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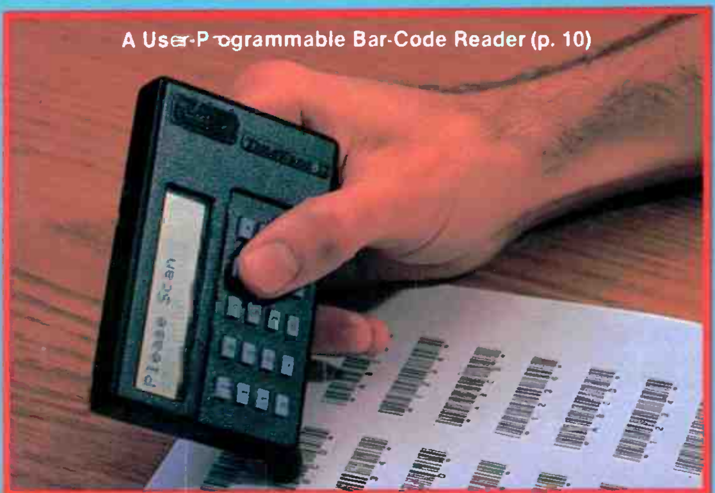
Under-Carpet Fiber Optics (p. 28)

Also In This Issue:

- Under-Carpet Fiber Optics Installation Guide for Voice and Data Signals
- Short-Slot Clock/Calendar Card for PCs and Compatibles
- Substitute Current Shunt—Automatic Circuit Protection Without Fuses or Circuit Breakers



A User-Programmable Bar-Code Reader (p. 10)

An IR Remote-Control System (p. 41)

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Plus: Reviewing Norton Utilities Advanced Edition Version 4.5 ● Electronic Components You Can Make Yourself ● Controlling the Yaesu FRG-9600 with an Apple II ● Two Video Capturing & Processing Packages ● Electronics & Computer News ● Latest Technical Books & Literature . . . more.

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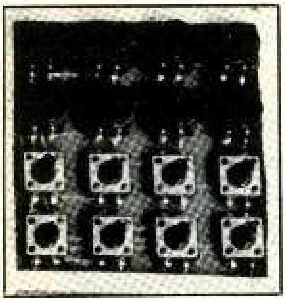
MODERN ELECTRONICS

THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

JUNE 1989

VOLUME 6, NUMBER 6



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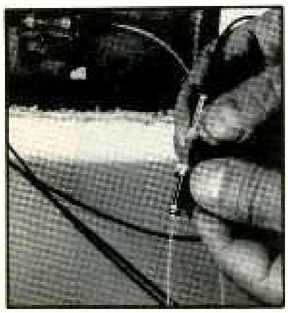

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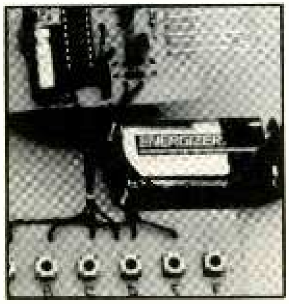

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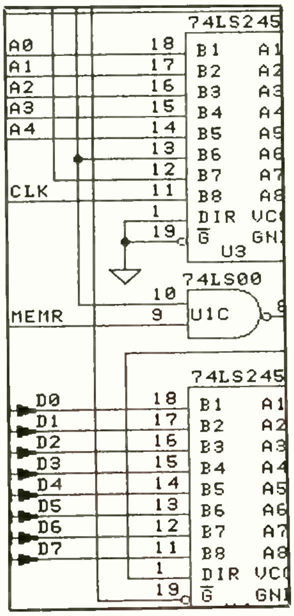

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FEATURES

COLUMNS

DEPARTMENTS

Offices: 76 North Broadway, Hicksville, NY 11801. Telephone: (516) 681-2922. FAX (516) 681-2926. Modern Electronics (ISSN 0748-9889) is published monthly by CQ Communications, Inc. Subscription prices (payable in US Dollars only): Domestic—one year $17.97, two years $33.00, three years $48.00; Canada/Mexico—one year $20.00, two years $37.00, three years $54.00; Foreign—one year $22.00, two years $41.00, three years $60.00. Foreign Air Mail—one year $75.00, two years $147.00, three years $219.00.

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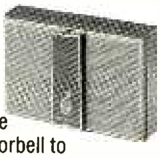
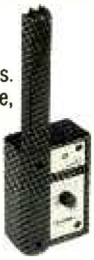
Spring Specials from Heath

Kit projects...

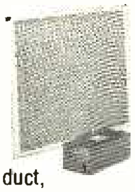
Heathkit Flood Alarm detects unwanted water Avert damage from leaking water pipes or basement wall seepage. Three hours to build. Needs 9V battery. 1¾" H x 3⅝" W x 4⅞" L. Kit GD-1701 (2 lbs.) .. **$12.95**



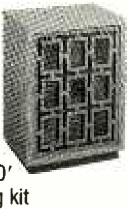
Program your doorbell with a favorite tune Arrange wire leads on one-octave keyboard inside doorbell to program any tune. Includes songbook with 50 + college, seasonal, Christmas and special occasion songs. Back door button activates a part-tune. Volume, tone, speed and delay adjustable. Two-evening kit. Takes standard 16 VAC, 50/60 Hz bell transformer.
Kit TD-1089 (3 lbs.) **$32.95**



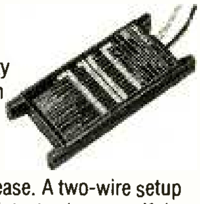
Build your own Heathkit draft detector Easily detect heat loss areas. Turn it on, adjust for silence, then move sensor in areas where heating or cooling losses occur. Temperature changes set off beeping alarm and flashing LED. Used in temperatures from 59-95F. Takes a 9-volt battery (not included).
Kit NE-2112 (2 lbs.) **$14.95**



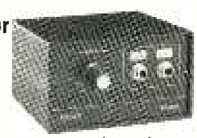
Heathkit Furnace Air Cleaner. Works with heating or A/C system to reduce the effects of pollen, dust and cigarette smoke. Power supply mounts onto a cold air duct, and turns on collecting cell when blower is running. 1" collecting cells below directly replace original furnace filter. 120VAC also works with GD-2196 2" filters. Kit GD-3196 (9 lbs.) **$79.95**
Accessory filters 4 sizes available. each **$74.95**



Heathkit Portable Air Cleaner. Helps solve tough air-cleaning problems, removes dust, smoke, other pollutants from 6,000 cubic feet (25'x30' x 8' room). One-evening kit includes power supply, 3-speed fan control and assembled filter. 120 VAC, 60 Hz. Dimensions 26½" H x 17¼" W x 13½" D.
Kit GDS-1297 (59 lbs.) **$199.00**
Accessory: Replacement Charcoal Filter Assd. GDA-1297-2 (2 lbs.).**$9.95**

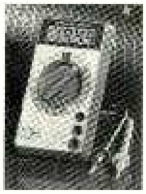


Charging system tester Diagnose faulty components in your car's charging system with accuracy and ease. A two-wire setup and three quick tests show you if the battery has sufficient charge to reliably start the engine, if the battery is being charged by the alternator, if the voltage regulator is faulty (causing the battery to become overcharged), or if the alternator stator windings and rectifier diodes are functioning properly. No external power or battery required. Dimensions are 5½" H x 2¾" W x ¾"D. Kit CI-2065 (2 lbs.) **$19.95**



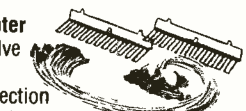
Noise generator kit To properly check out any stereo or sound system with a spectrum analyzer, you need a noise source with a nearly constant energy output. This one-evening Pink/White Noise Generator will do just that...and at a fraction of the cost of comparable noise generators.
Kit AD-1309 (2 lbs.) **$24.95**

For the electronic hobbyist...



Pocket-size digital meter for home and shop Compact digital meter includes 3½ digit, LCD display for readings up to 1999, audible continuity checker and diode test. Overload protected on all ranges, new transistor hFE test.
Assd. SM-2310 (1 lb.) Now only **$24.95**

Connector adapter kit Make 108 different coaxial connector adapters with gold-plated pins and Teflon insulation. Kit contains male and female, N, BNC, UHF, SMA TNC and mini UHF connectors. Special in-between fittings allow you to assemble your own adapters in seconds.
Assd. HCA-3000 (2 lbs.) **$69.95**



Coax adapter cables Solve frustrating coax connection problems with this convenient adapter cable assortment. Twenty cables in all help you make almost any connection. Two handy storage racks keep your cables neatly organized. 50 ohm impedance.
Assd. TPI-5000 (5 lbs.) . Now **$49.95**

Unbeatable Scanner Prices...

Uniden 10-Channel/10-Band Handheld Scanner. Save $31. Superportable, programmable, direct channel access, channel lockout, keyboard lock switch prevents accidental reprogramming. 55 dB @ +25kHz selectivity; audio output 300 milliwatts maximum. Receive 29 to 512 MHz with a 15-channel-per-second scan speed. Requires 5, AA (not included) or rechargeable NiCd batteries.
Assd. BC-55X-LT (1 lb.) **$108.88**

100-Channel/11-Band Uniden Handheld scanner. Reduced $41. 100 programmable channels, 10 scanning banks, 11 bands of coverage. Automatic and manual search, weather search, 10 priority channels, squelch, lockout and delay. Selectivity is −55 dB @ +25kHz; audio output is 450mW maximum. Snap-on battery pack gives full-powered portable scanning.
Assd. BC-100X-LT (3 lbs.) .. **$188.88**

Uniden Tabletop Scanner. 11 bands of coverage, 5 or 15 channels-per-second scanning speed. Features automatic memory search, backup, priority, programmable lockout, scan speed control and automatic squelch setting. Selectivity −45 dB @ +25 kHz, audio output one watt at 10% THD. Takes 117 VAC, 60 Hz from an external wall outlet. Originally priced at $169.95.
Assd. BC-175X-L (3 lbs.) ... **$148.88**

100 Channel/11-Band Uniden Mobile scanner. Auto search aircraft, police, marine and emergency bands. Fully programmable. Fits neatly under dash, flip-down stand and telescopic antenna included. Audio output is 1.5 watts at 10% THD; require 13.8 VDC (vehicle battery or AC adapter). Save $61+.
Assd. BC-580X-LT (5 lbs.) .. **$198.88**

Deluxe Uniden Mobile Scanner. Save $81+. 100-channel/12-band mobile scanner. Covers 800 MHz band for full 12-channel coverage. Weather search, priority, squelch, lockout, delay, auto and manual band search. Mount under dash, or AC adapter (included), flip-down stand and telescopic antenna. Takes 13.8 VDC.
Assd. BC-760X-LT (5 lbs.) .. **$248.88**

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Assd. MIA-2020-1 (4 lbs.) ... **$44.95**
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Assd. MIA-2020-2 (6 lbs.) ... **$99.95**

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EDITORIAL

The Radar Detector Battle

Radar detectors have been an important automobile add-on fixture for many years now. From the onset, however, assaults against them have been repeatedly levied by local governments and various special-interest association groups.

Recently, the Federal Highway Administration refused a request to ban radar detectors in commercial vehicles that are employed in interstate commerce, noting that it has no jurisdiction to do so. A more serious challenge to the radar detector industry and its users, though, is the joining of forces by a number of anti-radar groups into a unified coalition. Called "GUARD," for Group United Against Radar Detectors, its lobbyist effort to ban the popular device is led by very powerful insurance companies.

A counter group has been formed to fight GUARD's attacks. Comprised of radar detector manufacturers and suppliers, it's called RADAR, which stands for Radio Association Defending Airwave Rights.

The insurance companies' posture against radar detectors is that they allow motorists to exceed speed limits without suffering a penalty. GUARD defends this charge by observing that police radar guns are inaccurate and the majority of police officers using radar guns are untrained in their proper application. As a result, it's claimed that motorists are getting unjustified speeding tickets.

About 10 percent of households are reported to use radar detectors, which, detector defenders say, enable them to avoid unfair radar traps. I can empathize with this contention. Traveling East to West in Florida a few years ago, I got a speeding ticket when I didn't reduce my speed from around a legal 35- to around a 20-mph legal maximum that was instituted abruptly for a span of some three or four minutes driving time through a short stretch. The only warning, which I missed, was a small, new speed-limit roadside sign. Two police cars were stationed in a parking area, grabbing one "speeder" after another.

In another instance, in my own New York backyard, I moved from a 30-mph area into a three-block 20-mph area that I never knew existed. A tiny sign that no one I know ever observed warned about the new speed limit. A state policeman parked in an unmarked car was having a field day hauling in "speeders."

Both times, the policemen used radar guns as proof of speeding. And in both cases, the speed I was charged with going at was greatly exaggerated. This increased the amount of my fine and gave the officer a fat over-the-speed-limit cushion in the event the motorist pleaded not guilty in traffic court. Aside from this, there's no doubt in my mind that I did not undermine driving safety.

Like many motorists ticketed for speeding in such circumstances, I feel there's a blatant injustice here where a radar detector would have given me some reasonable protection against innocently exceeding a speed limit and having to pay a traffic fine. In many cases, one's insurance premium is increased, too. No wonder insurance companies would like to ban radar detectors!

The battle between the two radar groups has been joined. Position papers are being issued, press releases abound, educational videos have been produced, etc. May the best group win? No, I favor the status quo.

Let the people have their radar detectors. They're entitled to protect themselves in view of abrupt changes in speed limits, inaccurate radar guns, and undertrained and over-zealous traffic officers. Moreover, a recent study by Yankelovic Clancy Shulman reports that detector users were more likely to wear seat belts, drive more miles each year, and have an accident rate that's almost 25 percent lower than motorists who don't employ radar detectors. With such a record, we'd do well to have more people use detectors, not fewer.

Art Salsberg

LETTERS

Project Updates

• Here are a few clarifications to the schematics for my "Microprocessor Control With BASIC, Part I" article in the April 1989 issue: In Fig. 2, be sure to wire AD0 through AD7 pins 11 through 19 of IC9 to AD0 through AD7 pins 39 through 32 (note the reverse order here) of IC2 in Fig. 1. In Fig. 1, IC5 is a 6464LP and in Fig. 3, IC11 is a 7805K. Also, the telephone number for Datastorm Technologies is now 314-474-8461.

Jan Axelson

• In "A Switch Multiplier" (February 1989), I note that I was inconsistent in designations for R2, R3 and R4. Component values are in Fig. 2 are correct, but change the Parts List to show R2 and R3 as being 15,000 ohms and R4 as being 100,000 ohms. On page 51: change R4 to R5 at the end of line 8 in the first paragraph; change the R2 at the end of the second paragraph to R4; and change the C3R3 in the third paragraph to read C3R4. On page 54: change R2 to R4 in both references to the junction in the center of the middle column.

Robert E. Samuelson

• I've discovered several discrepancies between the schematic and Parts List for the "VCR Modulator" in the April 1989 issue. Specifically, the Parts List calls for values of 220 μF, 75 ohms and 1,000 ohms for C4, R7 and R11, respectively, while the values given in the schematic are 470 μF, 51 ohms and 2,000 ohms. Which are correct?

John Kramer
Mission Viejo, CA

The Parts List is correct in all three cases. Correct the values for these components on the schematic.—Ed.

• There are two discrepancies in the "Extension Phone Lockout" ("4-Add-On Phone Devices," February 1989). One is that the Parts List calls for a 100-microfarad capacitor, while the schematic shows a 10-microfarad capacitor. The other is that the text states that the circuit should be installed in series with the red-insulated line conductor, while the schematic shows it in series with the green-insulated conductor. Which are the correct versions?

Bernard Lau
Singapore

The correct capacitor value is 10 μF, and the correct telephone line conductor to use is the red-insulated one.—Ed.

(Continued on page 82)

HIGH RESOLUTION COLOR LCD. Sharp Electronics' Microelectronics Division has introduced two hi-res color LCD modules that reportedly provide picture resolution rivaling high-performance CRT monitors. A four-inch module produces a high-definition picture with 115,200 pixels, while a three-inch version offers 92,160 pixel resolution. The division's marketing people feel that the new modules will fuel new products that weren't conceivable in the past, such as behind-the-seat video monitors. Sampling starts in the first quarter. Call 201-529-8757 for more information.

HEADSTART COMPUTERS SOLD TO NAPC. North American Philips Corp. (NAPC) acquires the personal computer business of Vendex Technologies, Inc., headquartered in Long Island, NY. Vendex developed and marketed the HeadStart PC compatible personal computers. The new company will be called, HeadStart Technologies. NAPC, a subsidiary of The Netherlands' giant N.V. Philips, is among the top 100 industrial companies in the U.S., marketing such well-known brands as Philips, Norelco, Magnavox, Philco and Sylvania. Vendex International has a substantial interest in other U.S. companies, such as B. Dalton and Barnes & Noble bookstores.

WAKE UP LAUGHING. Alarm-clock haters might wake up laughing now if they use INTEG's (San Jose, CA) "Dynamite Alarm Clock." The new product is a talking alarm clock that shouts to the sleeper in a different language (English, French and Spanish) each day, along with the sound of an explosion. Running on four AA batteries, its design resembles colorful dynamite sticks, including detonator wires. In the center is a conventional clock with traditional hands and Roman numerals. Retail is $49.95.

THE FORTH ESTATE. The Forth computer language is alive and well, judging from reports. A 1988 year-end Real-Time Programming Convention, sponsored by the Forth Interest Group, for example, was said to have record attendance. Among events there was a contest with a $1000 prize to "the world's fastest programmer." The object was to program controlling of a device to be shown at the "go" sign. Only the serial port of a host computer was allowed to be used, along with any programming language. Only Forth was chosen by contestants, not surprisingly. Among systems used by the 14 contest participants were Amiga (Forth), Commodore (64Forth), Compaq (PC/Forth), Grid/New Micros (MaxForth), Macintosh II (MacForth+), Otrona (Z80/Forth), Samsung (polyForth), Sharp (F83), and Zenith (F83).

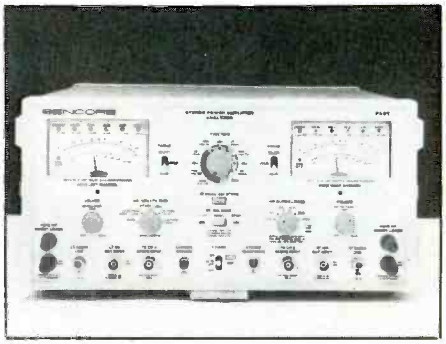
The surprise device unveiled was a working model of a hacksaw blade that swept back and forth in a continuous arc while LEDs at the blade's top end displayed a scrolling message in the air that made use of the human eye's retinal retention: "The rain in Spain falls mainly on the plain." The problem was solved 1 hour and 22 minutes after the contest began by the team of Phil Burk and Mike Haas from Delta Research in San Rafael, CA.

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.

Power Amplifier Analyzer

Sencore's new Model PA81 is an integrated stereo power amplifier analyzer that is designed to help pinpoint problems in audio power amplifiers in a fraction of the time it takes by traditional means. Two auto-ranged meters display measurements of wattage directly, on both stereo channels simultaneously, up to 250 watts/channel (up to 2,500 watts/channel using an optional dummy load accessory). Built into the PA81 are high-accuracy 2-, 4-, 8-, 16-, and 32-ohm, zero-reactance loads. All required bandpass IHF/EIA audio filters are available at the flip of a switch.

Two internal speakers with volume control permit the user to monitor sound quality at all times and at any output power setting. Audio amplifier driver and preamplifier faults are said to be easy to isolate with the external input rms voltmeter or dB meter as needed. A special programmable decibel function provides any zero reference so that stage gains can be read directly.



A dc balance tester tells the user whether push-pull amplifiers are in dc balance. Additionally, the standard "audio line" level of any audio-generating device can be checked into the industry-specified 10,000-ohm

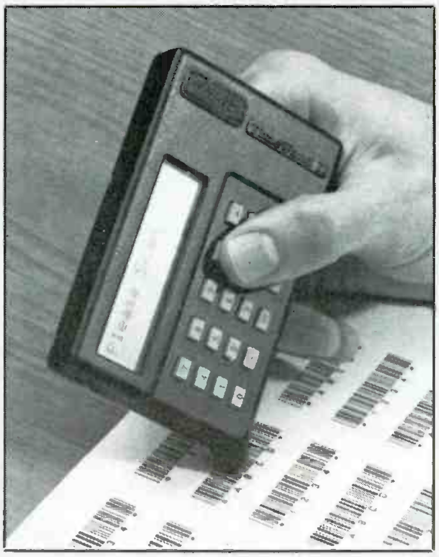
User Programmable Bar-Code Reader

TimeWand II is a new programmable bar-code reader from Videx, Inc. (Corvallis, CA). The palm-size, portable data collector offers the ability to read and collect bar codes without having to be connected to a host computer. Among its many features is rugged metal-case construction that makes it suitable for demanding environments, including industrial.

A two-line 32-character liquid-crystal display automatically shows the bar code just scanned, along with date and time. Each character position consists of a 5 × 7 dot matrix that can display 96 standard ASCII characters and eight user-defined characters.

Because it is programmable, TimeWand II can be instructed to prompt the user to scan a pre-described sequence of bar codes. If an error has been made, a delete button allows the user to erase it and re-enter the correct data. Also, at any time, the user can scroll and review previously scanned data to ensure that each entry has been made in correct order. A 19-button user-definable calculator-style keypad on the top of the scanner allows user entries to be made directly.

A tough shield protects the read



head on the TimeWand II. The head uses optics that operate in the visible-light range to permit reading of a variety of bar codes created with different printing techniques.

Aside from reading bar-code information, TimeWand II can control the order in which bar codes are scanned by allowing the user to define a hierarchy of scans. The device can even cross-reference bar codes with definitions so that when a bar code is read it displays the bar code data and the name of the object the specific code represents. By loading a list of names into the wand, bar codes of special significance can be searched out so that if a scanned code is in the list, TimeWand II sounds an alarm. The loud tone can be varied in pitch and duration to suit different industrial-environment sound conditions.

TimeWand II is powered by an internal rechargeable Ni-Cd battery. Its internal recharger recognizes the level of charge and adjusts charging current appropriately.

Three basic models of TimeWand II are available, differing from each other in the amount of memory each has on-board: Model TW2-032 has 32K and retails for $698; Model TW2-064 has 64K and retails for $798 and Model TW2-128 has 128K and retails for $975. Bar codes read by the reader include Code 3 of 9, Codabar, UPC-AS and E, EAN/JAN-8 and 13 and interleaved 2 of 5. An asynchronous RS-232 serial port built into each model can transmit data at rates from 300 to 19,200 baud.

Options available for the TimeWand II include a sapphire read head ($91), 117- and 220-volt recharger kits ($18 each), DB-9, DB-25 and DIN serial cables for PC/XT/AT and Macintosh computers ($28 each) and IBM and Macintosh communication software packages ($380 each). The last is required for TimeWand II-to-computer data transfer.

CIRCLE 63 ON FREE INFORMATION CARD

input impedance. Advanced decibel-measuring capability tests separation up to 126 dB, which far surpasses the separation achieved with any stereo FM receiver currently available. The twin meter movements on the instrument's front panel are frequency compensated so that any function generator can be used with good results.

CIRCLE 64 ON FREE INFORMATION CARD

Car Sound Silencer

Sound Quest's (N. Chicago, IL) new "Silencer", a handy little device, automatically silences a vehicle's sound system an instant before a cellular telephone rings. The driver no longer has to fumble with the sound system to silence it himself before answering the call. Also, the moment the sound

system silences, the driver knows a call is coming in and can simply reach for the receiver without having to divert some of his attention away from driving. The stereo sound is automatically restored as soon as the telephone is hung up. Three models are available. $39.95 to $69.95.

CIRCLE 65 ON FREE INFORMATION CARD

Battery Maintainer

Regular use of a new solar battery maintainer from Solarex Corp. (Newtown, PA) is said to significantly prolong battery life in most 12-volt motor vehicles, household appliances and power tools. The Battery-Mate™ is a photovoltaic unit that trickle charges any battery to which it is connected whenever enough sunlight is available to generate an out-

put. The unit is housed in a durable Lexan polycarbonate-resin enclosure. It measures 13 × $4\frac{7}{8}$ × about 1 inch thick and comes with a 7-ft. output cable terminated in a cigarette-lighter plug. It provides 80 mA peak output at 12 volts dc.

CIRCLE 66 ON FREE INFORMATION CARD

Radar Detector Tester

Snooper Radar Detectors (Dallas, TX) is offering a radar detector tester. Containing commercial gun oscillators that meet FCC center-frequen-

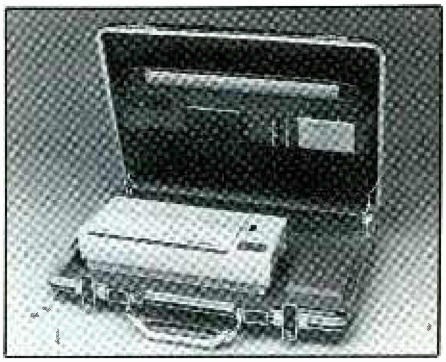
cy stability standards, the instrument is designed to test radar detectors in the retail environment, as well as in the field. For the latter, a cigarette-lighter adapter is provided.

CIRCLE 67 ON FREE INFORMATION CARD

Portable Computer Printer

The ExpressWriter301 from Toshiba America is a 24-wire letter-quality dot-matrix printer in a portable, lightweight package. It is said to be the first 24-wire printer to use the thermal-transfer process using plain paper. Five fonts are resident: Courier, Prestige elite, draft, condensed and proportional. Printing speed is rated at 60 characters per second in high-speed mode and 42 cps in normal mode. Toshiba/Qume and Epson LQ Series emulations are standard for maximum compatibility with software packages. Graphics resolution is 300 × 300 dots per inch.

A rechargeable Ni-Cd battery is built in for portable use, and a 117-volt ac adapter/charger is provided. The printer can be operated continuously for about an hour on full charge. It can also be operated con-



tinuously via the ac adapter/charger. The printer's control panel has an indicator on it that signals when the battery needs recharging.

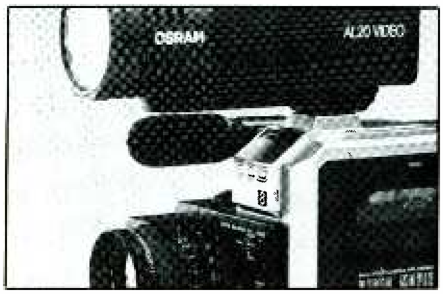
The printer comes standard with a parallel interface and 2K buffer. It offers 10, 12 and 16.7 horizontal and 3, 4, 6 and 8 lines per vertical inch spacing. In graphics mode, spacing is $\frac{1}{120}$" horizontally and $\frac{1}{48}$" vertically. The printer can handle paper widths ranging from 4" to 8.5" wide. It uses a black snap-in ribbon and has a built-in paper guide. The printer's mean time between failures (MTBF) rating is 25,000 hours. It measures 12.2"W × 5.5"D × 3"H and weighs just 4 lb. $489.

CIRCLE 68 ON FREE INFORMATION CARD

Camcorder Light

OSRAM's new Model AL-20 camcorder video light features very compact construction, a variable reflector and an ac adapter. The fully portable light operates without an external battery to power its 20-watt Xenophot® tungsten-halogen lamp. The lamp has a color temperature of 3,200 Kelvin. The computer-matched faceted reflector is designed to provide bright, even dispersion. The beam has a "flood" angle of approximately 35° for wide-angle shots and a "spot" of approximately 10° with farther reach for telephoto shots.

The light's removable back contains a rechargeable Ni-Cd battery that operates for approximately 30 minutes under normal use. It comes with its own 14-hour battery charger with 13-ft. cord. Extra batteries are available as options. A swing-arm mounting bracket permits the light to



be clipped onto the camcorder's hot shoe or mounted on a tripod, either on- or off-center for greater versatility when focusing the light.

The AL-20 measures 7"L × 2¾"H × 2¼"W and weighs 14 oz., including battery. $159.95.

CIRCLE 69 ON FREE INFORMATION CARD

Hand-Held LCR Meter

Beckman Industrial's new Model LM22A is a high-accuracy hand-held LCR meter that measures capacitance, inductance, resistance (equivalent series resistance) and dissipation over a wide range. Seven inductance ranges provide readings from 19 microhenries to 199.9 Henries; eight capacitance ranges from 19 picofarads to 1,999 microfarads; seven resistance ranges from 1 ohm to 19.99 megohms. Two differential internal test frequencies optimize the accuracy of readings between the high and low capacitance and inductance ranges.

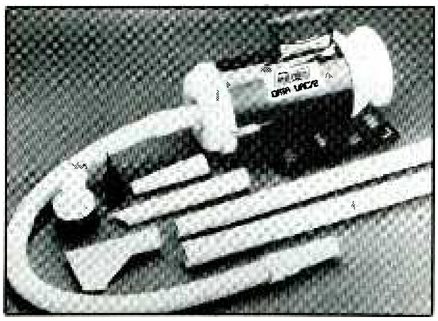
Rated accuracy ranges from 1% to 3% ±1 digit in all modes. Basic accuracy for dissipation readings varies from 1% ±2 counts to 2% and 3% in the extreme low and high inductance and capacitance ranges. The instrument is powered from its own 9-volt battery and can be powered from the ac line with an optional ac adapter.

Input protection and overrange indication are provided on all ranges, with protection to 250 volts ac on resistance and 117 volts ac on capacitance and inductance. Readings are displayed in a high-contrast 3½-digit LCD window, which also displays the low-battery condition. The meter is supplied with alligator-clip test leads, a spare fuse and operator's manual. Available options include a carrying case and ac adapter. $199.

CIRCLE 70 ON FREE INFORMATION CARD

Computer Vacuum Cleaner

DATA-VAC(MDV-1) is a new high-tech cleaning system developed by Metropolitan Vacuum Cleaner Co.



(Suffern, NY). It is claimed to be the first fully portable vacuum cleaner/blower specifically designed for cleaning and maintaining computers and other office equipment. It was engineered to clean hard-to-reach areas in computers and peripherals. Featuring an Air Pinpointer™, with an opening that is just millimeters in size for super-fine spot cleaning, the portable cleaner is easy to handle. It comes with a shoulder strap for convenient lugging around and a variety of attachments that include a 19-inch hose, crevice tool, soft-bristle dust brush for keyboards and printers, and five extra reusable/disposable paper bags. $65.

CIRCLE 71 ON FREE INFORMATION CARD

Line Voltage Monitors

Tep Inc. (Winona, OH) has two devices that continuously monitor the 117-volt ac line. The Model 2200 plugs directly into an ac outlet, while the Model 2250 connects to the outlet via a 6-ft. line cord/plug arrangement and comes with a table-top tilt stand. Both feature expanded-scale analog meter movements that indicate a range from 100 to 130 volts. The scales are color coded and claimed to be within 2 percent of pointer indication. The Model 2200 also comes with Velcro mounting "hardware" for secure installation in RVs, boats and other mobile equipment in which 117-volt ac line power is used. $21.95 Model 2200; $24.95 Model 2250.

CIRCLE 72 ON FREE INFORMATION CARD

Dubbing Cassette Deck

Onkyo has a dubbing cassette deck for the user who demands high-quality sound recording and reproduction. It features both Dolby B and C noise-reduction systems and Dolby HX Pro for increased high-frequency capability and reduced distortion. The transport is built around a dual-motor, logic-controlled system that offers quick automatic-reverse operation for recording or playback. A sensitive infrared sensor triggers reversal at the beginning of the leader tape to provide shorter gaps of silence than are possible with mechanical-sensor arrangements.

A real-time tape counter is incorporated into the deck to provide accurate elapsed and remaining times

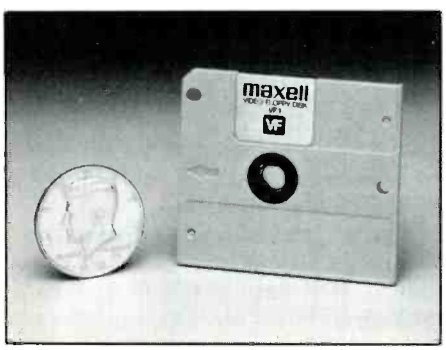
for all popular cassette lengths. In this deck, both transports have the ability to record, giving the user much more flexibility in his taping. A computer-controlled Synchro Dubbing capability automatically coordinates both transports when transferring material from one tape to another. Direct Music Search on both transports skips directly to any selection up to 16 ahead and 15 behind the current one.

Included is Onkyo's new RI (Remote Interactive) remote-control format that uses bidirectional digital data transmission to permit interaction between many Onkyo components. $630.

CIRCLE 73 ON FREE INFORMATION CARD

Video Floppy Disks

Maxell Corp. of America has announced arrival of its new 2″ video floppy disk for use in still video equipment recently released by hardware manufacturers. The VF-1 floppy disk's surface is coated with ultra-fine, high-coercivity metal particles to ensure high-quality image recording and reproduction. The coating is said to be further enhanced by Maxell's oxidation-resistant treatment.



VF-1's new high-dispersion coating technology is claimed to achieve high output and low noise and deliver sharp color still video images. A special binder technology produces a durable bond between the magnetic layer and base film.

Each disk stores up to 50 images (in field recording mode) or up to 25 images in frame recording. Resulting pictures can be viewed immediately on any home TV receiver, and color prints can be made with a special hard-copy printer. Images can also be transmitted over standard telephone lines.

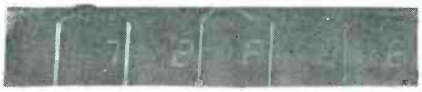
CIRCLE 74 ON FREE INFORMATION CARD

(Continued on page 82)

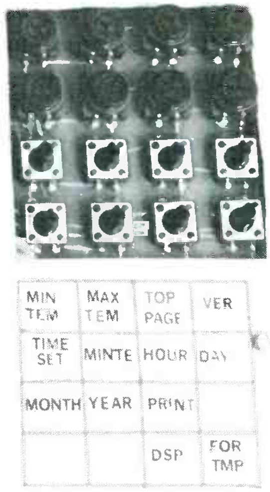
Project

WISARD

A Smart Weather Monitor



(Part 1)



An expandable stand-alone multifunction MCU-based real-world instrument that automatically records temperatures and can predict them as well

By Thomas R. Fox

At first glance, WISARD (an acronym for Weather Instrumentation System for Analysis and Recording of Data) might appear to be a fancy digital device that displays inside and outside temperatures and time of day. Closer inspection, however, reveals that it is much more. For example, it provides minimum and maximum temperature readings for the day. Furthermore, with the help of a computer printer, it produces hard copy of a number of different weather parameters. These include current temperature as well as minimum and maximum temperatures for the day, the time each occurred, and predictions on what the minimum and maximum temperatures will be for the next 24 hours. It also prints out when dawn and dusk occurred and when rain began to fall and when conditions cleared up.

WISARD is a stand-alone system that does not require a separate computer to operate. It has its own on-board computer-on-a-chip to do all the work normally assigned to a separate computer. (*Last month's "Smart" Thermometer had only a fraction of the "intelligence" of this one and required its own separate microcomputer with built-in BASIC interpreter—Editor.*) The project is built around commonly available and inexpensive components. Thus, it costs less to build than most weather-monitoring boards designed to be plugged into a separate computer and that have only a fraction of the flexibility of WISARD.

Features

Among WISARD's distinctive features is its automated record-keeping abilities. With a printer connected to the project, WISARD provides a hard copy of the previous day's weather conditions. It automatically prints out such information as hourly temperature and general hourly weather conditions (rain or no rain), mean and extreme temperatures and the time each occurred.

