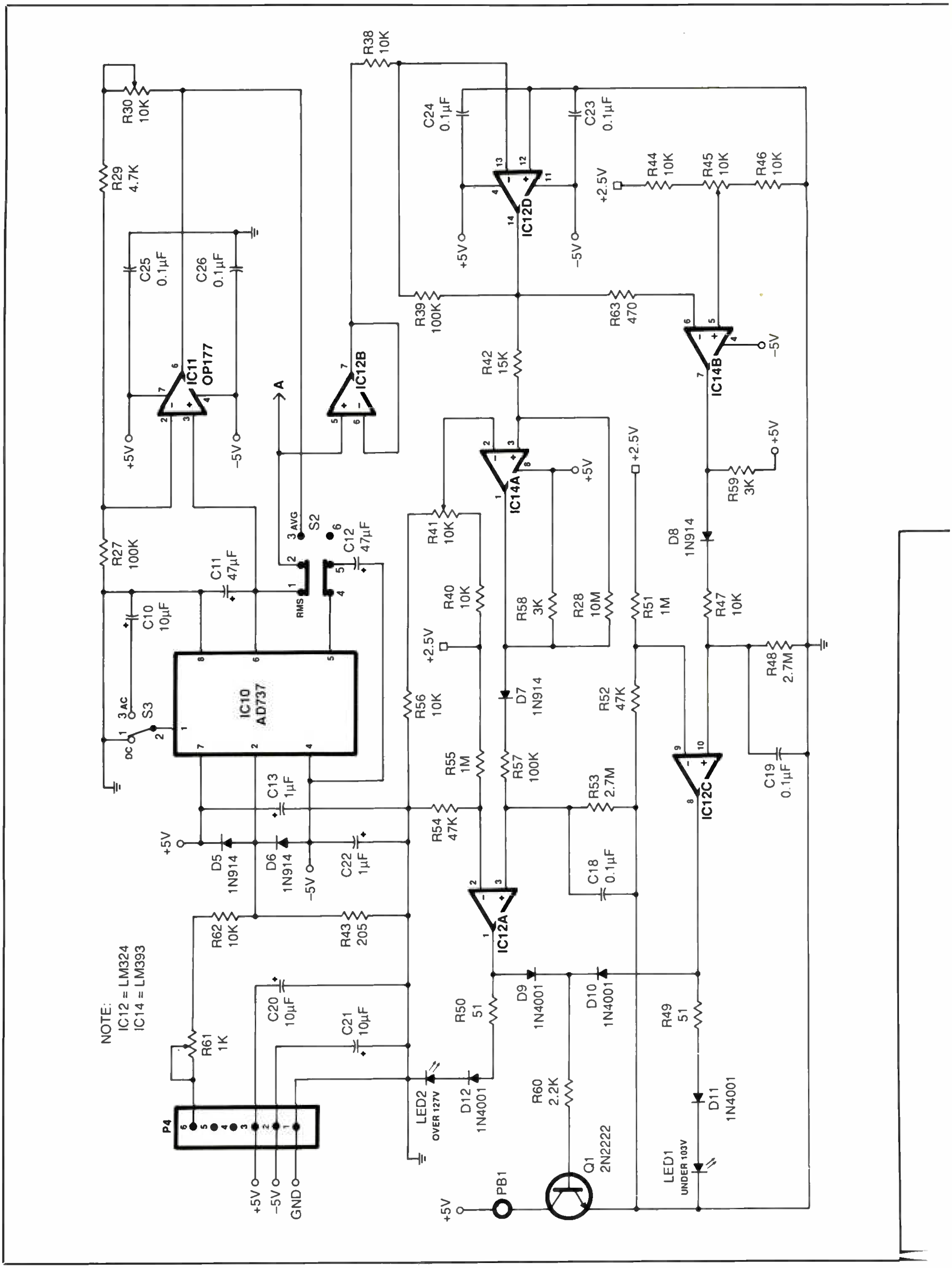
When the output of the eighth flip-flop in *IC4* goes from high to low (clears), the RS flip-flop is set, lighting the OVERRANGE decimal-point (dp) LED in *DISP1*. NAND gate *IC6A* allows only the overrange flip-flop to be set during the period between the clear pulse from *IC4* and enable pulse from *IC3*. This overrange flip-flop is cleared at the same time *IC4* is cleared.

Timing pulses are generated by 32.768-kHz crystal *XTAL1*. The starting frequency is scaled down to 2 Hz by 14-bit binary counter *IC5* and subsequently to 1 Hz by D-type flip-flop *IC2B*. The output of *IC2B* consists of a train of crystal-controlled 0.5-second positive-going pulses.

Shown in Fig. 4 is the schematic diagram for the voltage-measuring portion of the project. This circuit is greatly simplified by use of *IC13*, Intersil's 7107 voltmeter on a chip. This easy-to-use IC not only measures and generates a display of voltage, it even has a built-in voltage standard, although an external voltage reference is used in this project to assure maximum accuracy.

In this circuit, *IC15* is a 2.5-volt reference that is used by *IC13* and several other portions of the circuit. Trimmer control *R33* must be set for a 100-millivolt difference between pins 35 and 36 of *IC13* to provide a usable input range of −199.9 to +199.9 millivolts. Because pin 20 of *IC13* is not connected to any portion of the external circuit, polarity is not shown in the display.

Bear in mind that this project, as


NOTE:
IC12 = LM324
IC14 = LM393
IC10
AD737
IC11
OP177
IC12A
IC12B
IC12C
IC12D
IC14A
IC14B
R27 100K
R29 4.7K
R30 10K
R38 10K
R39 100K
R40 10K
R41 10K
R42 15K
R43 205
R44 10K
R45 10K
R46 10K
R47 10K
R48 2.7M
R49 51
R50 51
R51 1M
R52 47K
R53 2.7M
R54 47K
R55 1M
R56 10K
R57 100K
R58 3K
R28 10M
R59 3K
R60 2.2K
R61 1K
R62 10K
R63 470
C10 10µF
C11 47µF
C12 47µF
C13 1µF
C18 0.1µF
C19 0.1µF
C20 10µF
C21 10µF
C22 1µF
C23 0.1µF
C24 0.1µF
C25 0.1µF
C26 0.1µF
D5 1N914
D6 1N914
D7 1N914
D8 1N914
D9 1N4001
D10 1N4001
D11 1N4001
D12 1N4001
LED1 UNDER 103V
LED2 OVER 127V
Q1 2N2222
PB1
P4
S2
S3
RMS
AVG
AC
DC
A
+5V
–5V
+2.5V
GND

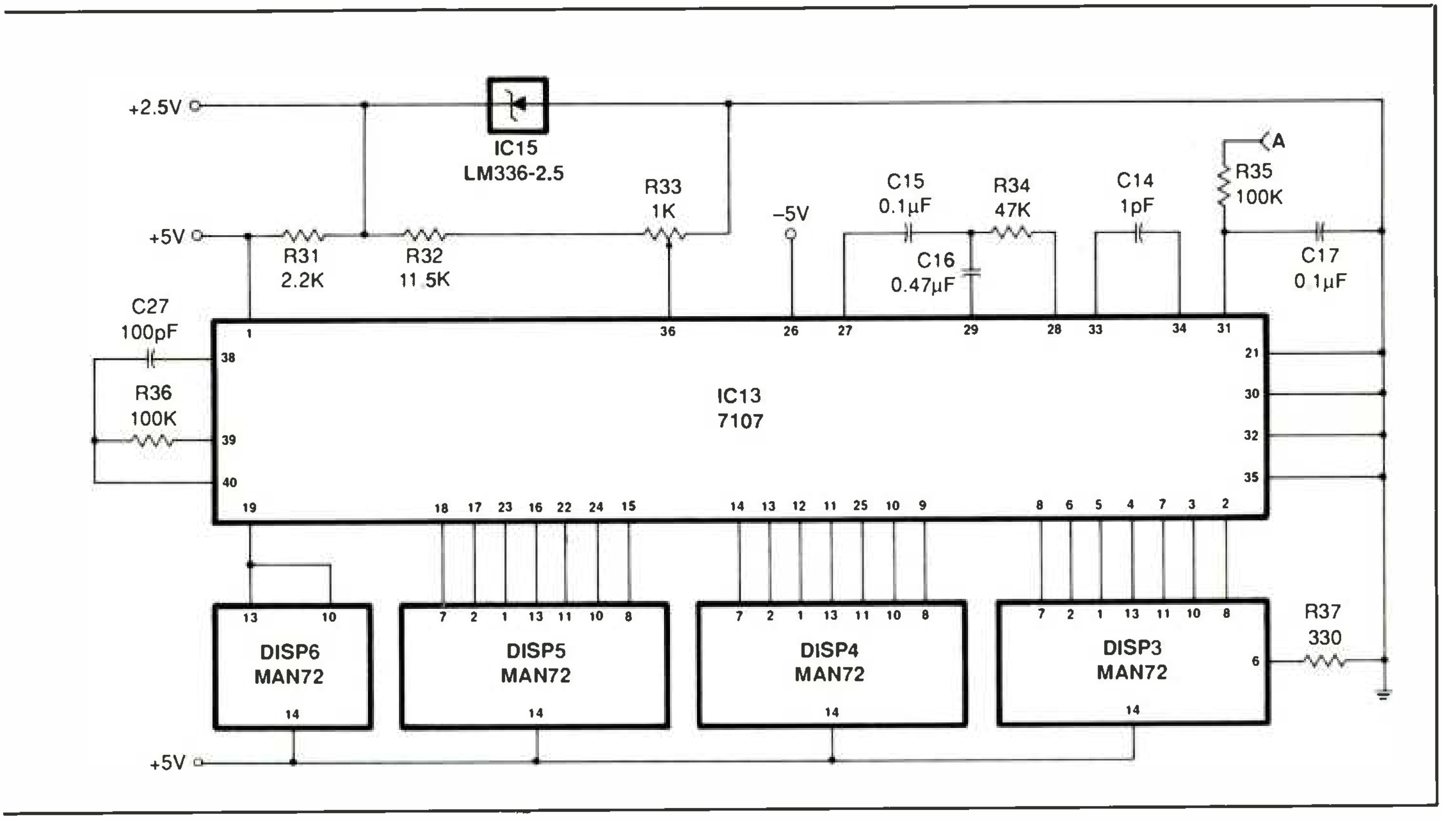


Fig. 4. Schematic diagram of voltage-measuring section, including four-decade numeric-display portion.

designed, measures ac potentials between 66 and 199 volts. Use of a 6.3-volt power transformer, shown as *T1* in Fig. 1, drops the ac line potential to a safe voltage and isolates the circuit from the ac line. This voltage is delivered to the Fig. 4 circuit via pin 6 of *SO7*. It is applied to the voltage divider composed of 1-percent precision resistors *R43* and *R62* and trimmer potentiometer *R61*.

During calibration, *R61* must be set (indirectly) so that the input to pin 2 of *IC10* rms-to-dc converter is exactly 1/1,000 that of the ac line. This chip has a rated accuracy of ±0.2 millivolts ±0.3 percent when the input is restricted to 200 millivolts rms. If no capacitor is connected between pins 4 and 5, the output voltage is the average of the ac input.

One of the oddities of the AD737 chip is that its output voltage is *less* than the common potential on pin 8. This means that if +5- and −5-volt supply rails are used, the output potential will be negative! This negative output voltage results because, for maximum accuracy, the output of the chip is taken directly from its core. No inverting output buffer is used because it would add offset error.

With no output buffer, the output of the AD737 must be connected to high-input-impedance circuits, such as a voltage follower, noninverting amplifier, etc. (Typical input current to the 7107 used here for *IC13* is just 1 picoampere!) The fact that the output of *IC10* is negative is not important because the 7107 is just as accurate with negative as it is with positive voltages. Since no polarity is indicated in the display in this circuit, there is nothing to cause confusion.

A voltage multiplication factor of 1.11 is provided by *IC1*. Thus, for sine-wave circuits, the average voltage measurement will equal the rms voltage.

Switch *S3* is used for coupling purposes. When set to the AC position, *C9* is placed across pins 1 and 8 of *IC10* to provide ac coupling. Shorting together pins 1 and 8 of *IC10*, by setting *S3* to its DC position, results in dc coupling.

The output voltage from *IC10* or *IC11*, depending on the setting of *S2*, is buffered and then amplified by a factor of 10 before being delivered to the two voltage comparators contained inside *IC14*.

Trimmer control *R41* must be set for a potential of 1.27 volts at its wiper. When the incoming ac line potential exceeds 127 volts rms, pin 3 of *IC14A* exceeds 1.27 volts, causing pin 1 of this chip to go high and trigger *IC12A*. This causes OVER 127V light-emitting diode *LED2* to turn on and triggers buzzer *PB1* to sound.

Detection of brief voltage spikes is accomplished with the network made up of *C18*, *R53* and *D7*. The low-voltage comparator and associated circuitry performs similarly. To be detected, a spike or voltage drop must last for at least several hundredths of a second.

Dc power for the circuits in this project is provided by any ac-operated system that can deliver +5 volts at a minimum of 1.5 amperes and −5 volts at a minimum of 100 milliamperes, both regulated.

Construction

This is a moderately complex project

to build. Almost all components that make up the various sections mount on two medium-size and one small printed-circuit boards. Though you might be able to wire together the circuitry on perforated board if you are very experienced at circuit wiring, pc construction is highly recommended. It reduces the possibility of wiring errors and aids in reliable operation of the various circuits.

Fabricate your pc boards using the actual-size guides shown in Fig. 5. Guide (A) is for the frequency-counter board, guide (B) the voltage-measuring board and guide (C) the small display board. When the boards are ready, refer to the wiring diagrams given in Fig. 6 for details on where to install each component.

Begin construction by mounting the sockets for all DIP ICs, numeric displays and optical isolator on each board in the indicated locations. Do *not* install the ICs in the sockets until after preliminary voltage checks have been conducted and you are certain

PARTS LIST

Semiconductors

D1 thru D4,D9 thru D12—1N4001 or similar silicon rectifier diode

D5 thru D8—1N914 or similar silicon diode

DISP1 thru DISP6—MAN72 or equivalent common-anode seven-segment LED numeric display

IC1—74LS14 low-power Schottky Schmitt trigger

IC2—74LS72 low-power Schottky dual D-type flip-flop

IC3—74LS373 low-power Schottky octal D-type tri-state latch

IC4—74HC390 high-speed CMOS dual decade counter

IC5—CD4060 CMOS 14-stage binary counter/oscillator

IC6—74LS00 low-power Schottky quad NAND gate

IC7—4N25 optical isolator

IC8,IC9—7474 TTL BCD-to-7-segment decoder/driver

IC10—AD737 rms-to-dc converter (see Note below)

IC11—Op-177 precision operational amplifier (see Note below)

IC12—LM324 quad operational amplifier

IC13—7107 3½-decade A/D converter (Intersil)

IC14—LM393 dual comparator

IC15—LM336-2.5 precision 2.5-volt reference

LED1—Yellow jumbo light-emitting diode

LED2—Red jumbo light-emitting diode

Q1—2N2222 or similar npn general-purpose silicon transistor

Capacitors

C1—0.22-μF, 100-volt metallized polyester

C2,C7—0.001-μF, 50-volt ceramic

C3,C8,C15,C17 thru C19,C23 thru C26—0.1-μF, 50-volt ceramic

C4,C5—22-pF. 25-volt ceramic

C6,C9,C10—10-μF, 25-volt electrolytic

C11,C12,—47-μF, 25-volt electrolytic

C13,C22—1-μF, 25-volt electrolytic

C14—1-pF, 50-volt ceramic

C16—0.47-μF, 25-volt ceramic

CX,CY—0.1μF ceramic (not shown in schematics)

Resistors (¼-watt, 5% tolerance)

R1—680 ohms

R2—3,300 ohms

R3,R4,R7,R8,R31,R60—2,200 ohms

R5,R6,R12—1,000 ohms

R9—33,000 ohms

R10—20 megohms

R11—270 ohms

R13 thru R26,R37—330 ohms

R27,R35,R36,R39,R57—100,000 ohms

R28—10 megohms

R29—4,700 ohms

R32—11,500 ohms

R34,R52,R54—47,000 ohms

R38,R40,R44,R46,R47,R56,R62—10,000 ohms

R42—15,000 ohms

R43—205 ohms (1% tolerance)

R48—2.7 megohms

R49,R50—51 ohms

R51,R55—1 megohm (1% tolerance)

R53—2.7 megohms

R58,R59—3,000 ohms

R63—470 ohms

R30,R33,R41,R45—10,000-ohm multi-turn pc-mount trimmer potentiometer

R61—1,000-ohm multi-turn pc-mount trimmer potentiometer

Miscellaneous

F1—3-ampere fast-blow 3AG 250-volt fuse

P1,P2—Two-circuit AMP Mate-N-Lok plug

P3—10-pin header with pins on 0.1" centers and with pin 9 removed (mates with SO6 below)

P4—Six-circuit plug (mates with SO1 below)

PB1—5-volt dc piezoelectric buzzer

SO1—Six-circuit socket with polarizing key in socket 5 with sockets on 0.156" centers (Digi-Key Part No. 2104 or equivalent; also requires WM2301 crimp terminals. Mates with P3)

SO2,SO3,SO5,SO6—Two-circuit socket (mate with P1, P2 and P3 above)

SO4—10-circuit center crimp terminal housing (Digi-Key Part No. WM2008) with polarizing key (Digi-Key Part No. WM2400) in socket 9 (mates with P3 above)

S1—Spst slide or toggle switch

S2—Dpdt slide or toggle switch

S3—Spdt slide or toggle switch

T1—6.3-volt ac power transformer

XTAL1—32.768-kHz crystal

Printed-circuit boards; sockets for all DIP ICs; optical isolator and LED numeric displays; holder for F1; suitable power supply (see text); suitable enclosure (see text); three-conductor ac power cord with plug; chassis-mount ac receptacles and 16-gauge insulated wire (optional—see text); display board cable with connectors at both ends; display filters and bezels (optional—see text); rubber grommet; plastic cable tie; machine hardware; hookup wire; solder; etc.

Note: Sockets, plugs, connecting cables and most other components for this project are available from from Digi-Key, 701 Brooks Ave., Thief River Falls, MN 56701-0677; tel.: 1-800-344-4539. The following items are available from Magicland, 4380 S. Gordon, Fremont, MI 49412: AD737JN, $8.00; OP-177GP, $2.50; data sheets, 50¢ each; heavy-duty Coleco power supply, $25.00 (while supplies last). Add $1.00 P&H per order. Michigan residents, please add state sales tax.

that the boards have been properly wired. Wire each pc board in turn, beginning with frequency-counter board (A), proceeding to voltage-measuring board (B) and finishing with display board (C).

As you wire each board, install first the resistors and then the capacitors, diodes and any transistors. Make sure you properly polarize each electrolytic capacitor and diode and properly base the transistor before soldering any leads into place.

Next, install and solder into place the various board-mounted connectors that will be used for wiring to the power supply and interconnection among the various circuit-board assemblies. If you have any doubt as to which holes a given component is to occupy, refer to the appropriate schematic diagram in Fig. 1 through Fig. 3 for details.

The frequency-counter and voltage-measuring boards must have a number of jumper wires installed at various locations. Use insulated solid hookup wire for these jumpers.

Mount *P3* on the copper-trace (soldering) side of the frequency-counter board. All other components on this and the other two boards mount on the component sides. When mounting the two LEDs on the voltage-measuring board, first temporarily plug a numeric display into the socket for *DISP1*. Plug the two LEDs into the holes in their respective locations (observe polarity) and space them from the top surface of the board so that their domes are at the same height as the numeric display. Solder the LEDs into place.

When you are finished wiring the three circuit-board assemblies, carefully examine each. Make sure all components are mounted in their correct locations and that those that require polarization are properly oriented and based. Turn over the boards and examine your soldering. Solder any connection you might have missed and reflow the solder on any suspicious connections. If you locate any solder bridges, especially between the closely spaced pads for the IC and numeric display sockets, clear them with a vacuum-type desoldering tool or desoldering braid.

If you are building an ac-operated power supply from scratch, you can wire together the rectifier assembly, filter capacitors and regulators on a small piece of perforated board. If they are physically large, any filtering capacitors used in the power supply should be mounted on a solder-lug terminal strip and connected to the rest of the circuit via hookup wires. Use *T1* to power the supply.

In the event you decide to use the Coleco power supply specified in the Parts List, you need only make arrangements for its +5- and −5-volt outputs and ground to be connected to the three circuit-board assemblies through suitable connectors. If you go this route, you still need power transformer *T1* to provide the ac-line input drive to the frequency-counter assembly.

The only components mounted off the circuit-board assemblies, other than those for a from-scratch power supply, are the switches and power transformer.

Select an enclosure that is large enough to accommodate all assemblies that make up the project and has adequate front-panel space for the two displays, LEDs and switches. The enclosure used for the prototype (see lead photo) is a Hammond Manufacturing No. 1401P instrument case. While very attractive and superbly designed, this instrument case is quite costly at about $45 and will set you back more than the total cost of the components it is to house. Therefore, you might want to shop around for a less costly enclosure.

Machine the enclosure as needed to mount the various elements that make up the AC Line Monitor. Drill mounting holes for the circuit-board assemblies. In the floor of the enclosure, drill mounting holes for the transformer and a terminal strip for the filter capacitors if you build a power supply from scratch. Then drill a mounting hole for the fuse holder and an entry hole for the ac line cord through the rear panel. Next, drill mounting holes for the piezoelectric buzzer and switches and cut suitably sized slots for the displays on the display voltage-measuring circuit-board assemblies.

Referring back to Fig. 1, you will note that a pair of ac receptacles have been included in the schematic diagram. These are optional and can be omitted. They were included here only to restore two outlets for the single one that the project occupies in a crowded computer or other arrangement. If you decide to include these in the project, cut the slots and drill the mounting holes for them in the rear or a side panel.

Examining the lead photo, you will also note that optional decorative bezels surround both displays. If you decide to include them, these bezels are available from a number of mail-order suppliers. When you purchase them, be sure to also get the transparent red plastic filters to increase the contrast of the lighted displays.

After machining your enclosure of choice, deburr all holes and cutouts to remove rough edges. Then line the hole drilled for the ac line cord with a rubber grommet. Drill a small hole about 1 inch from the line-cord entry hole to accommodate a 4-40 machine screw. Route the line cord through the grommet and secure it to the inside of the rear wall of the enclosure with a plastic cable tie and 4-40 machine hardware to provide strain relief. Leave about 8 inches of free line cord inside the enclosure.

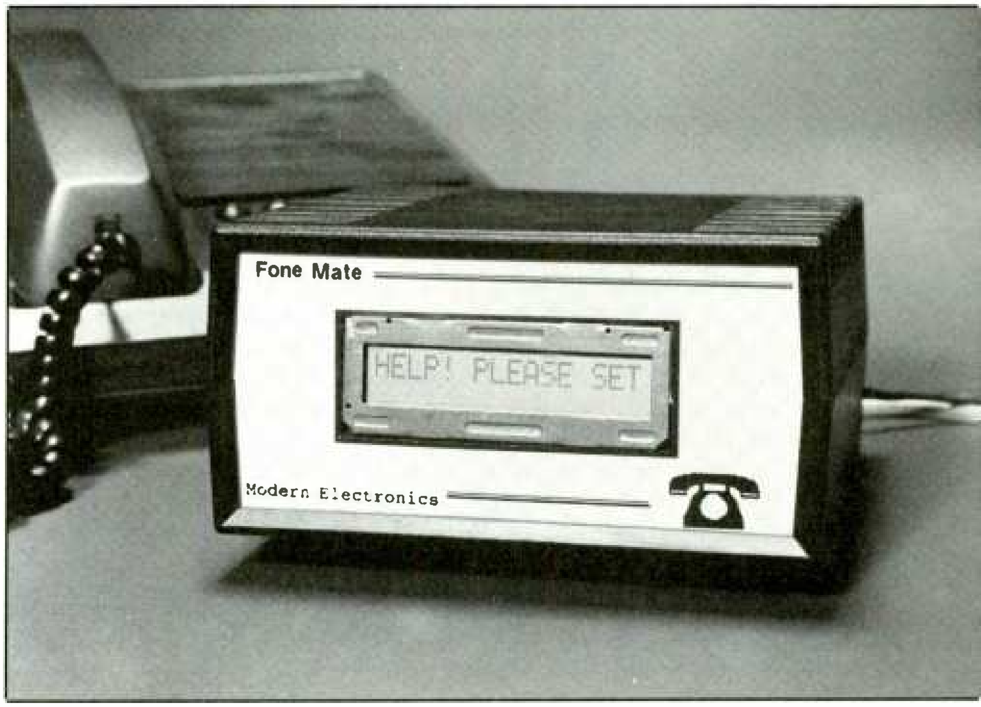
If you wish, paint the enclosure now. When the paint has completely dried, use a dry-transfer lettering kit or tape labeler to label the switches according to function and position and the displays (see lead photo). If

(Continued on page 70)

Fone Mate

This computerized telephone accessory provides hold, recall, warble-tone ringing, 12- or 24-hour clock display and dialed-digit display functions

By Steve Sokolowski



Ever since the courts put an end to AT&T's monopoly over home telephone systems, department stores have been selling telephone add-on devices. For $50 or so, you can purchase a device that places calls on "hold"; for another $50 or $60, you can add an answering machine; and the list goes on. With all these additions, before you know it, your phone takes up most of the space on your desk or phone table. Fone Mate, described here, considerably lessens the clutter.

This computerized wonder gives you five very useful telephone-enhancement devices in one compact unit. It lets you put your calls on hold. It also recalls a telephone number and sounds a pleasant electronic warble tone to alert you to incoming calls. Fone Mate also features an LCD clock that can display time in either 12- or 24-hour format, and the display shows the digits dialed as you make an outgoing call.

Features and Functions

Fone Mate makes use of Intel's 8052AH-BASIC microcontroller chip to provide a number of sophisticated functions. When properly programmed, this small slab of silicon can perform virtually any task you have in mind. In Fone Mate, the 8052's program provides five useful and practical telephone add-on features and functions.

Fone Mate was designed around a home (or office) telephone system that uses the Dual Tone Multi-Frequency (DTMF) dialing scheme. With DTMF dialing, when any given button on the phone's keypad is pressed, two frequencies that are unique to that button are generated. This frequency pair is decoded at the telephone company's Central Office back into its corresponding telephone number digit. If you wish an in-depth explanation of this process, see "The Talking Telephone" that appeared in the October 1989 issue of *Modern Electronics*. That article explained how DTMF signals are detected and decoded by a specialized G8870 integrated circuit, which also plays a central role in the Fone Mate.

The G8870 wires across the incoming telephone line. When a number is dialed, tones are generated and impressed across the line, where they are detected by the G8870 chip, which then converts them into their corresponding binary codes. This chip also delivers a 5-volt "strobe" signal every time a valid DTMF tone is received. This strobe signal and the binary output from the G8870 are applied to the 8052 computer chip. The program stored in a separate EPROM converts these two inputs into a language that can easily be understood by the user.

To translate this "computer" language into a more understandable output to the user, an LCD module is connected to the address/data lines in the Fone Mate. Every time a DTMF signal is detected by the G8870 chip, its corresponding number is decoded and displayed in the window on the module to provide visual verification of a telephone number as it is being dialed.

Whether the number you dial contains 7 or 11 digits, the EPROM's program always centers the number in the display window. The display also shows a - when needed, as in 1-800-468-1566 or 468-5687). Should you dial a wrong number, simply press the # button on the telephone instrument's keypad, which generates a unique two-frequency signal tone that the G8870 also detects. Upon detection of this signal, the G8870 tells the program in Fone Mate to branch to a "recall" subroutine within itself.

This subroutine clears the LCD display of the current phone number, displays a RECALL message and resets all internal computer variables to standby. It also causes a relay to energize and open its normally-closed contacts for about 2 seconds. The contact pair, in series with the telephone line, disconnects the Fone Mate and telephone instrument from the line. When the contacts close again, the current-flow path is restored, the Central Office re-applies a dial tone signal on the line and awaits the first digit to be dialed.

Fone Mate's hold function is not normally found in home telephone systems. Adding it to the programming for the 8052 requires only a few lines of instructions. Unlike business telephones that have a special switching arrangement to place calls on hold, however, Fone Mate uses the asterisk (*) button on the keypad of the telephone instrument.

