YOUR ONE-STOP SOURCE OF ELECTRONICS INFORMATION

ICD 08559

MODERN ELECTRONICS

MAY 1989 $2.50
CANADA $3.50

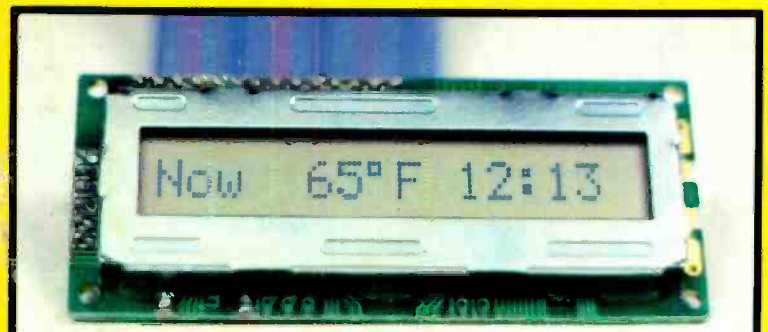
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

- Cumulative UV Alarm For Safe Suntanning
- How To Use Frequency Counters

Also:

- Understanding VGA Graphics
- Controlling AC Motor Speed
- Automotive Sensing/Switching Car Equipment Relay
- Add-On Telephone "Hold" Circuit
- An Analog-Display Digital Clock
- Microprocessor Control With BASIC

SunGuard Alerter For Safe Sunbathing (p. 22)



"Smart" Thermometer Accessory (p. 38)

Apple's New Macintosh SE-30 Computer (p. 68)

05
0 74820 08559

Plus: Apple's new Macintosh SE/30 68030-Based Computer • Forrest Mims Experiments with Thermistors • MIDI Computer Hardware & Software • Evaluating Conversion-Unit Software • Electronics & Computer News • Latest Technical Books & Literature . . . more.

OPTOELECTRONICS

COUNTER THEORY

Affordable, compact, and ultra-sensitive. More and more people are discovering new applications for our counters than ever before. Now used by technicians, engineers, law enforcement officers, private investigators, two-way radio operators, scanner hobbyists, and amateur radio operators, just to name a few.

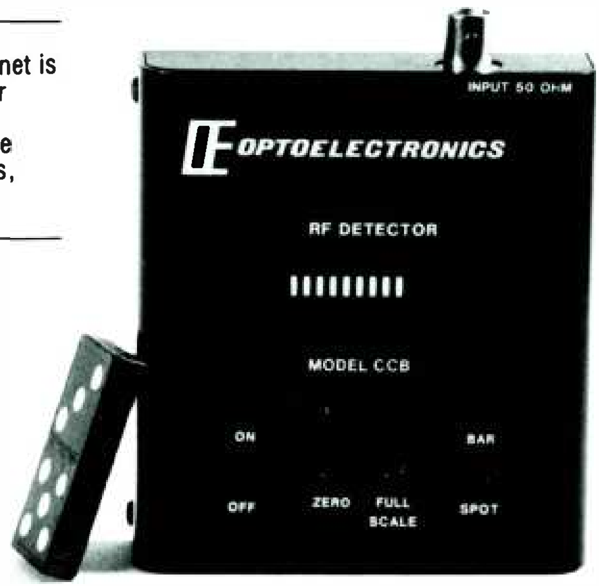
Over 15 years of service, quality, experience and dedication has proven you can count on us.

Hand Held Series Frequency Counters and Instruments

MODEL	2210 *New*	1300H/A	2400H	CCA	CCB *New*
RANGE: FROM TO	10 Hz 2.2 GHz	1 MHz 1.3 GHz	10 MHz 2.4 GHz	10 MHz 550 MHz	10 MHz 1.8 GHz
APPLICATIONS	GENERAL PURPOSE AUDIO-MICROWAVE	RF	MICROWAVE	SECURITY	SECURITY
PRICE	$199	$169	$249	$299	$99
SENSITIVITY					
1 KHz	< 5 mv	NA	NA	NA	NA
100 MHz	< 3 mv	< 1 mv	< 3 mv	< .5 mv	< 5 mv
450 MHz	< 3 mv	< 5 mv	< 3 mv	< 1 mv	< 5 mv
850 MHz	< 3 mv	< 20 mv	< 5 mv	NA	< 5 mv
1.3 GHz	< 7 mv	< 100 mv	< 7 mv	NA	< 10 mv
2.2 GHz	< 30 mv	NA	< 30 mv	NA	< 30 mv

ACCURACY ALL HAVE +/− 1 PPM TCXO TIME BASE.

All counters have 8 digit red .28″ LED displays. Aluminum cabinet is 3.9″ H x 3.5″ W x 1″ Internal Ni-Cad batteries provide 2-5 hour portable operation with continuous operation from AC line charger/power supply supplied. Model CCB uses a 9 volt alkaline battery. One year parts and labor guarantee. A full line of probes, antennas, and accessories is available.



OPTOELECTRONICS INC.
5821 N.E. 14th Avenue
Fort Lauderdale, FL 33334
(800) 327-5912 IN FL (305) 771-2050

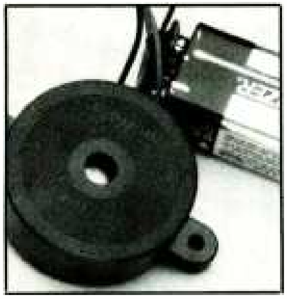
MasterCard VISA

CIRCLE NO. 145 ON FREE INFORMATION CARD

MODERN ELECTRONICS
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

MAY 1989

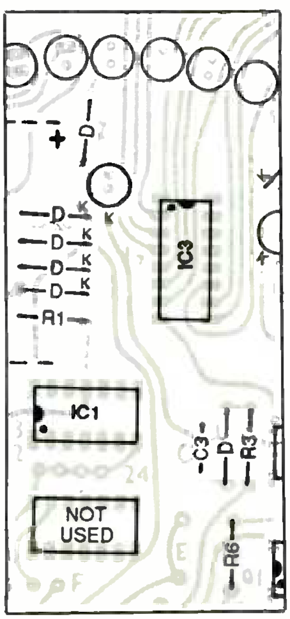
VOLUME 6, NUMBER 5



22

33

38



54

FEATURES

COLUMNS

DEPARTMENTS

EDITORIAL STAFF

Art Salsberg
Editor-in-Chief

Alexander W. Burawa
Managing Editor

Dorothy Kehrwieder
Production Manager

Melissa Kehrwieder
Production

Elizabeth Ryan
Art Director

Barbara Scully
Artist

Pat Le Blanc
Florence V. Martin
Phototypographers

Hal Keith
Illustrator

Bruce Morgan
Photographer

Forrest Mims III, Ted Needleman, Curt Phillips
Contributing Editors

BUSINESS STAFF

Richard A. Ross
Publisher

Art Salsberg
Associate Publisher

Dorothy Kehrwieder
General Manager

Frank V. Fuzia
Controller

Arlene Caggiano
Accounting

Catherine Ross
Circulation Director

Kathleen Bell
Customer Service

SALES OFFICES

Eastern/Midwest
Modern Electronics
76 North Broadway
Hicksville, NY 11801
(516) 681-2922
FAX: (516) 681-2926

Western Advertising Representative
JE Publishers' Representative
6855 Santa Monica Blvd., Suite 302
Los Angeles, CA 90038
(213) 467-2266
FAX: (213) 462-0684
Jay Eisenberg, Director

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.

Postmaster: Please send change of address notice to Modern Electronics, 76 North Broadway, Hicksville, NY 11801.

Spring Specials from Heath

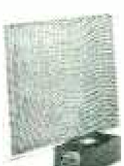
Kit projects...

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**

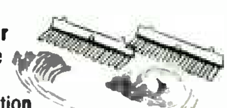
Noise generator kit To properly check out any stereo or sound system with a spectrum analyzer, you need a noise source with a nearly constant energy output. This one-evening Pink/White Noise Generator will do just that...and at a fraction of the cost of comparable noise generators. Kit AD-1309 (2 lbs.)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

Make life easier...

Full-featured remote control center for your TV, VCR and CATV Assd. GDZ-143 (1 lb.) ... **$29.95**
**Zenith cannot guarantee that the PCC will operate every model TV or VCR.

Recharge your NiCd batteries Assd. BP-1234 (4 lbs.) **$17.95**

Amber screen fish finder Assd. MI-2020 (6 lbs.) ... **$244.95**
Accessories: Transom Mount Transducer Assd. MIA-2020-1 (4 lbs.) ... **$44.95**
Through-Hull Transducer Assd. MIA-2020-2 (6 lbs.) ... **$99.95**

Full color fish finder Assd. MI-2040 (10 lbs.) .. **$399.00**

Portable weather computer travels in your shirt pocket Save over $15 on this compact weather instrument that goes with you hiking, biking, boating and camping. Gives time, date and current temperature, plus keeps a record of highest and lowest temperatures. Also acts as a stopwatch. Automatic power-down feature extends battery life. Requires three AAA batteries (not included). Assd. BW-100 (1 lb.).Now only **$24.95**

Heathkit®
to order CALL TOLL FREE
1-800-253-0570
Use order code 216-079

charg-a-kit VISA AMERICAN EXPRESS MasterCard

for credit card orders, 24 hours a day.

Some items are closeouts. All items are available in limited quantities. Prices for some items were previously reduced.

For your free Heathkit catalog call 1-800-44-HEATH.

CIRCLE NO. 115 ON FREE INFORMATION CARD

EDITORIAL

Profile of an M-E Reader

To get a fuller grasp on your professional and avocational background so that we may serve you better, we carry out reader research surveys from time to time. We just completed our second one, the "1989 Modern Electronics Reader Study," which was a four-page questionnaire sent to a large sampling of our subscribers. A similar study was taken three years ago.

The latest one reveals that much has changed, while, at the same time, little has changed. For example, 62.8% of respondents said that their interest in electronics or computers is primarily related to their employment. This is about the same percentage as the older 1986 Study disclosed, which was 65.4%. About 13% noted that their interest was due to studying electronics or planning to make it their career, as compared to 1986's 10.4%. Given error tolerances in all such sample-based studies, there's nary a difference here from three years ago.

On the other hand, three years made a great difference in responses to questions related to computers. Whereas 69.8% of respondents now indicate they plan to buy a computer within the next 12 months, only 27% had such buying plans only three years ago. Furthermore, IBM and compatibles were easily first choice in 1989, with 74.6% of *Modern Electronics* respondents who indicated they're buying a computer affirming this. In contrast, only 40.4% made this decision in 1986 (where this choice still ran first). At that time there were also some MS-DOS-type computers that were not compatible with IBM personal computers, and Commodore computers were much more popular then, which accounts for the difference in types of computers chosen.

Apple Macintosh computer brand preference rose to 10.4% from 4.4%, while Apple II-type computers dropped to 4.4% from 1986's choice by 7%. Apple Computer's product total, therefore, increased by 3.4% in brand preference buying among *Modern Electronics* subscribers.

The 1989 Study demonstrates how much Commodore-64 and -128 models dipped among readers' preferences, with only 2% choosing it among respondents saying they plan to buy a computer as compared to 1986's 21.9%!

Based on '89 results, *M-E* readers also will be heavily involved in upgrading their computers. For example, 50.1% noted that they plan to add a hard-disk drive in the next 12 months, as compared to 1986's 14%; 29.1% say they'll be adding a modem, while 14.9% said the same three years ago; 27.3% for a color monitor, while 11.7% of '86 readers noted this addition coming up. Laser printers were pinpointed for buying soon by 23% of respondents, while in 1986 *all* printer types expected to be purchased amounted to 13.9%.

Asked whether computers to be purchased will be used mostly for business/professional or personal applications, 38% chose business/professional, whereas 46.8% had made this choice in '86. What caused this change, one might wonder? I believe the increase in personal use of computers is due to a few cogent reasons: substantially lower selling prices of IBM clones, which at the same time are much more powerful than the old Commodore and Atari 8-bit machines. Furthermore, there's now plenty of low-cost, effective MS-DOS software available. Additionally, adults and their children are increasingly more computer literate.

In spite of the lower Business/Professional use percentage (−8.8), however, about *twice as many* readers plan to use the computer they plan to buy for business/professional applications! This is because the *total* number of expected *Modern Electronics* computer purchasers in 1989 is so much greater than it was in 1986—about 49,000 vs. 20,000 readers. So extrapolating the much higher figure with a moderately lower percentage against the entire *Modern Electronics* circulation yields a much higher number of buyers (in this case, double the number!).

Among subscribers who plan to buy test instruments this year, 68.9% say they'll be buying digital mutltimeters within the next 12 months (vs. 1986's 11%) and 64% noted that they plan to buy dual-trace oscilloscopes (vs. 1986's roughly 16%). Among them, 47.8% plan to buy test instruments mostly for business/professional purposes. (This application question wasn't posed in 1986.)

Respondents involved in company purchasing were asked, on a multiple-choice question, how many employees were in the company. Except for the extremes of the smallest number (1 to 9) and the largest groups (1,000 and over, and 250 to 999), the figures closely matched 1986's. Respondents who worked (or owned) very small companies gained 6.7%, now totaling 30.6%. The group ranging from 250 to 999 lost 2.6%, while 1,000 and over lost 3.2%; together they now total 34%. Remaining groups, 50 to 249 and 10 to 49 employees, account for 35.4%.

Length of time working in the electronics or computer fields are telling indicators of a reader's on-the-job knowledge, as well as a rough indicator of age. This is the way we posed our question, rather than in age brackets. Six choices were offered, starting with "None." 15.4% chose this category, the only one that's difficult to pinpoint by age since a respondent could be a young student, but could also be an older person who is considering a career change.

The next choice was 1 to 5 years experience, to which 20.4% checked off. Age here probably ranges from 21 to 27 years. This was followed by 24.9% for 6 to 15 years experience, which likely translates to 26 to 37 years old. For 16 to 25 years experience, which is probably a 36 to 47-year-old range, 20.2% were counted. Next, 10.5% were in the 26 to 35 years experience range, probably aged 46 to 57, while another 8.8% had over 35 years experience and are over 55 years old. The median years of work experience should then be about 11 years, while age should be around 31 or 32 years or so.

Comparing the foregoing figures to 1986 Study results indicates that the *Modern Electronics* reader's average age now is about five years younger than it was. Since the 1986 median age was 36 years old, our guesstimate of 31 to 32 years at present is about right on the head.

Readers holding the title, "Engineer," remain constant at 27.6% (27.5% in 1986). Technicians, though, exhibited a steep rise to 36.4% (from 27.5). With Management readers being the same (15.5% vs. 15.6), this came out of the hides of other principal titles. Educators came in at 6%, which adding to 6.2% Professional and Technical (Chemists, Computer Programmers, Physicians, Scientists, etc.) totals 12.2% compared to '86's 13.4%; Sales, Clerical, etc., had 1.7%, while Craftsmen (Mechanics, Electricians, etc.), had 2.4%, for a 4.1% total, as compared to 1986's 7.3%. Students were at 3.1%, whereas three years ago they were 6.2% of subscribers; and Retired/Unemployed came in with only 1.2% vs. 1986's 2.3%.

An interesting new question was posed this year to narrow down what our reader does during his working hours. It was: "What's your main function?" This was followed by five choices, including an "Other" category. Leading was Maintenance/Repair, with 37.1% noting this. Next was Design or Development, 28.9%;

(Continued on page 70)

AUTOMOTIVE ELECTRONICS. Toyota plans to produce electronic control units for their cars, likely beginning such operations in mid year in a new plant that's expected to employ about 1,000. Electronics in cars continues to expand, led by digital displays, electronic engine control and fuel injection, with sharp growth displayed by cruise control, electronic-controlled suspensions, and anti-skid braking. The U.S. Big Three, GM, Ford and Chrysler, have long been captive producers of automotive electronics, of course. Worldwide, though, independent suppliers lead, with West Germany's Bosch and Japan's Nippondenso accounting for some 30% of a nearly $15-billion market.

THE VOICE HAS IT. Computerized voice applications continue to grow. Heath/Zenith's latest "voice" is a simulation of a barking dog. Part of the company's Barking Dog Security Alarm System, with a suggested retail price of only $59.95, it's actually an infrared motion detector housed in a weather-tight case. The unit employs Pulse Count Technology to prevent small animals from falsely triggering the alarm. The dog bark can be switched to a pleasant-sounding chime, too....NYNEX Mobile Communications has introduced an exciting new cellular telephone that's activated by the operator's voice. It can be set up to automatically dial up to 20 pre-programmed phone numbers at just the sound of a voice. Additionally, its new NYNEX Model 832SR allows users to leave a 15-second personal voice message to incoming callers when away from the vehicle, and has an RJ11 jack output for use with portable laptop computers and modems. To use voice dialing, the operator simply depresses any key on the phone and says the name of the person to be called. The 832SR confirms the name and then automatically dials the number. Moreover, it has the ability to recognize a second voice so that if more than one person uses the car, both can employ voice dialing, with each programming up to 10 numbers. Now that's what we call "hands free" (and a lot safer to do while driving).

AUDIO MUSEUM. An Audio Museum tour will be a special attraction of a San Francisco-area high-end hi-fi show, April 21-23, at the Dunfey Hotel, San Mateo, CA. Co-sponsored by Stereophile magazine and Nelson & Associates, the exhibition consists of five "stations," each of which represents milestones in consumer audio. Many of the exhibit pieces still work and will be demonstrated. Examples are the 1877 Edison Phonograph, the 1896 Emile Berliner "Trade Mark" Gramophone disc player, the 1925 hand-cranked Victor Orthophonic Victrola, the first stereo LP recording, made in 1931 and featuring the Philadelphia Orchestra under Leopold Stokowsky, the Model K-4 Magnetophon World War II German tape recorder, the 1947 Webster-Chicago "18-8" stainless steel wire recorder, the 1953 Cook Binaural Record System, and much more. A Show ticket, good for all three days, is $15.

Further Observations

• Thank you for your review of Aldus PageMaker 3.0 in the January 1988 issue of *Modern Electronics*. Though Mr. Needleman is obviously familiar with the software, there were a few inaccuracies in the report:

Firstly, PageMaker's column guides can be created only with the "Column Guides" command from the Options menu (though they can be changed or overridden without disrupting already placed text). The horizontal and vertical ruler guides the review refers to as tools to define columns are meant to help maintain alignment and design consistency. They don't affect the flow of text.

Secondly, because Aldus PageMaker *can* automatically wrap text around graphics, before or after text is placed, each publication doesn't have to be started by first placing the graphics. You can place, draw and type any elements at any time.

Finally, because a graphic's text wrap specifications are always "attached" to the element, PageMaker *can* reflow text around, whether drawn or placed, each time the graphic is moved, cut, copied, pasted or even re-sized. When a cut or copied graphic is pasted, PageMaker won't reflow text around it until the graphic is dragged to a new location, even if it's just one pixel away.

Audrey Thompson, Editor
Aldus Corp.
Seattle, WA

I agree with these observations on several points and disagree on one. As I mentioned, column guides are created with the Column Guides choice from the Options menu. Ruler Guides, created by pulling them out from the sides and top with the mouse, however, do affect the flow of text. Horizontal guides, pulled from top or bottom, when used with the Snap To Guides option, limit column depth when manually flowing text. Text can be pulled past these guides but will normally stop at a horizontal guide.

The comments about placing graphics first are quite correct. I wasn't aware that I had to move a graphic before PageMaker would reflow around it. This feature

(Continued on page 83)

NOW! Training includes XT-compatible computer plus NRI's remarkable Robotic Discovery Kits!

Get training for industry's hottest new jobs as you build and program complete robotic control systems

Now you can get the skills in demand for the new jobs in industry today. With NRI's new at-home training in Robotics Technology, you actually build a fully IBM XT-compatible computer, then use it to program and control working robotic systems . . . each one engineered to recreate the exact operations performed by the robotic equipment found in today's industrial workplace.

It's no secret. Industry is being transformed by technology—with everything from precision electronic instruments to giant locomotives now being produced with the help of advanced robotic systems. And with automation have come jobs . . . thousands of jobs building, programming, and servicing the robotic systems in use today.

Now, unlike any other school, NRI offers you training that prepares you to take advantage of these new opportunities . . . training that gives you the practical know-how and the hands-on skills to advance on the job or start a new career as a robotics and industrial control technician.

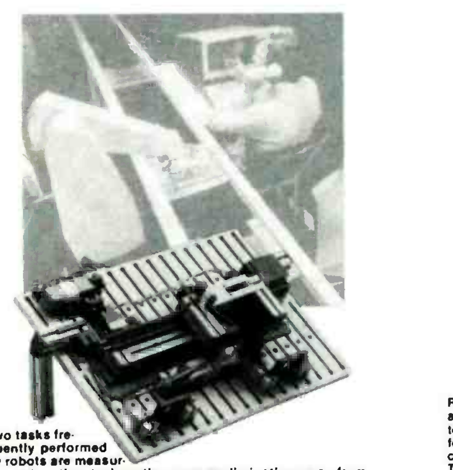
The powerful XT-compatible computer you build becomes central control for the robotic systems you construct

As an integral part of your NRI hands-on training, you build a fully IBM XT-compatible computer from the keyboard up. You assemble the power supply, install the 5¼" floppy disk drive, and attach the high-resolution monitor. Most important of all, by performing meaningful tests and demonstrations at each stage of assembly, you come to a full understanding and appreciation of the microprocessor technology that makes today's robotics applications possible. But that's just the beginning.

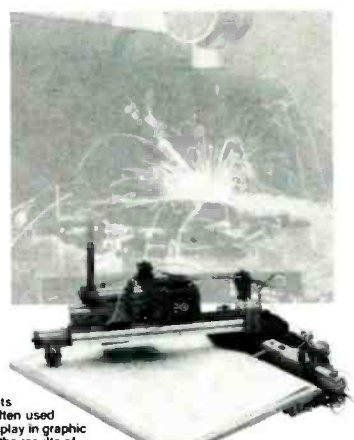
You go on to use your computer to program and control a diverse array of robotic systems you create with NRI's remarkable Robotic Discovery Kits.

Robotics comes to life as you see real-world industrial control principles in action

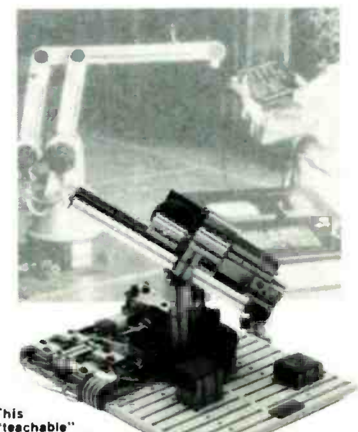
Your NRI Robotic Discovery Kits come complete with everything you need to create working, moving robotic systems. You get structural members, motors, gear drives, sensors, scanners, potentiometers, plus a special Robotics Interface that links the robots you build to your computer.



Two tasks frequently performed by robots are measuring and sorting, be it sorting eggs or eliminating scrap from a production line. You build this sorting system, then program it to accept short and long blocks, measure these blocks, and move them to the correct storage bins.



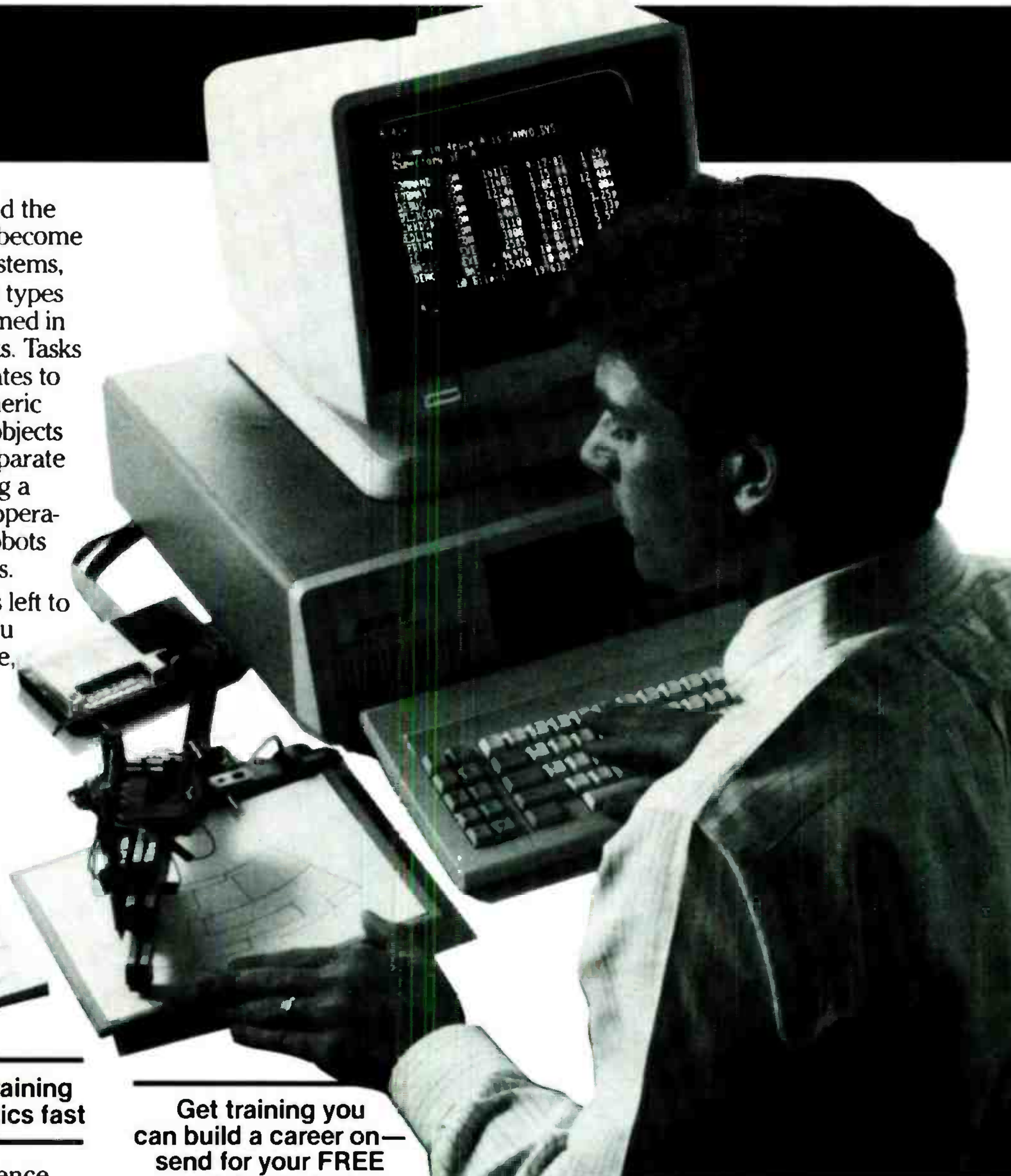
Robots are often used to display in graphic form the results of computer calculations. The polar coordinate plotter you build accepts analog data and positioning commands to create graphic displays. Your plotter uses two motors, an electromagnet, and gear mechanisms to position and activate the plotting pen, both manually and under program control.



This "teachable" robotic arm is the most complex robot model you construct. Once you manually put the robot through a sequence of operations, it will "remember" these steps and perform them whenever asked.

Together, your computer and the robotic devices you construct become fully integrated automation systems, programmed by you to do the types of operations and tasks performed in today's industrial environments. Tasks such as plotting polar coordinates to create graphic displays of numeric data . . . sorting different size objects and routing these objects to separate containers . . . even performing a preprogrammed sequence of operations again and again just as robots now do on manufacturing lines.

Nothing is left out, nothing is left to chance. You get everything you need—the skills, the confidence, and the equipment—to feel completely at home with today's robotics technology.



Step by step, you get the training you need to move into robotics fast

You need no previous experience to succeed with NRI training, because NRI takes you from electronics basics all the way up to the state of the art in robotics technology. You train from the ground up . . . first gaining a working knowledge of electronic circuits and components as you experiment with your NRI Discovery Lab® and professional digital multimeter.

Rapidly, theory becomes understanding as you move on to digital logic, computer fundamentals, right up to writing practical programs to control specific robotic operations using NRI's Robotic Programming Language software included in your course.

Your success is assured by your personal NRI instructor, whose expertise and personal guidance are always available to you whenever you need a helping hand along the way.

Get training you can build a career on—send for your FREE catalog today!

See for yourself how NRI's breakthrough training can put you at the heart of the robotics revolution. Send today for NRI's big, 100-page, full-color catalog that gives you all the details about NRI's exciting new training in Robotics Technology, plus training in computer electronics, TV/video/audio servicing, electronic music technology, security electronics, and other growing high-tech career fields.

If the coupon is missing, write to: NRI School of Electronics, McGraw-Hill Continuing Education Center, 4401 Connecticut Ave., Washington, DC 20008.

SEND COUPON TODAY FOR FREE NRI CATALOG!

NRI

McGraw-Hill Continuing Education Center
4401 Connecticut Avenue, NW, Washington, DC 20008

McGraw Hill

For Career courses approved under GI Bill
☐ check for details.

☑ CHECK ONE FREE CATALOG ONLY
- ☐ Computer Electronics
- ☐ TV/Video/Audio Servicing
- ☐ Electronic Music Technology
- ☐ Security Electronics
- ☐ Digital Electronics Servicing
- ☐ Electronic Circuit Design
- ☐ Industrial Electronics
- ☐ Radio Communications
- ☐ Basic Electronics
- ☐ Bookkeeping and Accounting
- ☐ Building Construction
- ☐ Automotive Servicing
- ☐ Air Conditioning, Heating & Refrigeration
- ☐ Small Engine Repair
- ☐ Electrician
- ☐ Locksmithing
- ☐ Cellular Telephone
- ☐ Paralegal

Name (Please print) Age

Street

City/State/Zip

We'll give you tomorrow. Accredited by the National Home Study Council 4-059

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.

Dual-Display DMM

John Fluke Mfg. Co., Inc. has a new multimeter that features a multi-function dual display so that the instrument can make more measurements from a single connection than is possible with a traditional DMM. The Fluke 25's dual five-decade vacuum-fluorescent displays provide 100,000 counts, but additional resolutions of 30,0000 and 3,000 counts can be user selected. The DMM also features a built-in RS-232 (serial) interface for PC instrumentation applications, and an optional IEEE-488 interface is available.

Functions are included for tolerance testing (using a hi/lo/pass scheme), counting frequency up to 1 MHz, counting decibels (with 21 reference impedances), indicating audio power and testing diode junctions and continuity. Other features include true rms + dc measurements in both voltage and current modes, MIN MAX, relative reference, Touch Hold® and autoranging. Manual or closed-case calibration are possible over either the RS-232 or optional IEEE-488 interface.

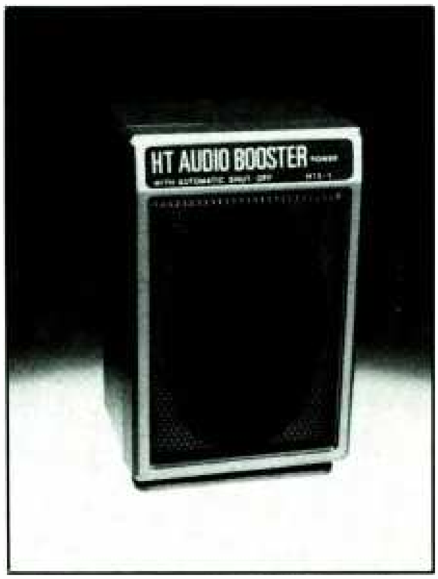
The instrument has a basic six-month Vdc specification of 0.02%. Basic one-year accuracy specifications include: 0.025% on dc volts and 0.2% on ac volts; 0.05% on dc current and 0.5% on ac current; 0.05% on resistance; and 0.05% on frequency counting.

Using the RS-232 interface, measurement data can be filed and manipulated by a PC, printed or transmitted by modem. Optional QuickStart 45 software permits automated communication and filing of measurements with the meter and an IBM PC or compatible computer via the RS-232 port. Available options include a battery, soft carrying case and rack-mount kit. $595.

CIRCLE 27 ON FREE INFORMATION CARD

Amplified Speaker

From Naval Electronics (Tampa, FL) comes the Model HTS-1, a tiny amplified speaker for users of hand-held radio and personal stereo equipment. The system's die-cast enclosure houses a 3.5" oval speaker that is driven by a built-in 10-dB (1 watt into 4 ohms) amplifier. Power for the amplifier can be gotten from an internal rechargeable Ni-Cd battery (the charger is built in) or any external 6- to 15-volt dc source. When the system is operated on battery power, a special automatic shut-off feature kills power to the amplifier whenever there is no audio input (receiver is squelched) for more than 10 seconds to conserve power. Setting the power switch to off bypasses the amplifier and connects the input jack directly to the speaker.