Every morning at dawn, WISARD prints out a dawn message that includes the exact time at which dawn occurred. Similarly, at dusk, WISARD prints out a dusk message that includes the hours and minutes of daylight and sunshine for that day.

When it rains, WISARD prints out a rain message. Conversely, when dry weather returns, that information is printed out as well.

As mentioned, WISARD is a stand-alone unit. Though it can be plugged into a computer printer to provide hard-copy printouts of messages, you can opt for no printout simply by turning off your printer or unplugging it from the project.

Battery back-up is included in this

Fig. 1. Schematic diagram of CPU module is shown here in six parts, labeled (A) through (F).

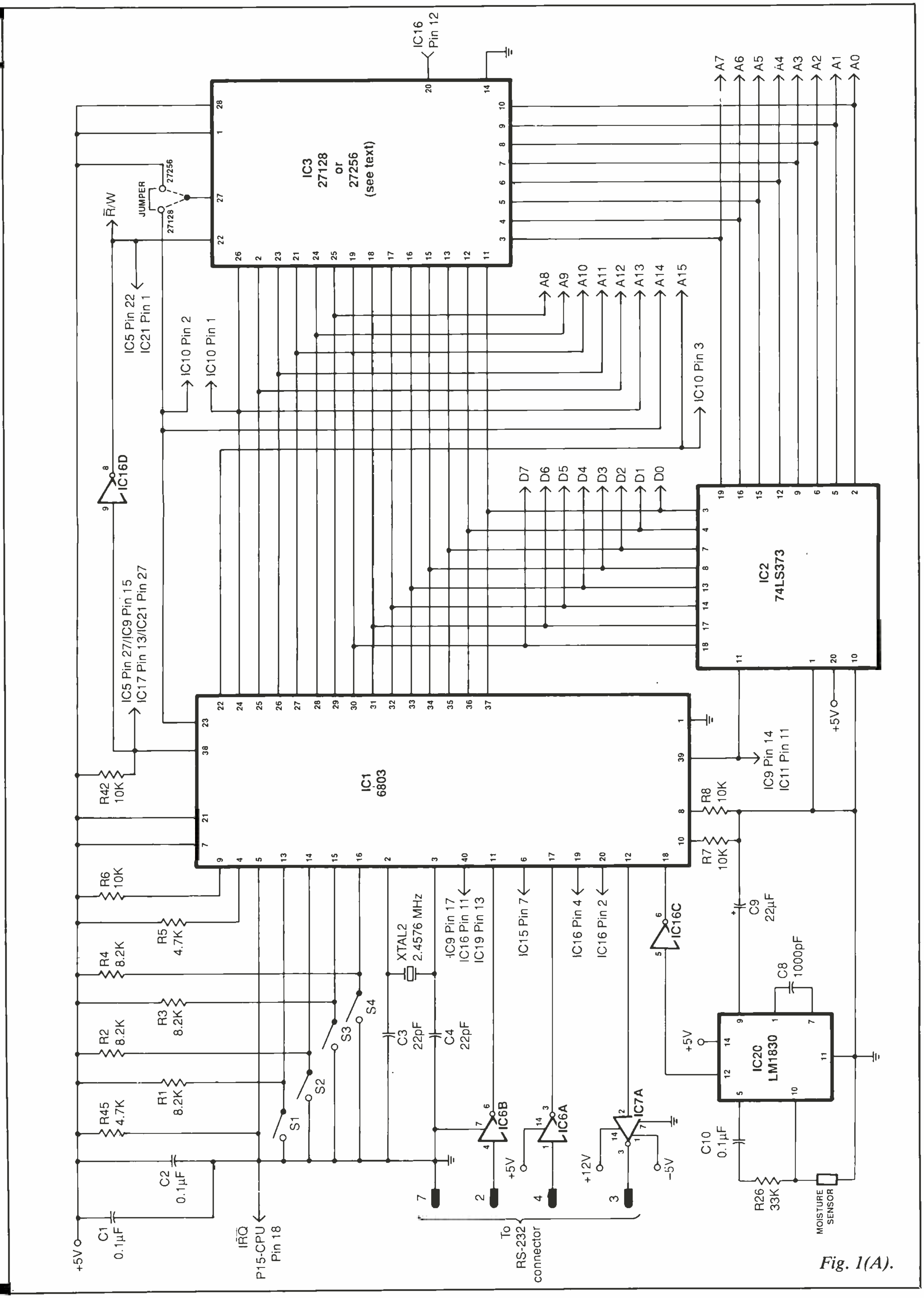

IC1
6803
IC2
74LS373
IC3
27128
or
27256
(see text)
IC2C
LM1830
MOISTURE SENSOR
To
RS-232
connector

Fig. 1(A).

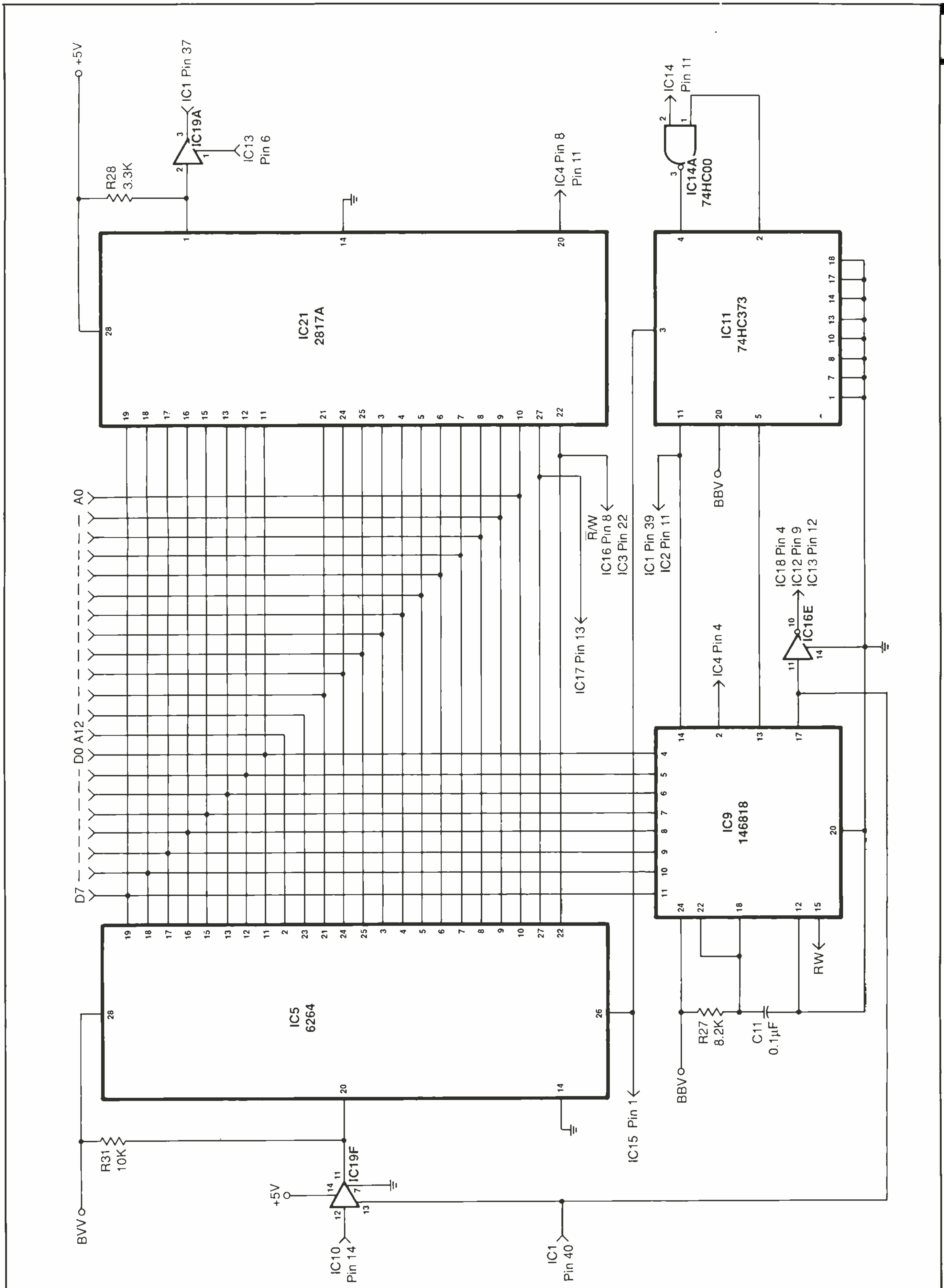

+5V
R28
3.3K
IC19A
IC1 Pin 37
IC13
Pin 6
IC4 Pin 8
Pin 11
IC14
Pin 11
IC14A
74HC00
IC21
2817A
IC11
74HC373
A0
D0 A12
D7
R/W
IC16 Pin 8
IC3 Pin 22
IC1 Pin 39
IC2 Pin 11
BBV
IC17 Pin 13
IC4 Pin 4
IC18 Pin 4
IC12 Pin 9
IC13 Pin 12
IC16E
IC9
146818
IC5
6264
RW
R27
8.2K
C11
0.1μF
BBV
IC15 Pin 1
R31
10K
BVV
+5V
IC19F
IC10
Pin 14
IC1
Pin 40

Fig. 1(B)

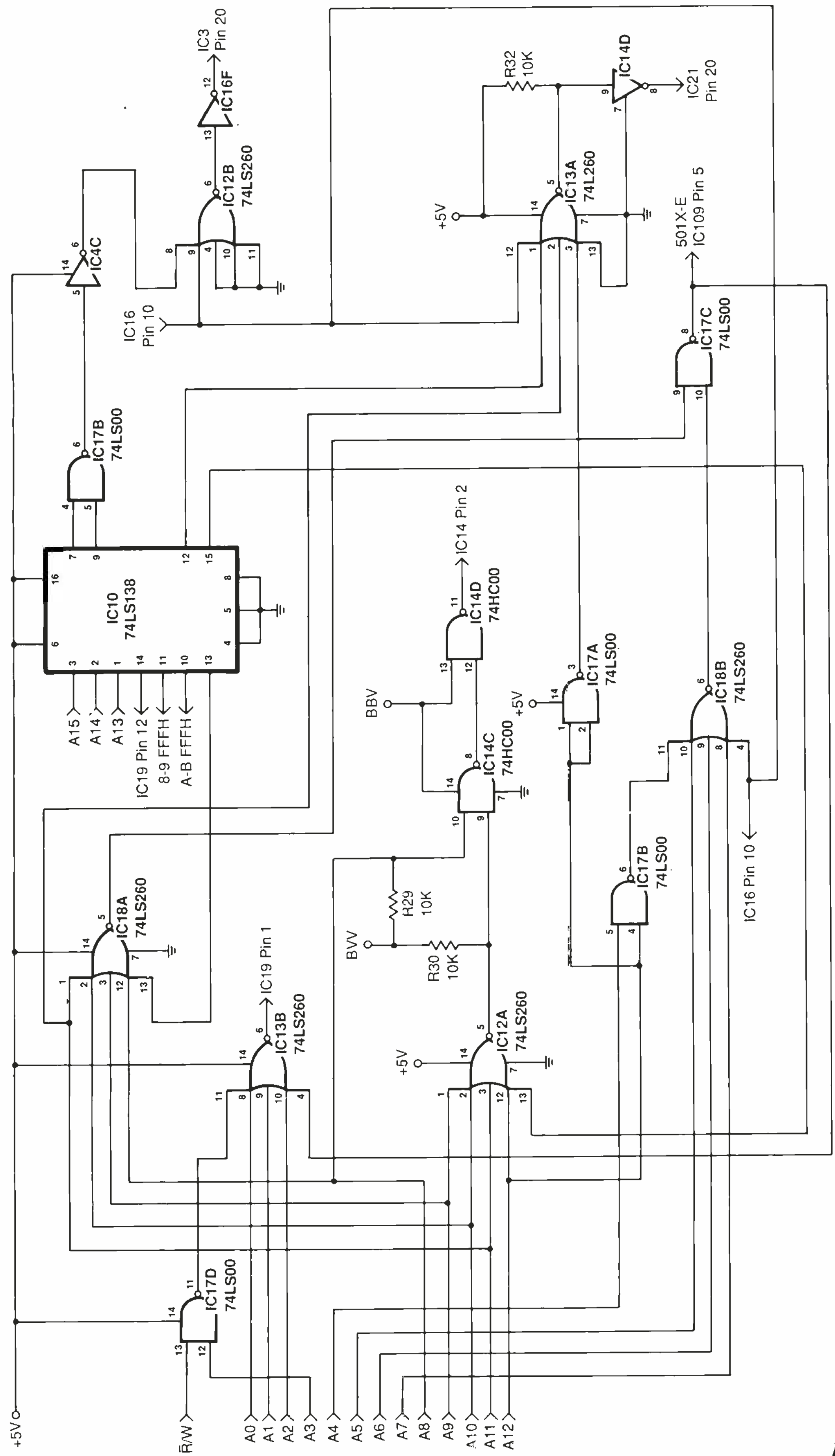

IC3 Pin 20
IC16F
IC12B 74LS260
IC4C
IC16 Pin 10
IC17B 74LS00
IC10 74LS138
A15
A14
A13
IC19 Pin 12
8-9 FFFH
A-B FFFH
R32 10K
IC14D
IC21 Pin 20
+5V
IC13A 74L260
501X-E IC109 Pin 5
IC17C 74LS00
IC14 Pin 2
IC14D 74HC00
BBV
IC14C 74HC00
IC17A 74LS00
IC18B 74LS260
IC16 Pin 10
IC18A 74LS260
IC19 Pin 1
IC13B 74LS260
R29 10K
BVV
R30 10K
IC12A 74LS260
IC17B 74LS00
IC17D 74LS00
+5V
R/W
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12

Fig. 1(C).

project to ensure against a 67F reading from becoming a 167F reading as the result of a power flicker.

Other features included in the WISARD project include display of current date, notification of when ac power has been interrupted and the time it was restored, and notification of battery failure.

On the keyboard is a PRINT switch that is used to force a printout of the current day's weather condition information. Temperature is given in either all Fahrenheit or both Fahrenheit and Celsius degrees, controlled by an OPTION switch.

Firmware version ME1 for WISARD (described here) has an abundance of features. Perhaps the most exciting thing about WISARD is its simplified expansion capability and versatility. For instance, while its RS-232 interface was designed with a printer in mind, you can hook up a modem to it to send the information to any modem-equipped telephone anywhere on Earth. You can also connect a terminal or computer (with the aid of a suitable terminal emulator program) to the project to display information on a video display's CRT. WISARD is electronically capable of two-way communication, but its firmware must be modified to accommodate this.

In its most basic form, WISARD has five separate sense inputs: two for indoor and outdoor temperatures and one each for rain, daylight and sunshine. The built-in display consists of six decades of seven-segment LED numeric readouts that can display 17 alphabetic characters and 0 through 9.

Although WISARD is able to "read" 20 keys, firmware version ME1 makes use of only 13 keys. This leaves seven keys for expansion.

The project also uses a 6803 MCU (see box for details on this device's heritage), and its memory consists of up to 38K of EPROM, 10K of nonvolatile RAM and 2K of EEPROM. It also has a real-time clock and an

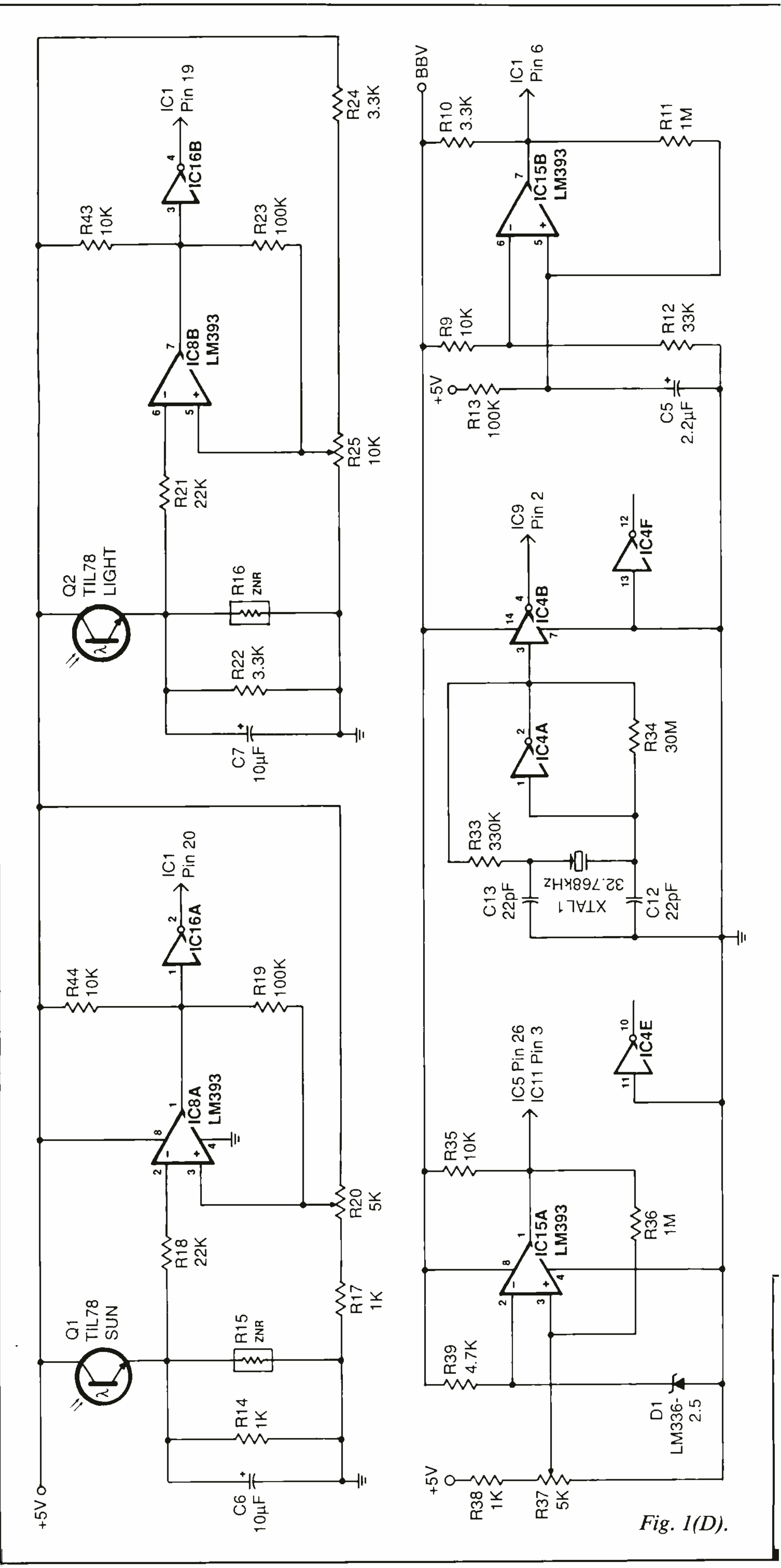


Fig. 1(D).

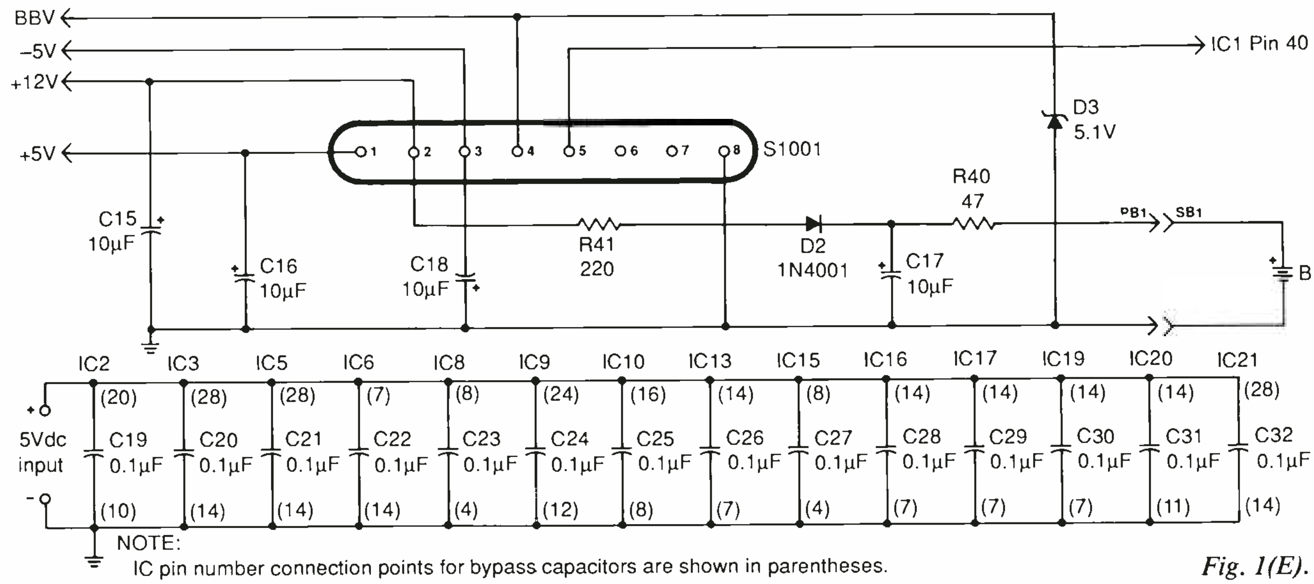


Fig. 1(E).

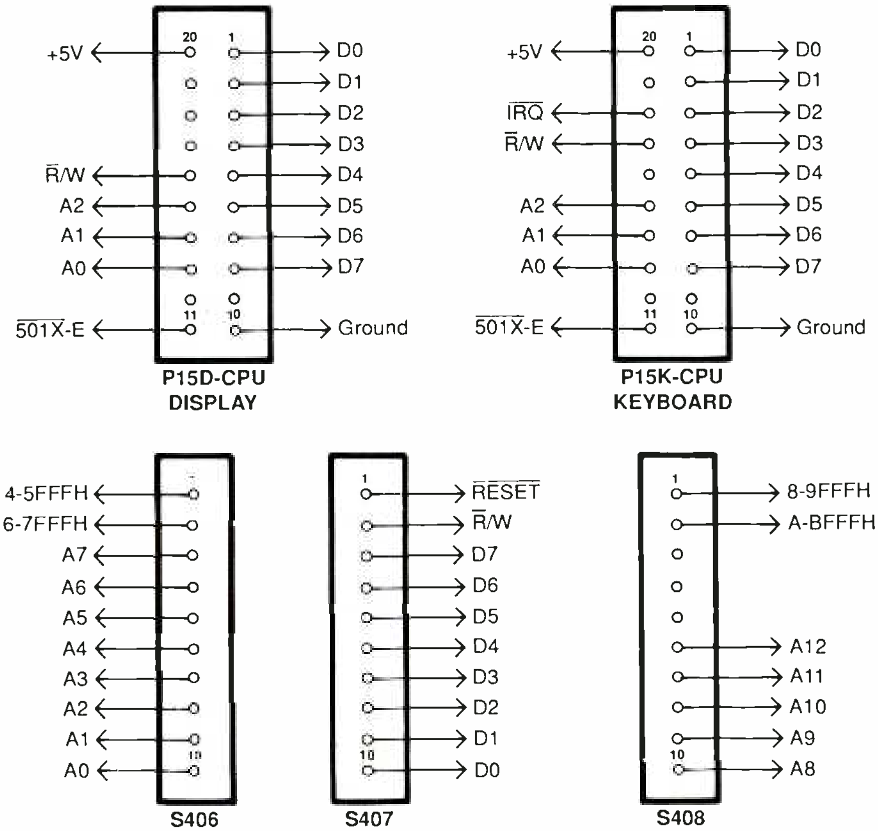


Fig. 1(F).

eight-channel A/D (analog-to-digital) converter. Only two channels of the A/D converter are used in the basic project, which leaves six channels for expansion purposes.

Up to eight high/low logic input lines are available to accommodate two-state input devices, such as micro switches. In addition to the LEDs and RS-232 interface, 16 output lines are available as well. With suitable buffering—using optical isolators and/or relays—these lines can be used to control heaters, cooling systems, lights, solenoid-operated valves, alarms, etc.

About the Circuit

WISARD consists of four circuit-function modules, the primary one of which is the CPU module that can function all by itself. The circuitry for this CPU module is complex, at least in terms of semiconductor-device count. The schematic diagram for this module is quite large and, thus, is presented here in six parts. For the following discussion, therefore, refer to the appropriate (A) through (F) part of Fig. 1.

In this circuit 6803 MCU *IC1* is operated at a clock frequency of 614.4 kHz, which is derived by dividing the 2.4576-MHz frequency of *XTAL2* by four inside *IC1*. Eight different operating modes are possible for *IC1*. However, since the 6803 has no on-board ROM, only two modes—2 and 3—are relevant here. The logic levels on pins 8, 9 and 10 of *IC1* at the rising edge of the reset signal determines which mode of the MCU chip is selected. WISARD uses mode 2, a multiplexed address/data bus and internal RAM.

Address strobe pin 39 of *IC1* is connected to ENABLE pin 11 of octal latch *IC2*, which demultiplexes ad-

PARTS LIST (CPU Board)

Semiconductors
D1—LM336Z-2.5 2.5-volt reference
D2—1N4001 silicon rectifier diode
D3—1N5231B or similar 5.1-volt, ½-watt zener diode
IC1—6803 MCU
IC2—74LS373 octal D flip-flop
IC3—EPROM (27128 or 27256—see text)
IC4—74HC14 hex inverter Schmitt trigger
IC5—6464LP-15 static RAM
IC6—LM1489 quad RS-232 line receiver
IC7—LM1488 quad RS-232 line driver
IC8,IC15—LM393 dual comparator
IC9—MC146818 real-time clock and RAM
IC10—74LS138 expandable 3-to-8 decoder
IC11—74HC373 octal D flip-flop
IC12,IC13,IC18—74LS260 dual 5-input NOR gate
IC14—74HC00 quad 2-input NAND gate
IC16—74LS14 hex inverter Schmitt trigger
IC17—74LS00 quad 2-input NAND gate
IC19—74LS126 tri-state quad buffer
IC20—LM1830 fluid-level detector
IC21—2817A (2K, 350-ns) EEPROM
Q1,Q2—TIL78 or equivalent phototransistor

Capacitors
C1,C2,C10,C11,C19 thru C32—0.1-µF, 50-volt monolithic or equivalent
C3,C4,C12,C13—22-pF, 100-volt disc
C5—2.2-µF, 25-volt tantalum
C6,C7,C15 thru C18—10-µF, 25-volt miniature electrolytic
C8—1,000-pF, 50-volt monolithic or equivalent
C9—22-µF, 25-volt miniature electrolytic
C14—Not used

Resistors (¼-watt, 5% tolerance)
R1 thru R4,R27—8,200 ohms
R5,R39,R45—4,700 ohms
R6 thru R9,R29 thru R32,R35,R42, R43,R44,—10,000 ohms
R10,R22,R24,R28—3,300 ohms
R11,R36—1 megohm
R12,R26—33,000 ohms
R13,R19,R23—100,000 ohms
R14,R17,R38—1,000 ohms
R15,R16—ZNR (Digi-Key Cat. No. P7022 or equivalent; optional—see text)
R18,R21—22,000 ohms
R33—330,000 ohms
R34—30 megohms (three 10-megohm resistors in series)
R40—47 ohms (½-watt)
R41—220 ohms (½-watt)
R20,R37—5,000-ohm subminiature 15-turn, pc-mount trimmer potentiometer
R25—10,000-ohm subminiature 15-turn, pc-mount trimmer potentiometer

Miscellaneous
B1—Nickel-cadmium C cells (three in series)
S1 thru S4—4-position DIP switch
S406,S407,S408—10-pin female sockets with holes on 0.1-inch centers (Digi-Key Cat. No. 929974-01-10)
XTAL1—32.768-kHz crystal
XTAL2—2.4576-MHz crystal
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware; home-fabricated moisture sensor (see text); suitable enclosure; sockets for all DIP ICs; P1001-CPU 8-circuit header with holes on 0.156 inches (Digi-Key Cat. No. WM4406 or WM4606);P15D-CPU,P15K-CPU 20-pin dual-row male headers with holes on 0.1-inch centers (Digi-Key Cat. No. 929836-01-36 or 929665-01-36); connectors for moisture sensor, B1, Q1, Q2 and power supply; RS-232 connector or/and cable (optional—see text); hookup wire; solder; etc.

Note: The following items are available from Magicland, 4380 S. Gordon, Fremont, MI 49412: Double-sided, plated-through pc board for A/D memory expansion, $22 (CPU, display and keyboard pc boards are not currently available commercially); 27128 EPROM containing Firmware ME1, Version 1.8, $18, and programmed 2732A EPROM (required for A/D board), $12, or both EPROMs, $25; 6803, $3.75; LM1830, $2.25; 74LS541, $1.45; 74LS126, 60¢; and for the required A/D board, ADC0809, $4; LM335, $2; 6116LP, $7. A PC-compatible disk that contains the firmware's assembly-language source code and Intel hex record that can be used by many EPROM programmers for $2.75 to cover duplication cost. Also available is a brand-new Coleco dc power supply that delivers: +5 volts at 3 amperes, −5 volts at 200 mA, two +12 volts at 2.9 amperes, and +18 volts at 1 ampere for $20 plus $5 shipping. Michigan residents, please add 4% state sales tax on all orders.

dresses A0 through A7 from the multiplexed A0/D0 through A7/D7 lines.

Contained within CPU EPROM *IC3* is the firmware that gives WISARD its "smarts." In firmware version ME1, *IC3* is a 16K-byte 27128 EPROM. However, a 32K-byte 27256 EPROM can be used instead of the 27128, which requires movement of a jumper as shown in the upper-right in Fig. 1(A).

Integrated circuits *IC18*, *IC14*, *IC4*, *IC12*, and *IC16*, in conjunction with primary address decoder *IC10*, provide address decoding for *IC3*, which is selected by addresses C000H through FFFFH (or 8000H through FFFFH if a 27256 is used in place of the 27128).

On reset (power first turned on), the interrupt vector points to address FFFEH. The data bytes stored at locations FFFEH and FFFFH is the starting address for the main program. (In firmware version ME1, this address is C000H.)

A suitable reset signal is required to start WISARD. From a power-down condition, RESET pin 6 of *IC1* must be held low (less than 0.8 volt) for a period of time sufficient to permit the clock to stabilize. A fairly sophisticated reset signal is developed by voltage comparator *IC15B* and support components *C5* and *R9* through *R13*. The output of this comparator, at pin 7, connects to RESET pin 6 of *IC1* and pin 1 of the header identified as *S407*.

Address decoding for the CPU circuit's primary RAM, *IC5*, is provided by *IC10*. Three-state buffer *IC19* ensures that the bus driver in the RAM is on only when the clock signal is high. Static RAM *IC5*, an 8K memory device, has battery back-up to make it nonvolatile (prevent the RAM's contents from being wiped out when an ac line power interruption occurs). This rechargeable Ni-Cd battery, consisting of three cells in series, keeps data in the RAM for a day with no ac power applied to the circuit. RAM *IC5* is selected by addresses 2000H through 3FFFH.

The 2K EEPROM identified as *IC21* is optional. The version ME1 firmware does not make use of this EEPROM. Nevertheless, the firmware does support it with a specialized write subroutine. A socket and complete decoding are provided for this EEPROM.

The 2817A EEPROM provides nearly permanent storage and can be written to and erased through software. It is reliable for up to 10,000 write/erase cycles per byte.

While the *IC21* EEPROM has many potential uses, one fascinating possibility is that it can be used in an advanced AI (artificial-intelligence) type of program that learns from past experience.

Address decoding that selects *IC21* is accomplished with *IC10*, *IC17*, *IC13* and *IC4*. This chip is selected for a read/write operation by addresses 7000H through 7FFFH. Notice that while *IC21* was designed specifically to be easy to use, it cannot be written to in the same manner as RAM because it requires up to 20 milliseconds to erase and write a bit from and into memory. Most ordinary RAM is more than 100,000 times faster than this.

Pin 1 of *IC21* is the RDY/BUSY line of the 2817A EEPROM. When this line is high, the chip is ready to be read or written to. This RDY/BUSY line is connected to three-state buffer *IC19A*, whose pin 1 output is connected to data line D0 at pin 37 of *IC1*. This buffer is selected by a read to address 5018H. Address decoding for this buffer is accomplished with *IC10*, *IC17*, *IC18* and *IC13*.

Real-time clock (RTC) *IC9* has battery back-up. This chip has 50 bytes of nonvolatile RAM on-board. The clock is selected by addresses 100H through 13FH. The first 14 bytes are used by the clock's registers. The remaining 36 bytes are user RAM. Decoding is accomplished with *IC10*, *IC12* and *IC14*. The purpose of *IC11* is to assure that CE pin 13 of *IC9* is synchronized with the address strobe.

The real-time clock uses a multiplexed data/address bus that reduces circuit complexity (as well as physical circuit layout on the circuit board). Though MC146818 *IC9* has an internal time-base oscillator, WISARD uses an external oscillator because the built-in oscillator caused reliability problems. The external oscillator is composed of Schmitt-trigger inverters *IC4A* and *IC4B*, 32.768-kHz crystal *XTAL1*, capacitors *C12* and *C13*, and resistors *R40* and *R41*.

The battery back-up circuit, shown in Fig. 1(E), consists of *R40*, *R41*, *D2*, *D3* and *B1*. The battery is made up of three Ni-Cd C cells in series. Zener diode *D3* ensures that the BBV (Battery Back-up Voltage) supply does not exceed 5.25 volts when ac power is supplied to the circuit. With ac removed from the circuit, BBV is slightly less than 4 volts.

Once it is fully charged, *B1* can retain the contents of 10K bytes of RAM and the real-time clock for more than 24 hours. For applications where memory *must* be retained permanently, you can make use of 2817 EEPROM *IC21*.

Because of its relatively high power drain in standby mode, no battery back-up source is is connected to *IC1*. Thus, all of this integrated circuit's internal RAM (addresses 80H through FFH) is volatile.

Included in the CPU module is a "shutdown" circuit, the output of which is connected to pin 26 of *IC5*. This shutdown circuit insures that the data stored in *IC5*, the primary RAM system, does not change while the +5-volt supply is dropping toward zero, which is normally caused by loss of ac power to the circuit. The output of the shutdown circuit is also connected to pin 3 of *IC11* to protect *IC9*'s data.

The shutdown circuit is made up of *IC15A*, *D1* and *R35* through *R39*. Trimmer potentiometer *R37* is adjusted during initial calibration for a potential of 2.7 volts at pin 3 of *IC15*. When ac voltage starts to drop, the potential on pin 1 of *IC15* drops to near ground potential. As you can see, *IC15* is powered by the battery back-up system.

The firmware in *IC3* initializes the Serial Communication Interface (SCI) of *IC1*. The actual procedure for accomplishing this is a bit complex. Suffice it to say that *IC3*'s pin 12 transmits, pin 11 receives and pin 10 is not used at all. The SCI is programmed to use the 6803's internal clock source.

Using a 2.4576-MHz crystal for *XTAL2* permits use communication rates of 150, 600, 4,800 and 38,400 baud, but only the 600- and 4,800-baud rates are used by WISARD. The firmware monitors the logic level at pin 14 of *IC1* to determine which baud rate to use.