By programming the 8052 computer chip to monitor for the tones generated when the * button, this chip can easily be programmed to supply a ground signal where needed to energize a relay whose contacts are wired

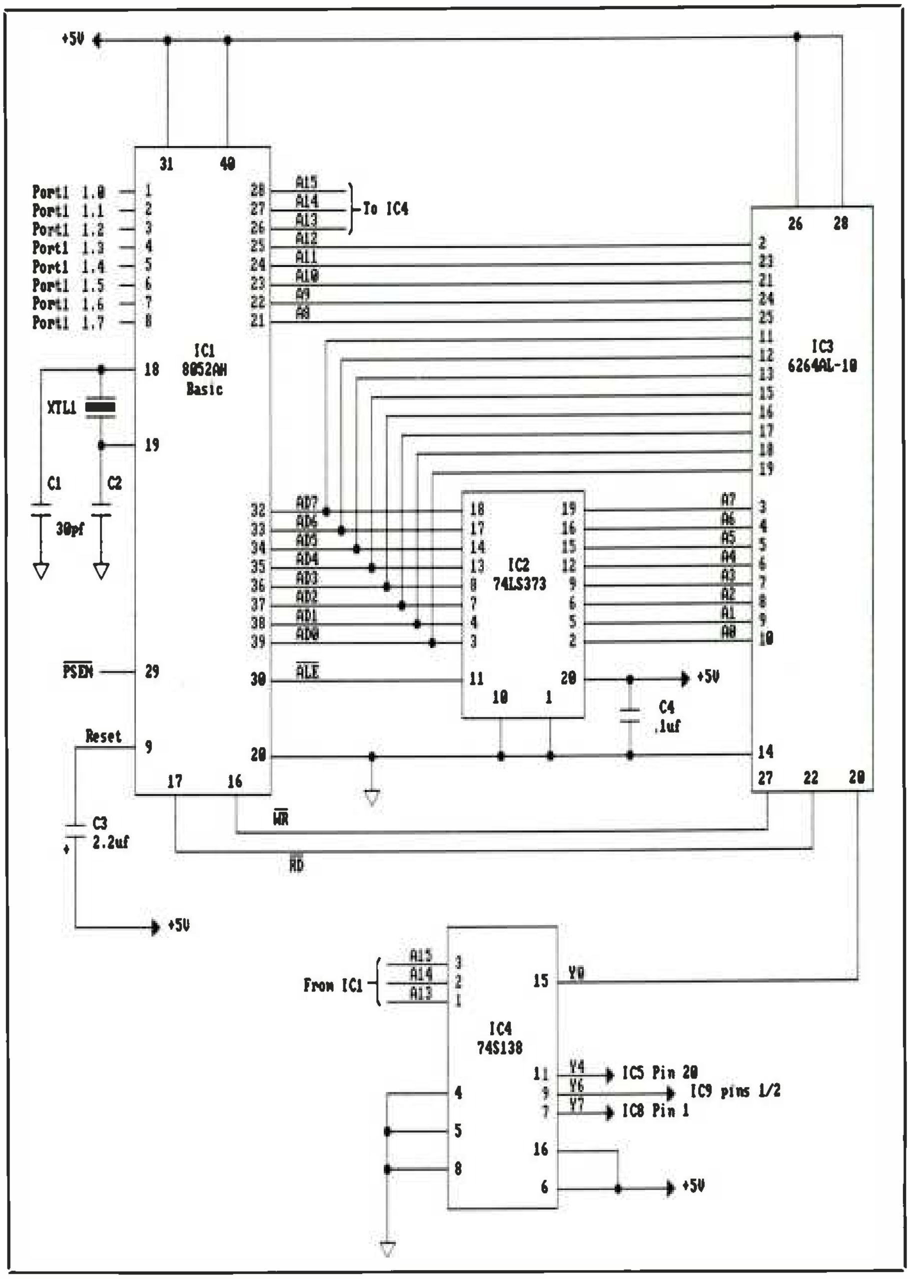


Fig. 1. Main processing section of Fone Mate project contains an 8052AH-BASIC microcontroller (IC1) *and static RAM chip* (IC3).

to place a resistor that simulates an off-hook condition across the telephone line. At this time, the telephone instrument's handset can be returned to the cradle without loss of the caller on the other end of the line.

To provide you with a visual indication that a call is on hold, a pulse-width modulation (PWM) command is part of the program. This command produces a beep via a crystal transducer at the desired frequency and duration about every 60 seconds. Since an LCD module was already a part of the computer circuit, commands were written into the program to display a HOLD message and the number of minutes that have elapsed

PARTS LIST

Semiconductors
D1 thru D6—1N4001 or similar silicon rectifier diode
IC1—8052AH-BASIC microcontroller
IC2—74LS373 tri-state octal D flip-flop
IC3—6264AL-10 8K static RAM
IC4—74L138 expandable 3-to-8 decoder
IC5—2764A EPROM (see Note below)
IC6—74LS08 quad 2-input AND gate
IC7—G8870 DTMF chip
IC8—4069 CMOS hex inverter/buffer
IC9—74LS00 quad 2-input NAND gate
IC10—7805 fixed +5-volt regulator
Q1,Q2—2N4402 or similar silicon pnp transistor

Capacitors
C1,C2—30-pF ceramic disc
C3—2.2-µF, 16-volt electrolytic
C4,C7—0.1-µF ceramic disc
C5,C6—0.01-µF ceramic disc
C8—470-µF, 35-volt electrolytic
C9,C10—1-µF tantalum
C11—100-µF, 16-volt electrolytic
C12—0.47-µF, 250-volt ceramic disc

Resistors (¼-watt, 5% tolerance)
R1,R2,R4—100,000 ohms
R3—47,000 ohms
R5—50,000 ohms
R6—220,000 ohms
R7,R8—1,000 ohms
R10—120 ohms, 1-watt
R9—5,000-ohm, pc-mount trimmer potentiometer

Miscellaneous
M1—Axial Vactrol optical isolator (Hosfelt No. 80-110)
M2—LCD display module (Digi-Key Cat. No. AMX116-ND)
RY1,RY2—5-volt dc relay with dpdt contacts (Hosfelt No. 45-161)
SW1—Normally-open, momentary-action spst pushbutton switch
T1—12-volt, 250-mA plug-in ac transformer
XTL1—11.0592-MHz crystal
XTL2—3.58-MHz crystal
XTL3—Crystal receiver element (see text)
Perforated board with holes on 0.1" centers and suitable Wire Wrap or soldering hardware (see text); suitable enclosure; sockets for all DIP ICs; telephone line cord; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Steve Sokolowski, P.O. Box 5835, Spring Hill, FL 34606: G8870 DTMF IC, $10; programmed 2764A EPROM, $8.50 (specify DDD-12 for 12-hour format or DDD-24 for 24-hour format); six-conductor telephone line cord with spade lugs, $1.75; used crystal receiver element, 75¢; all four items, $20. Add $2.50 P&H per order. Florida residents, please add state sales tax.

Names & Addresses

Digi-Key Corp.
701 Brooks Ave. South
P.O. Box 677
Thief River Falls, MN 56701
Tel.: 1-800-344-4539

Hosfelt Electronics
2700 Sunset Blvd.
Steubenville, OH 43952
1-800-524-6464

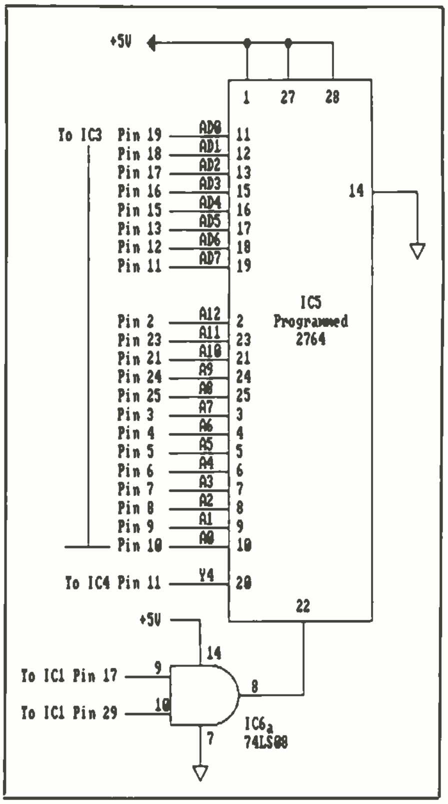


Fig. 2. Pre-programmed EPROM chip IC5 contains all programming needed to activate on-demand functions and create messages that appear in an LCD display.

since the call was first placed on hold.

Another feature designed into the hold routine is timing of a call placed on hold for up to 5 minutes and 30 seconds. When this period has elapsed, if connection is not re-established by pressing the * button, Fone Mate automatically removes the holding resistor from the line. This action is essentially the same as hanging up the instrument's handset and restoring the line and instrument to their standby conditions.

The ability to detect an incoming ring signal using a simple optical-isolator arrangement called a Vactrol is yet another feature built into the project. To accomplish this, Fone Mate once again calls upon the PWM command in the program. This time, the 8052 generates a signal to sound a pleasant warble tone similar to that produced by expensive NEC and Toshiba telephone instruments via the same crystal element as before.

Finally, included in the programming of the 8052 chip is a feature that makes use of a special CLOCK 1 command. This command causes the 8052 to produce highly accurate 60-second interrupt signals that, in turn, are used to drive the seconds input of a reliable clock module, which then displays the time in the window of the LCD module. Time can be displayed in either 12- or 24-hour format.

About the Circuit

To make this discussion easier to follow, the schematic diagram of the Fone Mate circuitry is shown broken into a series of function blocks, shown here as Fig. 1 through Fig. 6. The circuits shown in Fig. 1 and Fig. 2 make up the heart of the project and include 8052AH-BASIC chip *IC1*, 8K static RAM (SRAM) memory section *IC3* and programmed EPROM *IC5*. Because the 8052 contains programmed material, it must have external memory space, provided here by the *IC3* 6264 static RAM chip. (For an in-depth look at how the 8052AH-BASIC microcomputer chip and its associated components work, see "Microprocessor Control With BASIC" in the April and May 1989 issues of *Modern Electronics*.)

Figure 3 illustrates the hardware required to interface Fone Mate to the outside telephone line. In this circuit G8870 chip *IC7* does most of the work. It detects and converts the DTMF signal generated by pressing the buttons on the keypad of the telephone instrument into a usable binary output code at pins 11 through 14. Data lines D0 through D4, which carry the binary equivalent of the tone pair being generated by dial button being pressed, and the STROBE line connect to pins of *IC1*.

To read the code input to *IC1*, an ENABLE signal must be available at Address 0E000 (all addresses are expressed in hex format). Because *IC7* requires a positive voltage to be enabled and address decoder *IC4* generates only negative-going pulses, an inverter must be placed between these two chips. Signal inversion is accomplished here with *IC8A*.

When the program stored in EPROM *IC5* requires the status of *IC7*, pin 7 of *IC4* goes low. This signal is inverted by *IC8A* to turn on the output of *IC7* and allow its data to be read into memory. Programming determines whether to display a telephone number, place a call on hold or disconnect the telephone instrument from the line by using recall.

Crystal transducer *XTAL3* produces the audible output generated by the signal on pin 3 of *IC1*. This transducer can be a high-impedance earphone or, for louder output, an old telephone receiver element. Wired in parallel, inverters *IC8B* and *IC8C* provide buffering between *XTAL3* and pin 3 of *IC1*. They also provide provide audio drive power for *XTAL3*.

The relay drivers for both the recall and hold features are identical. Both require a switching transistor to activate the 5-volt dc relays when a ground potential is applied to the base circuits of the pnp transistors.

For the recall function, note that the normally-closed contacts between points A and B are used. These two points are wired in series with the incoming telephone line. When acti-

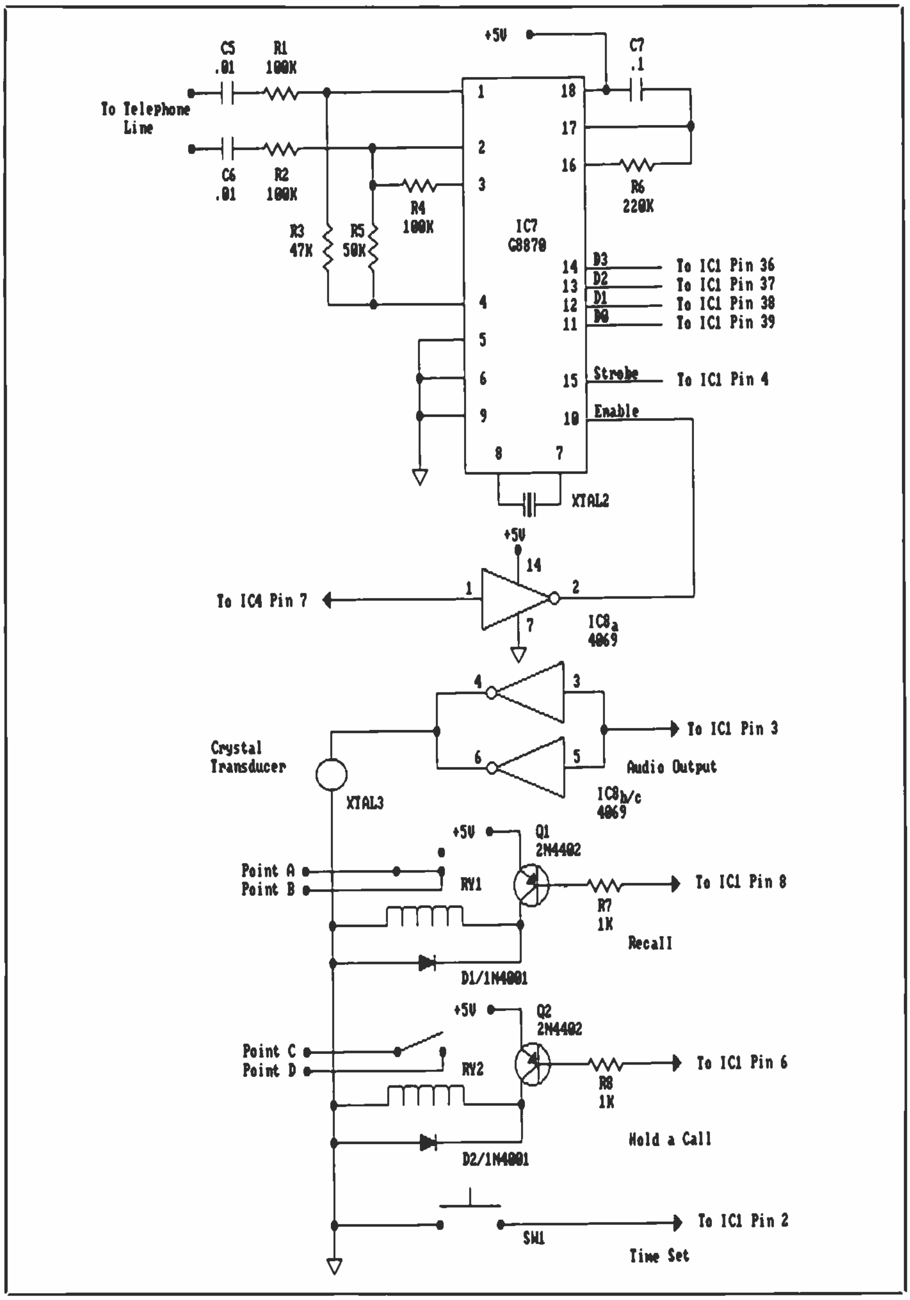


Fig. 3. Hardware details for interfacing Fone Mate to outside telephone line via DTMF chip IC7.

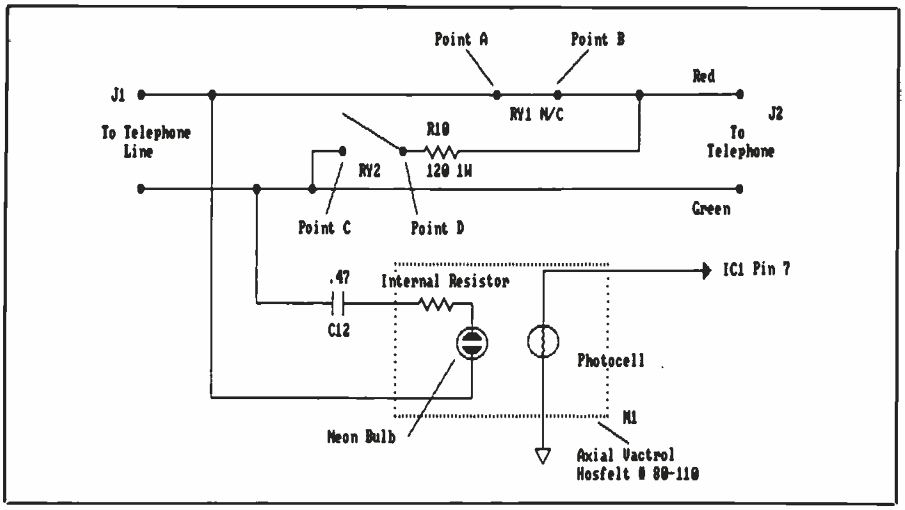


Fig. 4. Details of how incoming telephone line wire to contacts of relay RY2.

vated by grounding pin 8 of *IC1*, *RY1* disconnects the telephone instrument from the line. After about 2 seconds, a logic high appears on pin 8 of *IC1*. This turns off *Q1* and allows *RY1* to deenergize and reconnects the telephone instrument with the Central Office.

To hold a call, *IC7* detects the unique signal when the * button is pressed on the telephone instrument's keypad. Immediately, *IC1* responds by grounding pin 6. As with the recall function, this ground activates *RY2*, but this time, the normally-open contacts of the relay are in parallel via resistor *R10* with the telephone line. By placing this resistor across the line, the receiver of the telephone instrument can be hung up without losing connection with the person at the other end of the line.

Connection of the person on hold is regained simply by pressing the * button on the instrument's keypad a second time. Pressing this key again causes *IC1* to feed a positive voltage (logic high) to the base of *Q2*. This drives the transistor into cutoff and deenergizes *RY2*. In so doing, *R10* is disconnected from the telephone line.

The circuit shown in Fig. 4 illustrates how the contacts of *RY1* and *RY2* are connected to the incoming telephone line. The remaining components shown make up the ring-detection circuitry. When a ring signal is placed on the line by the Central Office, it is intercepted by *C12*.

By applying this large-excursion ac signal voltage across the neon lamp inside *M2*, light is generated when the neon gas inside the lamp ionizes. This light strikes the internal light-dependent resistor or photocell and lowers its resistance. With no light falling on the photocell, its resistance is high enough that, for all practical purposes, it represents an open-circuit condition. However, when light from the neon lamp falls on the photocell, its resistance drops dramatically. Connecting one side of the photocell to ground and the other side to a Port 1 pin of *IC1*, as shown, sensing of a ring signal is accomplished.

When the resistance of the photocell drops, *IC1* detects a ground condition on its port at pin 7. The ground placed on pin 7 allows *IC1* to generate the signal for a pleasant-sounding warble tone via *XTAL3* in Fig. 3.

The CPU continues to generate the warble tone for as long as the calling party stays on the line or until the receiver of the telephone instrument is picked up. No direct connection is made to the telephone line by the circuitry inside Fone Mate to indicate that the receiver has been lifted from its cradle. Therefore, you might discover that Fone Mate may continue to ring for 1 or 2 seconds after the call is answered. This is normal and need not concern you once the project is put into service.

In Fig. 5 is shown the wiring required to integrate the LCD module into the *IC1* circuit, using just a few gates. As in the case of *IC7*, LCD module *M2* must be given an address location at which it can be read and to

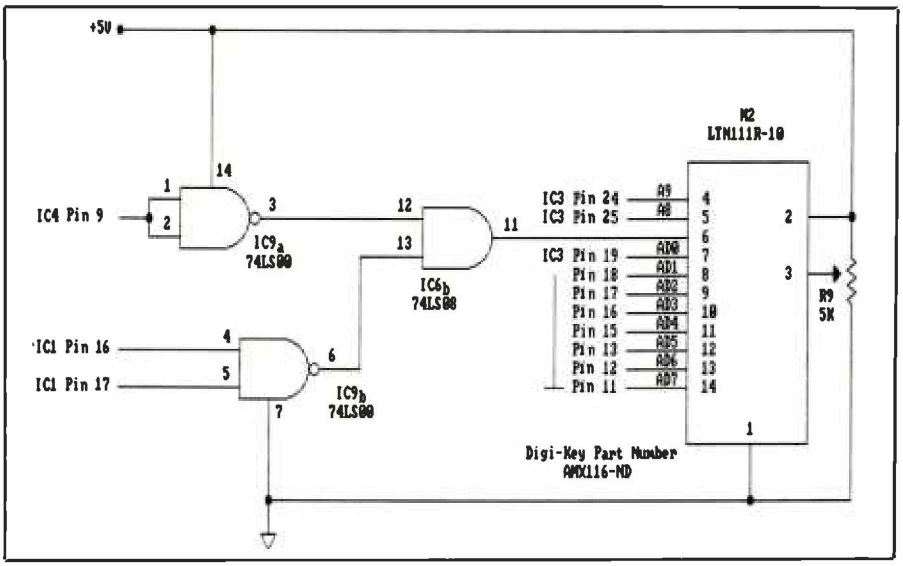


Fig. 5. Wiring details for integrating LCD display module M2 *into main project.*

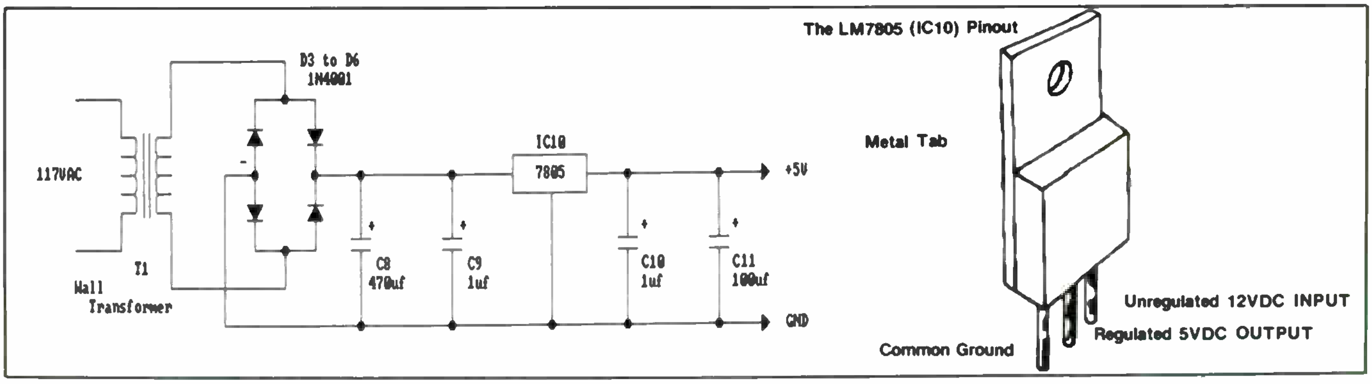


Fig. 6. Circuit details for a regulated 5-volt dc supply for powering project.

which the date can be written. This address information is made possible with *IC9A*, *IC9B* and *IC6C*.

Connecting pins 1 and 2 of *IC9A* to pin 4 of address decoder *IC4*, address 0C000 is used to enable *M2*. By applying the correct data to input pins A0 through A9 of *M2* and enabling address 0C000, just about any numeral or alphabetic character can be displayed under computer control on the LCD screen of the module.

The circuitry shown schematically in Fig. 6, delivers more than adequate power to handle the nominal 250 milliamperes of current drawn by Fone Mate. It consists of a simple full-wave, voltage-regulated + 5-volt supply driven from the ac line via plug-in transformer *T1*. Voltage regulation is provided by *IC10*.

Construction

Laying out components and routing conductors is not critical in this project, though it is somewhat involved. In terms of assembly, this project is quite complex. Because of the large number of wires that must be routed between the various components that make up the circuit, the Wire Wrap technique is highly recommended. For this, you will need a 6 × 4.5-inch perforated board that has holes on 0.1-inch centers and suitable Wire Wrap hardware, including DIP IC sockets. If possible, use perforated board that has narrow copper rings surrounding each hole to simplify assembly. This size board is more than adequate to accommodate all the components that make up the project.

Plan your layout on the perforated board carefully. Though there is nothing critical with regard to locating the various components and running wires between them, it is good practice to keep the assembly neat and the wiring as short as possible without excessive routing. You might begin by plugging the various DIP IC sockets into the holes in the board and test fit the other components to produce a neat layout without crowding that can lead to wiring difficulties.

Once you have a layout that satisfies you, remove from the board all but the DIP IC sockets. If you are using perforated board that has each hole surrounded by a copper ring, secure the sockets in place by sparingly tack-soldering only the four corner wrap posts on each socket to the rings. Use as little solder as needed and confine it to the the pin surfaces only near the copper rings. Do *not* plug the ICs into the sockets until assembly is complete and you have run initial voltage checks and are satisfied that all is well.

Place self-adhering labels on both sides of the board near each socket and write on them the individual schematic number assignments. Then, with an indelible pen or other permanent means, identify the location of pin 1 for each socket. Alternatively, use commercial socket labels that identify all pins. This will greatly ease any confusion as you make wire runs.

Now photocopy all sections of Fig. 1 and use these to check off each wire run and component installation as you make it. Better yet, make two copies so that you can use one for initial installation check-off purposes and the second for rechecking after you have completed wiring the circuit-board assembly.

Perhaps the best way to approach assembling the project is to build the circuits in modular fashion, starting with Fig. 1 and finishing with Fig. 6. As you make each wrap connection,

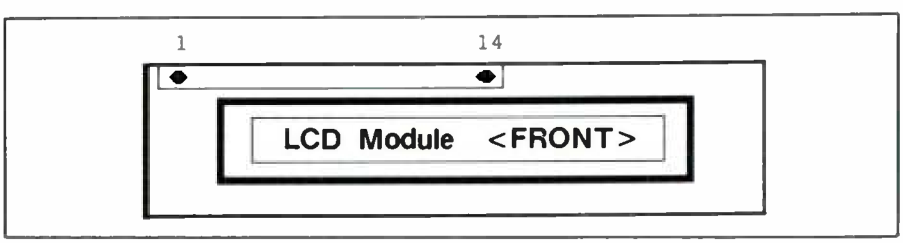


Fig. 7. Pinout diagram for LCD module. Interconnect wiring is accomplished by connection to solder pads on rear of module's board.

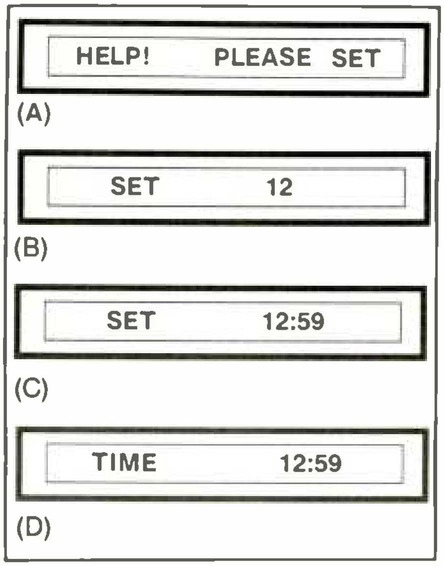


Fig. 8. Upon power-up, LCD displays message (A) to set time in either 12- or 24-hour format. Pressing a switch once, allows you to (B) activate display to set hours. Pressing again locks in hours and prompts for minutes to be set (C); pressing a third time locks in minutes and 5 seconds later displays current time (D).

check its electrical integrity with an ohmmeter set to a low resistance scale or an audible continuity checker. Work slowly and carefully, and use Wire Wrap or solder posts wherever a discrete component is to be installed. Also, make sure polarized components, such as electrolytic capacitors and diodes, and transistors are properly oriented.

Once you have finished wiring the computer sections shown in Fig. 1 and Fig. 2, wire into place the components for the sections shown in Fig. 3 and Fig. 4. Keep associated components together and make all wiring as short as possible. Then wire into the circuit sections shown in Fig. 5 and Fig. 6. Pinouts for the 7805 voltage regulator used for *IC10* are shown in Fig. 6.

Remember to isolate the input and output telephone line from any source of stray voltage. The telephone company frowns on an extra 5 or 12 volts on its line. So make absolutely certain that your wiring is correct when you are done.

Provide screw-type terminal connections for hookup of the incoming telephone line via the cable terminated in *J1*. Also, provide solder or wrap posts for connections to the transducer element and output connector *J2*. The lines that go to the LCD module should be about 2 inches long and stripped of ¼ inch of insulation at the module end, but do not wire them to the module just yet. Wire TIME SET switch *S1* into the circuit now via 6-inch leads.

When you have finished wiring the main circuit-board assembly, set it aside. Now machine the enclosure that will house the project. You can use any size and type of enclosure large enough to accommodate the circuit-board assembly and that has adequate front panel space to mount the LCD module. A suitable enclosure is shown in the lead photo.

To prepare the enclosure, you must drill mounting holes for the circuit-board assembly through the floor panel, entry holes for the cord from the power transformer and incoming telephone line cord and a mounting hole for the TIME SET switch. You must also cut a long rectangular slot for the display window of the LCD module in the front panel and a square opening for the output *J2* connector in the rear panel. If you wish, you can use a plug/jack arrangement for the line from the power transformer to the circuit-board assembly. Finally, drill a series of small holes in the area in which the crystal transducer will be mounted through the top panel to permit the sound to escape.

Deburr all holes and slots made in metal panels to remove sharp edges. Test fit the display window of the LCD module in its slot. Make any corrections needed to obtain a good fit. Then line the cable entry holes with rubber grommets. If you wish, you can now paint the front panel and label it as shown in the lead photo, using a dry-transfer lettering kit and protecting the artwork with light coats of clear spray acrylic.