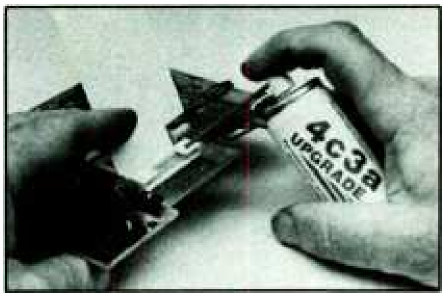


The system's rated frequency range is 200 Hz to 15 kHz, its input impedance is 100 ohms, and maximum input signal level is 400 mV. Features include a LED status indicator, tilted base for tabletop use, a 5-ft. cable with mini plugs and a stereo-to-mono converter. $29.95.

CIRCLE 28 ON FREE INFORMATION CARD

Permanent Repair for Intermittent Connections

Now available from Micro-Circuits Co., Inc. (New Buffalo, MI) for permanent repair of intermittent connections is 4c3a in aerosol-can form. The aerosol addition to the company's line of products was developed to simplify application of the 4c materials to pin connectors that are difficult to treat with the company's 4c3m rub-on "crayon" applicator system. The 4c materials are said to "overwhelm" intermittents and potential intermittents by providing thousands of times as many microscopic metal-to-metal contact paths as connections without it. Each contact point is encapsulated in a corrosion-protective, nontoxic lubricating film.



CIRCLE 29 ON FREE INFORMATION CARD

8-mm Camcorder

Nikon's new Model VN-830 point-and-shoot 8-mm camcorder features an ultra-compact design, 6× power zoom lens with macro close-up, autofocus with manual override switch, TTL auto white balance, and variable shutter speeds up to 1/4000 second. Features include: a 2/3-inch CCD image sensor with 270,000-pixel resolution; fast 9-lux-minimum lens automatic exposure; edit search; still-frame and slow-motion playback; macro close-up lens; unidirectional microphone; and built-in electronic viewfinder (tilts up for low-angle shooting). Such data as function mode and alarm indicators are displayed on the viewfinder's screen. Also, the VN-830 lets you record date or time with the picture.

Advanced editing functions built into the camcorder include edit search, a flying erase head, a linear tape counter, and an edit switch. Edit search simplifies reshooting of scenes by allowing the user to play back scenes in forward or reverse at normal speed while operating in either "camera" or "VTR" mode so that new scenes can be inserted over old ones. Edit/Search allows the user to review a scene just recorded, while Scene Search provides high-speed access to any scene on the tape. Recording review quickly confirms the last few seconds of a just recorded sequence. The Edit switch reduces signal loss during editing. The flying erase head completely erases the signal at the beginning and end of a scene for clean recordings.

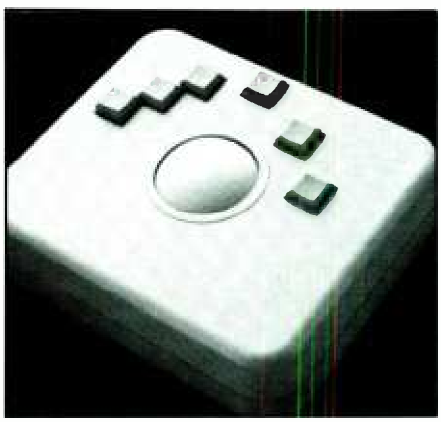
Power for the camcorder can be provided by a rechargeable Ni-Cd battery, an ac adapter/battery charger or a separate lithium battery. The compact camcorder weighs 2.6 pounds without battery.

CIRCLE 30 ON FREE INFORMATION CARD

Computer Trackball

Fulcrum Computer Products' (Healdsburg, CA) high-resolution Trackball Plus cursor pointing alternative to the mouse interfaces to IBM PC and compatible computers and many CAD/CAM environments via a standard RS-232 serial port. Ball motion is optically detected and transformed into one of many formats by a local microprocessor before being sent to the computer. Claimed to be easier to use and more reliable than a mouse, Trackball Plus emulates both Microsoft Mouse and Mouse Systems Mouse, as well as popular digitizers like Summagraphics Bit Pad One. In all, eight popular pointing devices are emulated.

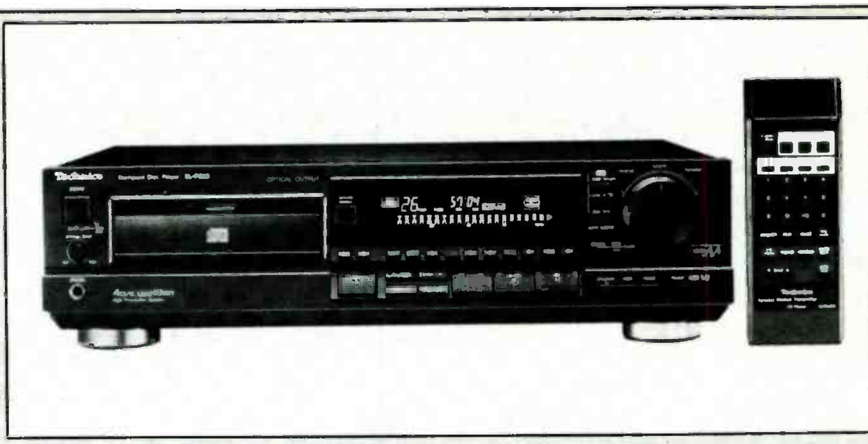
Trackball Plus requires just enough desktop space to set it in place. It permits use of an Alternate Cursor switch for CAD/CAM applications and has a Drag function that gives the user the ability to hold down a button and roll the ball at the same time. In addition to the universal-direction ball, six general-purpose pushbutton switches are available. Separate versions with DB-9 and DB-25 connectors are available.



Supplied with software drivers for the Microsoft Mouse and Mouse Systems Mouse, Trackball Plus also features MenuKey for programs that do not normally support a mouse. Menu support is provided for Lotus 1-2-3 and WordPerfect. The software has the ability to change the sensitivity of the device while in a program. Response can be customized by downloading more than 20 commands, and arrow-key emulation is built-in. $99.

CIRCLE 31 ON FREE INFORMATION CARD

A CD Player For Recording



Technics' Model SL-P555 CD player features Peak Level Search with an output signal meter and an Edit Guide that are very useful when transcribing disc programs to tape. Peak Level Search checks an entire disk for the highest signal peak and repeatedly plays the 3 seconds that precede and follow the peak to permit recording levels to be accurately set—all done in a maximum of 3 minutes for a 60-minute CD program. Edit Guide lets the user select C-46, C-60 or C-90 tape length, from which the player automatically calculates the tracks and playing times that will fit on each tape side. Alternatively, the user can select the tape length and then specify a recording time.

A disk link key is included for use when transferring more than one CD onto a tape. When a new disk is inserted into the player, the user uses the disk link key to calculate which selections will fit onto the remaining tape.

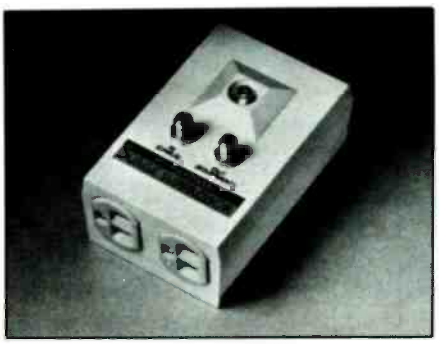
The player uses 18-bit, quadruple oversampling digital signal processing, with completely separate D/A converters for each channel that allow the player to perform simultaneous conversions. This two-converter scheme eliminates the need for compensation circuitry and improves phase coherence for accurate stereo imaging, while 18-bit resolution permits better reconstruction of the analog waveform.

An optical digital output can directly couple digital data to amplifiers and other devices that are equipped with digital-to-analog converters. It also supplies the digital signal in an optical format for transmission over a fiber-optic cable. A high-speed linear motor access system is used in the player, and a high-resolution laser increases pickup accuracy.

Features include: random play; 32-step random-access programming; skip and index skip; auto cue; repeat/A-B repeat; music scan; 5"/3" disc accommodation; shuttle search; 20-segment output signal meter (to −50 dB); timer play; large insulator feet; headphone jack with separate volume control; illuminated disk window; and multi-function wireless remote controller. $410.

CIRCLE 32 ON FREE INFORMATION CARD

Video Surge Suppressor



A new Cable-Line™ Surge Suppressor from Perma Power Electronics (Chicago, IL) protects sensitive electronic equipment from transient voltage surges on the TV cable or antenna line and power line. This Model PTC-209 suppressor can be used to safeguard new TV receivers, VCRs, cable converters, satellite receivers and audio equipment.

According to Perma Power, the circuitry in the suppressor is designed to protect against surges on the coaxial cable without causing meaningful loss of picture signal. Accordingly, the device can be used on antenna cable or satellite lead-in cable without creating a snowy picture or loss of the picture, even at uhf frequencies. This circuitry is also claimed to have a virtually unlimited lifetime, unlike other power-line surge suppressors that can wear out or burn out if subjected to repetitive or high surges.

Featured are gold-plated connectors to provide high-level conductivity and resistance to corrosion and carbonization. The device provides protection against all three ways that surges from lightning or switching can travel on the power line in the normal and both common modes. Rated at 1,800 volts, the device has a let-through potential of less than 2 volts. It plugs into any grounded ac receptacle. It has a fail-safe shutdown feature that automatically disconnects the power line from the protected devices should the device ever wear out or burn out.

Dimensions of the device's plastic case are 4¾" × 3½" × 2¼" and weight is 11 ounces.

CIRCLE 33 ON FREE INFORMATION CARD

Marine Range Extender

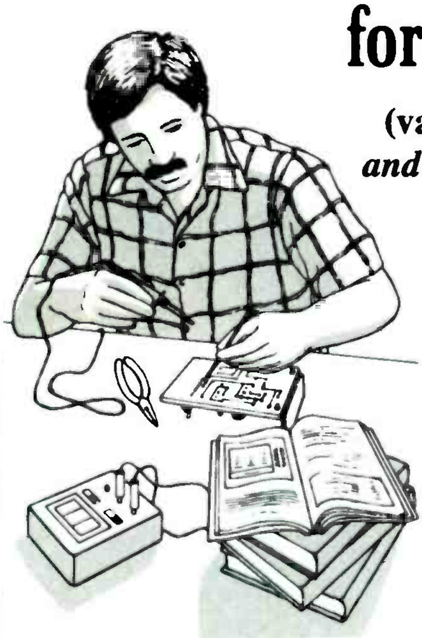
The RFTR-M Signal Intensifier from Electron Processing, Inc. (Medford, NY) is a receive preamplifier that is said to improve the coverage of vhf marine radio transceivers by amplifying received signals. It installs in the antenna lead of any vhf marine transceiver and connects to the unit's 12-volt dc power supply. Received signals are boosted by at least a specified 13 dB. An internal relay automatically bypasses the RFTR-M preamp

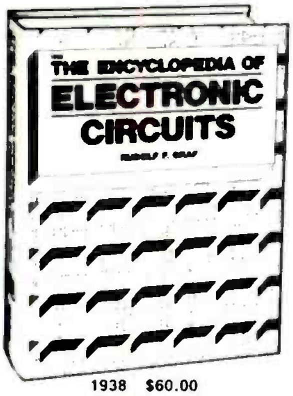
(continued on page 69)

SELECT 5 BOOKS

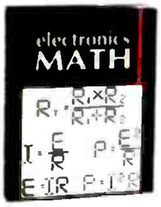
for only $3.95

(values to $134.70)
and get a FREE Gift!



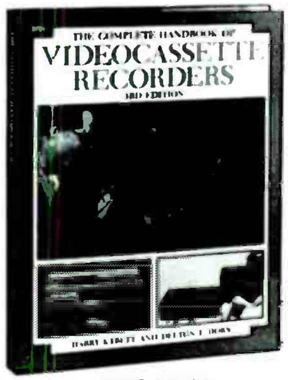


1938 $60.00
Counts as 3

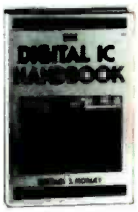


1982 $22.95

1199P $18.95

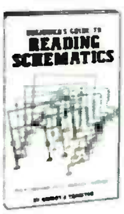


2731P $14.95

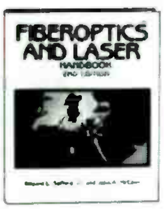


3002 $49.50
Counts as 2

2947 $21.95



1536P $9.95

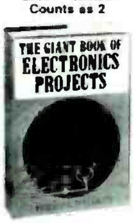


2981 $24.95


3054 $19.95

2707 $26.95
Counts as 2

3133 $15.95



1367P $18.95


2900 $34.95
Counts as 2

2885 $16.95

Electronics projects . . . ideas . . . the latest technology all at up to 50% off publishers' prices!

Membership Benefits • **Big Savings.** In addition to this introductory offer, you keep saving substantially with members' prices of up to 50% off the publishers' prices. • **Bonus Books.** Starting immediately, you will be eligible for our Bonus Book Plan, with savings of up to 80% off publishers' prices. • **Club News Bulletins.** 14 times per year you will receive the Book Club News, describing all the current selections—mains, alternates, extras—plus bonus offers and special sales, with scores of titles to choose from. • **Automatic Order.** If you want the Main Selection, do nothing and it will be sent to you automatically. If you prefer another selection, or no book at all, simply indicate your choice on the reply form provided. As a member, you agree to purchase at least 3 books within the next 12 months and may resign at any time thereafter. • **Ironclad No-Risk Guarantee.** If not satisfied with your books, return them within 10 days without obligation! • **Exceptional Quality.** All books are quality publishers' editions especially selected by our Editorial Board.

All books are hardcover unless number is followed by a "P" for paperback (Publisher's Prices shown).

FREE when you join!

15 Easy Electronic Projects From Delton T. Horn
Projects you can build—some unique, some old favorites—from the author's vast treasury of electronics know-how.

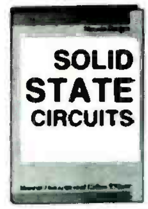
a $7.95 value!

ELECTRONICS BOOK CLUB®
Blue Ridge Summit, PA 17294-0810

Please accept my membership in the Electronics Book Club® and send the 5 volumes listed below, *plus* my FREE copy of *Delton T. Horn's All-Time Favorite Electronic Projects* (3105P), billing me $3.95 plus shipping and handling charges. If not satisfied, I may return the books within ten days without obligation and have my membership cancelled. I agree to purchase at least 3 books at regular Club prices (plus shipping and handling) during the next 12 months and may resign any time thereafter.

Name ____________________
Address ____________________
City ____________________
State __________ Zip __________ Phone __________
Signature ____________________

Valid for new members only. Foreign applicants will receive special ordering instructions. Canada *must* remit in U.S. currency. This order subject to acceptance by the Electronics Book Club®.
MDNE589



2975 $24.95

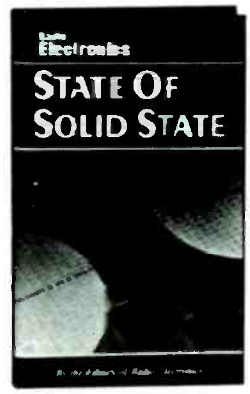
2809 $26.95
Counts as 2

1599P $17.95


2865 $21.95


3034 $19.95

2826P $15.95

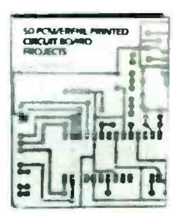


2733 $14.95

2995 $25.95

2790 $19.95

2883 $25.95


2972 $23.95

1532P $14.95

3031 $24.95

Understanding VGA

More colors, more pixels, and extended modes promise to keep VGA at the leading edge of PC graphics technology

By TJ Byers

It wasn't too long ago that PC users were singing the praises of IBM's Enhanced Graphics Adapter (EGA) that offered real benefits in video display of text and graphics. Today, though, even enhanced versions of EGA hardware are being elbowed into the background by the new kid on the block—IBM's VGA, which stands for Video Graphics Array. VGA's 640 by 480, high-resolution screen is 37 percent better than EGA. Its great for display of text and general-purpose graphics, but it really shines for most desktop publishing, CAD/CAM and serious graphics applications.

IBM may have created the VGA standard for its PS/2 series of computers, but the good news is that you don't need a PS/2 to reap its benefits. There are currently dozens of VGA-compatible adapters available for the PC and PC clones in the marketplace. They range in price from a low of about $400 up to and beyond $1,000, depending on speed and options. Many of these products offer features not found in the original IBM VGA. And thanks to stiff competition, prices for VGA hardware are only slightly more expensive than those for EGA, making the former—with all its advantages—the better investment for the future

VGA Modes

Mode	Mode	Colors	Box Size	Format	Comment
Standard Modes					
0,1	Text	16	8 × 8	40 × 25	CGA
2,3	Text	16	8 × 8	80 × 25	CGA
0*,1*	Text	16	8 × 14	40 × 25	EGA
2*,3*	Text	16	8 × 14	80 × 25	EGA
0+, 1+	Text	16	9 × 16	40 × 25	VGA
2+, 3+	Text	16	9 × 16	80 × 25	VGA(1)
4,5	Graphics	4	8 × 8	320 × 200	CGA(2)
6	Graphics	2	8 × 8	640 × 200	CGA
7	Text	mono	9 × 14	80 × 25	MDA
7+	Text	mono	9 × 16	80 × 25	VGA
D	Graphics	16	8 × 8	320 × 200	EGA
E	Graphics	16	8 × 8	640 × 200	EGA
F	Graphics	mono	8 × 14	640 × 350	EGA
10	Graphics	16	8 × 14	640 × 350	EGA(3)
11	Graphics	2	8 × 16	640 × 480	VGA
12	Graphics	16	8 × 16	640 × 480	VGA(4)
13	Graphics	256	8 × 8	320 × 200	VGA(5)
Popular VGA Extended Modes					
	Text	16	9 × 16	80 × 43	
	Text	16	9 × 16	80 × 60	
	Text	16	9 × 16	132 × 25	
	Text	16	9 × 16	132 × 28	
	Text	16	9 × 16	132 × 43	
	Text	16	9 × 16	132 × 60	
	Graphics	256	8 × 14	640 × 350	enhanced EGA
	Graphics	256	8 × 16	640 × 480	enhanced VGA
	Graphics	16	8 × 14	800 × 600	multisync monitor required (6)
	Graphics	256	8 × 14	800 × 600	Tseng VGA chip
	Graphics	16	8 × 16	1,024 × 768	Tseng VGA chip, IBM 8514 monitor required

(1)—VGA color default text mode; (2)—CGA color graphics mode; (3)—EGA color graphics mode; (4)—VGA color graphics mode; (5)—MCGA color graphics mode; (6)—Proposed VESA color graphics mode; *—Enhanced from EGA; +—Enhanced modes

What VGA Offers

Unlike the IBM video modes that came before it, VGA offers a potpourri of possibilities. In just the IBM VGA mode alone, you have up to 17 "flavors" from which to choose. The 640-by-480 mode is the hot new graphics mode for VGA. It can support up to 16 simultaneous colors, and draws from a palette of 256K (262,144) colors.

Users who have a large appetite for color usage will relish the 256-color screens of VGA's MultiColor Graphics Adapter (MCGA) mode, which supports a 320-by-200 graphics screen and derives its colors from the 256K palette. Unfortunately, this is the same resolution used by the four-color Color Graphics Adapter (CGA) that IBM introduced eight years ago—and the result is the same poor resolution that creates "jaggies" and text so boxy that it's difficult to tell an "A" from an "8."

To improve MCGA's image, VGA double scans each line for a total of 400 lines on the screen. Essentially, the VGA controller takes the information from the first line and duplicates it on the line directly below it. Then it does the same with the second line, then the third, and so on, until 200 lines become 400. Although this doesn't actually improve the mode's resolution, doubling of the number of pixels on the screen gives the *illusion* of a more detailed display.

VGA text modes are served up in the traditional 80-column by 25-row format, using a 9 by 16 character block. Contrast this with CGA's 8 by 8 character and EGA's 8 by 14 character block, and you'll appreciate what this means in improved display of text characters. VGA text can be displayed in either monochrome or with up to 16 simultaneous colors (one color per character) with 25 or 43 lines.

The Compatibility Issue

Most manufacturers claim 100-percent IBM compatibility for their VGA boards, but not all VGA boards are created equal. The problem is that there isn't just one way to clone the VGA. Three basic ways exist at present and include extended-mode EGA boards with VGA software drivers, BIOS-compatible boards, and VGA register-level-compatible boards.

In a BIOS-compatible clone, the BIOS chip is programmed to recognize and execute VGA mode commands. However, if a program bypasses the BIOS and addresses the VGA hardware instead, the board can't respond to the instruction. VGA board makers deal with this situation by using logic schemes that trap VGA hardware calls and reroute them to the BIOS. Sometimes the traps are set in firmware; at other times, the traps are activated by software from a disk.

With register-level-compatible VGA boards, VLSI chips duplicate IBM's VGA controller at the hardware level. Consequently, a program that makes hardware calls to the chip will find the register it's looking for, which eliminates the need to set logic traps and thereby improve speed.

Of the two, register-level compatibility is the more desirable. It has fewer software compatibility problems and is faster than BIOS compatibility. Unfortunately, it's difficult to tell the two apart—they both look alike.

While all the boards listed in the "Where to Buy" section of this article are register-level compatible, they may have siblings that are not. Two such cases are the Quadram QuadVGA and Video Seven VEGA VGA, both of which are currently available at very low prices through mail-order houses with the claim that both are VGA register-level compatible. In point of fact, these boards are only partially register-level compatible and mostly BIOS compatible. On the other hand, their more expensive counterparts, the Quadram QuadVGA Spectra and Video Seven FastWrite VGA, are fully register-level compatible.

When shopping for a VGA board, don't be fooled by claims of VGA compatibility. If you're not sure of what type of board you're buying, ask someone who does. Just keep in mind here that while dealers are usually the most convenient source of information, they don't always have the correct answer to technical questions. A call to the technical department of the manufacturer of the board will get you the correct information. If the particular board you're calling about isn't absolutely register-level compatible, the person you speak to will tell you which of the company's VGA products are.

Upping the Ante

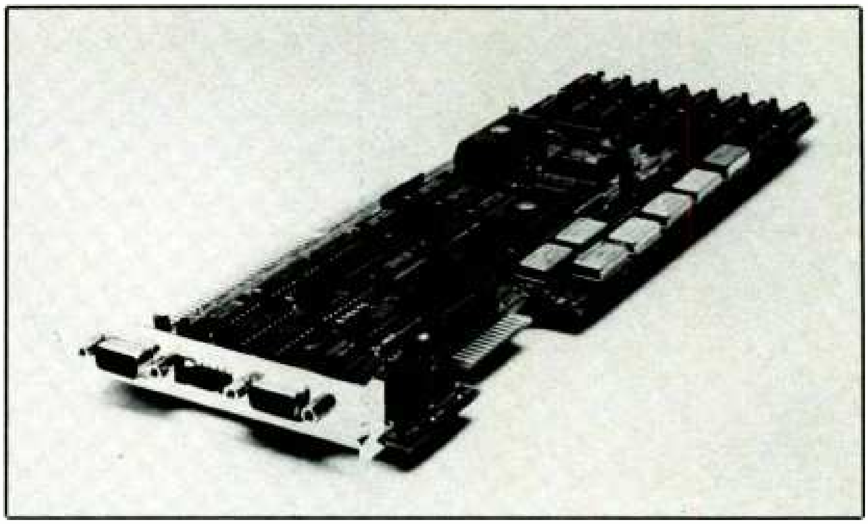
Standard VGA is just the tip of the iceberg, of course. Most VGA boards go beyond basic VGA to offer better performance, greater resolution and more on-screen colors. Let's begin our examination with mode emulators.

Although the VGA standard embraces all previous IBM video modes, a few programs (such as Lotus 1-2-3 and MicroSoft *Flight Simulator*) refuse to work with IBM's VGA emulation of CGA or EGA. VGA board makers solve these incompatibilities by providing proprietary emulators that bypass the VGA BIOS. Hercules Graphics Card (HGC) emulation is also very popular and is supported by all VGA cards except the ones from IBM and Compaq. The emulators are generally loaded into RAM from a utility menu, but a few boards have an auto-switching feature that senses the video mode the software is seeking and automatically loads the correct emulator for you.

Virtually every VGA card—again, except for those from IBM and Compaq—also supports up to 256 colors in the 640-by-480 mode, plus an 800-by-600, 16-color screen. Boards that use the Tseng Labs VGA controller chip (which accounts for about half the VGA boards in production today) can display up to 256 colors at 800-by-600 resolution. A few boards even support 1,024-by-768 graphics.

Extended text support has not gone unnoticed, either. Text modes with 80- and 132-column displays in up to 60 lines are also very popular. Increased numbers of columns and text lines can make working with desktop publishing programs and spreadsheets a whole lot more pleasant.

Tecmar VGA/AD: A Board For All Seasons



If you want VGA performance but can't afford an analog video monitor, Tecmar's VGA/AD board could be just what you need. This $695 board displays 640 by 480, plus 800 by 600 and 1,024 by 768, 16-color graphics on an EGA monitor using interlace scanning. It also provides a wide range of standard and extended-VGA mode drivers, including graphics drivers for *Windows*, *Ventura* and *AutoCAD* in resolutions up to 1,024 by 768. Included is a generous helping of 132- and 80-column extended-mode text support for *1-2-3*, *Symphony*, *WordPerfect* and *WordStar*. The board also supports Tecmar's very popular EGA Master 480/800 video mode (which has a large base of existing software for 800 by 600, 16-color graphics) when the $100 Master Graphics option is installed.

Supplied standard with 512K of video RAM, the board can support up to 256 colors in the 800-by-600 mode for applications like *PC Paintbrush Plus*, *Publisher's Paintbrush* and other programs that list the Tseng board as a video option.

The VGA/AD's only negative feature is that the displayed image on the video screen flickers a lot when displaying VGA and extended VGA modes on the EGA monitor because of the interlace scanning. Bear in mind, too, that the EGA monitor is also limited to 16 colors. Performance and color options are better with a VGA monitor and are excellent with a multisync monitor (like the NEC MultiSync), but expect to pay more for the monitor as performance increases.

If you don't have a lot of money, but want high-end VGA performance and can live with the limitations of interlace scanning, Tecmar's VGA/AD board offers an appealing way to go.

CIRCLE NO. 132 ON FREE INFORMATION CARD

Video modes that support resolutions or colors beyond VGA are called "extended VGA" modes. To take advantage of an extended VGA mode, you need a special software driver that interfaces the software application to the video mode. As a consequence, each application that wishes to use an extended VGA mode must have its own driver. Until recently, manufacturers of VGA boards have had to write their own applications drivers, which explains why you generally see extended-mode driver support for only the most popular software packages, such as *Windows*, *1-2-3*, *AutoCAD*, etc.

A newly formed committee hopes to rectify the situation by introducing the Video Electronics Standards Association (VESA) super VGA standard. VESA boasts 800-by-600 screen resolution in up to 16 colors. Though these specifications are not new to VGA boards, adoption of the VESA standard would be an important step forward because it allows software manufacturers to write their own extended-mode drivers and maximize screen performance for each particular application. This not only boosts performance, it also gives the user a wider range of applications from which to choose, instead of being limited to the handful of extended VGA drivers board makers are able to supply.

VESA is not a standard yet. The greatest obstacle standing in the way of it becoming so is deciding on a common timing scheme to make VESA compatible with all boards and video monitors. The proposed standard sets VESA's horizontal scan rate at 35 kHz and vertical scan rate at 56 Hz. However, many VESA proponents feel that the flicker at 56 Hz is excessive; they would like to see the scan rate increased to 60 Hz. Other committee members would like to see an increase in the horizontal scan rate to improve the sharpness of displayed images.

No one knows for sure when the VESA standard will be finalized or approved—if at all. If it is adopted, VESA will represent the first industry-wide acceptance of a video mode that was not developed by IBM since the Hercules Graphics Card appeared on the scene .

VGA Monitors

The secret to VGA's multi-colored success lies with the VGA video monitor. Unlike CGA and EGA, which use a digital display monitor, VGA uses an analog monitor.

Digital display monitors (also called TTL monitors) display colors by feeding binary values to the color guns of the CRT. Each gun has its own separate input that is assigned a position in a binary code. To display red, for example, the green and blue

Manufacturers & Suppliers of VGA Boards

Amdek VGA Adapter/132 ($445)
Amdek Corp.
3471 N. First St.
San Jose, CA 95134
408-922-5700

AST VGA Plus ($599)
AST Research
2121 Alton Ave.
Irvine, CA 92714
714-863-1333

Compaq Video Graphics Controller ($599)
Compaq Computers Inc.
20555 FM 149
Houston, TX 77070
713-370-0670

Everex EVGA ($399)
Everex Systems, Inc.
48431 Milmont Dr.
Fremont, CA 94538
415-498-1111

Genoa SuperVGA ($429)
Genoa Systems Corp.
75 E. Trimble Rd.
San Jose, CA 95131
408-432-9090

Hewlett-Packard HP VGA ($445)
Hewlett-Packard Co.
Roseville Terminals Div.
8020 Foothills Blvd.
Roseville, CA 95678
916-786-8000

IBM PS/2 Display Adapter ($595)
IBM
900 King St.
Rye Brook, NY 10573
800-IBM-2468

Orchid Designer VGA ($545)
Orchid Technology
45365 Northport Loop W.
Freemont, CA 94538
414-683-0300

Paradise VGA Plus ($399)
Paradise VGA Plus 16 Card ($499)
Paradise VGA Professional ($599)
Paradise Systems, Inc.
99 S. Hill Dr.
Brisbane, CA 94005
415-960-3353

Quadram QuadRAM Spectra ($549)
Quadram Corp.
One Quad Way
Norcross, GA 30093
404-923-6666

Sigma VGA/H ($399)
Sigma Designs
46501 Landing Pkwy.
Fremont, CA 94538
415-770-0100

SotaVGA/16 ($445)
Sota Technology, Inc.
657 N. Pastoria Ave.
Sunnyvale, CA 94086
408-245-3366

STB VGA Extra/EM ($399)
STB Systems, Inc.
P.O. Box 850957
Richardson, TX 75085
214-234-8750

Tecmar VGA/AD ($695)
Tecmar Inc.
6225 Cochran Rd.
Solon, OH 44139
216-349-0600

Video Seven FastWrite VGA ($599)
Video Seven V-RAM VGA ($799)
Video Seven, Inc.
46335 Landing Pkwy.
Fremont, CA 94538
415-656-7800

guns would be turned off and only the red gun would be turned on, using a binary input number of 100. Yellow is created by blending red and green, using the binary number 110. Using this approach, which is similar to the way CGA drives its monitor. Eight colors are possible with this arrangement.

EGA goes a step further by including an intensity bit as well as a color bit for each of the color guns. So, instead of just on or off, you can turn a gun off, half on, or full on. This leads to creation of 64 possible colors, but now six inputs are required to achieve this. Thus, as the number of colors increases, so does the number of control lines required. To match VGA's 256K color palette, you would need a monitor with 18 color inputs.

With an analog monitor, colors are represented by voltage levels, rather than binary codes. Each of the three color guns in the picture tube has a single input that connects to a voltage driver. When the input voltage is low, the gun is off. Conversely, when the input voltage is high, the gun is fully on. Any voltage between these two extremes represents a different intensity of that color, and this intensity is continuously variable. All colors of the rainbow can be made using just three inputs. For example, to change from white to pink, the only thing that need be done is to increase the input voltage to the red gun. Theoretically, there is no limit to the number of shades you can display on an analog monitor.

Several VGA boards support both TTL and analog monitors. This dual support permits you to use an existing CGA or EGA monitor with the VGA adapter. This is a handy feature for those people who can't afford both a VGA board and VGA monitor at the same time, but it does prevent them from displaying VGA or extended-mode images until an analog monitor is purchased and added to the system.