Pin 14 of *IC1* is connected to *S4*. Pins 13 through 20 are connected to Port 1 of *IC1*, which is located at address 02H. During reset, Port 1 is configured as an input.

No built-in handshaking is included in the SCI. No handshaking is needed for fast printers and/or low baud rates. However, WISARD does use handshaking. One input of Port 1, at pin 17 of *IC1* acts as a BUSY input. The firmware will not permit the SCI to send data while pin 17 (port 1's D4 data line) is high.

An EIA receiver, *IC6A*, has its output connected to pin 17 of *IC1*.

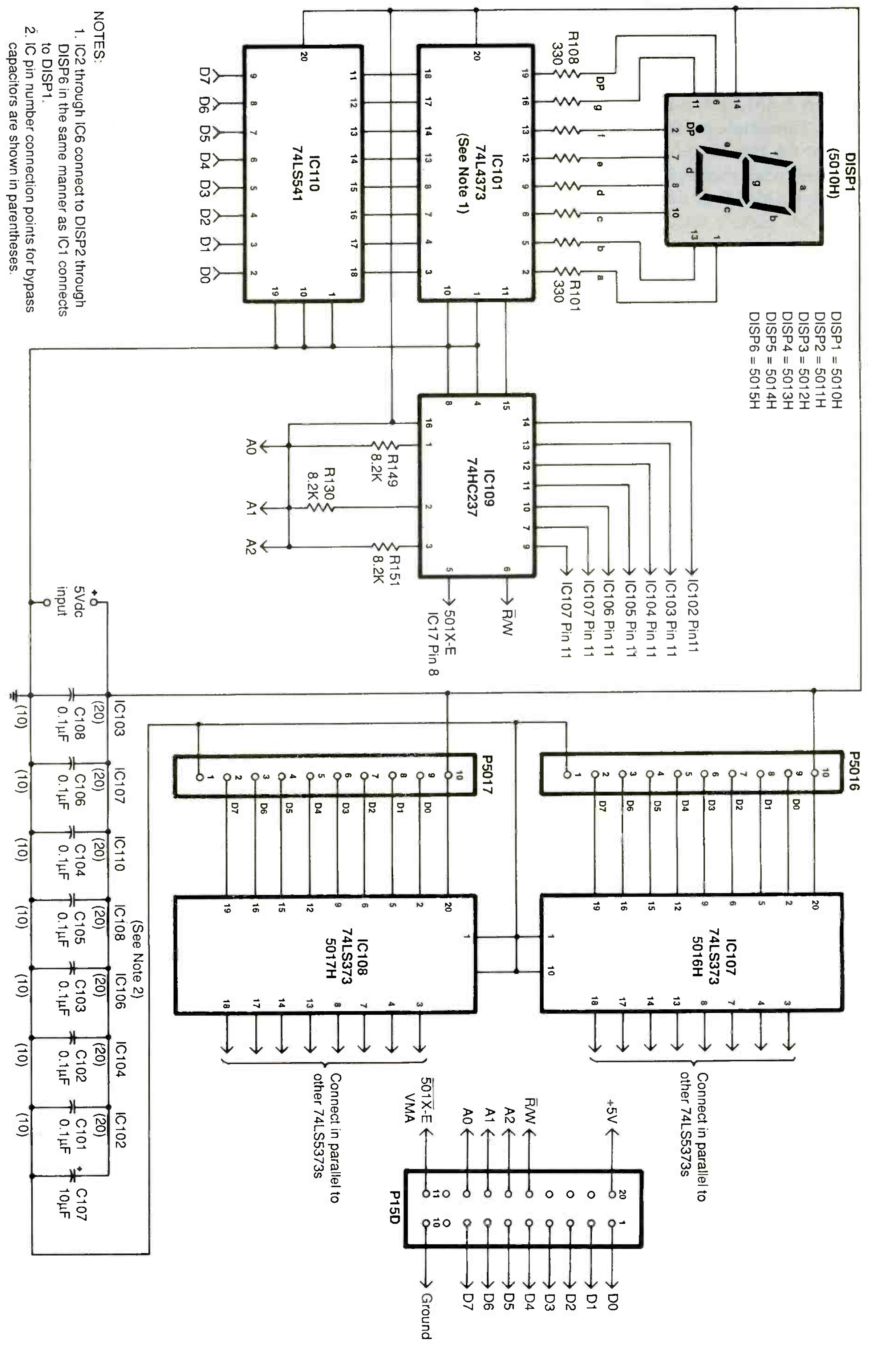


Fig. 2. Complete schematic diagram of display module.

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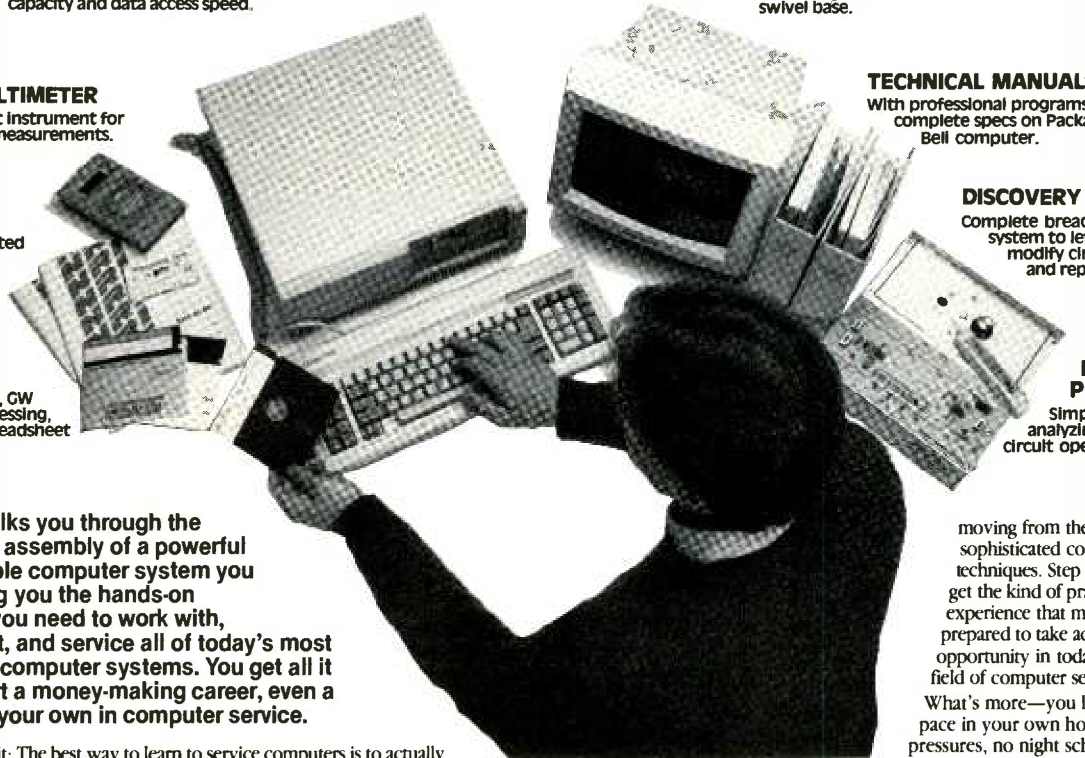

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4-069

PARTS LIST (Display/Output Board)

Semiconductors

IC101 thru IC108—74LS373 octal D flip-flop

IC9—74HC237 3-to-8 line decoder with latches

IC110—74LS541 octal buffer

DISP1 thru DISP6—MAN72A 7-segment LED numeric display

Capacitors

C101 thru C106,C108—0.1-µF, 50-volt monolithic ceramic

C107—10-µF, 25-volt tantalum

Resistors (¼-watt, 5% tolerance)

R101 thru R148—330 ohms

R149,R150,R151—8,200 ohms

Miscellaneous

P15D—20-pin dual-row male header with holes on 0.1-inch spacing (Digi-Key Cat. No. 929836-01-36 or 929665-01-36 or similar)

P5016,P5017—10-pin single-row male header with 0.1-inch spacing (Digi-Key Cat. No. 929834-01-36 or similar)

Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware; sockets for all ICs; 18-inch long, 20-conductor cable terminated in sockets at both ends (Digi-Key Cat. No. R8322-18-ND or similar); hookup wire; solder; etc.

The printer's Request To Send (RTS) line, from RS-232 connector pin 4, connects to pin 1 of *IC6*. Since inverter *IC6A* is between pin 4 of the connector and pin 17 of *IC1*, WISARD stops transmitting serial data when connector pin 4 is low.

For the rain (moisture) sensor shown at the lower-left of Fig. 1(A), a small piece of printed-circuit-board material with narrowly spaced parallel copper traces is used. This simple sensor is a home-made device.

Integrated circuit *IC20* is a special-purpose fluid level detector that eliminates plating problems because of the ac voltage applied to the sensor. Connected as shown, the logic level at pin 18 of *IC1* will be low when the resistance of the moisture sensor drops to less than 35,000 ohms. This resistance drop is normally the result of water coating the copper-trace side of the sensor. Pin 18 of *IC1* is connected to data line D5 of Port 1.

Day LIGHT and SUN light sensors are also connected to the CPU module and are both TIL78 phototransistors. (The temperature sensors used with this project connect to the A/D module that will be described next month.) Sensors *Q1* and *Q2* connect to separate comparators *IC8A* and *IC8B*, respectively.

Trimmer control *R20* in the SUN sensor circuit is set so that output pin 1 of *IC8A* goes low when sunlight falls directly on the sensitive surface of *Q1*. Similarly, trimmer *R25* is set so that output pin 7 of *IC8B* goes low at dawn and high at dusk. The outputs of both converters are passed through inverters *IC16A* and *IC16B* and on to Port 1 at pins 19 and 20 of *IC1*. When the sun is shining, Port 1's most-significant bit (MSB), on data line D7 goes high. Also, when there is sufficient daylight, Port 1's D6 data line is high.

The purpose of ZNRs *R15* and *R16* on the input sides of both light-sensing circuits is to protect WISARD during electrical storms, though their effectiveness has not been conclusively proven. Consequently, if you wish, you can omit these devices from the circuit without affecting normal project performance.

Options switches *S1* through *S4* are all contained inside an eight-pin DIP package and are connected to Port 1. Switches *S1*, *S2*, *S3* and *S4* represent data D0 through D3 inputs to *IC1*. These switches allow you to custom configure WISARD. For example, in the ME1 version of the firmware, *S1* is "off" if the 2716 EPROM in the A/D module is installed, *S2* is "on" if a CPU test is wanted, *S3* is "on" if only Fahrenheit displays are desired, and *S4* is "on" for 4,800-baud and "off" for 600-baud communication rates.

Shown in Fig. 2 is the schematic diagram of the display module's circuitry. As you can see, this module contains six seven-segment MAN-72A numeric displays, identified as *DISP1* through *DISP6*. In this circuit configuration, each segment and the decimal point of each display connects to a separate 74LS373 octal D-type latch that can be "set" or "reset" by instructions from the CPU module. This enables each decade to display 0 through 9 and 17 alphabetic characters.

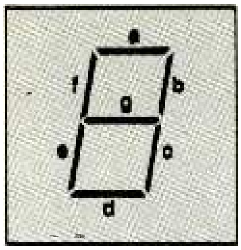
Each 74LS373 latch has a separate address, and the D input of each is connected to a data line. Also, each of these TTL latches can sink sufficient current to directly drive the LED segments in the displays.

Since the MAN72A numeric display features a common-anode arrangement, a LED segment is turned on when its 74LS373 latch output is low. Thus, to light all segments of the display, you "write" 00000000 (0H) at the address of the latch. In 6803 mnemonics, all segments in left-most display *DISP1*, which has an address of 5010H, would light after the following instructions were processed.

```
LDAA #0      ;load accumulator
              A with 0
STAA 5010H ;store 0 at 5010H
```

By storing different data at address 5010H, you can have the display form more than 27 different recognizable numeric and alphabetic characters. For example, the letter "H" can be formed by storing 10001001 (89H) at the appropriate address. If you wish to modify the firmware, refer to Fig. 3, which gives details on addressing displays and forming numerals and letters.

Returning to Fig. 2, note that there are two more 74LS373 latches than there are numeric displays. With this arrangement, there are 16 latches that can be used to control a combination of just about any electrically operated devices you would like.



DATA LINE	SEGMENT
D7	DP
D6	g
D5	f
D4	e
D3	d
D2	c
D1	b
D0	a

SYMBOL	DATA IN HEX
0	C0
1	F9
2	A4
3	B0
4	99
5	92
b	83
7	F8
8	80
9	98
A	88
b	83
c	87
d	A1
E	86
F	8E
6	82
H	89
i	F3
J	E1
L	C7
n	AB
P	8C
r	AF

Fig. 3. Details on addressing displays and forming letters and numbers.

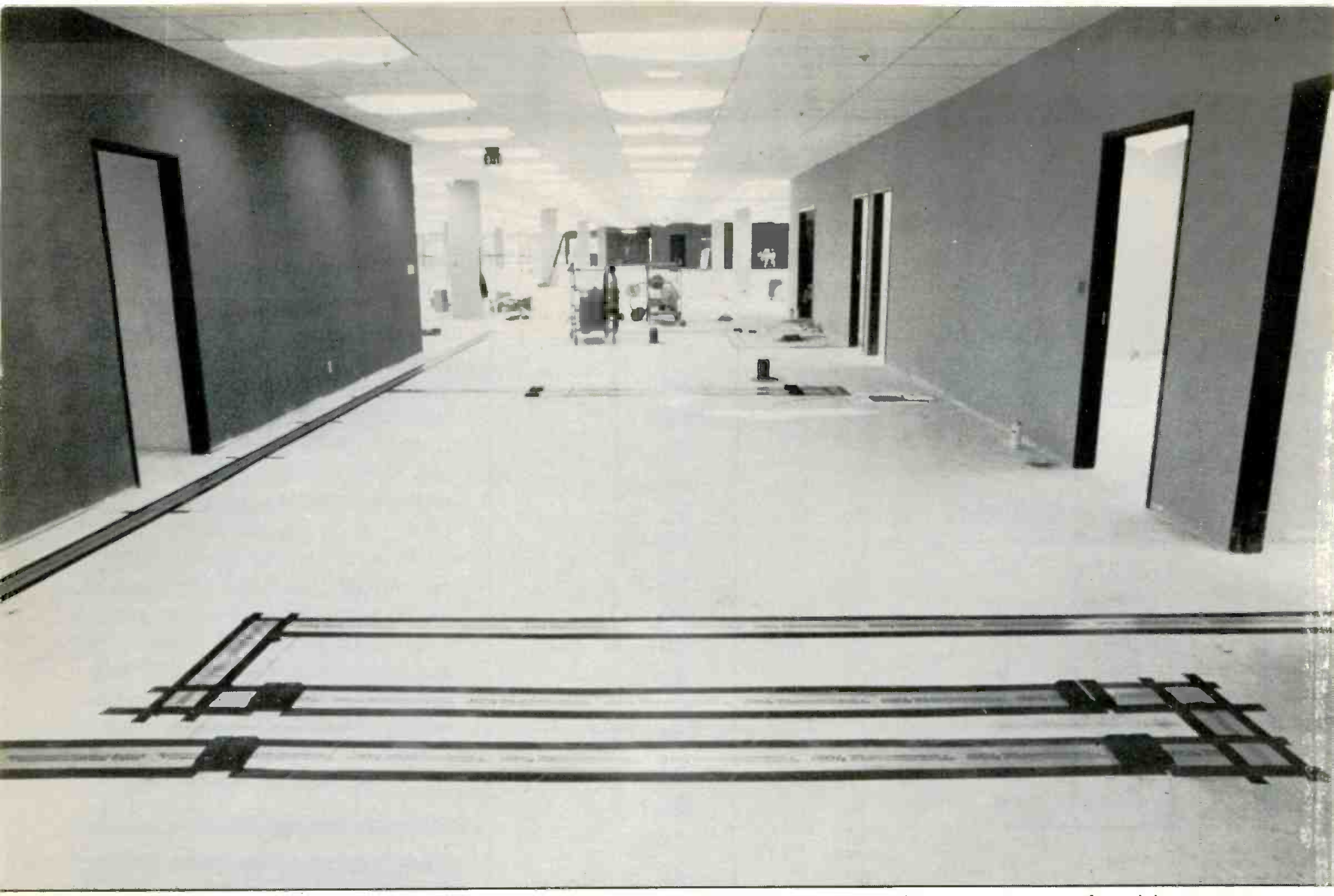
With the addition of an appropriate optical isolator or relay, you can use these latches to control on/off action of heaters, air conditioners, alarms, solenoid-operated valves, and other electrical devices from independent power sources. Part 3 of this article will discuss in detail use of these 16 extra latches.

The purpose of *IC110* in the Fig. 2 circuit is to provide buffering of the data bus from the CPU module. The CPU module provides address decoding at pin 8 of *IC17C* (see Fig. 1). This line is low for all addresses that start with "501" in hexadecimal. For example, a write to or read from addresses 5010H, 50522H . . . 5015H will cause the line from pin 8 of *IC17C* to go low. Finally, *IC109* in Fig. 2 provides final address decoding for each individual latch.

Data connections from the CPU module to the display module are made via data lines D0 through D7 at pins 2 through 9 of *IC110* at the lower-left in Fig. 2. Similarly, pins 1, 2, 3 and 6 of *IC109* connect to address lines A0, A1, A2 and R/W in Fig. 1. Decoding lines from the CPU go to the display module via pins 7, 9, 10, 11, 12, 13 and 14 of *IC109*.

Coming Attractions

This completes the first installment in this series of articles on our Smart Weather Monitor. Next month, we will continue with complete construction details for the CPU and display modules and give fabrication information for the various sensors used with the project. In the subsequent issue, our coverage will include operational details and construction of the two remaining modules—an A/D (analog-to-digital converter) and memory-expansion board and the input keyboard. A final installment will deal with physical placement of the various sensors used with the project and how to use WISARD.



Under-carpet wiring provides uncluttered aesthetics and eases the task of making revisions to the wiring system when required in future.

Under-Carpet Fiber Optics

Simplifies routing of lines to carry power, voice signals and data signals throughout an office or building

By Terry Bowen & Jim Kevern*

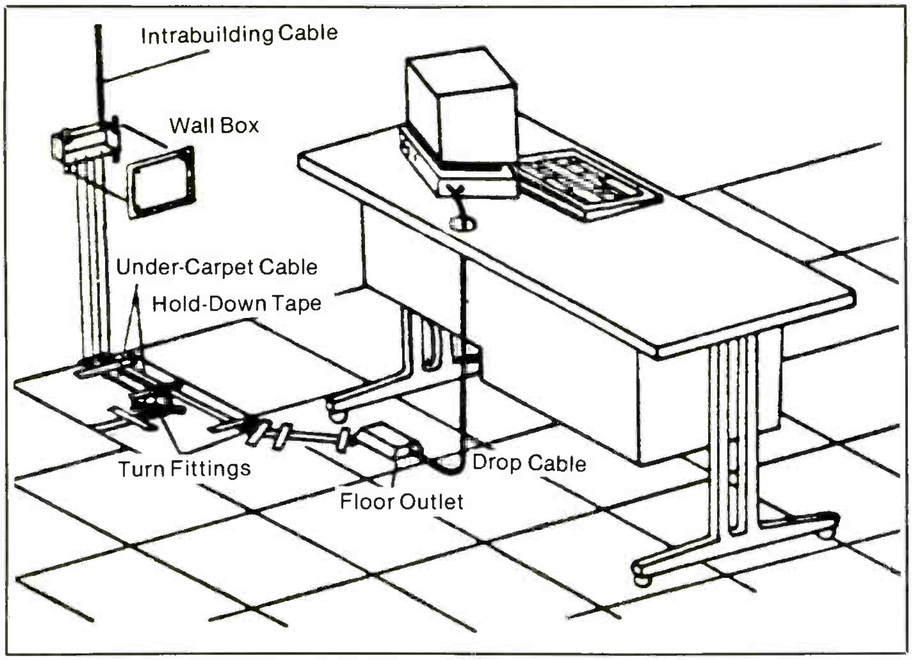
Under-carpet cable, which carry power, voice and data, are being selected with increasing frequency in today's building designs. For wiring an open office, the most common type of under-carpet cable, coaxial copper, is being challenged now by super-thin fiber-optic cable. An under-carpet version becomes an important ingredient in a total system solution, as the use of optical fibers for premise wiring increases. It offers high performance and durability. For example, optical fibers offer greater bandwidth than copper cables. Moreover, its dielectric properties provide better security of sensitive computer data and immunity to error-causing noise. To properly plan an under-carpet system, one must evaluate cost and performance requirements, comparing copper versus fiber optics.

*AMP Inc., Harrisburg, PA

Copper Cable Overview

Copper cable varies according to the application:

- *For Power:* cable is available in 3-, 4- and 5-conductor flat versions in 10 and 12 gauge.
- *For Telephone:* cable is available in 2-, 3-, 4- and 25-pair versions in 26 gauge.
- *For Data Communication:* cable is available in 26- and 28-gauge paired versions, 25-conductor versions, and 50-, 75- and 93-ohm coaxial versions.



A typical optical-fiber cable application.

There are three important issues when considering copper cable versus optical fibers:

• *Signal Radiation & Confinement:* Copper cables radiate and collect electromagnetic energy. To maintain shield effectiveness, cables should use single or double braids, or triaxial construction. Optical fibers, in contrast, convey energy by propagation in a dielectric, rather than a conductor, the latter causing radiation of energy at high frequencies.

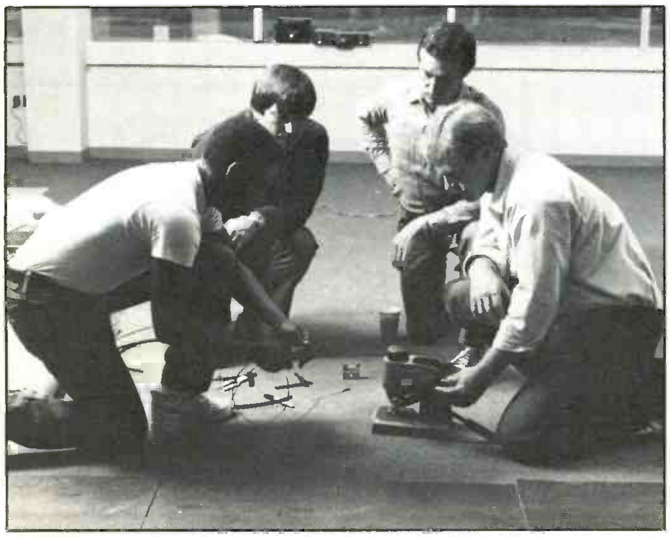
• *High Attenuation at HF:* In copper cable, attenuation is related to signal frequency. Transmission distance is primarily limited by frequency-dependent attenuation. Higher frequencies have greater attenuation per unit length and shorter useful transmission distances. In comparison, attenuation in an optical fiber is unrelated to signal frequency (slight receiver sensitivity degradation does occur in high-frequency, long-length links, though).

• *Limited Bandwidth:* Optical fibers have greater bandwidths than most copper cables.

Fiber-Optic Choices

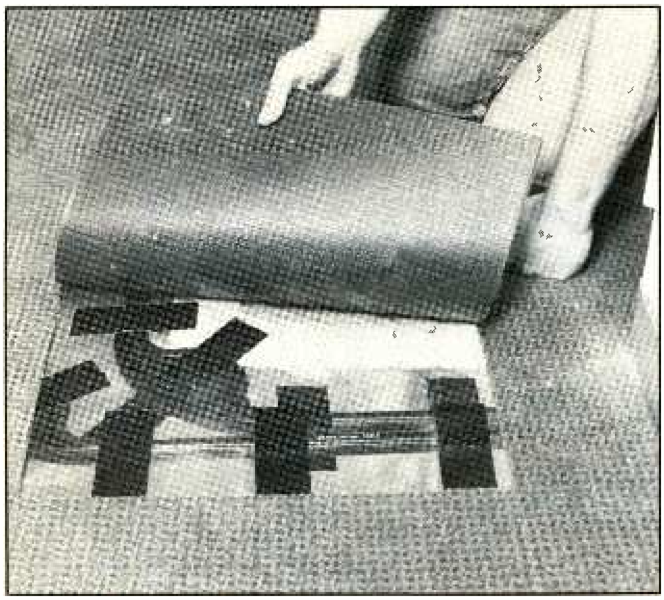
Various cable designs that an engineer has to choose from when routing a fiber cable to a specific building location include plenum and non-plenum multiple-fiber, duplex and single-fiber designs. A given installation may involve several different cable constructions. Since cable runs under carpets, in walls, raceways, conduits and air plenums, each has specific requirements.

One specific under-carpet fiber-

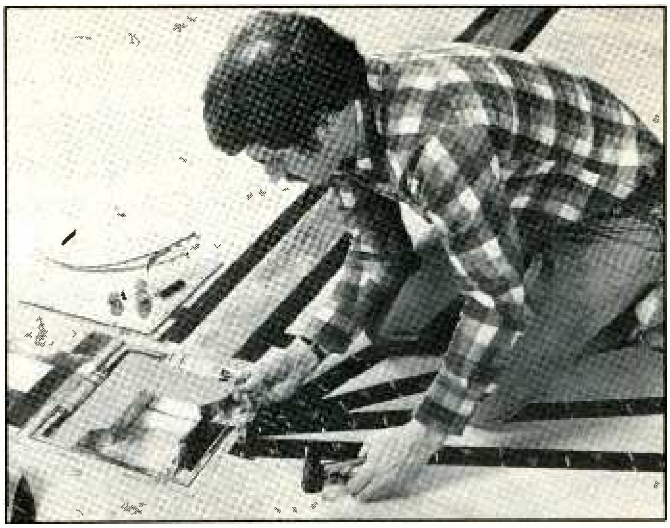


Special tools help simplify installation of fiber-optic cable. When small slitting block is pulled lengthwise over cable, strength members and ramp material are precisely separated from the jacketed optical fibers. A blanking tool is then used to square off the end of the optical fiber.

Carpet tiles, which completely conceal flat fiber-optic wiring, are usually held down with release-type adhesive to permit easy removal if outlets or wiring require rearranging. Fiber-optic cable does not require any special shielding or other protection.



Turn fittings are positioned for 45- or 90-degree turns in small areas.



Technicians make a transition splice between a flat optical cable and a round optical cable in recessed floor junction box. The blanking tool, shown, provides a clean, precise square-off end of the optical fiber.

optic cable features a two-channel cable that has two optical fibers and three strength members. A polyester elastomer material covers the fibers to protect the glass from abrasion. The strength members are a proprietary fiber-reinforced plastic with good crush and impact resistance.

All the elements are enclosed in a tough flame-retardant polyvinylchloride jacket. The cable has a low profile (0.075 inch high) for installation under carpet or tile without causing a bulge. The fiber-optic cable withstands harsh mechanical and chemical exposures that could destroy flat copper data transmission cable.

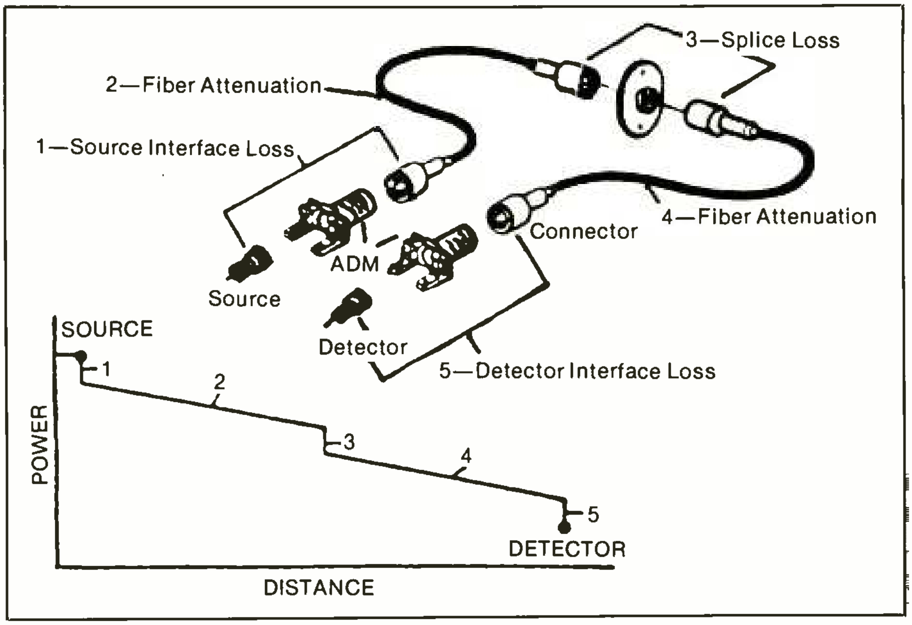
Installation

When routing duplex fiber-optic cable, stress may be induced on fibers if the cable is bent severely. At corners, the inner fiber must, therefore, take a shorter path than the outer fiber.

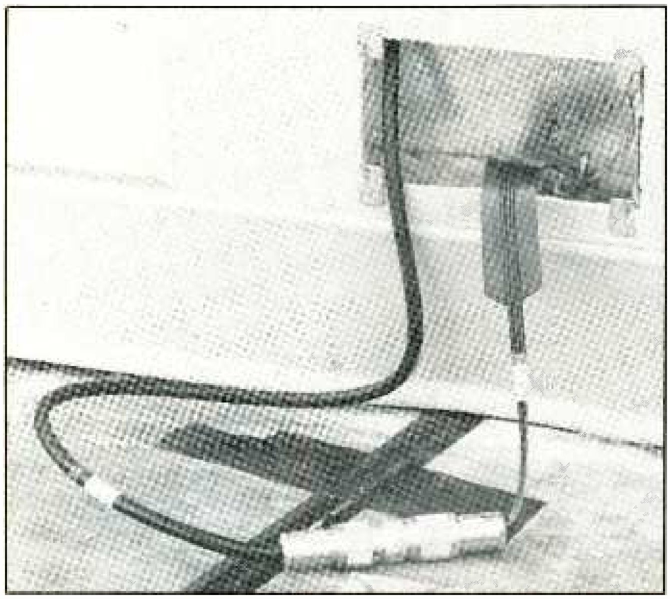
One way to attempt to alleviate stress is to gradually turn the cable, rather than directly bend it. In most office areas, however, gradual turning is impractical because of space limitations. Also, a difference in path length of two fibers still occurs, even if the curve is gradual.

The length of each fiber can be matched if they are first removed from the cable, then laid in different paths, and finally encased in turn fittings. Tracks in 45- and 90-degree turn fittings are designed to provide equal lengths and optimum radii.

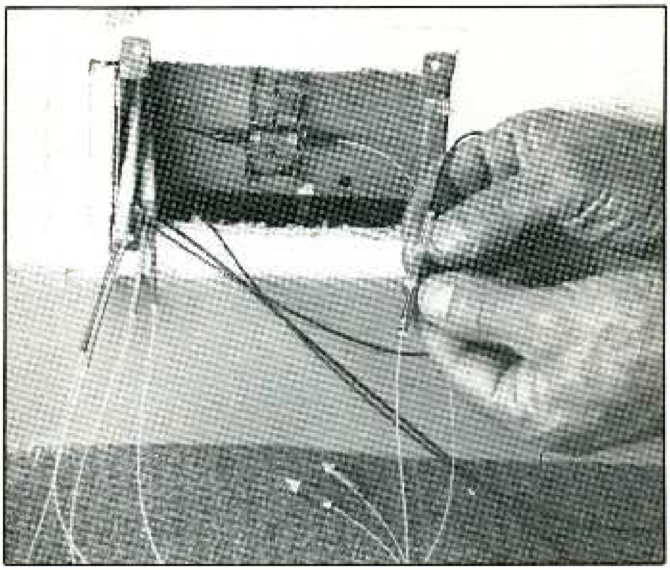
Such turn fittings replace the cable's strength members and side ramps, while providing crush resistance and low profile. By using various combinations of turn fittings, complex cable routes easily can be achieved. It is important to properly prepare the floor before laying the cable under the carpet. Three basic steps should be taken:



Sources of loss in a fiber-optic link.



Transitions between conventional and under-carpet cables are behind cover plates on an interior wall.



Round fiber-optic feed wiring is connected to flat under-carpet cable at wall transition box with disconnectable fiber-optic splices.

(1) All holes or imperfections in the concrete slabs should be filled and all bumps removed;

(2) Porous floors should be sealed and free of grease, oil and moisture;

(3) Floors should be thoroughly cleaned and vacuumed.

System Loss Budgeting

Any fiber-optic cable application requires a loss budget analysis of the system. This analysis quantifies losses throughout the system and power available at the receiver.

To minimize loss, all cables in a building should have the same core and cladding diameter. Total system loss can then be generalized as the sum of the individual losses: SLB (in dB) = L1 + L2 + L3 . . . Ln.

A fiber-optic link must deliver enough of the transmitter power to operate a receiver within system specifications. To provide a wide margin for future re-arrangement and component degradation, losses throughout the system should be minimized.

The main sources of loss in a link are: *Fiber Attenuation; Fiber-to-Fiber Connections*, including numerical aperture (NA) mismatches, core diameter mismatches, connector insertion loss, intrinsic fiber mismatch; and *Loss Margins*, to account for source aging, temperature variations, and loss from bends and mechanical stress.

Loss at connectors is caused by several different factors, including intrinsic fiber mismatch and connector misalignment.

Optical fiber attenuation in an under-carpet system can be viewed as proportional with length. If the cable is specified to have an attenuation of less than 6 decibels per kilometer (dB/km), a 50-meter cable run has only 0.3 dB of loss. For systems with LED (light-emitting diode) sources,

Table 1. Power Budget Analysis

Transmitter Launch Power*	– 15 dBm
Receiver Sensitivity	– 28 dBm
Total Power Budget	13 dB
Power Allocation Example	
System Margin	
(A) LED Aging	1 dB
(B) Temperature Effects	1 dB
(C) Other Factors	1 dB
Total Margin	3 dB
Available Power	10 dB
Cable Loss	
(A) (Attenuation 1 km at 4.5 dB/km)	4.5 dB
(B) Transient Loss:	0.5 dB
Connector Loss (4 connectors at 1.0 dB)	4.0 dB
Installation & Repair Splice Loss (4 splices at 0.25 dB)	1.0 dB
Total Loss	10 dB

*Power specified by equipment manufacturer for size of fiber being used.

Table 2. Under-Carpet Cable Specifications

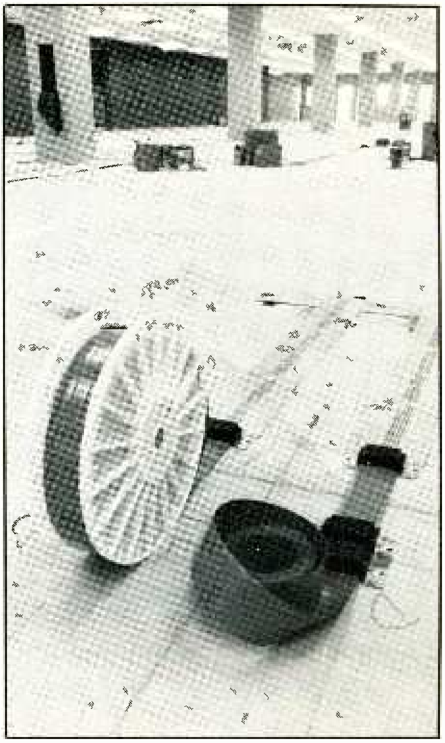
Fiber (μm)	Attenuation (dB/km) 850 nm	Attenuation (dB/km) 1,300 nm	Bandwidth (MHz-km) 850 nm	Bandwidth (MHz-km) 1,300 nm	NA
50/125	< 5	< 3.5	> 400	> 400	0.215/0.185
63/125	< 6	< 4.5	> 100	> 200	0.305/0.275
85/125	< 6	< 4.5	> 100	> 200	0.275/0.245
100/140	< 7	< 6.0	> 100	> 100	0.305/0.275
485/500	< 300 at 650 nm		> 0.5 at 450 nm		0.50/0.44

(Columns 2–5 are grouped under "Optical Characteristics".)