Mount the switch in the rear panel hole you drilled for it. Route the free end of the incoming telephone line cable through its grommet-lined hole and tie a strain-relieving knot in it about 6 inches from the free end inside the enclosure. Do the same for the cable from the plug-in wall transformer. If you opted for a plug/jack arrangement for this latter cable, mount its jack in the hole you drilled for it through the rear panel.

Mount the circuit-board assembly inside the enclosure using spacers and 4-40 machine screws, lockwashers and nuts. This done, mount connector *J2* in its square hole in the rear panel, the LCD module on the front panel (make sure the latter is oriented so that the interconnection pads on the rear of the board are near the top of the enclosure) and the crystal transducer element to the top panel. Use fast-setting epoxy cement or silicone adhesive to secure each in place. Allow the cement or adhesive to set at least overnight.

When the cement or adhesive has fully set, connect the incoming telephone line cord to the appropriate points on the circuit-board assembly, using the screw-type connectors. Connect the free ends of the wires coming from *J2* to the appropriate points on the circuit-board assembly. Then carefully connect and solder the 14 wires coming from the circuit-board assembly to the LCD module in the proper order.

As shown in Fig. 7, these wires connect to the LCD module via the unoccupied holes along the top of the modular assembly. Make sure each wire goes into the appropriate hole from the rear of the module before soldering it into place. Then connect the remaining two wires coming from the circuit-board assembly to the crystal transducer element.

Secure a small heat sink to the met-

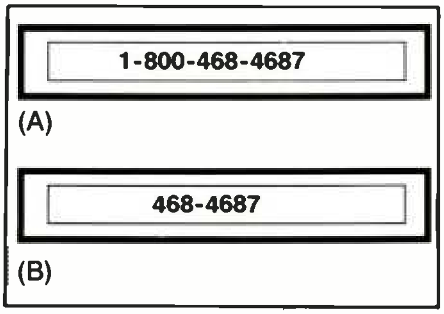


Fig. 9. When dialing a number, display shows it centered and with hyphens in traditional locations for 11-digit (A) and 7-digit (B) numbers.

al tab on regulator *IC10*. Now use a small screwdriver or tuning tool to set the rotor on LCD Module CONTRAST trimmer control *R9* to its center of rotation.

Checkout & Use

The only IC that should be in the circuit at this time is voltage regulator *IC10*. Use a dc voltmeter or a multimeter set to the dc-volts function to make the following tests.

Clip the common lead of the meter to a convenient point in the circuit that is at ground. Plug the power transformer into an ac outlet and touch the "hot" probe of the meter to the OUT pin of *IC10* and note the meter reading. If you do not obtain a reading of approximately +5 volts, power down and troubleshoot the circuit. Do not proceed with voltage tests until you have corrected any problem.

Once you obtain +5 volts at the output of the voltage regulator, touch the "hot" probe of the meter to pins 31 and 40 of the *IC1* socket; pin 20 of the *IC2* socket; pins 26 and 28 of the *IC3* socket; and pins 6 and 16 of the *IC4* socket. In all cases, you should obtain a +5-volt reading.

Continue touching the "hot" probe of the meter to pins 1, 27 and 28 of the *IC5* socket; pin pin 14 of the *IC6*, *IC8* and *IC9* sockets; and pin 18 of the *IC7* sockets. Once again, the readings obtained should be +5 volts, as should be the readings at the emitters of *Q1* and *Q2*.

When you obtain the proper voltage readings at all specified locations in the circuit, power down the project and wait a minute or so. Then install the ICs in their respective sockets, making sure that each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

Now power up the project once again. The LCD module should display the message "HELP! PLEASE SET," as in Fig. 8(A). This message will be displayed every time Fone Mate is initially powerered up.

To set up the system for displaying the correct time, press and release SET switch *SW1*. Only the two hours positions in the display should appear, advancing by one count at a rate of about once per second until it reaches reaches 12, as in Fig. 8(B) (or 24 if you selected the 24-hour display mode). As it passes through 12, the count should start again from "01." When the correct hours digit appears in the display, press and release *SW1* again to lock it in.

The minutes half of the clock display will appear, as in the center illustration in Fig. 8(C), and advance from 00 to 59. Again, when the correct minute appears in the display, press and release *SW1* to lock it in. After a second or so, the LCD module should display "TIME 12:59" (or whatever time you locked in), as in the bottom illustration in Fig. 8(D).

For the following tests, connect Fone Mate to a standard telephone line, observing proper polarity and using *J1*. Also, connect *J2* to a telephone instrument that has Touch Tone dialing. This completes installation of the project, though further tests must be conducted to assure that Fone Mate is operating properly.

Now check the ability of the project to decode and display a dialed telephone number. Lift the telephone handset from the cradle and dial an 11-digit number—as shown in Fig. 9(A), for example. Fone Mate now erases the time from the display and reads out the dialed number in the center of the window. Note in this illustration that the hyphens are placed in the correct traditional locations.

After about 5 seconds, Fone Mate replaces the dialed digits in the display with a readout of the correct time. If all is well to this point, replace the handset in the cradle of the instrument.

To check the decoding and display of a seven-digit number, pick up the handset and listen for a dialtone. Then dial the seven-digit number. As before, Fone Mate should replace the current time in the display with the dialed digits of the phone number, centered in the window as in Fig. 9(B). Note here, too, that the hyphen is in the correct location. Hang up and dial another number that has different digits in it so that you check operation with all buttons labeled 1 through 0 on the Touch Tone keypad of the telephone instrument.

To test the Recall feature, lift the handset and dial a two- or three-digit number (*not* the emergency number 911 or any other three-digit number

(Continued on page 68)

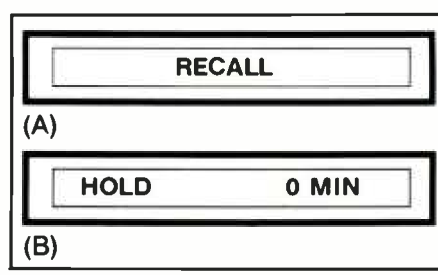


*Fig. 10. "Recall" function (A) is activated by operating # button on keypad of telephone instrument; "Hold" function (B) is activated by pressing * button. Placing call on hold displays message shown and starts a timer that automatically disconnects project from telephone line if hold period exceeds 5 minutes and 30 seconds. Beeping tone sounds for as long as call is on hold.*

Designing Square-Wave Generators

The theory and practice of designing square-wave generators that can stand alone or be integrated into circuit systems

By Joseph J. Carr

Square wave generators are commonly used to test a wide variety of electronic circuits, particularly in the digital area. The general utility of the square wave is the result of its rich harmonic content. A pure sine wave is composed of a single (fundamental) frequency. A square wave, on the other hand, contains a fundamental frequency (like the sine wave) and theoretically an infinite number of odd harmonics. As a general rule, the sharper the rise time, the greater the harmonic content of the square wave.

In this article, we focus on how to design and build custom square-wave generator circuits that can be used as part of a complex circuit or as a stand-alone signal source for bench testing. In designing such a circuit, be prepared to deal with a fair amount of arithmetic, though nothing more complex than simple algebra, to determine the values of resistors and capacitors to use.

The Square Wave

Depicted in Fig. 1 is a graphic representation of the symmetrical square wave. Each time interval of the wave is quasi-stable. Therefore, you might conclude that the square-wave generator has no permanent stable states and, hence, is astable. The waveform snaps back and forth between $-V$ and $+V$, dwelling on each level for a period of time given as t_a or t_b. Period T is calculated using the formula:

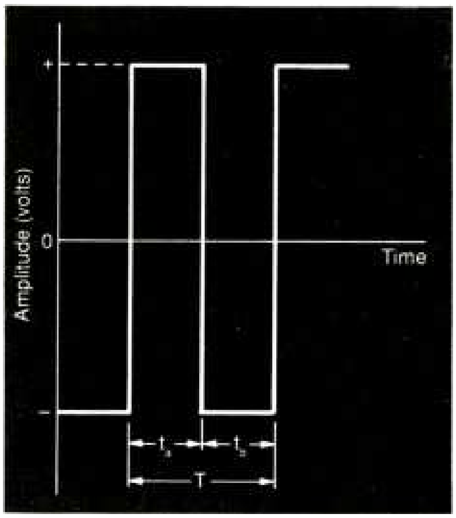


Fig. 1. Perfect square wave is symmetrical across 0-volt baseline and also between right and left halves. Time T is period; frequency is reciprocal of T, or 1/T.

$$T = t_a + t_b \quad [1]$$

where *T* is the period of the square wave (t1 to t3), t_a is interval t1 to t2 and t_b is interval t2 to t3.

Frequency of oscillation F is the reciprocal of T:

$$F = 1/T \quad [2]$$

The ideal square wave is both base- and time-line symmetrical, which means that the absolute value of $+V$ is equal to the absolute value of $-V$ and $t_a = t_b$. Under time-line symmetry $t_a = t_b = t$. Hence, $T = 2t$ and $f = (1/2t)$.

The schematic diagram for an operational-amplifier square-wave generator is shown in Fig. 2(A). The basic circuit configuration is similar to the simple voltage comparator. Operation depends upon the relationship between V(−IN) and V(+IN). The voltage applied to the noninverting (+) input [V(+IN)] is determined by the resistive voltage divider composed of *R2* and *R3*. This voltage is shown as V1 in Fig. 1(A) and is calculated as follows:

$$V1 = (V_oR3)/(R2 + R3) \quad [3]$$

When V_o is saturated, the formula is rewritten as follows:

$$V1 = (V_{sat} \times R3)/(R2 + R3) \quad [4]$$

Once again, the factor R3/(R2 + R3) is often designated B:

$$B = R3/(R2 + R3) \quad [5]$$

Because Equation [5] is always a fraction, V1 is less than V_{sat} and is of the same polarity as V_{sat}.

Voltage V(−IN) applied to the inverting (−) input is the potential that appears across *C1*, or V_{C1}, and is created when *C1* charges under the influence of current I that, in turn, is a function of V_o and the R1C1 time constant. Timing of the circuit is shown graphically in Fig. 2(B).

At turn-on $V_{C1} = 0$ volts and $V_o = +V_{sat}$. Therefore, $V1 = +V1 = B(+V_{sat})$. Because V_{C1} is less than V1, the op amp sees a negative differential input voltage; hence, the output remains at $+V_{sat}$. During this

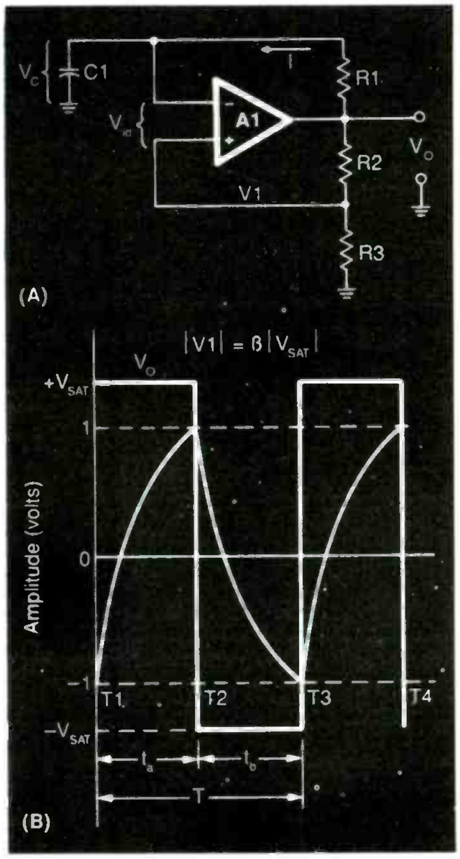


Fig. 2. (A) Circuit details for a simple op-amp square wave generator and (B) timing waveforms.

time, however, V_{C1} is charging towards $+V_{sat}$ at a rate of:

$$V_{C1} = V_{sat}[1 - e(-t2/R1C1)] \ [6]$$

When V_{C1} reaches $+V1$, however, the op amp sees V_{C1} as being equal to V1; so $V_{id} = 0$. The output now snaps from $+V_{sat}$ to $-V_{sat}$, which is time t2 in Fig. 2(B). The capacitor now begins to discharge from $+V1$ towards zero, and then recharges towards $-V_{sat}$. When it reaches $-V1$, the inputs are once again zero; so the output again snaps to $+V_{sat}$. The output continuously snaps back and forth between $-V_{sat}$ and $+V_{sat}$, thereby producing a square wave output signal.

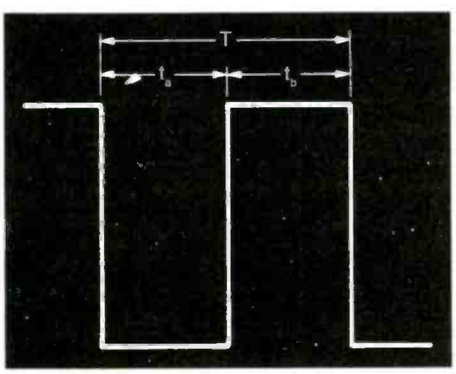


Fig. 3. Square wave train.

Time constant required to charge from an initial V_{C1} voltage to a V_{C2} end voltage time t is defined by the formula:

$$RC = -T/\{[(V - V_{C2})]/Ln \times [(V - V_{C2})/(V - V_{C1})]\} [7]$$

In Fig. 2(A), the RC time constant is calculated for the R1C1 values. From Fig. 2(B), it should be apparent that for interval t_a $V_{C1} = -BV_{sat}$, $V_{C2} = +BV_{sat}$ and $V = V_{sat}$. To calculate period T, use the formula:

$$2R1C1 = -T/\{Ln[(V_{sat} - BV_{sat})/(V_{sat} - (-BV_{sat})]\} [8]$$

By rearranging Equation [8], we obtain:

$$-T = 2R1C1 \times Ln \times [(V_{sat} - BV_{sat})/(V_{sat} - (-BV_{sat}] \ [9]$$

$$-T = 2R1C1 \times Ln[(1 - B)/(1 + B)] \ [10]$$

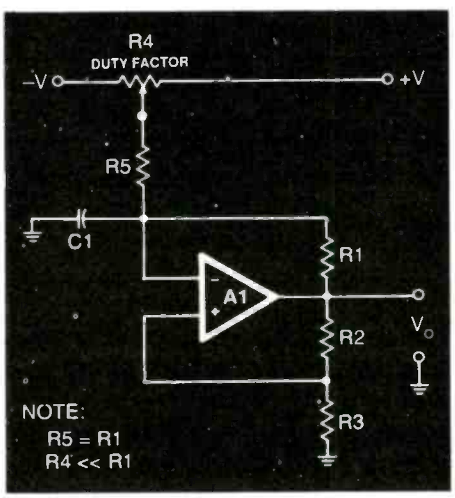


Fig. 4. Potentiometer provides variable duty cycle square wave.

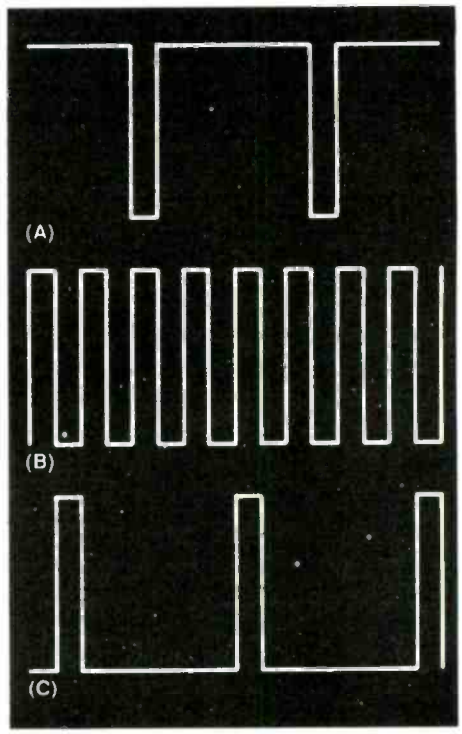


Fig. 5. Output waveforms for three different settings of the potentiometer (see text).

$$T = 2R1C1 \times Ln[(1 + B)/(1 - B)] \ [11]$$

Because $B = R3/(R2 + R3)$,

$$T = 2R1C1 \times Ln \{\{1 + [R3/(R2 + R3)]/\}/\{1 - [R3/(R2 + R3)]\}\} [12]$$

which reduces to:

$$T = 2R1C1 \times Ln (2R2/R3) \ [13]$$

Equation [13] defines the frequency of oscillation for any combination of *R1*, *R2*, *R3* and *C1*. In the special case where R2 = R3 and B = 0.5,

$$T = 2R1C1 \times Ln[(1 + 0.5)/(1 - 0.5)] \ [14]$$

$$T = 2R1C1 \times Ln (1.5/0.5) \ [15]$$

$$T = 2R1C1 \ [16]$$

Equations [13] and [16] should be remembered because they are the basic

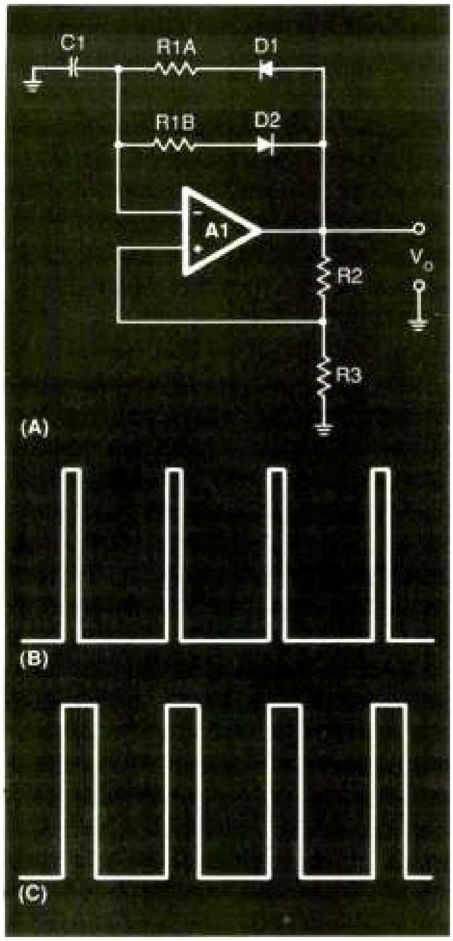


Fig. 6. (A) Diode circuit for producing asymmetrical, but fixed, duty-cycle square wave. (B) Two different ratios of feedback resistors.

design formulas for the general and special cases, respectively.

The circuit shown in Fig. 2(A) produces time-line symmetrical square waves ($t_a = t_b$), such as Fig. 3. If time-line asymmetrical square waves are required, a circuit like those shown in Fig. 4 or Fig. 6(A) is required.

The Fig. 4 circuit utilizes potentiometer *R4* and a fixed resistor *R5* to establish a variable duty cycle asymmetry. This circuit is similar to the one shown in Fig. 2(A), except offset circuit *R4/R5* has been added. Assumptions here are that R5 = R1 and R4 is much less than R1. If V_a is the potentiometer output voltage, *C1* charges at a rate equal to (R1/2)C1 towards a potential of $V_a + V_{sat}$. After output transition, however, the capacitor discharges at the same (R1/2)C1 rate towards ($V_a - V_{sat}$). Therefore, the two interval times are different so that t_a and t_b are no longer equal.

Shown in Fig. 5 are three extremes of V_a: (A) $V_a = +V$, (B) $V_a = 0$ and (C) $V_a = -V$. These traces represent very long, equal and very short duty cycles, respectively.

The circuit shown in Fig. 6(A) also produces asymmetrical square waves, but the duty cycle is fixed instead of being variable. Once again, the basic circuit here is like that shown in Fig. 2(A), except that it has added components. In Fig. 6(A), the RC timing network is altered in such a manner that the resistors are different on each swing of the output signal. During t_a, $V_a = +V_{sat}$; so *D1* is forward biased and *D2* is reverse biased. For this interval:

$$t_a = R1A \times C1 \times Ln[1 + (2R2/R3)] \quad [17]$$

During the alternate t_b half cycle, output voltage V_o is at $-V_{sat}$. Hence, *D1* is reverse biased and *D2* is forward biased. During this interval, *R1B* is the timing resistor, while *R1A* is effectively out of the circuit. The timing equation is now:

$$t_b = R1B \times C1 \times Ln[1 + (2R2/R3)] \quad [18]$$

Total period T is $t_a + t_b$; so

$$T = R1A \times C1 \times Ln[1 + (2R2/R3) + R1B \times C1] \times Ln[1 + (2R2/R3)] \quad [19]$$

Collecting terms, we obtain:

$$T = (R1A + R1B) \times C1 \times Ln[1 + (2R2/R3)] \quad [20]$$

Equation [20] defines the oscillation frequency of the Fig. 6(A) circuit. Figures 6 shows the effects of two

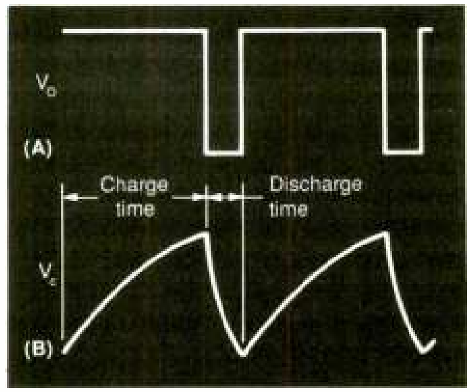


Fig. 7. Relationship between output voltage V_o and capacitor voltage, V_c.

values of R1A/R1B ratio. In (B), the ratio of R1A/R1B is 3:1, while in (C), the ratio of R1A/R1B is 10:1.

The effect of this circuit on capacitor charging can be seen in Fig. 7. Notice here in the lower lower trace that the capacitor charge time is long compared with the discharge time.

The standard op-amp circuit sometimes produces a relatively sloppy square output waveform. By adding a pair of back-to-back zener diodes across the output, as in Fig. 7(A), the signal can be cleaned up. By doing this, though, you pay a penalty in reduced output signal amplitude. For each polarity the output signal sees one forward-biased and one reverse-biased zener diode. On the positive swing, the output voltage is clamped at V_{Z1} + 0.7 volt. The 0.7-volt factor represents the normal junction potential across the forward biased diode (*D2*). On negative

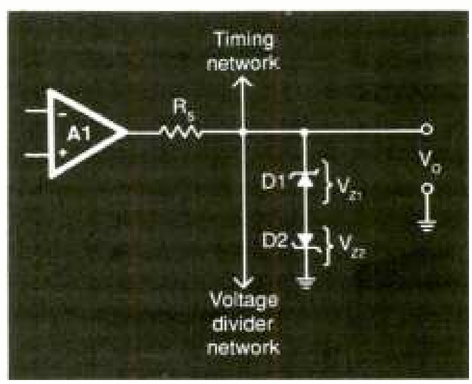


Fig. 8. Output limiting circuit.

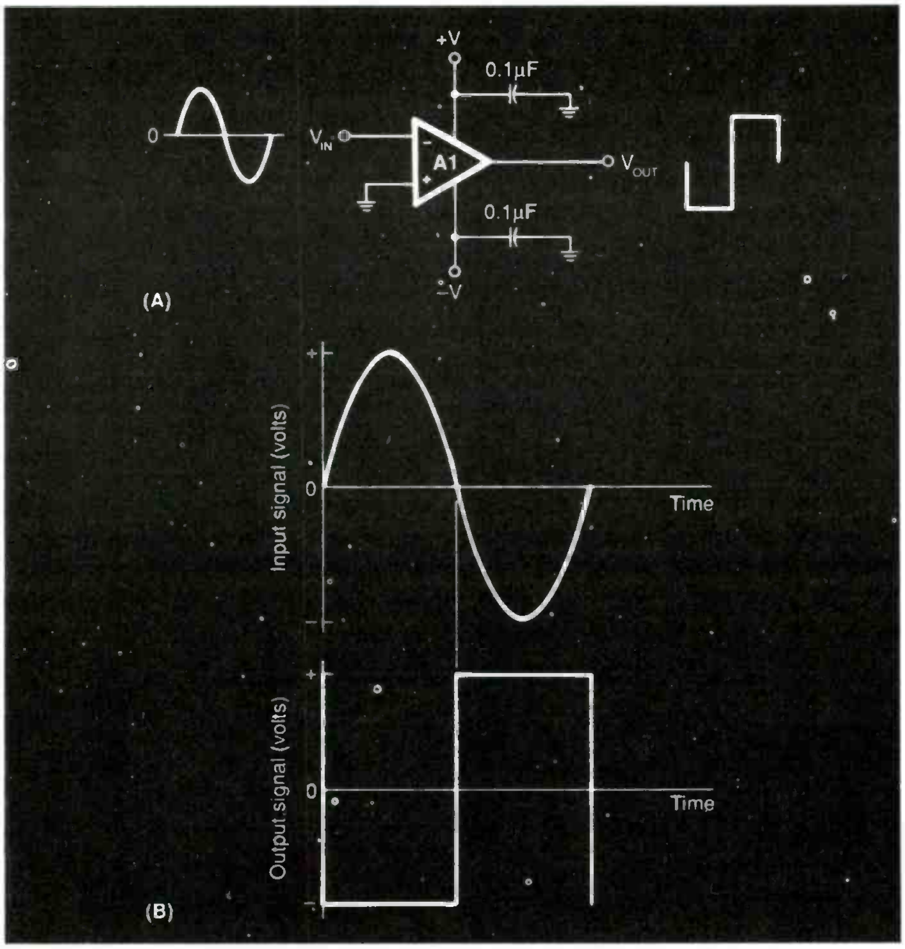


Fig. 9. (A) Voltage comparator used to make square waves from sine-wave input. (B) timing diagram waves.

swings, the situation reverses, and the output signal is clamped to $-V_{Z2} + 0.7$ volt.

Square From Sine Waves

Figure 9 shows a method for converting sine waves to square waves. The circuit configuration is shown in (A), while the waveforms are shown (B). The circuit uses an op amp connected as a comparator. Because the op amp has no negative feedback path, the gain is very high (A_{vol}). In op amps gains of 20,000 to 2,000,000 (250,000 typical) are frequently found. Thus, a voltage difference across the inputs of only a few millivolts will saturate the output of the op amp, which is illustrated in Fig. 9(B).

The input waveform to the Fig. 9(A) circuit is a sine wave. Because the noninverting input is grounded, the output of the op amp is zero only when the input signal voltage is also zero. When the sine wave is positive, the output signal will be at $-V_o$; and when the sine wave is negative, the output signal will be at $+V_o$. The output signal will, thus, be a square wave at the sine-wave frequency, with a peak-to-peak amplitude of $+V_o - (-V_o)$.

Designing and building square-wave generators using operational amplifiers is a simple task that can be accomplished by nearly everyone with a basic knowledge of electronics. Using the formulas provided here and a little common sense, you should be able to "roll your own" with ease. **ME**

A PC-to-VicModem Interface

Simple circuit interfaces a likely unused Commodore VicModem to any RS-232 port for inexpensive telecommunications

By Jim Stephens

If you've been around personal computers, you've probably amassed a number of hardware items whose day has come and long since gone. A case in point is the VicModem that allowed the Commodore VIC-20 computer to communicate with other computers over the telephone line. With the VIC-20 all but defunct, the VicModem you now have is probably gathering dust somewhere in your home. Fortunately, with a simple modification, this lowly piece of hardware can be reanimated for use with your present-day computer via its serial port.

In this article, we will describe the circuitry for successfully adapting the VicModem for use with any modern personal computer that has an RS-232 serial port for communication over the telephone line. The interface circuit is easy to build from commonly available components and is just as easy to use. With this combination, you can use your computer to communicate via teleconferencing, message boards, bulletin boards, Netmail and other services available to computer users via the telephone-line network.

About the Circuit

Like most older peripherals, the VicModem will not directly plug into other standard equipment without some work. The VicModem serial port uses 5-volt TTL logic levels, while today's PCs require ± 12-volt RS-232 levels. The latter 24-volt swing is good for long-distance cable runs, needed in old terminals, but is not really required for telephone and radio links. Even so, the RS-232 standard still exists, and most standard peripheral equipment that connects to a computer's serial port expects to "see" the levels standardized for it.

The incompatibility of the VicModem can easily be corrected with a small two-IC interface circuit that changes the 12-volt logic levels to a 5-volt level. The circuitry required to do this is shown in Fig. 1.

Since three different voltages are required for the two interface ICs shown in Fig. 1, most of the circuitry shown in the schematic is for the power supply. An inexpensive 9-volt ac plug-in wall transformer supplies the power required by the circuit.

A diode network consisting of *D1*, *D2* and *D3* serves as a voltage doubler and inverter to produce the + 12 and − 12 volts required by the computer with which the project is used. Bridge rectifier *RECT1* and fixed 5-volt regulator *IC1* supply the + 5 volts required by the modem.

Power for the modem is obtained directly from the 9 volts ac delivered by the plug-in wall transformer. Voltage levels indicated in Fig. 1 should be as close to the indicated values as possible when measuring them with a meter. Note that lines that go to the VicModem are labeled with an "M," while those that go to the computer are labeled with a "C."