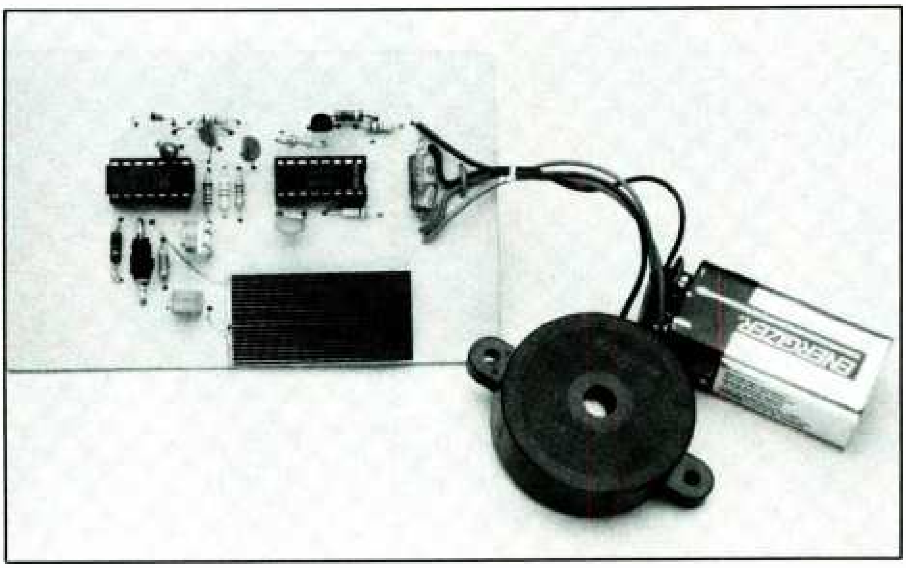
Generally, a multisync monitor, like the NEC MultiSync, is required for extended-mode 800 by 600 graphics. However, at least one VGA board, the Tecmar VGA/AD (see "The Tecmar VG/AD" box elsewhere in this article), can display extended-mode graphics on an EGA or VGA monitor using interlace scanning. In interlace scanning, the monitor doubles the resolution of the display by first writing one image on the screen and then going back and filling in the blank spaces between the lines with another image in an interwoven pattern. This is similar to, but different from, the double-scanning

(Continued on page 90)

The SunGuard

This compact device keeps tabs on cumulative ultraviolet energy detected over a period of time and sounds an alert when the total exceeds a preset limit for safe tanning

By Anthony J. Caristi



With summer almost here, millions of us will soon be flocking to the beach, where we'll bask in the sunlight. Summer sun can be very beneficial, but too much of a good thing can also be dangerous to your health, from painful sunburn to more serious sun-exposure-related ailments.

The amount of sunlight that will not cause harm varies from person to person. But even if you know your tolerance level, it is sometimes difficult to judge a safe exposure time when the sky is overcast or partly cloudy. You must also consider that the time of day and even month of the year determine how intense the sunlight will be. This is a lot to keep in mind, but "SunGuard" remembers it all effortlessly to help you stay healthy as you enjoy the sun.

SunGuard's sensing element accurately measures sun intensity. A built-in memory circuit integrates measured intensity over a period of time and totals the cumulative exposure to the sun's rays. When a safe exposure limit is reached, which you set beforehand, a piezoelectric buzzer sounds to alert you to either turn over or cover up.

SunGuard's solar-cell sensor responds to ultraviolet energy. This makes the project immune to false measurements that might otherwise occur from passing clouds or hazy sunshine that can give the appearance that the UV energy is less intense than it really is. This is important because it is UV energy, which penetrates clouds, that causes tanning and burning.

About the Circuit

The sensing element used in SunGuard produces an output that is directly proportional to the intensity of the detected ultraviolet energy from the sun. This controls the rate of a built-in clock that counts the number of minutes of relative exposure. With the way the circuit is designed, the warning signal will be generated at the desired amount of exposure whether the sun is shining through a clear sky, intermittent cloudiness or a hazy sky. Thus, SunGuard automatically takes into account variations in sun intensity and totals the cumulative amount of exposure.

You manually set the desired amount of time of exposure to the sun before you begin a sunbathing session. An adjustment range of less than 10 minutes to almost 2 hours is possible with the circuit as shown in the Fig. 1 schematic diagram.

Power to operate the circuit is provided by a common 9-volt transistor radio battery. Current drain of the circuit is very low; so one alkaline battery should easily last through the entire summer season. Also, a handy pushbutton switch allows you to quickly check battery condition to determine if there is sufficient energy to operate the circuit.

Referring to the complete schematic diagram shown in Fig. 1, the heart of SunGuard is photocell *PC1*, which is the reference that continuously monitors the intensity of the sun's energy and generates a current that is directly proportional to the de-

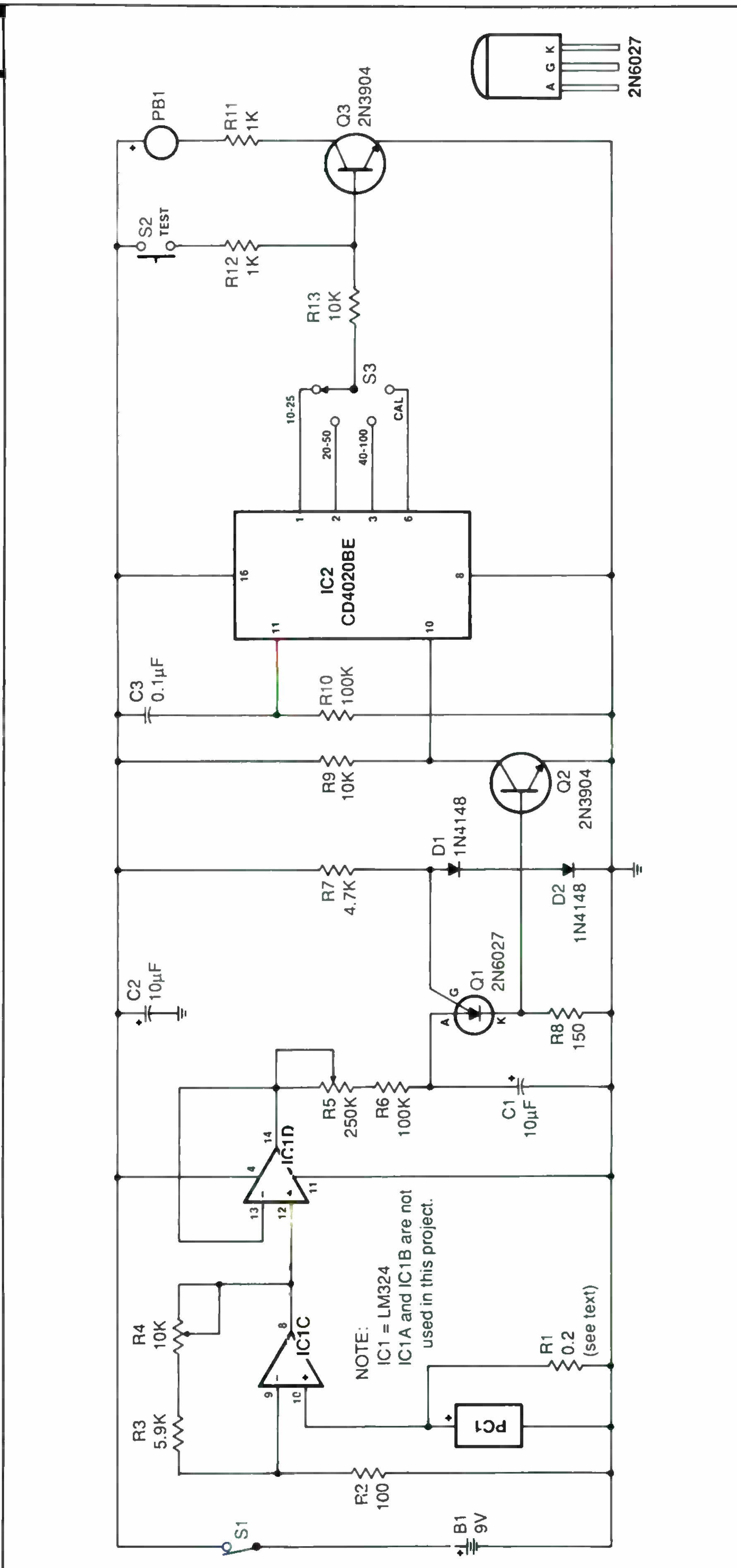


Fig. 1. Complete schematic diagram of SunGuard's circuitry.

tected intensity at every given moment. On a day of unobstructed bright sunlight when the sun is directly overhead, the sun's energy intensity is at its maximum and is referred to as 1 full sun. As the sun traces its path across the sky from east to west, this intensity will vary, increasing in the morning and becoming less than 1 full sun as the day progresses. Of course, any haze or clouds in the sky will obscure (filter) the sunlight to some degree, resulting in less than 1 full sun of intensity.

Under 1 full sun conditions, *PC1* generates about 0.3 ampere (or 300 milliamperes) of current. Because there will be variations in output from one solar cell to another under identical detecting conditions, SunGuard's circuit is equipped with calibration potentiometer *R4* that allows you to adjust for the particular solar cell used in the project.

The open-circuit output generated by *PC1*, about 0.5 volt, is of no consequence, since it is the generated current that is proportional to the intensity of the sun's energy. To provide a voltage that is proportional to the detected energy, *PC1* is loaded with a very low 0.2-ohm resistance by *R1*. The potential that appears across *R1* will be approximately 60 millivolts under conditions of 1 full sun and will vary linearly with changes in sun energy intensity: 45 millivolts at ¾ sun, 30 millivolts at ½ sun, and so on.

To provide a usable voltage source for the circuit, as well as a means for calibrating the solar cell, *IC1A* is connected as an operational amplifier with its gain determined by the values of *R2*, *R3* and *R4*. Potentiometer *R4* covers a range that is sufficient to provide an output at pin 8 of *IC1* of 5.5 volts under conditions of 1 full sun exposure of *PC1*. Once *R4* is adjusted for this output voltage, the solar cell has been calibrated.

PARTS LIST

Semiconductors
D1,D2—1N4148 or similar silicon diode
IC1—LM324 operational amplifier
IC2—CD4020BE 14-stage binary divider
Q1—2N6027 programmable unijunction transistor
Q2,Q3—2N3904 or similar npn silicon transistor

Capacitors
C1—10-μF, 16-volt low-leakage electrolytic or tantalum
C2—10-μF, 16-volt electrolytic
C3—0.1-μF, 50-volt ceramic disc

Resistors (¼-watt, 10% tolerance)
R2—100 ohms, 1% metal-film
R3—5,900 ohms, 1% metal-film
R6—100,000 ohms, 1% metal-film
R7—4,700 ohms
R8—150 ohms
R9,R13—10,000 ohms
R10—100,000 ohms
R11,R12—1,000 ohms
R1—0.2-ohm wirewound (see text)
R4—10,000-ohm pc-mount cermet potentiometer
R5—250,000-ohm linear-taper panel-mount potentiometer

Miscellaneous
B1—9-volt battery
P1—Piezoelectric sound element (Radio Shack Cat. No. 273-065 or similar)
PC1—Silicon solar cell (Radio Shack Cat. No. 276-124 or similar 0.3-ampere solar cell)
S1—Spst slide or toggle switch
S2—Spst normally open pushbutton switch
S3—Single-pole 3- or 4-position switch (optional—see text)
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable soldering or Wire Wrap hardware (see text); clear plastic enclosure (see text); DIP sockets for IC1 and IC2; snap connector and holder for B1; pointer-type control knob (2); silicone adhesive or fast-setting epoxy cement (see text); double-sided thick foam tape; machine hardware; hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463: Ready to wire pc board, $9.95; LM324, $2; CD4020BE, $3.50; 2N6027, $3; 0.2-ohm wire-wound resistor, $1.50; set of three metal-film precision resistors, $1.50. Add $2.00 postage/handling. New Jersey residents, please add state sales tax.

Connected as a voltage follower *IC1B* provides a low-impedance driving source for the clock circuit. After calibration, the output at pin 14 of *IC1B* will be 5.5 volts under conditions of 1 full sun, and will vary linearly, from zero to 5.5 volts, with changes in sunlight intensity. Programmable unijunction transistor *Q1* and its associated components, which make up a relaxation oscillator circuit, are used to convert the voltage generated by *IC1* into a time-dependent function.

Capacitor *C1* is charged through *R5* and *R6* by the voltage generated at the pin 14 output of *IC1B*. The rate at which *C1* charges is proportional to the voltage delivered by *IC1B* and the total resistance of *R5* plus *R6*. With increasing sunlight intensity *C1* charges faster, and with less intensity it charges slower. Also, greater values of resistance result in slower charging, and lesser values speed up the charging rate.

Programming of *Q1* is accomplished with a voltage (about 1.4 volts) fed to its gate, which is provided by the series-connected, forward-biased *D1-D2* silicon diode pair. The forward-biasing voltage is delivered from the circuit's positive supply bus through *R7*. The voltage fed to the gate of *Q1* will remain essentially constant as the terminal voltage of the battery falls with use.

The anode of *Q1* is connected to the positive side of the charging capacitor *C1*. When the voltage across the capacitor exceeds the programmed 1.4-volt potential at the gate of *Q1*, the transistor suddenly triggers into conduction and dumps most of the charge stored in the capacitor into *R8*. As a result, the voltage across *C1* falls to near zero, at which point, the capacitor begins charging again to repeat the cycle.

As you can see, the frequency of oscillation of *Q1* is proportional to the charging rate of *C1*, which, in turn, is a function of the intensity of sunlight striking the solar cell. An increase in sunlight intensity causes the frequency of the signal generated by the *Q1* oscillator to increase, and vice-versa. TIME potentiometer *R5* also controls the operating frequency of the oscillator and provides a 3.5:1 adjustment range that allows you to manually adjust the desired time of exposure.

A voltage spike appears across *R8* when *C1* suddenly discharges. This spike is applied to the base of *Q2* to forward-bias the transistor into conduction. As collector current flows in *Q2*, a narrow negative pulse whose amplitude is equal to the voltage of battery *B1* is used as a clock for counter *IC2*.

Integrated circuit *IC2* is a 14-stage binary ripple counter/divider. In this project, it serves as both a memory device and a clock. The counter has all but two of its binary stages available at output pins. For this application, only output pins 6, 1, 2 and 3 are of interest. These represent clock signals that have been divided by 128, 4,096, 8,192 and 16,384.

When power is first applied to the circuit, the sudden application of voltage is fed through *C3* to the master reset input of *IC2* at pin 11 to cause the counter to be set to zero. At the same time, the clock input at pin 10 is being triggered by the pulses that appear at the collector of *Q2*, assuming *PC1* is intercepting sufficient sunlight intensity to cause the oscillator to run. Clock pulses cause the counter to advance one count at a

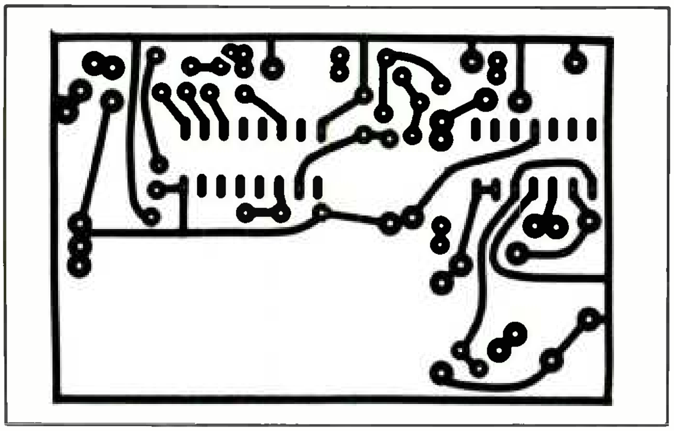


Fig. 2. Actual-size etching-and-drilling guide for project's printed-circuit board.

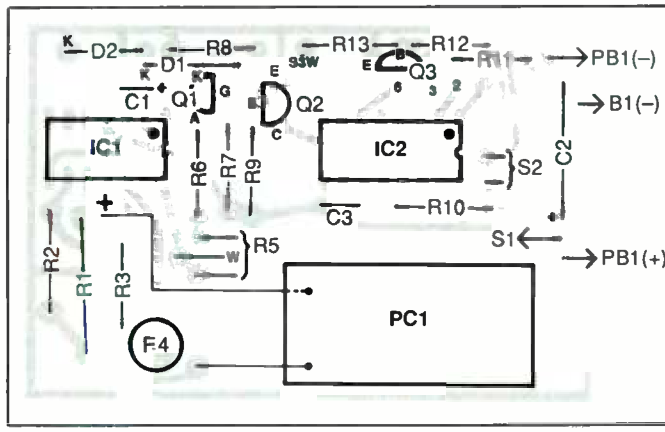


Fig. 3. Wiring guide for printed-circuit board. Use this as a rough guide to component layout on perforated board.

time, at a rate that represents the amount of UV energy striking the solar cell.

The unijunction oscillator operates at a frequency in the 0.25-Hz range; hence, a predictable amount of time is required before any of the outputs of *IC2* can be advanced to a logic 1 level. In this circuit, pin 1 of *IC2* would go to logic 1 after a delay of about 8 minutes in full sunlight with *R5* set to minimum resistance. Similarly, pins 2 and 3 would not reach a logic 1 condition until 16 or 32 minutes of time, respectively, have elapsed. This time delay, which is a function of the unijunction oscillator frequency, provides the trigger signal that operates the warning device, *PB1*.

Resistor *R13* is connected to one of the pin 1, 2 or 3 outputs of *IC2*. When that output assumes a logic 1 condition, *Q3* is forward biased. This causes current to flow into piezoelectric sound element *PB1*. The high-pitched warning signal emitted by *PB1* then tells you that the selected elapsed time is up.

Resistor *R13* is connected to the outputs of *IC2* through single-pole, three-position switch *S3* to provide three possible time-delay ranges that can be selected. If you require only one time-delay range, you can wire *R3* directly to the appropriate output pin of *IC2* and eliminate switch *S3*. A fourth output, at pin 6 of *IC2*, provides a means for quickly checking time-delay calibration without having you wait the full 8 minutes. This output, because of the internal division of the clock frequency by 128, will assume a logic 1 condition in full sunlight after a time delay of about 15 seconds.

Resistor *R12* and TEST switch *S2* permit you to check battery condition. When you push *S2*, *R12* draws a current that exceeds the normal operating current of the circuit. If the battery has sufficient energy to supply this current, *Q3* is forward-biased and *PB1* sounds. If *PB1* does not sound, you know that it is time to replace the battery.

Construction

There is nothing critical about component placement or conductor routing in this project. Therefore, just about any traditional means of wiring the circuit can be employed. If you wish, you can fabricate a printed-circuit board for the project, using the actual-size etching-and-drilling guide given in Fig. 2. Otherwise, you can purchase a ready-to-wire pc board from the source given in the Note at the end of the Parts List. Alternatively, you can use perforated board that has holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware. Whichever way you go, though, it is a good idea to use sockets for the integrated circuits.

From here on, we will assume you are building the project on a printed-circuit board. Start assembly by placing the pc board in front of you in the orientation shown in Fig. 3 and follow this wiring guide exactly when installing components in the various locations. If you elect to use perforated-board construction, use Fig. 3 as a general layout guide, and make sure to keep the wiring between *PC1*, *R1*, *R2* and *IC1* as close as possible to that shown in Fig. 3 since the op amp operates on a very small input voltage produced by the solar cell and *R1*.

Begin wiring the board by installing and soldering into place the IC sockets. This done, install and solder into place the resistors and potentiometers, followed by the diodes and capacitors. Make certain that diodes *D1* and *D2* and electrolytic capacitors *C1* and *C2* are properly polarized before soldering their leads into place. Install the transistors in their respective locations and double check their basing before soldering their leads to the copper pads on the bottom of the board.

When assembling the pc board, do *not* mount the solar cell or remove it

Wire Length Chart for R1	
Wire Size	Length in Inches
28	38
30	24
32	15½
34	10¼
36	6¼

Time-Delay Range for IC2 Outputs		
Output	Time Delay	
Pin	Minimum	Maximum
6	15 seconds	52 seconds
1	8 minutes	28 minutes
2	16 minutes	56 minutes
3	32 minutes	112 minutes

from its protective package until instructed to do so later. This component is extremely fragile and is easily damaged by careless handling.

Be sure to use the components specified in the Parts List for *R2*, *R3* and *R6*. The values of these metal-film resistors, which remain relatively stable as the temperature changes, determine calibration accuracy, which is something you do not want to change once you have calibrated the project. Ordinary carbon resistors do not have the value stability required for this part of the circuit.

Resistor *R1* is specified at 0.2 ohm, which is not a readily available value. However, it is easy to make the required value resistor from enameled (magnet) wire and a resistor. The Wire Length Chart specifies lengths of wires of various gauges that can be used to fabricate this resistor. Cut the wire whose gauge you have chosen to the length specified for it in the Chart. Then scrape ½ inch of enamel insulation from each end.

Now wind ½ inch of one end of the magnet wire onto the bare lead of any ½-watt resistor that has a medium to high resistance value. Start near the body of the resistor. Solder this wire end into place. Then wind the entire length of wire except for the last ½ inch onto the body of the resistor. It does not matter if you wind in a random fashion and end up with more than one layer. Wind the remaining bare portion onto the resistor wire opposite the soldered end, and solder it in place.

Paint a smooth layer of coil dope or a fast-setting epoxy cement over the coil to hold the windings in place. After the coil dope has dried or the epoxy cement has set, plug the leads of the resistor into the R1 holes in the circuit-board assembly and solder them to the copper pads on the bottom of the board.

As mentioned above, you have the option of using a three- or four-position, single-pole switch in your project for switch *S3* if you wish to have a wide range of exposure times. A four-position switch allows you to be able to include a CALIBRATE position that connects *R13* to pin 6 of *IC2* to be able to quickly check Sun-Guard's accuracy.

The Time Delay table illustrates the range of exposure times that are obtainable for each of the selected outputs of *IC2* at pins 6, 1, 2 and 3 using the specified values for *R5*, *R6* and *C1* in the oscillator circuit. If you wish to modify the specified timing ranges, change the value of *C1*. The time relationship is linear with the value of *C1*. That is, doubling the value of this capacitor doubles the time specified in the table and halving its value halves the time. It is not recommended that the value of either *R5* or *R6* be changed from those specified for these resistors in the Parts List since the oscillator transistor places a restraint on the maximum and minimum values of resistance used in the circuit.

Strip ¼ inch of insulation from both ends of 11 (9 if you are planning on using a single range for your project) 5-inch hookup wires. If you are using stranded hookup wire, tightly twist together the fine conductors at both ends and sparingly tin with solder. Plug one end of two of these wires into the holes labeled R5 and solder into place.

Plug one end of another wire into the hole labeled S3W between *Q2* and *R13* on the board and solder this into place. Now, depending on whether you are using a single range or three ranges, plug three wires or one wire into the holes labeled 3, 2 and 1 or the appropriate hole for the single range and solder into place.

Plug one end of another pair of wires into the holes labeled S2 and solder them into place. Then do the same for the remaining two wires and the holes labeled S1 and B1 – .

If you omit *S3*, temporarily solder a jumper wire between the hole labeled S3W and pin 6 of the *IC2* socket to make a quick calibration of your project. Then, once *R5* is calibrated, permanently wire *R13* to the desired output terminal of *IC2* in accordance with the selected time delay listed in the Time-Delay Range chart.

When you have completed wiring of the circuit-board assembly, carefully examine both sides of it to make sure all components are installed in the proper locations and orientations. Check the solder side of the board, keeping an eye out for missed connections, poor soldering and solder bridges, the latter especially between the closely spaced IC socket pin pads. Solder any connections missed, reflow the solder on any point that appears to be suspicious and use desoldering braid or a vacuum-type desoldering tool to remove any bridges.

When you are satisfied that the circuit-board assembly has been properly wired, place the solar cell on the board. Very carefully remove it from its protective package. Note that one side has a series of lines stopping short at each end, leaving a clear strip about ⅓₂ inch wide. This is the negative terminal of the cell. The back side is the positive terminal.

Scrape ³⁄₁₆ inch of insulation from one end of two 2-inch lengths of enamel-insulated magnet wire (not

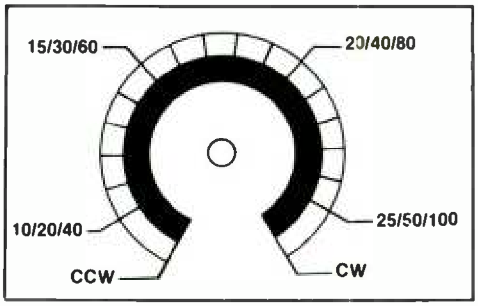


Fig. 4. Actual-size artwork for calibrating potentiometer control.

heavier than 24 gauge). Use a low-wattage iron to carefully solder the stripped ends to the clear portion on the front of the solar cell and the back of the cell.

Place the solar cell with its front, or negative, side up in the indicated location on the circuit-board assembly and trim the two magnet wires to proper length. Carefully scrape away about ⅛ inch of insulation from the free end of each. Then insert the wires into the proper holes in the board, making sure to observe correct polarity, and solder into place. Cut off any excess wire on the bottom of the board.

Secure the solar cell to the top surface of the board with a drop of silicone or any other suitable adhesive. Set the circuit-board assembly in a safe place until the adhesive sets.

Tightly twist together the fine wires at the free ends of the leads of the battery snap connector and tin with solder. Plug the black-insulated (negative) connector lead into the hole labeled B1– in the board and solder it into place. Crimp and solder the red-insulated (positive) lead to one lug of *S1*. Then plug the free ends of the wires coming from the buzzer into the PB1 holes, making certain that you observe correct polarity, and solder them into place.

Be sure to connect the free ends of the R5 wires to the lugs of this potentiometer so that clockwise rotation results in increasing resistance. Otherwise, you will not be able to properly calibrate the circuit.

Crimp and solder the free end of the wire coming from hole S3W to the common wiper lug on this switch (if you are using it). Then crimp and solder the free ends of the wires coming from holes 6, 3, 2 and 1 to the remaining lugs of the switch in the proper sequence. Finally, crimp and solder the free ends of the wires coming from the S2 holes to the lugs of the pushbutton switch.

House your project inside a small clear plastic enclosure that is capable of preventing sand and other contaminants from entering. Use of a clear plastic enclosure is mandatory to permit the solar cell to get full exposure from the sun.

Machine the enclosure by drilling mounting holes for the three switches (two switches if you opted to omit *S3*), potentiometer *R5* and the clip that will hold the battery in place. Do not drill mounting holes for the circuit-board assembly; it will be mounted with strips of thick double-sided foam tape.

Mount the piezo-buzzer element inside the enclosure, securing it in place with a daub of silicone adhesive or fast-setting epoxy cement. There is no need, nor is it recommended, for you to drill holes in the enclosure to allow the sound to escape since the intensity of the alerting tone is sufficient to be heard through the enclosure's walls. When mounting the components on and inside the enclosure, do not forget to allow room for the battery.

Shown in Fig. 4 is actual-size artwork you can cement on the outside of the enclosure for use in calibrating *R5*. Make a photocopy of this artwork instead of cutting up the page if you wish. If you need a slightly smaller or larger illustration, many photocopy machines permit reduction and enlargement of the original. After cementing the artwork to the enclosure spray over it two or three light coats of clear acrylic to protect it from wear and abrasion. Allow each coat to dry before spraying on the next. Place suitable pointer-type control knobs on the shafts of the potentiometer and multiple-position switch (*S3*).

Checkout & Calibration

If you installed the integrated circuits in their sockets during assembly, carefully remove and set them aside. Snap a fresh 9-volt battery into its connector and set POWER switch *S1* to its "on" position. Use an ordinary dc voltmeter or multimeter set to the dc volts function to perform voltage checks before installing the ICs in their sockets. This meter should have an input resistance of not less than 1 megohm.

Clip the meter's common probe to the negative (–) lead of electrolytic capacitor *C2*. Then touch the meter's positive probe to pin 14 of the *IC1* socket and pin 16 of the *IC2* socket. In both cases, you should obtain a meter reading of approximately 9 volts. If not, power down the circuit and carefully check your work for wiring errors, components installed in the wrong locations and/or wrong orientations, etc. Do not proceed until you have rectified the problem.

Once you are certain that everything is okay, install the ICs in their respective sockets. Make you properly orient each and that no pins overhang the sockets or fold under between the ICs and sockets. Now proceed to calibrating the project.

SunGuard is easily calibrated with the aid of the meter you used to perform checkout, a watch or clock with a sweep second hand or a seconds counting function, and a regulated dc power supply that is capable of supplying 5.5 volts. The last is a convenience but not a necessity.

The first part of the circuit to be calibrated is the solar cell and operational amplifier *IC1*. For calibration of this circuit, you must have clear-sky conditions and the sun at full brightness.

(Continued on page 84)

AC Motor Speed Controller

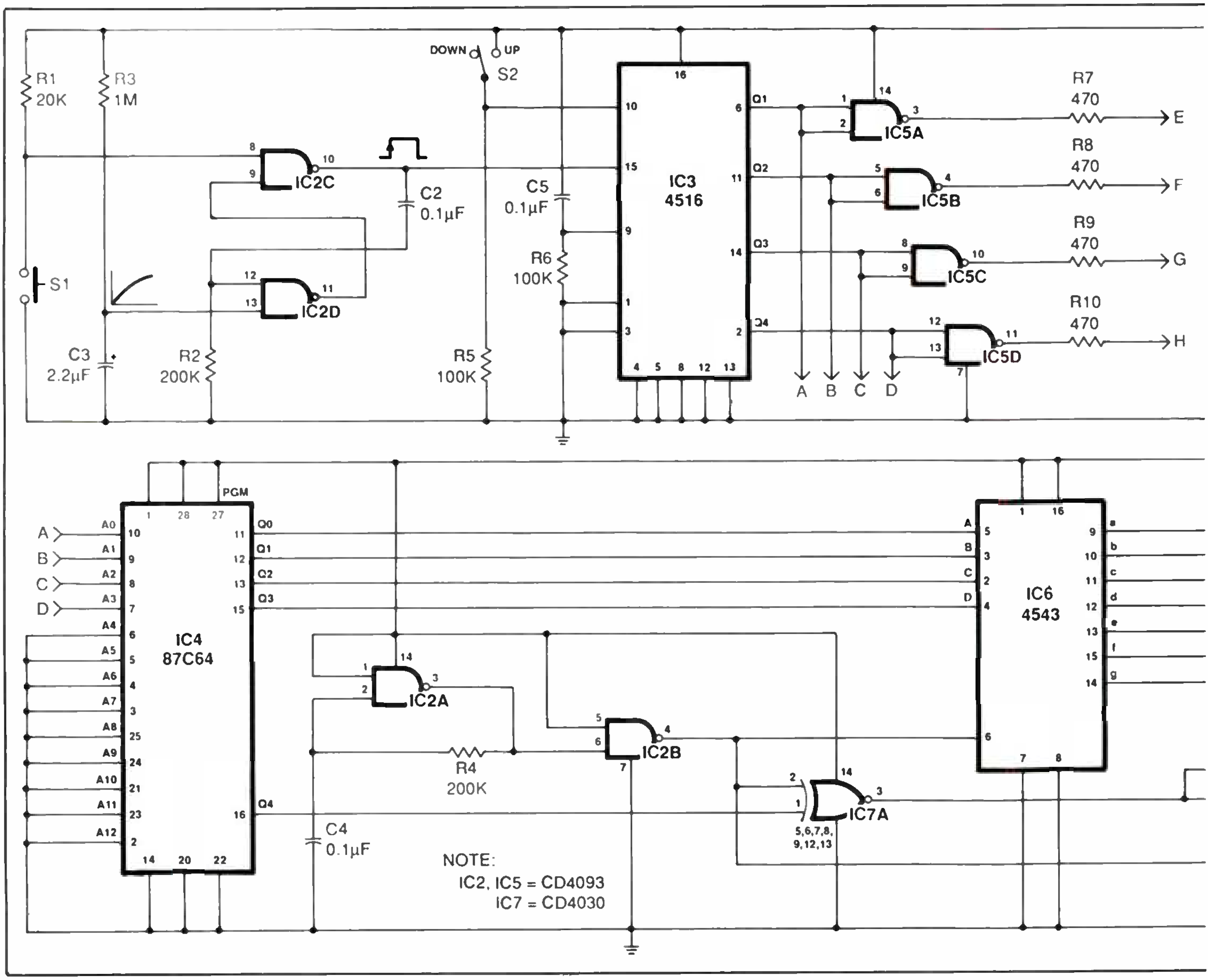
Setting speed of an ac motor with optical couplers and a binary counter

By Ricardo Jiminez-G

Are you looking for an elegantly simple and low-cost circuit for controlling the speed of an ac motor? If so, here is one you should look into. It uses four optocouplers and a single binary counter as the speed-control elements and features a decimal numeric display as well.