Mechanical Characteristics

Operating Temperature Range	0° to 50° C
Storage Temperature Range	− 120° to + 60° C
Minimum Bend Radius	1.5 inch
Maximum Tensile Loading	22.5 pounds
Flammability	Passes UL B3

*Plastic fiber



A newly completed tilt-up building requires an under-slab membrane to prevent methane gas seepage from entering the building. Opting for under-carpet wiring systems avoids the possibility of disturbing the building's protective barrier.

an additional one-time penalty of 0.5 to 1.0 dB is allowed for transient loss. This loss is due to high-order modes launched by LEDs, which are not efficiently carried by the fibers.

The obvious best approach is to use the same fiber diameter throughout an installation. However, this is not always possible. Telephone fibers entering a building may be 50/125 μm, while equipment such as computers and terminals may be designed for 100/140 μm cable.

Also, the direction of light transmission may not be known by the cable installer, and losses may not be the same in both directions. Signals moving in one direction may go from smaller to larger fibers, meaning no diameter or NA mismatch loss. Signals moving in the opposite direction *are* affected by these losses.

A loss margin must be allowed for performance change over time and temperature extremes, as well as for loss due to mechanical stress and bends. An allowance of 1 to 3 dB for LED aging and 2 dB for temperature variations and allowance for stress and bends is common.

Also, analysis must consider source type (laser diode or LED), emission characteristics like diameter and NA, output power, and operating wavelength (fiber attenuation is lower at 1,300 nm than at 850 nm, for example). The source manufacturer will usually provide information on the power coupled into the fiber.

Given the amount of power coupled into the fiber, the system loss budget analysis shows how much power remains to operate the receiver. Sufficient power must reach the detector to maintain the desired bit error rate (BER).

On the other hand, too much power will saturate the receiver. Therefore, received power must lie within the dynamic range of the receiver. Saturation can be prevented by introducing additional attenuation into the system, of course.

Conclusion

A power budget analysis can be performed by developing a worksheet. The example provided in Table 1 is for electric power.

The worksheet includes information on the sensitivity of the receiver and the power launched by the transmitter. Next, system power is allocated to the various components that make up the system.

The number of ways one might configure a system is countless. Each configuration will be determined by the particular building layout. The use of the Power Budget Analysis Worksheet will ensure that power allocated falls within the total power budget available.

In sum, then, under-carpet fiber-optic cable provides a convenient and flexible way to obtain the benefits of optical communications in an office environment, where it is desirable to install hidden wiring that can better withstand mechanical stress and chemical exposure to assure the integrity of data communication.

PC Clock/Calendar Card

Short-slot board gives IBM PC, XT and compatible computer users battery-backed day/date functions

By Vaughn D. Martin

In its basic configuration, the popular IBM PC and XT and compatible computer has no functions for automatic time and date keeping. The circuit to be described here gives these computers those functions at a very reasonable kit cost of just $20 including software on disk. The board plugs into a short slot on the computer's bus and is nonvolatile (it has battery backup power). It also provides a cheerful "beep" and greeting message when you turn on your computer on selected holidays.

About the Circuit

Shown in Fig. 1 is a block diagram of the elements that make up the National Semiconductor MM58167A clock/calendar chip around which this project is built. This chip runs on very low power; thus, a 3-volt lithium battery can run the project's circuitry for more than a year when the computer is turned off.

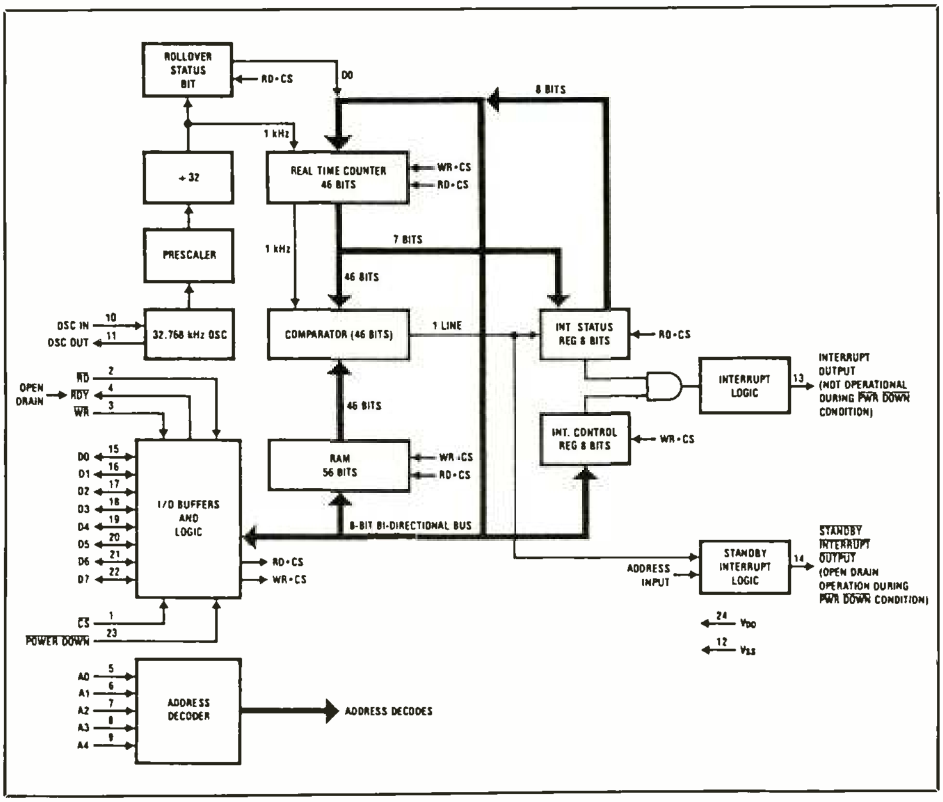


Fig. 1. Block diagram of internal details of National Semiconductor MM58167A clock/calendar chip around which this project is built.

As you can see in Fig. 1, the MM58167A clock/calendar chip consists of eight major sections. The oscillator section has an inverter that is on-chip and works in concert with several off-chip components. The two capacitors, one resistor and 32.768-kHz miniature crystal (featured in most digital wristwatches) make up a classical Pierce parallel-resonant arrangement. The prescaler divides the 32.768-kHz oscillator signal down to 1 kHz. The timekeeping counters consist of a 14-stage BCD counter, each stage of which has a read/write capability in a 24-hour international format. A read-only rollover status bit informs the user that invalid data may have been read.

The random-access memory (RAM) section is provided with 14 nibbles, or "half-bytes" (four bits), for alarm interrupts and general storage. This project uses the RAM section for general storage (see the Table for the RAM memory map).

The comparator is a 46-bit device that compares values stored in RAM against the counters and provides an alarm (compare) interrupt. However, in our project this feature is not used because the RAM section is utilized here only for general storage purposes.

Two interrupt outputs—the main and standby interrupts—make up the interrupt hardware.

The Input/Output and Control Lines are the most vital section of this versatile integrated circuit. The basic I/O structure consists of a five-bit address bus and an eight-bit bidirectional bus. The control lines are chip select, power down, read and write. An additional output line accommo-

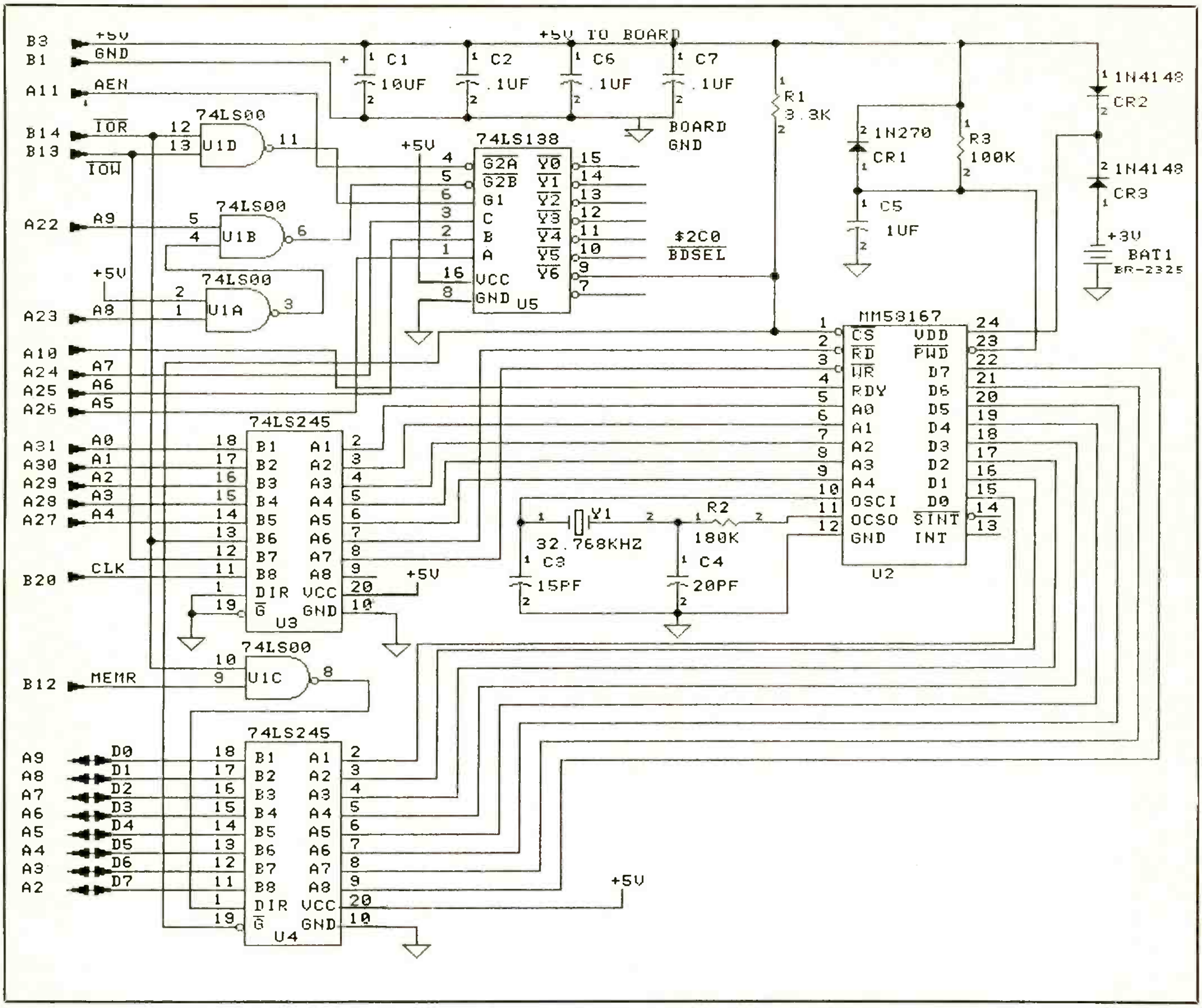


Fig. 2. Complete schematic diagram of PC Clock/Calendar Card's circuitry.

dates microprocessors that have a wait state.

Several registers are included in this IC. The lowest address register is where thousandths of a second are read, followed by minutes, hours, and so on. There are also latches for comparisons to the clock registers, which keep track of the year. Since the alarm feature is not used in this project, these latch locations are used as ordinary RAM—always retaining memory because of the battery that provides standby power.

You read time by reading the appropriate registers. Each time a register is read, the status bit is also read. This bit tells you if any of the time counters have changed during the read operation.

Shown in Fig. 2 is the complete schematic diagram of the PC Clock/Calendar Card's circuitry. Address decoders *U1* and *U5* generate an active-low board-select signal at pin 5 of the latter chip. Addresses 20C through 2DF (all addresses are given in hexadecimal) drive the board select low. Integrated circuit *U3* and *U4* are an address-line and clock buffer and a bidirectional data buffer, respectively. The latter selects the board-select line from pin 9 of *U5* Using a combination of the "memory read" (MEMRD) and "read" (active-low IOR) at pins B12 and B14 of the board's edge connector, *U1C* controls the direction of data flow on the bidirectional A2 through A9/D0 through D7 bus at the lower-left of the schematic.

Lithium battery *B1* conducts through diode *CR3* to power the clock circuit in the battery backup mode when the computer is powered

MM58167A RAM Memory Map		
Hex Address	**D7 D6 D5 D4**	**D3 D2 D1 DO**
8	milliseconds	no RAM exists
9	tenths of seconds	hundredths of seconds
A	tens of seconds	units of seconds
B	tens of minutes	units of minutes
C	tens of hours	units of hours
D	no RAM exists	day of week
E	tens days of months	units days of month
F	tens of months	units of months

PARTS LIST

Semiconductors
CR1—1N270 or similar small-signal germanium diode
CR2,CR3—1N4148 or similar small-signal silicon diode
U1—74LS00 TTL quad NAND gate
U2—MM58165A (National) microprocessor real-time clock/calendar
U3,U4—74LS254 TTL bi-directional line driver
U5—74LS138 TTL expandable 3-of-8 decoder
Capacitors
C1—10-μF, 16-volt tantalum
C2,C5,C6,C7—0.1-μF, 25-volt ceramic disc
C3—10-pF NPO ceramic
C4—22-pF NPO ceramic
Resistors (¼-watt, 5% tolerance)
R1—3,300 ohms
R2—180,000 ohms
R3—100,000 ohms
Miscellaneous
BAT1—3-volt coin-type lithium battery (Panasonic Part No. BR-2325-BH or Digi-Key Cat. No. P142)
Y1—32.768-kHz quartz crystal (Digi-Key Cat. No. X32768)
Printed-circuit card or PC-type perforated prototyping card and suitable Wire Wrap Hardware (see text); holder for BAT1 (Digi-Key Cat. No. BH906-ND); sockets for ICs (optional); solder; etc.

Note: The following items are available from Specialty Electronics Services, Inc., P.O. Box 680712, San Antonio, TX 78268-0712: Complete kit of components, including software on diskette, $19.95. Also available separately, pc card, $9; program disk, $5; and assembled and tested clock/calendar card, $29.

down. Diode *CR2* prevents battery current from flowing back into the computer's power supply.

The network made up of *CR1*, *R3* and *C5* ensures that the clock chip's correct power-up/down sequence is done in proper order. "Power Down" (active-low PWD) line pin 23 of clock chip *U2* must be held low long enough so that all other lines become stable. A germanium diode was selected for *CR1* for its lower (than silicon diode) voltage drop. This network further ensures that voltage is supplied to pin 23 of *U2* slowly at power-up and is removed quickly on power-down.

Construction

This PC Clock/Calendar Card project was designed to wire together on a double-sided printed-circuit board to assure stable, long operating life. If you wish, however, you can use a plug-in PC-type prototyping card and suitable Wire Wrap hardware. Whichever way you go, though, it is a good idea to use sockets for the DIP ICs to make it easy for you to replace a defective integrated circuit in the event one expires at any time.

You can fabricate your own pc board using the actual-size etching-and-drilling guides shown in Fig. 3, or you can purchase a ready-to-wire board from the source given in the Note at the end of the Parts List.

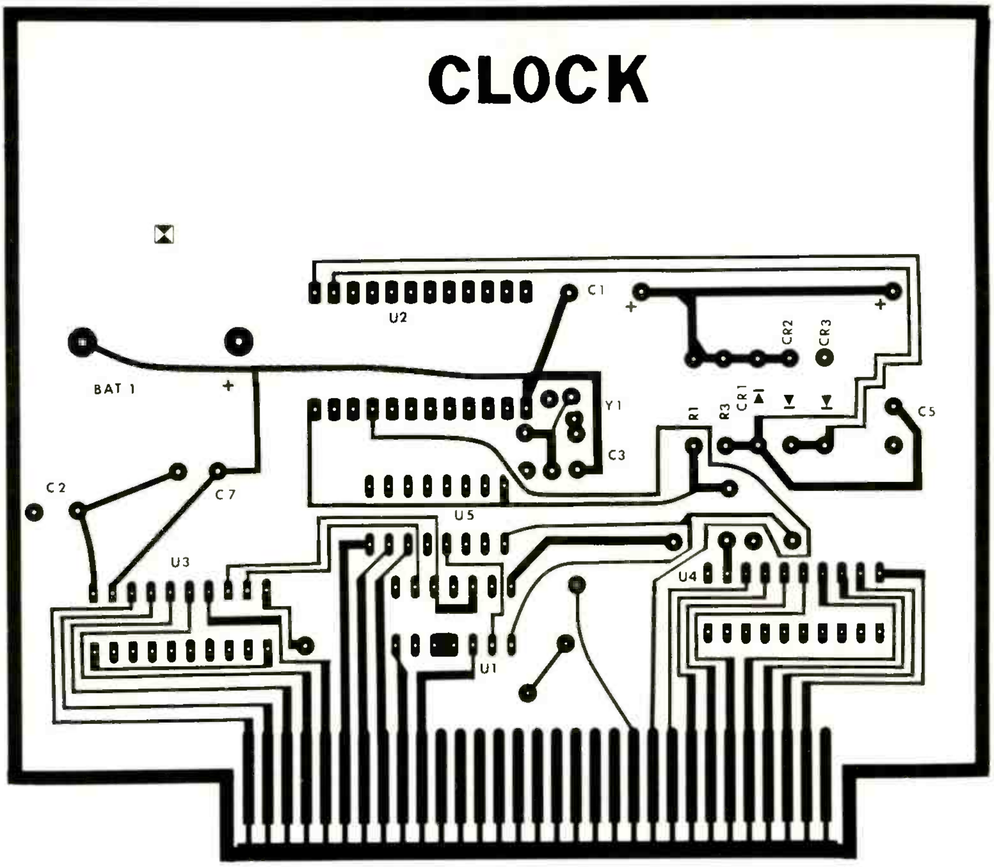
Wire the board exactly as shown in Fig. 4. (Note: Use Fig. 4 as a rough guide to component placement if you opt for point-to-point wiring on a prototyping board.) Start populating the board by installing and soldering into place the IC sockets. If you are using a home-fabricated board that does not have plated-through holes, use Molex Soldercons instead of sockets to give you soldering access to the pads on *both* sides of the board.

With the sockets installed, proceed to installation of the resistors and then the diodes, making sure that the latter are properly oriented before soldering their leads to the pads on both sides of the board. Then install and solder into place the capacitor, making sure the electrolytic ones are properly oriented before soldering their leads into place.

Next, install and solder into place crystal *Y1*. Use heat judiciously to avoid damaging the crystal. Finish up by installing and soldering into place the battery holder in the indicated location.

With the card assembly wired, carefully examine your work. Make sure that each component is in its correct location and is properly oriented. Check all soldered connections. Look for unsoldered and poorly soldered connections. Solder any connection you missed and reflow the solder on any suspicious connection. Also check for solder bridges, especially between the closely spaced IC pads. If you find a solder bridge, use wicking-type desoldering braid or a vacuum-type desoldering tool to remove it.

When you are sure all components have been properly installed (except the ICs in their respective sockets), clip one lead of an audible continuity tester or the common lead of an ohmmeter set to a low-ohms range to +5V pin B3 of the board's edge-connector



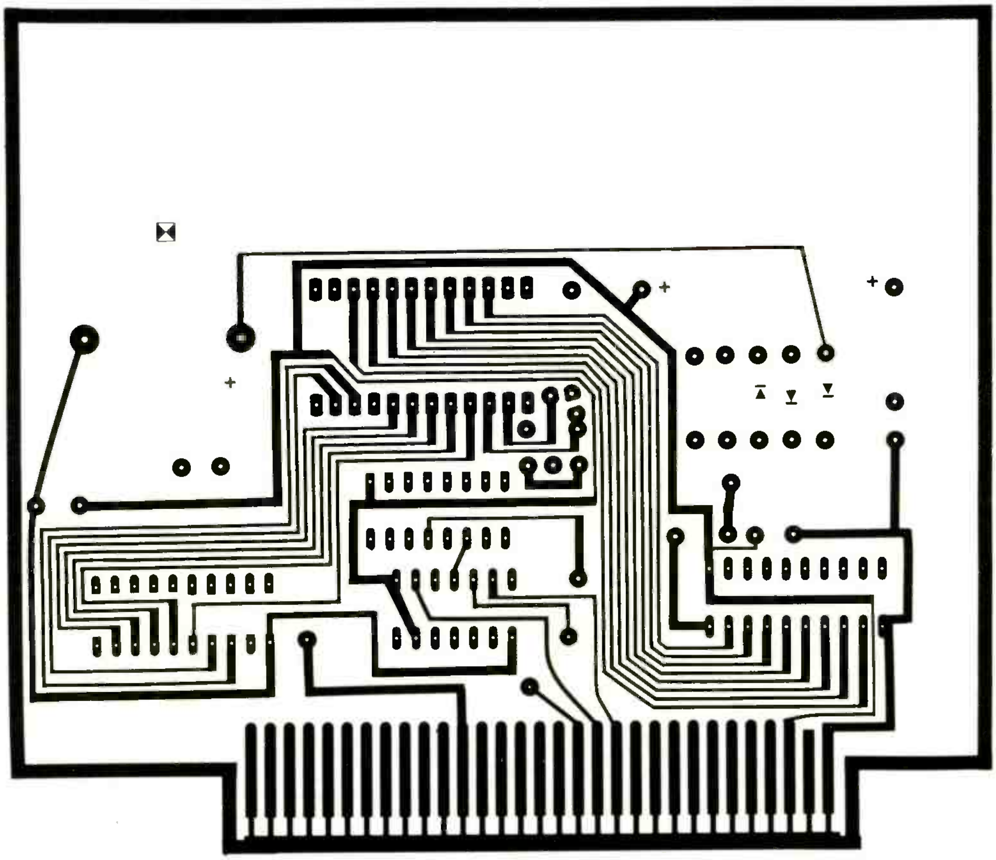


Fig. 3. Actual-size top (A) and bottom (B) etching-and-drilling guides for home fabrication of double-sided printed-circuit card on which project is to be wired.

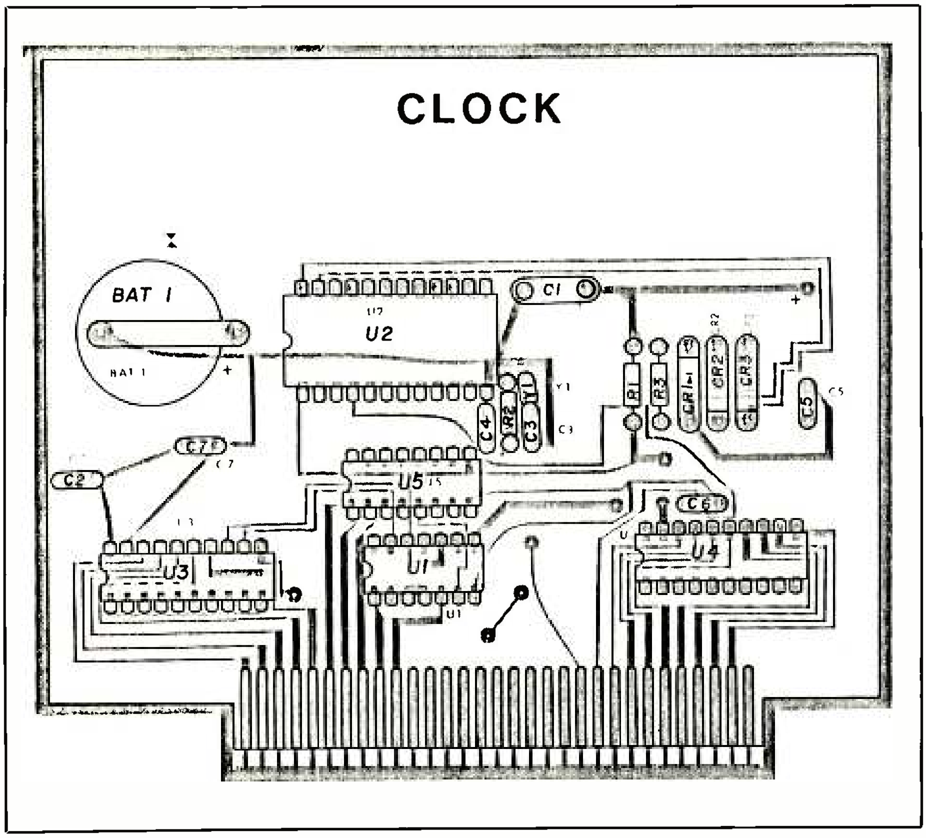


Fig. 4. Wiring guide for pc card. Use this as a rough guide to wiring circuit on perforated prototyping board (see text).

Battery holder and coin-like lithium battery used as backup power for PC Clock/Calendar Card.

finger. Then probe pin 14 of the *IC1* socket, pin 24 of the *IC2* socket, pin 20 of the *IC3* and *IC4* sockets and pin 16 of the *IC5* socket. In all cases, you should obtain an audible indication of continuity or a reading of 0 ohm. If not, rectify the problem before proceeding to installation of the ICs in the sockets.

When you are certain that all is well, install the ICs in their respective sockets. Make certain each goes into the proper socket in the correct orientation and that no pins overhang the sockets or fold under between the ICs and sockets. Also, exercise the usual safe-handling techniques for MOS-type devices when installing clock chip *U2*. Your PC Clock/Calendar Card is now ready to be installed in your computer.

If you have not already done so, turn off your computer. Open its case and install the card in a free short slot. Make sure you install the card in the proper direction and that it is seated all the way in the computer's bus connector before closing the case. Do *not* power up your computer just yet. Do so only after reading through the following section on Software Operations.

Software Operations

Shown in Fig.s 5 and 6 are a pair of flow charts that outline the two programs required for interfacing the PC Clock/Calendar card to your computer. The CLOCKSET program (Fig. 5) initially sets the clock when you first install the card in your computer and later when a time change has occurred when you change the battery or when you adjust for Daylight Savings or Standard times. This program prompts you to key in the date. It also checks for valid date entry. If you enter an invalid date, an INVALID DATE message will appear on the screen of your computer's video display monitor and you will again be prompted to key in the proper date. Once you key in a valid date, the program asks you to key in the current time.

After you enter the correct time, the CLOCKSET program checks its validity. If an invalid time was entered, an INVALID TIME will be displayed on-screen and you will be prompted to to reenter the time. Upon valid entry, the program goes into a loop to consecutively set the valid time and date into the appropriate battery clock registers. The program loops until all required registers are set. It then makes an orderly exit to the operating system.

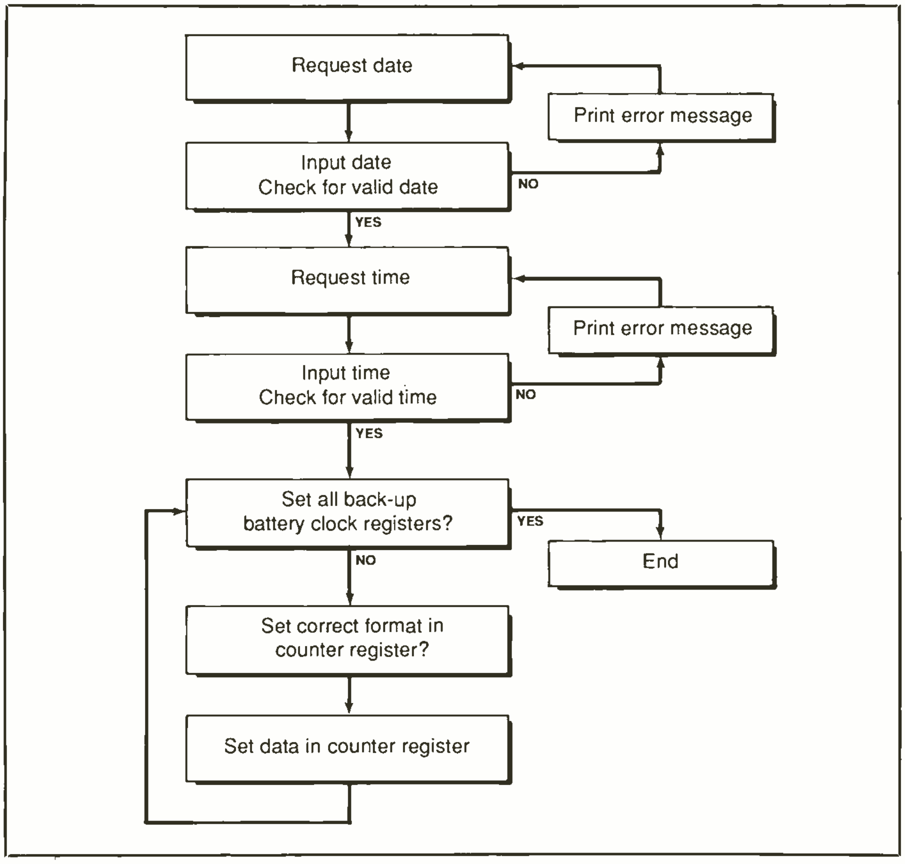


Fig. 5. Flowchart for CLOCKSET program needed to interface project to your computer.

The READCLOCK program (Fig. 6) reads all the registers from the battery backed up clock/calendar IC and then reads the status register to determine if the clock changed during the read operation. If a change is detected, the registers are read again until the status register indicates that the clock did not change. The date and time are first checked to determine if a valid date was read from the clock/calendar. If the time or date was not valid, an appropriate error message is displayed on-screen. At this point, it displays the message, "a default time and date are to be used." A default of January 1, 1986 is used in lieu of the familiar January 1, 1980 used by IBM.

If the time and date are valid, the program begins to check for special dates, such as New Year's Day, Valentines Day, Independence Day and Christmas. If it detects one of these dates, the program displays an appropriate message, such as "Happy New Year," on the screen and reads the time and date from the clock/calendar chip. If no special date is detected, the program only displays time and date.

The READCLOCK program uses the time and date read from the clock chip (or a default time and date) to set the internal time and date on the computer. The program then returns to the operating system.

Both programs are available on 5¼-inch floppy disk from the source given in the Note at the end of the Part List. ME

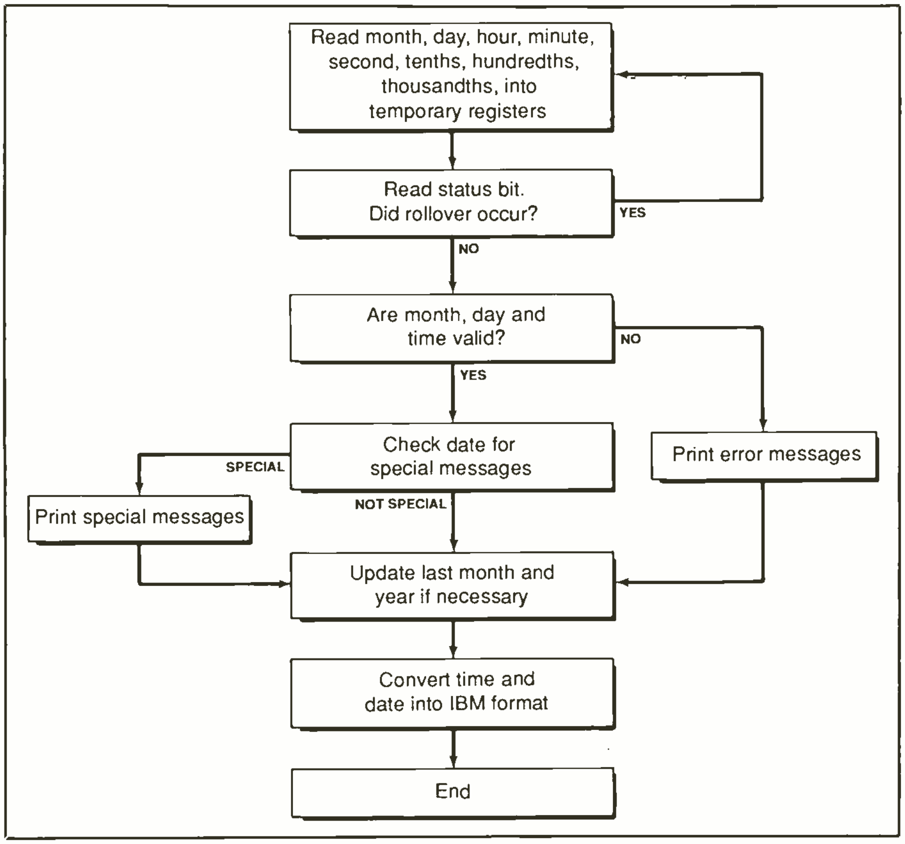
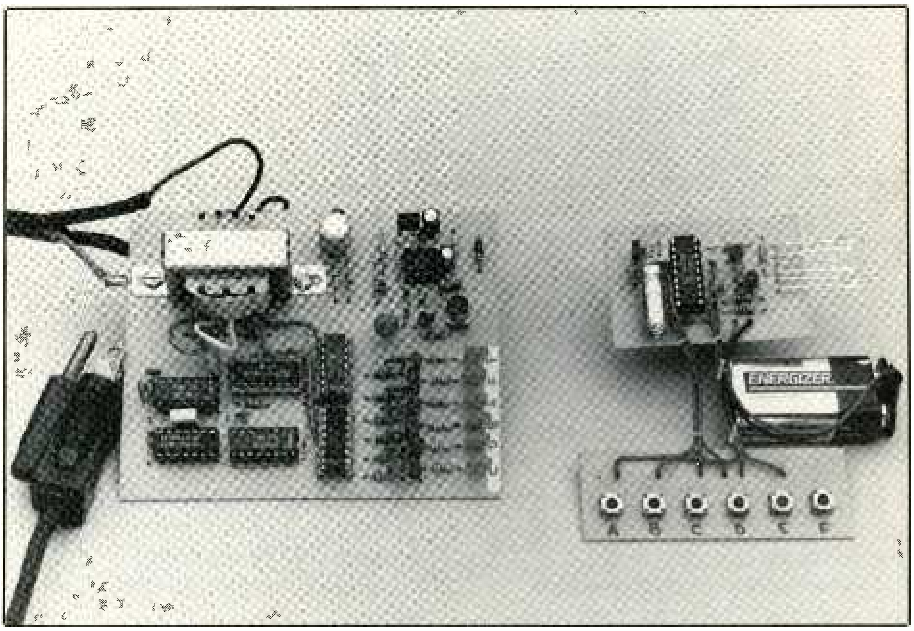


Fig. 6. Flowchart for READCLOCK program that displays time and date information on-screen and greetings for selected holidays (see text).

An IR Remote-Control System
(Part 1)

Lets you remotely control up to six lights and appliances from a single hand-held transmitter

By Anthony J. Caristi



Readers who own a remote-controlled TV receiver, VCR or audio system are familiar with the convenience of using wireless infrared remote-control systems. If you've ever wished you could put this type of convenience to work controlling other devices as well, the project to be described is for you. It's a basic IR system that provides on/off control of up to six electrically operated lights and appliances in a single room from a reasonable distance away using a hand-held battery-powered portable transmitter, an ac-powered stationary receiver/decoder and suitable "interface" modules between the latter and devices you wish to control.