Interface integrated circuits *IC2* and *IC3* are MC1488 RS-232 quad line driver and MC1489 quad line receiver chips, respectively. Both are readily available from Radio Shack and other sources. The transmitted RS-232-level data (TXD), sent from the computer, is fed into *IC2* at pin 1 and exits at pin 3 to the VicModem as

TTL-level data. Incoming 5-volt TTL-level data from the VicModem is fed into *IC3* on pins 12 and 13 and exits at pin 11 to the computer's RXD received data line.

Each signal that exits the computer must be referenced to ground. This ground reference is taken from the SIG. GND at pin 5 of the *P1* or pin 7 of the *P2* serial-port connector on the computer. This signal ground pin is tied to the circuit-ground bus of the interface circuit.

Shown in Fig. 1 is the pinout configuration of the standard 25-pin DB-25 connector used for *P2*. Most IBM PC-compatible computers use this type of connector for their serial ports. IBM PC/AT and some compatible computers use the smaller-version DB-9 connector shown as *P1* in Fig. 1 for their serial ports. Also shown in Fig. 1 are the details of the port connector for the VicModem that are important for this project.

The best way to locate the TXD and RXD on the serial port of your computer is to check in your computer manual. Pins referenced for these points in Fig. 1 are for the standard RS-232 serial-port connector. Be aware, though, that some computer manufacturers juggle the pin assignments of their connectors; so make sure when you utilize the interface circuit that you use the correct pins for your particular computer. As you can see, only three lines of the serial port are required for this project—or any modem, for that matter, if the modem is set up to disregard other control protocols.

Data Set Ready (DSR) and Data Terminal Ready (DTR) lines are important when fast transmitting rates are being used. Also, two other lines are available on the RS-232 port to keep things organized at high com-

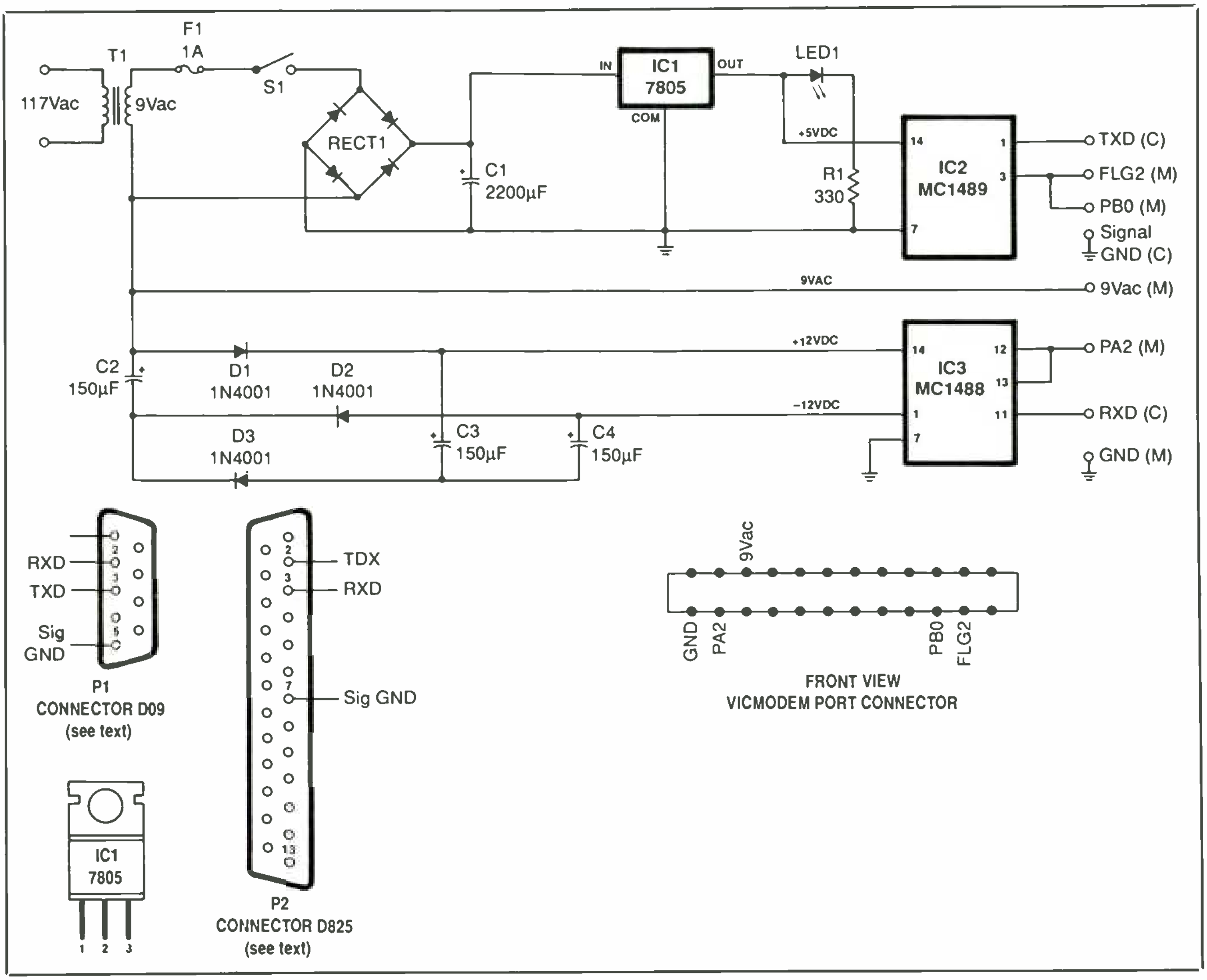


Fig. 1. Complete schematic of a simple interface circuit to adapt a VicModem for use with a modern personal computer.

PARTS LIST

Semiconductors
D1,D2,D3—1N4001 silicon rectifier diode
IC1—7805 +5-volt regulator
IC2—MC1488 RS-232 line driver (Radio Shack Cat. No. 276-2520 or equivalent)
IC3—MC1489 RS-232 line receiver (Radio Shack Cat. No. 276-2521)
LED1—Red light-emitting diode
RECT1—1.5-ampere bridge-rectifier assembly (Radio Shack Cat. No. 276-1151 or similar)

Capacitors
C1—2,200-μF, 50-volt electrolytic
C2,C3,C4—150-μF, 35-volt electrolytic

Resistors
R1—330 ohms, ¼-watt, 10% tolerance

Miscellaneous
F1—1-ampere slow-blow fuse
P1—DB-9 connector (see text)
P2—DB-25 connector (see text)
S1—Miniature spst toggle or slide switch
T1—9-volt, 250-mW plug-in wall transformer (Jameco Cat. No. AC975 or similar)
Printed-circuit board or perforated board with holes on 0.1-inch centers (Radio Shack Cat. No. 276-154 44-contact multi-purpose board or similar) and suitable Wire Wrap or soldering hardware (see text); sockets for IC2 and IC3; suitable enclosure (Radio Shack Cat. No. 270-223 or similar); 3-conductor cable (see text); ½-inch spacers; machine hardware; hookup wire; solder; etc.

munication baud rates. These are the Request To Send (RTS) line from the modem and the Clear To Send (CTS) line from the computer. Use of all these lines on an RS-232 serial port connector lessens the chances of errors in the serial data stream.

Operating at only a 300-baud communication speed, the VicModem is slow enough to permit its use without connecting all control lines. Faster speeds are not really needed with most modem communications, since much of the time is spent typing and reading information as it is transmitted and received over the telephone lines.

Construction

Data through the VicModem is handled via its 24-contact edge connector. This connector is designed to accommodate a printed-circuit board edge pattern. You can buy a prototyping board with perforations and copper traces in and on it that mates with the VicModem edge connector. A less-expensive approach is to use a standard 44-contact card and trim it to leave 12 conductive fingers on both sides and to fit the connector on the modem exactly. This card provides plenty of room for laying out the components.

There is nothing critical about laying out and wiring the circuit. Therefore, you can assemble the circuit on prototyping board that has holes on 0.1-inch centers, using suitable Wire Wrap or soldering hardware. If you wish, however, you can instead design and fabricate a printed-circuit board with suitable edge fingers.

Use sockets for *IC2* and *IC3*. Wire the circuit exactly as shown in Fig. 1, installing first the IC sockets. (Do *not* plug the ICs into the sockets until after you have conducted voltage checks and are certain that circuit is properly wired.) Continue assembly with installation of the resistor, fuse, capacitors, diodes, bridge-rectifier assembly and 5-volt regulator. Make certain that the electrolytic capacitors and diodes are properly oriented and that the regulator and bridge rectifier are properly based before soldering any leads or pins into place.

Strip ¼ inch of insulation from both ends of six 4-inch-long hookup wires. If you are using stranded wire, tightly twist together the fine strands at both ends of both wires and sparingly tin with solder. Connect and solder one end of two of these wires to the OUT pin 3 of *IC1* and the free end of *R1*. The free ends of these wires now connect to the leads of the light-emitting diode.

Determine which lead of the LED connects to the cathode and clip it to ½ inch long. Form a small hook in the lead stub. Slip a ½-inch length of small-diameter heat-shrinkable tubing over the free ends of both wires coming from the circuit-board assembly. Crimp and solder the wire coming from the resistor to the shortened cathode lead of the LED. Then trim the anode lead to ½ inch in length, form a small hook in the remaining stub and crimp and solder it to the free end of the other wire.

When the connections have cooled, slide the heat-shrinkable tubing over both connections until it is flush with the bottom of the case of the LED to insulate the leads from each other and the rest of the circuitry. Shrink the tubing solidly into place.

Connect and solder one end of two of the remaining wires into the circuit at the connection points for POWER switch *S1*. Crimp and solder the free ends of these wires to the lugs of the switch. Connect and solder the two remaining wires to the 9-volt ac power input points on the circuit-board assembly. The free ends of these wires will be terminated in the power connector after the circuit-board assembly has been mounted inside its enclosure.

Now, referring to Fig. 1, wire the main circuitry on the board to the appropriate fingers that plug into the edge connector of the VicModem. Note that all but the TXD and RXD lines that go to the cable used to link with the computer with which the VicModem is used terminate at the fingers noted at the end of the board.

Once the board-edge fingers have been wired into the circuit, wire the cable that goes to the computer into the circuit. Use ordinary 36-inch or so length of three-conductor twisted cable or two-conductor cable with separate mesh shield. Strip 1½ inch of outer plastic jacket from both ends of this cable.

If you are using shielded cable, undo the mesh back to the cut-off plastic jacket and tightly twist together the fine strands a distance of 1 inch or so from the free end. Sparingly tin with solder. Strip ¼ inch of insulation from all conductors at both ends of the cable, tightly twist together the exposed fine wires and sparingly tin with solder. Then, referring to Fig. 1, wire one end of this cable to the circuit-board assembly, connecting the shield (if used) to circuit ground.

Terminate the other end of the cable in either a male DB-9 or DB-25 connector, whichever is required for the RS-232 serial port on your computer. Again, the shield (if used) goes to the ground pin. The two other conductors go to the appropriate pins on the connector, as explained above. Match the TXD and RXD lines at both ends of the cable. Temporarily set aside the circuit-board assembly.

Because of the long rectangular slot required for the finger edge of the circuit-board assembly to protrude from it, the best type of enclosure to use is either an all-plastic one or one that is all plastic except for a top metal panel. Machine the enclosure as follows. Begin by drilling mounting holes for the circuit-board assembly, POWER switch and LED. Then cut the long rectangular slot for the edge of the circuit-board assembly. Finish up by cutting the slots in which to mount the connector for the cord from the plug-in wall transformer and exit for the cable that connects to the computer.

When the enclosure is ready, mount the circuit-board assembly in place, using ½-inch spacers and 4-40 × ¾-inch machine screws, nuts and lockwashers. Then mount the power connector. Locate the two wires coming from the circuit-board assembly and crimp and solder them to the lugs of the power connector. Since this is an ac input, there is no need to concern yourself with polarity. Either wire can go to either lug on the connector.

Initial Checkout

With neither *IC2* nor *IC3* plugged into the sockets on the board, plug the output cord from the 9-volt ac plug-in wall transformer into the power jack. Clip the common lead of a multimeter set to the dc-volts function to a convenient circuit-ground point in the project. Plug the wall transformer into an ac outlet and set the POWER switch to "on."

Touch the "hot" probe of the meter to pin 14 of the *IC2* socket and note that the reading obtained should be +5 volts. Once this is confirmed, touch the "hot" probe to pin 14 and then pin 1 of the *IC3* socket and note the readings obtained; the first should be +12 volts, the second −12 volts.

If you fail to obtain the proper reading at any given point in the circuit, immediately power down the project and unplug the transformer from the ac receptacle. Rectify the problem before proceeding. Check especially for proper orientation of the diodes and electrolytic capacitors and proper basing of the voltage regulator and bridge-rectifier assembly. If all is well here, double-check all connections made to the pins of the IC sockets.

Once you are certain that the circuit is properly wired, power down and allow sufficient time for the charges to bleed off the electrolytic capacitors. Then plug the ICs into their respective sockets. Make sure that each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

Mount the POWER switch and LED in their respective holes in the top panel of the enclosure. If the LED does not remain in place by friction, apply a small daub of fast-setting epoxy cement or silicone adhesive to secure it. Then mount the top panel to the enclosure with the screws provided with it.

Plug the project into the VicModem, your telephone receiver's handset cord into the phone jack on the modem and the transformer into an ac outlet. Set the POWER switch on the project to "on." With the modem set to "originate," you should hear a clean tone on an extension telephone instrument. If not, you may have made a wiring error in the power-supply circuitry or the fingers at the edge of the interface board are not aligned properly with the contacts on the VicModem's connector. Once again, rectify the problem before proceeding.

Next, switch the VicModem to "answer." You should now hear a loud, clear tone that is higher in frequency than before. If everything is okay up to this point, you can proceed with an operational check of the system.

Programming the RS-232 Serial Port

The serial port on your computer is usually located at COM 1. With no power applied to either the project or your computer, plug the cable on the interface into the COM 1 (or whatever other port your computer is using for serial communications). Power up both project and computer. Then boot up in the normal manner.

A modem communications program must be loaded into your computer and run to send and receive data on that port. The only requirement for using any of a number of communications packages (I have successfully used SmartCom, ProComm and Bitcom with this arrangement; a multitude of others should work as well, including public-domain programs) is to set the parameters to ignore DSR, CTS and RTS. However, be sure to set the communication rate to 300 baud.

If you do not have a modem program, you can check out the system and two-way communications can be established by keying in and running the BASIC program given elsewhere in this article. Be sure to save the program to disk under the name "TERMCHK" or other easily remembered filename before re-loading and running it. This short program can be entered in either Microsoft BASIC or GW-BASIC. It scans the computer's keyboard and asynchronous communications COM 1 port and then receives and transmits data to the screen.

After keying in and saving the program, double-check it for extra commas and double or missing semicolons. All commas and semicolons shown send linefeeds to the screen and modem.

Lines 20 and 30 of the program set the screen width to 80 columns and clear the screen. When RUN is entered, "ON LINE" appears on-screen, along with a blinking cursor that tells you that the program is waiting for data either from the keyboard or the serial port. Either will cause printing to begin. Since the program prints whatever character it sees, backspaces and other control characters also appear on-screen and do not always work as you expect them to.

Line 70 is the most important in the program. It opens the serial port at COM 1 and tells the communications UART that 300 baud, no parity, eight data bits and one stop bit are to be used. This permits enough synchronizing to avoid most data errors. If any of these parameters are not met, the program stops and tells you it has an error. This rarely occurs; but if it does, simply type "RUN" again to clear the error for communication to continue.

The remainder of line 70 tells the UART to ignore the CTS, RTS, DSR and CD (Carrier Detect) signals. These extra synchronizing signals are important in high-speed transmission but can be ignored when communicating at the slow 300-baud speed of the VicModem.

BASIC Program for Testing VicModem Interface

```
10 REM TERMCHK
20 SCREEN 0,0: WIDTH 80
30 KEY OFF:CLS: CLOSE
40 DEFINT A-Z
50 FALSE=0: TRUE=NOT FALSE
60 XOFF$=CHR$(19): XON$=CHR$(17)
70 OPEN "COM1:300,N,8,1,RS,CS0,DS0,CD0" AS #1
80 OPEN "SCRN:"FOR OUTPUT AS #2
90 LOCATE 1,1
100 PRINT #2, "ON LINE"
110 PAUSE=FALSE
120 B$=INKEY$: IF B$<>"" THEN PRINT #1,B$;
130 PRINT #2,B$;:REM SCREEN ECHO
140 IF EOF(1) THEN 120
150 IF LOC(1)>128 THEN PAUSE=TRUE
160 PRINT #1,XOFF$;
170 A$=INPUT$(LOC(1),#1)
180 PRINT #2,A$;: IF LOC(1)>0 THEN 150
190 IF PAUSE THEN PAUSE=FALSE
200 PRINT #1,XON$;
210 GOTO 120
```

Going On-Line

After saving and checking the program, turn off your computer and connect the interface to the VicModem and the DB-connector at the end of the cable coming from the interface to your computer's COM 1 serial port. Plug in the transformer and verify that the originate tone is present, as described above.

Now load first BASIC and then the TERMCHK program. This done, RUN the program. Call a local electronic bulletin board, which will now answer with a tone of higher frequency. Plug the handset cord from your telephone instrument into the jack on the VicModem. You should now be greeted with the sign-on message from the bulletin board service streaming across your computer's video screen in 80 columns.

Once you are connected to the bulletin board, you will be asked to type in responses to a few questions. After typing in each response, enter a carriage return. If you get double characters on-screen when you type in your responses, stop the program with the BREAK key and delete line 130 from the program. This line contains the screen echo command. Most electronic bulletin boards echo your characters; so line 130 is not usually needed once you are in communication with the service.

If the cursor just sits there in the same spot on your computer's video screen after you plug in the handset cord from your telephone instrument, the bulletin board may be waiting for you to type in something so that it can adjust to your system's baud rate. Many BBSs require you to tap the space bar on your computer several times to establish the link. Others just start transmitting in either seven- or eight-bit data format to welcome you.

If you get an immediate I/O error or garbage streaming across your screen after several tries, try changing the 8 in line 70 of the program to a 7. More than likely, the BBS is not sending the same data format you have set up in line 70. The N, 8 and 1 in line 70 can be changed as needed. Do not forget to include the commas when you enter the replacement line 70.

If operating the space bar fails to produce a response after a few tappings, the data may not be getting through from your computer's keyboard. This can be checked, again by use of the extension phone. You should be able to clearly hear the data chirps, along with the originate tone, as you type via the keyboard. If you do not hear any chirps, make certain that the project is plugged into the COM 1 serial port on your computer.

Sometimes, there are switches inside your computer console that must be set to tell the computer which is the serial port.

If incorrect connection to the computer is not the problem, recheck the TERMCHK program you typed into your computer and are currently running. On the other hand, if you are using COM 2, simply change the wording in line 130 of the program to change it to COM 2 which should correct the problem.

If the problem still persists, power down the project and disconnect it from both the VicModem and ac line. Recheck all wiring and component installations. Rectify any problem in component installation and/or wiring before proceeding.

Once you have the system up and running, you will appreciate the work you put into adapting the VicModem you had gathering dust for want of use to your computer. With it, you have access to a whole new world of communicating.

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Dual-Application Telephone Security System

(Conclusion)

Construction, checkout, use and installation details for this automatic call-screening and remote appliance controller device

By Anthony J. Caristi

Last month in Part 1 of this article, we discussed in detail the operation of the various elements that make up this extremely useful Security System and its optional Answer Module and various interface circuits. This time around, we focus on construction details, checking out the wired project and installation and use.

Construction

The main part of the Security System (and Answer Module, if used) can be wired on singled-sided printed-circuit boards. If you do not wish to fabricate your own boards or obtain them from the source given in the Note at the end of the Parts List, you can wire the circuitry on perforated board that has holes on 0.1-inch centers, using suitable Wire Wrap or soldering hardware. If you wish to fabricate your own pc boards, use the actual-size guides shown in Fig. 7 for the Security System and Fig. 8 for the Answer Module circuitry.

From here on, we will assume that you are using pc construction. Therefore, refer to Fig. 9 for wiring instructions for the main Security System board. (If you are using point-to-point wiring, arrange the components approximately as shown in the Fig. 9 and Fig. 10 wiring guides for the main Security System and optional Answer Module boards.)

Begin wiring the main board by installing and soldering into place the sockets for the ICs. Do *not* plug the ICs into the sockets until after you have conducted preliminary voltage checks and are certain that the board has been correctly wired.

Continue populating the main board by installing and soldering into place the resistors. Follow with the capacitors, diodes and crystal. Make certain that the electrolytic capacitors and all diodes are properly oriented before soldering their leads into place. Then install and solder into place regulator *IC11*, making certain that it is properly based before soldering its pins into place. Now install power transformer *T1* in the location shown. Make absolutely certain that you do not interchange the primary and secondary leads.

This circuit-board assembly requires installation of 12 jumper wires to properly complete the circuit. The board includes pads for these installations. Use 24- or 26-gauge stranded insulated hookup wire for these jumpers. As you cut each wire to length, strip ¼ inch of insulation from both ends. Then tightly twist together the fine conductors at both ends and sparingly tin with solder before installation. Install the jumpers as follows:

- ☐ IC3 pin 14 to IC6 pin 16
- ☐ IC6 pin 16 to IC4 pin 16
- ☐ IC5 pin 16 to IC4 pin 16
- ☐ IC8 pin 2 to IC6 pin 9
- ☐ IC8 pin 4 to IC7 pin 9
- ☐ IC6 pin 2 to IC4 pin 11
- ☐ IC6 pin 7 to IC4 pin 9
- ☐ IC6 pin 15 to IC4 pin 14
- ☐ IC5 pin 9 to IC7 pin 7
- ☐ IC6 pin 8 to IC4 pin 8
- ☐ IC3 pin 8 to IC4 pin 8
- ☐ IC8 pin 15 to IC3 pins 1 and 2

As you install each jumper, check the appropriate box above.

Strip ¼ inch of insulation from both ends of 12 5-inch-long hookup wires. If you are using stranded wire, prepare them as above. Plug one end of nine of these wires into the holes labeled A through G and any of the GND holes in the circuit-board assembly. Plug one end of two more wires into the holes labeled S3 and the remaining wire into the hole labeled TO F1. Solder each wire into place as you install it. The free ends of the first nine wires go to the *S1/S2* DIP switch assembly, which mounts on the top panel of the enclosure in a DIP socket of its own.

If you are using the optional Answer Module, wire it exactly as shown in Fig. 10. Again, use sockets for the DIP ICs, but do not plug the ICs into the sockets until after you have conducted preliminary voltage checks and are certain that the circuit-board assembly has been properly wired. Make sure the diode and electrolytic capacitors are properly oriented before soldering them into place. Also, install wire leads for the LED, +5-volt, ground, and telephone-line connection lines.

The entire project, including main circuit-board assembly and any options you plan to use with it, can be housed inside a suitable enclosure. This can be any commonly available type that accommodates the circuit-board assembly and has room on one of its panels for the DIP switch assembly, toggle- or slide-type POWER and pushbutton RESET switches, two telephone jacks and the piezoelectric buzzer, plus interior room for the optional Answer Module and any remote-control interface you might wish to use.

Machine the enclosure as needed. Drill mounting holes for the main circuit-board assembly through the floor of the enclosure and an entry hole for the ac line cord and another smaller hole for mounting the fuse holder through the rear panel. This done, machine the top panel to permit mounting a 16-pin DIP solder-tail IC socket in which the *S1,S2* code-selector switch assembly will plug. Then make the cutouts for modular telephone jacks *J1* and *J2*. Next, drill the holes in which to mount RESET switch *S3* and POWER switch *S4*. Finally, drill a series of small holes through the panel in the area where piezoelectric buzzer *PB1* will mount.

If you are employing the Answer Module, also drill a small hole in the top panel in which to mount the LED for the Module and two other holes to mount the Module's circuit-board assembly.

Should you be employing any of the remote-control interface circuits discussed, mount the components for the chosen one on a small perforated board and wire them together. Then drill mounting holes for the small assembly. Also, make a cutout in the rear panel of the enclosure for the ac receptacle into which the light or appliance to be controlled plugs. Finally, if you are using a high-power relay for the interface circuit, drill suitable holes to permit mounting it inside the enclosure.

When you are finished machining the enclosure, deburr all holes and cutouts made in any metal panels to remove sharp edges. If you are using a metal enclosure, line the entry hole for the ac line cord with a rubber grommet. Then use a dry-transfer lettering kit to label the top panel (see lead photo for suggested component layout and legends). Protect the legends with two or more light coats of clear acrylic spray.

When the top panel is ready, mount the two modular telephone jacks, POWER switch and DIP socket for the *S1/S2* switch assembly in their respective cutouts and holes. Use silicone adhesive or a fast-setting epoxy cement to secure the modular telephone jacks in place. Then use silicone adhesive to mount the piezoelectric buzzer in place, centering its sound element over the small holes you drilled for the sound to escape.

Since only the red- and green-insulated conductors from the modular telephone jacks are used in this project, clip off the yellow- and black-insulated wires to prevent them from interfering with the rest of the circuitry. If the ends of the connector wires are not already prepared for installation, strip ⅜ inch of insulation from the free ends of each. Tightly twist

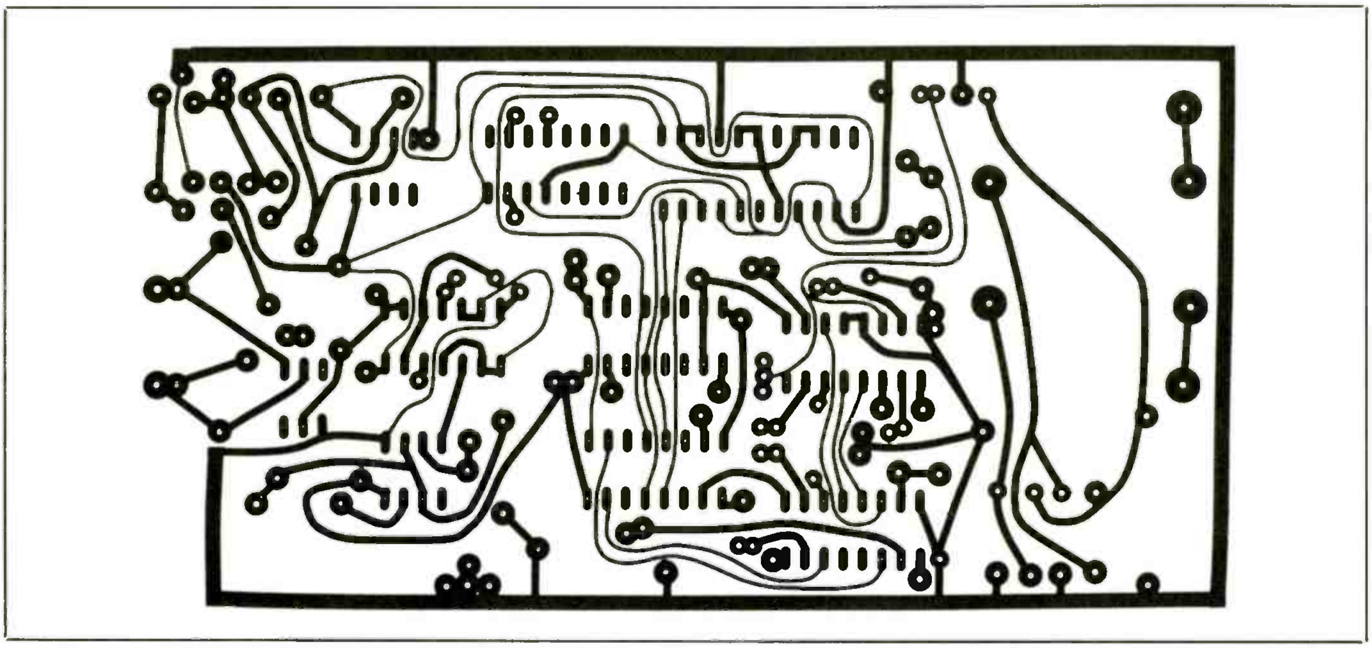


Fig. 7. Actual-size etching-and-drilling guide for main printed-circuit board.

PARTS LIST

Main Circuit

Semiconductors

D1 thru D5—1N4004 or silicon rectifier diode

IC1—LM358N operational amplifier

IC2—M957-20 DTMF receiver (Teltone)

IC3—CD4011B quad 2-input NAND gate

IC4,IC5—CD4585B 4-bit magnitude comparator

IC6,IC7—CD40175B quad D-type flip-flop

IC8—CD4017B Johnson decade counter

IC9—LM555CN timer

IC10—H11A1 or equivalent optical isolator

IC11—AN78L05 fixed +5 volt regulator

Capacitors

C1,C2—0.001-µF, 300-volt ceramic disc

C3,C6—0.1-µF, 50-volt ceramic disc

C4,C9—1-µF, 10-volt electrolytic

C5—10-µF, 25-volt electrolytic

C7—47-µF, 10-volt electrolytic

C8—0.01-µF, 50-volt ceramic disc

Resistors (1/4-watt, 10% tolerance)

R1,R2—470,000 ohms

R3—220,000 ohms

R4,R5,R7,R9,R12 thru R19—47,000 ohms

R6—56,000 ohms

R8,R10—1 megohm

R11—390,000 ohms

R20—4,700 ohms

Miscellaneous

PB1—Piezoelectric buzzer (Radio Shack Cat. No. 273-060 or similar

J1,J2—Chassis-mount modular telephone jack

S1,S2—Eight-position spst DIP switch (see text)

S3—Normally-open spst pushbutton switch

S4—Spst toggle or slide switch

XTAL—3.58-MHz colorburst crystal

Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); suitable enclosure; sockets for all DIP ICs and S1/S2 assembly; modular connectors; machine hardware; hookup wire; solder; etc.