About the Circuit

The schematic diagram of the speed-controller circuit is shown in Fig. 1. This circuit controls the speed of ac motor *M* by changing the conduction angle of triac *Q1*. At the heart of this circuit are optical couplers *IC8* through *IC11*, which control triac *Q1*. A resistive network made up of



R11, *R12*, *R13* and *R14* controls the magnitude of the current that passes through diac *D1*. Hence, the conduction angle depends upon the state of the four parallel *R11* through *R14* resistors. Four resistors give 16 possible steps, making a 15-speed ac motor controller. By adding more resistors, optocouplers, up/down counters and EPROMs, it is possible to obtain 31, 63, etc., speeds from the circuit.

When the circuit is first powered up, the *R3/C3* network disables the monostable multivibrator made up of *IC2C* and *IC2D* for a period of 0.43 second and the *R6/C5* network resets counter *IC3* to zero. Under these conditions, the motor will not run because the LEDs inside the four optocouplers are not turned on. The four NAND gates that make up *IC5* are configured here as inverters. They function as buffers that supply the 13 milliamperes of current required by the LEDs inside each optocoupler.

To start running the motor, normally-open pushbutton switch *S1* must be pressed. Counter *IC3* then changes its zero state to decimal 1 (0001). This generates a pulse at the pin 6 Q1 output of *IC3*, which is coupled through *IC5A* and pulses on the internal diode of optocoupler *IC8*. This "enables" *R11* to transmit the voltage across *C6* to the gate of *Q1*. With diac *D1* between *C6* and the gate of *Q1*, however, the triac does not immediately turn on.

As the 117-volt ac source passes through zero on each cycle alternation, the charge on *C6* increases. Only when the potential across capacitor *C6* reaches 30 volts, which is the break-over potential of the diac, is *D1* triggered into conduction. When the diac triggers on, the charge on *C6* is "dumped" into the gate and trig-

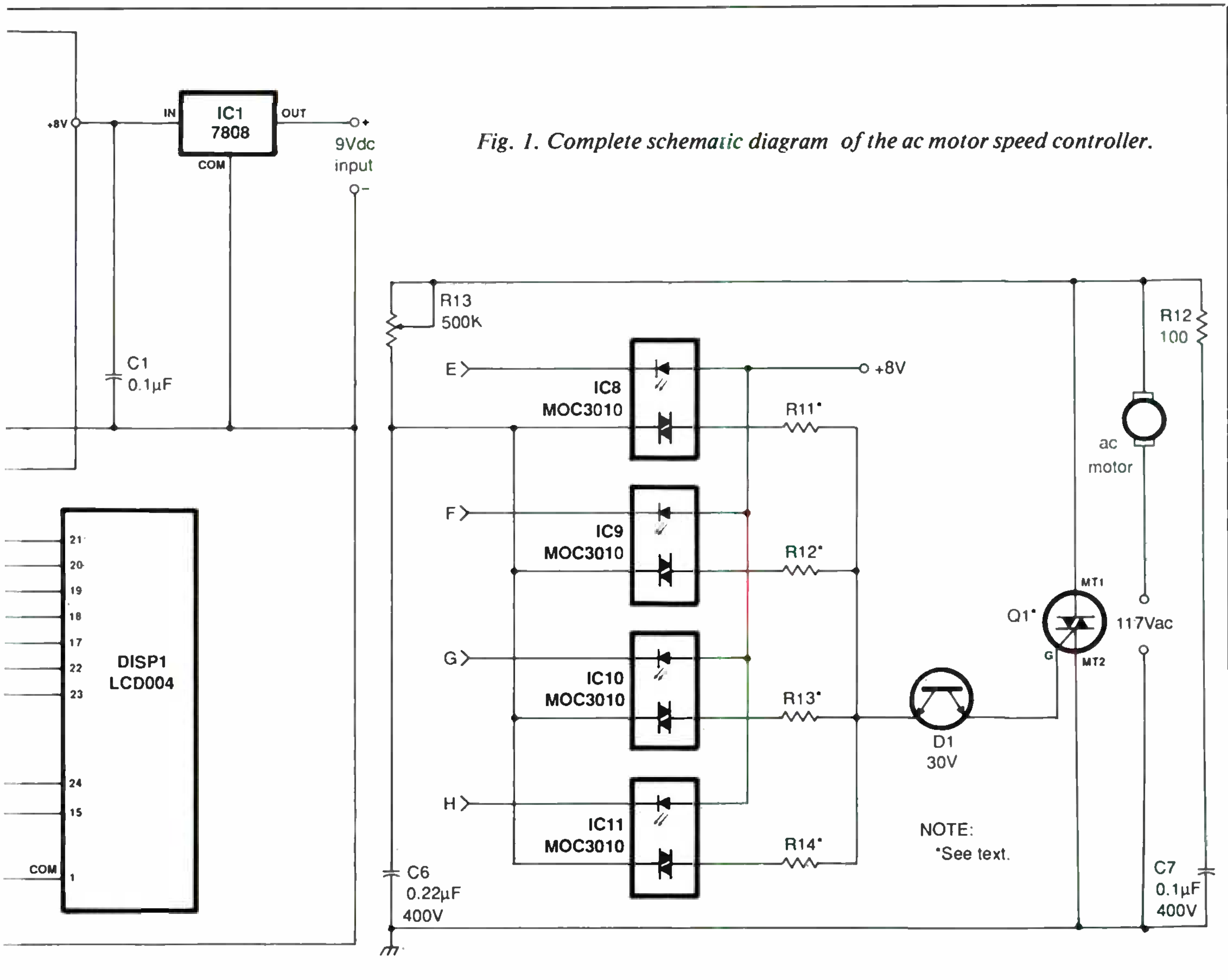


Fig. 1. Complete schematic diagram of the ac motor speed controller.

PARTS LIST

Semiconductors
D1—30-volt diac
IC1—7808 fixed +8-volt regulator
IC2,IC5—CD4093 quad 2-input NAND gate
IC3—4516 counter
IC4—87C64 or similar EPROM
IC6—4543 decoder
IC7—CD4030 XOR gate
IC8 thru IC11—MOC3010 or similar triac-output optical isolator
Q1—Triac (see text)

Capacitors
C1,C2,C4,C5—0.1-μF, 16-volt disc
C3—2.2-μF, 16-volt electrolytic
C6—0.22-μF, 400-volt disc
C7—0.1-μF, 400-volt disc

Resistors (¼-watt, 5% tolerance)
R1—20,000 ohms
R2,R4—200,000 ohms
R3—1 megohm
R5,R6—100,000 ohms
R7 thru R10—470 ohms
R11 thru R14—See text
R12—100 ohms
R13—500,000-ohm, linear-taper, panel-mount potentiometer

Miscellaneous
DISP1—LCD004 liquid-crystal display module
M—Existing ac motor
S1—Spst momentary-action pushbutton switch
S2—2-position slide or toggle switch 9-volt dc, 150-mA plug-in power supply

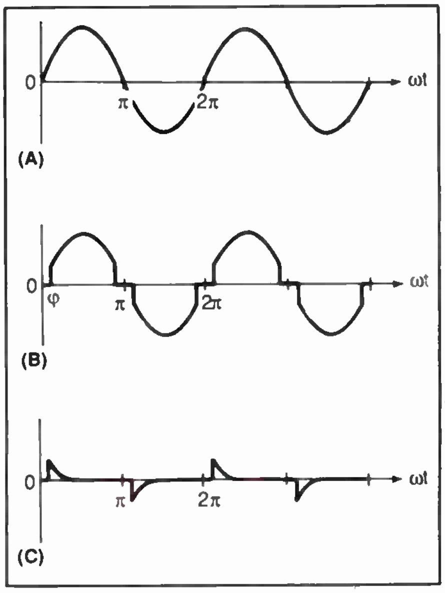


Fig. 2. Typical waveforms: (A) 117-volt rms sine wave from ac line; (B) load voltage if triac turns on when source voltage reaches instantaneous value of 30 volts; (C) gate current waveform produced by C6 discharging through D1.

gers on triac *Q1*. When this occurs, the motor begins to operate at its slowest speed.

Incrementing counter *IC3* by using *S1* to have the monostable oscillator pulse input pin 15 of *IC3* will cause the motor to operate at a faster speed, depending upon which and how many of the optocouplers are triggered on. For this to occur, though, DIRECTION switch *S2* must be in its UP position. Placing this switch in the DOWN position will have just the opposite effect.

EPROM *IC4*, an 87C64 chip, is used here to represent the 16 steps of the controller that are counted off in the *DISP1* LCD display. The EPROM's program is given in the table. Decoder *IC6* converts the output from the EPROM into a format that can be used by *DISP1*. Note that the Q4 output at pin 16 of *IC4* is coupled to input pins 15 and 24 of *DISP1* through XOR gate *IC7A*. (Note: The other XOR gates in *IC7* are not used in this circuit.)

Schmitt-trigger inverters *IC2A* and *IC2B* make up a 40-Hz oscillator that drives the LCD's backplane and decoder *IC6*'s phase input at pin 6 according to the recommendation given in the CD4543's data sheet.

Your choice of triac for *Q1* will depend upon the amount of current required to operate the motor. The greater the demand, of course, the higher should be the current rating of the triac chosen. This current rating should be at least 1.25 times the maximum amount of current the motor will normally draw.

A good starting value for the parallel resistor network made up of *R11* through *R14* (and any other networks you might incorporate into your controller design) is 10,000 ohms. That is, if you use 10,000 ohms for *R11* (R), *R12*'s value should be 5,000 ohms (R/2), *R13*'s should be 2,500 ohms (R/4) and *R14*'s should be 1,250 ohms (R/8).

As you can see in the upper-right corner of the schematic, this circuit receives its 8-volt dc power from a simple voltage-regulator circuit that is fed from a common 9-volt dc plug-in power supply. If you build the circuit from scratch, you might want to incorporate the dc power supply in the basic design, using a 12.6-volt, 150-milliampere transformer, bridge rectifier assembly and large-value filter capacitor in place of the plug-in power supply.

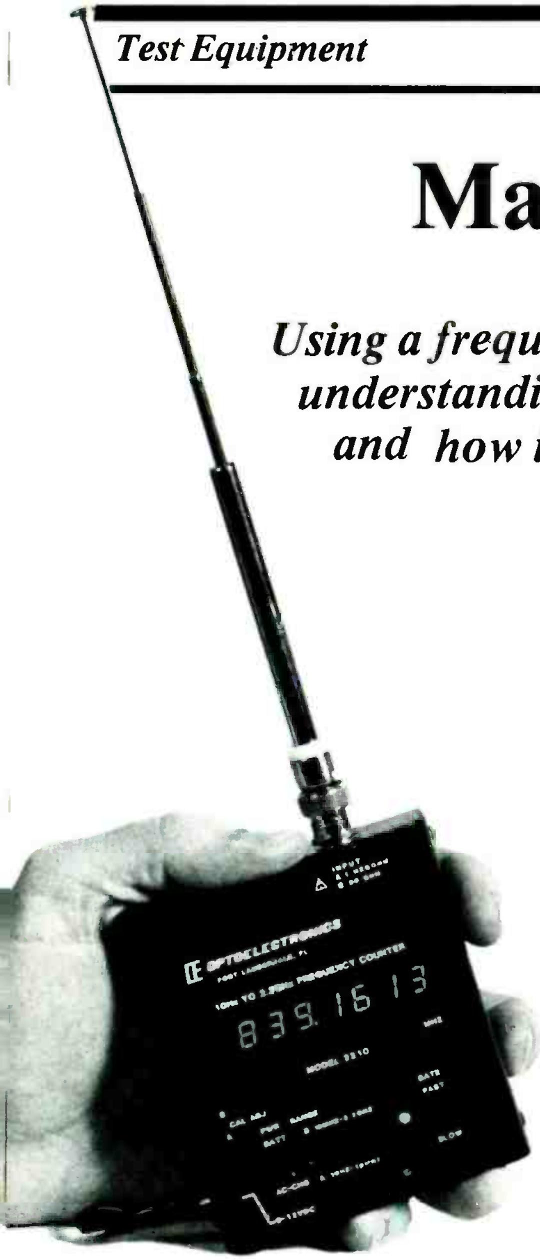
Bear in mind when assembling the circuit, that all unused segments of the LCD004 display module must be tied to common pin 1 of the assembly. Also, when putting the circuit into operation, adjust the setting of *R11* to a value of 250,000 ohms. **ME**

EPROM Program—Converts Binary Code into BCD Code

Hex Address	Hex Data
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
A	10
B	11
C	12
D	13
E	14
F	15

Making It Count

Using a frequency counter requires some basic understanding of the instrument's capabilities and how it can be applied



(Photo credits: Tracey Trumbull)

By Bill Owen

Last month, we presented plans to build a compact, portable frequency counter that spans audio through microwave frequencies. Making it count, as with any other frequency counter, is simply a matter of understanding how to use it properly.

To use such an instrument effectively, and without damaging it, requires the operator to know something about the signal it will receive. This shouldn't be surprising; the same is true when working with a multimeter, where you should know if the signal is ac or dc and what is the anticipated voltage range to be set. And as with any test instrument, different models often have different features and operating nuances. It's important, therefore, to study the manufacturer's operating manual and familiarize yourself with the counter's switches and controls.

You should never exceed any instrument's input limitation, of course. In the case of a frequency counter, neophytes may overlook such a precaution for one reason or another. For example, one might have an inordinate desire to check out his electric utility company's ability to maintain ac current at precisely 60 Hertz by connecting a counter's input probe directly to a 117-volt ac outlet. Do *not* do this, naturally . . . unless you want to see your counter go up in a puff of smoke and possibly suffer an electric shock yourself!

Use caution, too, when measuring a transmitter's antenna output. Do not directly connect the counter's input to the transmitter's output because the instrument's input circuitry will likely be damaged when the transmitter is keyed. Other, safe ways to check a transmitter's output will be explored later.

To give you a clearer idea about the seriousness of keeping in mind the strength of any input signal applied to a frequency counter, let's look at the compact counter for which construction plans were presented. Each of its two frequency-range modes has a different maximum input signal it can accept without damage.

Range A, which has a frequency range of 10 Hz to 12 MHz and a 1-megohm input impedance, has a maximum input specification or damage level of 100 volts ac plus dc. Range B, which covers 10 MHz to 2.2 GHz and has a 50-ohm impedance input, has an input limit of only 2 volts. Imagine what a disaster it would be if the range switch was accidentally changed from "A" to "B" while inputting, say, a 50-volt signal!

There are other unfamiliar elements of concern when operating a frequency counter. For example, its input sensitivity might change with frequency. Consequently, one should have some idea of the approximate frequency to be counted. Furthermore, signals have to be properly coupled between the counter and the device being checked. Ignoring the foregoing, the counter might display no reading, an unstable reading or even a wrong count.

None of the foregoing operating considerations can be considered to be outrageous. However, they may indeed be somewhat disconcerting to anyone not used to working with high frequencies, the major area in which frequency counters are used, whether it's for checking a ham radio transmitter's frequency or a computer's clock frequency.

There are two basic ways to make a counter read frequencies. One is the traditional way of directly coupling the counter's input connector through a cable or a probe to a device's output (always observing the precautions previously cited). Alternately, a pickup antenna can be employed to receive the signal to be counted through the air.

Direct-Connection Method

As an example of the direct-connection method, you can verify frequencies of various signal generators by directly connecting a cable between the generator's output and the counter's input. This might sound easy enough, and it is—with an exception. Using the right connectors for the job can be a frustrating chore at times. Consequently, plan on having an assortment of adapters on hand.

The counter in this project uses a female "BNC" (military designation, UG1094U) for its input connector, which is pretty much standard on many types of generators and other test equipment. Type "N" is also commonly used, so a Type N-to-BNC adapter would certainly be useful to have. I recommend, too, having a 6-foot-long coaxial cable with a male BNC on each end on hand for connection adapting purposes.

Many oscilloscopes also have a vertical signal output connector on the rear panel. You can directly connect the counter's input to it to give you a frequency readout of the waveform being displayed on the scope. Only high-priced scopes have accurate frequency readouts, which you can match for a modest investment.

I cited some frequency counter connection caveats earlier, warning about the dangers of direct connection in some instances. There are ways around this, though. For example, what if you really had to know the frequency of the current coming out of a wall tap? One way to circumvent destroying the instrument by taking a frontal connection attack (and possibly exposing yourself to an electrical shock because the portable counter will be grounded through your hand) is to use a low-voltage transformer to step down voltage to a tolerable level and to isolate the power line. Note that the subject portable counter must be set to its "A" range even here to avoid damage.

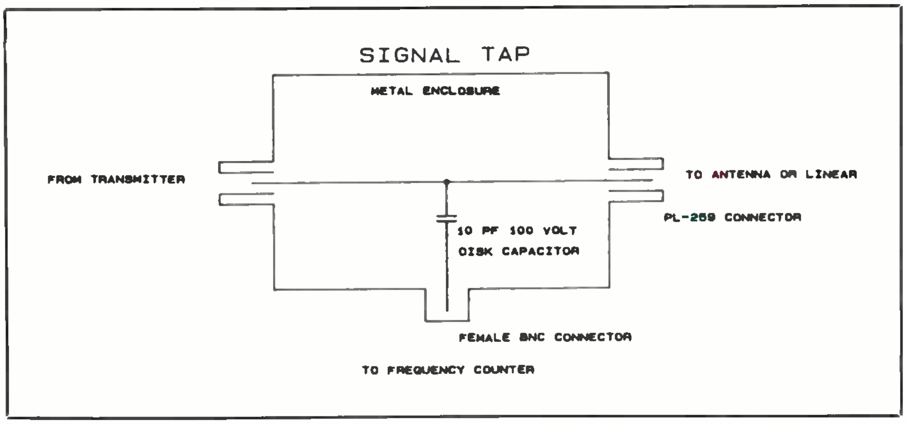


Fig. 1. Details of a tap arrangement for safely counting the frequency at the output of a radio transmitter.

You can measure a transmitter's output frequency by using some keen coupling techniques that avoid a straight connection line between it and the counter. For example, you might use the signal tap illustrated in Fig. 1. The design has to be approximated because the transmission frequency and power level will affect operation. As a result, some insertion loss might be incurred.

There are more ways to skin the cat, of course. You can use adequate attenuators to reduce the power level to a safe level for the counter's input, for instance. Some much costlier frequency counters even have built-in switchable attenuators.

Keep in mind that testing a transmitter without using a non-radiating dummy load can interfere with the radio communications of others who are active on the same frequency. Also remember that counters measure steady radio-frequency energy, such as a continuous carrier wave. The instrument is not designed to work with an audio modulated carrier, much as Morse Code isn't. This might seem to indicate that you cannot count the output of a single-sideband transmitter since audio has to be used to generate it.

You can get around this, however, because some SSB transmitters have carrier-insertion provisions. What if yours doesn't? Well, old timers say you can simply send a single tone whose frequency is known through the microphone. According to them, then count the output, taking care that you do not do so with a direct connection, and subtract or add the single tone's frequency (depending on whether you're switched to upper or lower sideband) from your frequency counter's reading.

Specialized probes can enhance the utility of a frequency counter. This can be the case with the counter project at hand, which could try to count a low-frequency source such as an audio signal while having an inherent gigahertz (GHz) bandwidth. The counter has to be able to distinguish between a low-frequency signal and high-frequency noise and harmonics that could be present.

To do this with our low-cost compact counter requires the use of an attenuation probe, such as a 10× oscilloscope probe. For instance, you might have a 5-volt signal with a signal-to-noise ratio of 40 dB that could have a 50-millivolt noise level. The signal is clearly sufficiently high to be counted. The hat trick is simply to reduce the 5-volt level to the point where it's still high enough to be measured, while at the same time the noise component has been reduced to

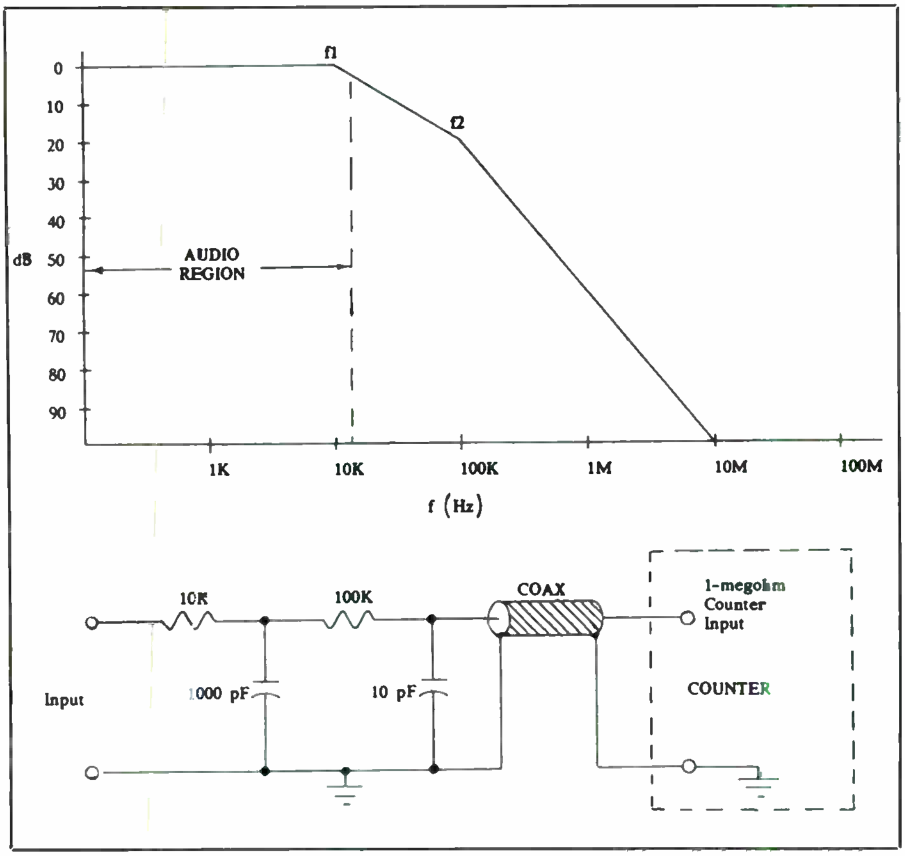


Fig. 2. Frequency-response plot of a low-pass filter and schematic diagram of a low-pass probe.

the point where it cannot be counted.

In using this technique, be sure that the counter is in the higher input impedance range ("A" is 1 megohm in the project counter). If you switch to the low 50-ohm impedance range ("B" in the project counter), the scope probe's 10-megohm series impedance will eat up most of the signal. This would leave too low a signal value to trigger the counter. Only 1 × probes or direct cables can work on the very-high-frequency range ("B") due to its very low input impedance.

Low-frequency measurements are made easier by using a low-pass-filter probe. It reduces false counting from higher-frequency components. A schematic for such a two-stage filter is illustrated in Fig. 2, along with its response curve. Component values are not critical and the device is easy to build. (The probe can only be used for low-frequency counting, as in the project's "A" range.)

There will be times when you may want to take your count inside a circuit. Perhaps this is in the oscillator circuit. Don't be surprised to discover that you can't get a satisfactory reading in such instances. The signal level will likely be too low. You'll either require a preamplifier or probe with a built-in wideband amplifier to boost the gain or use a high-priced counter with a built-in wideband amplifier to obtain a usable signal.

Measuring crystal oscillators can be a problem because a probe might load the circuit, causing the frequency to shift or, worse, cause the oscillator to cease oscillating. Many oscillator circuits provide a calibration test point to avoid this. The best way to proceed in a crystal oscillator is to use either a 10× scope probe or a large-value series resistor.

The largest possible resistor value should be used that will still allow a measurement to be made. Typical values range from from 100K to 100 megohms. You might also use a multi-turn loop of wire (sometimes called a "sniffer") as a pickup that's placed close to the crystal if the device radiates sufficient energy. This method should have minimal influence on the oscillator's frequency since the circuit isn't loaded.

Note that only the relatively low-frequency range ("A") should be used for direct measurements. Signals of higher-frequency oscillators have to be indirectly counted using the sniffer device to avoid having the counter's 50-ohm input impedance stop the circuit's oscillation.

Indirect-Connection Methods

The "sniffer" device mentioned earlier is an example of an indirect-connection method of "coupling" a counter to whatever you're counting. You can also use a short whip antenna connected to the counter's input to pick up a radiated signal from, say, a transmitter—if you're close enough and the output signal is strong enough. This is a popular way to use a frequency counter, greatly expanding its applications.

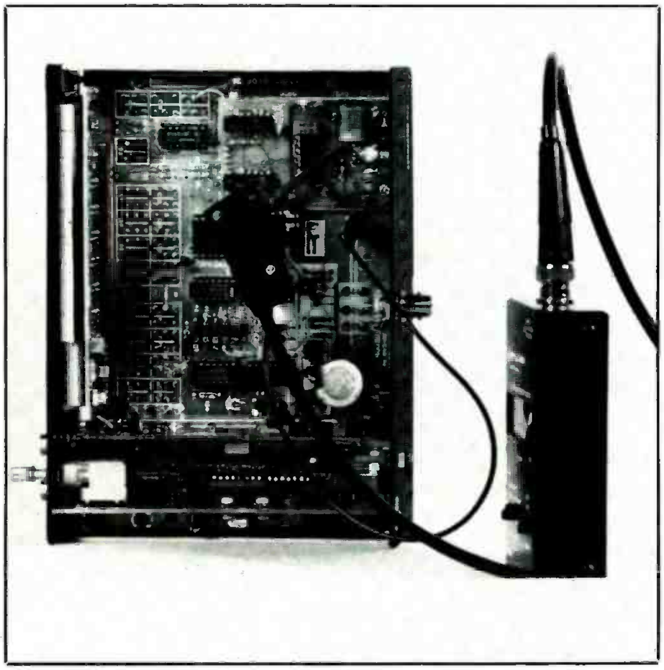
A frequency counter isn't like a radio, of course. Whereas a radio is designed to be tuned to selected frequencies, a counter is a broad-band device that responds to the dominant (strongest) frequency of the moment.

In practical terms, there may be a 100-kW transmitter a few blocks away and a 1-watt transmitter 10 feet away. The counter will see the 1-watt unit first because there's an inverse-square relationship between signal strength and distance.

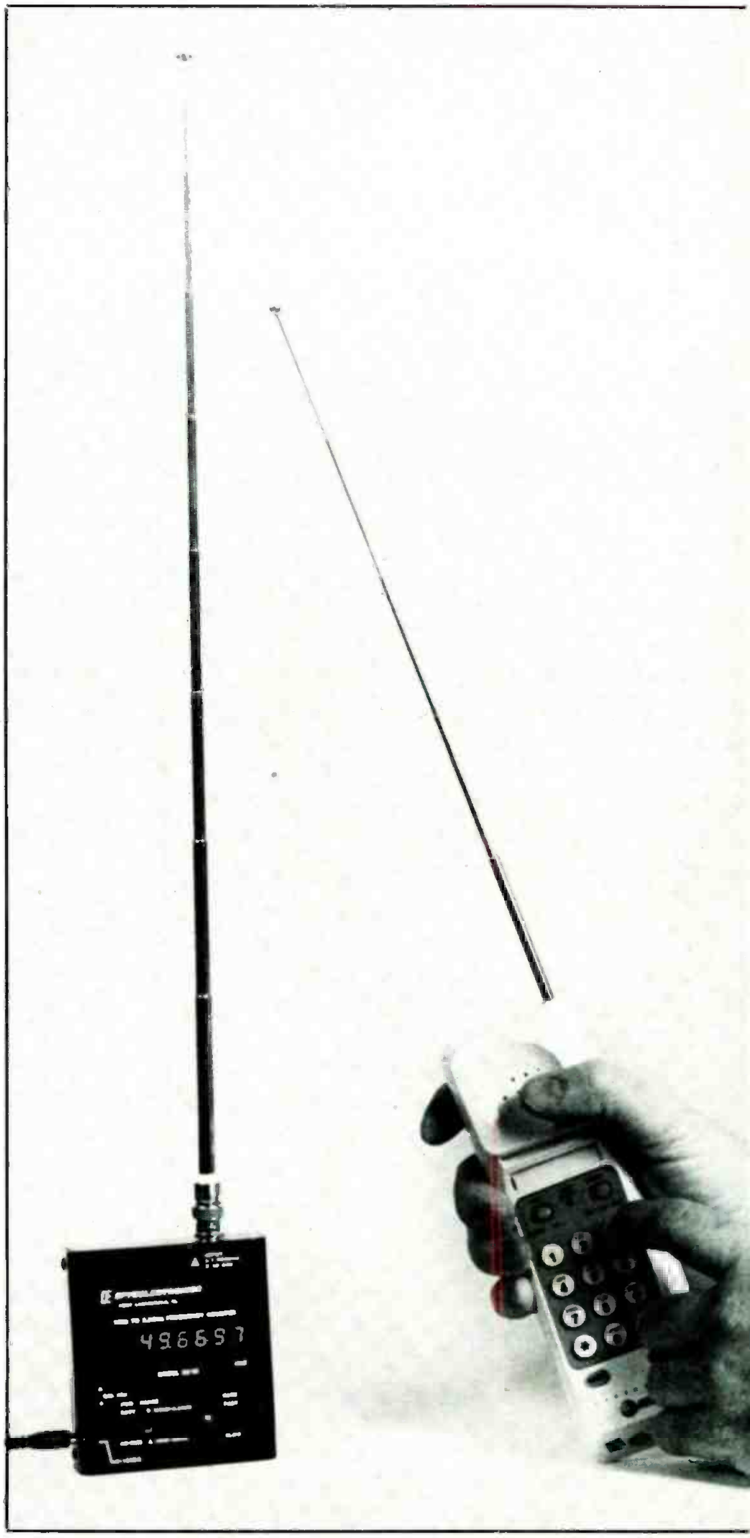
As a result of the foregoing, the counter can be used to measure an unknown signal near it without the operator having to tune in the frequency. This opens new vistas for the

Counter Connection Methods

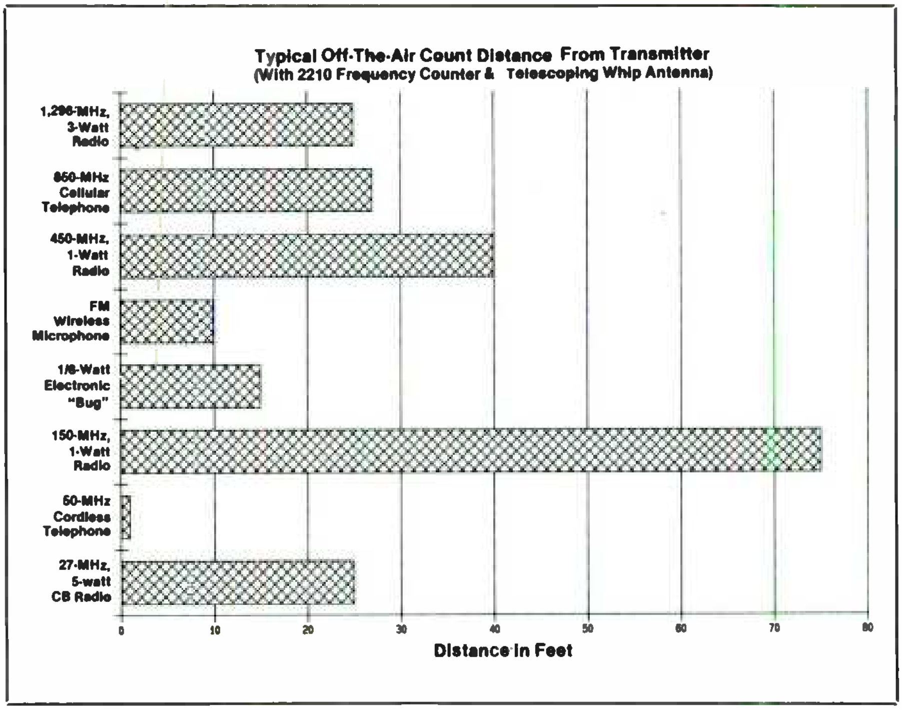
Direct Cable. Directly connecting a frequency counter to an oscilloscope's vertical channel output jack at the rear verifies a 1-kHz signal.



Direct Probe. A 1×, general-purpose direct probe is used to connect the counter to a crystal oscillator circuit.