The basic system is limited to six channels of control in any given room. However, it can easily be expanded to control up to six devices in as many rooms as you wish from a single transmitter unit. To accomplish this, all you need do is build another receiver/decoder for each room in which you want control, plus whatever interfaces are needed.

In this installment, we focus on operation and construction details for the transmitter and receiver/decoder units. Next month, we will detail how to build a variety of interface devices to control just about any electrically-operated item you wish.

About the Circuit

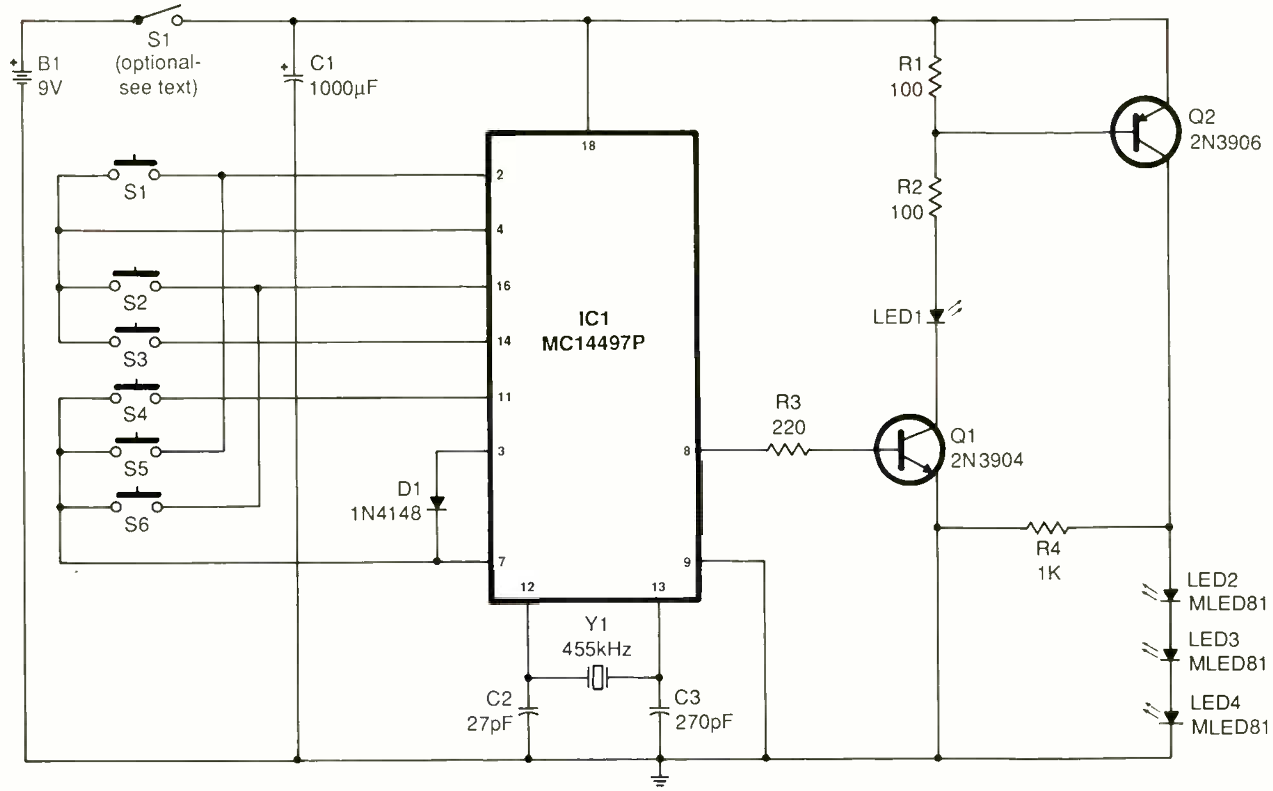
To avoid confusion, we'll discuss operation of the transmitter and receiver/decoder circuits separately.

• *Transmitter.* Shown in Fig. 1 is the complete schematic diagram of the transmitter circuit. This one-chip circuit is powered by an ordinary 9-volt transistor battery. It provides a series of 28.4-kHz infrared energy pulses that are encoded according to which of the six pushbutton switches is pressed at any given moment.

When no transmitting switch is activated, the circuit remains in standby, drawing virtually no current from battery *B1*. When any one of switches *S1* through *S6* is pressed, its closed contacts activate circuitry inside *IC1* that causes the transmitter to generate a group of pulses that are sent through the air by infrared-emitting diodes *LED1*, *LED2* and *LED3*. These pulses are repeated at 90-millisecond intervals, as long as the particular switch is held closed.

Designed specifically as a PCM (pulse code modulation) transmitter, *IC1* is capable of encoding up to 62 channels in accordance with the selection of one row input terminal and one scanner input terminal, which are shorted together by means of a single-pole switch. As mentioned above, in this project only six channels are used, specifically channels 2, 4, 6, 8, 10 and 12. These are identified in this project as channels A through F, respectively.

Integrated circuit *IC1* is capable of operating in either FSK (frequency shift keying) or AM (amplitude mod-



PARTS LIST (Transmitter)

Semiconductors
D1—1N4148 or similar silicon diode
IC1—MC14497P remote-control transmitter
LED1—2-volt, 20-mA red visible light-emitting diode
LED2,LED3,LED4—MLED81 or equivalent infrared light-emitting diode
Q1—2N3904 or similar npn silicon transistor
Q2—2N3906 or similar npn silicon transistor

Capacitors (16-WV or greater)
C1—1,000-µF, 16-volt radial-lead electrolytic
C2—27-pF ceramic disc or film
C3—270-pF ceramic disc or film
Resistors (¼-watt, 10% tolerance)
R1,R2—100 ohms
R3—220 ohms
R4—1,000 ohms
Miscellaneous
B1—9-volt battery
S1 thru S6—Normally open spst push-button switch

S7—Spst toggle or slide switch (optional—see text)
Y1—455-kHz ceramic resonator
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware; socket for IC1; 9-volt battery snap connector and holder; suitable enclosure; hookup wire; solder; etc.

Note: See Receiver Parts List for availability of pc board and semiconductors.

Fig. 1. Complete schematic diagram of transmitter circuit.

ulation) mode. Diode *D1*, connected between pins 3 and 7 of the chip, programs the circuit to operate in AM mode. Figure 2 illustrates the output pulse train generated by the circuit when channel 2 (channel A hereafter) is transmitted.

The output pulse train, called a "word," consists of a series of 28.4-kHz bursts that represent a binary code of ones and zeros of the selected channel. The least-significant bit (LSB) follows the second start bit, and the most significant bit (MSB) is last. This format is commonly referred to as "serial" data.

In Fig. 2, the binary word for channel A (channel 2 for the IC) is 000010, which indicates that all bits are zero except one, which has a binary weight of 2. The pulse train contains two additional bursts, called start bits, which precede the binary-coded word. In this pulse train, the position of the amplitude modulation for each bit of the word determines if the bit is a "1" or a "0," as in Fig. 3. A bit with a value of 1 is transmitted with the infrared burst occupying the first half of the allotted space. If the bit is zero, the second half of the space contains the burst.

Although this project uses only six channels, the chip is capable of encoding channel numbers 0 through 62 by transmitting six bits of information, any of which may be a one or zero. Thus, channel 0 would consist of a code word of 000000, channel 1 would consist of code word 000001, and so on up consecutively to channel 61, which would have the code word 111101. Channel 62 is automatically sent when the transmitting key is released, signifying end of transmission (EOT). Channel 63 is not used at all.

Frequency control of the transmitter output is provided by 455-kHz ceramic resonator *Y1*. Frequency dividing circuits inside *IC1* generate the 28.4-kHz IR modulating frequency as well as the timing for the output pulse train.

Transistors *Q1* and *Q2* serve as a driver circuit for the three IR LEDs. Using three LEDs as shown provides almost triple the amount of infrared energy with no increase in battery current drain. As long as visible light-emitting diode *LED1* in the collector circuit of *Q1* lights when a transmitter button is pressed, the battery has sufficient energy to power the circuit.

• *Receiver/Decoder.* Shown in Fig. 4 in three sections is the complete schematic diagram of the receiver/decoder circuitry. Integrated circuit *IC7* detects and amplifies the infrared pulses generated by the transmitter and detected by IR detector diode *D1*. The six remaining chips in this circuit decode the transmitted pulse train, and emitter-follower transistor *Q2* through *Q7* output stages provide six channels. Since this project contains just six active channels, only three bits of the transmitted word are needed for full control.

The specified chip used for *IC7* has been specifically designed to serve as an infrared detector/amplifier. Infrared energy striking photodetector *D1* is coupled to the pin 7 input of *IC7*. The 28.4-kHz IR bursts are converted to electrical pulses by *D1*. The resulting electrical pulses are amplified, and the amplitude-modulated waveform is detected to produce the waveform envelope that contains the binary-coded information of the transmitted pulse train. Wave-shaping circuitry inside *IC7* provides a clean, solid waveform at the pin 1 output. This is inverted by *Q1* and fed to the decoder circuit for further processing.

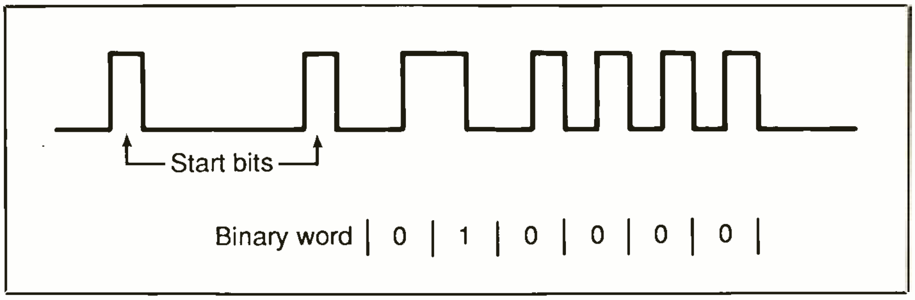


Fig. 2. Binary word for channel A is 000010, which indicates that all bits are 0 except one, which has a binary weight of 2.

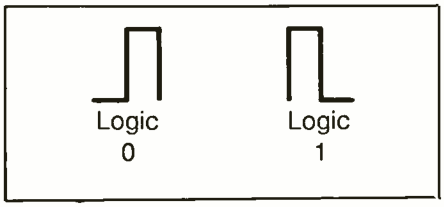


Fig. 3. Position of amplitude modulation for each bit of the word determines if bit is a 1 or a 0.

As shown in Fig. 2, the recovered transmitted pulse train (channel A is illustrated) contains six bits of information that must be decoded to determine which of the six possible channels, A through F, has been transmitted. A truth table illustrating the six possible code combinations is shown in Fig. 5.

Since each individual bit of the coded word occurs in sequence, the information presented by the pulse train is in serial data form. To recover and store this information, serial-to-parallel converter *IC4* is used. This eight-bit shift register IC is capable of converting data from serial form to parallel form and latching it in its output stages. Operation of the decoder circuit is best understood by referring to timing diagram Fig. 6, which illustrates what the waveforms should look like at various points in the circuit.

To synchronize the decoder timing circuits with the transmitter, ceramic resonator *Y1* operates at the same 455-kHz frequency as the resonator in the transmitter. Gate *IC1C* is wired to operate as a simple inverter and is biased into its unstable linear region by means of *R5*. The ceramic resonator, connected between output pin 10 and input pins 8 and 9 of the gate, causes the circuit to oscillate at the resonant frequency of *Y1*. Gate *IC1D*, also wired as an inverter, is used as a buffer for the oscillator.

Gates *IC1A* and *IC1C* are configured to form a bistable multivibrator, or common flip-flop. This circuit has two stable states that depend upon the logic levels fed to the inputs at pins 1 and 6. This circuit is a latch that controls operation of counter divider *IC3* and shift register *IC4*.

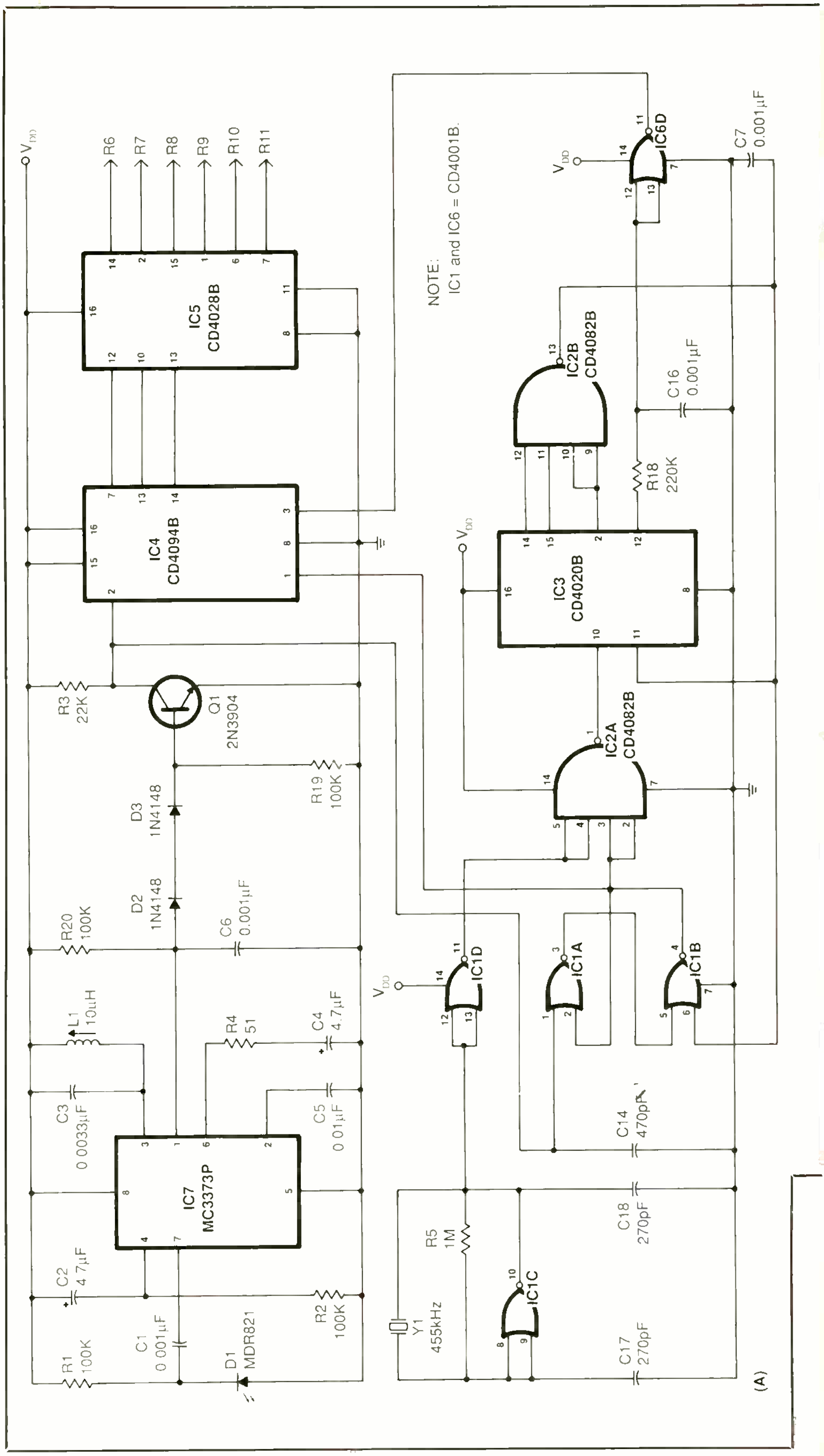
When the first pulse of the received transmission reaches input pin 1 of *IC1A*, output pin 3 of this gate assumes a logic 0 level and pin 4 goes to logic 1. The output at pin 4 of *IC1B* enables AND gate *IC2A* and allows the oscillator waveform to be impressed upon the clock input of *IC3* at pin 10. At the same time, shift register *IC4* is enabled by the logic 1 level that is fed to its strobe input at pin 1.

Integrated circuit *IC3* is a 14-stage binary ripple counter. This chip serves two functions in this circuit. The first part of the chip, consisting of nine binary stages, is used as a divide-by-512 circuit that provides the correct clock rate for the shift register. This clocking signal appears at output pin 12. The second part of the chip, along with AND gate *IC2B*, is used as a divide-by-11 counter that permits the shift register to be clocked just 11 times during each discrete transmission. This will cause the three desired bits of the serial transmission to be stored in the outputs of *IC4* at locations represented by pins 7, 13 and 14.

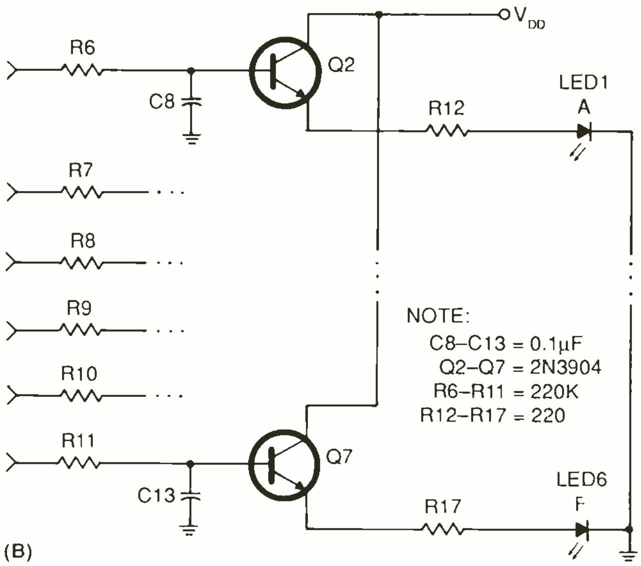
The detected signal from *Q1* goes to the serial input at pin 2 of *IC4*. At the onset of the first start pulse, when the latch circuit is set to the active state, the shift register is clocked synchronously with the transmitter. Hence, each pulse of the transmitted word enters *IC4* and is shifted down the line like a bucket brigade. The clock pulses are delayed by an RC network composed of *R18* and *C16* to ensure that the data is present at the serial input of *IC4* before the shift takes place.

The output circuits of *IC4* assume the logic levels of the input pulses as they enter the chip and shift down the line. When the count of 11 is complete, the reset pulse generated at pin 13 of *IC2B* sets the latch back to the idle state, stops the clock inputs of *IC3* and *IC4*, resets *IC3* to a count of zero, and latches the outputs of *IC4* so that the transmitted word is stored in its output registers. The circuit remains in this condition until the next group of pulses is received by *IC7*.

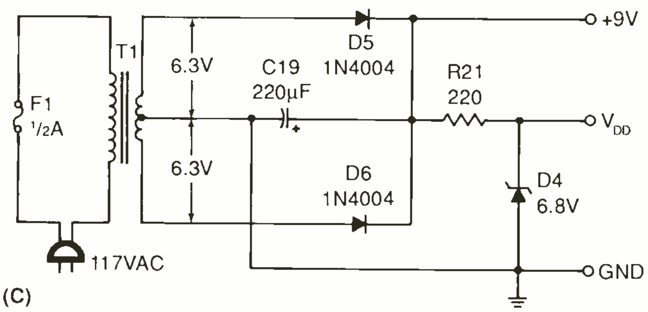
The desired six-bit binary information, illustrated in Fig. 6, is stored in the output circuits of *IC4* at pins 5, 6, 7, 14, 13 and 12, with the least-signif-



(A)



(B)



(C)

PARTS LIST (Receiver)

Semiconductors

D1—MRD821 or equivalent infrared photodetector (Motorola)

D2,D3—1N4148 or similar silicon diode

D4—1N5235B or similar 6.8-volt zener diode

D5,D6—1N4004 or similar silicon rectifier diode

IC1,IC6—CD4001B quad 2-input NAND gate

IC2—CD4082B dual 4-input AND gate

IC3—CD4020B 14-stage binary counter

IC4—CD4094B 8 bit shift register

IC5—CD4028B BCD-to-decimal decoder

IC7—MC3373P infrared receiver/amplifier

Q1 thru Q7—2N3904 or similar npn silicon transistor

Capacitors (16-WV minimum)

C1,C6,C7,C16—0.001-μF ceramic disc

C2,C4—4.7-μF, 16-volt radial-lead electrolytic

C3—0.0033-μF Mylar or metal-film

C5—0.01-μF ceramic disc

C8 thru C13—0.1-μF ceramic disc

C14—470-pF ceramic disc

C15—100-μF, 16-volt radial-lead electrolytic

C17,C18—270-pF ceramic disc

C19—220-μF, 16-volt radial-lead electrolytic

Resistors (¼-watt, 10% tolerance)

R1,R2,R19,R20—100,000 ohms

R3—22,000 ohms

R4—51 ohms

R5—1 megohm

R6 thru R11,R18—220,000 ohms

R12 thru R17,R21—220 ohms

Miscellaneous

F1—½-ampere slow-blow fuse

L1—10-μH inductor (Toko No. 126LNS-T1032Z)

T1—12.6-volt C.T. power transformer (Radio Shack Cat. No. 273- 1365 or similar)

Y1—455-kHz ceramic resonator

Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware; sockets for all DIP ICs; three-conductor ac line cord with plug; fuse holder; suitable enclosure; machine hardware; hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Transmitter pc board, $7.50; receiver pc board, $15.50; MC3373P, $3.00; MC14497P, $15.00; CD4001B; $1.25; CD4082B, $1.25; CD4020B, $2.00; CD4094B; $2.25; CD4028B; $1.75; three MLED81s, $6.50; MRD821, $4.00; 1N5235B, $1.00; L1, $4.00; Y1, $3.75 each. Add $2.00 P&H. New Jersey residents, please add state sales tax.

Fig. 4. Complete schematic diagram of receiver/decoder circuit, shown here in three sections.

icant bit stored at pin 12. The information contained at pins 13, 14 and 7 of *IC4* is the only data required for this six-channel decoder. Note that the bits of data (see Fig. 6) stored at these three terminals represent a binary number between 1 and 6.

BCD-to-decimal decoder *IC5* accepts four bits of binary-coded-decimal data and provides a single output that represents the decimal equivalent of the data fed to its input. Since the data to be decoded is contained in just three bits, the most-significant-bit input at pin 11 of *IC5* is grounded, and the data from *IC4* is fed to the three remaining inputs at pins 7, 14 and 13. This permits *IC5* to decode the information stored in *IC4* and to provide a logic 1 output at the output pin (14, 2, 15, 1, 6 or 7) of the transmitted channel.

The decoded output at one of the pins of *IC5* remains at logic 1 level for as long as the transmitting switch is held closed. When the switch is opened, the transmitter generates the EOT (end-of-transmission) code (channel 62), and the logic level at the decoded output pin returns to logic 0. In this manner, the decoded output is automatically returned to a logic 0 level at the end of each transmission.

The emitter-follower stages *Q2* through *Q7* in Fig. 4(B) are driven by the outputs of *IC5*. RC filtering ensures that no transistor will be driven into conduction during the time that the circuit is shifting data. When any transmitter switch is closed, the appropriate transistor stage is driven into conduction and turns on the LED that identifies the selected channel. The output of each emitter-follower stage can be used to drive a variety of circuits to perform the desired remote action.

Power for the receiver/decoder circuit is provided by the 117-volt ac line using the dc power supply whose circuitry is shown schematically in Fig. 4(C). The 117 volts ac from the power line is converted to 12.6 volts ac by power transformer *T1*. This reduced ac voltage is rectified to pulsating dc by full-wave rectifier *D5/D6*. The pulsating dc is then filtered to pure dc by capacitor *C19*.

Two dc output voltages are available from the power supply: an unregulated +9 volts and a regulated (by zener diode *D4*) +6.8 volts V_{DD}. The +9-volt output will be used by the interface circuits, which will be covered next month. Since the receiver/decoder circuit should never be shut off, there is no power switch in the primary circuit of *T1*.

Construction

Both transmitter and receiver are best wired on separate single-sided printed-circuit boards. You can fabricate your own pc boards using the actual-size etching-and-drilling guides shown in Fig. 7 (transmitter) and Fig. 8 (receiver/decoder), or you can purchase ready-to-wire boards from the source given in the Note at the end of the Parts List. Alternatively, you can wire the transmitter circuit on perforated board that has holes on 0.1-inch centers using suitable soldering hardware. Whichever way you go, though, it is a good idea to use sockets for all ICs. However, use only pc-board construction for the receiver/decoder to assure that its very-high-gain amplifier operates with maximum stability.

Begin building this project by wiring the simple transmitter. Place the transmitter's pc board in front of you in the orientation shown in Fig. 9 and install and solder into place the IC socket. Do **not** install the IC itself in the socket until after you have checked out the wired circuit.

Install and solder into place the remaining on-board components. Make sure that electrolytic capacitor *C1* and the diode and LEDs are properly oriented before soldering their leads into place. Then, making certain that the 2N3904 npn and 3906 pnp transistors are installed in the Q1 and Q2 locations, respectively, and that both transistors are properly based, solder their leads into place. Install and solder into place resonator *Y1*, using heat judiciously.

Strip ¼ inch of insulation from both ends of 14 4-inch-long hookup wires. If you are using stranded wire, tightly twist together the fine conductors at both ends of all wires and sparingly tin with solder. Then plug

CHANNEL	BINARY WORD LSB					MSB
A	0	1	0	0	0	0
B	0	0	1	0	0	0
C	0	1	1	0	0	0
D	0	0	0	1	0	0
E	0	1	0	1	0	0
F	0	0	1	1	0	0

Fig. 5. Truth table illustrates that project has six possible channel code combinations.

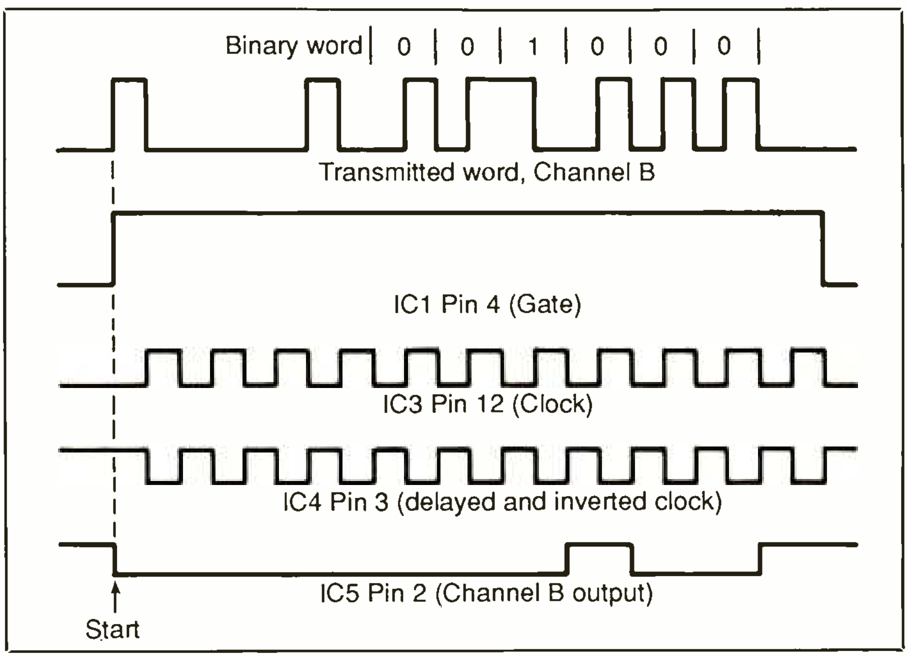


Fig. 6. Decoder circuit timing diagram.

one end of these wires into all remaining unoccupied holes in the board, except those labeled B1, and solder them into place.

You have the option of incorporating into your transmitter circuit power switch *S1* or leaving it out and wiring the positive (+) terminal of the battery directly to the B1+ pad. Current drain of the circuit is very low (about 10 microamperes) in standby, but if you anticipate that there will be extended periods lasting weeks at a time during which the transmitter will not be used, installation of *S1* is recommended.

Plug the black-insulated negative (−) lead of the 9-volt battery snap connector into the B1− hole and solder it into place. If you opted to omit *S1* plug the red-insulated positive (+) lead of the connector into the B1+ hole and solder it into place. Otherwise, prepare another 4-inch wire as above, plug one end of it into the B1+ hole and solder it into place. Then crimp and solder the free end of this wire to one lug of *S1* and the red-insulated lead of the battery connector to the other lug of the switch.

It is important that you wire the three IR LEDs into the circuit in proper polarity. If even one of these components is wired backward, none of the LEDs will operate. You will not be able to visually determine if these LEDs are operating. If necessary, use an ohmmeter to ascertain the polarity of each. (The polarity can be identified in a similar manner as with any semiconductor diode.)

Once you have determined the polarity of each IR LED, clip the cathode (K) leads of all three to a length of ½ inch. Form a small hook in the remaining cathode-lead stub in each case. Slide a 1-inch length of small-diameter heat-shrinkable or insulating plastic tubing over the free ends of all LED wires coming from the circuit-board assembly. Then crimp and solder the free ends of the wires coming from the LED2, LED3 and LED4 K holes individually to the cathode leads. Trim the other leads of the LEDs to ½ inch and crimp and solder them to the end of the remaining LED wires. Slide the tubing up over the soldered connections until it is flush with the bottoms of the device cases and shrink into place.

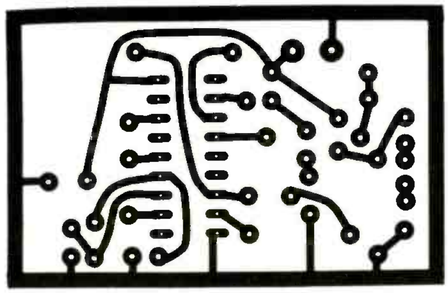


Fig. 7. Actual-size etching-and-drilling guide for transmitter pc board.

Wire visible light-emitting diode *LED1* to the ends of the LED1 wires coming from the circuit-board assembly exactly as you did for the IR LEDs, including using insulating tubing on its leads.

Referring to Fig. 1 and Fig. 9, wire the six pushbutton switches into the circuit, using additional hookup wire as needed to complete the wiring.

House the transmitter circuit board and battery in a plastic box that is small enough to hold comfortably in one hand and allows you easy access to the six pushbutton switches and clear line of sight to *LED1* that will mount on its top surface.

Machine the box as needed. You do not have to drill mounting holes for the circuit-board assembly, which will be held in place with a layer of thick double-sided foam tape. However, you should plan on using a clip-type holder for the battery, which requires a single mounting hole. Remaining machining includes drilling mounting holes for the buttons of the pushbutton switches (and a rectangular slot and small hardware holes for the power switch if you use it) and four holes for the visible and IR LEDs.

Drill the mounting holes for the three IR LEDs in the end panel of the box that will be facing away from you when holding the project in your hand. The hole pattern should have

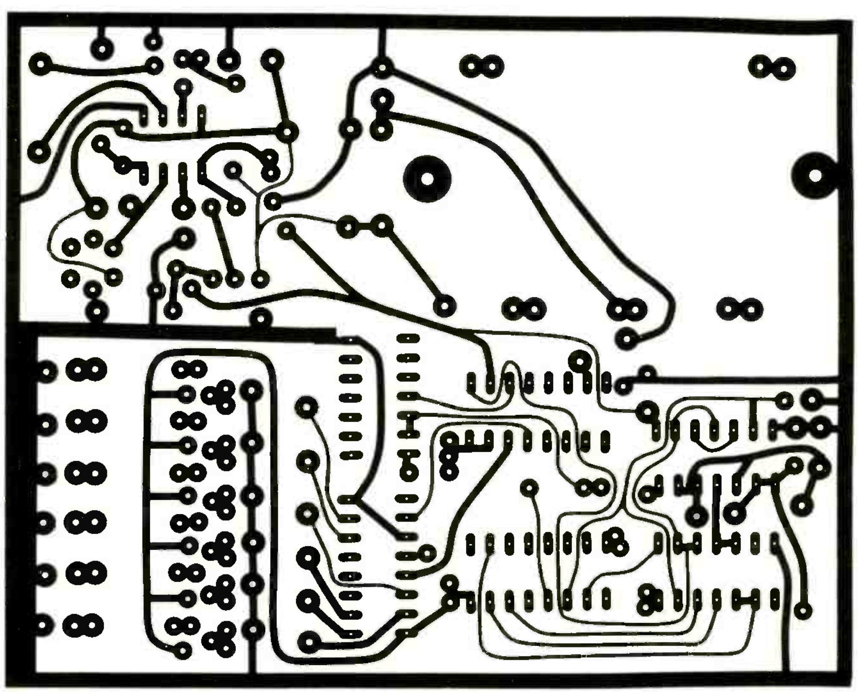


Fig. 8. Actual-size etching-and-drilling guide for receiver/decoder pc board.

the three LEDs mounted so that their emitted energy points in the same direction for all three to assure that your transmitter has the greatest possible range. Orient the LEDs so that they are parallel and as close as possible to each other.

Carefully check all wiring. Make sure each component is installed in its correct location and is properly oriented. Flip over the circuit-board assembly and check your soldering. Solder any missed connections, reflow the solder on any suspicious connection and remove any solder bridges with desoldering braid or a vacuum-type desoldering tool.

Mount the battery clip and circuit-board assembly in place. Then carefully plug the cases of the IR LEDs into their respective holes and, if necessary, secure each in place with a small drop of fast-setting clear epoxy cement or a daub of silicone adhesive from the *inside* of the box so as not to obstruct the emitted IR energy when the transmitter is keyed.

Mount the switch buttons in their respective holes in the top panel of the box, using the hardware provided with them. Then mount the visible LED in its hole in the same manner used to mount the IR LEDs. Save installation of the IC in the socket until after you have performed a preliminary voltage check and are certain of your wiring and soldering.

Since the receiver will be set in a permanent location, from which it will control some appliance or device, it is powered from the 117-volt ac line using a small 12.6 volt transformer. It is important that you use a three-conductor line cord to feed the primary of the transformer. The grounded line cord conductor must be tied to both circuit ground and the frame of the transformer to minimize any stray interference from other devices in the area.

Mount the photodetector directly on the circuit-board assembly facing the outside of the enclosure used to house the receiver. Because it is the most sensitive part of the circuit and is sensitive to unwanted electrical pickup, be sure keep the detector close to the board. You will note that one side of the detector has the "lens" that gathers and focuses the infrared energy. This side should be directed towards the planned location of the transmitter.

Inductor *L1* has five pins, only two of which are active. They are the two end pins on the side that has three pins in line. You can cut off the center pin prior to installing the inductor on the circuit board.

As you can see, the receiver/decoder board requires seven jumper wires, as shown in Fig. 10. Use insulated hookup wire to make these jumper connections to make certain that none of the jumpers short to another. Make each wire only as long as needed to permit routing between the terminating holes in the board.

If you have decided to delete one or more transmitting channels, you can also omit the corresponding driver circuits and LEDs driven by *IC5*.

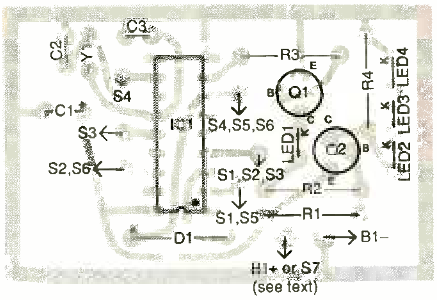


Fig. 9. Wiring guide for transmitter pc board.