Answer Module

Semiconductors

D6—1N4004 or similar silicon rectifier diode

IC12—TCM1520AP ring detector (Texas Instruments)

IC13—H11A1 or equivalent optical isolator

IC14—LM555CN timer

IC15—H11D2 or equivalent optical isolator

LED1—2-volt, 20-mA light-emitting diode

Capacitors

C10—0.33-µF, 250-volt Mylar or paper

C11—10-µF, 50-volt electrolytic

C12—33-µF, 10-volt electrolytic

Resistors (¼-watt, 10% tolerance)

R21—2,200 ohms

R22—560 ohms

R23—47,000 ohms

R24—1 megohm

R25—150 ohms

R26—150 ohms (½-watt)

Miscellaneous

Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); sockets for DIP ICs; machine hardware; hookup wire; solder; etc.

Interface Circuits

Semiconductors

D7,D8—1N4004 or similar silicon rectifier diode

IC16,IC17—MOC3011 or equivalent optical isolator

IC18—LM555CN timer

SCR1,SCR2,SCR3—MCR100-4 or similar sensitive-gate silicon-controlled rectifier

Q1—6-ampere, 200-volt triac (Radio Shack Cat. No. 276-1000 or similar—see text)

Q2—2N3904 or similar npn silicon transistor

Resistors (¼-watt, 10% tolerance)

R27,R31,R34,R38—2,200 ohms

R28,R32,R35—10,000 ohms

R29,R33—220 ohms

R30—150 ohms

R36,R37—4,700 ohms

Miscellaneous

K1,K3—5-volt dc relay with spst or spdt contacts (Radio Shack Cat. No. 275-243 or similar—see text)

K2—117-volt ac relay with 10-ampere spdt or dpdt contacts (Radio Shack Cat. No. 275-217 or similar—see text)

S5,S6,S7—Spst toggle or slide switch

S8,S9—Normally-open, momentary-action spst pushbutton switch

Machine hardware; hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Ready-to-wire main pc board, $19.75; Answer Module pc board, $9.75; LM358N, $1.75; M957, $18.75; CD4011, $1.75; CD4585, $3.95 each; CD40175, $3.75 each; CD4017, $1.75; AN78L05, $1.50; TCM1520AP, $6.75; optoisolators, $3.95 each (state quantity and type number); MCR-100, $1.95 each. Add $2.50 P&H per order. New Jersey residents, please add sales tax.

together first the green-insulated and then the red-insulated conductors on both jacks.

If you are using the optional Answer Module, also twist its input leads with the appropriately coded conductors from the jacks. Plug the ends of these conductor pairs (or triplets) into the holes in the main circuit-board assembly—observe proper polarity!—and solder into place.

Wire the +5-volt and ground leads of the Answer Module to the main circuit-board assembly and slip 1-inch lengths of small-diameter heat-shrinkable tubing over the free ends of the wire leads coming from it for the LED. Then identify the cathode lead of the LED and clip it to a length of ½ inch. Form a small hook in the remaining stub and crimp and solder the free end of the cathode wire coming from the circuit-board assembly to it. Repeat with the anode lead and wire. When the connections cool, slide the tubing up over the connections until it is flush with the bottom of the LED case and shrink into place. Then, observing polarity, wire the piezoelectric buzzer to the main circuit-board assembly.

Assuming you are using one of the remote-control interface circuits described earlier, wire it to the main circuit-board assembly, making sure you correctly polarize its power leads and connect its input wire to the output at pin 4 of *IC3B* on the main circuit-board assembly.

Mount the ac receptacle of the remote-control interface option on the rear panel in its cutout. Then mount the fuse holder and any interface relay you are using in their respective locations with appropriate machine hardware.

Pass the free end of the ac line cord through the hole you drilled for it in the rear panel and tie a strain-relieving knot in it about 5 inches from the unfinished end inside the enclosure. Tightly twist together the fine wires in each conductor and sparingly tin with solder. Plug one conductor into the hole labeled LINE CORD on the main circuit-board assembly and solder into place.

Now mount the main circuit-board assembly in place on the floor of the enclosure, using ½-inch spacers and 4-40 × ¾-inch machine screws, nuts and lockwashers. Using suitable machine hardware, mount any other circuit assemblies you plan on using inside the enclosure.

Carefully crimp and solder the free ends of the *S1* and *S2* wires coming from the main circuit-board assembly to the appropriate pins of the DIP socket you mounted on the top panel of the enclosure. Use the positions 1 through 4 socket pins for *S1* and positions 5 through 8 pins for *S2*.

If the DIP switch assembly does not have one side of all eight switches in the DIP-switch assembly internally wired in common, connect and solder a shorting wire across all IC socket pins that go to the toggles of the switches and terminate this connection with the *S1/S2* common wire coming from the main board.

When you are done, carefully inspect your work, particularly for inadvertent solder bridges between the closely spaced pins of the socket. If you missed a connection, solder it now. If any connection appears grainy, reflow the solder on it. If you locate any solder bridges, clear them with desoldering braid or a vacuum-type desoldering tool.

Crimp and solder the remaining ac line cord conductor to one lug of the POWER switch. Crimp and solder the free ends of the *S3* wires to the lugs of the pushbutton RESET switch. Then use a short length of hookup wire to bridge from the other lug of the POWER switch and one lug of the fuse holder. Locate the wire coming from the TO F1 hole on the main circuit-board assembly and crimp and solder its free end to the other lug of the fuse holder. Place a ½-ampere slow-blow fuse in the holder.

Plug the LED coming from the Answer Module circuit-board assembly into the hole you drilled for it through the top panel. If the LED does not remain in place by friction, secure it with a small daub of silicone adhesive or fast-setting epoxy cement.

Checkout & Use

To check out the project, all you need is an analog or digital multimeter capable of measuring dc potentials of up to 20 volts. If you discover a problem, an oscilloscope can be very useful for troubleshooting the project.

Before applying power to the project, make sure that no DIP ICs are plugged into the sockets of any circuit module. Begin by clipping the common lead of the meter, set to measure dc volts, to any convenient point that is at circuit ground and leave it there throughout the following tests.

Plug the project into a convenient ac outlet and set the POWER switch to "on." Now, keeping well clear of the potentially lethal ac line voltages in

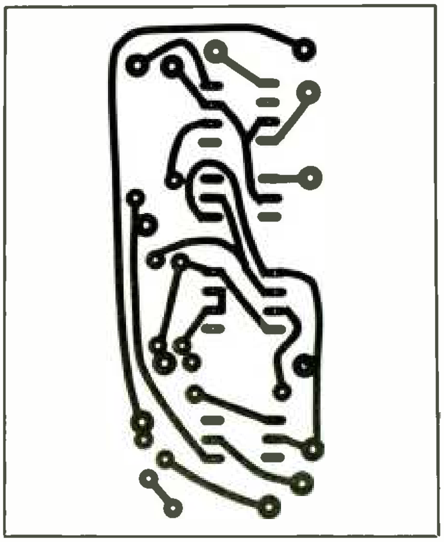


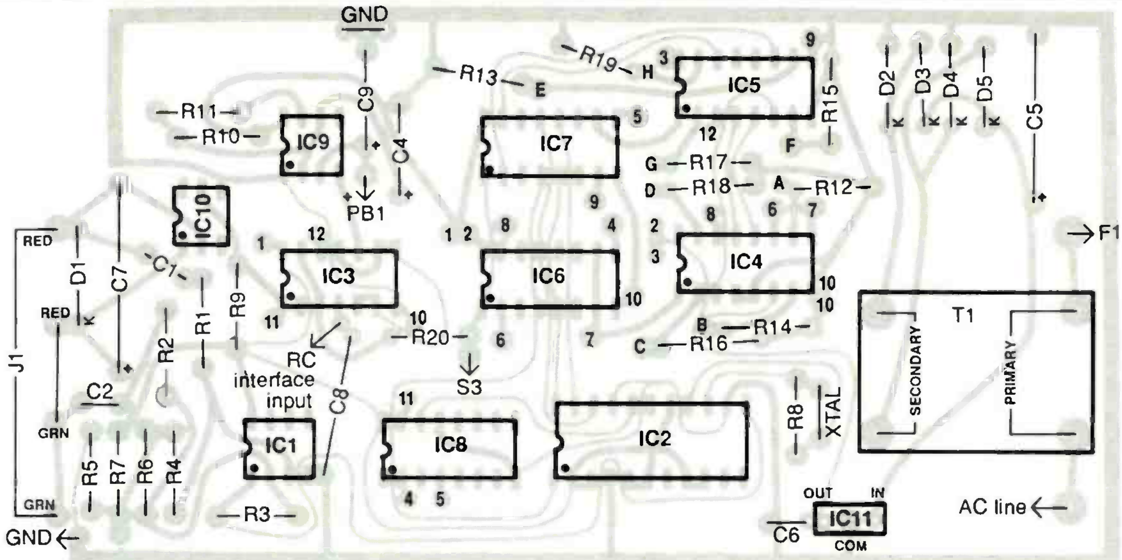
Fig. 8. Actual-size etching-and-drilling guide for Answer Module.

the *T1* primary circuit, touch the "hot" probe of the meter to the OUT pin of *IC11* and note the reading obtained. If it is not +5 volts, power down and unplug the project from the ac line. Check out the entire power supply for correct wiring and component orientations and basing. Do not proceed until the problem has been corrected.

Once you are sure of the power-supply wiring, touch the "hot" probe of the meter to pin 8 of the *IC1* and *IC9* sockets; pins 2, 3, 5, 6, 8, 9 and 16 of the *IC2* socket; pin 14 of the *IC3* socket; pins 6 and 16 of the *IC4* socket; pin 16 of the *IC5* through *IC9* sockets; and pin 5 of the *IC10* socket. In all cases, you should obtain a reading of approximately +5 volts. If not, power down and rectify the problem before proceeding.

Next, check out the Answer Module circuit-board assembly. Leave the common lead of the meter connected to circuit ground. Touching the "hot" meter probe to pin 5 of *IC13* and pins 4 and 8 of the *IC14* socket should yield a reading of about +5 volts if all is okay.

Finally, check out power distribution in any remote-control interface circuit you may have incorporated



NOTES:
1. A thru H and GND go to S1 and S2.
2. 1 thru 12 are bottom-of-board jumpers (match numbers)–see text.

Fig. 9. Wiring guide for main pc board.

into your project.

Once you are certain that the project has been properly wired, set the POWER switch to "off" and unplug the line cord from the ac receptacle. Allow time for the charge to bleed off the electrolytic capacitor in the power supply. Then plug the ICs and optical isolators into their respective sockets and the DIP switch assembly into its socket on the top panel of the enclosure.

Make sure you properly orient each IC as you plug it into its socket. Also, make sure that no pins overhang any socket or fold under between IC and socket.

Connect the project to the telephone line using a standard telephone cord between the telephone wall jack and TELEPHONE LINE jack *J1* on the project. Plug a Touch Tone-type telephone instrument into ANSWERING MACHINE jack *J2* on the project. (If you built in the optional Answer Module, disconnect it and temporarily connect the red- and green-insulated wires of the telephone in its place, observing correct polarity).

Set the SECURITY CODE DIP switches to any two-digit code. Table 1 details the four-bit codes for the 12 possible choices of each digit. In this Table, a 0 represents an open switch, a 1 a closed switch. If you want the security code to be 15, for example, set S1 and S2 as follows with the sequence: ON OFF OFF OFF (*S1* portion) and ON OFF ON OFF (*S2* portion).

Once the SECURITY CODE switches have been set, apply power to the project. With the handset of the telephone instrument on-hook, the piezoelectric buzzer should be silent because the on-hook logic generated by *IC3* causes pin 4 of *IC9* to be zero, which inhibits the ring circuit.

Now lift the handset and listen for a dialtone. When you hear it, enter the security code by pressing the correct buttons of the telephone keypad. When the second digit is entered, the buzzer should sound with a 1-second on/1-second off period. Placing the telephone handset back on-hook should silence the buzzer.

Pick up the handset once again and enter the security code to enable the buzzer. While the handset is off-hook, pressing the RESET button should silence the buzzer.

If you do not obtain the correct responses, power down the project and rectify the problem before proceeding with final checkout.

The circuit can be checked using an orderly sequence of tests to determine the location of the fault. This can be done by measuring logic levels at strategic points in the circuitry with your multimeter.

Begin checkout with an operational test of *IC2*. With the project powered and the telephone off-hook, press any phone keypad buttons as you measure the voltage at pin 18 of *IC2*. Each time you press and hold a button, you should obtain a reading of about 5 volts. This indicates that the DTMF receiver is responding to the dual tones generated by the telephone. The data outputs at pins 20, 21, 22 and 1 of *IC2* should assume the logic levels listed in Table 1 as you hold down any keypad button.

If *IC2* does not properly decode the tones, check the *IC1* circuit. If an oscilloscope is available, check pin 14 of *IC2* to be certain that the crystal oscillator is working. Normal indication here is a 3.58-MHz waveform with an amplitude of approximately 5 volts peak-to-peak. Check the voltage at the + 5-volt and grounded pins of *IC2* to be sure that every such pin of the chip has the correct voltage.

With the telephone handset on-hook, the data outputs at pins 2, 7, 10 and 15 of *IC6* and *IC7* should each be 0000. Taking the handset off-hook and entering any two digits for the security code, should cause the hexadecimal data output of *IC6* to contain the identity of the first digit and *IC7* to contain the identity of the second digit. If not, check pins 1 and 2 of *IC3* to see if the transistor portion of *IC10* conducts during off-hook operation and provides a logic 0 level to *IC3A*.

Check pin 15 of *IC8* to be sure that it is high during the on-hook condition and low for the off-hook condition. Check pins 3, 2 and 4 of *IC8* for the logic-1 condition that occurs when the chip is incremented from a count of 0 for on-hook to 1 and then 2 as the digits are entered via the telephone keypad.

Check pin 3 of *IC5* to ascertain that it remains at 0 with the handset on-hook and goes to 1 (+5 volts) when the correct security code is entered. If not, make sure you have properly connected the data lines of the SECURITY CODE DIP switches into the circuit and check Table 2 to be sure you have properly set the switches. Pin 10 of *IC4* and *IC5* should be connected to the least-significant bit (LSB) switches of *S1* and *S2*. Pins 7 and 2 represent more-significant bits up to the most-significant bit (MSB), which is located at pin 15 of *IC4* and *IC5*.

With pin 3 of *IC5* high when the correct security code is entered, pin 4 of *IC9* should be high, enabling this chip and causing it to oscillate. If not, check all sections of *IC3* for correct logic levels.

If *IC9* does not oscillate at about 0.5 Hz when enabled with a high logic condition at pin 4, check the values of *R10* and *R11*. Make sure *IC9*, *C4* and *C9* are properly oriented. If all else fails, try another 555 chip.

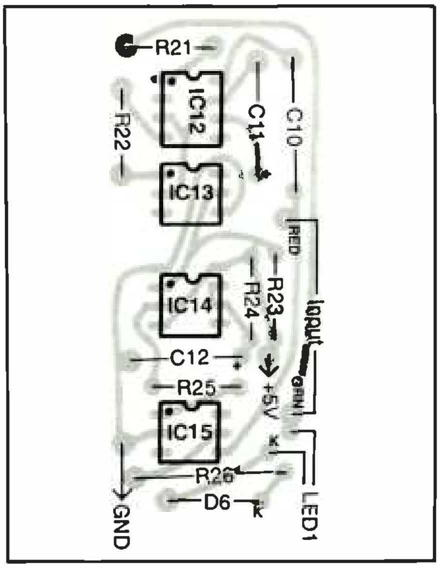


Fig. 10. Wiring guide for Answer Module pc board.

To check out the Answer Module, reconnect it to the telephone line inside the project in correct polarity (see Fig 1). To make the test, have someone call the number of the line from an outside telephone. When the call is made, the Answer Module should immediately capture it, light the LED and terminate the ring signal. The caller may not hear the normal ring signal in his handset, and any telephone connected to the called number may not ring. When the call is answered by the Answer Module, the caller hears no sound other than a click when the line is seized. At the end of the 30-second timing cycle of the Answer Module, another click will be heard, indicating that the line has disconnected.

Table 1. IC2 Hex Output Values

Keypad Digit	Hexadecimal Code 8	4	2	1*
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	1	0	1	0
*	1	0	1	1
-	1	1	0	0

* Binary values at pins 20, 21, 22 and 1, respectively

If you do not obtain the above responses, check all plug-in and polarized components to be sure that they have been properly installed. If a visual check fails to reveal the problem, check out *IC11* by connecting it to a telephone line (with correct polarity) and using the ring signal when that line is called to provide power. The ring signal detector can be checked by measuring the dc voltage between pins 4 and 7 of *IC11*. When the ring signal is present, normal potential is about 5 volts dc.

With 5 volts dc from the main circuit-board assembly in the project applied to the Answer Module, *IC14* can be triggered by momentarily shorting pins 1 and 2 of the chip. When this is done the one-shot timing is initiated and pin 3 rises to a level of about +3 volts and remains there throughout the timing cycle.

When *IC15* is activated by *IC14*, the phototransistor inside *IC15* conducts and connect *R26* across the red- and green-coded input terminals. The LED will provide visual indication of the current draw from the telephone line. If *IC14* operates properly with the telephone line ring signal but the circuit does not seize the line, check the orientations of *D6* and *LED1* and the polarity of the telephone line input connections to the Answer Module.

There are several ways in which the Dual-Application Telephone Security System can be connected into your telecommunications system. You can use the system with an existing telephone answering machine. Alter-

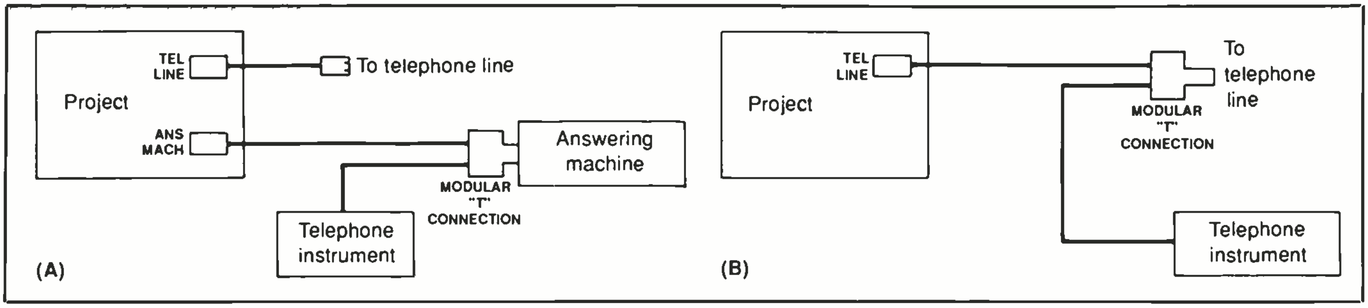


Fig. 11. Two methods of connecting project into a telecommunications system: (A) When using optional Answer Module and (B) when using an existing answering machine, both with an optional local telephone instrument.

natively you can use it with the optional Answer Module in place of an answering machine. In either configuration, you can use the system with or without a local telephone.

If you do not have an answering machine, simply use the optional Answer Module in its place. Any local telephone instrument then plugs into the ANSWERING MACHINE jack on the project. Connection to the telephone line is accomplished with a standard telephone cord plugged into the TELEPHONE LINE jack on the project and telephone wall box. This is illustrated in Fig. 11(B).

If you use the basic system with an existing answering machine, you can connect a standard telephone cord between the telephone wall jack and the TELEPHONE LINE jack on the project. Then plug the input cord from the answering machine into the ANSWERING MACHINE jack on the project. This arrangement is illustrated in Fig. 11(B). If you want to use a separate telephone instrument with this arrangement, you can plug it into the TO TELEPHONE jack on the rear of the answering machine. If the answering machine does not have such a jack, plug a T adapter into the ANSWERING MACHINE jack on the project and plug and the answering machine and instrument into the receptacles on the adapter.

Connect the project into your telecommunications system according to what other equipment you have. If you are going to use your telephone security system as a call-screening device with an existing answering machine, record an outgoing message that informs the caller to enter the security code. If a caller does not have the security code, instruct him to leave a message.

If your project is to be used as a remote-control device, there is no need to change your existing answering machine outgoing message. Alternatively, you can install the Answer Module in place of the answering machine. Remember, with the Answer Module, callers will not hear a message.

Connect the project to the telephone line and answering machine or Answer Module, if used, according to the appropriate diagram in Fig. 11. Make sure not to interchange the two telephone cables shown. Apply ac power to the project and select your security code via the DIP switches in accordance with Table 1. Any two-digit code indicated in Table 2 is permissible, including the characters * and #.

If you have a second telephone line, use it to call the number to which the project is connected. Otherwise, have a friend call your number so that you can check the operation of the project.

When the number is called, the answering machine will transmit its outgoing message or the Answer Module will seize the line as soon as the call is received. When the call is answered, the security code should be entered by the caller. As soon as the second digit is entered, the buzzer should sound its 1-second on/1-second off ring signal. Any telephone instrument connected to the called number can be picked up to permit conversation. Pressing the RESET button on the project should silence the ring.

If you want a two-tier system for call screening, you can inform whomever you wish of one security code and others of the "priority" code. During normal hours, your Security System can be set to respond to the first code, while late at night, the code can be changed to "priority." Should important callers ever call on the first code and get no response, they can call again and use the priority code to get through.

It is not necessary to silence the ringer of the telephone instrument or answering machine connected to the telephone line. The Security System always intercepts the call and stops the telephone company ring signal. However, if your answering machine takes one or two rings to do this, you can usually switch off the ringer of the telephone or machine if desired. This way, you will not be disturbed by any call not authorized to get through to you.

When the project is to be used as a remote-control device, call your number and enter the security code after the call is intercepted by the answering machine or Answer Module. Then simply hang up. When you get home, you will find that your command has been obeyed. ME

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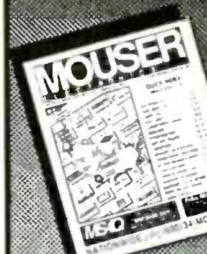

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High-Power Visible Light-Emitting Diodes

By Forrest M. Mims, III

Once as rare and costly as rubies, light-emitting diodes (LEDs) have become one of the most widely available electronic components. In recent years, there have been significant reductions in prices for visible LEDs. Equally important is the development of a new generation of high-power LEDs that produce as much as or more light than an incandescent lamp.

In this column, I'll cover the various kinds of high-power red LEDs and describe several applications. While some of these applications specifically require visible light, others show how high-power red LEDs can sometimes be substituted for their infrared cousins.

Early Visible LEDs

Last month, I told how in 1966 Dr. Edwin Bonin of Texas Instruments gave me some early high-power near-infrared emitting diodes for use in a travel aid I had designed for the blind. During our meeting, Dr. Bonin reached into a desk drawer and pulled out a small penlight that emitted a pinpoint of red light, which was generated by a new kind of LED I had not yet heard about, one that emitted visible light, rather than near-infrared.

I was as intrigued by that relatively feeble red LED as by the array of powerful near-infrared emitters Dr. Bonin placed on his desktop. A few years would pass before I could experiment with red LEDs since they were still experimental devices.

The visible LED Dr. Bonin showed me was made from gallium arsenide phosphide (GaAsP). While GaAsP LEDs are inexpensive and widely used as indicators, a new generation of aluminum gallium arsenide (AlGaAs) heterostructure LEDs generate ten times or more optical power when driven by the same current level. These new LEDs are so efficient that their output power is comparable to near-infrared emitting LEDs driven by the same current level. Even more remarkable is that these new LEDs emit usable light when driven by a current of a milliampere or less.

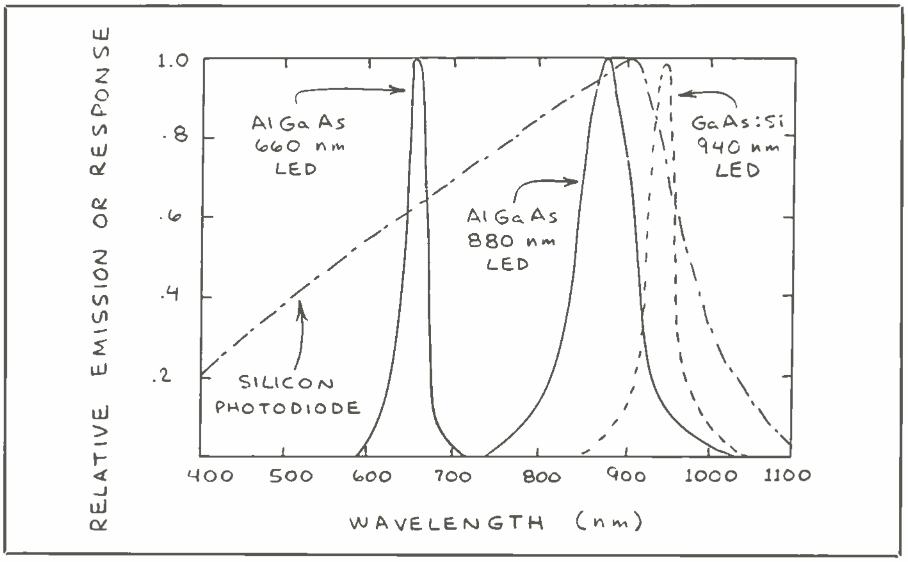


Fig. 1. Spectral emission of 660-nm LED and infrared LEDs.

Figure 1 is a spectrum graph that compares the peak wavelength of an AlGaAs 660-nanometer red LED with the peak wavelengths of the two most common high-power near-infrared LEDs. Note that a silicon detector is only about 60 percent as responsive to the radiation from a 660-nm device as to the near-infrared wavelengths emitted by the other two devices.

Powering High-Power LEDs

Most epoxy-encapsulated high-power red LEDs are rated for a maximum continuous forward current of 50 milliamperes. As with infrared LEDs, maximum drive current can be increased considerably if it is applied in brief pulses that don't appreciably heat the chip. For example, Stanley's H2K is specified as a 2,000-millicandela emitter when driven by 20 milliamperes of forward bias. This corresponds to an output power of around 6 milliwatts.

This same diode can be driven by current pulses having a peak amplitude of 300 milliamperes, as long as the pulse duration does not exceed 1 millisecond and duty cycle remains below 5 percent. At 300 milliamperes, the diode emits more than 10 times the optical power it emits at 20 milliamperes.

Light emitted by a high-power LED is a linear function of the forward current so long as the LED is not overheated. Figure 2 shows the power in the central beam emitted by a Stanley H2K LED biased by from 0 to 50 milliamperes. To make this graph, I directed the light in the central beam emitted by the LED at a calibrated silicon solar cell. I then measured the current from the solar cell for each of a range of LED currents and calculated the power emitted by the LED. As you can see, this AlGaAs 660-nm red LED provides about the same power level as an AlGaAs 880-nm near-IR LED.

Low-Power Operation Of High-Power LEDs

While the amazingly bright light produced by high-power LEDs is what interests most users most, it's important to remember the low-power advantage of high-power LEDs. Because of their very high power conversion efficiency, a typical super-bright LED will emit a visible red glow when forward biased by a current of a milliampere or less. This means high-power LEDs can be directly driven

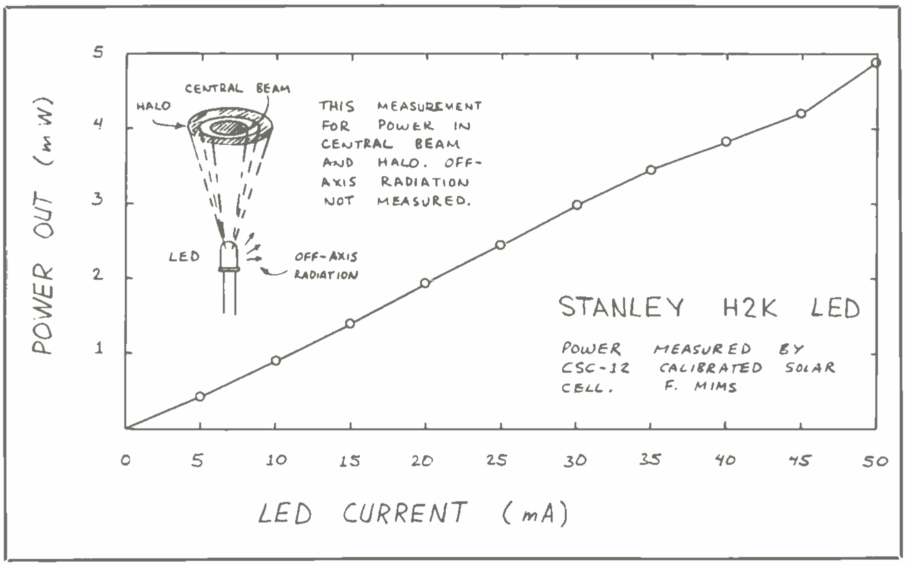


Fig. 2. Output power in central beam of H2K super-bright LED.

from CMOS and other low-current sources. They can even be powered by super capacitors, various kinds of home-made batteries and tiny solar cell arrays.