Off-The-Air. A counter with a telescoping whip antenna measures the frequency generated by a cordless telephone.



owner of a frequency counter, especially if it's a battery-powered portable one like the project is.

An accompanying frequency chart illustrates typical distance-to-transmitter plots for counting the frequency of a host of common r-f sources. Measurements were made with our assembled project counter using an 18-inch telescoping whip antenna connected to the device's input. Obviously, distances in which accurate counting could be accomplished would be greater if an antenna made expressly for the radio frequency to be picked up were used. Other variables here would include transmitter output power, transmitter height, and the counter's sensitivity to the frequency being captured.

With a 1-watt 2-meter radio transmitting at nearly 150 MHz being counted from 75 feet away, it's shown that a telescoping whip antenna can be readily used when the source isn't far away. The whip was fully extended in this case; it would be collapsed as frequency increased. A "rubber duck" antenna, though conveniently small, causes the effective counting range to decrease as much as 50 percent in some cases.

For scanner frequency counting, broad-band antennas designed for these frequencies will provide greater range than the whip used here. There are a number of sources that sell such scanner antennas.

The public service frequencies transmitted locally are favorites for frequency catching. It's legal to sniff out any frequency, you know, punch it up on a scanner if it's in its range, and listen in on the transmission. (*Of course, the listener is still prohibited from using the information heard for personal gain or disclosing its contents to other parties not involved unless by the express permission of the originating party—Ed.*) This enables one to catch the frequency that, say, a patrol car officer is transmitting on, and listen in through your scanner. The same holds true for fire-department transmissions, commercial two-way mobile radio communications, and other transmissions.

When frequency-catching from a car, an external antenna is recommended, such as Antenna Specialties' Model MON-52. When properly configured, a drive through a military base or airline terminal area can be interesting projects.

Since the frequency-counter project combines high sensitivity with portability, it lends itself to the cloak-and-dagger world, too. Simply walking around a room with the hand-held counter's telescoping antenna fully extended will likely lock in on a "bug" if it's there. Professional r-f listening devices are almost exclusively in the 100-MHz through 450-MHz range and, typically, have at least 100 milliwatts of power.

Once you know a bug is present, you'll likely find it with some careful searching. Amateur spies with no access (or money) to commercial listening devices will use cheap FM wireless microphones, which have very low power outputs. The counter project won't pick up its frequency as readily as the professional listening devices, of course. Our chart shows that 10 feet is about maximum distance for the mike. However, the associated threat from this type of snooping is generally a lot less perilous than that of the pro.

Bear in mind that if you're walking around a room with a powered-up counter with antenna attached, and there is no strong r-f signal in the area, a constantly changing counter display will likely be generated. Don't try to interpret such readings, which are meaningless. Such self-oscillation from internal r-f amplifier/antenna interaction is due to a counter having good sensitivity. It's merely responding to background radio frequencies. With a little experimenting, you'll quickly learn how to distinguish between this and a frequency-locked readout.

Conclusion

Frequency counters are finding wider areas of application than ever before

(Continued on page 85)

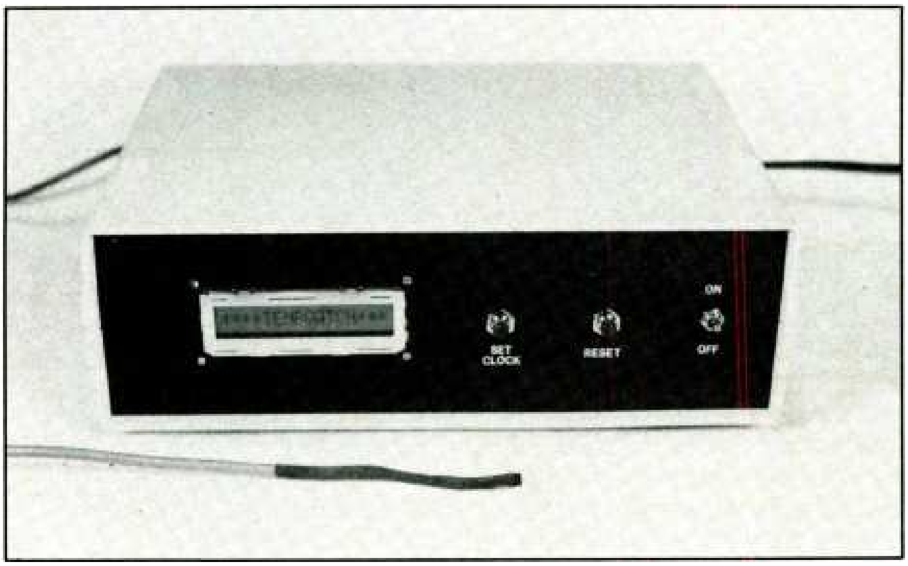
Microprocessor Control with BASIC

(Conclusion)

Adding a "Tempwatch" accessory to last month's Microsys development unit creates a "smart" thermometer

By Jan Axelson & Jim Hughes

Last month in Part 1 of this article, we showed you how to build and use the Microsys development system for microprocessor-based projects. The basic system described so far consists of an 8052AH-BASIC microcontroller, RAM, EPROM, and a serial port for connection to a terminal (or a computer being run as a terminal). Now we'll add inputs and outputs that will turn the Microsys into a complete, stand-alone temperature-measuring instrument. We call this our Tempwatch "smart" thermometer.



Tempwatch isn't just an ordinary thermometer. It displays the present temperature and time and also the maximum and minimum temperatures measured and the times these occurred. To add these capabilities to the basic Microsys, you must add a few more modules. For input, you'll add a temperature sensor, an ADC (analog-to-digital converter), and two pushbutton switches for user control. A 16-character dot-matrix LCD (liquid-crystal display) module serves as the "output" device.

About the Circuit

In Fig. 5 is shown the schematic diagram for the ADC and its associated circuitry. Input to the ADC is provided by LM34 temperature sensor *IC13*. The output of this three-terminal device is an analog voltage that is proportional to temperature at a rate of 10 millivolts per degree Fahrenheit. At 70 degrees, its output is within 0.8 millivolt of 700 millivolts. Resistor *R18* and capacitor *C21* form a low-pass filter to reduce noise on the input.

The output from *IC13* is the analog input that is applied to input pin 6 of ADC0804 analog-to-digital converter *IC12*. The ADC converts this analog input into an eight-bit word whose value represents the analog voltage.

LM385-1.2 precision reference diode *IC14* provides a stable 1.2-volt reference at pin 9 of *IC12*. The potential at pin 9 is half the voltage that causes a full-scale output on the ADC. That is, a 2.4-volt input (which is twice the reference voltage) causes an output of 11111111 at AD0 through AD7 of *IC12*. This gives the ADC a resolution of a little less than 10 millivolts, which translates into 1 degree Fahrenheit per bit.

Measurement range of the Tempwatch depends partly on the version of chip used for *IC13*. The LM34C, for example, is accurate over a range of −40 to +230 degrees Fahrenheit

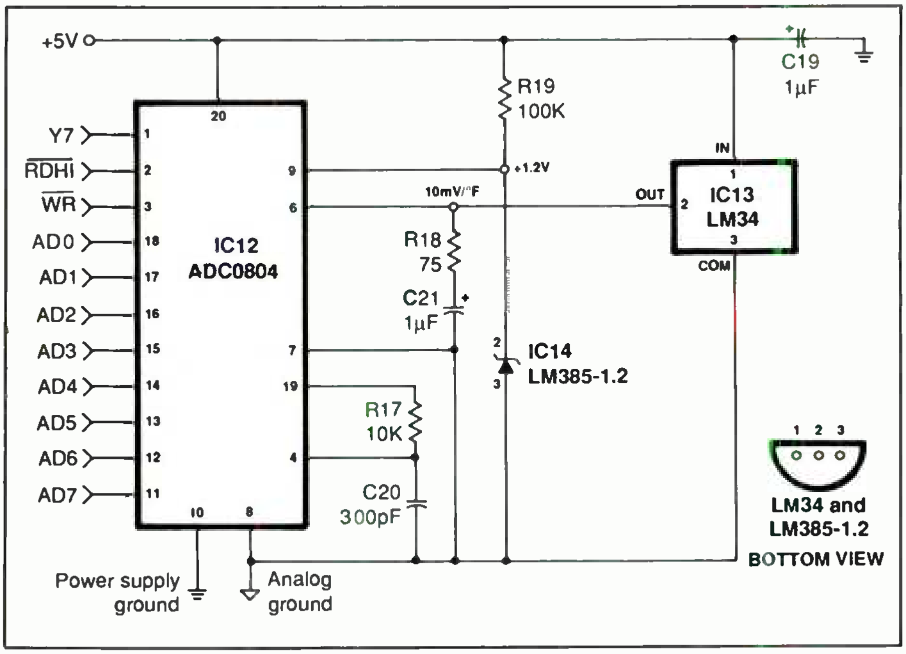


Fig. 5. Schematic diagram for the temperature-sensor and A/D converter circuitry that connect to the Microsys.

(though the Tempwatch measures only down to zero degrees). The LM34D, on the other hand, has a narrower range of +32 to +212 degrees Fahrenheit, as well as a lower price to match; so it may be a better choice if this range suits your needs.

A separate ground return for analog signals in the sensing circuit helps to reduce noise, which improves measuring accuracy. Ground connections for *IC13*, *IC14*, and *C21* connect to *IC12*'s analog ground at pin 8. A single ground wire then connects pin 8 directly to ground on +5-volt regulator *IC11*.

The eight data lines on *IC12* (pins 11 through 18) connect directly to AD0 through AD7 on *IC2*. CHIP SELECT at pin 1 of *IC12* is generated by Y7 at pin 7 of *IC3*. Output Y7 is low when A13, A14, and A15 are all high. This places *IC12* at hexadecimal address E000. Reading and writing to *IC12* are controlled by RDHI at pin 3 of *IC7A* and WRITE at pin 16 of *IC2*.

Resistor *R17* and capacitor *C20* provide the ADC's clock at about 300,000 Hertz (300 kHz).

A low-to-high transition on pin 1 or pin 3 of *IC12* causes the ADC to begin converting its analog input (the temperature voltage) to an eight-bit word. The 8052 can be programmed to read this word on AD0 through AD7 and convert it to a temperature. Next we need a way to display the measurement.

Figure 6 shows the wiring for *M1*, an Amperex-Philips No. LTN111R-10 LCD module. This module has a 16-character display and contains a CMOS controller/driver and its own ROM and RAM. Each of the 16 characters in the display is created by turning on and off the LCD segments arranged in a 5 × 7 matrix. (A matrix display was chosen for this project because it allows much more flexibility in character—which can be letters, numbers or other symbols—design than seven-segment displays do.)

The module's ROM stores the patterns that create 160 different characters, and the RAM stores display data. As Fig. 7 shows, virtually all of the circuitry of *M1* is contained in one LSI surface-mount device. Figure 8 shows a sample display on *M1*.

Data and instructions are written

PARTS LIST

Semiconductors

IC12—ADC0804 analog-to-digital converter

IC13—LM34 precision Fahrenheit temperature sensor (Digi-Key)

IC14—LM385-1.2 voltage-reference diode (Digi-Key)

IC15—74LS00 quad NAND gate

Capacitors (25-WV)

C19,C21—1.0-µF tantalum electrolytic

C20—300-pF ceramic

Resistors (¼-watt, 5% tolerance)

R17—10,000 ohms

R18—75 ohms

R19—100,000 ohms

R20—5,000-ohm pc-mount potentiometer

Miscellaneous

M1—LTN111R-10 16-character LCD module (Digi-Key Cat. No. AMX116-ND)

S2,S3—Spst normally-open, momentary action pushbutton switch

Three-conductor shielded cable (60 inches long); 34-conductor ribbon cable with connectors at both ends (8 inch long—see text); 14-pin single-row header; 34-pin double-row header; Wire Wrap IC sockets and hardware; rubber grommet; small-diameter heat-shrinkable tubing; machine hardware; hookup wire; solder; etc.

Note: For a 2764 EPROM containing the 10 programs listed in this article, plus temperature-alarm program, send $19 to Lakeview Microdesigns, 2209 Winnebago St., Madison, WI 53704. Include $2 P&H per order. Wisconsin residents, please add 5% state sales tax.

Supplier Addresses

Digi-Key Corp.
701 Brooks Ave. S.
Thief River Falls, MN 56701-0677
1-800-344-4539

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002
415-592-8097

Sources of Information

Applications information for LTN111R-10 LCD module (and others)—Digi-Key (Cat. No. AMXDS)

National Semiconductor 1988 Linear Data Book #2; contains data sheets and applications notes for ADC0804, LM34, LM385-1.2—Digi-Key (Cat. No. 9052B) or Jameco (Cat. No. 400042)

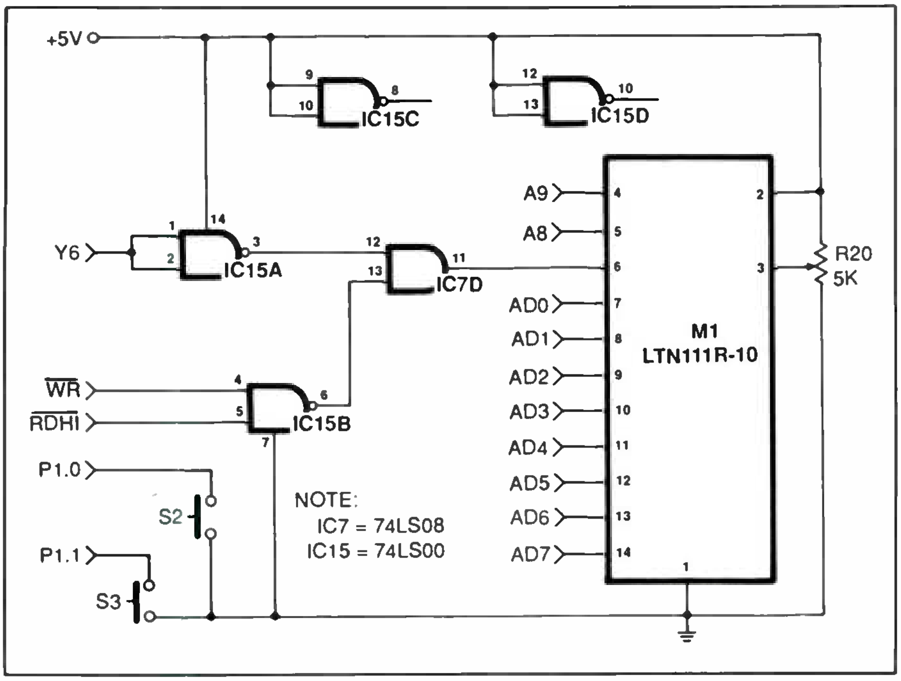


Fig. 6. Schematic diagram of LCD module and switches that connect to the Microsys.

to *M1* on AD0 through AD7 on pins 7 through 14. Three control lines at pins 4, 5 and 6 complete the interface with *IC2*. Pin 3 is a contrast-adjust input for the display, and connections to +5 volts and ground are at pins 2 and 1, respectively.

To display a character on *M1*, *IC2* writes the address of the position desired to *M1*.(Alternatively, *M1* increments or decrements the address automatically after a character is written to the display.) *IC2* next writes the code for the character desired to *M1*. The module then displays the character desired at the position requested.

Logic gates *IC15A*, *IC15B* and *IC7D* generate an enable signal at pin 6 of *M1*. When Y6 at pin 9 of *IC3* is low and either RDHI or WRITE is low, *M1* can be read or written to. Line Y6 is low when A14 and A15 are high and A13 is low, which places *M1* at hexadecimal address C000.

Address lines A8 and A9 select the operation to be performed when *M1* is enabled. When A8 and A9 are both low, instructions can be received by *M1* on AD0 through AD7. When A8 is low and A9 is high, character codes can be received.

The applications notes for *M1* describe the various instruction codes and their functions. They also illustrate the possible characters and their character codes.

Momentary-action pushbutton switches *S2* and *S3* permit user input to the system. Each switch connects to a line on Port 1, an I/O (input/output) Port of *IC2*. In the Tempwatch program, *S2* resets the maximum and minimum temperatures and times to the present temperature and time, and *S3* lets the user set the Tempwatch's clock.

Construction

Creating the Tempwatch from the Microsys you built last month requires you to add the circuitry for the ADC, sensor, LCD module and switches. The control program must also be written and saved in the EPROM. Figure 9 shows a completed Tempwatch mounted in its enclosure. Adding the hardware is the first step. Here is where the locking connectors we specified for the Microsys come in handy. Unplug both connectors and remove the circuit-board assembly from the Microsys' enclosure.

Wire Wrap the new components specified here on this circuit-board assembly. Begin by mounting the sockets for *IC12* and *IC15*. Do *not* install the ICs themselves in the sockets until after you have ascertained that your wiring is correct and power-distribution tests have been conducted. As you did last month, solder the pins of the sockets to the copper rings through which they pass on the board. Then wire the power-supply and ground pins to the +5-volt and ground buses on the circuit board.

Using Fig. 5 as a guide, wire the circuitry associated with *IC12*, adding *IC14*, *R17*, *R18*, *R19*, *C19*, *C20* and *C21* to the board as required. Mount *IC14*, *R18*, *R19* and *C21* as close to *IC12* as possible, to minimize noise in *IC12*'s analog circuitry. Wire the analog grounds (ground connections to *C21*, *IC13* and *IC14*) directly to pin 8 of *IC12*. Connect and solder one wire from pin 8 of *IC12* to a ground point near *IC11*.

To permit flexible use of the project, it is a good idea to mount temperature sensor *IC13* at the end of a 5-foot-long cable. Use three-conductor shielded cable for this to assure good immunity to noise.

Prepare the sensor cable as follows. First remove 2 inches of the outer plastic jacket from each end. If the shield is made up of wire mesh, separate the wires at both ends back to the cut-off plastic jacket and clip its conductors off ar only *one* end. Twist together the fine wires of the braid at the other end and sparingly tin with solder. If the shield is foil with a wire tracer, unwind it back to the cut-off plastic jacket, trim the foil at both ends and clip the wire tracer at only *one* end. Strip ½ inch of insulation from all conductors at both ends of the cable, tightly twist together the fine wires of each conductor and sparingly tin with solder.

At the end of the cable from which the shield (and tracer wire) was clipped, slide a 1-inch length of small-diameter heat-shrinkable tubing over and form a small hook in the end of each conductor. Next, trim the leads of IC13 to a length of about ¾ inch and also form small hooks at the ends of the remaining lead lengths. Crimp and solder a cable conductor to each lead on IC13. At the other end of the cable, identify conductors, for later use in wiring them. Do this either by recording the insulation colors for each conductor at *IC13*, or by using an ohmmeter to identify the wires and temporarily labeling each with masking tape.

Slide the tubing over the soldered connections until it is flush with the bottom of *IC13*'s case and shrink the tubing into place. Slide a 4-inch length of larger-diameter heat-shrinkable tubing over the entire cable so it overlaps slightly the bottom of the IC's case and shrink it into place.

Slide a 1½-inch length of tubing onto the shield at the other end of the cable and shrink it into place. Slide another larger-diameter piece of tubing onto the cable, placed so that about 1 inch of the cable conductors extends out the end of the tubing, and shrink into place.

Insert the three cable conductors in the circuit board and solder connections to pins 6, 7, and 20 of *IC12*, using Fig. 5 and your previous identification of the conductors as guides. Solder a connection between the shield and pin 8 of *IC12*.

Because module *M1* contains CMOS integrated circuits, be sure to exercise the normal safety precautions for handling devices that are subject to damage from electrostatic discharge. In addition, the display can be damaged by mechanical shock or pressure; so handle it with care.

The *M1* circuit board has a single row of 14 holes on 0.1-inch centers for mounting on it an interface-cable connector. Unfortunately, this configuration doesn't seem to match any readily available connectors; so some improvisation is in order.

For the sake of convenience, a 34-pin ribbon cable is used to connect *M1* to the circuit board, even though many of the cable's conductors will go unused. You can buy or make the cable, which should be about 5 inches long and have socket connectors at each end.

Solder a 14-pin single-row header to *M1*. On the Microsys circuit board, a 34-pin double-row header is recommended, to match the connector and minimize the chances of plugging it in incorrectly. Use an indelible marker to place an identifying dot near pin 1 of each header. On *M1*, pin 1 is nearest the corner of the module's circuit board. On the Microsys circuit board, pin 1 will be the pin that is nearest the pin 1 arrow when the connector is plugged in.

Plug the ribbon cable's connectors into the headers, matching pin 1 to pin 1 on the connector and header at

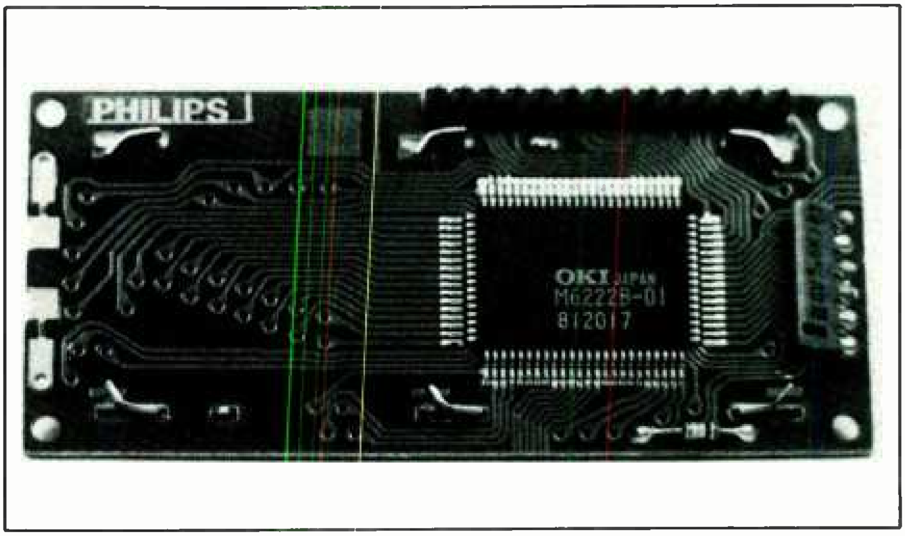


Fig. 7. LCD module has one IC that contains virtually all of the module's controller and driver circuitry.

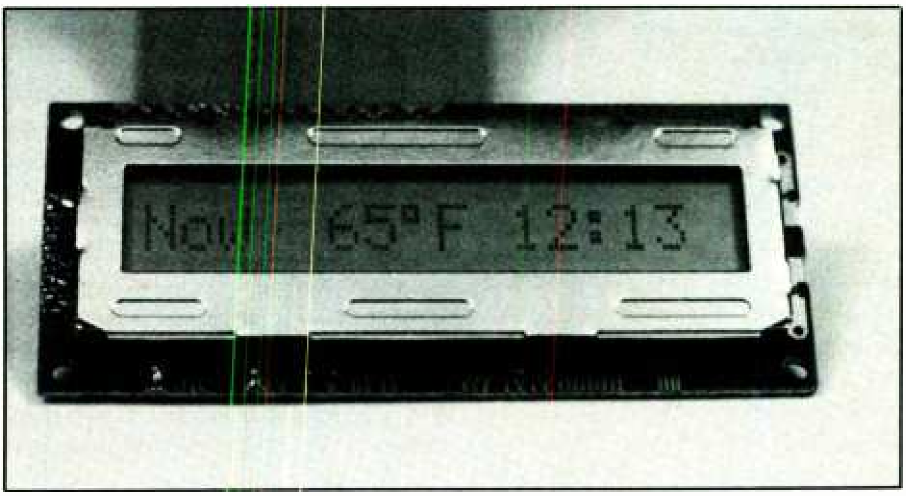


Fig. 8. LCD module used in this project can display message of up to 16 characters, using letters, numbers, or other symbols.

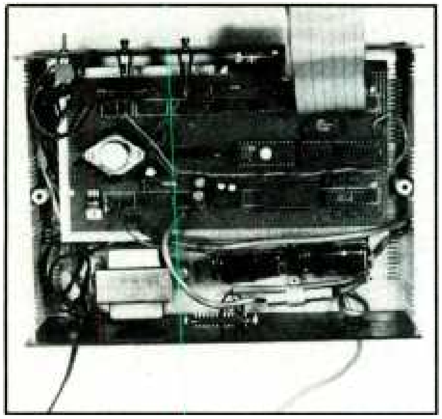


Fig. 9. Circuit board, transformer and batteries mount on the floor of the enclosure; serial-port connector and sensor cable exit through rear panel.

each end. On *M1*, plug the socket nearest the pin 1 arrow into pin 1 on *M1*'s header. One entire row of sockets on the connector, as well as the bottom three sockets of the other row, are not used in this project.

Once you are satisfied that everything physically meshes together, disconnect the cable. Then install *R20* on the circuit board, and wire the circuitry shown in Fig. 6. To wire *S2* and *S3*, prepare three 8-inch and one 4-inch lengths of hookup wire by stripping ½ inch of insulation from the ends of each. Twist together one end of the 4-inch wire and one end of one 8-inch wire and crimp and solder the twisted pair to one lug of *S2*. Crimp and solder the free end of the 4-inch wire to one lug on *S3*. Then crimp and solder the other two wires to the remaining switch lugs.

Connect the wire common to both switches to ground on the circuit board. Connect *S2*'s other wire to pin 1 of *IC2*, and *S3*'s other wire to pin 2 of *IC2*.

Route the sensor cable through a rubber-grommet-lined hole in the enclosure's rear panel.

Switches *S2* and *S3* and module *M1* mount on the front panel, the switches in suitable-size holes and the module in a $2\frac{7}{8}$ by $1\frac{1}{16}$-inch slot you must cut into the panel. In addition to the slot, *M1* requires that you drill four mounting holes for it in the front panel. Cut the larger display window opening first, making it large enough that the module fits easily into it to obviate mechanical stress on the display.

When the opening is ready, insert *M1* in the front panel and mark the locations for the four mounting holes. Remove and set aside the module and drill appropriate size holes in the marked locations.

Temporarily remove S1 from the front panel and label *S1*'s positions ON and OFF, *S2* RESET, and *S3* SET CLOCK on the front panel. Use a dry-transfer lettering kit and protect the legends with two light coats of clear spray acrylic. Allow the first coat to dry before spraying on the next.

Mount M1, using spacers of sufficient length to assure that fit between *M1* and the front panel is correct. Install the circuit board in its enclosure and connect the two sets of locking connectors. Tie a knot in the sensor cable to act as a strain relief, and route this cable through the rubber grommet in the back panel. Do *not* connect the ribbon cable until preliminary power supply checks have been made and you are certain that the circuit has been wired correctly. Mount *S1*, *S2* and *S3* in their respective holes on the front panel.

Checkout

Power up the Microsys and use a dc voltmeter or multimeter set to the dc volts function for the presence of +5 volts, ±0.2 volt, between output of *IC11* and circuit ground. Connect the meter's common lead to any convenient circuit-ground point in the circuit and use the "hot" lead to probe the circuit for this measurement. Also measure for +5 volts from pin 2 to

Program 6. Write Temperature to Screen

```
1     REM Program 6, write temperature to screen
10    DO
20   XBY(0E000H)=255 :  REM write to adc to start conversion
30   ADC=XBY(0E000H) :  REM read adc output
40   TEMP=ADC*2.47*100/255 :  REM calculate temperature
50    PRINT "The temperature is ",TEMP," degrees Fahrenheit"
60    WHILE 1=1
70    END
```

Program 7. Write Temperature to LCD Module

```
1     REM Program 7, write to LCD module
10   XBY(0C000H)=1 :  REM clear display
20   XBY(0C000H)=38H :  REM select 8-bit data, 2 logical lines
30   XBY(0C000H)=0CH :  REM turn display on, cursor off
40   XBY(0C000H)=6 :  REM increment address counter after each write
50   XBY(0C000H)=80H :  REM select position 1 on display
60    FOR I=1 TO 4 :  REM write "*****" to display
70   XBY(0C200H)=2AH
80    NEXT I
90   XBY(0C200H)=ASC(T) :  REM write "TEMP" to display
100  XBY(0C200H)=ASC(E)
120  XBY(0C200H)=ASC(M)
130  XBY(0C200H)=ASC(P)
140  XBY(0C000H)=0C0H :  REM select position 9 on display
150  XBY(0C200H)=ASC(W) :  REM write "WATCH" to display
160  XBY(0C200H)=ASC(A)
170  XBY(0C200H)=ASC(T)
180  XBY(0C200H)=ASC(C)
190  XBY(0C200H)=ASC(H)
200   FOR I=1 TO 3 :  REM write "****" to display
210  XBY(0C200H)=2AH
220   NEXT I
230   END
```

pin 1 on the double-row header, and from pin 20 to pin 10 of *IC12*.

If at any point the meter doesn't register the proper voltage, power down the circuit and locate the source of and rectify the problem before continuing.

When everything looks okay, power down the circuit and plug *IC12* and *IC15* into their respective sockets, making sure you properly orient each IC and that no pins overhang the sockets or fold under between the ICs and the sockets. Then connect *M1*'s ribbon cable, being sure to observe proper orientation for pin 1. If possible, insert a new or freshly erased EPROM into *IC9*'s socket. This will allow you to take advantage of the 8052's special PROG2 command, which will be described later.

Boot the Microsys to MCS BASIC-52 as before: configure your terminal for communication with eight bits, one stop bit, and no parity. Connect the Microsys to the serial port of your terminal, power up the Microsys and press the SPACE bar at the terminal.

If you don't see the READY prompt, power down and locate and fix the problem before continuing. Re-examine the added wiring on the Microsys. Be sure your terminal is configured properly, as described last month.

When you do obtain the READY prompt, you can begin measuring temperature. The listing given in Program 6 "reads" the output of *IC12*, converts it to a temperature and displays the result on the terminal's video display screen. Key in Program 6 at your terminal and follow this by typing RUN and a carriage return (ENTER key) to run it. The terminal screen will now display any measurements, in degrees Fahrenheit, taken by the sensor.

Program 6 uses the special operator XBY in MCS BASIC-52 to read and write to external memory. Line 20 writes the value 255 to *IC12*, which is located at hex address E000. Writing to *IC12* causes this IC to

Program 8. Test Operation of Switches

```
1      REM Program 8, switch test
10     PRINT "(CONTROL/C to quit)"
20     DO
30    X=PORT1 :  REM read port 1
40    Y=X-4*INT(X/4) :  REM calculate (bit 1 + bit 2) of port 1
50     IF Y=2 THEN  PRINT "Bit 0 of port 1=0; S2 pressed"
60     IF Y=1 THEN  PRINT "Bit 1 of port 1=0; S3 pressed"
70     WHILE 1=1
80     END
```

begin converting its analog input to a digital word. (The actual value written to the ADC is unimportant; any write command serves the purpose.)

Line 30 reads the byte at AD0 through AD7 of *IC12* and stores it in the variable ADC. Line 40 converts the byte to a Fahrenheit temperature, and line 50 displays the temperature on the terminal screen.

The number 2.47 in line 40 represents twice the reference voltage at pin 9 of *IC12*. Although the voltage across the reference diode is stable, it can vary among individual ICs from 1.223 to 1.247 volts. For greatest accuracy in the temperature-measuring circuit, measure the voltage from pin 9 to pin 8 of *IC14* on your system and enter twice this value in line 40, in place of 2.47.

To exit Program 6's infinite loop, use CONTROL/C.

Program 7 writes the message "****TEMPWATCH***" (minus the quotation marks) in the LCD module's display. Type in and run this program as you did before. After running Program 2, adjust *R20* to give the desired contrast on the display.

Because *M1* is quite powerful in itself, programming it is relatively straightforward. Lines 10 through 40 in Program 7 initialize and configure the module by writing values to hex address C000. Address C000 enables *M1* by bringing line Y6 low. The initialization and configuration codes are described in the applications notes for *M1*.

Line 50 selects position 1 on *M1*, at hex location 80, and lines 60 through 130 cause the message "****TEMP" (again, without the quotation marks) to appear in the first eight character positions of *M1*. The character codes for the letters in the message are the standard ASCII codes for the letters, specified by the ASC operator in BASIC.

Characters are written to *M1* at hex address C200. The "2" in C200 sets A9 high, to program *M1* to receive the character codes. The module increments its address counter after each character is displayed, so the eight-character message fills the first eight positions on the module.