Checkout & Use

Check out the transmitter first, since it will be necessary to have it operating to be able to check out the receiver. Be sure to use a known fresh 9-volt battery to power the circuit. You can use an ohmmeter to check the transmitting switches first. If you have a general-purpose triggered-sweep oscilloscope, examine the output pulse waveform and compare it with that of Fig. 1.

With *IC1* not installed in its socket

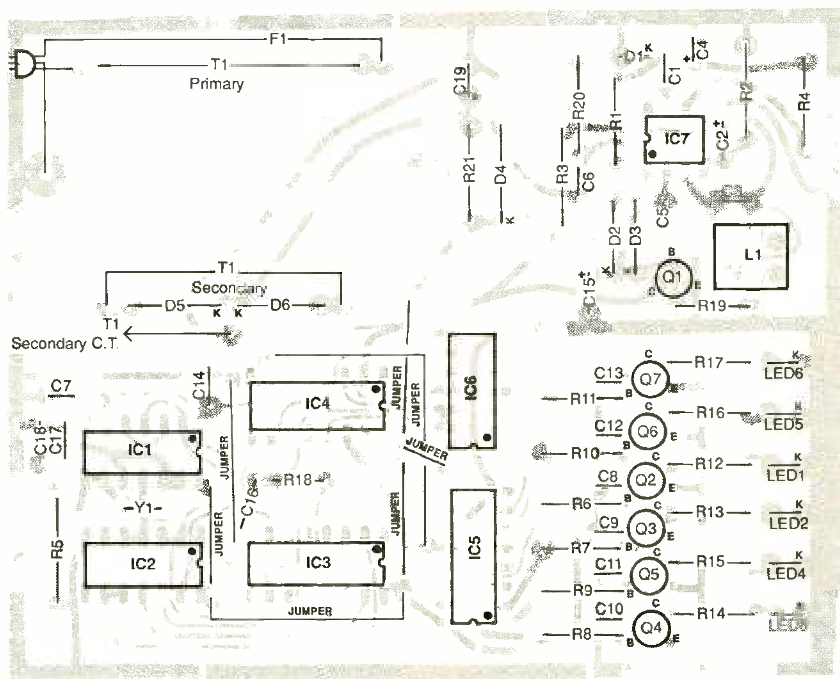


Fig. 10. Wiring guide for receiver/decoder pc board.

and no battery connected to the circuit, verify the wiring to the transmitting switches by connecting an ohmmeter to the appropriate pins of the *IC1* socket and pressing each transmitting pushbutton switch in turn. Ascertain that the proper pins of the socket are shorted together as indicated in accordance with the Fig. 1 transmitter schematic diagram.

If you have determined that the transmitting switches are properly wired install *IC1* in its socket, orienting it as shown in Fig. 1 and making sure that no pins overhang the socket or fold under between IC and socket.

Connect a fresh 9-volt battery to the circuit via the snap connector and press any transmitting switches. Light-emitting diode *LED1* should flash brightly at a rapid rate of about 10 times per second.

Although you will not be able to see the infrared flashes, an oscilloscope probe connected between the collector of *Q2* and circuit ground will display the encoded pulse train that is being transmitted. Transmit on channels A and B (one at a time) to verify that the transmitted pulse train displayed on the screen of the oscilloscope agrees with the pulse waveforms shown in Fig. 2 and Fig. 3.

Press each transmitting switch in turn and verify that *LED1* flashes at a rapid rate as long as the pushbutton of the switch is pressed. This completes transmitter checkout.

If you do not obtain the correct response as when checking out the transmitter, you must troubleshoot the circuit before proceeding to receiver checkout. To do this, first inspect the circuit-board assembly to ascertain that all components are installed in the correct locations and that they are properly oriented, using Fig. 9 to guide you. Also, inspect the board for open and short circuits, and bad solder joints. And do not forget to verify the polarity of the connections to the battery. If all else fails, replace the battery with a fresh one. Finally, check *IC1* to make sure it is oriented properly and is firmly seated in its socket.

Before installing the integrated circuits in the sockets on the receiver circuit-board assembly, apply power to the primary side of the transformer and check with ac voltmeter or multimeter set to the ac volts function that the power supply is operating properly. Be careful not to touch any part of the primary circuit of the transformer, where potentially lethal 117-volt ac line power appears.

Next, use a dc voltmeter or a multimeter set to the dc volts function that has an input resistance of 1 megohm or more to measure the voltage across *D4*. You should obtain a reading of about 6.8 volts. If you do not obtain the correct voltage reading, check the orientations of *D4*, *D5* and *D6*, and double check to make sure that no short circuit exists between the cathode of *D4* and circuit ground. Also, check the orientations of electrolytic capacitors *C15* and *C19*. Do *not* proceed until you are satisfied that the power supply is performing properly.

When you are satisfied that the power supply is operating properly, disconnect the line cord from the 117-volt ac source and allow time for the electrolytic capacitors to discharge. Then install the integrated circuits in their respective sockets. Make certain that you orient each IC properly and that no pins overhang the sockets or fold under between ICs and sockets. Seat each IC securely in its socket.

Place the transmitter near the receiver (it will not be necessary to have the transmitting LEDs directly in line with the photodetector) and press one of the transmitter's buttons. The appropriate LED in the receiver should turn on and exhibit a slight flicker for as long as the pushbutton is held down.

At this time, you can adjust *L1* for maximum receiver sensitivity. This adjustment is not critical, however. The proper way to adjust this coil is to use an oscilloscope to monitor the 28.4-kHz pulses at pin 3 of *IC7* as you adjust *L1* for maximum waveform amplitude. When making this adjustment, orient the transmitter and receiver so that the received signal is relatively weak. One way to do this is to partially block the infrared beam with an opaque object. Another is to separate the two units physically, though this way entails having an assistant operate the transmitter as you make the coil adjustment

Try each transmitter pushbutton to ascertain that the respective LED in the receiver turns on. If each transmitting pushbutton activates its corresponding receiver LED, try operating the transmitter from across the room, pointing the infrared LEDs towards the photodetector. You should be able to achieve a response at a distance similar to that obtained from your TV or VCR remote-control.

If you are not able to obtain the proper responses, power down the receiver and troubleshoot it—assuming, of course, that the transmitter is operating properly. To do this, use a triggered-sweep oscilloscope to examine the waveforms in the receiver.

Examine the waveform at the collector of *Q1* in the receiver as channel A pushbutton is activated. Normal indication here is a pulse train similar to that shown in Fig. 2. Then check pin 11 of *IC1* to ascertain that the oscillator is operating. The signal at this point should be a 455-kHz square wave. Next, examine the clock signal at pin 12 of *IC3*, which should be a train consisting of 11 square pulses, as in Fig. 3.

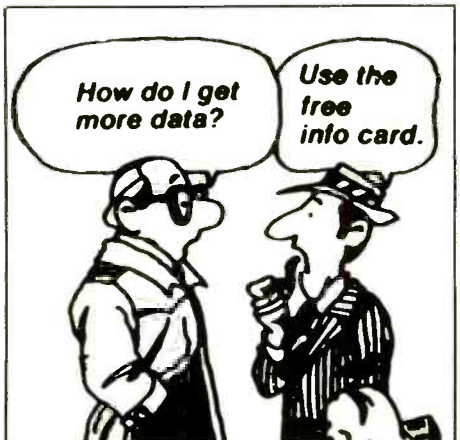
Check the outputs of *IC4* at pins 7, 14 and 13 to verify that the logic levels at these terminals agree with the truth table of Fig. 3 as each channel is transmitted in turn. Note that the logic levels are verified only during the time between transmissions, where the data is latched into the output registers of the chip.

Ascertain that the outputs of *IC5* at pins 14, 2, 15, 1, 6 and 7 assume a logic 1 condition when the appropriate transmitter pushbutton is pressed. This will, in turn, forward bias the corresponding emitter-follower transistor and its LED.

When you are able to turn on each LED in response to pressing its corresponding transmitter pushbutton, checkout is done.

Coming Next Month

Next month, we will show how this infrared remote-control system can be used to operate just about any electrical device that you may desire. Our coverage will include a variety of circuits that interface the project with a variety of electrical devices and appliances ranging from low-power on up to high-power devices.



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Substitute Current Shunt

Shuts off power when excessive current is drawn and restores power when safe to do so—all automatically and without the need for fuses or circuit breakers

By Mike McGlinchy

Traditional current shunts are usually bulky, heavy and expensive, which is why they're used only to protect expensive equipment when current drawn becomes excessive. Going the less expensive route of installing a fuse or circuit breaker, though compact and inexpensive, is far from the ideal solution. Once the fuse blows or circuit breaker trips, you must be present to replace the former or reset the latter. Here, we'll describe an inexpensive alternative to the traditional current shunt that works automatically.

Our Substitute Current Shunt continuously monitors the current drawn by an electrical device. Installed between the power source and device being monitored, when the Shunt detects excessive current flow it automatically opens a pair of relay contacts and deprives the device being protected of power. Shutdown is not permanent, as is the case with a fuse or circuit breaker. The Substitute Current Shunt automatically restores power to the device when the current drawn falls below the predetermined threshold.

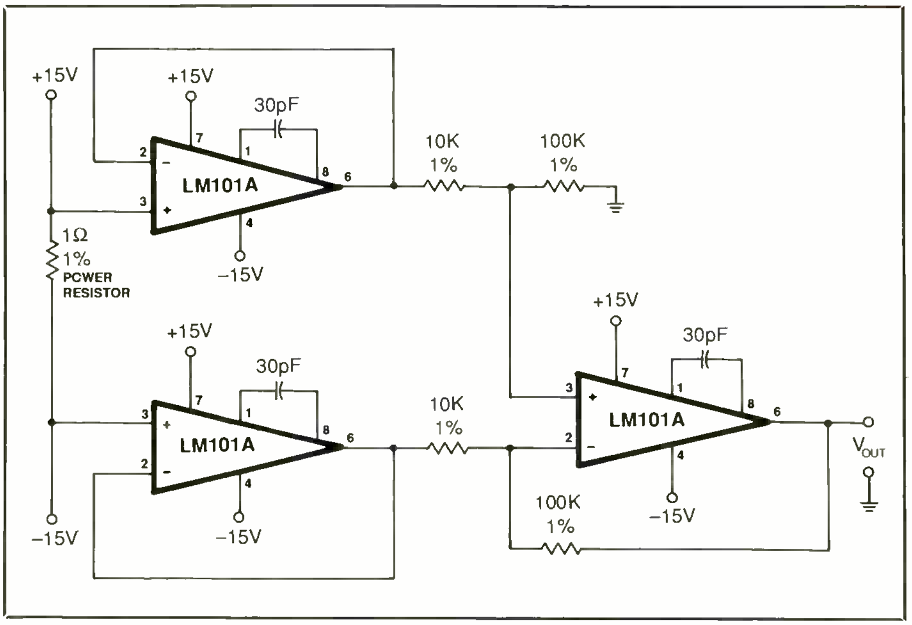


Fig. 1. Schematic diagram of a basic solid-state substitute current shunt.

About the Circuit

Shown in Fig. 1 is a schematic diagram of a basic current shunt circuit built around commonly available LM101A integrated-circuit differential amplifiers. The 1-ohm sense resistor goes in series with the main power bus to the device being protected. The value of this resistor is low enough to have only a negligible effect on operation of the device. Its power-handling capability (wattage) must be selected to safely accommodate the maximum power expected to be drawn by the device being protected.

Assume that the device being protected draws nominally 400 milliamperes under ideal operating conditions and, furthermore, that it should never under any circumstances draw more than 450 milliamperes. This being the case, if the device begins to draw 500 milliamperes, something is most definitely wrong and corrective measures must be taken to prevent its destruction.

Using Ohm's Law, you can calculate the the voltage drop that appears across the sense resistor by multiplying 500 milliamperes by the resistor's 1-ohm value, which yields 500 millivolts. This voltage drop is fed to the inputs of the differential amplifier. In this example, the gain of the differential amplifier is set at 10 (from 100,000 ohms/10,000 ohms). Therefore, 500 millivolts × 10 = 5 volts, which is the potential that appears at pin 6 of the LM101A differential amplifier and is, thus, the output from the circuit.

Shown in Fig. 2 is a more complete schematic diagram of the Substitute Current Shunt that is the subject of this article. This schematic lacks only

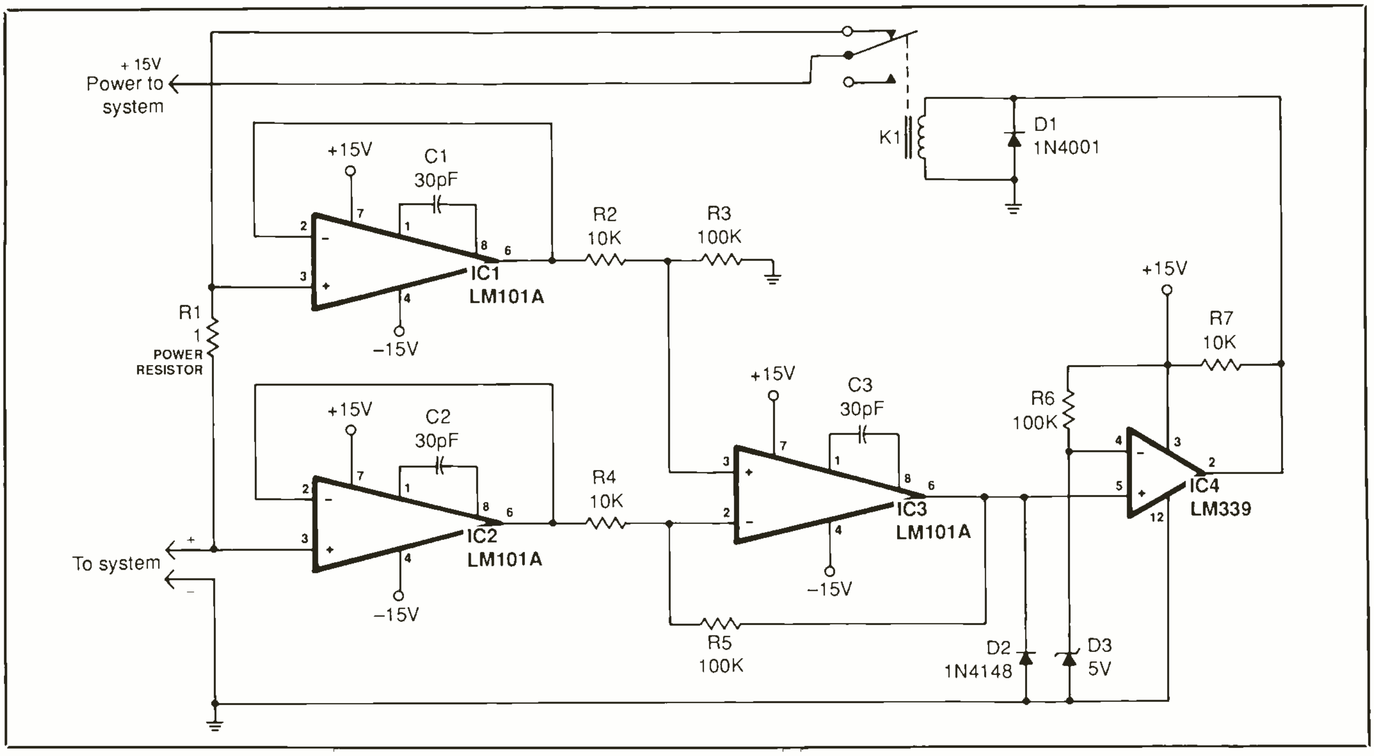


Fig. 2 Schematic diagram of the complete Substitute Current Shunt circuit, including the relay switching circuit that automatically interrupts power to the protected system when excessive current is drawn and restores power when conditions return to normal.

PARTS LIST

Semiconductors
D1—1N4001 or similar rectifier diode
D2—1N4148 or similar silicon switching diode
D3—5-volt zener diode
IC1 thru IC3—LM101A differential amplifier
IC4—LM339 voltage comparator

Capacitors
C1,C2,C3—30-pF disc

Resistors (¼-watt, 10% tolerance)
R2,R4,R7—10,000 ohms
R3,R5,R6—100,000 ohms
R1—1-ohm power resistance (wattage according to amount of current drawn under abnormal conditions—see text)

Miscellaneous
K1—12-volt dc spst relay
Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware (see text); sockets for all ICs; suitable enclosure and small rubber grommet (if needed—see text); machine hardware; hookup wire; solder; etc.

the ±15-volt supply needed to power the circuitry. Note here that the circuitry containing differential amplifiers *IC1*, *IC2* and *IC3* and their associated components is identical to that shown in Fig. 1. The difference in this circuit is the addition of the *IC4* LM339 voltage comparator circuit and relay *K1*.

Zener diode *D3* provides a 5-volt reference to the noninverting (+) input at pin 4 of *IC4*. It's this reference against which the voltage at output pin 6 of *IC3* is compared. As in the Fig. 1 circuit, the magnitude of this potential is determined by the voltage dropped across sense resistor *R1*.

As long as the potential being fed to noninverting input pin 5 of *IC4*, the output at pin 2 of this IC is nominally 0 volt. However, when the *IC3* differential amplifier outputs +5 volts or greater to pin 5 of *IC4*, as would occur when 500 milliamperes is being drawn by the system in the above example, pin 2 of *IC5* will go to +15 volts. When this occurs, relay *K1* energizes. Its contacts then spring open to deprive the device or system being protected of its power source.

Once the circuit trips, the voltage dropped across sense resistor *R1* drops to 0 volt. In turn, this causes the output of *IC3* at pin 6 to drop to nominally 0 volt, which is applied to the noninverting pin 5 input of *IC4*. The pin 2 output then drops to 0 volt, causing *K1* to deenergize and apply power back to the system or device being protected. If the current flowing through *R1* still exceeds the preset "safe" level, the Substitute Current Shunt circuit will once again cause the relay to energize to deprive the protected system or device of power. Should the project determine that the voltage dropped across *R1* is within safe limits once again, however, it restores power to the protected device or system.

Diode *D2* shown installed between noninverting pin 5 of *IC4* and circuit ground is in the circuit to protect the LM339 from negative voltages. Diode *D1* protects the output of *IC4* from damage that might otherwise occur if it weren't in the circuit to absorb the inductive kickback from the relay's coil when it is deenergized.

The above example and Fig. 2 both assume that the device or system being protected will be powered by a 15-volt or less dc power supply. Of course, this needn't be the case. You can rig the circuit to work with any other low dc-voltage circuit or system.

Not shown in Fig. 2 is the bipolar dc power supply needed to operate the Substitute Current Shunt circuit. Because current drain of the Shunt is minimal, just about any ±15-volt power supply will do.

Construction & Checkout

Because of the simplicity of the circuitry that makes up the Substitute Current Shunt, any traditional wiring technique can be used to build the circuit. For example, you can mount the components on perforated board that has holes on 0.1-inch centers and use soldering or Wire Wrap hardware to make interconnections between the components. Alternatively, you can design and fabricate a printed-circuit board. Whichever way you go, however, it is a good idea to use sockets for the ICs. All components, including the relay (unless it is large and heavy), should be mounted on the board.

Be sure to observe proper polarity when installing *D1*, *D2* and *D3*. Also, make sure to use heavy wire for the connection from the relay's normally-closed contact and *R1* and from *R1* to the circuit or system being protected. Additionally, mount power resistor *R1* so that it sits about ½ inch above the surface of the circuit board to allow air to freely circulate around it and carry off heat.

Do *not* install the ICs in their respective sockets. Once you have wired the entire circuit, clip the common lead of an audible continuity checker or multimeter set to the ohms function to a convenient point in the circuit that is to be at ground potential. Then touching the "hot" lead or probe to pins 4 and 7 of the *IC1*, *IC2* and *IC3* sockets and pin 3 of the *IC4* socket should yield no audible indication from the continuity checker or an infinity reading on the meter in all cases.

Now connect either lead or probe to any point along the +15-volt bus. Touching the other lead or probe to pin 7 of the *IC1* through *IC3* sockets and pin 3 of the *IC4* socket should cause the continuity checker to sound an audible tone or ohmmeter to register a 0-ohm reading.

Finish up your tests by checking the −15-volt distribution bus. To do this, connect one lead or probe to any convenient point along the −15-volt bus. Then, touching the other lead or probe to pin 4 of *IC1* through *IC3* should cause a tone to be generated or a 0-ohm reading to be registered.

If you do not obtain any of the cited indications, locate the cause of and rectify the problem. Do not attempt to put the circuit into service until you are certain that it is properly wired. When you are sure the circuit is properly wired, install the ICs in their respective sockets. Make sure that each is properly oriented and that no pins overhang the socket or fold under between IC and socket.

If possible, install the project inside the enclosure that houses the circuit or system to be protected. If there is no room or the circuit or system to be protected has no ±15 volts to power the project, house the project and its dc power supply in a separate enclosure.

For the separately housed Substitute Current Shunt and its power supply, bring out the leads that connect to the movable contact's lug of *K1* and the two wires labeled TO SYSTEM through a rubber-grommet-lined hole in the enclosure. Label the first lead V+ and the two remaining leads SYSTEM + (upper arrowed lead in Fig. 2) and SYSTEM GND.

If you are installing the project inside the protected equipment's enclosure, make sure that no part of the Substitute Current Shunt electrically contacts any portion of the protected equipment's circuitry. The *only* connections that are to be made to the protected circuitry are via the V+ and ground leads.

To make the installation, first solidly connect the project's SYSTEM GND lead to the circuit or system's ground bus. Next, locate the circuit or system's V+ bus and track it back to the final output capacitor in the power supply, and interrupt the bus at this point. Connect and solder the free end of the SYSTEM + wire to the circuit side of the interrupted connection and the V+ wire to the power-supply side. This completes installation.

ELECTRONICS NOTEBOOK

Do-It-Yourself Components

By Forrest M. Mims III

Fifty years ago, electronics experimenters often made many of the components they used. Some experimenters even devised components of their own invention, while others used plans published in books and magazines of the time.

A. Frederick Collins's *The Amateur Electrician's Handbook* (Thomas Y. Crowell Co., 1924) was one of the many guides for do-it-yourselfers. This book described how to make gold-leaf electroscopes, magnets, bells, motors, spark coils and the components required to assemble wireless transmitters and receivers.

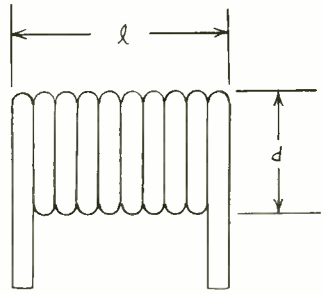
Today, with thousands of different components readily available from a host of sources, do-it-yourself components have almost become a thing of the past. Yet homemade components still have a role to play. They are an important teaching tool at the very least. Also, in an emergency, a defective piece of electronic equipment can sometimes be put back into operation with the help of a homemade component.

In this column, I'll describe a wide range of do-it-yourself components that you can make from readily available materials. Some of these components, like homemade coils, are traditional with the electronics hobbyist. Others, like homemade super capacitors are new. Even if you don't plan now to make any components, what follows can at some time in the future be of help to you.

Much of the material contained here applies to both do-it-yourself and conventional components. You'll gain a better appreciation of "store-bought" components when you finish reading this column, and some day you might decide to try your hand at making some components of your own.

Finding Materials

Most electronic parts suppliers are in the business of selling finished components. Fortunately, there are many alternative sources for such materials. For example, discarded radio and television receivers can be mined for coil forms and cores.



$$L = \frac{d^2 n^2}{18d + 40\ell}$$

$$n = \frac{\sqrt{L\,(18d + 40\ell)}}{d}$$

L = INDUCTANCE (MICROHENRIES)

n = NUMBER OF TURNS

Fig. 1. Coil formulas from the ARRL Handbook.

Hardware stores are an excellent source of plastic and aluminum tubing and heavy-gauge copper and aluminum wire. Craft shops sell various kinds of plastic and fabric as well as copper and brass sheets, and some sell steel wire. Hobby shops sell many kinds of small-diameter aluminum, brass and plastic tubing and rods, and some also sell unusual items like nichrome (nickel-chromium) wire. Welding supply companies sell iron rods that you can cut down to size for making magnets and relays.

If you think the materials you need are too specialized to find locally, use your imagination before giving up. I once needed some conductive paint or adhesive to build a miniature surface-mount circuit. The material I ordered wouldn't arrive for a week; so I tried to think of possible consumer uses for conductive paints and adhesives. Then I remembered that conductive paint is used to repair broken conductor paths in self-defrosting rear windows in automobiles. A quick call to a local supply store turned up a tiny bottle of conductive paint, thus solving my problem.

A Word About Safety: Before looking at how to make your own components, a few words about safety are in order. It is essential that a component—whether do-it-yourself type or otherwise—can be capable of withstanding the voltage placed across it and the current flowing through it. Otherwise, the component will fail and may take others with it.

A good example of an unsafe do-it-yourself component is a burnt-out fuse that has been wrapped with aluminum foil and reinserted in its holder. It's better—and *much* safer—to simply replace the fuse than to risk damaging the equipment it is designed to protect.

Inductors

Inductors have traditionally been among the most common of do-it-yourself components in electronics. Construction project details published in books and magazines often include detailed information on how to wind a coil or even transformer that is not available from the usual retail outlets. Many reference books contain formulas that you can use to determine the inductance of an existing coil and for winding a coil for a specified impedance.

One of the best references is *The 1989 ARRL Handbook for the Radio Amateur*. This must-have book, a new edition of which is published annually by the American Radio Relay League, belongs in every electronics experimenter's library. Among other things, it gives several formulas for winding coils. For a single-turn, air-wound coil, the number of turns (n) required to give a specified impedance (L) is calculated using the formula given in Fig. 1.

After determining the number of turns required to make a coil of a particular inductance, you must wind the coil. Air-core coils can be self-supporting or wound around a permanent form. Self-supporting coils are made from solid wire and usually consist of a dozen or fewer turns of the wire. For this application, No. 18 wire is a good choice of wire size to

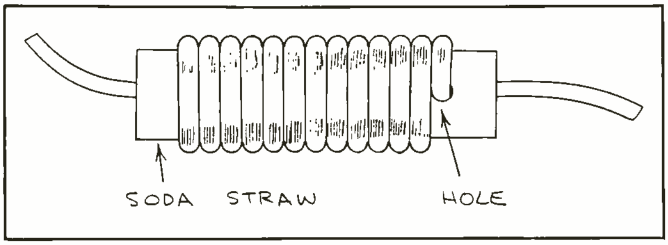


Fig. 2. A do-it-yourself coil wound on a soda-straw "coil form."

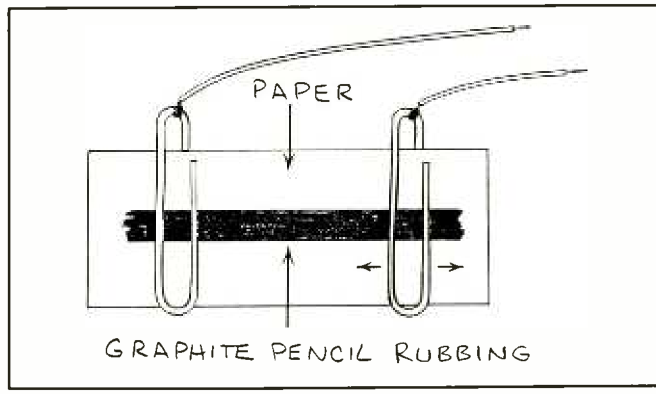


Fig. 3. A homemade adjustable resistor.

use. The wire doesn't have to be insulated, as long as the individual turns are kept from touching each other.

Wind a self-supporting coil on a form that is slightly smaller in diameter than the desired coil's diameter. When you slip the wound coil off the form, it will spring outward slightly.

Many different forms can be used for coils that require them. The main requirements are that the form be a good insulator and that it be sturdy enough to support the coil under any mechanical stresses that might be encountered in the environment in which the circuit containing the coil is used. Very small coils can be wound on short lengths of plastic soda straw, as illustrated in Fig. 1. I've often used this method to make the coils for tiny micro-power r-f transmitters. Larger coils can be wound around standard coil forms, plastic pill containers and even sections of plastic tubing.

For best results, drill two or three small holes in opposite ends of the coil form. Thread one end of the wire through the holes in one end of the form. If the coil is physically large, attach the opposite end of the wire to the knob on a closed door. Remove any kinks in the wire, and wrap the coil around the form while walking toward the knob to which the other end of the wire is attached. Finally, thread the finish end of the wire through the second set of holes drilled in the form.

If the coil requires a space between turns, wrap both a small-diameter string and the coil around the form. Then, after winding the coil, unwind the string.

Table 1. Characteristic Resistances in Ohms of 1 Foot of Wire Made From Different Materials

Material	Resistance
Aluminum	0.01050
Brass	0.02590
Gold	0.00904
Iron	0.03700
Copper	0.00638
Lead	0.08150
Silver	0.00603
Steel (piano wire)	0.04370
Nichrome	0.42190
Tungsten	0.02040

It's usually best to apply a protective sealant to the exposed turns of wire that make up the coil. I've used tape, wax and various glues. Lately, I've become impressed with hot-melt adhesive and will probably use this material to seal the next coil I wind.

Though coils are usually made from wire, they can also be fabricated by etching spiral patterns in an etched circuit board. This method is especially well suited for miniature r-f circuits.

Ferrite-core coils provide more inductance than air-core coils. Their construction is similar to air-core coils wound around a permanent form. However, an alternative means for anchoring the wire to the form may be required if the core is adjustable or removable.

Determining the specifications for a ferrite-core coil requires a knowledge of the ferrite's permeability (μ). The permeability of a core is a measure of the material's ability to conduct a magnetic flux. At high frequencies, the permeability of ferrites is greater than that of iron.

You can buy ferrite-core coil forms, but a cheaper approach is to use forms salvaged from old radio and television receivers. Electronics parts dealers often sell bags of used and new coils that contain enough raw material to supply your coil-winding requirements for some time.

Want to know more? Ferroxcube (5083 Kings Hwy., Saugerties, NY 12477) publishes an excellent reference, *Linear Ferrite Materials & Components* you might want to study. This book contains detailed information about the permeability of various ferrite materials and the design of ferrite inductors. Another excellent and especially well written reference is Eric Lowdon's *Practical Transformer Design Handbook* (Howard W. Sams, 1980).

Electromagnets & Solenoids

An electromagnet can easily be made by wrapping an insulated wire around an iron rod or bar and connecting the ends of this "coil" to a source of current. You can buy iron rods at a welding shop. Mild steel can also be used for this application, but iron is best. Hard steel will produce a smaller magnetic field than either iron or mild steel. The core material will become a permanent magnet when the current is removed.

Table 2. Resistance in Ohms of 1 Foot of Three Common Wire Materials			
Gauge	Copper	Nichrome	Steel (piano wire)
20	0.0102	0.6592	0.0695
22	0.0161	1.0550	0.1100
24	0.0257	1.6710	0.1760
26	0.0408	2.6700	0.2790
28	0.0649	4.2510	0.4440
30	0.1030	6.7500	0.7060

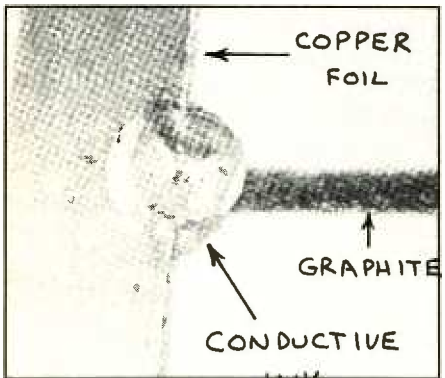


Fig. 4. Conductive ink connects graphite resistor to copper foil.

A solenoid is officially known as an electromechanical inductor. It's actually an electromagnet with a movable iron core. The wire coil of the solenoid is wound around a hollow form. When an iron rod is placed part-way into the hollow form and current is passed through the coil, the rod is immediately pulled into the center of the form. This explains why solenoids were once called "sucking magnets."

You can make miniature solenoids by wrapping magnet wire around a short length of plastic soda straw or small-diameter plastic tubing. I've used such solenoids as tactile stimulators. Mount the solenoid a short distance above a flat surface on which rests a small nail or pin armature inserted into the solenoid coil. When you apply a current to the coil, the armature will "jump" up and strike your finger. When you remove the current, gravity will pull the armature down to the surface below the solenoid coil until the next pulse of current arrives.

Resistors

You can easily make resistors from wire, conductive paint and even graphite pencil lead. Wire resistors are particularly important, since you can make them with very precise resistances.

The easiest way to make a wire resistor is to wind the necessary length of wire around a form. You can use a form salvaged from a choke or coil, or you can use a high-resistance resistor as the form. Start by soldering one end of the wire to one of the form's wire leads. Then wind the wire around the form and solder the free end of the wire to the other wire lead of the form. Since wire-wound resistors generally have relatively small resistances, the very-high resistance of a high-value resistor used as a form will have very little effect on the home-made resistor's overall value.

You can find the resistance of various gauges and kinds of wire in reference works like *Handbook of Tables and Formulas* and *Reference Data for Engineers*, both published by Howard W. Sams & Co. Copper wire is easiest to find, but it has a very low resistance. Wire made from most other materials has a higher characteristic resistance. Examples of the resistance of 1 foot of No. 18 wire taken from the sixth edition of the *Handbook of Chemistry and Physics* (CRC Press, Inc., 1987, pp. F-120 and F-121) are listed in Table 1.

Higher-gauge (that is, smaller-diameter) wire provides higher resistance. For example, the resistances from the *Handbook of Chemistry and Physics* for 1 foot of various gauges of three common wire materials are listed in Table 2.

During the past few years, I've spent considerable time designing and building miniature circuits using surface-mount components. An important technique I've learned is that it's possible to make miniature resistors with graphite pencil lead and conductive paint.

You can easily experiment with graphite resistors with a pencil, some paper and a VOM. First, draw a heavy line on the paper with the pencil. Next, draw over the line a dozen or so times. Then touch the probes of your VOM, set to the resistance function, to the line. Depending on the separation of the probes along the line and thickness of the graphite layer deposited on the paper, you can measure a resistance from a few thousand to a few million ohms. If your VOM doesn't respond, you probably didn't use a pencil whose "lead" is made from graphite. If this is the case, find a pencil that does have graphite lead and try again.

Figure 3 shows a homemade adjustable graphite resistor with paper-clip terminals. The "substrate" is a strip of paper cut from a common 3 × 5-inch card or a business card. You can alter the resistance of the resistor by sliding one of the paper clips along the graphite line.

I've built surface-mount circuits on paper substrates by attaching the components to the paper with glue. I connect the terminals of the components to each other with conductive paint, I make my resistors by drawing small squares or lines with a graphite pencil. Such resistors can be connected to the rest of the circuit with thin lines of conductive paint. Figure 4 is a macrophotograph of the junction between a line of conductive ink and a graphite resistor that I formed on a business card.