When operating a super-bright LED continuously, be sure to provide an appropriate value of current limiting resistance. Otherwise, the LED will draw excessive current from the source and defeat the advantage of its ability to glow when driven by a very small current.

The value of series resistance is found by subtracting the LED forward voltage (see the data sheet) from the supply voltage and dividing the result obtained by the desired forward current using the formula $R_{in} = (V_{in} - V_{LED})/I_{LED}$.

Assume, for example, that you are using a 3-volt lithium cell to power an AlGaAs LED with a forward potential of 2.2 volts. You want to drive the LED at a forward current of around 5 milliamperes. The series resistance is then (3 − 2.2)/0.005, or 160 ohms. The closest standard resistance value to this is 150 ohms. Rearranging the formula to solve for LED current gives $I_{LED} = (V_{in} - V_{LED})/R_s$. Inserting 150 ohms for R_s gives a forward current of 5.33 milliamperes, which is only around 6 percent more than your objective.

How Bright is Bright?

The brightness of visible LEDs is specified in millicandelas. An article on this subject in *The Hewlett-Packard Journal* (August 1988) noted that a diode's on-axis viewing intensity, the so-called millicandela rating, can be very misleading. This is because the same LED chip can have strikingly different millicandela ratings when encapsulated in different packages that alter the beam pattern emitted by the chip. Here, for example, is how changes in the beam pattern from the same chip installed in various packages affects the millicandela rating:

On-Axis Intensity (millicandelas)	Beam Angle (degrees)
60	60
100	45
200	30
250	24
500	17
1,000	8

From this table, it's immediately obvious

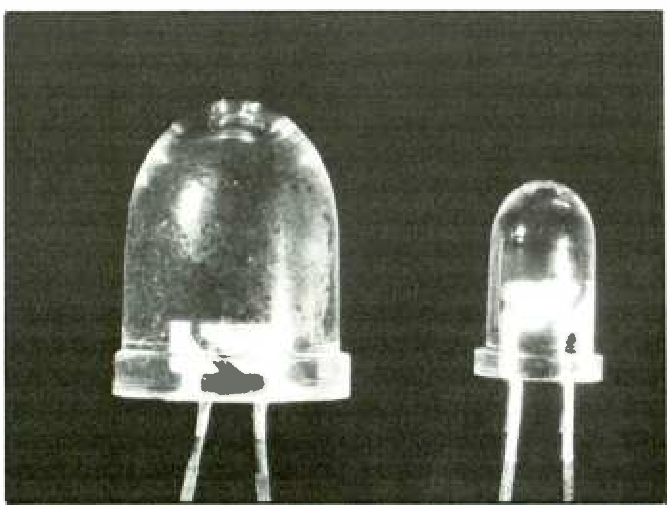
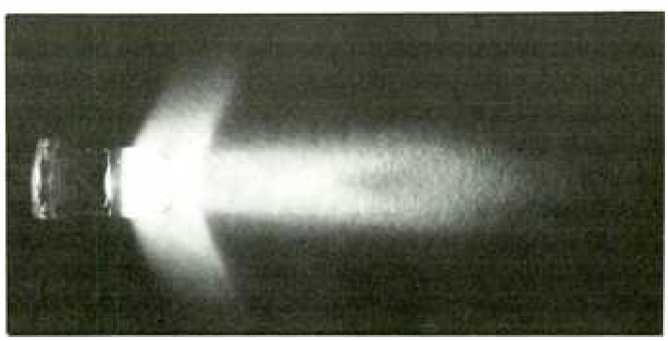


Fig. 3. A large Sharp LT9512U high-power red LED (left) alongside a standard high-power red LED.

Fig. 4. Light emission pattern from a typical high-brightness red LED.



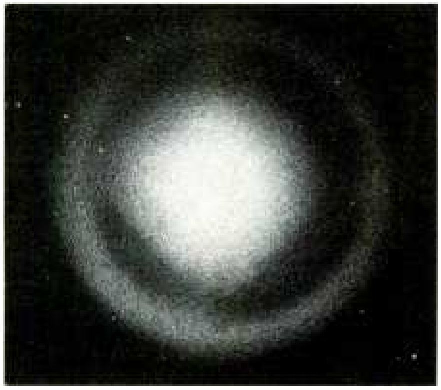


Fig. 5. Beam cross-section of a Stanley H1K with centered chip.

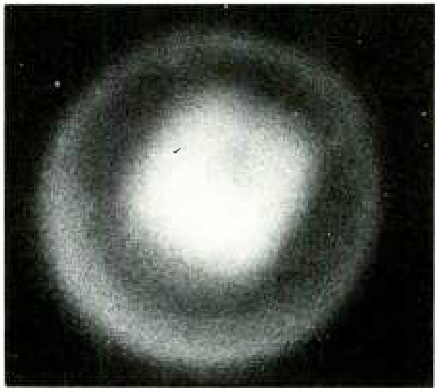


Fig. 6. Beam cross-section of a Stanley H1K with slightly misaligned chip.

Fig. 7. Beam cross-section of International Devices ID 3000-UR LED.

that a diode that has a narrow beam pattern has a far higher on-axis intensity rating than a diode with a broad beam pattern.

The easiest way to increase the on-axis viewing intensity, hence millicandela rating, of a LED, is to mold the epoxy encapsulant into a suitable collimating lens. Since the LED chip is large in relation to the focal length of the lens provided by a conventional LED package, beam divergence is limited to a minimum of around 20 degrees or so at the half power points.

A standard super-bright LED is shown alongside a much larger LT-9512U LED made by Sharp Corp. in Fig. 3. This LED is available from Radio Shack (Cat. No. 276-086) for $4.99. The advantage of the large LED over the smaller unit is the increased distance between the LED chip and the lens formed by the end of the epoxy package. This provides a narrower beam and, therefore, a higher brightness when the LED is viewed along its axis. Consequently, the LT-9512U is rated for a luminous intensity of 5,000 millicandelas while the smaller LED, which has a similar chip but a larger beam divergence, is rated at 2,000 millicandelas.

LED Beam Patterns

If you've used near-infrared LEDs, you know the frustration of trying to determine the shape of the projected beam. For this reason alone, I look forward to using a super-bright LED as an optical source in a miniature lightwave communication system I'm planning to build. For example, the super-bright LED in Fig. 4 clearly shows the projected beam as it illuminates the white card on which the LED is resting. Note the substantial off-axis illumination that forms a halo around the central beam when viewed on-axis.

Although LED manufacturers specify the beam shape of their LEDs, slight misplacement of the LED chip can alter the specified beam pattern. You can quickly evaluate a LED's beam pattern by pointing the device at a white card or by observing it through a piece of ground glass. Figure 5, for example, shows the beam pattern produced by a Stanley H1K with a properly centered chip. The same type of LED in Fig. 4 is shown with a slightly misaligned chip in Fig. 5. I made both photos by placing the LEDs a few centimeters behind a ground glass screen on which a camera was focused.

The chips in Fig. 5 and Fig. 6 are so well focused that their square edges are visible. Figure 7 shows the beam pattern from an International Devices ID 3000-UR LED. Because of slight de-focusing, the chip is less well defined and the off-axis halo is blurred. While this LED will have a somewhat broader beam, it will provide a more diffuse light source.

Finally, Fig. 8 shows the beam pattern from a Sharp LT9512U LED. Even though the square chip is not well defined, the very large dimensions of this light-emitting diode provide a very narrow and intense beam.

Pulsed High-Current LED Driver Circuit

Figure 9 shows the details of a driver circuit that can apply very fast, high-current pulses to an LED. The circuit is based on a similar driver I described last month for high-power near-infrared LEDs. The major difference between the two circuits is that both the pulse generator and driver sections are powered by the same supply. In the previous circuit, the pulse generator and driver sections of the circuit were powered by separate supplies to permit a higher voltage to be applied to the driver section. In turn, this provides a higher current capability.

The 555 timer chip in Fig. 9 is connected as a pulse generator whose repetition rate is determined by the values *R1* and *C1*, pulse duration by the value selected for *C1*. With the values shown, the 555 supplies a train of negative 10-microsecond pulses to a parallel array of CMOS inverters made by interconnecting three (or more) gates of a 74C04 or similar chip as shown.

The positive pulses from the inverters are then applied to the gate of power MOSFET *Q1*, which switches on during each pulse. This connects the power sup-

Fig. 8. Beam cross-section of Sharp LT9512U oversize LED.

ply directly across the LED and *Q1*'s drain and source terminals. Capacitor *C2*, which is connected directly across the power supply leads, helps keep the top of each pulse relatively flat.

For best results, use an n-channel power MOSFET that has an on-resistance of less than 1 ohm for *Q1*. The IRF-511, an International Rectifier power MOSFET available from Radio Shack for $1.99, has an on-resistance of 0.6 ohm. For even higher efficiency, use an IRFZ40 with an on-resistance of only 0.028 ohm. You can obtain this MOSFET from Digi-Key (P.O. Box 677, Thief River Falls, MN 56701-0677) for $6.12.

Resistor *R3* is included in the circuit to permit the current through the LED to be monitored with an oscilloscope. Therefore, *R3* is referred to as a current-monitoring, rather than current-limiting. resistor. In most LED circuits, a current-limiting resistor is required to limit the current through an LED to a safe value.

Since the objective of this circuit is to supply very high pulses of current, a series resistor isn't needed. Instead, the current through the LED is determined by the power supply voltage. However, a series resistor can be used when necessary. For example, if the available supply voltage is too high, a series resistor can be inserted to reduce the amplitude of the current pulses applied to the LED.

If you don't have access to an oscilloscope, you can omit *R3*, as long as you connect the source of *Q1* directly to ground. Otherwise, you should keep *R3* in the circuit.

If you can't find a l-ohm resistor, you can make a substitute by connecting nine or ten 10-ohm resistors in parallel. The fastest way to do this is to twist the opposing leads of the resistors together and solder them in place. Clip off all but one lead from each end of the bundle of resistors. A neater way is to drill or punch nine holes in two matching squares of copper foil or thin pc-board material. Insert one lead from each resistor through one of the squares; then insert the second lead from each resistor through the holes in the second square to form a cubical assembly. Solder the leads to each foil square and clip off all but one lead. Which ever approach you take, be sure to protect your eyes when clipping the leads.

Since nearly all super-bright red LEDs are encapsulated in epoxy and don't have metal surfaces for attachment of a heat sink, it's very important to follow the manufacturer's recommendations concerning peak pulse current. Pulse duration and duty cycle are equally important.

The following table shows the current values I measured for a high-power Sharp LT9512U driven by the circuit shown in Fig. 9:

Supply Voltage	LED Current (amperes)
3.0	0
3.5	0.11
4.0	0.33
4.5	0.43
5.0	0.53
5.5	0.61
6.0	0.70
6.5	0.80
7.0	0.88
7.5	0.98
8.0	1.06
8.5	1.18
9.0	1.28
9.5	1.38
10.0	1.48
10.5	1.60
11.0	1.70
11.5	1.80
12.0	1.90

These values are plotted as the lower trace in the graph shown in Fig. 10.

The upper trace in Fig. 10 is the LED current for a high-power 880-nm near-IR emitter driven by the same circuit under

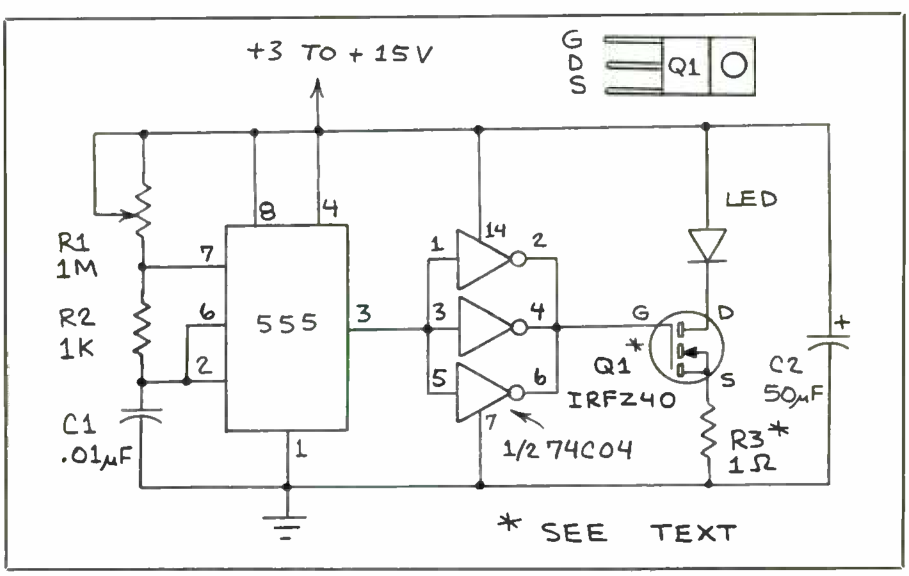


Fig. 9. A MOSFET high-current LED pulse drive circuit.

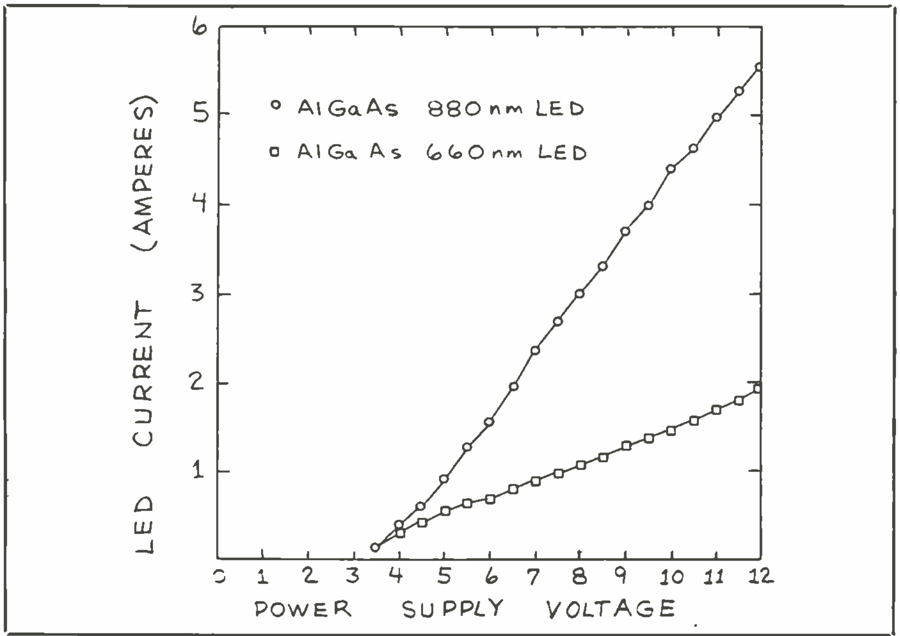


Fig. 10. LED current produced by Fig. 9 MOSFET LED pulse drive circuit.

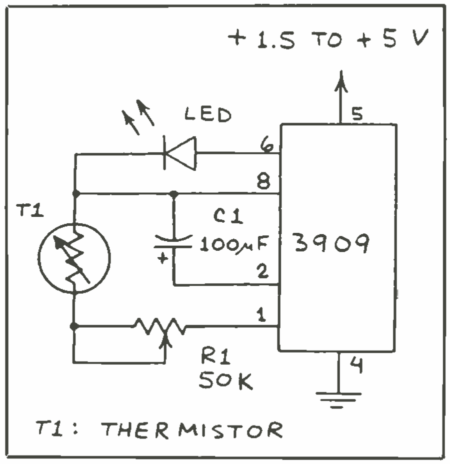


Fig. 11. A LED temperature transmitter.

the same conditions. Note that while both LEDs are made from AlGaAs, considerably more drive current is delivered to the near-IR LED as compared to the red LED. This is because near IR LEDs have a lower forward voltage than do LEDs that emit visible light. The result in this case is that for a supply potential of 12 volts, the infrared LED receives nearly three times the current as the red LED.

You might be tempted to expand the duration of the pulses applied to the LED by increasing the value of *C1*. The following table, repeated from last month's column, shows the pulse durations I measured for a range of values for *C1*:

C1 (μF)	Pulse Duration (μs)
0.0047	0.85
0.001	1.7
0.005	6.0
0.01	10.0
0.047	40.0
0.1	88.0

The pulse durations you measure will be affected by the tolerances of the capacitors you use. Therefore, while these are the pulse durations that I measured, you should consider them as approximate. Make sure the capacitor is rated for the power supply voltage.

Note that the last table doesn't show values for *C1* above 0.1 microfarad. You might be tempted, as I was, to use higher values, but this greatly increases the likelihood of over-stressing the LED. I have used up to 10 microfarads at very low repetition rates. At more than a few tens of Hertz, the LED will quickly overheat and be destroyed—as I found out when I inadvertently fried one of those big beautiful LT9512U LEDs.

Temperature Transmitter

Ultra-bright red LEDs can be used as optical telemetry transmitters. For example, shown in Fig. 11 is a very simple circuit I've used to transmit temperature information over hundreds of feet at night.

The Fig. 11 circuit is from my new *Engineer's Mini-Notebook: Science Projects* (Radio Shack, 1990, p. 44). The objective of this circuit is to flash a super-bright LED at a rate slow enough to be easily counted by eye sight. This eliminates the need for a receiver. The count rate is then compared with a calibration curve to determine the temperature of the transmitter.

The LED in the Fig. 11 circuit can be any super-bright unit, the brighter the better. Trimmer resistor *R1* is used to alter the flash rate. Thermistor *T1* has a resistance of around 10,000 ohms at room temperature and is a Radio Shack Cat. No. 271-110 or similar device. Although the circuit can be powered by up to 5 volts, increasing the voltage will also increase the flash rate. I recommend you stick to a single 1.5-volt alkaline cell for most applications.

I calibrated the circuit by insulating the thermistor and immersing it in cold water along with an accurate thermometer. I then counted the number of flashes that occurred in 30 seconds and recorded the flash rate and the temperature. Next, I added a small amount of warm water to the cold water and again counted the number of flashes that occurred in 30 seconds. I repeated this procedure until the temperature of the water reached 100° F.

A typical calibration curve for the Fig. 11 circuit is for when the circuit was powered by a single penlight cell is shown in Fig. 12. The curve you obtain will vary depending on the tolerance of *C1* and the

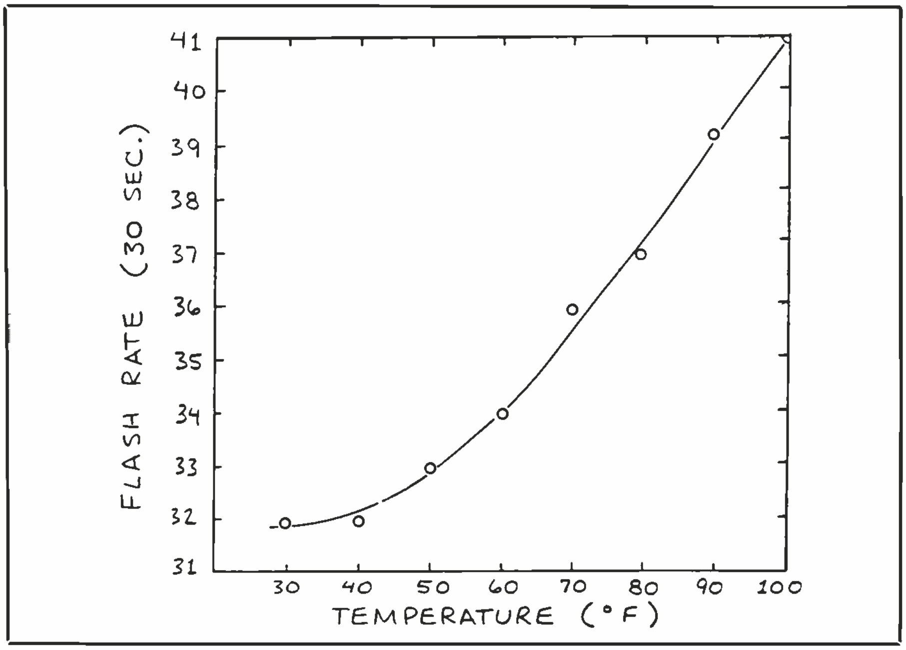


Fig. 12. Typical calibration curve for Fig. 11 LED temperature transmitter.

power supply voltage and, of course, the setting of *R1* and the characteristics of your thermistor.

This calibration method is quick, but it's not necessarily accurate since flash rate varies with the battery voltage. If there's a chance that the battery voltage will be altered by the ambient temperature, calibration should be performed by cooling and heating the entire circuit, battery and all. This can be done by enclosing the circuit in a water-tight plastic bag and immersing it in a water bath.

The temperature transmitter produces very bright flashes of red light, especially when your eyes remain within the main portion of the LED's beam pattern. Late one night, I placed the circuit on the front porch of my office, switched off the porch light, and walked a few hundred feet down the lane to my mailbox. The flashes from the LED were surprisingly bright over the entire distance.

Thus far I've described operation of the Fig. 11 circuit as a temperature transmitter powered by a single 1.5 volt cell. The circuit can also be used as a general-purpose flasher and can be powered by a higher voltage supply. To use the circuit as a 1-Hz flasher, remove *R1* and the thermistor and connect pin 1 of the 3909 directly to pin 8. Use a 330-microfarad capacitor for *C1*. A 3-volt lithium coin cell makes a very compact power source, as does a 1.5-volt N cell.

Probably the most unique power source for the flasher circuit is a super capacitor charged to from 3 to 5.5 volts. I connected both 5.5 volts and a 0.1-Farad super capacitor across the power supply leads. When the 5.5-volt supply was disconnected after a minute or so, the LED continued to flash at a rate of about 1 Hz for around 3 minutes before the flash rate slowed appreciably. This is plenty of time to use the circuit as a tracking light for photographing and recovering boomerangs, frisbees and the like at night.

Incidentally, a super capacitor will hold its charge for a considerable time. While preparing this column, I charged a 0.1-Farad capacitor to 5.5 volts late one evening. The next morning, this capacitor powered the flasher circuit at about a 1-Hz rate for nearly 3 minutes before the flash rate began to slow.

Going Further

I hope this column has stimulated your interest in high-power red LEDs to a point where you want to try one of these remarkable light sources in one of the many applications for which they are so well suited. For more information about the LM3909, see the National Semiconductor data sheet. Also, see National's LM-3909 application note (AN-154, "1.3V IC Flasher, Oscillator, Trigger or Alarm" by Peter Lefferts, 1975).

One application I want to try is a miniature temperature transmitter to be flown from a helium-filled balloon or trash bag at night. Another is a visible-light lightwave communicator. Finally, the 660-nm light emitted by super-bright red LEDs is transmitted well by plastic optical fibers. This opens up many applications in communications and sensing.

New No-Code Ham License Proposed

By Curt Phillips

If you've been an electronics enthusiast for very long, you probably have considered getting an amateur radio license at one time or another. Many of you, when you discovered that learning the International Morse Code was a requirement for a ham license, however, were deterred from pursuing amateur radio as a hobby. Now the code obstacle may soon be gone for at least one amateur radio license, and you can have input into the final shape of the new code-free license.

This impending change was formalized recently by the Federal Communications Commission's (FCC) Notice of Proposed Rule Making (NPRM) to "establish a codeless class of amateur radio operator license." The reason for this proposal, as explained in the Federal Register, is "so that technically-oriented persons, who are not interested in Morse code can become involved in the amateur service." Although such proposals were made in 1974 and 1983, the overwhelming opposition of the amateur radio community caused the FCC to drop the idea on both occasions.

Table A. Amateur Radio Bands

Frequency Range (MHz)	Band (Meters)
High Frequency (hf) Bands	
1.800 to 2.000	160
3.500 to 4.000	80
7.000 to 7.300	40
10.100 to 10.150	30
14.000 to 14.350	20
21.000 to 21.450	15
24.890 to 24.990	12
28.000 to 29.700	10
Very High Frequency (vhf) Bands	
50.0 to 54.0	6
144.0 to 148.0	2
220 to 225	*
420 to 450	*
902 to 928	*
1,240 to 1,300	*

*Meter designations not generally used on these bands.

The Times, They Are A-Changin'

The new proposal differs from these first two, however, since it was prompted in large part by a petition from the American Radio Relay League (ARRL), the national organization of amateur radio operators.

In 1974 and 1983 code-free license proposals, the ARRL was in the forefront of the opposition, based on the overwhelming sentiment of the membership. That sentiment among both ARRL members and the ham population in general has been changing, as additional privileges incorporated into the Novice license (Novice Enhancement) failed to bring the desired growth to the hobby as hoped. Moreover, the loss of 2 MHz of the 220-MHz band (soon to be 222 to 225 MHz) showed that low growth might cause a further loss of frequencies.

Although a substantial and vocal segment of the amateur radio community remains opposed to a code-free license, a committee formed by the ARRL recommended in favor and prompted the petition that led to this NPRM.

Existing License Classes

Before I get into the proposed new class of license, I'll review the license structure as it is now. At present, there are five classes of amateur radio licenses issued by the FCC.

The *Novice* class license is the easiest license to obtain. It requires the ability to copy code at 5 words per minute (wpm) and the written portion of the test uses Element 2, which covers (very) elementary theory and regulations. This license grants privileges for radiotelegraph operation on selected portions of the 80-, 40-, 15- and 10-meter bands, as well as radiotelephone operation on portions of the 10-meter and 220-MHz bands and on a little-known and little-used segment at 1,270 to 1,295 MHz.

Novice power output is limited to 200 watts on all bands except 220 and 1,296 MHz, where they are limited to 25 watts and 5 watts, respectively. The radiotelephone privileges are the result of the previously mentioned "Novice Enhancement." Although Novices seem to be enjoying their new operating bands, especially on 10 meters where the sunspot cycle is allowing world-wide communication, the growth in licensees has been minimal.

The *Technician* license was created to encourage experimentation on the vhf and uhf frequencies. Its examination uses Element 3, covering general level theory proficiency, but the code requirement remains at 5 wpm. The Technician license provides all amateur privileges above 50 MHz, plus all the privileges of the Novice license. In addition to the ham bands listed in Table A, Technician and higher class licensees have access to a large number of frequencies in the GHz/microwave range. Although these frequencies aren't heavily used, they offer great potential for the type of experimentation that the Technician license and amateur radio in general wants to promote. With a few exceptions, Technician and higher class licensees can use up to 1,500 watts PEP (Peak Envelope Power) output.

The *General* class license offers the privilege to operate on large portions of every amateur band. It uses the same Element 3 theory examination as Technician, but it requires 13 wpm of code proficiency.

The *Advanced* class license code requirement remains at 13 wpm, but it uses a slightly more advanced theory test, Element 4A. Advanced class licensees get a little more frequency space than Generals (but no more bands).

The *Amateur Extra* class license is the Ph.d. of the ham radio world, using a 20-wpm code test and theory Element 4B, which covers advanced techniques. There are a few frequencies set aside for exclusive use of those holding this license.

Proposed License Structure

Under the newly proposed license structure, the General, Advanced and Amateur Extra classes of license would remain exactly as they are now. The new no-code license, tentatively called the *Communicator* class, is proposed to replace the Novice license, although it will carry substantially different privileges. Actually, the frequency assignment for the Communicator license is similar to Technician; that is, all ham bands above 220 MHz, with 200 watts maximum output power allowed. One important exception is the omission of the popular 2-meter band (144 to 148 MHz). This was calculated and intentional, since including this band would have substantially increased opposition to this license.

As proposed, this license would replace the Technician license in addition to the Novice class license, although current holders of both of these licenses could renew them indefinitely. With no code test, the written examination for Communicator would consist of 60 questions, compared to the 30 currently used for Novice and 55 questions in the present Technician test. Even with its level of difficulty more closely approximating the Technician license, the Commission feels that its no-code characteristic would make it the preferred entry-level license. Even though no new Technician-class licenses would be issued, Communicator class license holders who pass the 5-wpm code test would be granted operating privileges equivalent to the present Technician license, which includes 2-meter FM, though the license would continue to be called Communicator.

Uncle Charlie Wants To Hear From You

If you look at the proposal, the *Modern Electronics* reader ("technically-oriented persons") is precisely the person that is being targeted for the new license. The FCC is also specifically asking for you to send in your comments, which in Federalese they call an "ex parte presentation."

Would the existence of a no-code license cause you to become an amateur radio operator? Do you think the Novice and Technician class licenses should be eliminated by this new license? Should 2- and 6-meter (50 to 54 MHz) privileges be included in the Communicator class license? Should it be called "Communicator"? (I prefer the "Experimenter" designation of one of the earlier failed attempts at a no-code license.) The FCC wants to know your opinions.