Although the 16 character positions of *M1* are physically arranged in a single line, they are addressed in two logical lines. Positions 1 through 8 are at hex 80 through 87, while positions 9 through 16 are at C0 through C7. The jump in addresses between the two lines has to be taken into account when programming the module.

This is why line 140 sets *M1*'s address counter to C0, to specify position 9. Lines 150 through 220 write "WATCH***," to positions 9 through 16 to finish the message.

Program 8 tests the operation of switches *S2* and *S3* by continuously monitoring Port 1 and giving a message on the terminal screen when a switch is pressed. Type in and run this program. Then press *S2* and *S3* and watch for the appropriate messages.

The switches connect to otherwise unused lines on Port 1, an eight-bit I/O port of *IC2*. Line 30 reads the value of Port 1, and line 40 finds the sum of bit 0 and bit 1. If the sum equals 2, bit 0 is low, which means *S2* has been pressed. If the sum equals 1,

Program 9. Combine Features of Programs 6 & 7

```
1       REM Program 9, display temperature on LCD module
10      PRINT "(CONTROL/C to quit)"
20     XBY(0C000H)=1 :  REM clear display
30     XBY(0C000H)=38H :  REM select 8-bit data, 2 logical lines
40     XBY(0C000H)=0CH :  REM turn display on, cursor off
50     XBY(0C000H)=6 :  REM increment address counter after each write
60      DO
70     XBY(0E000H)=255 :  REM write to adc to start conversion
80     TEMP=XBY(0E000H)*2.47*100/255 :  REM get & calculate temperature
90      IF TEMP-INT(TEMP)>=.5 THEN TEMP=INT(TEMP)+1 ELSE TEMP=INT(TEMP)
100    DIGIT1=INT(TEMP/100) :  REM divide temperature into 3 digits
110    DIGIT2=INT(TEMP/10)-DIGIT1*10
120    DIGIT3=TEMP-DIGIT1*100-DIGIT2*10
130    XBY(0C000H)=80H :  REM select position 1 on display
140    XBY(0C200H)=DIGIT1+48 :  REM write ASCII codes of digits to display
150    XBY(0C200H)=DIGIT2+48
160    XBY(0C200H)=DIGIT3+48
170    XBY(0C200H)=0DFH :  REM write degree symbol to display
180    XBY(0C200H)=ASC(F) :  REM write "F" to display
190     WHILE 1=1
200     END
```

bit 1 is low, which means *S3* has been pressed.

Listing 9 combines features of Programs 6 and 7. It reads the temperature at *IC12*'s output, then displays it on *M1*. Lines 20 through 50 initialize *M1*. Lines 70 through 80 get and calculate the temperature at *IC12*. Lines 100 through 120 divide the temperature reading into three digits, and lines 130 through 180 write the three digits to the display. To give the correct character codes, 48 is added to each digit's value.

Finally, the listing in Program 10 gives the full-featured Tempwatch. With this program, the Tempwatch monitors temperature and displays the present, maximum, and minimum temperatures and the times they occurred.

Carefully key in this program, just as you did the previous ones and run it. You'll see three alternating displays, giving the three temperatures and times. If you don't see these displays, LIST the program and carefully check it against the one shown here. Rekey any portions of the program that contain errors in them. Use CONTROL/S and CONTROL/Q to stop and start the listing for this program on the monitor's screen.

On power-up, the time is set to 24:00. To set the correct time, momentarily press and release *S3*. The display will now show a rotating display of numbers from 1 to 24 (for a 24-hour clock). When the correct hour is displayed, once again press and release *S3*. You'll then see numbers from 0 to 59 rotate on the display. When the correct minute is displayed, again press and release *S3* and the program will return to normal operation, with its clock set to the correct time.

To test the capability of the Tempwatch to store maximum and minimum temperatures, heat and cool the sensor and monitor the results on the display. Heat the sensor by holding it near (not on) a heated soldering iron. When the sensed temperature has risen several degrees, move the sensor away from the soldering iron and allow it to return to room temperature. The maximum-temperature display should now show the highest value measured and the time it occurred.

Similarly, you can test the minimum-temperature display by spraying the sensor with an aerosol component cooler. The minimum-temperature display should show the coldest temperature measured, along with the time it occurred.

To reset the maximum and minimum temperatures to the current temperature, momentarily press and release *S2*.

If you have any problems in running this program, use the LIST com-

Program 10. Full-Featured Tempwatch Program

```
10      REM ****************Tempwatch program*************************
20      STRING 25,5
30     XTAL=4915200 :  CLOCK 1 : TIME=0
40     TEMP=0 : MIN=255 : MAX=0 : HOUR=24 : MINUTE=0
50     VREF=1.225 :  REM reference-diode voltage
60     $(1)="Now " : $(2)="Max " : $(3)="Min "
70     XBY(0C000H)=1 :  REM clear display
80     XBY(0C000H)=38H :  REM select 8-bit data, 2 logical lines
90     XBY(0C000H)=6 :  REM automatic increment of display address counter
100    XBY(0C000H)=0CH :  REM turn display on, cursor off
110     DO
120     ONTIME 60,770
130    XBY(0E000H)=255 :  REM write to adc to start convert
140    TEMP=XBY(0E000H)*VREF*200/255 :  REM get temperature
150     IF TEMP-INT(TEMP)<.5 THEN TEMP=INT(TEMP) ELSE TEMP=INT(TEMP)+1
160     IF TEMP>=MAX THEN MAX=TEMP : XHR=HOUR : XMIN=MINUTE
170     IF TEMP<=MIN THEN MIN=TEMP : NHR=HOUR : NMIN=MINUTE
180    N=1 : DTEMP=TEMP : DHR=HOUR : DMIN=MINUTE :  GOSUB 230
190    N=2 : DTEMP=MAX : DHR=XHR : DMIN=XMIN :  GOSUB 230
200    N=3 : DTEMP=MIN : DHR=NHR : DMIN=NMIN :  GOSUB 230
210     WHILE 1=1
220     END
230     REM ***********write-to-display subroutine*********************
240    XBY(0C000H)=80H :  REM select position 1 on display
250     FOR I=1 TO 4 : XBY(0C200H)=ASC($(N),I) :  NEXT  :  REM display message
260     REM display temperature (3 digits)
270    D1=INT(DTEMP/100) : D2=INT(DTEMP/10)-D1*10 : D3=DTEMP-D1*100-D2*10
280     IF D1=0 THEN XBY(0C200H)=32 ELSE XBY(0C200H)=D1+48
290     IF D1.AND.D2=0 THEN XBY(0C200H)=32 ELSE XBY(0C200H)=D2+48
300    XBY(0C200H)=D3+48
310    XBY(0C200H)=0DFH :  REM display degree symbol
320    XBY(0C000H)=0C0H :  REM select position 9 on display
330    XBY(0C200H)=ASC(F) : XBY(0C200H)=32
340     REM display time
350     IF DHR>9 THEN XBY(0C200H)=INT(DHR/10)+48 ELSE XBY(0C200H)=32
360    XBY(0C200H)=DHR-10*INT(DHR/10)+48 : XBY(0C200H)=ASC( : )
370    XBY(0C200H)=INT(DMIN/10)+48
380    XBY(0C200H)=DMIN-10*INT(DMIN/10)+48 : XBY(0C200H)=32
390     FOR I=1 TO 50
```

mand to review it and verify that all lines are entered correctly. (CONTROL/S and CONTROL/Q will stop and start the listing of a long program on the screen.)

MCS BASIC-52 is usually quite helpful in generating error messages, so these may also help you in tracking down the source of problems.

To save the program in EPROM, snap *B1* and *B2* into their battery connectors type "PROG" (do *not* type the quotation marks in this or any other instruction to key in a command), and the Microsys will program the EPROM with the program currently in RAM. An additional command allows you to configure Tempwatch to begin running immediately upon power-up, which frees you from having to connect to the terminal at all to use the Tempwatch.

To provide this capability, type "PROG2." This command is required in addition to the PROG command that saved the program. It causes the 8052 to run Program 1 in the EPROM immediately on power-up.

Now you can power down the Tempwatch, disconnect it from the terminal, and move it to a new location. When you power up again, the Tempwatch program runs automatically.

There are plenty of enhancements, in both the hardware and the software areas, that you can add to the Tempwatch. For example, you could add a temperature alarm or a program that measures and stores the temperatures at a particular time of day. Or, you can turn your Microsys into something else, such as an instrument to measure sound or light, to control relays, or to monitor or control whatever real-world conditions or devices you wish.

The great appeal of the Microsys is that you are ultimately in control. By adding appropriate inputs, outputs, and programs, you can tailor the Microsys to fit your own requirements, whatever they may be. **ME**

```
400     X=PORT1-4*INT(PORT1/4) :  REM check for switch press
410      IF X=1 THEN  GOSUB 450
420      IF X=2 THEN  GOSUB 730
430      NEXT I
440      RETURN
450      REM ****************set-clock subroutine************************
460     XBY(0C000H)=1 :  REM clear display
470     COUNT=24 : POS=0C2H : CHAR=58 : UNIT=HOUR :  GOSUB 510
480     COUNT=60 : POS=0C5H : CHAR=32 : UNIT=MINUTE :  GOSUB 510
490      GOSUB 730
500      RETURN
510      REM ************set hours, minutes subroutine*******************
520      DO  : X=PORT1-4*INT(PORT1/4) :  UNTIL X>1 :  REM wait for switch open
530     SELECT=0
540      DO
550      IF COUNT=24 THEN J=1 ELSE J=0
560      DO
570     DELAY=0
580      DO
590     DELAY=DELAY+1
600     XBY(0C000H)=POS :  REM set display postion
610     XBY(0C200H)=INT(J/10)+48 :  REM display digit 1 of hour or minute
620     XBY(0C200H)=J-INT(J/10)*10+48 :  REM display digit 2 of hour or minute
630     XBY(0C200H)=CHAR :  REM display colon or space
640     X=PORT1-4*INT(PORT1/4) :  REM check for switch press
650      UNTIL DELAY=6.OR.X<2
660      IF X=1 THEN SELECT=1 : TIME=0
670     J=J+1
680      UNTIL J=COUNT+1.OR.SELECT=1
690      UNTIL SELECT=1
700      IF UNIT=HOUR THEN HOUR=J-1 ELSE MINUTE=J-1
710      DO  : X=PORT1-4*INT(PORT1/4) :  UNTIL X=3 :  REM wait for switch open
720      RETURN
730      REM ***********reset max, min subroutine************************
740     MAX=TEMP : XHR=HOUR : XMIN=MINUTE
750     MIN=TEMP : NHR=HOUR : NMIN=MINUTE
760      RETURN
770      REM ***************update-time subroutine***********************
780     TIME=TIME-60 : MINUTE=MINUTE+1
790      IF MINUTE=60 THEN HOUR=HOUR+1 : MINUTE=0
800      IF HOUR=25 THEN HOUR=1
810      RETI
```

Put Your Telephone On Hold

Low-cost add-on circuit gives any telephone instrument a "hold" feature

By Andrew Van Loenen

One of the nice features you will find on many modern telephone instruments is a "hold" button. The ability to put your line on hold allows you to hang up the phone in one room and pick up an instrument in a different room without disconnecting the person at the other end of the line or having to run back to hang up the original instrument. It also allows you to converse privately with someone in the same room without having to hold your hand over the mouthpiece of the handset or juggle with the tiny "mute" button found on some phones. Hence, the hold feature also doubles as a "mute" function.

In this article, we describe a simple, low-cost circuit that you can build and install in just about any telephone instrument to give the latter a true hold feature. The circuit is so simple, containing just five very small components and a standard size switch, that it can easily mount *inside* virtually any telephone instrument, no matter how compact it might be. Installation in no way interferes with normal operation of your telephone instrument.

About the Circuit

Most single-line home telephone instruments operate from a single pair of wires. The exception are instruments that have a light in the dial; but even then, the talk/listen path is a single pair of wires that come from your local telephone company. By tradition, the wires are identified by the telephone company as "tip" (green insulation) and "ring" (red insulation). These identifiers date back to when operators used to patch telephone lines from origin to destination with patch cords that had plugs with "tip" and "ring" contacts on them. Also by tradition, telephone voltages are negative with respect to ground (common).

Green-insulated wire is the common "ground" line, and the red-insulated wire carries −48 volts when your telephone instrument is on-hook and about −6 volts when the handset is lifted off the hook.

To answer a telephone, it is necessary to provide a relatively low-resistance dc current path across the tip and ring conductors. As long as this path is maintained, the telephone line is in the "busy" mode. The object of our hold circuit is to provide this path, by pushing a button, as you replace the handset in its cradle. Furthermore, the circuit automatically deactivates when you pick up the same handset or one on another instrument.

If you were to connect a resistor with a value in the range of 1,000 to 2,000 ohms across your telephone line while the instrument is in use, replacement of the handset in its cradle would maintain the talk/listen path active. However, the hookswitch, located in the cradle, will have disconnected the handset from the circuit so that whoever is at the other end of the line will be effectively excluded from any communication with you.

Shown in Fig. 1 is the schematic diagram of the hold feature's very simple circuit. With the circuit connected to the telephone line as indicated, resistor *R1* provides the actual hold function. This resistor is ordinarily kept isolated from the telephone line by silicon-controlled rectifier *SCR1*.

One of the operating principles of an SCR is that it is connected in series with its load—in this case, *R1*—and appears to be an open circuit through its anode/cathode (A/K) circuit until its gate (G) "sees" a positive-going pulse voltage. Once gated on, the SCR continues to conduct current through its anode/cathode circuit until that circuit is interrupted or its current falls below the threshold where conduction is possible. At this point, the SCR goes back to being an open circuit and remains as such until it is once again gated on by a positive-going pulse voltage applied to its gate.

Normally-open pushbutton switch *S1* provides the gating signal for *SCR1* through the voltage divider made up of *R1* and *R2*. Diode *D1* puts a small bias on the cathode of *SCR1* to make it work more reliably in this application. Light-emitting diode *LED1* is a visual indicator that turns on whenever the line is put on hold (*SCR1* is conducting current).

Construction

Owing to the very few components that make up this circuit, construction is extremely simple and straightforward. You can use any mounting medium that suits your fancy, including a printed-circuit board, perforated board and soldering hardware or a solderless breadboarding block.

If you wish to fabricate a printed-circuit board for this project, use the actual-size etching-and-drilling guide shown in Fig. 2(A). With only four on-board components, you can easily use a resist pen or dry-transfer patterns to directly etch the board. Note that no outline is provided in Fig. 2(A) for the etch pattern. This is because you can make the board as large or small as needed to fit inside the case of any particular telephone instrument. For example, for my prototype, I needed a board that measured 1 inch by 3¾ inches because that

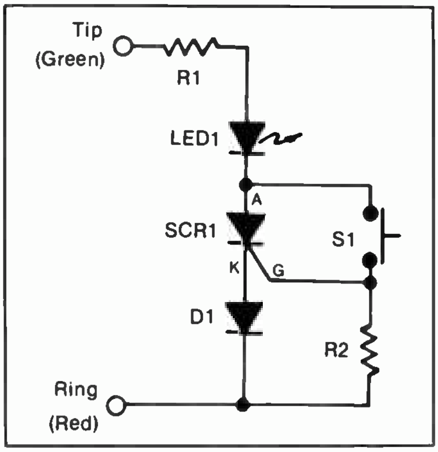


Fig. 1. Schematic diagram of the extremely simple circuit that makes up the telephone hold function.

size fitted a ready-made but unused mounting bracket in the base of the telephone instrument I selected to house my hold circuit. You can make the board as small as ¾ inch wide by 1¼ inches long.

Wire the board exactly as shown in Fig. 2(B). Note here that the switch and LED mount off the board. When you install *D1* and *SCR1*, make absolutely certain that the former is properly oriented and the latter is properly based before soldering their leads to the pads on the bottom of the board.

If you decide to use a perforated board or a solderless socket instead of a pc board, use Fig. 2(B) as a guide to component layout and orientation and interconnections.

You need six 10-inch-long stranded hookup wires to complete wiring the circuit. One of these wires should have green insulation, two should have red insulation, a fourth should have black insulation, and the remaining two can have any other color insulation. Strip ¼ inch of insulation from both ends of all six wires. Tightly twist together the fine conductors at both ends of all wires and tin with solder.

Plug one end of the green- and one red-insulated wire into the holes labeled GREEN and RED, respectively and solder into place. Using the holes for *LED1*, plug one end of the black- and the remaining red-insulated wires into the cathode and anode holes, respectively, and solder both connections. Loosely twist together these two wires. Plug one end of the remaining two wires into the two S1 holes and solder them into place.

Select a location inside the telephone instrument to mount the circuit-board assembly where it will not physically or electrically interfere with any portion of the instrument. If necessary, *carefully* trim away the tab on the SCR (there will be no degradation in circuit performance if you do this). If there is no room inside the instrument for the circuit-board assembly, house it in a separate box and connect it to the telephone line via a cable equipped with a modular connector (this is an FCC requirement for all telephone accessory devices).

Wherever you mount the circuit-board assembly, make certain that you insulate its bottom from any

Special Note

This project was designed to fit inside just about any telephone instrument. For you to exercise this mounting option, you must drill holes in the instrument's housing to permit you to mount a switch and light-emitting diode on it. Therefore, make sure you do this only to an instrument you own—not one you are leasing.

If you do not own your telephone instrument(s) but would still like to use the hold circuit described in the text, you can do so by housing the circuit in a separate enclosure. In this event, connect the project to the telephone line via a standard cable terminated in a modular plug.

Keep in mind that this project connects directly across the telephone line. If it causes problems on the line, the telephone company has the right to temporarily discontinue service to you. In this event, you will be notified and given the opportunity to correct the problem. However, it is always better to make sure no problem exists from the start.

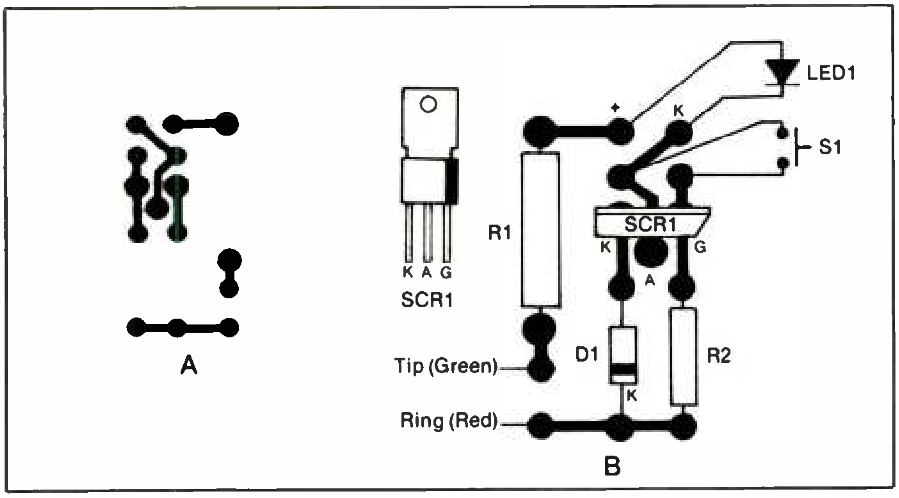


Fig. 2. Actual-size etching-and-drilling guide (A) for fabricating a printed-circuit board for the project. No board outline is shown because the dimensions of the board you actually use will depend on available space and mounting conditions inside a particular telephone instrument. Wiring details (B) for on- and off-board components for pc board. Use this as a guide to mounting components and wiring them together if you use perforated board instead of a printed-circuit board.

PARTS LIST

D1—1N4003 or similar silicon rectifier diode
LED1—General-purpose light-emitting diode
R1—1,500-ohm, 1-watt, 5% tolerance resistor (see text)
R2—680-ohm, ½-watt, 5% tolerance resistor
S1—Normally-open, momentary-action spst pushbutton switch
SCR1—C106B1 (General Electric), ECG 5455 or S3597 silicon-controlled rectifier
Misc.—Printed-circuit board or perforated board (see text); panel clip or small rubber grommet for mounting LED1; small-diameter heat-shrinkable or plastic tubing; small enclosure and modular cable/plug assembly (needed only if project is housed separately from telephone instrument—see text); thick double-sided foam tape; hookup wire; solder; etc.

metal or other parts of the telephone instrument. One way to assure this is to use thick double-sided foam tape as the mounting medium, rather than machine hardware.

Once the circuit-board assembly is mounted, drill holes for mounting the switch and LED on the instrument's case where they will be readily visible and accessible. Examples of typical locations for these holes are shown in the lead photo. Mount the switch in its hole, and use a panel clip or small rubber grommet to mount the LED.

Crimp and solder the free ends of the S1 wires coming from the circuit-board assembly to the lugs of the switch. Then untwist the LED wires a distance of 1½ inches at the free end and slip 1-inch lengths of small-diameter or insulating plastic tubing over the ends of both LED1 wires. Identify and clip the cathode lead of the LED to a length of ½ inch. Form a small hook in the remaining lead stub and crimp and solder this to the black-insulated cathode wire. Do the same with the LED's anode lead and red-insulated anode wire. Push the tubing up over the connections until it is flush against the bottom of the LED's case. Shrink into place.

With the telephone instrument's cover removed (see Fig. 3), find the points in the circuitry to which the incoming red- and green-insulated telephone-line conductors connect. Plug the instrument's cord into the wall jack. Holding the hookswitch down, use a multimeter set to the dc volts function and a 100-volt full-scale range to take a reading across the incoming telephone line. Connect the meter's "hot" and common probes to the line's red- and green-insulated conductors, respectively as you take this reading.

If you obtain a reading of −48 volts or so, the line is wired correctly. If your reading is +48 volts or so, the line is wired backward. It is much more important to observe polarity that to match insulation colors when connecting the project to the telephone line. If you connect the project in reverse polarity across the telephone line, the hold function will not work. Once you know the polarity of the telephone line, unplug the instrument from the wall jack and tag the two remaining wires coming from the circuit-board assembly accordingly.

The two wires that remain to be connected go to the telephone line and must be connected in proper polarity, as determined above. Route these wires from the circuit-board assembly to any two points inside the instrument to which wires from the incoming telephone line connect. If these points are soldered, solder the free ends of these wires to their respective points.

Checkout & Use

Checkout of the hold function is simple. Start by placing the telephone instrument's handset on-hook. Then plug the instrument's cord into the wall jack. Pick up the handset and press the HOLD button you installed and note that the LED lights.

While continuing to press the HOLD button, return the instrument's handset to its cradle and release the button. The LED should remain lit when you release the button. At this point, picking up the handset

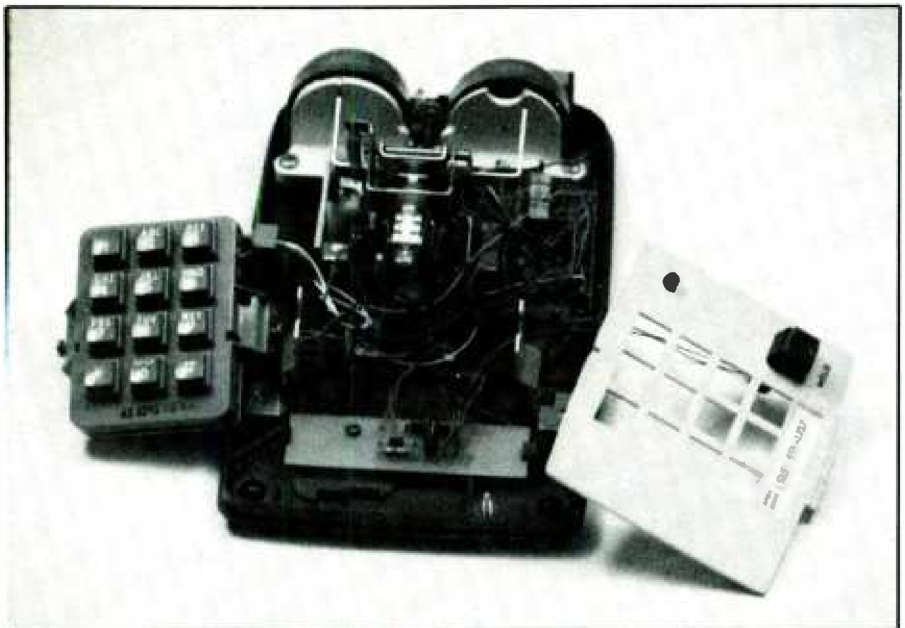


Fig. 3. Interior view of disassembled telephone instrument with dial assembly removed to permit project to be mounted on floor and LED and switch on dial bezel. Other instruments offer different mounting locations.

should cause the LED to extinguish and the telephone line to return to its normal off-hook condition.

If the LED does not light at all, check to make sure you connected the circuit to the telephone line in the proper polarity. If so, the LED may be installed in the wrong polarity or it might be defective. Whichever the case, either correct your wiring or replace the LED.

If the LED turned on but did not remain lit after you replaced the handset in its cradle and released the HOLD button, in that order, the value of *R1* is probably too high for your particular phone line. Solve this problem by replacing *R1* with a resistor of lower value. Both 1,200- and 1,300-ohm, 5-percent tolerance resistors are available, with the former being more common. Just keep in mind that you should generally use the highest value of resistance for *R1* that permits reliable operation of the hold circuit.

If the LED remains lit all the time, no matter what you do with the HOLD switch and handset, look for a shorted SCR, shorted HOLD switch or a short circuit on the circuit board or in your wiring related to these components. In any case, rectify the problem before attempting to put the project into service.

This hold function is extremely easy to use. Whenever you wish to place a call on hold, simply press the HOLD button and continue to do so until you have hung up the handset. You then release the HOLD button to keep the telephone line on hold.

Picking up the handset of the instrument in which the hold-function circuit is installed or any other instrument connected to the same telephone line automatically reinstates the two-way connection.

A bonus offered by this implementation of the hold function is that you can activate it to place a "busy" signal on the line to prevent calls from getting through when you do not want to be bothered. To activate the "busy" signal, simply press the hold button while leaving the handset in its cradle. The LED will light and any caller who dials your number will get a busy signal. To deactivate this function, all you have to do is lift the receiver from the cradle. **ME**

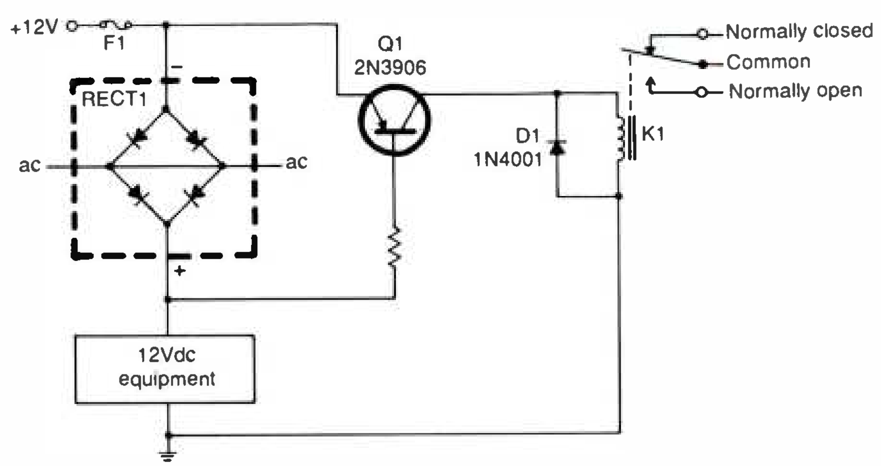
A "Smart" Car Relay

Provides automatic operation sensing and switching for equipment used in an automotive electrical environment

By Dennis Eichenberg

There's a need in the automotive electrical environment for a circuit that develops a control signal when it senses that any electrical device is operating. For example, you might connect an under-dash tape player to existing in-dash speakers. In this application, the speakers are normally connected to the in-dash unit, but the "Smart" Car Relay automatically switches them to the under-dash unit when the latter is turned on. In another application, a power antenna can be made to extend or retract whenever the vehicle's radio is turned on or off.

The "Smart" Car relay described here is just the ticket to provide automatic switching for such applications. This compact, inexpensive and easy-to-build and install project requires no modifications to be made to the equipment whose operation it is used to sense and control. Furthermore, it provides protection against reverse-polarity hookups of the equipment being sensed.



PARTS LIST

D1—1N40001 or similar 50-PIV, 1-ampere silicon power rectifier
F1—Fuse (see text)
K1—12-volt dc, 120-ohm or greater relay with 10-ampere or more contacts (see text)
Q1—2N3906 or similar general-purpose pnp transistor
R1—47-ohm, ¼-watt, 10% tolerance resistor
RECT1—50-PIV, 25-ampere bridge rectifier assembly or individual power diodes (see text)
Misc.—Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware (see text); suitable enclosure (see text); in-line automotive fuse holder; small rubber grommets; ½" spacers; lettering kit; machine and sheetmetal hardware; heavy-duty stranded hookup wire; solder; etc.

Fig. 1. Complete schematic diagram of "Smart" Car Relay's circuitry. This is the simplest circuit configuration. Other configurations use relays with more contacts and/or more relays.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the "Smart" Car Relay's circuit. The heart of this circuit is full-wave bridge rectifier *RECT1*, which can be a common rectifier module or four separate silicon power diodes connected into a bridge configuration with the individual diodes connected together as shown. Note that the four diodes are wired so that they are in a series-parallel arrangement. This configuration provides redundancy for the circuit.

When the electrical device whose operation is to be sensed is turned on, current flows from the negative (−) terminal of *RECT1* through the two parallel sets of series-connected diodes to the positive (+) terminal and then through the operating device to circuit ground. Each diode has a forward voltage drop of approximately 0.7 volt. Thus, the potential generated from positive to negative terminals of *RECT1* is roughly 1.4 volts when the monitored device is turned on.

For this application, *RECT1* must have a peak-inverse voltage (PIV) rating of at least 20 volts and a current rating that is at least equal to the peak current plus 20 percent or so of

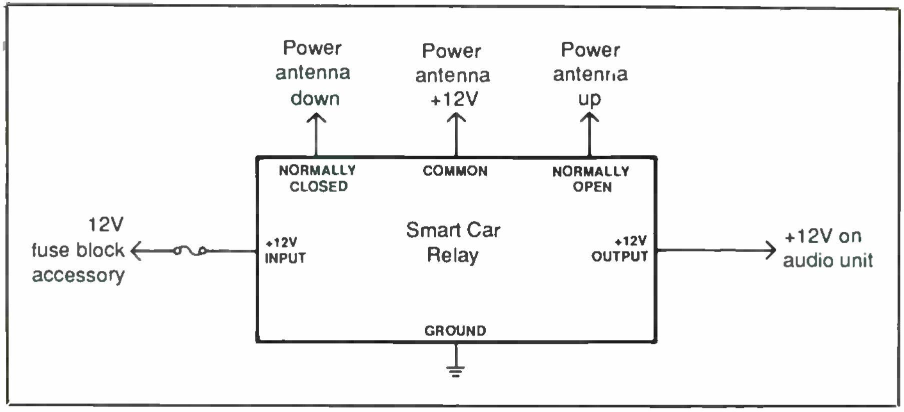


Fig. 2. Typical wiring instructions for using project to control deployment and retraction of an electrically operated radio antenna.

the device being monitored and controlled. For the original prototype, I selected a 50-PIV, 25-ampere bridge-rectifier assembly, which was deemed adequate for just about any sense/control application I was likely to encounter.

The 1.4 volts dropped across *RECT1* is coupled to the base of 2N3906 pnp transistor *Q1* through current-limiting resistor *R1*. Base current for the transistor is limited to 15 milliamperes by *R1*. The emitter of *Q1* is tied to the V+ rail of the vehicle's electrical system, while the collector is tied to ground through the coil of relay *K1*. The relay has a coil rating of 12 volts dc and a resistance of 120 ohms or greater, which limits the current through the transistor to 100 milliamperes or less.

The current rating of the contacts of *K1* must be at least 120 percent of the current normally drawn by the device being controlled. A normally-open contact of *K1* can be used to energize auxiliary relays if additional contacts beyond those available on the relay chosen are required.

Diode *D1* provides protection for *Q1* from reverse-voltage spikes developed by *K1* when the collapsing electromagnetic field around its coil induces a bucking voltage in the coil. Fuse *F1* in series with the project and device being controlled is included to provide a safety device against overcurrent damage. Its current rating, like that of the relay's contacts and bridge rectifier, must be at least 120 percent of the current normally drawn by the device being controlled.