If the resistance of your homemade graphite resistor is too high, you can easily add more graphite. If it's too low, you simply take care in scraping away some of the graphite. In both cases, use an ohmmeter to monitor your work. The fin-

Table 3. Dielectric Constants of Some Common Plastics		
Material	**At 1 kHz**	**At 1 MHz**
Polyethylene	2.26	2.26
Polyvinyl chloride	4.55	3.30
Plexiglas	3.12	2.76
Polystyrene	2.55	2.55

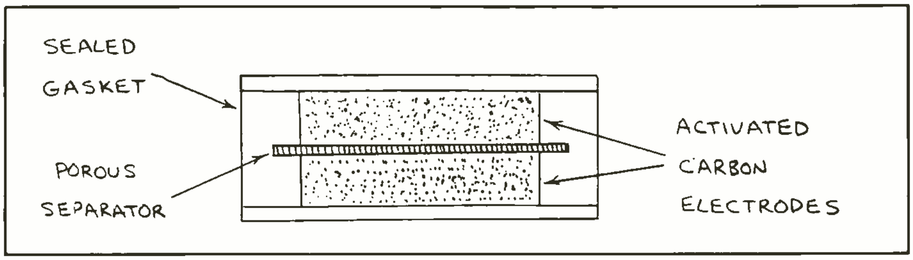


Fig. 5. Internal construction details of a super capacitor.

ished resistor can be protected from the elements with a thin coating of adhesive.

Various kinds of conductive paint can also be used to make resistors. As with graphite resistors, you'll have to experiment with various application methods to arrive at resistors that have specific ohmic values.

Capacitors

If you build radio-frequency (r-f) circuits, you're probably already familiar with what is called the "gimmick capacitor." This capacitor, which can have a capacity of up to a few tens of picofarads, is made by twisting together two short lengths of insulated wire. While the circuit is operating, short lengths of the ends of the two wires are clipped away until the circuit performs as desired. Though I haven't yet tried one in this role, a gimmick capacitor should also be able to fine-tune a quartz crystal h-f oscillator.

Small-capacity fixed capacitors can also be made by forming circular or square shapes of copper foil on opposite sides of a double-sided printed-circuit board. Thin p.c. blank of course, yields higher-capacity capacitors. Other components can be attached to the same circuit board, or a circuit board by itself can be made into a separate capacitor.

Aluminum foil and plastic films can be used to make higher-capacity capacitors. Electronics reference books list the dielectric constants of various types of plastics. The dielectric constants of several common plastics are listed in the *Handbook of Chemistry and Physics* on page E-55 and in Table 3. Values given are for room temperature and will change with deviations from this reference.

Lengths of coaxial cable can also be used to make capacitors with faster rise and fall times than are possible with conventional capacitors. This kind of capacitor has been used to supply high-current drive pulses for laser diodes. The length of the drive pulse can be reduced by trimming the length of the coaxial cable.

Super Capacitors

Super capacitors are the newest member of the capacitor family. These remarkable devices have farad-level capacities. Indeed, they can store enough charge to enable them to perform as a back-up power source for low-power CMOS memory and microprocessor circuits. They can also supply short-duration power for LEDs, relays and even small motors.

Since super capacitors are a relatively new development, they might appear to be rather exotic devices. Yet you can make your own with commonly available materials.

Figure 5 shows the construction details of a basic super capacitor. The conductors that store the charge are opposing layers of activated charcoal that are separated by an insulating layer of porous plastic film. A sulfuric-acid electrolyte permits charges to be transported through the plastic film. Activated charcoal is a highly porous substance that has an enormous surface area. This permits an enormous charge to be stored on the surface of each layer of charcoal.

A single super capacitor has a breakdown potential of about 1.2 volts, which is the point at which its electrolyte begins to decompose. Commercial super capaci-

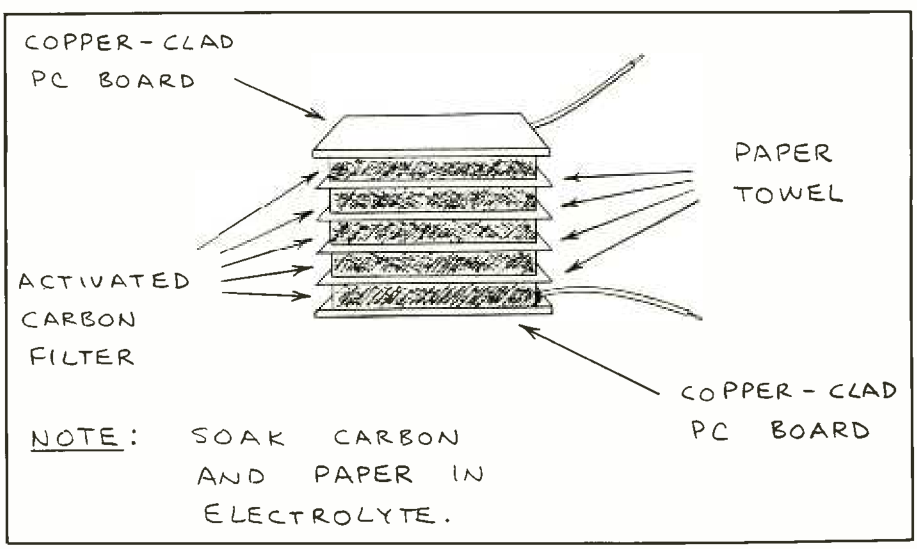


Fig. 6. A homemade super capacitor.

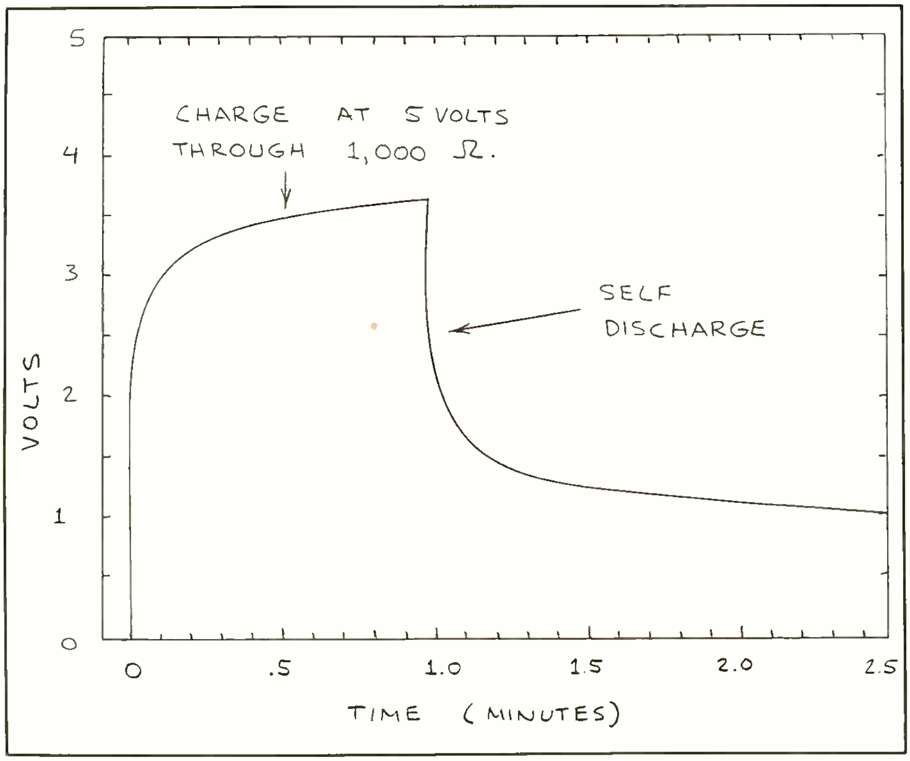


Fig. 7. Plot of charge/discharge cycle of a homemade super capacitor.

tors are made by stacking several cells in series with each other to provide working potentials of 5 volts or more.

Construction of a super capacitor resembles that of some kinds of electrovoltaic cells. But a super capacitor should not be confused with conventional cells and batteries. No chemical reaction occurs when a super capacitor charges or discharges. Also, the terminals of a super capacitor are not polarized.

You can find out more about super capacitors and their applications by referring to "Electronics Notebook" in the March 1989 issue of *Modern Electronics*. Shortly after writing that column, I decided to attempt construction of a homemade super capacitor. First, I visited the pet department at a nearby store to buy some activated charcoal, since the stuff is used in filters for aquarium tanks. While looking for a box of activated charcoal, I noticed various kinds of fibrous filter elements impregnated with activated charcoal. For $1.38, I purchased a sheet measuring about 5.5 × 4 inches and blister packages under the label Black Magic: The Power Filter Cartridge is made by Aquarium Pharmaceuticals, Inc.

Back in my shop, I cut five 1-inch squares from the cartridge sheet and four slightly larger squares of paper towel. Then I stacked alternate layers of each. Finally, I placed the copper sides of two 1-inch-square pieces of single-sided printed-circuit blank against the opposite sides of the stack, as illustrated in Fig. 6. The sandwich was held together with a small C clamp.

All that remained to make a working super capacitor was to drench the assembly with electrolyte. Instead of sulfuric acid, which is rather dangerous, I used concentrated lemon juice. After pouring a spoonful of juice over the capacitor, I connected a power supply to the homemade module and allowed the assembly to charge at several volts for a few minutes. After removing the charging source, I connected a red LED across the capacitor. The LED glowed brightly for several seconds before gradually beginning to dim.

Next, I monitored the charge/discharge cycle of the homemade super capacitor with a chart recorder. Figure 7 shows the charge on the capacitor after it was allowed to charge for 1 minute through a 1,000-ohm resistor connected to a 2-volt power supply and then self-discharge.

Figure 8 shows the discharge curve of the same capacitor after it was charged by a 5-volt supply for 10 minutes and then discharged through a red LED and 680-ohm series resistor. The LED glowed for 45 seconds.

From some of the manufacturer's literature about super capacitors, I had assumed that the activated-charcoal/insulator/activated-charcoal layers must be squeezed tightly together. This is true only if the end terminals are conductive plastic. The copper terminals I used didn't require the pressure of a C clamp. Consequently, a rubber band would have worked just as well.

These simple experiments prove that super capacitors can be built by experimenters. One fascinating possibility is to make a giant super capacitor inside a plastic food container or even a small aquarium. While a capacitor this size would require a considerable charging time, it would store a massive charge.

Caution: Be sure to follow appropriate safety procedures when assembling super capacitors. Always wear protective clothing and goggles if you use sulfuric acid! Protect others and the environment by properly storing and disposing of sulfuric acid. The internal resistance of a super capacitor will limit the maximum discharge current. Nevertheless, use caution to avoid the possibility of electrical shock.

Batteries

Electrovoltaic cells were at one time among the most common of do-it-yourself components. Now hundreds of different kinds of power cells and batteries of almost unlimited size, voltage and capacity are available. Nevertheless, there is still a role for homemade power cells. I've used them to power tiny radios and oscillators. Since homemade power cells can be made very small and in various shapes, you might be able to use them in applications for which no conventional cell is suited.

from a silver dime and a small piece of magnesium ribbon purchased from a hobby shop. Place a piece of paper towel soaked in lemon juice on the dime and follow up with the magnesium ribbon. This assembly will produce more than 1.24 volts and will easily light a red LED connected across the dime (+) and magnesium (−).

You can easily make a water-activated
that will power micro-power
uits. Figure 9 shows the details
many different arrangements
make such a power cell. The
making this cell is to soak
towel in salt water. After the
dries, cut it into small strips.
r connection wires to a gal-
l or strip of zinc and a piece of
. Then assemble the cell by
ied piece of salt-impregnated
l on the copper sheet and
ne copper and paper around
ed nail or zinc strip.

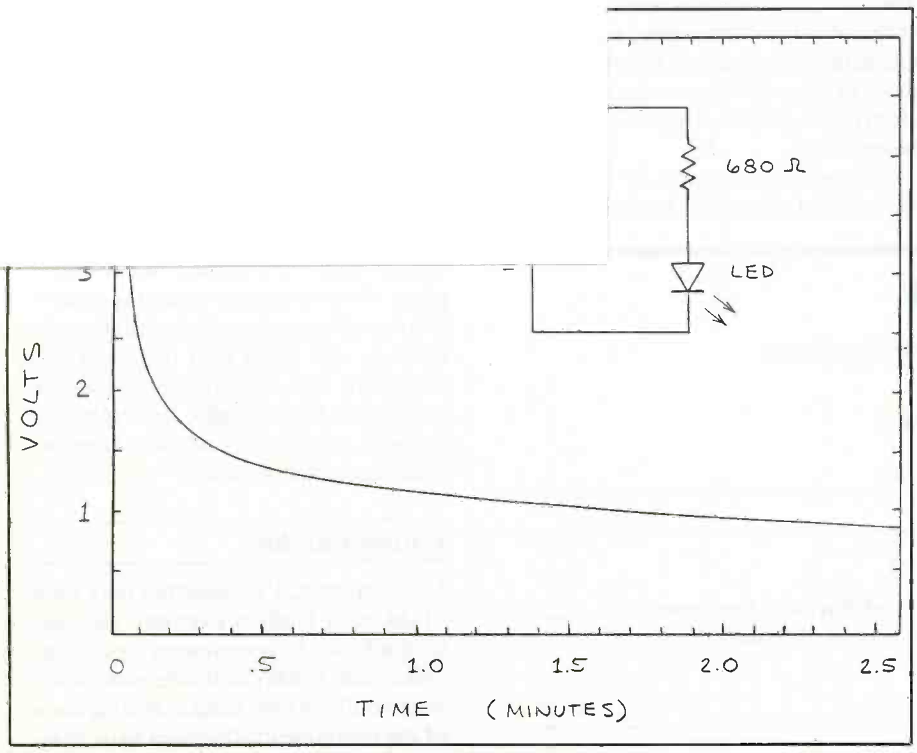


Fig. 8. Plot of discharge characteristic of homemade super capacitor through a light-emitting diode.

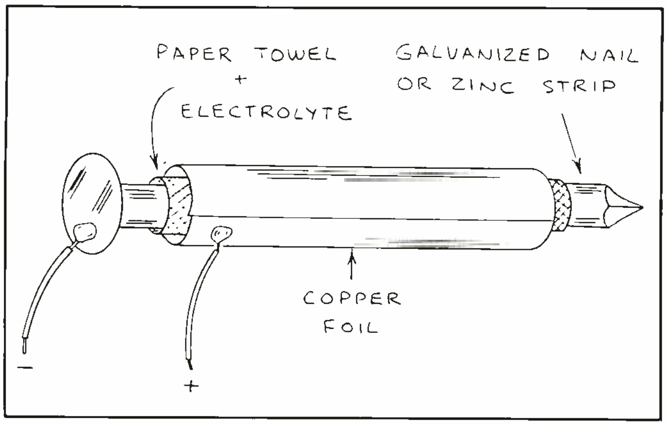


Fig. 9. Construction details of a do-it-yourself power cell.

Table 4. Measured Cell Voltages With Different Electrode Metals and Electrolytes

Electrodes		Electrolyte Salt	Electrolyte Acid
Copper (+)	Zinc (−)	0.759	1.000
Copper (−)	Silver (+)	0.200	0.131
Copper (+)	Magnesium (−)	1.400	1.484
Copper (+)	Aluminum (−)	0.570	0.720
Zinc (−)	Silver (+)	0.720	0.828
Zinc (+)	Magnesium (−)	0.622	0.546
Zinc (−)	Aluminum (+)	0.248	0.350
Aluminum (+)	Magnesium (−)	0.778	0.820
Aluminum (−)	Silver (+)	0.395	0.450
Silver (+)	Magnesium (−)	1.242	1.231

To activate the cell, place a few drops of water or even saliva on the exposed paper towel emerging from each of its ends. Alternatively, simply dip the entire cell in water for a moment.

Homemade power cells are an experimenter's delight. You can build up a stockpile of materials from which you can quickly assemble working power cells. You can make the cells in countless sizes and shapes. You can wire them in series with each other to achieve greater voltages. And you can experiment with various metals to achieve different cell potentials. Table 4 shows the voltage I measured for various combinations of five different metal electrodes and two different electrolytes.

The copper for these measurements was the foil on a pc blank; the zinc was the head of a galvanized roofing nail; the aluminum was ordinary aluminum foil; the silver was a silver coin; and the magnesium was purchased at a hobby shop. The salt electrolyte was made by mixing table salt with warm water, while the citric acid was powdered lemon drink. A piece of paper towel was soaked in each electrolyte and placed between the metals being tested.

Output voltages given in Table 4 are the peaks I measured in each case. In most cases, the measured voltage began to decline after the electrodes were pressed against the electrolyte paper. In some cases, the voltage increased to twice or more its initial level after 20 seconds or so. The results you obtain may differ according to the materials you use; so be sure to keep a record of your experiments.

Both the voltage and available current of a chemical power cell decline as one of the electrodes is dissolved or is coated with a film of hydrogen bubbles. The electrolyte of commercial power cells is designed to reduce or delay these factors.

When a homemade cell no longer functions, you can quickly restore it to its original condition. To do so, first disassemble the cell and discard the electrolyte paper. Rinse away any remaining electrolyte from the metal surfaces and allow the metal to dry. Then buff the metal surfaces with fine sandpaper until they are bright and shiny. Finally, reassemble the cell with a new sheet of electrolyte between the metal surfaces.

Going Further

In this column, I've described only some of the many kinds of electronic and electromechanical components you can make from readily available materials. I hope you'll try your hand at making some of the components described here. Maybe you'll even device some additional kinds of do-it-yourself components. **ME**

SOFTWARE FOCUS

Norton Utilities Advanced Edition Ver. 4.5

By John McCormick

It would be an understatement, indeed, just to say that Peter Norton Computing has done it again with the introduction of the Norton Utilities Advanced Edition 4.5. Packed onto the two floppy disks (both 5.25- and 3.5-inch formats are included) are now all the tools even experts should need to maintain disks and files on any MS-DOS-compatible machine.

The latest version of Advanced Edition sells for $150 and features utilities I've never seen before in such an easy-to-use form.

```
BE  Batch Enhancer        | Batch Enhancer       BE command [parameters]
DI  Disk Information      |                   or BE filespec
DS  Directory Sort        |
DT  Disk Test             |    Enhance Batch files with sound (BEEP),
FA  File Attributes       |    color (SA), keyboard input (ASK), screen
FD  File Date/Time        |    addressing (ROWCOL), character output
FF  File Find             |    (PRINTCHAR, BOX, WINDOW), and other
FI  File Info             |    attributes (CLS and DELAY).
FR  Format Recover        |
FS  File Size             | Available Commands
LD  List Directories      |    ASK         BEEP         BOX
LP  Line Print            |    CLS         DELAY        PRINTCHAR
NCC Control Center        |    ROWCOL      SA           WINDOW
NCD Norton CD             |
NDD Disk Doctor           | BE menufile
NU  Norton Utility        |    Execute multiple BE commands from the
QU  Quick UnErase         |    file, 'menufile'.
SD  Speed Disk            |
SF  Safe Format           | BE ASK ?
SI  System Information    |    Get help on using the ASK command.
                 more...  |
```

A Print Screen of Norton Integrator with Batch Enhancer highlighted.

What NU Does

Utility programs differ from applications software like spreadsheets and word processors because they deal only with the computer and other software. They are intended to assist computer users in solving common problems like locating files and making DOS easier to use.

Peter Norton was the first to provide a well-documented set of programs that help users recover inadvertent file deletions on PCs along with an easy-to-use binary editor that lets you view and edit the actual hexadecimal numbers that make up files stored on your disks.

The reason you can recover deleted files is due to a "lazy" feature of DOS, which renames it instead of removing a file when you use DEL or Erase. Norton Utilities includes a feature that locates the file and changes its name back to something usable.

Format Recover finds files on hard disks that have been accidentally reformatted. This works best if you install a special program in advance of an accident, but Norton can usually recover most of the data even if you didn't prepare for this eventuality in advance.

The reason you can recover files even after reformatting is that, just as with the delete operation, format usually doesn't overwrite any data areas. Obviously, if the deleted areas are overwritten, they cannot be restored.

Enhancements

Version 4.5 now supports DOS 3.3 extended partitions, Compaq DOS 3.31 large partitions, PC-MOS/386, and DOS 4.0 with its large partitions. Nearly all operations now have improved user interfaces, including pop-up windows and fill-in-the-blank dialogue boxes.

Speed Disk is the Norton utility that unfragments disk files by moving files around until they are arranged better. This speed-enhancing unfragmentation also makes it more likely that accidentally deleted files can be fully recovered.

The enhancement to SD in version 4.5 is that you can select the exact order in which files and entire directories are stored on-disk, a feature advanced users can use to further speed disk access.

Since the DOS DEL command merely renames files, to really remove a file (perhaps for reasons of data security) you must overwrite it; that is, you need to write new data to the same disk area. WipeFile and WipeDisk do this for individual files or entire disks and offer the chance to just overwrite deleted files.

Disk Information provides a much-needed way to append short descriptions to complement the limited file names provided by DOS, an important feature with 70-MB-plus hard disks becoming more common.

The Real Norton Utility

Norton Utilities is actually the name of the program that's used to view and modify even hidden and system files bit by bit. If you are familiar with what files should contain, then the various views (text or hex and binary) will let you explore every bit on your disk and make changes or repairs in data files or programs.

Even if you are inexperienced, this makes an excellent program to use as an aid in learning about files and disk structure with no risk of damage unless you are quite careless.

New Features

Norton Disk Doctor (NDD) adds an entirely new level of power to Norton Utilities Advanced.

First, Disk Doctor tests the DOS boot record, the FAT (File Allocation Table), the ROOT directory, and the directory structure. It then gives you the option of testing every sector of the disk and having NDD attempt to move data found in bad sectors as well as permanently lock out those bad sectors.

It takes about 45 seconds to analyze a 360K floppy on a fast computer and not much longer even on an old XT. A 33-MB hard disk requires about eight seconds for the initial tests and an additional three minutes for complete sector testing.

Beyond performing testing, NDD will also automatically repair most problems that it can locate.

SOFTWARE FOCUS . . .

Reformatting a defective diskette *without* removing the data it contains is something that NDD will do automatically, but is almost impossible to perform with any other utility program! This feature may help keep you from tearing your hair out when you encounter the famous DOS disk read error that results in the "Abort, Retry, Cancel?" prompt (the signal that you have lost some or all of the data you placed on that disk).

NDD can also take any disk (as long as there is enough empty space left) and make it a system disk, moving files out of the system area and copying IBMBIO.COM and IBMDOS.COM to the system area. This makes the disk bootable without copying off the information and reformatting the entire disk.

Safe Format is a utility that offers several faster and safer alternatives to the DOS FORMAT command.

Batch Enhancer is packed with useful enhancements that make DOS BAT (batch) files easier to create and more powerful, but is not all that new; rather, it is a collection of older programs.

ASK is now part of BE and provides for easy creation of interactive batch files (ones that ask the user a question before proceeding).

The other BE sub-programs include: BEEP, which adds tone feedback to batch files; BOX, which draws a rectangle on screen; SA, which modifies the way the screen appears; and WINDOW, a utility that creates a working window for creating your own dialogue boxes.

BE isn't as useful as you might at first think because any use of BE.EXE on a second computer, or inclusion of BE.EXE on any disk to enhance operation of batch files involving programs you wish to sell or distribute, violates the License Agreement.

New Documentation

A new publication, "The Norton Trouble Shooter," has been added to the Disk Companion and the excellent standard documentation. This new booklet contains step-by-step directions to help the novice user diagnose and repair nearly every major disk problem.

Adding this book makes Norton Utilities accessible to people who would otherwise never feel confident enough to tackle the problems that all computer users eventually encounter.

As just one example, on page 52 you learn that, while DOS 2.xx saves files just as you might by overwriting the previous file of the same name, starting with DOS 3 something entirely different happens.

If you save a file using a later version of DOS and there is enough room on your disk, the old file is deleted, but the new copy is placed elsewhere. That is, your old file remains intact and can, theoretically, be recovered if you can locate it on the disk.

Performing such an operation by brute force (looking through the entire disk for recognizable text) is feasible on a floppy disk, but out of the question for hard

```
FA  File Attributes      | Safe Format        SF [d:] [switches]
FD  File Date/Time       |    Safely format a disk without overwriting the
FF  File Find            |    data on the disk, so the data can be recovered
FI  File Info            |    if the format was accidental.
FR  Format Recover       |
FS  File Size            | Switches
LD  List Directories     |   /A         Automatic mode; useful in batch files
LP  Line Print           |   /S         Copy system files to the disk
NCC Control Center       |   /B         Leave space for system files
NCD Norton CD            |   /V:label   Place a volume label on the disk
NDD Disk Doctor          |   /1         Format for single-sided use
NU  Norton Utility       |   /4         Format a 360K diskette in a 1.2M drive
QU  Quick UnErase        |   /8         Format 8 sectors per track
SD  Speed Disk           |   /N:n       Sectors per track (8, 9, 15, or 18)
SF  Safe Format          |   /T:n       Number of tracks (40 or 80)
SI  System Information   |   /size      Size of disk (/720 will create 720K)
TM  Time Mark            |   /Q         Quick Format
TS  Text Search          |   /D         DOS Format (same as DOS)
UD  UnRemove Directory   |   /C         Complete Format (diskettes only)
```

Norton Integrator with Safe Format Highlighted.

disks, except in the case of the most critical files.

Fortunately, step-by-step instructions like "Choose Explore disk" are provided to help any user make use of NU to automatically locate this deleted but not overwritten file.

What you basically do is have NU search for a string of text that is located in the replaced file, and then write down the cluster number where the text is located.

The process is complex but will work if you follow the directions exactly, with one change. Although the directions tell you to "write down the file name that you want to recover," this doesn't work because that file is the name of the new copy and will be rejected when you try to enter the name during the recovery process. What you really want to do is type a dummy file name like XXXX and recover the data to that file, which can then be renamed easily enough.

More than 150 pages of directions help the user do everything from recovering a deleted file or repairing an accidentally formatted hard disk to making absolute sector fixes to repair master boot records or edit the partition table.

The most important thing to remember about Norton Utilities is that even if you don't know what these terms refer to, you can make the indicated repairs if you can follow simple directions.

Integration

The Norton Integrator is a simple menu listing of every feature it contains with commands used to start the stand-alone programs shown along the left side, and descriptions of the *highlighted* operation (along with an explanation of all switches and options) displayed on the right side.

This is an important feature, because there are so many utilities, with numerous options, that even an expert user would be unlikely to remember very many of them.

Conclusions

This program could be called the Clark Kent of utilities: a very powerful set of programs disguised as a simple-to-use program under Norton Integrator.

Since many of the problems that you can run into that might require the help of Norton Utilities can happen as easily to the most experienced user as they can to the novice, this is a program that belongs on every computer user's shelf if there is any information on your disks worth insuring.

The ability to add SYSTEM files to a disk not formatted with /B to leave room for those boot files, formerly beyond the skill or patience of almost every computer guru, is now available to even a novice.

Programs like File Find, that will search an entire hard disk for a text string or file name, are fairly common in collections of "hackers'" utilities floating around in user groups and on BBS (Bulletin BoardS). Thus, they are often taken for granted by many more advanced users. Their presence in this set of reliable, virus-free, utilities is essential for completeness and a welcome addition for those new to computing.

Too bad, though, that the failure to specifically exempt the BE.EXE from copy and distribution restrictions makes it of little value for most potential users.

Speed Disk is another item that looks better at first glance than it actually is. Although SD recognizes many copy-protection schemes, protects your carefully installed programs and is intelligent enough to rapidly unfragment a large disk with only a few fragmented files, if there are more than a small number of problem files SD will start moving nearly every file on the disk, which may take as much as 20 minutes.

SD doesn't do a really good job of packing files, and the disk will quickly become unfragmented again unless you have enough knowledge to carefully rearrange files before running SD.

Despite these problems, I certainly recommend Norton Utilities Advanced Edition because of the Safe Format, Norton Disk Doctor, Format Recover, and UnErase features. **ME**

ELECTRONICS OMNIBUS

Microcassette Recorders

By Curt Phillips

The widespread availability of inexpensive tape recorders is one of the more practical benefits of the state of electronics technology today. Ignoring the music available for the more high-fidelity machines, the least expensive recorders allow us to increase our efficiency by listening to recorded excerpts from a book as we drive, as well as to learn a foreign language, practice Morse code or listen to an inspirational or educational lecture.

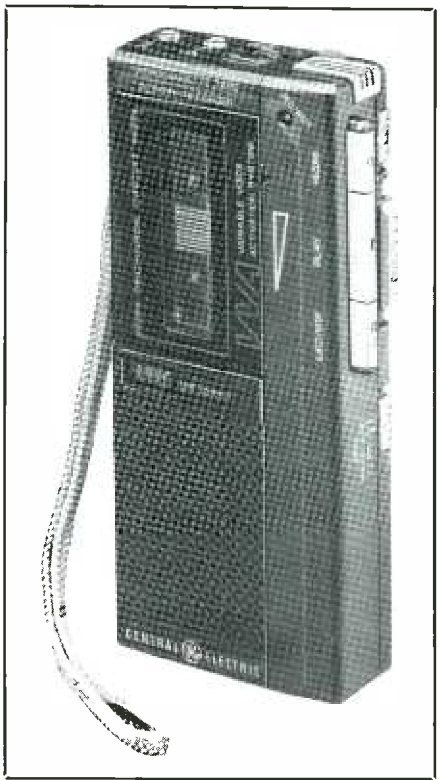
The record feature of these units allows us to record notes and ideas while driving or otherwise occupied. It often used to distress me that I wasted so much productive time while I was driving to work. A tape recorder in my car now allows me to create an audio "To Do" list that I can later transcribe. Some people, unaccustomed to hearing their voices as others hear them, use a recorder to help them improve their diction and moderate regional accents (fortunately, we southerners don't have a problem with accents).

For radio hobbyists, a recorder is invaluable both at home and in the car. At home, it can record activities on the shortwave or scanner bands for future reference and enjoyment. In the car, it can help log contacts being made so that QSL (acknowledgment) cards can be obtained. I found that having a recorder in the car at the ready for use in conjunction with my ham radio is also very useful for recording directions while traveling. Also, the microphones in most recorders are sufficiently sensitive to enable holding the recorder anywhere near the radio to provide a copy of whatever one wishes so that it can be replayed as often as desired.

The drawback of the least-expensive full-size cassette units is their size. In the past several years, however, a "microcassette" standard has emerged, which provides most of the advantages listed above in a much smaller package.

General Electric's Micro Recorders

Recently, I had a chance to become acquainted with two of General Electric's entries in the moderate-cost microcassette recorder field: the low-end Model 3-5370 and the Model 3-5326 (pictured here). In using these recorders, I've been able to compare them to a Panasonic Model RN-120 microcassette recorder (now discontinued) that has served me well for several years.



Both GE models are two-speed capstan drive microcassette recorders. Both have built-in microphones and the typical play, stop/eject, fast-forward and rewind controls. All of these controls are on the right side of the machine (when the observer has the microcassette door facing him). It took me several days of using them to notice that these controls are placed opposite those on my old Panasonic unit. Though my old RN-120 has the controls on the left side, investigation revealed that the new Panasonic microcassette recorders, as well as the new Sony units, have the controls on the right side. I can find no advantage to placing the controls on one side versus the other, which is one reason it took me so long to notice it (I never had the two different recorders side by side during this period).

One problem that I did notice quickly is the fast-forward and rewind control placement. On my old Panasonic unit, when holding the recorder with the microphone up as is normal, you slide the switch up for fast forward and down for rewind. Perhaps it is just the years of usage, but this arrangement seems logical to me; up is forward, down is reverse.

Conversely, on both GE recorders, sliding the switch up rewinds the tape and down fast forwards it. However illogical this may seem to me, this is also the pattern of the new Panasonic and Sony microcassette recorders. Evidently, some ergonomics engineers somewhere in Japan must have decided this was best. On all the units, manipulation of the fast-forward and rewind switch while in the "Play" mode allows for high-speed audible "preview" or "review" of the tape.

Some of the very early microcassette-type recorders displayed poor sensitivity from the built-in microphone, a fact that was most obvious when recording a meeting or when surreptitiously recording from a coat pocket. These latest recorders, however, have sufficient sensitivity for an average conference room meeting and also do well from a coat pocket. The more expensive 5426 has provision for an external microphone or connection to a telephone recording device. It also features "Variable Voice Activation," a mode that starts the recorder when audio is sensed either through the internal microphone or external jack. This mode is very useful for saving tape when recording off a scanner or telephone. It can be disabled, too.

Most full-size microcassette recorders have a jack next to the microphone jack that will switch the recorder on and off. Quite often, such a switch is located on an external microphone included with the recorder. Telephone recording devices and scanner interfaces that use this switching function will not connect directly with any of these microcassette recorders because they don't have such a jack. Both GE units have a pause switch, but there's no external jack that controls this function. The voice control of the

5326 will achieve a similar result, but you'll have to experiment with the connections to be sure everything works as you expect.

Recording & the Law

Because of the voice-activation feature and its small size, the 5326 could be used as a recording "bug." *Be sure to check your local and federal laws before using it in this fashion or before recording telephone calls. Surreptitious recordings is a federal offense.* It is illegal to record a call where neither party knows that the call is being recorded. This is called "wiretapping." Just because it's a recorder you connect to your home phone and all it's recording is the babysitter and her boyfriend doesn't make it legal. Recording a telephone call where one party (you) knows it is being taped is also not legal. You should notify the other party or at least have a device that intermittently beeps so that the person on the other end of the line knows something is amiss.

At $5\frac{1}{4} \times 2\frac{1}{2} \times 1$ inches, the Model 5326 stands slightly higher than the $4\frac{7}{8} \times 2\frac{1}{2} \times 1$ inches Model 5370. Unlike the 5370, the 5326 has a digital tape counter, which is useful when transcribing notes, and a LED "record" indicator light. The latter is especially useful in automobiles at night, where you're never quite sure you pressed the right buttons and it's too dark to see the microcassette's reels turning.

Both units provide a jack for an external earphone and another jack to connect an external 3-volt dc power supply for use in lieu of the two internal AA cells. Both units also have switchable speeds of 2.4 and 4.8 centimeters per second (cm/s). There are tapes available that will pack 90 minutes of recording time on *one side* of a Microcassette, which is extraordinary, considering its size.

One feature that's conspicuously missing from my old Panasonic and both GE microcassette recorders is auto-stop. Even the cheapest full-size cassette recorder automatically stops and shuts off when it reaches the end of the tape, but this feature has evidently not made it to the middle-price microcassette units.

The GE Model 3-5370 retails for $49.95, the Model 3-6326 for $39.95. Both are readily available for approximately $13 less than retail.

Facsimile Copying

A small-business-owner client of mine, who has been struggling to justify the purchase of both a photocopier and a FAX machine, came to me with a mail solicitation offering a reasonably priced combined copier/FAX machine. Although the offer was legitimate, I knew that this piece of equipment wouldn't do the job he expected. He wanted a plain-paper copier. On both this FAX machine and every one I could find at local dealers, the copy function prints on the same thermal paper as the FAX does. Additionally, the quality of the copy is approximately the same as a fine-resolution FAX reproduction. Although in both cases the copy is usable, it's not the quality of paper and print most people have come to associate with photocopy machines.

If you have business friends who may be similarly confused, you may want to warn them of the difference between a "facsimile" copy and a "photocopy."

Your comments and suggestions are welcome. You can contact me through The Source (BDK887), Delphi (CURTPHIL), CompuServe (73167,2050) or at P.O. Box 678, Garner, NC 27527. **ME**

A Few Pictures—A Few Thousand Words

By Ted Needleman

An image of the author's son, Marc, that was captured with Publisher's VGA and printed out on paper with Picture Publisher.

If the old cliche about a picture being worth a thousand words is true, how many words are two or three pictures worth? After spending a few columns on electronic music, I find myself drawn back to another obsession of mine—computer video. The acquisition, manipulation, and use of video images on a computer has numerous applications, some of which are only now becoming obvious. The most popular of these, at the moment (and, incidentally, the one of most personal interest) is capturing an image from a video camera for use with desktop publishing software. This is an obvious use of the technology; people and other 3-D objects are rather difficult to run through a page scanner.