Your comments must be received on or before August 6, 1990! Given that this is the government, there are some precise rules on how the comments must be prepared. With each "ex parte presentation" must be included two additional copies (three in all). The presentation (as well as any transmittal letter) must clearly indicate on its face the docket number (PR Docket No. 90-55;FCC 90-62) and the fact that two copies are being submitted to the Secretary for inclusion in the public record. It also must be labeled or captioned as an ex parte presentation.

Of course, since you've lived this long without getting involved in amateur radio, perhaps you're wondering why you should care about a no-code or any other type of ham radio license.

Why Ham Radio?

For many of us, involvement in ham radio followed closely after an interest in electronics. I built a code-practice oscillator and shortwave receiver when I was twelve, and went on to get my first amateur license when I was thirteen.

Although there are many areas of hobby electronics that you can pursue without a ham license, amateur radio can open a whole new spectrum of possibilities. Computers and ham radio can be interfaced to achieve a number of digital communications modes including high-speed Morse code, radioteletype and the continuous error correcting modes, AMTOR and packet.

Amateur radio offers unique areas for experimentation, too, if you're so inclined. Sending television signals around the world can be done with slow-scan TV, and amateur fast-scan (regular) television is becoming increasingly popular on the amateur uhf frequencies. Some of the more esoteric areas of ham radio experimentation are transmitting via any one of the several amateur radio satellites in orbit (OSCAR) and by bouncing signals off the moon (known as EME, for Earth-Moon-Earth).

Whereas many facets of hobby electronics are essentially solitary pursuits, amateur radio provides an easy means of contact with other electronics hobbyists, as well as an *esprit de corps* that has been likened to a fraternity. A small vhf radio in the car or beside the workbench or computer can provide a useful way to call on others for help in projects. When someone asks a technical question on a frequency, I've often heard the answering station say that they didn't have the answer but somebody else listening probably did. Very often, this is true. In my years as a ham, I've received an enormous amount of help and useful information over the ham bands, and hopefully I've aided a few others.

Assisting others is also a part of amateur radio. Hams practice communicating by using generator power and quickly erected antennas during regularly scheduled events, such as Field Day and the Simulated Emergency Test. Field Day is the most publicized of these, often getting TV and newspaper coverage. Since it's held the last weekend in June, you may have heard of local activity recently. Field Day is a contest as well as an emergency exercise. Some groups participate in Field Day solely as an emergency exercise; some just compete for contest points; and for some it is a recreational event. I've operated two Field Days from a 35-foot sloop moored off North Carolina's Cape Lookout (but we *did* use generator power and temporary antennas!).

Emergency preparedness can be fun. Nevertheless, the service it allows can be vitally important. The swath of destruction that Hurricane Hugo cut through the Carolinas last fall provided us with an unwelcome chance to see how good our emergency skills really were. Hams also played a vital role in emergency communications in last year's San Francisco-area earthquake.

So since there are lots of interesting and important things to do in amateur radio, and you already have some electronics expertise, let the FCC know you're interested in the no-code license by submitting your comments.

The Code

Ah . . . the Morse code. Even if the proposal is enacted, there will only be one no-code class of license and three classes that require code. Why do they make you learn that archaic language, when there are so many easier and "high-tech" ways to communicate?

At present, *international* law requires code proficiency for amateur operation below 30 MHz. The Communicator license will provide for operation on almost all the frequencies above 30 MHz, but for the international communications available on the shortwave bands code will remain a requirement. Perhaps you may even want to get a license before the new license is enacted (if it is enacted).

All is not lost. Morse-code proficiency, despite the cries of anguish you sometimes hear, isn't difficult to achieve and is one of the few *digital* forms of communication directly readable by both man and machine. (I've heard stories of people who can copy radioteletype by ear, but I don't believe them.)

The tools available for learning the code are much better today than they were 22 years ago when I was learning. Almost everyone has a cassette player/recorder (a rarity then) and many learning-and-practice tapes are available at reasonable cost. Some people tend to memorize practice tapes and are constantly seeking new sources of code practice. If you have a good shortwave receiver, an endless supply of code is available on the air, including transmissions by the ARRL's flagship station W1AW sent expressly for this purpose.

If you don't have access to a shortwave receiver and don't want to buy a tape, there are many programs available on computer bulletin boards that will cause your computer to send random letters at speeds between 5 and 50 words per minute. Most of these send the code over the computer or monitor speaker, while simultaneously displaying the letter sent on the screen. You turn the screen intensity to black while you're copying the code (to avoid cheating), then turn the screen on to check your accuracy.

The menagerie of computers I own has caused me to accumulate such programs for PC compatibles, as well as for the Commodore 64 (and 128) and VIC-20. Programs for all three of these computers can be downloaded from many BBSes, but if you can't find them locally, call my BBS, The Triangle Telecomputer (919-772-9745, PC Pursuit node NCRTP).

If you don't have a modem (or a friend with one), send me a letter stating which type of computer you have and whether you want diskette or cassette tape (the latter for the Commodores) along with $6 for postage and handling and I'll send you a copy of the appropriate program. I've modified the program for PC compatibles, so it can be used while you're learning the code. Most code-tutoring systems have you learn the most common letters first (E,T,O,A,N,I,S) so that you get the most practice with the letters that are the most frequently used. The program I've modified allows you to select the letters to be included in stages. So you can begin to use it after you've learned only the first seven letters.

Many people think the first thing they need obtain to learn the Morse Code is a code oscillator. Actually, owning a code oscillator isn't necessary at all. By the time you can receive code at the required speed, it will take a only little practice to get your sending speed up to par, and by then you'll probably know someone who'll lend you an oscillator.

Exam Prepping

If you've been an electronics hobbyist for several years, you probably already know much of the theory required for the existing and the proposed licenses. Few non-hams know the rules and regulations, however, and some electronics theory required for radio amateurs may be in areas that you have had no need to explore; for example, antennas.

No matter where you are on the learning curve, though, there are many excellent textbooks to help you with the information needed for the examination. The American Radio Relay League (225 Main St., Newington, CT 06111) has a number of publications and code tapes to help prepare you for the licensing tests, but beware of one course called, "Tune in the World with Ham Radio." Although it's a good course for rank beginners, you may be put off by elementary electronics covered in its manual. Other sources of information can be obtained from our sister publication, *CQ* magazine, available on newsstands, at many amateur radio dealers and by writing to the magazine at 76 North Broadway, Hicksville, NY 11801.

All testing for amateur radio licenses are done by volunteer examiners; so it is usually easy to find an examination being given nearby. The Communicator examination, if implemented, will also be conducted by volunteer examiners. The sources listed previously can help you find out where and when tests are scheduled. These sources will also help you locate nearby radio club.

Many radio clubs have classes to teach the code and theory to people interested in becoming hams, although as with "Tune in the World . . ." they often start at a very elementary level. Even if they don't have classes, you can usually find a ham willing to help you. The person who helped me, Chuck Littlewood K4HF (ex-W4RUH and K2EKS), has remained a life-long friend and advisor on amateur radio matters.

The cost of setting up an amateur station is moderate. A good used transceiver and antennas for the hf bands can be obtained for less than $400. Good used equipment for the vhf frequencies that will be the mainstay of the Communicator license can be had for even less. Compared to computers and other facets of hobby electronics, the cost is very reasonable.

Your comments and suggestions are welcome. You can contact me through Delphi (CURTPHIL), CompuServe (73167,2050) or at P.O. Box 678, Garner, NC 27529.

ME

New Static RAMS for High-Speed Caching

By Joseph Desposito

In the past few years, the speed of microprocessors has increased well beyond the speed of dynamic RAM memory. In this column, we'll explain how a static RAM cache provides a solution to this problem.

High-Seed CMOS SRAMs

Logic Devices Inc. (Sunnyvale, CA) announced 16 new high-speed CMOS SRAM products that together implement a complete cache memory system. With speeds to 10 ns, these products remove earlier performance restrictions by allowing CPU clock rates of 50 MHz and beyond. This allows workstation manufacturers to offer systems that double the performance of current models, accelerating CAD, scientific and other numerically intensive applications.

The 16 products fall into three families: Cache-tag memories, 16K data RAMs, and 64K data RAMs. The cache-tag devices are specifically designed to quickly match memory addresses to cache contents. The data RAMs, which use industry-standard pinouts, are specifically tailored for extremely high speeds, particularly in those parameters crucial to cache data applications. One-, four- and eight-bit wide organizations are offered at each density, providing maximum flexibility in memory organization.

With speeds as fast as 10 ns, the new SRAM families are targeted to serve the needs of ultra-high-speed RISC vendors who are attempting to crack the 50-MHz barrier. Memory bandwidth has been a pressing issue in both RISC and high-end PCs for some time. These products are intended to remove cache-memory cycle time as a performance barrier for the next generation of designs.

All of the devices are implemented in an advanced, 0.9-micron (drawn), dual metal technology. The devices use a six-transistor-cell design, resulting in nanoampere standby current levels for laptop and battery back-up applications. In addition, all devices feature Logic Devices' Auto Powerdown™, which results in reduced active power dissipation for many applications. For lowered ground-bounce at extremely high switching speeds, the parts also feature an N-channel source-follower pullup for reduced output swing and easier signal termination.

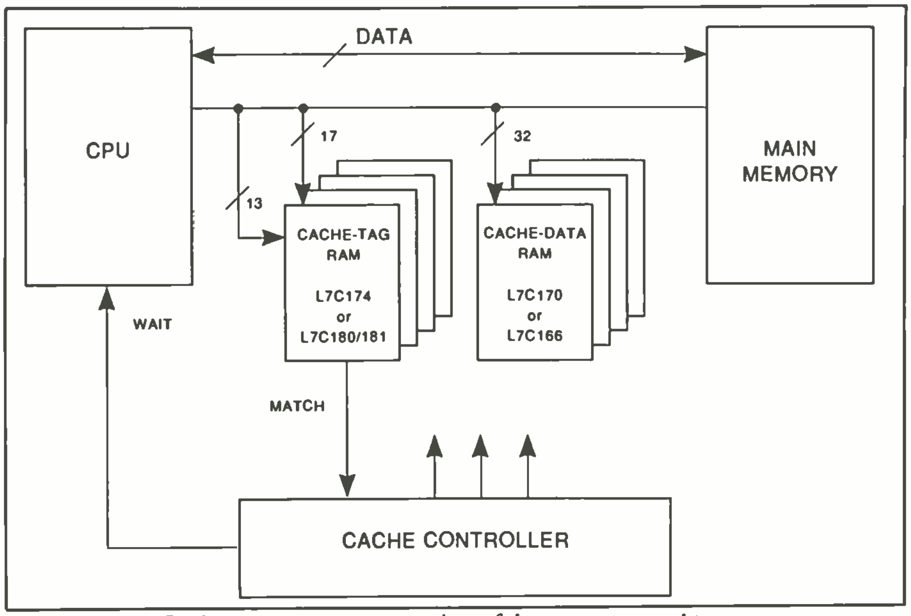


Fig. 1. Cache memory system consists of data memory and tag memory.

Cache-Memory Fundamentals

Cache memory is a design technique used to solve a pervasive problem in high-speed computer architecture. For years, CPU clock rates have increased without any significant change in the speed of the DRAMs used as their main memory. When computers cycled at 200 ns and DRAM memory also cycled at 200 ns, there was a good match of computing rate and memory bandwidth. As the clock speed of RISC computers and CISC microprocessors pushed to 33 MHz (30 ns) and beyond, however, DRAMs were left behind.

Cache memory solves this problem by taking advantage of a fundamental truth about most software: Almost every program reads and writes information in memory in tightly clustered groups, rather than at random locations. This phenomenon is called locality. It can be intuitively understood by realizing that most programs include several nested loops. The data and instructions in the innermost loop are generally small but are executed many times. Thus, if the access time of this frequently needed data can be improved, overall performance will benefit dramatically.

Cache memory is a small, fast memory inserted between the CPU and its main memory. Cache memory systems consist of two parts (see Fig. 1), the data memory and the tag memory. Both are governed by a cache controller. The cache as a whole stores each data item read from main memory by the CPU, in anticipation that it will be needed again. On the second and subsequent reads of the same item, main memory is not used; rather the item is read from the high-speed cache. If a high percentage of reads are to items in the cache, overall machine performance approaches the cycle time of the cache instead of the (slower) main memory.

The cache controller is a state machine designed to control the cache resources and direct memory accesses to the cache or main memory, as appropriate. Cache controllers are implemented both as VLSI devices and as PAL-based state machines. These approaches trade off performance and complexity for cost.

Data memory stores the frequently used data items from main memory. Tag memory is a specially constructed SRAM used by the cache controller as a directory of the contents of data memory. When the CPU requests a data item, the cache controller must quickly decide whether or not the item is present in the cache. Tag RAM serves this function by comparing the requested address to the address stored in its internal directory and indicates whether a match exists. It contains special comparators and a MATCH output for this purpose. The MATCH signal is used by the cache controller as an indication of whether a main-memory cycle is necessary to satisfy the CPU data request.

Cache memory systems are pervasive in PCs operating above 16 MHz and in almost all RISC systems. They boost performance far beyond non-cached systems. This allows manufacturers to design computer systems that support the enormous performance demands of modern VLSI designs, finite-element mechanical modeling and other CPU-intensive tasks.

Cache Tag SRAMs

Logic Devices' L7C180, L7C181 and L7C174 are high-performance, low-power CMOS SRAMs with tag comparison logic optimized for use as the address tag comparator in high-speed cache memory systems. Wide address tags are easily accommodated by paralleling devices. The L7C181 makes this particularly convenient by providing for wire-ORing of the MATCH outputs. The L7C180/181 4K × 4 devices are available in speeds to 10 ns. The L7C174 8K × 8 device has a minimum access time of 15 ns.

The address tag is input on shared I/O pins, and a comparison is performed between the tag and a value stored in memory. A match indicates the addressed word is present in the cache. Also provided is a high-speed CLEAR control that resets all memory locations simultaneously. This allows the cache memory to be effectively flushed of all data. This function is necessary in multi-processor applications when main memory is shared and is also used to initialize the cache at power-up.

The L7C180/181 4K × 4 CMOS cache-tag SRAM is offered in plastic and ceramic DIP, as well as SOJ packages. Pricing starts at $44.50 for the 12-ns device in 100-piece quantity and $54.50 for the 10-ns grade. The L7C174 8K × 8 CMOS cache-tag SRAM is available in plastic and ceramic DIP, and SOIC (small outline integrated circuit) packages. Pricing is $49.50 for the 15-ns speed grade at 100 pieces.

16K and 64K standard SRAMs form a complete family of devices. Implemented in sub-micron CMOS technology, these devices have access times as fast as 10 ns. They also feature fast write pulse and output enable times to support extremely fast cache access requirements and late-write timing.

A full family of organizations allow the devices to be used in any high-speed SRAM application. 4K × 4 and 16K × 4 devices are offered in common I/O and separate I/O configurations, with and without output enable functions. A wide variety of packages is available, including plastic DIP and SOIC (gull-wing and J-lead). Military applications are supported with CERDIP and side-braze ceramic. All devices are available in MIL-STD-883C form.

The 16K and 64K SRAMs are offered in plastic and ceramic DIP, as well as SOIC and SOJ packages. 16K pricing starts at $17.35 for the 12-ns device in 100-piece quantity, and $21.35 for the 10-ns grade. The 64K devices are priced from $14.65 for the 15ns speed grade and $20.00 for the 12-ns devices.

Microprocessor Supervisory ICs For Power-On Reset

Maxim Integrated Products (Sunnyvale, CA) introduced two new low-cost microprocessor supervisory circuits, the MAX-698, a power-on reset controller, and the MAX699, a power-on reset controller with watchdog input. These devices provide a reliable, cost-effective solution to μP monitoring in basic applications. Maxim's monolithic MAX690-7 series is available if more functionality is needed.

The MAX698/699 (see Fig. 2) supply an inverted RESET pulse of at least 140-ms duration on power-up, power-down and during low-voltage "brownout" conditions. The MAX699 has a watchdog in-

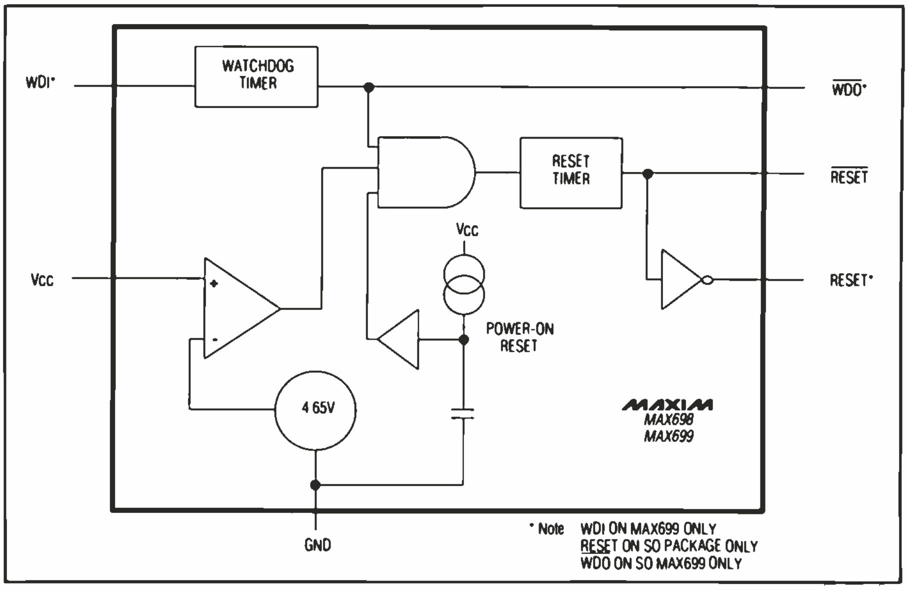


Fig. 2. Maxim Integrated Products' microprocessor supervisory ICs for power-on reset supply an inverted RESET *of at least 140-ms duration.*

put that monitors microprocessor activity. The watchdog pulls the inverted RESET output low if the watchdog input is not toggled within 1 second. This feature can be disabled by leaving the watchdog input floating.

Applications include portable computers, low-power controllers, intelligent instruments and any microprocessor system that requires accurate power-supply monitoring.

Maxim offers the devices in 8-pin plastic DIP and 16-pin small-outline (wide SO) packages. They are available in commercial (0° to 70° C) and extended industrial (−40° to +85° C) temperature ranges. The small-outline versions have additional outputs not available in DIP packages. These are RESET (without inversion) and Watchdog Output.

Prices for quantities of 100 and up start at $2.00 for the MAX698 and $2.30 for the MAX699 in commercial grade, 8-pin DIP packages.

Low-Power Comparator Plus Alarm Diver

Motorola's new MC14471 low-power comparator contains both digital and analog components for use as an alarm driver. It consists of three comparators: one for detection of an alarm condition; a second to detect a low-battery condition; and a third to track the voltage of the alarm-detect input without loading down that input. The device also contains circuitry to drive an external piezoelectric horn and LED. An on-chip oscillator is provided and requires two external passive components to operate.

The trip point for the alarm input is typically 50% of V_{DD}, while the trip point of the low-battery input is established by an on-chip zener diode. These thresholds can be altered over a limited range with the use of external resistors.

MC14471 applications include liquid-level detectors, soil moisture content detectors, low-battery detectors and virtually any place an alarm is needed. The MC14471 is available in 16-pin DIPs at $1.69 each in quantities of 500 to 999. For more information, call 512-928-6880. ME

Good News For Laser Printers

By Ted Needleman

The Color Tag kit consists of a hand-held applicator, two packages of 25 color strips, a special rubber pad, a package of polished-surface paper and an instruction booklet.

Lately, I seem to be spending a lot of what little free time I have playing with laser printer-oriented utilities. Part of the reason for this is that I've had a number of new laser printers cross my path in the last few months, including the Hewlett-Packard IIP and LaserJet III that I've covered in recent columns. Another reason is that I'm heavily into desktop publishing and computer video, both of which seem to cry out for the 300-dot-per-inch resolution of a laser printer.

Regardless of the reasons, there are enough hardware, software and other accessories that we could easily rename this column "Laser Capers" and run for a number of years without ever covering everything available. Don't worry, there's little likelihood of that happening. But with the prices rapidly coming down on these terrific printers, I think that more and more of you will be joining the ranks of laser owners soon, if you haven't already given in to the impulse. By the end of this year, you should be able to buy a 4-page-per-minute laser printer for $800 or less, which puts a laser right smack at the price point of many 24-pin dot-matrix printers.

There are some things, however, that you can do with a laser printer that are just not possible to accomplish with a dot-matrix printer. We'll take a look at a few of them in this month's column.

Color Tag

One of the few things that I don't like about laser printers is that it's difficult and expensive to print in color. With many dot-matrix printers, you can get a special ribbon to do color printing. For the printers that support them, these ribbons usually have three or four bands of color. The software sends a command to the printer to shift the ribbon position so that the desired band is under the print head. By making multiple passes per line, you can get numerous colors and shades onto the paper. It's a slow process, and the colors aren't usually very vivid, but it does allow you to do color printing.

With a laser printer, alternatively, the toner is all a single color, most often black. You can get toner in other colors, but to do a multi-color page with these colored toners you need to emulate the color-separation process that is used in commercial printing. In effect, you have to print all the areas on a page that contain a particular color, change the toner cartridge to a different color, then print all the areas on the page with that color and so on. Not only is this a pain in the neck and time consuming, it's also very difficult to put the same page through a laser printer several times and get halfway decent registration on the multiple passes. What you usually end up with is something that looks like the old three-dimensional comic books that were printed in the '50s and '60s.

It's possible, though, to get spot color on your laser printouts without quite so much difficulty. One way, which was discussed several years ago by a former ME columnist, is by using the Kroy Color process. Kroy Color, marketed by the same people who make the well-known Kroy lettering machines, is a version of the OmniChron process developed in Europe. It consists of a special colored sheet and processor. Recently, the Letraset company purchased rights to market the OmniChron system. It has developed Color Tag, a very inexpensive system based on OmniChron for graphic artists and other laser users who'd like to use color on their printouts but don't have a thousand dollars or more for the OmniChron or Kroy approaches.

Because laser toner is actually a powdered plastic that is electrostatically applied to the paper and then melted and fused by pressure, it's possible to re-melt the toner already applied to a laser printout. All three of the above processes take advantage of this characteristic. They all use a special color material that is pressed against the laser toner as it is melted. As the toner cools, it bonds and adheres to the color material (sort of like hot-melt glue). When you peel the laser printout away from the color sheet, the color remains bonded to the toner. By judicious positioning of the color material, you can select where the color is applied and apply multiple colors on a page.

Although the process and materials are similar, Color Tag is much less expensive because it differs in the mechanical approach to applying the material. Both the Kroy Color and OmniChron systems use a heavy-duty processor that mechanically feeds the printout color-material sandwich through a station that melts the toner and a set of pressure rollers that compresses the two together. This produces a very good bond between toner and color material, but between the mechanical paper feed, the thermostatically-controlled fuser station and the pressure rollers it's a very expensive approach for a casual user.

Color Tag, on the other hand, uses a small ac-powered heater to warm up a hand-held "applicator." This small unit measures about 4 × 3 × 1 inch and has a metal plate on the bottom to retain the heat. A measuring device inside the unit lights a LED when the unit is up to operating temperature.

To apply color to your printout, you place a Color strip (these measure about 9 by 2 inches) over the area you wish to cover and place both onto a rubber pad included with the Color Tag outfit. Then rub the applicator across the area where you want to transfer the color, pressing down fairly hard. You can apply 5 or 6 inches of color before the green LED on the applicator goes out, indicating that reheating is needed.

As the applicator takes about 10 minutes to initially warm up, and 2 or 3 minutes to re-heat, applying a fair amount of color on a page can be a time-consuming process. And, to be honest, it doesn't work quite as well as a Kroy Color processor—you'll probably have to reapply some areas that suffer from incomplete color transfer.

That's the downside. With a suggested list price of $99 for the applicator, two packages of 25 color strips, the special rubber pad, a package of polished-surface paper and a sparse instruction book in several different languages, the Color Tag system is a quite practical and affordable alternative for those who can't begin to justify the thousand-dollar outlay for one of the more sophisticated machine-based color transfer systems.

The color strips are also a very affordable $6.50 per package of 25. They come in 35 different matte and metallic colors and are available, as is the applicator, at numerous art supply and graphic supply stores. Granted, the Color Tag isn't perfect, but it's affordable, and with a little time and effort brings color to your laser-printed reports, cards, letterheads and the like. If you have a laser printer, you owe it to yourself to at least take a look at the Color Tag. I recommend it highly.

BlackLightning Transfer Toner

While we're on the subject of laser color, there's a product that I've had for a while that I think you should know about. I'm feeling guilty—it's been here for a number of months, but I haven't yet been able to review it. Not because it's difficult to use, but simply because the application I want to test it out on requires a great deal of time-consuming preparatory work. The product is a transfer laser toner from a company called BlackLightning.

BlackLightning's transfer toner is a simple idea and is easy to use. It's available in cartridges for Canon-based laser printers (both CX and SX) and in four colors (blue, charcoal, red and green), which just insert into the laser printer. Print out your image on plain paper, and you have a transfer you can iron onto a sweatshirt, T-Shirt, or other item!

What makes this process interesting is that it's affordable (the "personal" cartridge costs $79 plus shipping and makes between 500 and 1,000 pages) and has a rather unique application for *Modern Electronics* readers. I seriously doubt that very many of you have the need or desire to go into the T-Shirt business, but BlackLightning assures me that the company has also had excellent results transferring images to a number of metals, including aluminum. As most project boxes have aluminum front panels, you can use any computer-based draw or paint program to produce a professional quality front panel, flip it 90 degrees along the vertical (that is, produce a mirror image) and print it out using a transfer toner cartridge. Get out your iron, and you have a production-quality front panel for your *Modern Electronics* projects. So throw away your Dymo tape and dry-transfer lettering kit. For $79, you can produce a project that rivals any commercial piece of equipment, and when you're done, you make a T-Shirt!

All hyperbole aside, this seems like a pretty neat item if you have a laser printer. What's held me back from actually trying it out is that I have two T-Shirt ideas in mind, either of which will take a half day or more to create using any of the graphics packages I currently have. Once these are created, it shouldn't take more than 10 minutes to get a printout and iron on the transfer, but finding the half day has been difficult.

I've seen samples of the transfers, though, and actually tried the sample transfer BlackLightning sent me. So I can state that the process works, at least on cloth. If you'd like to try it out on aluminum, give BlackLightning a call and ask for a sample transfer to play with. The company also has very good prices on toner cartridge refills and other laser printer and personal copier accessories.

ME

Products Mentioned

Color Tag
Letraset USA
40 Eisenhower Dr.
Paramus, NJ 07653
201-845-6100

Laser Transfer Toner
BlackLightning, Inc.
RR 1-87, Depot Rd.
Hartland, VT 05048
800-252-2599

BOOKS

Customize Your Phone. *By Steve Sokolowski. (Tab Books. Soft cover. 162 pages. $12.95.)*

This book, by a regular contributor to these pages, consists of details on 15 electronic projects that can improve a home telephone system. The first five chapters are for the non-technical reader who wants to take advantage of the projects. The first defines what a telephone is and discusses project installation and telephone wiring, the second focuses on assembly tips and selecting components and the next three chapters deal with reading schematics, building projects and how to solder.

With the preliminaries out of the way, the remaining 15 chapters each discuss how to build a specific project. The first project is a device that visually indicates if a listening or recording device is being used. This is followed by electronic "hold" button, tone and melody ringer, conference call, telephone intercom system for up to 10 instruments, telephone amplifier, speaker phone and two simple visual ring indicator projects. Another project permits a tape recorder to automatically record both sides of a telephone conversation whenever an instrument is taken off-hook and to stop recording when the instrument is placed back on-hook. Other projects visually inform a user if a call came in while he was out and allow him to remotely control electrical appliances using the telephone line. Among the specialty projects are an electronic lock that prevents unauthorized use of a phone unless a special four-number code is used, a telephone line tester and a novel animated ring indicator built around an electromechanical toy as the signaling device.

Project chapters begin with a brief description of what the project does. Circuit operation is then discussed, and details on building (including printed-circuit etching-and-drilling and component-placement guides) and installing the project are given. Schematic diagrams and complete parts lists accompany each project's description, and line drawings are included where needed to clarify details not immediately apparent in the schematics and/or text.

Encyclopedia Macintosh. *By Craig Danuloff & Deke McClelland. (Sybex Inc. Soft cover. 782 pages. $24.95.)*

In both arrangement and number of pages, this book is truly encyclopedic in nature. Between its covers, it manages to sandwich in an amazing range of information about and relating to the Apple Macintosh line of computers. Thousands of tips, techniques (many of them little known until now), quick-reference charts, product reviews and resources are alphabetized under their appropriate headings to make this book a Mac resource in its own right.

Under System Software & Utilities are entries on customizing, disks and drives, error codes, fonts, macros, security, sound and viruses. Practical tips and shortcuts and reviews of public-domain and shareware utilities for enhancing the Mac system are also given in this section. The Applications section looks at major software packages for drawing, painting, file managing, HyperCard, word processing, spreadsheet and page layout applications. Also included here are quick-reference keyboard charts for major Macintosh applications.