Let us assume that you are going to use the project to automatically switch an in-dash speaker from the output of an in-dash mono radio to the output of an under-dash mono tape player when the latter is turned on. The simple relay contact arrangement shown in Fig. 1 is adequate for this. The "hot" line from the speaker would connect to the COMMON relay contact, the output line from the radio to the NORMALLY CLOSED contact and the output line from the tape player to the NORMALLY OPEN contact.

Under normal conditions, with the radio off or on and the tape player off, the speaker would be connected to the radio's output. Now, if you wish to listen to a tape, you simply turn on the tape player. This causes current to be routed through *RECT1*. The resulting 1.4-volt drop across the rectifier assembly is then coupled through *R1* to the base of *Q1*. When this occurs, *Q1* conducts and energizes *K1*. Now the relay's armature is pulled down, closing the NORMALLY OPEN contact and opening the NORMALLY CLOSED contact. In so doing, the circuit is completed between the output of the tape player and speaker.

If you had planned on using the project to switch speakers in a stereo system, you would have needed a relay that has dpdt contacts for *K1*. (The project is versatile enough to control even more lines than this, depending on the relay contact arrangements or even number of relays used. More about this later. In this event, a separate set of contacts would be used to switch the speaker between the outputs of the radio and tape player in each channel.)

To return to normal conditions, you simply switch off the tape player. Now there is no voltage dropped across *RECT1* and *Q1* cuts off. This causes *K1* to deenergize and restore the circuits between the radio's output(s) and speaker(s).

Construction

There is nothing critical about component layout or conductor routing in this project. Therefore, you can use just about any traditional wiring technique to assemble the "Smart" Car Relay. For example, if you wish, you can design and fabricate a printed-circuit board on which to wire the project. Alternatively, you can use perforated board and suitable soldering or Wire Wrap hardware.

Begin assembly on your chosen circuit-board medium by installing the bridge-rectifier assembly (or individual diodes, if you have chosen to use these instead of the rectifier assembly). Then install transistor *Q1*, diode *D1* and resistor *R1*. Make sure the diode is properly oriented and that the transistor is properly based before soldering any connections these make with the rest of the circuit.

Strip ¼ of insulation from both ends of as many 12-inch-long stranded hookup wires as needed for the relay-contact lugs and the three electrical system connections. Choose wire weight according to the current that will be drawn by the device being

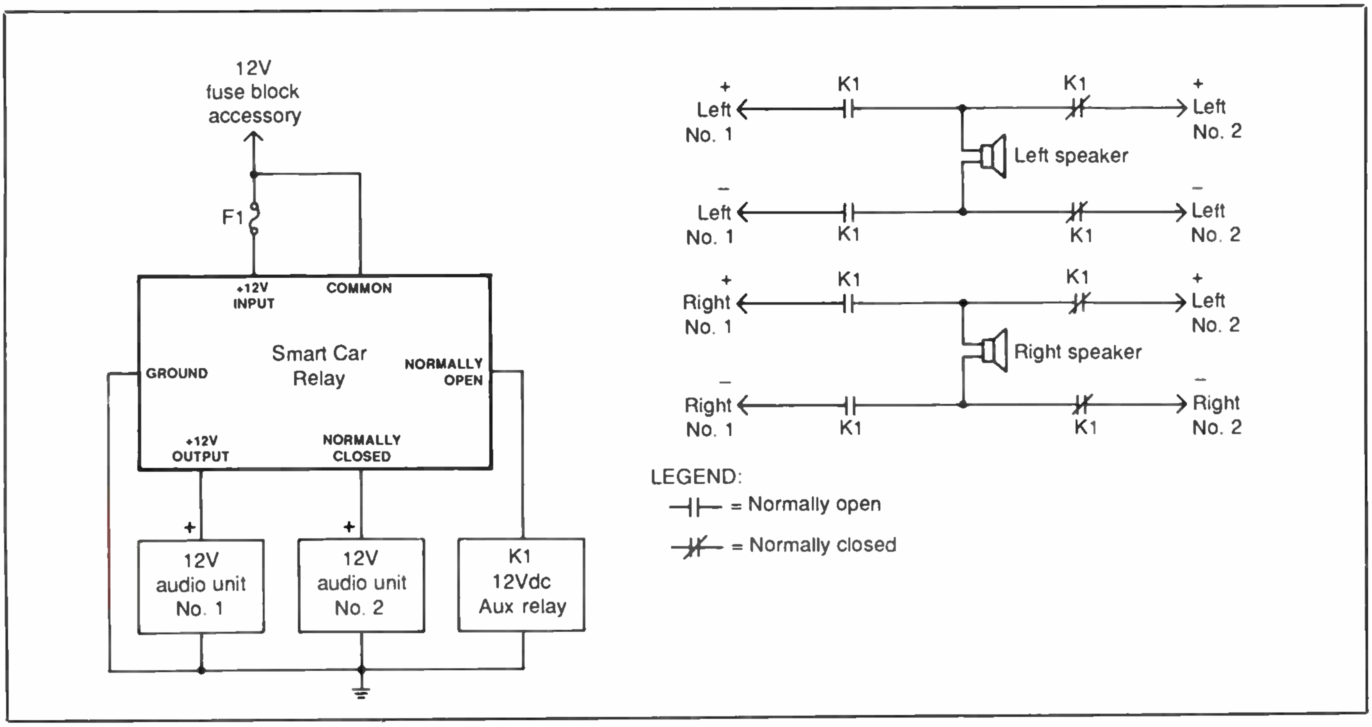


Fig. 3. Automatic speaker switching between two audio units and single pair of stereo speakers. As shown in pictorial, this arrangement requires an additional auxiliary relay.

controlled, but not less than No. 18 in any application. Tightly twist together the fine wires at all ends and sparingly tin with solder. These wires are for the coil and contacts of the relay and for the conductors that connect from the bridge rectifier to the vehicle's electrical system and device being sensed and controlled.

Use an all-metal enclosure or a plastic box that has a removable aluminum top panel as an enclosure for the project. Select one that accommodates all components that make up the project, including any relays that might be used. Machine the enclosure for mounting the circuit-board assembly and routing the free ends of the conductors that are to connect to the outside world. Drill two more holes in the floor of the enclosure for mounting the project inside your vehicle.

If you are using an all-metal enclosure, line the exit holes for the wires with small rubber grommets. If you are using a plastic enclosure, drill the lead-exit holes through the plastic walls and forget using grommets.

Tie a strain-relieving knot in each wire that exits the enclosure inside the enclosure and with about 1 inch of slack. Mount the circuit-board assembly in place using ½-inch spacers, 4-40 or 6-32 × ¼-inch machine screws, lockwashers and nuts. Then thread the free ends of the wires through the holes drilled for them and label each according to the legends detailed in Fig. 2. If you are using a dry-transfer lettering kit, protect the lettering with two or more light coats of clear spray acrylic. Allow each coat to dry before spraying on the next.

When wiring the project into your vehicle's electrical system, take particular care with the sections that carry heavy current. Make sure you provide adequate insulation and that all connections are both mechanically and electrically secure before soldering them. Double check all wiring to make certain that you assembled the circuit correctly.

Decide where in your vehicle you are going to mount the project. Select a location very near the device whose operation is to be monitored and controlled. Resiliently mount the project in the selected location. To do this, drill two holes in the vehicle's chassis work the same distance apart as those you drilled for project mounting in the enclosure. Make these holes slightly smaller than the panhead sheetmetal screws you will be used for mounting purposes.

Place a suitable flat washer on each of two No. 6 or No. 8 sheetmetal screws and follow with a small rubber grommet. Plug the ends of the screws into the mounting holes drilled in the floor of the enclosure and follow with a small rubber grommet on the end of each screw. Then drive the screws into the holes you drilled in the vehicle's chassis work. Fasten the

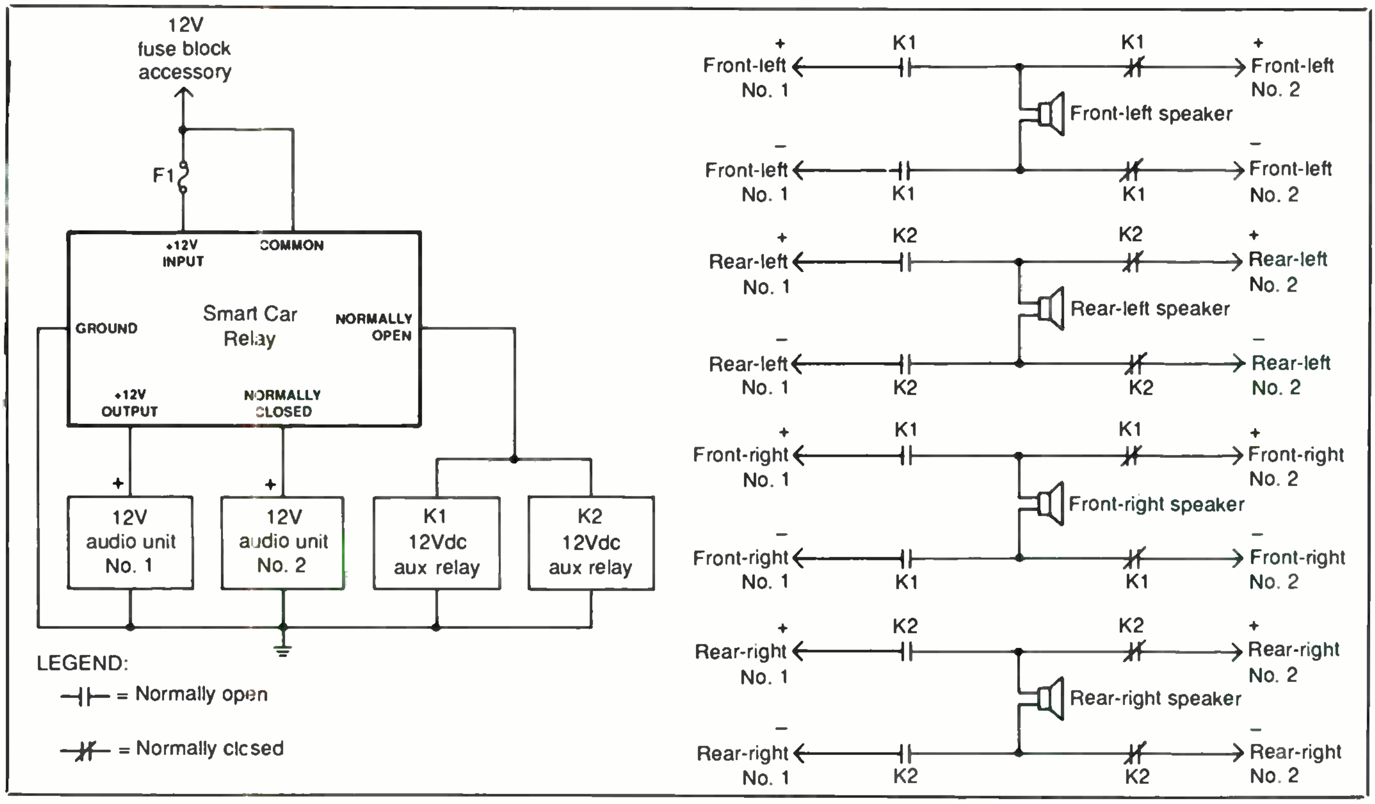


Fig. 4. Automatic speaker switching between two audio units and four speakers. This requires two auxiliary relays.

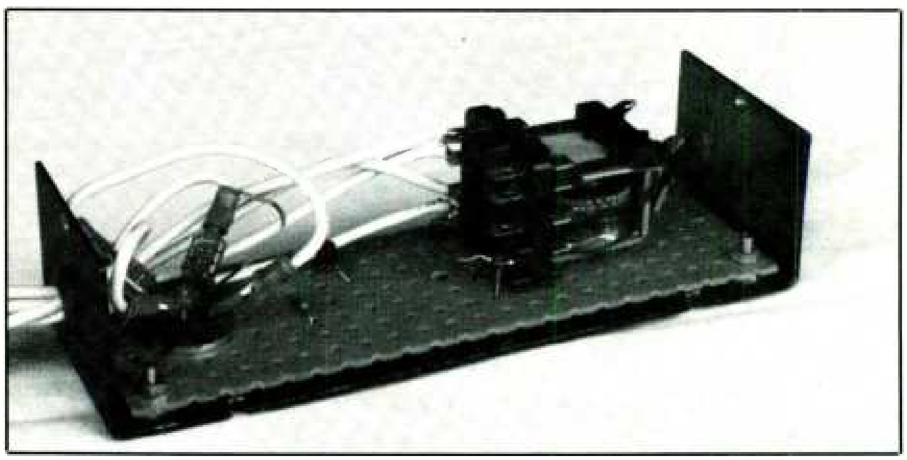
screws down only tight enough to slightly compress the rubber grommets—not so tight that the project is rigidly mounted.

Now disconnect the +12-volt lead from the device that is to be controlled. Clip the lug from the end of this wire and strip ¼ inch of insulation from the end of the wire. Crimp and solder the same type of lug onto the free end of the +12V OUTPUT wire (coming from the junction of *R1* and *RECT1* +) on the circuit-board assembly and plug this onto the terminal of the device being controlled from which the +12-volt wire was removed.

Crimp and solder one end of an automotive in-line fuse holder (obtainable from any auto supply outlet) to the free end of the +12V INPUT wire (coming from the junction of *Q1*'s collector and *RECT1*'s negative terminal). Crimp and solder the free end of the +12-volt wire that was removed from the device to be controlled to the other lug of the fuse holder. Open the fuse holder and place a suitably rated fuse in it.

Complete the electrical-system wiring by connecting the free end of the GROUND to any convenient chassis-ground point in your vehicle. Terminate the GROUND wire from the project in a ring lug. Then fasten the ring lug to the vehicle's chassis with an existing screw or a separate sheet-

(Continued on page 90)



Interior view of author's prototype built on perforated board and housed inside a standard metal utility box.

An Analog-Display Digital Clock

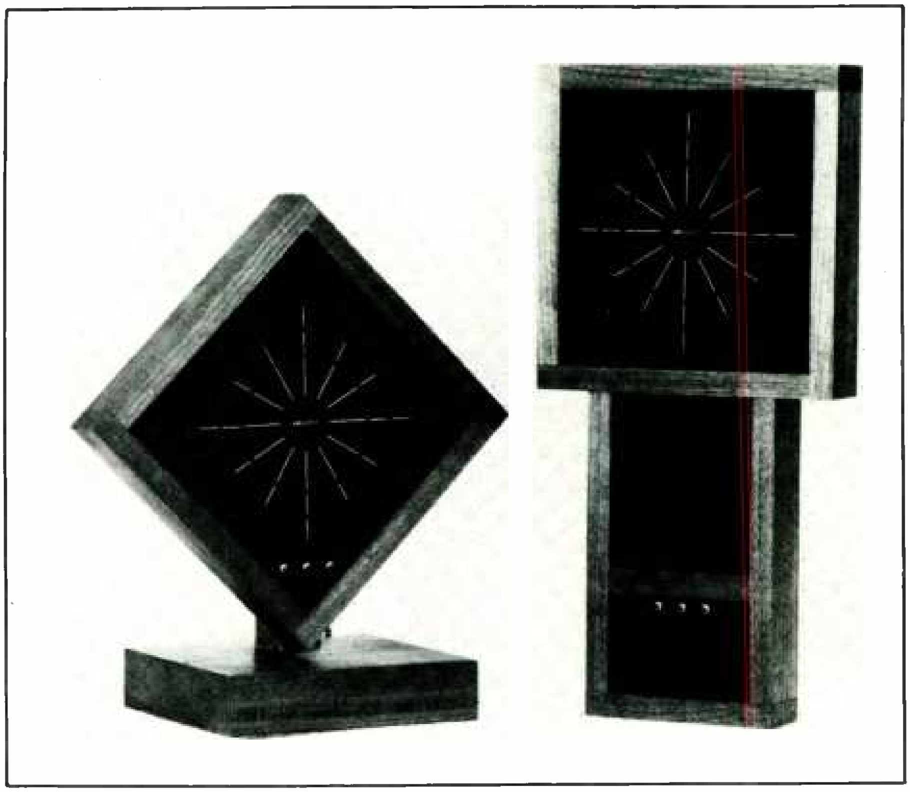
Combines appeal of the round "dial" of traditional analog movements with high-technology digital driving circuitry

By James Marshino

The clock desscribed here combines a timepiece that has the appeal of a traditional analog display with the high-tech performance of a digital "movement." This clock uses concentric circles of 60 seconds LEDs, 60 minutes LEDs and 12 hours LEDs instead of the traditional hands found on analog clocks to "point" to the time of day.

You can build either of two versions of the clock: a basic version that consists of the simple hours/minutes/seconds display and a more sophisticated version that adds to this an optional "pendulum" that consists of 10 LEDs arranged in an arc. Both versions use the same display and "movement."

You can house your clock in any of a number of different enclosures, ranging from traditional clock styles to a contemporary shallow square, depending upon your woodworking skills and taste. A shallow square enclosure that hangs on a wall is the easiest way to go, but if you are really ambitious and are a skillful woodworker, a wall-hung Regulator case or even a floor-standing long-case "grandfather" enclosure can be built to complement different decors. You can obtain either of two enclosures for your clock from the source given in the Note at the end of the Parts List if you prefer not to build your own.



About the Circuit

The complete schematic diagram of the clock's circuitry, including optional pendulum circuit, is shown in Fig. 1, which consists of four parts. At the upper-left in Fig. 1(A) is the clock's simple power supply. Incoming 117 volts ac is stepped down to 9 volts ac by power transformer *T1* and is rectified to pulsating dc by the bridge rectifier made up of diodes *D1* through *D4*. This pulsating dc is filtered to pure dc by capacitor *C1* and is subsequently delivered to the remainder of the circuitry that makes up the clock. At any given time only three LEDs will be on. Consequently, the circuit draws very little current and power demand is minimal.

A 60-Hz ac signal is picked off the secondary of *T1* and coupled through a Schmitt-trigger circuit composed of *R1*, *R2*, *IC1*, *IC2A* and

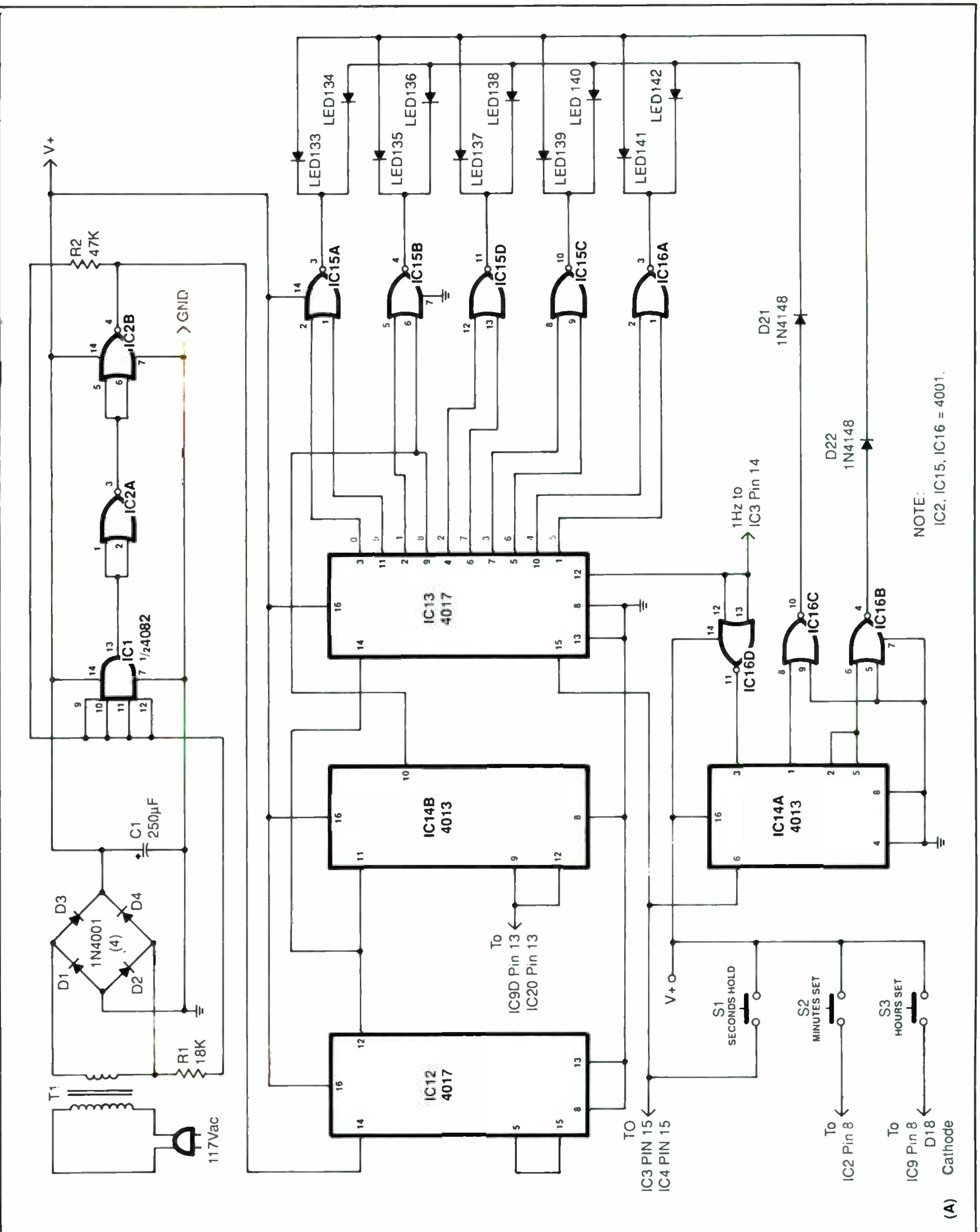
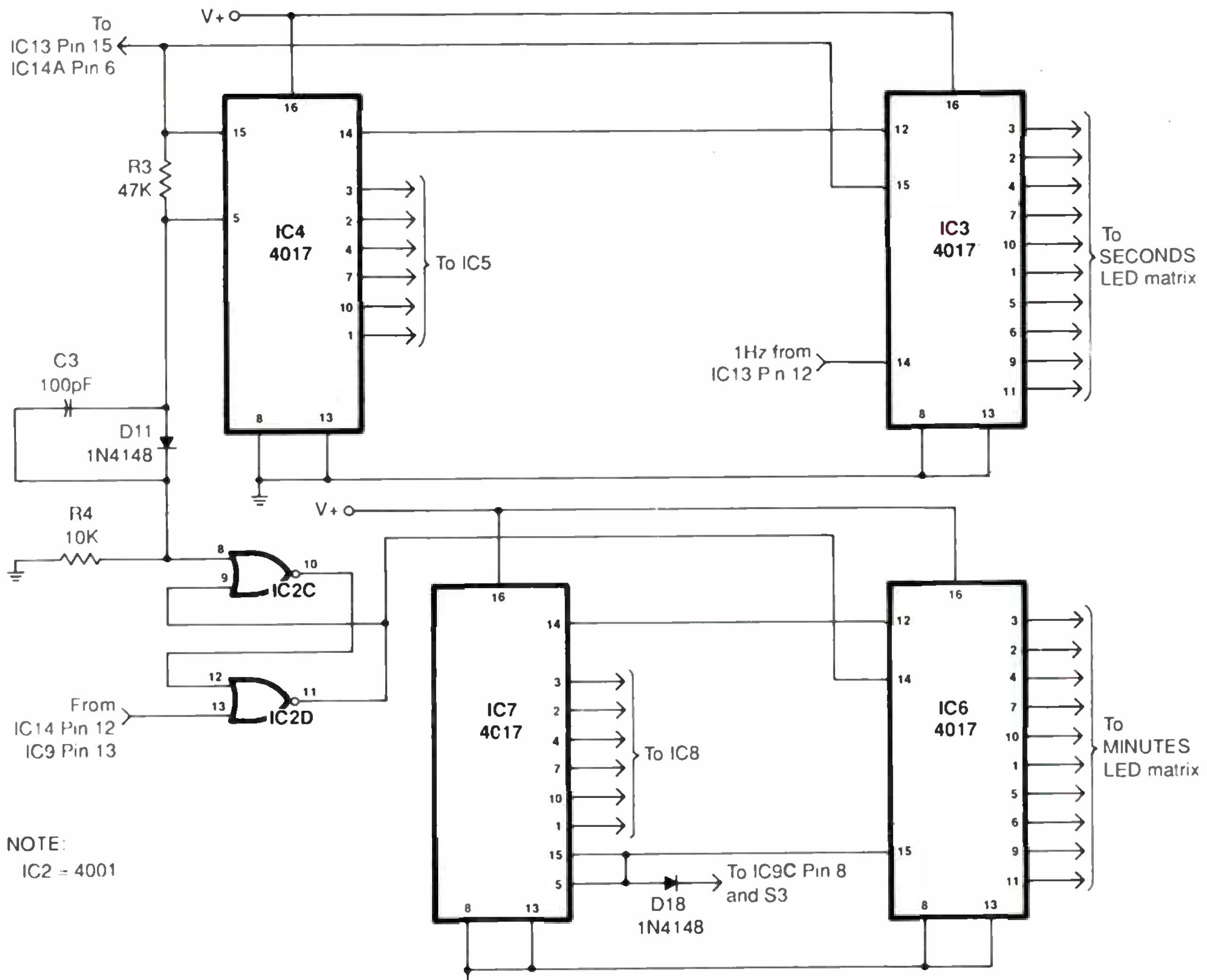
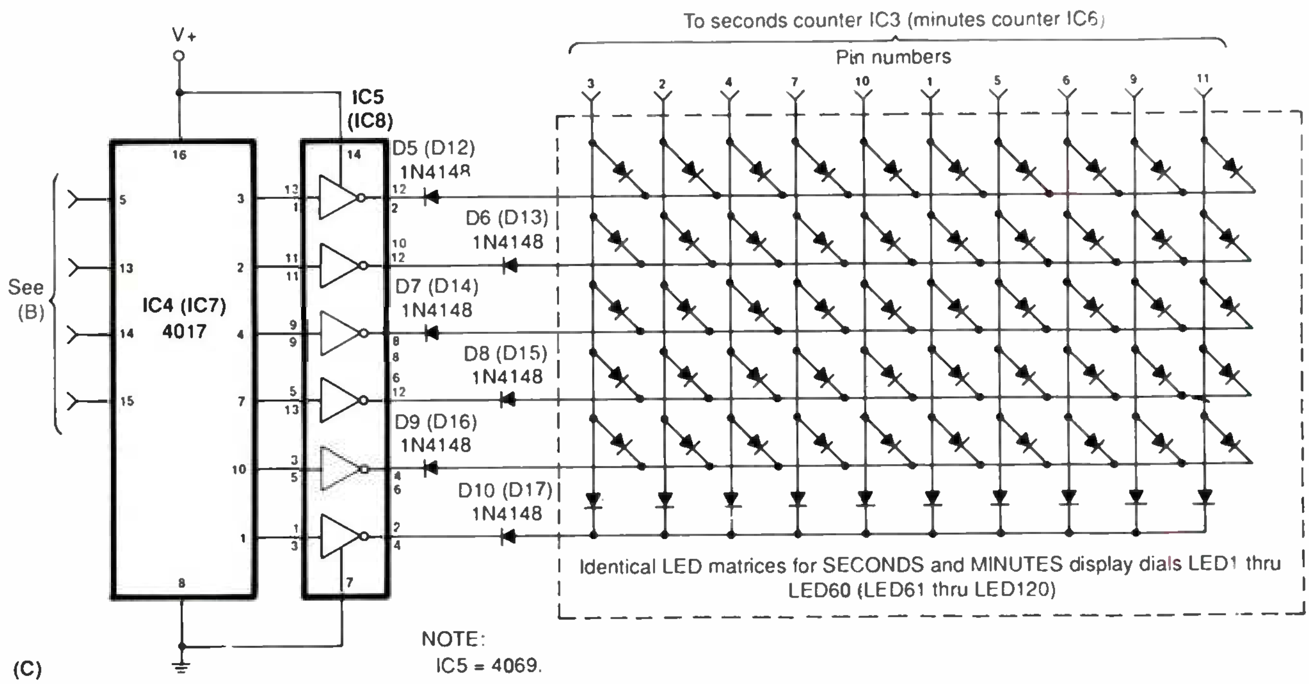


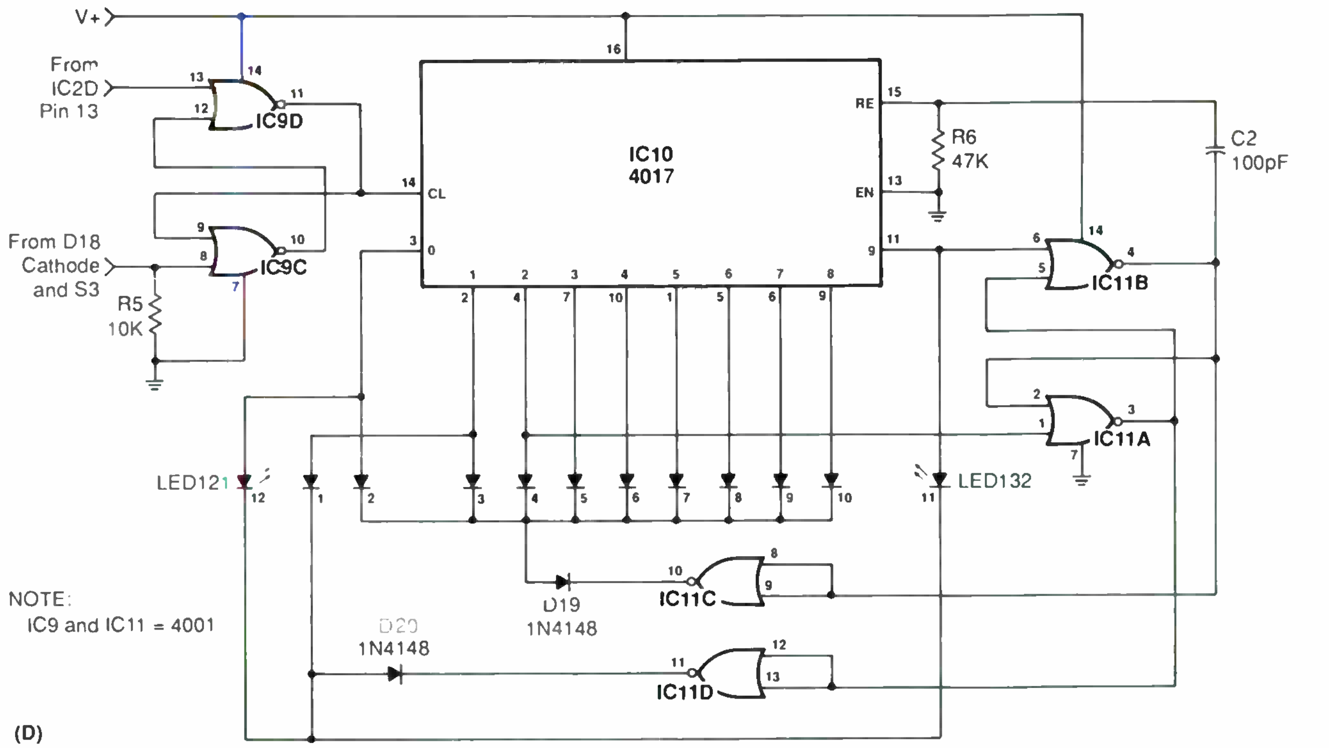
Fig. 1. Complete schematic diagram of the clock's circuit is shown here in four sections: (A) is the basic 1-Hz timing pulse generator and optional pendulum circuit; (B) is the counter/decoder circuitry for the seconds and minutes section; (C) is the circuitry for the discrete-LED displays for the seconds and minutes rings; and (D) is the counter/display circuitry for the hours ring. Parts (B), C) and (D) follow on next two pages.


To
IC13 Pin 15
IC14A Pin 6
V+
R3
47K
IC4
4017
To IC5
IC3
4017
To
SECONDS
LED matrix
1Hz from
IC13 Pin 12
C3
100pF
D11
1N4148
R4
10K
IC2C
IC2D
From
IC14 Pin 12
IC9 Pin 13
IC7
4017
To IC8
IC6
4017
To
MINUTES
LED matrix
To IC9C Pin 8
and S3
D18
1N4148
NOTE:
IC2 = 4001

(B)


V+
To seconds counter IC3 (minutes counter IC6)
Pin numbers
IC5
(IC8)
D5 (D12)
1N4148
D6 (D13)
1N4148
D7 (D14)
1N4148
D8 (D15)
1N4148
D9 (D16)
1N4148
D10 (D17)
1N4148
See
(B)
IC4 (IC7)
4017
Identical LED matrices for SECONDS and MINUTES display dials LED1 thru LED60 (LED61 thru LED120)
NOTE:
IC5 = 4069.