Many other fields, though, are using video processing. These applications are as diverse as robotics and medicine. One particularly interesting use of the technology on the medical side is to capture and digitize a set of X-rays taken of the same field at different times. X-ray films, because of their nature, can often be difficult to digitize using a conventional page scanner. For one, they are often oversize for the standard 8.5 by 11-inch scanner. More importantly, X-ray films are "read" by passing light *through* them by means of a light box. Standard paper output is read by a page scanner by bouncing light *off* the surface.

By using a video camera to record the image of an X-ray film mounted on a light box, you can then digitize the video image and wind up with a digital representation of the X-ray image. In the particular application I encountered, the digitized X-ray images were of a tumor site undergoing treatment. By projecting (on the CRT) a time series of digitized images of the same field of view, the shrinkage of the tumor could be visualized. The technique itself is exactly the same as that employed in animation, where each image is slightly different from the ones that came previous to it.

A refinement of this technique, comparing two images of the exact same field of view, is used in medicine, security, and astronomy applications. By quickly alternating the views back and forth, any moving object, whether it is a growing tumor, a person moving within a secured area, or the movement of an astronomical object, seems to move against the fixed images of the rest of the frame. This approach, called the BLINK method, was originally developed decades ago by astronomers, and has resulted in the finding of numerous planets, comets, and other astronomical objects.

The foregoing was mentioned just to give you an idea of the some of the many uses video capture and processing hardware and software are being put to. Many of these applications require the use of high-resolution capture devices called "frame grabbers." A frame grabber works by analyzing one video-scan frame and converting the resolution of the video camera into the resolution of the computer's display. It then maps the displayed image into RAM memory contained on the frame grabber board, converting it into a digital representation of the gray scale image displayed. Again, depending on the amount of RAM the grabber board contains, the image may contain up to 256 shades of gray. The gray-scaled image is then saved to disk in one of a variety of formats, depending on how you intend to use it.

For this process to work, several things must be in place. Because the resolution of your image is dependent on the resolution of two devices, both the video device and the display should have the capacity for high resolution. Some video cameras that use CCD sensors have slightly lower resolution than the older tube-type cameras. This may be noticeable in the captured images.

On the computer display side, a VGA adapter card and monitor are almost necessary. VGA monitors are, for the most part, analog devices, capable of displaying shades of gray in addition to black and white. They also have higher resolution than most other display types. The exception to this is the Hercules adapter. It has a resolution higher than than that of the VGA adapter, but cannot display gray-scale images.

In addition, your display adapter should also have a considerable amount of on-board RAM. The greater the amount of RAM on the adapter, the larger the number of gray-scale levels you can capture. Ironically, in many applications (including desktop publishing), the number of levels of gray-scale is often more important than the resolution of the image. A 320 × 200-pixel image captured with 256 levels of gray-scale will often look better than 640 × 400-resolution images containing only 16 levels of gray.

I've recently been experimenting with two video capture systems. One is an inexpensive frame grabber/video adapter combination, and the other is an even less-expensive system based on slow-scan technology.

Publisher's VGA

As mentioned, there are numerous applications for video capture technology. The best way to go about implementing many of these applications is with a frame-grabber. The only problem with using this approach is that frame grabbers are expensive. Many, such as those available from Matrox and Targa, cost in excess of $1,500. Furthermore, they require a second monitor to preview the video that you intend to "grab" from. These second monitors must be analog displays, such as a multisync or good quality video display.

One relatively inexpensive solution is the economical Publishers' VGA card from Willow Peripherals. At $695, this card would be expensive if it were just a VGA adapter. Boards that provide VGA resolution can be purchased for under $300. What makes this board special is that it also has a built-in frame grabber on the card. Even if you already have a VGA adapter in your system, the under-$700 price is inexpensive for a frame-grabber.

When not using the frame-grabbing capabilities of the card, the Publishers' VGA functions as a standard VGA adapter. The standard VGA resolution of 640 by 480 pixels with 16 colors, 320 by 200 pixels with 256 colors, and 800 by 600 pixels with 16 colors are available with the 256K of RAM the board comes with. A resolution of 1,024 by 768 with 16 colors is available as an option on a special version of the board that can be ordered from Willow. The resolutions in excess of standard VGA (640 by 400) require the installation of special software drivers. The extended resolutions, however, are equivalent to those offered on expensive high-resolution monitors. Willow can supply the additional RAM, but recommends that a user purchase them mail-order from other sources, which are often much less expensive.

It is the frame grabber, however, that really sets the Publishers' VGA apart from the competition and provided the most fun for me. Using the frame-grabber feature is simple. Once the card has been installed, and the software copied to your hard disk, just plug a video camera or the video output from a VCR into the board. The card offers a standard RCA jack for this purpose. My three-year-old Panasonic camera was designed to be used with a portable recorder, taking power from the tape deck. Rather than the required RCA plug output, it has a round plug that mates on the video recorder. Most VCRs (mine included) have a VIDEO OUT jack where a standard RCA plug to RCA plug patch cable can be plugged in. The other end of this cable feeds the Publishers' VGA card input.

Installing the board was easy. There are two jumpers on the card. These are only changed if you need to use a non-standard port address, or wish to use a second monitor as a preview monitor for the frame-grabber. As there is little to be gained by this (you can capture an image right off the main display screen), most users will never alter the factory jumper settings. After plugging the card into a free expansion slot (8 or 16 bit) in your PC, install the software on your disk. Willow provides drivers for Windows and Ventura Publisher, and a software program called VCAP (Video CAPture). The drivers that Willow includes are for using the higher resolution modes (including VGA) with the Windows and GEM environments.

Incidentally, while Willow's documentation does not in clude this as a requirement, you will probably need a hard disk to make use of the frame-grabber. Depending upon the resolution and format of the image you're saving, you can expect each image to take up to a megabyte or more of disk space.

Using the frame-grabber mode of the Publishers' VGA is simple: just run the VCAP program. The first time this program is run, it will ask if you've changed any of the jumpers on the board. If you have, you'll have to specify which jumper was changed. If you did not change any jumpers, you just hit ENTER. You are then presented with a menu that allows you to acquire and manipulate an image.

The ACQUIRE IMAGE command displays the video image coming into the card. By pressing ENTER, you freeze and store what is displayed on the screen. There is a screen buffer that allows you to capture up to four images. You can then choose among these images as to which you wish to enhance. The menu allows you to make several modifications on an image. You can adjust the contrast, brightness, reverse black and white with the NEGATE command, soften the image with the OIL command, and perform edge enhancement and posterization on an image. When you are satisfied, you can save the image in either regular or compressed TIFF format (used with Windows and PageMaker), IFF (used with certain paint programs), EPS (Encapsulated PostScript), or PCX format, used with Publishers' Paintbrush and PC Paintbrush Plus.

With the PCX format, there are three resolutions available; 320 × 200 × 256 color, 640 × 400 × 16 color, or 1280 × 800 × 2 color. Separate utilities included with the hardware allow you to produce a halftone image using a dithering technique. To print out a saved image, though, you'll need a second piece of software, such as those mentioned earlier, VCAP has no provisions for printing. The image of my son Marc was captured at VGA resolution and printed with a program called Picture Publisher from Astral Development. I'll be covering this software package in detail next month, but it (and others of its type for the Macintosh, such as Image Studio and Digital Darkroom) allows you to perform such actions as merging multiple images, and cutting and pasting of images, which really enhance the utility and fun of using a frame-grabber or other image capture technique.

The Publishers' VGA card is easy to set up and use. If you've been thinking about upgrading your video adapter to one offering VGA resolution, the Publishers' VGA is a great buy. For a few hundred dollars more than a plain-vanilla VGA adapter, you get a frame-grabber similar in function and features to those costing $1,500 or more. If you already have a VGA adapter, Willow tells me they're working on a low-cost stand-alone frame-grabber board. I hope to have one of these soon, and will let you know what I think of it.

An image of the author's wife, Lynn, this one captured with COMPUTEREYES and printed with PageMaker.

COMPUTEREYES

While the Publishers' VGA card reviewed above is fun to use, not everyone can justify the $695 price tag, and the required VGA monitor, just to play around with video acquisition. If you fall into this category (as many of us do), don't despair. Digital Vision's COMPUTEREYES provides an inexpensive ($299) alternative. I first ran across Digital Vision three or four years ago when I reviewed its first video acquisition system, COMPUTEREYES for the Apple II. Over the years, they have improved the product, and now offer similar systems for the IBM PC and compatibles, as well as the Mac. I reviewed the PC version, though I would expect their other models to offer similar performance.

COMPUTEREYES is not a frame-grabber, but rather is based on a slow-scan acquisition technique. This means that it can take between 6 and 12 seconds (depending on the resolution you've specified) to acquire an image. This makes COMPUTEREYES less suitable than a frame-grabber for imaging objects, such as small children, which tend to move. I state that it is less suitable, rather than unsuitable, because there is a way around this limitation. Like most video acquisition systems, COMPUTEREYES doesn't care *where* the video image is coming from. If you have a fairly decent four-head VCR with freeze-frame capability, you should be able to get relatively good results by feeding a frozen frame into the COMPUTEREYES.

The board itself is a half-size PC peripheral, which means it can go into a short slot in your system if you have one. On the bracket that mounts to the PC's back panel, there is a grommeted pass-through from which three cables come out. These are terminated with RCA type phono connectors, one female and two male.

The female connector is the video input. As with the Publishers' VGA, if your video camera does not have this type of output, you can generally pass it through a VCR to obtain it (as I, in fact, did). The two male connectors go to the composite output jack, if one is available, on your

PC's video adapter card and to a composite monitor.

If your PC uses CGA graphics with a composite monitor, this allows you to preview an image before acquiring it. If you're using the 9-pin DB connector on your video adapter board, or an EGA, VGA, or Hercules compatible graphics adapter, you can connect the cable labeled "M" directly to an additional monitor with composite input to retain the preview function. I did not have a composite monitor available to me, so I had to monitor the image through my video camera's viewfinder.

I also experienced a bit of trouble installing the COMPUTEREYES board in my PC because the connectors on the ends of the cables were a little larger than the cut-outs in the back of my machine, and needed to be forced through. You may or may not have this problem (the system I used is an Acer 1100, a 386 PC with 8 expansion slots. With all these slots, the room between the slots is rather narrow, which necessitates slightly narrower cut-outs in the back of the PC).

The slight difficulty physically installing the board was the only difficulty encountered, though. The software consists of a single program, named EYES.EXE, and can be run from a floppy disk if desired. This software allows you to adjust the brightness and contrast (though you can have the software automatically calibrate itself), and capture and view an image. As with the more expensive Publishers' VGA, COMPUTEREYES makes no provision for printing an image. You'll have to use an additional paint package or desktop publishing software for this.

COMPUTEREYES can save an image in several different formats, such as TIFF, PIC, PCX, and MSP. It can also save in a format Digital Vision calls Raw Data. If you save the image as raw data, it can be reloaded and re-saved in a different format.

To a large extent, the format you save an image in will determine the maximum resolution and gray-scale data that is associated with the image. For example, a TIFF image, used with Aldus' PageMaker and many other desktop publishing packages, is saved at a resolution of 640 by 200 pixels, with 64 intensity levels per pixel. This is considerably less resolution than the Publishers' VGA, which offers 640 by 480 pixels (VGA resolution) with 256 levels of gray, and is evident in the unenhanced image of Marc's mom, Lynn. Lynn's image was captured as a TIFF file and placed into PageMaker, sized and printed out.

Both of the images reproduced here are un-enhanced, and used the default brightness and contrast settings. You can considerably improve the quality of captured images by first adjusting the contrast/brightness, then cleaning up the captured image with a paint program.

Granted, the image captured and reproduced from COMPUTEREYES is of a lower quality than that of the Publishers' VGA. To some extent, this results from the method (frame-grabbing vs. slow scan) used to obtain the image. Of course, you generally get what you pay for (if you're lucky), and COMPUTEREYES is less than half the price of the frame-grabber.

If you already have a VGA or multisync monitor, or are seriously considering adding VGA capability to your PC, I'd recommend going with the Publishers' VGA. If, however, you have CGA, EGA, or Hercules compatibility on your PC, and just want to get started playing with captured video, COMPUTEREYES is inexpensive and fun. ME

Manufacturers Mentioned

Publishers' VGA
Willow Peripherals, Inc.
190 Willow Ave.
Bronx, NY 10454
(212) 402-0010

COMPUTEREYES
Digital Vision, Inc.
66 Eastern Ave.
Dedham, MA 02026-9912
(617) 329-5400

Taming the Yaesu FRG-9600 vhf/uhf Receiver: An Apple II Interface

By Robert R. Frahm

Users of the Yaesu Model FRG-9600 vhf/uhf communications receiver soon discover the difference between a "scanning receiver" and just a "scanner." The memory scan feature of the Yaesu (scanning) receiver may be functional, but it is not fast, flexible, or large enough to satisfy most FRG-9600 users. The Apple II computer can overcome these limitations through use of the optional Yaesu Model FIF-65A interface. This connection results in an extremely useful data collection and analysis capability as well. (For details on CAT Control of the FRG-8800 with a Commodore C-64 computer, see the February 1988 "Communications" column.)

Making Entries

The format required for frequency entry when using an Apple II computer with the FRG-9600 using the FIF-65A interface is presented in Listing 1, lines 1 through 6. In line 2, for example, the data array location R(1) stores the second frequency. The value 1542650 equates to 154.265 MHz. Six frequencies are included to serve as examples. These values should be adjusted to reflect active frequencies in your locale.

Program line 1 sets the number of frequencies possible at 99. This number could be increased if required, along with appropriate renumbering of the program. The program tests sequential data array entries for null or non-entry. It resets to the top of the list when a null value is encountered. To avoid problems, you should enter your frequencies in adjacent data array locations.

Listing 1 assumes the receiver is set to the desired demodulation mode manually, and that all frequencies use the same mode. Optional lines given in Listing 2 permit you to use a special value, instead of a frequency entry, to direct a demodulation mode change. Group your frequencies together to follow the correct mode setting. In a mixed mode program, you must include at least two mode changes to permit you to reset the original demodulation mode.

Lines 100 through 210 allow the Yaesu FIF-65A interface to work from any slot inside the Apple II computer. As presented, the program assumes the interface is installed in slot 5. To change the slot reference, simply change the "5" in program line 150 to match the slot number for the installed interface. The instruction manual states that the interface will work only from slot 4. The ROM on the Yaesu FIF-65A interface contains computer code that has been written exclusively for slot 4. The program installs a

Listing 1. The Main Program

```
1 DIM R(99): DIM L(99): DIM D$(99): R(0) = 1541300:
  D$(0) = "FIRE"
2 R(1) = 1542650: D$(1) = "FIRE"
3 R(2) = 1542800: D$(2) = "POLICE"
4 R(3) = 1543000: D$(3) = "POLICE"
5 R(4) = 4505500: D$(4) = "POLICE"
6 R(5) = 1558650: D$(5) = "FIRE"
100 FOR I = 768 TO 794
110 READ J
120 POKE I,J
130 NEXT
140 DATA162,255,142,214,192,173,214,192,41,1,240,6,202,240,
    3,76,5,3,142,157,128,162,0,142,214,192,96
150 SLOT = 5 * 16: REM SLOT NUMBER * 16
160 L = -151
170 P = (49280 + SLOT): J = (P + 1): REM INITIALIZE FIF-65A
    INTERFACE
180 POKE J,0: POKE J,0: POKE J,0: REM INITIALIZE FIF-65A
    INTERFACE
190 POKE J,64: POKE J,207: POKE J,55: REM INITIALIZE FIF-65A
    INTERFACE
200 POKE (P + 4),0: REM MOVES ROM CODE TO $C800
210 CD = SLOT + 134: POKE 771,CD: POKE 774,CD: POKE 792,CD:
    REM SETS A->D CONVERTER CODE FOR SLOT NUMBER
220 T = 150: REM INITIAL THRESHOLD VALUE
230 PE = - 16384: REM USED TO IDENTIFY KEY PRESSED
240 PO = - 16368: REM USED TO CLEAR KEYBOARD STROBE
250 HOME
260 PRINT "CHAN. THRESHOLD  CALLS  FREQUENCY": PRINT
270 POKE 34,2

     Note:Do not type REM statements below this point,
          as they slow the channel scan routines and
          may cause timing errors during the frequency
          setting routine. They are provided here for clarity.

280 I = FRE (0):REM FORCES GARBAGE COLLECTION
290 C = R(G): G = G + 1: REM ADVANCES CHANNEL COUNTER
300 IF C < 60 THEN G = 0: GOTO 280: REM TESTS FOR LAST CHANNEL
310 D = C: REM START OF FREQUENCY SET ROUTINE
320 FOR I = 7 TO 1 STEP - 1
330 F(I) = D - (INT (D / 10) * 10)
340 D = INT (D / 10)
350 NEXT I
360 D1 = 10
370 POKE P,D1: REM INDICATES TO Yaesu FRG-9600 THAT THIS IS A
    FREQUENCY CHANGE (VS. A DEMODULATION MODE CHANGE)
380 D2 = (F(1) * 16) + F(2): POKE P,D2
390 D3 = (F(3) * 16) + F(4): POKE P,D3
400 D4 = (F(5) * 16) + F(6): POKE P,D4
410 D5 = (F(7) * 16) + 00: POKE P,D5
420 K = PEEK (PE): POKE PO,0: REM TEST AND CLEAR KEYBOARD
430 IF K = 212 THEN GOTO 700: REM T - SET THRESHOLD
440 IF K = 210 THEN GOTO 750: REM R - SUMMARY REPORT
450 DA = 0: REM BEGINNING OF AGC TEST
460 FOR I = 1 TO 8
```

copy of the ROM code in another portion of memory, then changes the code to be consistent with the slot number.

"Garbage" Collection

Line 280 forces a "garbage-collection" operation before each frequency change. ("Garbage collection" is a term used to describe the computer's periodic recalculation of available memory.) This action will occur unpredictably, if it is not forced and, thus, can occasionally interfere with proper timing of data pulses. This interruption can result in the setting of unpredictable frequencies or modes.

The program permits a new threshold value (similar to setting the squelch control by manual means) to be used by pressing the "T" key on the Apple II's keyboard. The initial threshold value is set in line 220 of the program. It may require adjustment, depending upon the level of electrical noise in the local environment. Manual squelch can be set independently of the software threshold, of course.

Pressing the "R" key on the computer's keyboard will return an on-screen report of activity. However, if a particular frequency was not active, nothing will be reported. When a report is made, the percentage figure displayed represents the number of stops at the reported frequency, divided by the total number of stops. If a printer is activated with "PR#1" (or similar command) before running the program, a hard-copy printout of all screen activity will result.

Program lines 450 through 490 measure the receiver's automatic-gain control (agc) voltage. This measurement is directly proportional to signal strength. Line 500 determines if the frequency is active or inactive. The agc voltage is measured and summed eight times before being compared to the threshold value. This method seems to differentiate between voice and other modulation patterns. Lines 510 through 690 in the program continue to test signal strength, and delay after the frequency is clear.

The delay time is set in line 670 of the program. The value "3000" permits five seconds of delay. This feature allows the computer to pause a reasonable period of time on a formerly active frequency, to await a reply. This "dwell" time can be adjusted by changing the initial value in line 670.

```
470 CALL 768
480 DA = DA + PEEK ( -32611)
490 NEXT I
500 IF DA < T THEN GOTO 280: REM TEST FOR BUSY CHANNEL
510 L(G) = L(G) + 1: REM ADVANCE INDIVIDUAL CHANNEL BUSY DATA
    (USED IN SUMMARY REPORT)
520 PRINT G;: REM PRINTS CHANNEL NUMBER
530 HTAB 8
540 PRINT DA;: REM PRINTS SIGNAL STRENGTH (RELATIVE AGC VOLTAGE)
550 HTAB 20
560 PRINT L(G);: REM PRINTS NUMBER OF TIMES CHANNEL WAS BUSY
570 HTAB 25
580 PRINT (C / 10000);: REM PRINTS FREQUENCY ASSIGNED TO THE
    CHANNEL
590 PRINT " "; D$(G - 1): REM PRINT THE REMARK ASSIGNED TO THE
    CHANNEL
600 W = W + 1: REM ADVANCE THE TOTAL BUSY CHANNEL COUNTER
610 DB = 0: REM BEGINNING OF ROUTINE TO SEE IF THE CHANNEL IS
    STILL BUSY
620 FOR I = 1 TO 8
630 CALL 768
640 DB = DB + PEEK ( -32611)
650 NEXT I
660 IF DB => T THEN GOTO 610: REM LOOP UNTIL CHANNEL IS NOT BUSY
670 FOR B = 1 TO 3000: REM DELAY FOLLOWING BUSY CHANNEL RELEASE
680 NEXT B
690 GOTO 420: REM ADVANCE TO NEXT CHANNEL
700 PRINT "NEW THRESHOLD VALUE? ";: PRINT T;: HTAB 23: REM SET
    NEW THRESHOLD VALUE
710 INPUT ""; TT
720 IF TT = 0 THEN GOTO 280: REM DOES NOT CHANGE THRESHOLD IF 0
    IS ENTERED
730 T = TT
740 GOTO 280
750 PRINT "CHAN.:;: REM BEGINNING OF SUMMARY REPORT ROUTINE
760 HTAB 6
770 PRINT "ACTIVITY";
780 HTAB 23
790 PRINT "FREQUENCY"
800 FOR X = 0 TO 99
810 IF L(X) = 0 THEN GOTO 910: REM TESTS TO SEE IF THERE IS
    ANYTHING TO REPORT
820 HTAB 3
830 PRINT X;
840 HTAB 6
850 PRINT L(X);" (";
860 PRINT INT (100 * (L(X)/W));
870 PRINT " %)";
880 HTAB 20
890 PRINT R( X ) 1) / 10000;
910 PRINT " "; D$( X - 1)
910 IF R(X) < 60 THEN X = 99: REM TESTS TO SEE IF THIS IS THE
    LAST CHANNEL
920 NEXT
930 PRINT "END OF REPORT"
940 GOTO 280
```

Running the Program

The following lines can be added to Listing 1 to verify that the program is operating correctly:

```
495 PRINT "SCANNING "; DA
655 PRINT "HOLDING "; DB
685 PRINT "DELAYING"
```

These program additions can help determine the correct initial value for the threshold. "SCANNING" and the program variable "DA" value are printed on the computer's video screen while the Yaesu receiver is scanning under computer control.

Following the first value above the threshold value printed, the screen indicates "HOLDING," which is then followed by the program variable "DB" values. When a DB value that is below the threshold value is printed, the program prints "DELAYING" and begins the delay discussed above. Following the delay, the program scans at the busy frequency once again to determine if it is still busy and prints another DA value before proceeding to the next phase.

Once proper program operation and threshold values have been determined, the lines given in Listing 3 should be removed from the main program. If they are not deleted, these extra lines will slow the scan operation.

Because different activities require different frequencies, I have one program version crammed with all the published frequencies that are active in my area and other programs tailored to specific situations, like ham, fire, police, aircraft, etc. activities.

I also control my Yaesu FRG-8800 hf communications receiver with my Apple II computer and a second Yaesu interface. This second interface card is installed in my Apple II computer's slot 3. With the information presented here, you should find the task of interfacing the Yaesu FRG-9600 vhf/uhf communications receiver and other Yaesu CAT products a little easier to perform.

Listing 2. Optional Program Lines

```
7 R(6) = 21: REM WILL SET WIDE BAND AM DEMODULATION
8 R(7) = 1215000: D$(7) = "EMER.AIR": REM AIRCRAFT FREQUENCY
9 R(8) = 22: REM WILL SET NARROW BAND FM DEMODULATION
295 IF C > 15 AND C < 24 THEN D1 = C: GOTO 370

     Note: R(X) = 17 will set upper sideband.
           R(X) = 23 will set wide-band FM.
           R(X) = 20 will set narrow-band AM.
```

BOOKS

The Laser Cookbook by Gordon McComb. (Tab Books. Soft cover. 404 pages. $17.95.)

This is a "hands-on" book for readers who not only want to know about helium-neon and semiconductor lasers and how they operate, but want to build projects around them that they can put to practical use. Though it does give healthy doses of theory, the book's main thrust is the 88 practical projects it details how to build. To get things started, though, there are a few introductory chapters that deal with general topics, like the developments leading up to the laser, safety precautions to be observed when working with lasers, and the anatomy of the typical He-Ne laser. From here onward, the book concentrates on projects and techniques.

This book covers a wide range of topics and applications. Among them are communication over a laser beam, creating and viewing three-dimensional holographs, building equipment for creating fascinating laser light shows, studying aerodynamics and airflow, coherent-light seismology experimenting and using a laser beam to create intrusion-detection systems. Aside from these, the book also covers use of fiber optics in laser systems.

Using this book, the reader can construct a Michelson interferometer, free-air light communicator, He-Ne laser pistol, perimeter burglar alarm and dozens more projects. Accompanying each project entry are a full circuit diagram, complete parts list, an explanation of how the projects operates and a discussion of how to use it. Other detailed drawings are supplied where needed. Projects are geared to both the the curious person who has no technical training with lasers as well as the more advanced person who wishes to get deeper into experimenting with laser technology and applications. To this end, some application topics like light-beam communications, holography and light shows have separate beginners and advanced chapters.

To make the book as complete as possible, the author includes a chapter devoted entirely to tools for laser experimenting and another to buying laser parts. Additionally, an appendix gives sources for components, parts and systems and another appendix lists magazines and books to check out for further study. In sum, this book provides a fascinating tour through the world of lasers. It is well written, amply illustrated—and lots of fun.

NEW LITERATURE

Full Product Line Catalog. The Spring edition of the Heathkit catalog is now available. Listed, pictured and fully described in the colorful 98-page catalog are hundreds of kit and factory-assembled products ranging from audio/video to communications to test equipment to computers and more. Among the new offerings described in this catalog is a 27-inch digital color TV receiver with picture-in-picture capability that lets one view two channels or sources simultaneously on the same picture screen. Other items highlighted in the catalog are Heath's first radio-controlled sailboat, airplanes, and a complete selection of fish-finding and navigational equipment. For a free copy, write to: Heath Co., Dept. 350-041(ME), Benton Harbor, MI 49022.

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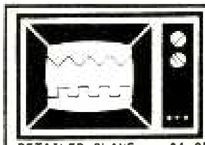

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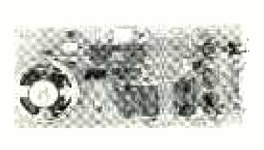

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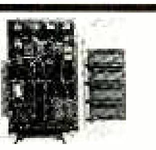

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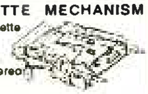

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2N3904	[illegible]	TO-92	5 for 75¢
2N[illegible]	[illegible]	TO-92	5 for 75¢
[illegible]	[illegible]	TO-92	5 for 75¢
[illegible]	[illegible]	TO-92	5 for 75¢
[illegible]	[illegible]	TO-92	[illegible] $1.00
2N5880	[illegible]	[illegible]	$2.00 each
2N5882	[illegible]	[illegible]	$2.00 each
MJ2955	[illegible]	[illegible]	$1.50 each
MJE2955T	[illegible]	[illegible]	[illegible]
MJE3055T	[illegible]	[illegible]	[illegible]
TIP[illegible]	[illegible]	[illegible]	[illegible]
TIP31	[illegible]	[illegible]	[illegible]
TIP[illegible]	[illegible]	[illegible]	[illegible]
TIP41	[illegible]	[illegible]	[illegible]
TIP[illegible]	[illegible]	[illegible]	[illegible]
TIP131	[illegible]	[illegible]	[illegible]
TIP[illegible]	[illegible]	[illegible]	[illegible]

WIDE BAND AMPLIFIER

NEC# UPC1651G. 1200 Mhz @ 3 db.
[illegible] 19db @ [illegible]-500 hz. 5 volt operation
Small package 4mm dia. X 2.5 mm thick.
CAT# UPC-1651 2 for $1.00
10 for $4.50 • 100 for $35.00

N-CHANNEL MOSFET

IRF-511 TO-220 case
CAT# IRF 511
$1.00 each - 10 for $9.00
LARGE QUANTITY AVAILABLE

OPTO SENSOR

U shaped package with mounting ears. 1/8" opening. 3/4" mounting holes. CAT# OSU-5 50¢ each
10 for $4.50 - 100 for $40.00

WALL TRANSFORMERS

ALL PLUG DIRECTLY INTO 120 VAC OUTLET

6 Vdc @ 200 ma.	CAT#	DCTX-620	$2.25
6 Vdc @ 750 ma.	CAT#	DCTX-675	$3.50
9 Vdc @ 250 ma.	CAT#	DCTX-925	$2.50
12 Vac @ 930 ma.	CAT#	ACTX-1293	$3.50
18 Vac @ 1 amp	CAT#	ACTX-1888	$3.50

SWITCHES

ITT PUSH BUTTON
ITT MDPL series. 3/4" X 1/2" gray rectangular key cap. S.P.S.T., N.O. Push to close. RATED: 0.1 amp switching, 0.25 amp carry current. P.C. mount. CAT# PB-6
65¢ each • 10 for $6.00 • 100 for $50.00

10 POSITION MINI-ROTARY
Grayhill# 56P36-01 [illegible] ON-C
Mini rotary switch. Non-shorting. 1 deck, 10 positions. .125" dia. shaft X .375" long. .377" behind the panel depth. P.C. pins.
CAT# MRS-10 $2.50 each

HALL EFFECT SWITCH
MICROSWITCH# 4BE3
Slanted keyboard switch with hall effect sensor. Snaps into 5/8" square chassis hole. Hall effect sensor slides easily from switch and can be used in other applications.
CAT# HESW 4 for $1.00
10 for $2.00 • 100 for $15.00

SPDT PUSHBUTTON
Marquardt# 1843
Rated 6 amps @ 125/250 Vac.
Black plastic pushbutton.
Switch body: .92" X .94" X .65"
CAT# PB-18 $1.85 each • 10 for $1.50 each

LED'S

STANDARD JUMBO
DIFFUSED T 1-3/4 size
RED CAT# LED-1
10 for $1.50 • 100 for $13.00
GREEN CAT# LED-2
10 for $2.00 • 100 for $17.00
YELLOW CAT# LED-3
10 for $2.00 • 100 for $17.00

FLASHING LED
with built in flashing circuit operates on 5 volts.
RED $1.00 each
CAT# LED-4 10 for $9.50
GREEN $1.00 each
CAT# LED-4G 10 for $9.50

BI-POLAR LED
Lights RED one direction GREEN the other. Two leads.
CAT# LED-6 2 for $1.70

LED HOLDER
Two piece holder.
CAT# HLED 10 for 65¢

RELAYS

12 VOLT D.C. COIL S.P.D.T.
Omron# G2E 184P
4 Amp contacts
335 ohm coil
Sugar cube size.
.61" X .42" X .44" high
P.C. mount with pins on DIP spacing.
CAT# RLY-787 $1.50 each

120 VOLT A.C. - D.P.D.T.
GUARDIAN# 1220U-04
10 Amp contacts
1,100 ohm coil
1.703" X 1.578" X 1.687". Clear polycarbonate cover. Gold plated solder or socket mount terminals.
CAT# RLY-220 $3.50 each

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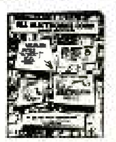

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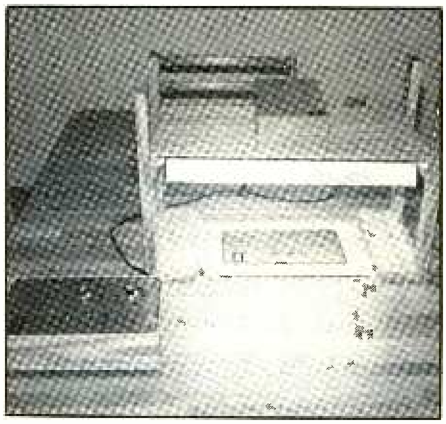
ADVERTISERS' INDEX

LETTERS...

(from page 7)

• Publication of the "Programmable Appliance Timer" (February 1989) and "UV Exposure Light" (March 1989) couldn't have been at a more fortuitous time for me. I've needed this combination for some time now and thought I would have to design them myself. As you can see in the photo of both projects I built, I made a few modifications in the Exposure Light to create a cleaner appearance. But to get both projects to work, some changes had to be made in the published material.



In the Timer article's Parts List, change C4's rating to 25 volts, change the value of R33 to 820 ohms and include XTAL1 with a frequency of 32.768 kHz. Labeling of IC8 and IC9 in Fig. 1 should be transposed and some gates relabeled to conform to Fig. 6, though Fig. 1 is technically correct. (It would have been helpful if pin numbers had been included in the schematic.) In the Light article, Fig. 2, label the top ends of B1, B2 and B3 with B1A, B2A and B3A, respectively, and use these three designations to replace N1C, N2C and N3C in Fig. 4. The Parts List specifies 15-watt starters for the lamp, while 20-watt units are mentioned in the text. Either can be used, though I would go with the latter.

David H. Bevel
Norcross, GA

NEW PRODUCTS...

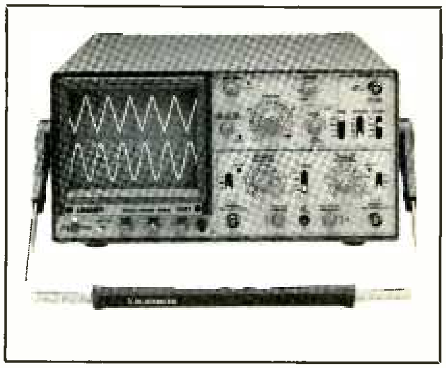
(from page 13)

Low-Cost 80386 Computer

HiTech International (San Jose, CA) announces a low-cost 16-MHz 80386 computer that is claimed to be Compaq compatible. The Model SAM-30001/386 computer comes with 1M byte of RAM and a 1.2M-byte floppy disk. It also includes hard/floppy-disk controller, 200-watt power supply and 101-key enhanced keyboard. Optional are 80287 and 80387 math coprocessors, hard disks and video monitors. $999.

CIRCLE 76 ON FREE INFORMATION CARD

20-MHz Oscilloscope



Leader Instruments Corp. has a new modestly priced two-channel 20-MHz bench oscilloscope. The Model 1021 scope features an ergonomic front panel that is said to make operation simple and straightforward while offering comprehensive triggering controls that include variable trigger hold-off, TV-V and TV-H sync separators, LF-Reject and line triggering. The scope offers 1 mV sensitivity so that very-low-level input signals can be observed on the 8 × 10-cm rectangular CRT screen. An internal graticule, automatic focus and scale illumination are standard features. The scope is housed in a rugged metal case and comes with a carrying handle that doubles as a tilt stand. $550.

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(The VHF converter options must be used in the R-5000 and R-2000.)

R-5000

The R-5000 is a high performance, top-of-the-line receiver, with 100 memory channels, and direct keyboard or main dial tuning—makes station selection super easy! Other useful features include programmable scanning, large, built-in speaker, 110 volt AC or 12 volt DC operation (with optional DCK-2 cable), VHF capability (108-174 MHz) with the VC-20 option, dual 24-hour clocks with timer, and even voice frequency readout with the VS-1 option.

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.

Optional Accessory
• **PG-2N** Extra DC cable

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 • **HS-7** Mini-headphones.

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