Under Hardware, the book explains what the CPU, disk drives, mice, monitors, ports and memory do, how they work and when and why they are needed. Technical charts and diagrams, detailed comparisons of the different Macintosh models and instructions for installing additional memory and performing hardware upgrades are included. The drawings for guiding the reader in this section are exceptionally well-rendered and easy to follow.

The Resources section discusses books, magazines, bulletin boards and user groups. A particularly welcome inclusion is the Alphabetical Product Listing at the end that lists products by alphabetical order, most including supplier name, address, telephone number and price. An extensive glossary of terms used in the Mac world closes the book. This well-written book is comprehensive in its coverage, easy to read and understand and excellently illustrated with line art. It deserves a place in the library of every Mac user.

The 1990 ARRL Handbook for the Radio Amateur, 67th Edition. *(American Radio Relay League, Inc., 225 Main St., Newington, CT 06111. Hard cover. 1,200 pages. $23.)*

This massive latest edition of the amateur radio "bible" has been extensively updated and expanded to include new projects, current information on the OSCAR 13 amateur radio satellite and information on compandored SSB. It also contains a completely revised chapter on space communications and plans for three high-performance vhf/uhf yagi antennas and a new four-element helical array for Mode L (1,260 to 1,270 MHz) operation.

Divided into six basic sections, the Handbook covers an introduction to amateur radio, radio principles, modulation methods, transmission, construction and maintenance and on-the-air topics. Each section is subdivided into chapters that deal with specific related areas. The Radio Principles section, for example, deals separately with power supplies, audio and video, digital basics, modulation and demodulation, r-f oscillators, synthesizers, etc.

Each chapter includes theory, practice, tables, schematics and photos where applicable. Taken as a whole, the Handbook comprises a complete course in the fundamentals of electronics and radio communication in general. It covers theory, practice and Federal Communications Commission Rules and Regulations as they apply to the radio amateur. Hundreds of schematic diagrams, photos, line drawings and tables accompany and support the text.

Construction projects presented in this latest edition include: power supplies, keyer and measuring devices; QRP transmitters and vhf/uhf preamps; a high-performance communications receiver; high-power hf and vhf amplifiers; 1,296-MHz transverter; and a digital memory keyer. Complete information for each is given, including theory of operation, construction details, pc guides (where applicable) and parts list.

This is a must-have book for anyone who aspires to becoming an amateur radio operator. It is also an excellent textbook for learning the fundamentals of electronics and radio communications. Whether you are an aspiring ham or already have your license, this book will provide a wealth of information and serve as a one-stop reference.

NEW LITERATURE

Ham/SWL Accessories Catalog. The new 1990 MFJ Amateur Radio/SWL Accessories Catalog lists and describes a wide range of devices for radio communication. Listings provided in the 16-page catalog include: antenna tuners, portable transmitting antenna, SWR/wattmeters, coaxial switches, dummy loads, receiver noise bridge, multiple dc power outlet, rfi-free choke kit, artificial r-f ground, hand-held accessories, SWL accessories, phone patch, ham software for IBM, Macintosh and commodore computers, packet-radio units, multi-mode data controller, video digitizer and more. For a copy, write to: MFJ Enterprises, Inc., P.O. Box 494, Dept. ME, Mississippi State, MS 39762.

General Instruments Catalog. The 148-page 1990 general catalog from Contact East lists and describes products for testing, repairing and assembling electronic equipment. Listings are given for oscilloscopes and other electronic test equipment, static-protection devices, soldering supplies, precision hand tools and Contact East's exclusive line of tool kits. Other items featured include voice/data communication test instruments, wire and cable aids, electronic adhesives, magnifiers and inspection equipment. All products listed are described in detail with specifications, color photos and prices. For a free copy, write to: Contact East, 335 Willow St., Dept. ME, N. Andover, MA 01845.

Trimmer Resistor Primer. An updated *Best of Trimmer Primer* that includes application-specific and surface-mount technology devices is available from Bourns, Inc. It consists of 75 pages of illustrated tutorial broken into sections. Section 1 introduces typical types and uses of trimmer potentiometers and discusses selection of trimmers for various manufacturing processes. Section 2 explains fine tuning circuits with variable resistors and center-tapped trimming pots using multiturn trimmers. Section 3 deals with the voltage-divider and rheostat modes, linearity, adjustability and resolution and end-zone characteristics and discusses power and current ratings, resistance values and tolerances, dry circuit conditions and circuit applications. Section 4 discusses soldering, board washing, mechanical menaces, inspection and operating environments and explains the advantages, assembly techniques and putting the right component-insertion equipment into a manufacturing plan for SMT. For a free copy, write to: Randy Brown, Public Relations Manager, Bourns, Inc., 1200 Columbia Ave., Riverside, CA 92507.

reserved for special emergency purposes). The dialed number should appear in the display. When it does, press the # key. The number in the display should now be replaced with the message "RECALL," as in Fig. 10(A). The speaker in the handset should go dead for about 2 or 3 seconds. When it reconnects, you should hear a dialtone and the LCD module should once again display the current time.

If you ever wish to replace the dialed number or regain a dialtone, just remember to press the # button on the keypad of the telephone instrument. Just by hanging up, you regain dialtone, but the contents currently displayed in the LCD window will not be erased.

To test the hold feature, have someone call your number. When you answer, put the call on hold by pressing the * button on the keypad of the telephone instrument. Immediately, the time in the display should be replaced with the message "HOLD 0 MIN," as in Fig. 10(B). You can now hang up the handset without losing the call. The count in the display window advances upward for as long as the call is on hold, and a beeping sound will be heard from the built-in crystal transducer.

To reconnect at any time, simply lift the handset from the cradle and press the * button. The "HOLD..." message in the display immediately reverts to the current time. If you do not reconnect the holding party within 5 minutes and 30 seconds, Fone Mate automatically removes the resistor (*R10*) that simulates the off-hook condition from the line and generates an on-hook condition. This restores the dialtone to the line and permits the telephone instruments at both ends to resume normal operation.

To test the tone ringer, have someone call your telephone number. When Fone Mate detects the incoming ring signal, the built-in crystal transducer should sound a pleasant-sounding warble tone. This tone should continue to sound for as long as the calling party tries to get through or you lift the handset.

If at any time during the above test procedures you fail to obtain the proper responses, immediately power down the project, disconnect it from both the telephone line and instrument and troubleshoot it. Do not proceed with final installation and use until you have corrected the problem. ME

More Information

Further information on telephones and the 8052AH-BASIC microcontroller chip used in this project can be obtained from:

Customize Your Telephone: 15 Electronic Projects
Tab Books
Blue Ridge Summit, PA 17294-0850

MCS Basic-52 Users Manual
Intel Part No. 270010-003

Embedded Controller Handbook
Intel Part No. 210918

Both Intel products are available from authorized distributors of products made by this company or by calling 1-800-54-4725.

PC Shareware

By Art Salsberg

Shareware or user-supported computer software is marketed directly by authors on a sort of payment honor system. That is, there's no charge or just a disk plus shipment cost for the program. You then have the opportunity to use it, copy it, modify it, or whatever. If you feel the program suits you, you're asked to send in a modest registration fee that entitles you to expanded documentation, technical support and upgrade version information.

It's a marvelous sales prescription since the user can live with the software without plunking down a fair-sized chunk of money. The honor system evidently works since there are so many shareware authors utilizing this means of distributing their programs. The late Andy Fluegelman, who was editor of *PC World* magazine, is credited with initiating this type of software distribution about eight or nine years ago. When I had dinner with him at a West Coast computer show, I was surprised to learn that he was a lawyer, a profession I thought would have caused him to lean toward legal prohibitions on doing this or that with copyright material.

A recent book, *The Best of Shareware: IBM PC Utilities*, authored by Mark Sawusch and published by Windcrest Books (a Tab Book subsidiary, which, in turn, is now part of McGraw-Hill Book Publishing Co.), illustrates a host of top shareware programs that compete with commercial software. The 220-page book, priced at $29.95, is accompanied by a 5¼" floppy disk that contains 75 useful programs discussed in the text.

Programs were compressed in order for all of them to fit on one disk. Typing a given code word expands the files when copied to one's disks; recovered files fill up two floppies. The program disk requires DOS 3.0 or later, although virtually all the recovered files require only DOS 2.0 or later. An additional 25 or so programs are examined by the author, including some commercial ones, to which shareware equivalents are compared.

The book is arranged by program function: File Management Utilities, Keyboard and Screen Enhancing Utilities, Printer Utilities, Disk and Director Maintenance Utilities, Clock and Calendar Utilities, Operating System Enhancements, Batch File Utilities and Miscellaneous Utilities.

In-Use Comments

Reading descriptions and comments about the shareware programs selected as top ones among the thousands available is educational and interesting. Each program is broken down into Purpose, Hardware, Software, Description/Features, Example and Author/Source. Program notes present command and feature summaries, and candid evaluations.

I tried a handful of programs, and they worked like a charm. Among them was CPU.Com, which instantly displayed the effective clock speed of my CPU. Another interesting file is Remind.Com. Remind can be used as a clock (hours, minutes, seconds) displayed in the upper-right corner of your video monitor screen or as a pop-up reminder. With the latter, you enter the pop-up alarm time you wish and a description of what you want to be reminded about. When the selected time is reached, a pop-up box appears over your application for a few seconds before disappearing.

Another neat program along the lines of Remind is Mjog.Exe, which is short for memory jogger. Using this program, which should be in your Autoexec.Bat file, you can generate pop-up reminders all through the year about dates you want to be reminded (birthdays, anniversaries, meetings, and so on). You would include text notes, of course, such as Mary's birthday, 6 p.m. dinner with Don, etc. Reminders are displayed about ten days in advance. Also, you can list upcoming appointments and display a specific month's calendar.

With so many programs on hand, there are sure to be many others you'll find very useful. Choose among a file defragmentizer, keyboard speedup, memory cache, hard disk diagnostics, backward scrolling, RAM disk, disk drive speed-up, DOS command shell, printer spooler, macro program, Lotus 1-2-3 unprotection up to version 2.0, and so on.

The package isn't flawless. For example, many of the programs aren't of recent vintage, so don't support VGA or even EGA. Also, where an author is unknown (and listed as such) one can't be fully confident that the program is essentially bug-free. Most programs include the author's name, however, and some have a full address.

In sum, here's an easy way to get inexpensive software for an IBM PC that will help you enhance your computer work. For $29.95, you can't go wrong. ME

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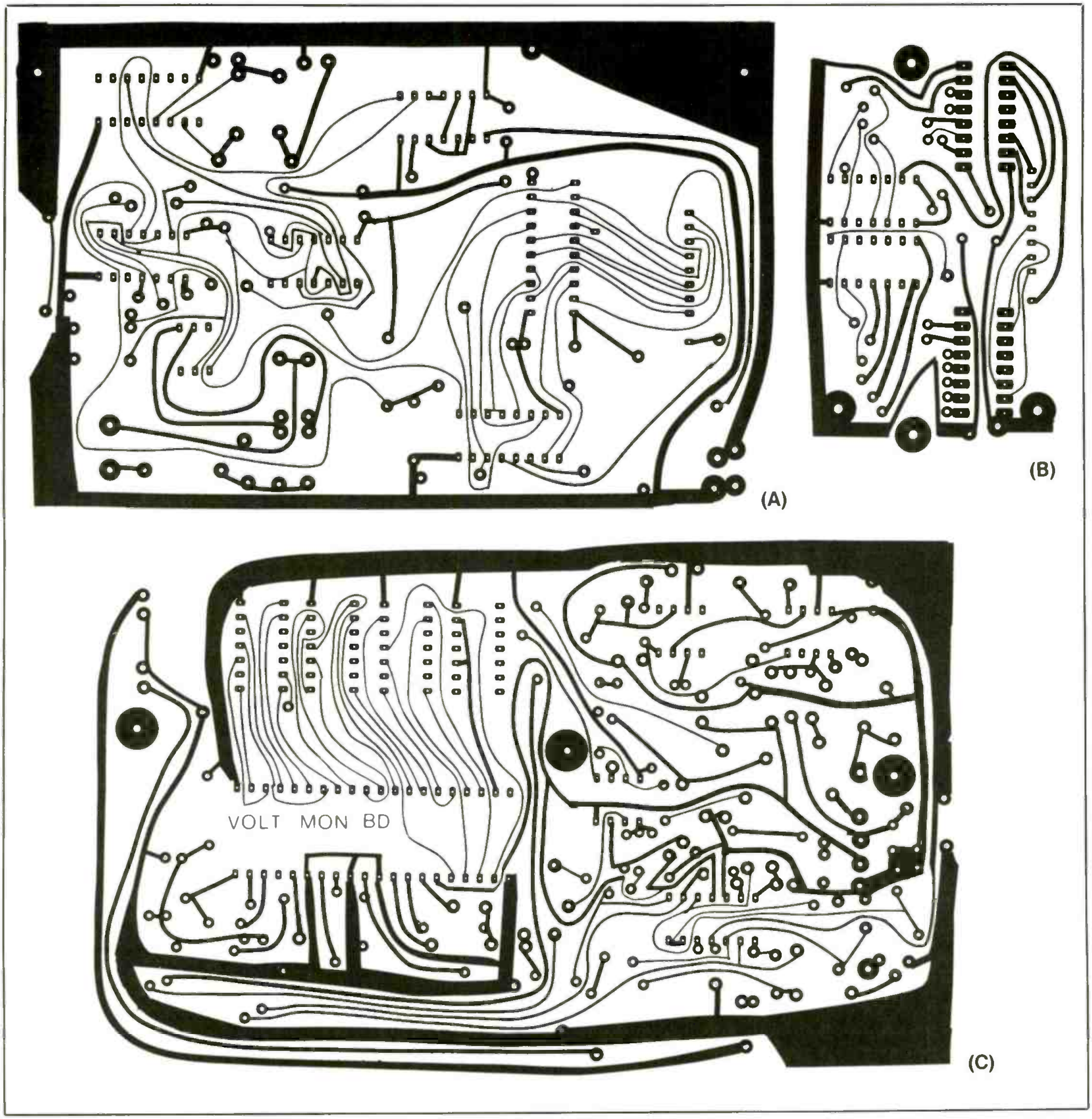


Fig. 5. Actual-size etching-and-drilling guides for printed- circuit boards: (A) frequency-counting module, (B) display module for frequency counter and (C) voltage-measuring module.

you use a dry-transfer kit, protect the legends with two or more light coats of clear acrylic spray.

When you wire the ac line cord, fuse, POWER switch and power transformer, make certain to adequately insulate all points that are at 117-volt ac line potential. Use heat-shrinkable or other insulating tubing.

Connectors and cables are used to supply all power and signals between the various elements that make up the project. The specific types required are detailed in the Parts list. A nine-conductor ribbon cable with connectors at each end interconnects the frequency counter and display circuit-board assemblies. If you wish to economize, you can eliminate the connectors and simply wire together the boards using hookup wire.

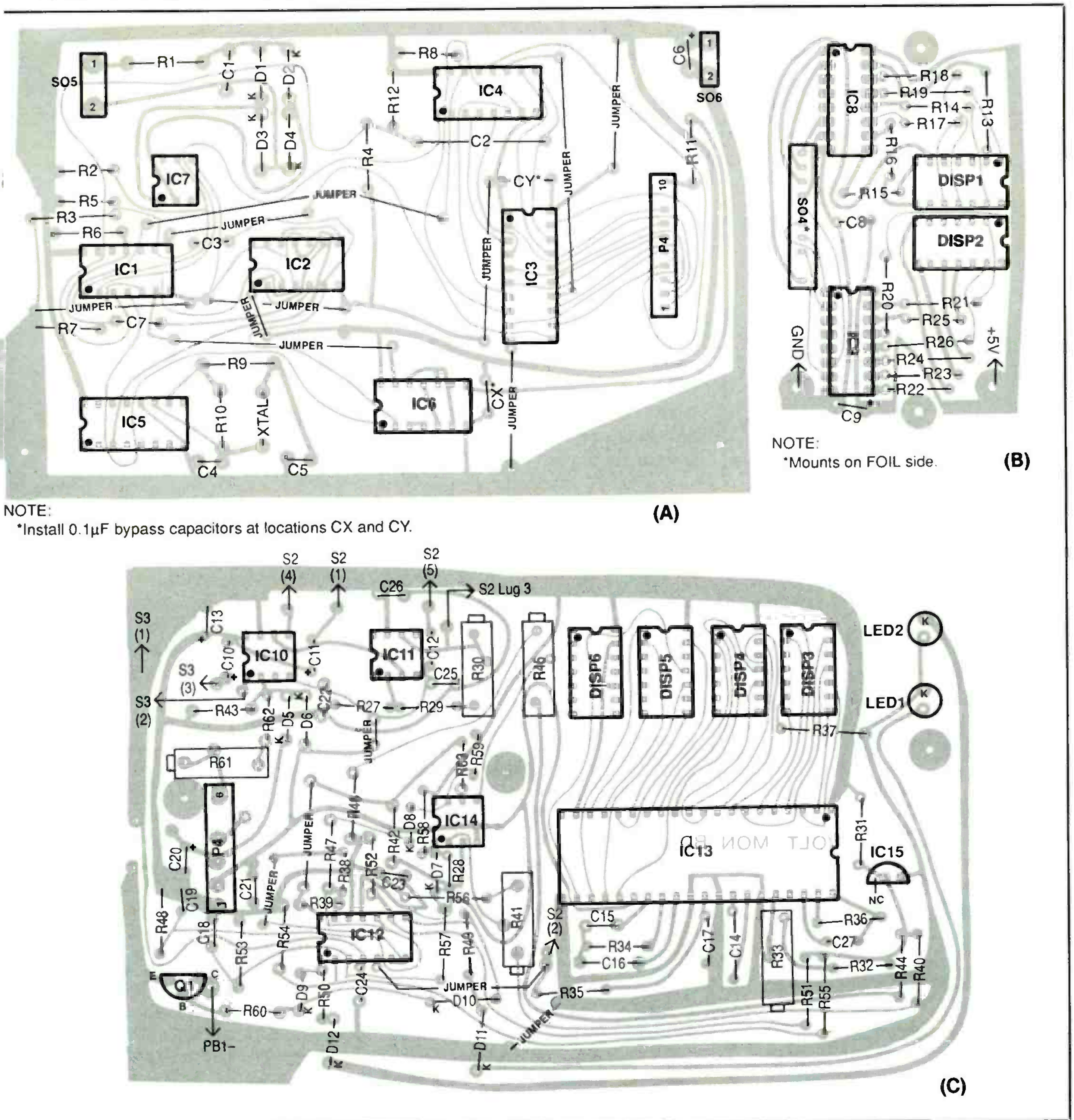


Fig. 6. Wiring guides for: (A) frequency counter board, (B) display board and (C) voltage measuring board.

When you are done wiring the circuit, place a 3-ampere fast-blow fuse in its holder. The project is now ready to be tested and calibrated.

Test & Calibration

Connect the power supply to all circuits with suitable cables, but do *not* plug any ICs, displays or the optical isolator into any of the sockets. Plug the line cord into a nearby ac outlet. Connect the common lead of a dc voltmeter or multimeter set to the dc-volts function to any convenient circuit ground in the project. Then set POWER switch *S1* to "on."

Exercising extreme care to avoid touching any parts of the primary circuit of the power transformer, touch the "hot" probe of the meter to the power pins of the IC sockets on all circuit-board assemblies while monitoring the readings obtained. On the frequency-counter board, you should obtain a +5-volt reading at pin 14 of the *IC1* and *IC6* sockets; pins 1, 4, 10, 13 and 14 of the *IC2* socket; pin 20 of the *IC3* socket; pin 16 of the *IC4* socket; and pin 16 of the *IC5* socket.

On the display board, pin 16 of the *IC8* and *IC9* sockets and pin 14 of all display sockets should also yield a reading of +5 volts. No readings are required on the *IC7* socket. The readings obtained on the voltage-measuring board at pin 7 of the *IC10* socket, pin 7 of the *IC11* socket, pin 4 of the *IC12* socket, pin 1 of the *IC13* socket, pin 8 of the *IC14* socket and pin 14 of all display sockets should also all be +5 volts.

Once you ascertain that the +5-volt bus distribution is correct, touch the "hot" probe of the meter to pin 11 of the *IC12* socket and pin 8 of the *IC4* socket. This time, the meter should display −5 volts.

If you fail to obtain the proper reading at any socket pin, power down the project and disconnect it from the ac power line. Correct any problems encountered.

When you are sure the project has been properly wired, plug the ICs, displays and optical isolator into their respective sockets. Make sure you observe proper orientation in all cases and that no pins overhang the sockets or fold under between devices and sockets. Also, handle any IC, especially the 7107 (*IC13*), that can be damaged by static electricity with the usual precautions for MOS and other such devices. If you are not sure which ICs are static-sensitive, handle all with the same care.

Set AC/DC switch *S3* to the AC position and RMS/AVG switch *S2* to the RMS position. Connect the leads of a high-quality digital multimeter (set

RMS vs. Average Value

The AC Line Monitor described in the main text of this article is capable of measuring the average value as well as the true rms value of the ac line voltage it is monitoring. When in the average responding mode (*S2* set to AVG), the average absolute value of the ac (or ac plus dc if *S3* is set to the DC position) is achieved by full-wave rectification and low-pass filtering. The resulting output is then scaled by multiplying by 1.11 for the rms equivalent value of a sine wave.

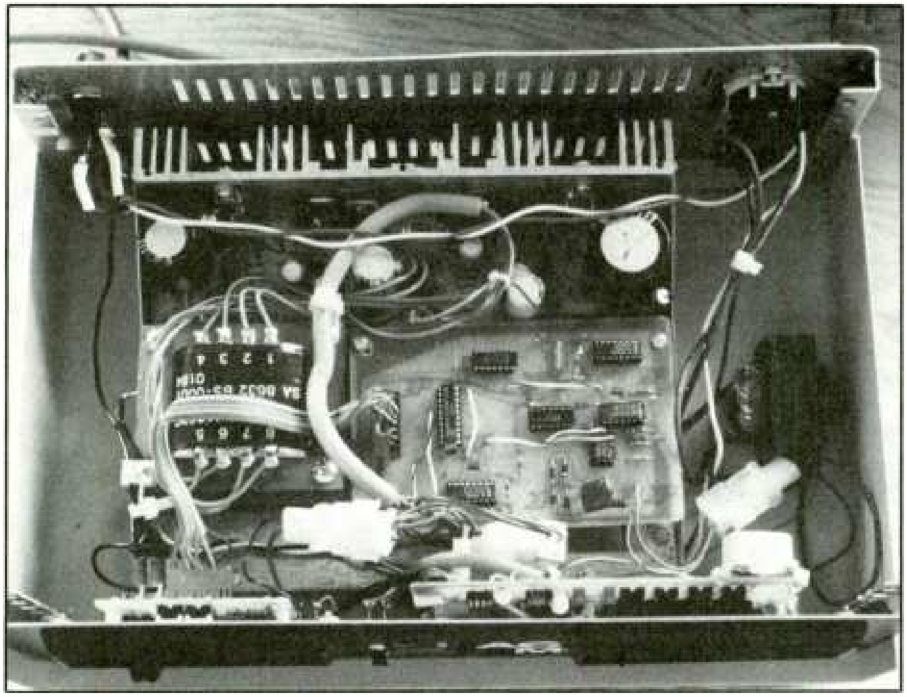
From the definition of rms, the rms value can be determined by squaring the waveform, averaging it and then taking the square root of the result. Rms is a direct measure of the heating value of an ac voltage compared to that of a dc voltage. For example, a 117-volt ac rms signal produces the same heat in a resistive load as a 117-volt dc signal.

For perfect sine-wave voltages, average absolute value is 0.636 that of peak voltage. The corresponding rms value is 0.707 times peak voltage. Therefore, for sine-wave voltages, if you multiply the average value by 1.11, you obtain the equivalent rms value. This is exactly what is done in many ac voltmeters that are designed to measure voltages in terms of rms value.

Bear in mind that 1.11 times the average value of a voltage yields the true rms value for a perfect sine-wave voltage. Attempting to multiply the average value of a square wave by 1.11 will result in an 11-percent too high a reading, while for a triangular wave, the reading will be about 2 percent too low.

Some other types of waveforms, such as rectangular pulse trains, will result in readings that are only a fraction of the true rms value.

From the foregoing, you can use the AC Line Monitor to estimate how close the output waveform of a generator, SPS, UPS or other back-up power source is to a true sine wave.



Interior view of finished prototype of AC Line Monitor.

to read dc volts) across pins 35 and 36 of *IC13*, and adjust *R33* for a reading of exactly 0.100 volt.

Next, switch to the ac-volts function on the multimeter (preferably, the meter being used will have a true rms measuring capability in this function), and measure the ac potential at the ac outlet to which the project is connected. Adjust *R61* for the correct voltage in the display of the AC Line Monitor.

We assume that you want the OVER 127V LED to light when ac line potential exceeds the 127-volt threshold and the UNDER 103V LED to light when the line potential drops below 103 volts. If you wish other voltages for the trip points, divide the warning voltage by 100 to determine proper voltage adjustment.

With the common lead of your multimeter (set to measure dc volts) connected to circuit ground, touch the "hot" probe to pin 2 of *IC14*. Adjust *R41* for a reading of 1.27 volts. To adjust the low voltage trip point, move the "hot" probe to pin 5 of *IC14* and adjust *R45* for a reading of 1.03 volts.

You are now ready to put your AC Line Monitor into service. When you turn on and off power to it, the piezoelectric buzzer will sound for a few seconds. It will also sound when a voltage spike of sufficient duration or voltage drop occurs, the latter even for a few seconds at the onset of a blackout.

When operating from power delivered by a utility company, the project should display a constant 60 Hz, perhaps with a 59 appearing briefly every few minutes or so. If 59, 61 or some frequency other than 60 Hz consistently appears in the display, the crystal oscillator is probably not generating an exact 32,768-Hz ± 1-Hz signal. If this is the case, try replacing the crystal, or replace *C4* with a 10-to-39-picofarad trimmer capacitor.

If the overrange indicator (left-hand decimal point) in the voltage display blinks, the power-line frequency is beyond 99 Hz. **ME**

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EDITORIAL

(from page 4)

to build it into a very successful monthly magazine.

Ever the entrepreneur, George searched for a way to get into this field in a development and business way. The opening he found was the RCA 1802 CPU, which was only being used for a video game whose construction plans we published, and for dedicated industrial control applications. He took the 1802 and developed a little computer called the Elf, which we published as a construction project. The Elf's sales took off, even though the heart of it was within the framework of waning technology, and many thousands of electronics buffs cut their computer eye teeth on it.

Meyerle is working on modestly priced electronics projects that uses a waning-edge-of-technology IC that will provide most of you with a fabulous learning experience in the electronics circuitry area. We expect to kick this one off as a series in a few months time.

The waning edge of technology was good to RCA, too. When I worked for RCA's Solid State Division many years ago, I still remember passing a floor nearly every day that was packed with operating automated machinery that was manufacturing *vacuum tubes*. The company had bought everyone's tube-making machinery and was pumping out tubes to meet the needs of radio and TV service technicians, even though the new sets were solid state. It was a great business for many years.

Clearly, a trailing technology needn't die quickly. It can go on for many years as important constituents for the maintenance and experimenter market. For the latter, it also allows one to get true hands-on experience with electronics circuits without spending a small fortune. With this in hand, many of you will transfer this know-how to components that are indeed at the *leading* edge of technology.

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R-2000

The R-2000 is an all band, all mode receiver with 10 memory channels and many deluxe features such as programmable scanning, dual 24-hour clocks with timer, all-mode squelch and noise blankers, a large, front-mounted speaker. 110 volt AC or 12 volt DC operation (with the DCK-1 cable kit), and 118-174 MHz VHF capability with VC-10 option.

Optional Accessories
R-2000:
- **VC-10** VHF converter
- **DCK-1** DC cable kit for 12 volt DC use.

R-5000:
• **VC-20** VHF converter • **VS-1** Voice module • **DCK-2** for 12 volt DC operation • **YK-88A-1** AM filter • **YK-88SN** SSB filter • **YK-88C** CW filter • **MB-430** Mounting bracket.

Other Accessories:
• **SP-430** External speaker • **SP-41** Compact mobile speaker • **SP-50B** Mobile speaker • **HS-5** Deluxe headphones • **HS-6** Lightweight headphones

RZ-1
Wide-band scanning receiver

The RZ-1 wide-band, scanning receiver covers 500 kHz-905 MHz, in AM, and narrow or wideband FM. The automatic mode selection function makes listening easier. One hundred memory channels with message and band marker, direct keyboard or VFO frequency entry, and versatile scanning functions, such as memory channel and band scan, with four types of scan stop. The RZ-1 is a 12 volt DC operated, compact unit, with built-in speaker, front-mounted phones jack, switchable AGC, squelch for narrow FM, illuminated keys, and a "beeper" to confirm keyboard operation.

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