(C)



PARTS LIST

Semiconductors

D1 thru D4—1N4001 silicon rectifier diode
D5 thru D22—1N4148 or similar switching diode
LED1 thru LED142—Jumbo red light-emitting diode
IC1—CD4082 dual 4-input CMOS AND gate
IC2—CD4001 quad 2-input NOR gate
IC3,IC4,IC6,IC7,IC10,IC12,IC13—CD4017 CMOS decade counter
IC5,IC8—CD4069 CMOS hex inverter/buffer
IC9,IC11,IC15,IC16—CD4001 quad 2-input CMOS NOR gate
IC14—CD4013 dual CMOS D flip-flop

Capacitors

C1—250-μF, 35-volt electrolytic
C2—100-pF Mylar or ceramic disc

Resistors (¼-watt, 5% tolerance)

R1—18,000 ohms
R2,R3,R6—47,000 ohms
R4,R5—10,000 ohms

Miscellaneous

S1,S2,S3—Momentary-action spst push-button switch
T1—9-volt, 30- to 40-mA power transformer (see text)
Main and pendulum printed-circuit boards; sockets (or Molex Solder-cons) for ICs; ribbon cable; hardware; hookup wire; solder; etc.

Note: The following items are available from Jim Marshino, Box 262, Goodland, IN 47948: Kit containing all electronic components and both pc boards but no IC sockets or enclosure, $89.50 plus $10 P&H. Also available: double-sided main and pendulum boards with plated-through holes, $34.50; all ICs, $12.50; 9-volt power transformer, $9; packet of 143 LEDs (all needed plus a spare), $19.50; clock face kit, $9.50; plain cabinet, $45, or schoolhouse Regulator cabinet, $75. Cabinets are available in either walnut or cherry lumber (specify choice). A wired clock, not including enclosure, is also available for $124.50. Add $2.50 P&H for all orders, except $10 for electronics kit, either cabinet and wired clock. Indiana residents, please add state sales tax.

IC2B. Emerging from the output of this circuit at pin 4 of *IC2B* is a square waveform that reliably triggers the initial counter in the clock.

Shown immediately below the power-supply section in Fig. 1(A) is 1-Hz divider/pendulum circuitry. Three basic functions are served by the this circuit: it divides the line frequency down from the initial 60 Hz to 1 Hz; it provides fast-set pulses that allow you to quickly set the time in the clock's display; and it displays a LED "pendulum" that appears to swing in an arc.

Shown in Fig. 1(B) are the circuit details of the seconds and minutes counters. Figure 1(C) contains the details of the circuit for the drivers and light-emitting diode matrices that make up the seconds and minutes dial displays. Finally, Fig. 1(D) contains the circuit details for the hours counter and LED display dial.

Following the pendulum circuitry are the basic clock circuits. These are made up of two divide-by-60 and one divide-by-12 counters. Each divide-by-60 counter contains a 6 by 10 matrix of LEDs, as shown in Fig. 1(C). The LEDs are physically arranged to form two separate circles on the project's dial face, with the outer and inner circles indicating seconds and minutes, respectively.

Figure 1(C) shows the details for

just one divide-by-60 counter/display setup. Two identical such circuits are used in the clock. One consists of *IC4*, *IC5*, *D5* through *D10* and *LED1* through *LED60* and makes up the seconds counter/display system. The other consists of *IC7*, *IC8*, *D12* through *D17* and *LED61* through *LED120* and makes up the minutes counter/display system. Counters *IC3* and *IC6*, also part of the seconds and minutes counting circuitry, are shown in Fig. 1(B).

The divide-by-12 counter shown in Fig. 1(D) is simply an extended version of the standard decade counter used here to count to 12. Its outputs go to 12 hours LEDs that form the innermost display circle.

Operation of the clock circuitry is as follows. The conditioned 60-Hz square wave from the output of the Schmitt trigger goes to CLOCK input pin 14 of decade counter *IC14*. The pin 5 output from this IC coupled directly to the RESET input at pin 15 to create a divide-by-6 arrangement. Since the CLOCK OUTPUT at pin 12 of *IC14* is high for the first five counts (input pulses) and is low for the sixth count, this output is used to drive the next counter in the chain—*IC13*, which is another 4017 decade counter.

ENABLE input pin 13 of *IC12* is connected to circuit ground. The COUNT OUTPUT at pin 12 of *IC12* goes to the CLOCK inputs at pin 11 of *IC1B* and pin 14 of *IC13*. The signal that appears at the not-Q output at pin 12 of *IC14B* directly connects to the DATA input at pin 9 to form a divide-by-two counter. Hence, the FAST SET output from *IC14B* at pin 12 is a 5-Hz (60 Hz/12) square-wave pulse train that is used to quickly set the clock.

Decade counter *IC13* is permitted to run in normal-count mode, with its 10 outputs counting up and down. Its COUNT OUTPUT at pin 12 is inverted by *IC1D* to drive the CLOCK input at pin 3 of *IC14A*. The Q and not-Q outputs at pins 1 and 2 of *IC14A* are inverted and buffered by NOR gates *IC16C* and *IC16B*, respectively. These two gates, along with the diode action of pendulum light-emitting diodes *LED133* through *LED142* make up a 5-by-2 multiplexer. The LEDs are physically arranged in the display to form an arc that simulates the swinging action of a pendulum.

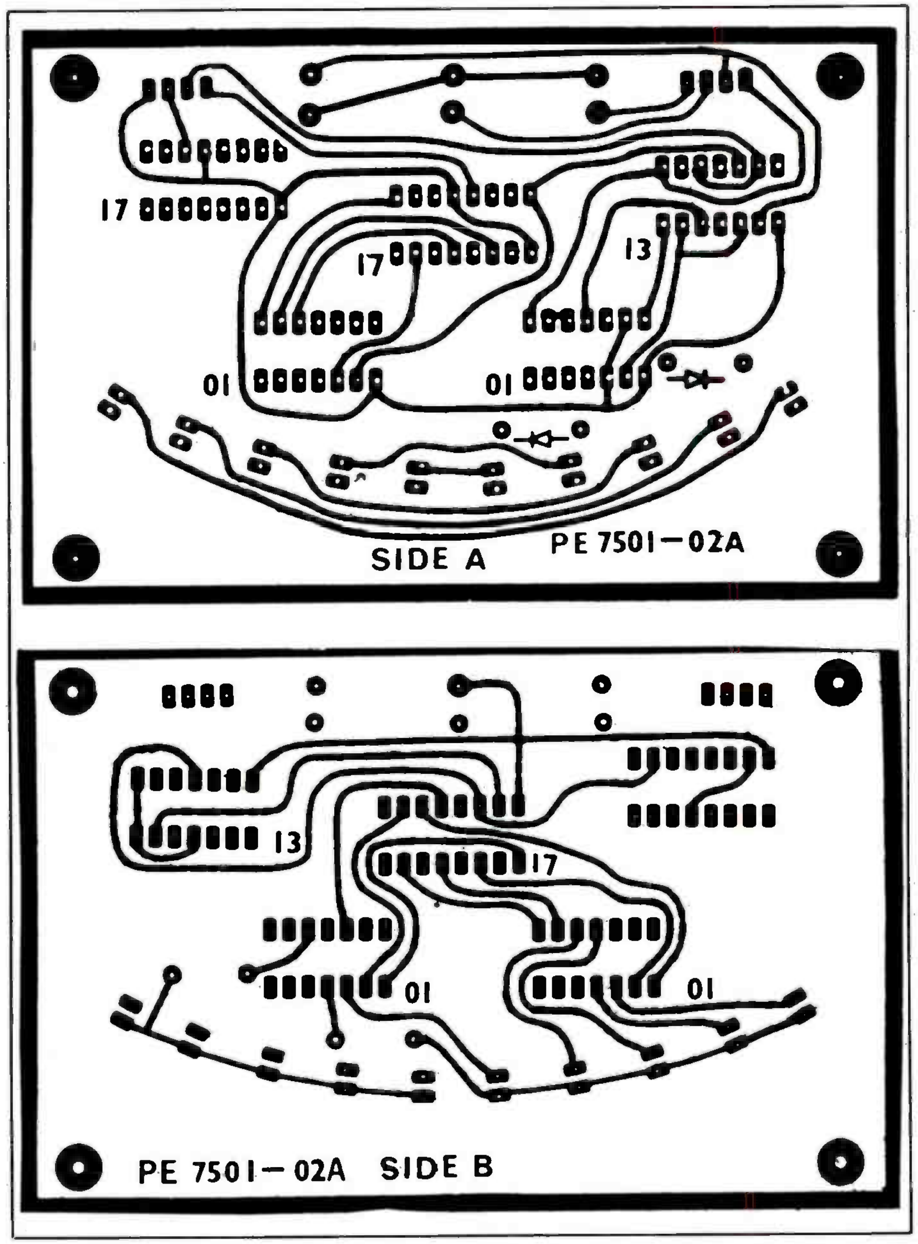


Fig. 2. Actual-size etching-and-drilling guides for the top (upper) and bottom (lower) of the pendulum printed-circuit board.

There are 10 LEDs in the pendulum circuit. These are divided into two groups of five LEDs each. Note the sequence of the numbers on the lines exiting the right side of *IC13* in Fig. 1(A). Follow these lines to the *IC15* and *IC16* NOR gates that drive the LEDs. As you can see, when the output at pin 1 of *IC13* goes high, the output at pin 3 of *IC1A* also goes high. This clocks *IC14A*, changing the states of its Q and not-Q outputs at pins 1 and 2.

The outputs of *IC16B* and *IC16C*

each drive one of the groups of five LEDs. Therefore, one pendulum LED at a time is on for about 0.1 second for each count of *IC13*. Pendulum "swing" direction changes when output pin 11 of *IC13* goes low and output pin 3 goes high because these two outputs are connected to the same *IC15A* gate. Since the counter wraps around, each pendulum LED is on for two counts, giving a more pendulum-like action.

Output pin 9 of *IC13* is used to reset *IC14B* via its pin 10 RESET input to ensure that *IC14B* is in proper phase with the rest of the clock-setting circuits. Output pin 11 of *IC16D* has a 1-second repetition-rate square wave on it and is used for timing functions in the rest of the clock.

The seconds and minutes counters shown in Fig. 1(B) are divide-by-60 units. These circuits are virtually identical to each other. The only difference between the two is in the set functions. The seconds counter is reset to 0 and minutes counter is advanced at the set frequency.

The divide-by-60 counters are each made up of two 4017 decade counters, a units counter and a tens counter with the COUNT OUTPUT at pin 12 of the units counter connected to the CLOCK input at pin 14 of the tens counter. The counter pairs for the seconds and minutes counters in Fig. 1(B) are *IC3/IC4* and *IC6/IC7*, respectively. The pin 5 outputs of *IC4* and *IC7* are connected to the RESETS at pin 15 of both counters in both cases. This forces both counters to be in proper sequence at all times.

Tens counters *IC4* and *IC7* in the seconds and minutes counting circuits, respectively, have their outputs inverted by hex inverters *IC5* and *IC8*. Circuit details are shown in Fig. 1(C). The outputs from the inverter chips are connected to the cathode side of each group of 10 LEDs by an isolation diode. For the seconds counter circuit, these diodes are *D5* through *D10*, and for the minutes counter they are numbered *D12* through *D17*.

After both counters are reset, the pin 3 outputs of both *IC3* and *IC6* are high. This turns on the first LED in the first group of 10. As the units counter is clocked, the LEDs come on in sequence thereafter.

When pin 3 of either counter chip goes high, so does COUNT OUTPUT pin 12, thus advancing the counter one increment. Now the second group of LEDs comes on. This process continues until the fifty-ninth count is reached. Then when pin 1 of the counter goes low and pin 5 of the tens counter goes high, both counters are reset. At this point, the process repeats itself for as long as ac line power is applied to the clock.

Note in Fig. 1(B) resistor *R3* connected between output pin 5 and RESET pin 15 and SECONDS HOLD switch *S1* connected between pin 15 and the V+ bus. As the name of *S1* implies, this is the "hold" circuit that allows you to adjust your clock's timekeeping to single-second accuracy.

The set circuit for the minutes counter is a set-reset (SR) flip-flop made up of NOR gates *IC2C* and *IC2D*, with *IC2C* being the set side and *IC2D* being the reset side. The output pulse at pin 5 of *IC4* is fed to the pin 8 (set) input of *IC2C*. Normally-open pushbutton MINUTES SET switch *S2* in Fig. 1(A) is also connected to pin 8 of *IC2C*, while the fast-set pulses from pin 12 of *IC14B* are fed to the reset side of the SR flip-flop at pin 12 of *IC2D*.

The pulses from the seconds counter are much narrower than are the fast-set pulses. Since the fast set is constantly occurring, the output at pin 11 of *IC2D* is kept low. When a pulse from the seconds counter occurs, the output at pin 10 of *IC2C* is forced low, which forces the pin 11 output of *IC2D* high until the arrival of the fast-set pulse resets the flip-flop. This advances the next counter with a pulse whose width is one-half the fast-set period.

To advance the counter at the fast-set rate, MINUTES SET switch *S2* must be pressed. Doing this causes *IC2D* to behave like an inverter that passes the fast-set pulses to the next counter. The hours-set circuit is operated in exactly the same manner as is the minutes-set counter, this time using the SR flip-flop made up of *IC9C* and *IC9D* and HOURS SET switch *S3*. The set and reset sides of this SR flip-flop are *IC9C* and *IC9D*, respectively.

Last but not least is the hours counter, which is depicted schematically in Fig. 1(D). The counter is made up of decade counter *IC10* and quad NOR gate *IC11*. The SR flip-flop for this circuit is made up of *IC11B* (set) and *IC11A* (reset). The other two *IC11* gates are employed as inverting buffers on the flip-flop's outputs.

Output 9 at pin 11 of *IC10* connects to the pin 6 set input of *IC11B*, and output 2 at pin 4 of *IC10* goes to the pin 1 reset input of *IC11A*. The output of the flip-flop at pin 10 of *IC11C* goes through isolation diode *D19* to hours LEDs 2 through 10 o'clock, and the output at pin 11 of *IC1D* goes through isolation diode *D20* to hours LEDs 1, 11 and 12 o'clock.

Assume that decade counter *IC10* is reset and *IC11B* is low and the hours counter is begun to be advanced. When the 2 output at pin 4 of *IC10* goes high, the output of *IC11B* at pin 4 is forced high, in turn forcing a pulse to go to RESET input pin 15 of *IC10* via the integrator made up of *C2* and *R6*. Now the 0 output at pin 3 of *IC10* goes high again, but the hours LEDs for 2 through 10 o'clock have been selected, thereby turning off the 2 o'clock LED. The decade counter now advances until its 9 output at pin 8 of *IC10* goes high. At this point, the output at pin 3 of *IC11A* is forced high, thereby selecting hours LEDs for 1, 11 and 12 o'clock.

Construction

Printed-circuit assembly is highly recommended for this project, both

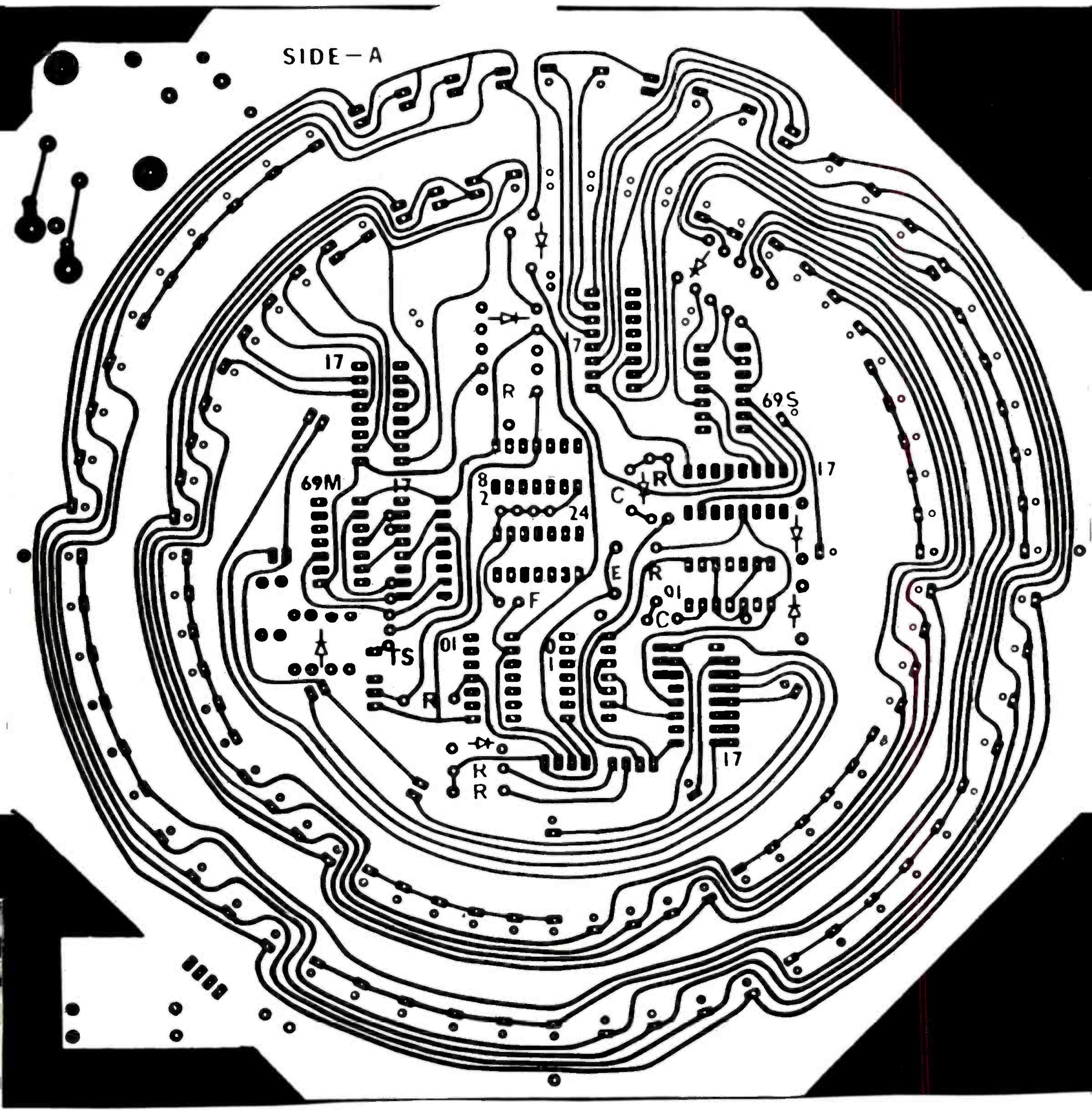
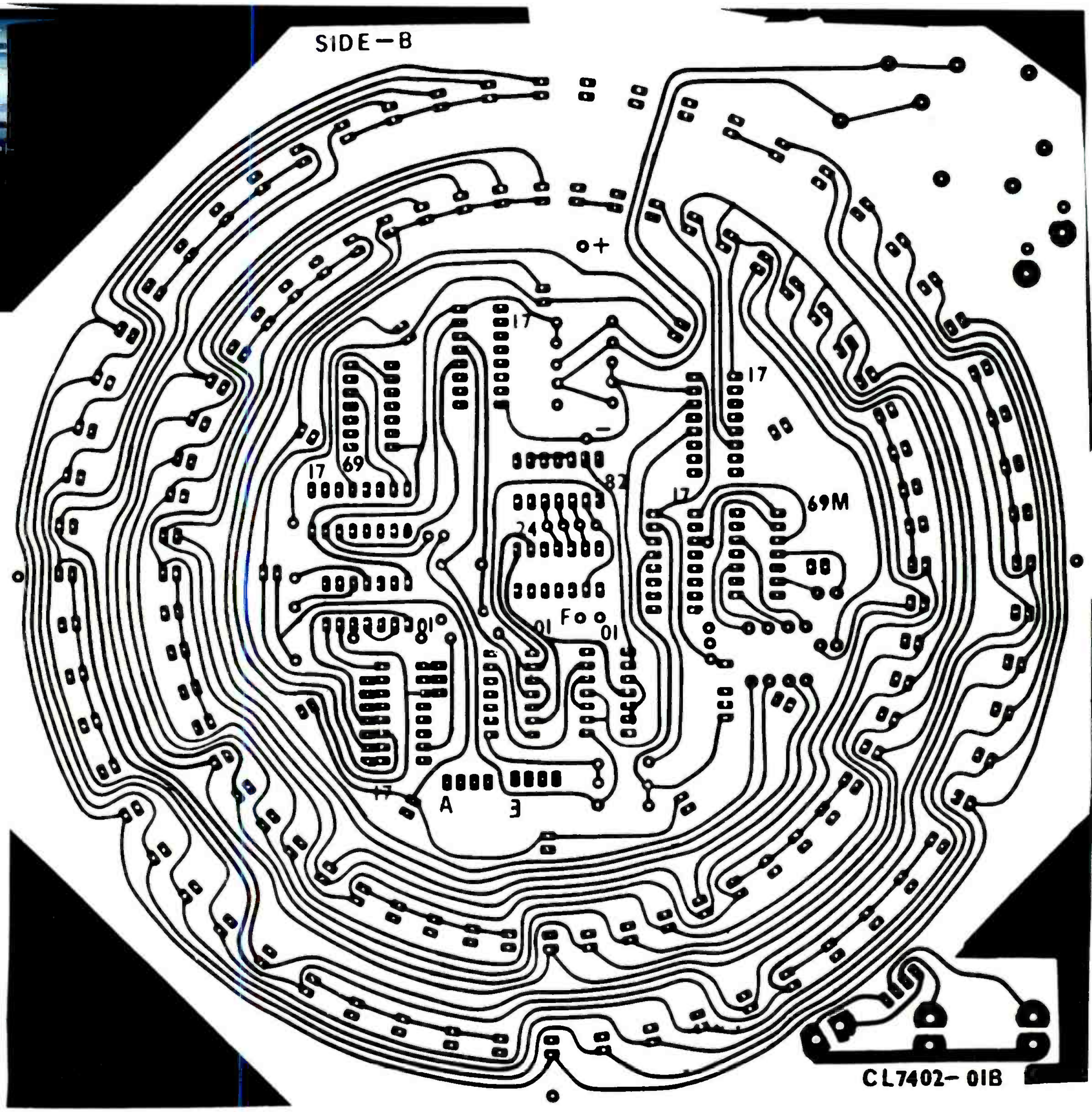


Fig. 3. Actual-size etching-and-drilling guides for the component (left) and solder (right) sides of the main board.


SIDE—B
CL7402—01B

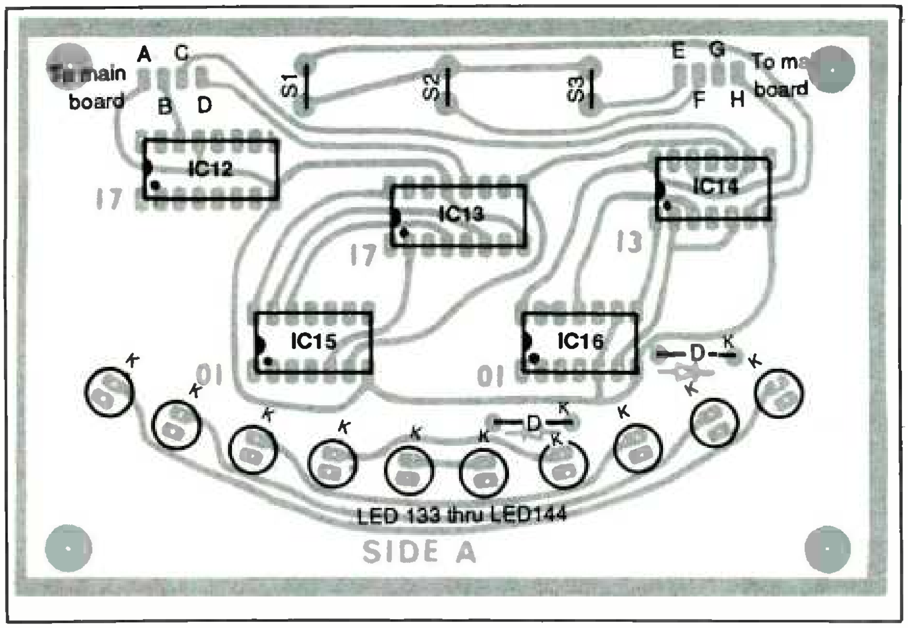


Fig. 4. Wiring guide for the pendulum board, viewed from the component side.

to simplify installing and wiring together the many components (especially LEDs) used and to reduce the possibility of creating wiring errors. Of course, if you wish, you can build the project on perforated board that has holes on 0.1-inch centers and using suitable soldering or Wire Wrap hardware. If you go this route, you might want to arrange the dial in a square or diamond pattern with 15 LEDs on each side for the seconds and minutes and 3 LEDs on each side for the hours displays.

Two printed-circuit boards are needed—one for the main circuitry and the other for the divider/pendulum circuitry. The latter is needed even if you decide not to build the pendulum into your clock because it contains the circuitry for the 1-Hz divider that drives the remainder of the clock's circuits.

Pc boards for this project are double-sided. You can make your own boards using the actual-size etching/drilling guides for the pendulum and main boards shown in Fig. 2 and Fig. 3, respectively. Keep in mind that home-made boards will not have plated-through holes and, thus, require that you solder all component pins and leads to the pads on *both* sides of the board. If you prefer not to make your own pc boards, you can obtain ready-to-wire pc boards from the source given in the Note at the end of the Parts List.

Wire the pendulum board first, referring to Fig. 4 for details. (Note: The views shown in Fig. 4 and Fig. 5 are from the top of the board.) Install the sockets (or Soldercons) first but *not* the ICs themselves in the indicated locations. This done, identify the cathode leads of the 10 light-emitting diodes that make up the pendulum. Install these LEDs on the board in the indicated locations and solder their leads into place. Note that the cathode (K) leads all face toward the top of the board. Position the LEDs so that the bottoms of their cases are a uniform ¼ inch above the surface of the board.

Plug the pins of the three switches into the holes identified by the legends S1, S2 and S3 and solder into place. Then install the two diodes near the IC16 socket, taking care to properly orient each before soldering their leads into place.

Carefully inspect your work for properly installed components and proper soldering. If you are using a home-made board, make sure that all connections are soldered to the pads on *both* sides of the board. If you locate any connections that have not been soldered or ones that have questionable soldering solder the ones missed and reflow the solder where necessary. Check also for solder bridges, particularly between the closely spaced IC pads. If you locate any bridges, remove them with desoldering braid or a vacuum-type desoldering tool.

Set aside the pendulum board and place the main board on your work surface in the orientation shown in Fig. 5. Begin populating this board by installing and soldering into place the sockets (or Soldercons) in the indicated locations. Note that no socket should be installed in the location in the center of the board. Again, do *not* install the ICs in the sockets yet. Then install and solder into place the resistors and diodes, making sure that the latter are properly oriented before soldering their leads to the copper pads.

Next, install and solder into place the capacitors. Small capacitors *C2* and *C3* mount on the top of the board with the other components. Large electrolytic capacitor *C1*, on the other hand, mounts on the *bottom* of the board; observe proper polarity when installing *C1*.

Finish up installing components on the main board with the 132 light-emitting diodes that make up the seconds, minutes and hours indicators. Before you solder any LED into place, make sure it is properly oriented. Also, position each LED so that the bottom of its case is ¼ inch above the surface of the board. When you are finished installing the LEDs, carefully position them so that they form three concentric perfect circles.

Carefully check your work as you did for the pendulum board. Follow

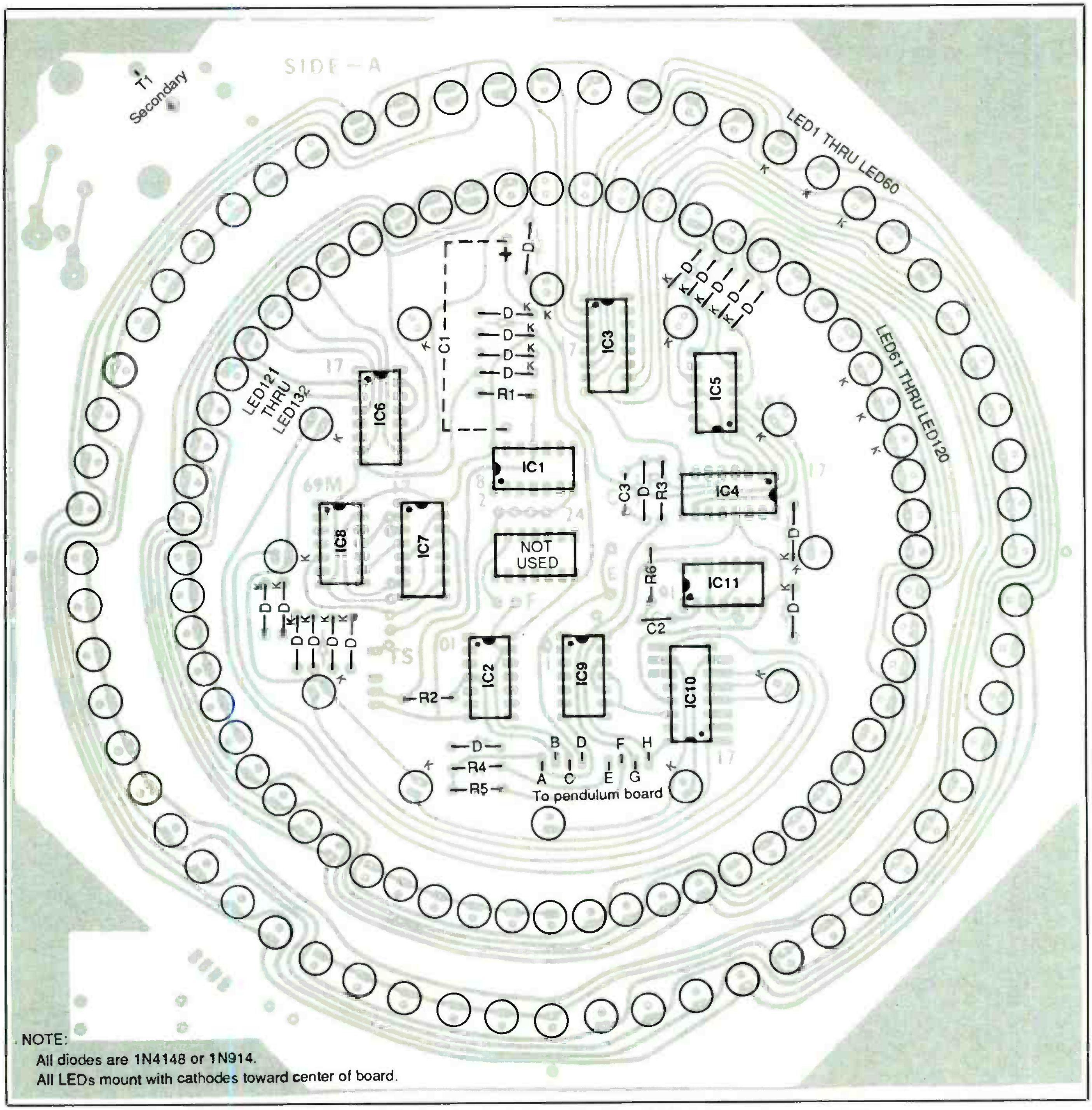


Fig. 5. Wiring guide for the main board, viewed from the component side.

the same steps detailed above for this operation.

The length of the eight-conductor ribbon cable that links the two circuit-board assemblies together depends on how far apart the two boards will be located in your clock's enclosure. If you are building a wall-hung or mantel-top version, the distance separating the two assemblies will be short. Alternatively, if you are building a long-case ("grandfather") version, the distance separating the two assemblies will be considerably greater.

It is preferable to use ribbon cable that has color-coded insulation to make it easy to keep track of which conductor goes where. Cut the cable to length. Then separate the conductors at one end into two bundles of four conductors for a distance of 6 inches. Then separate all conductors at both ends a distance of 1 inch and strip from each ¼ inch of insulation. Twist together the fine wires in each conductor and tin with solder.

Flip over the main board and plug the conductors at the end of the cable where separation is only 1 inch in all cases into the holes labeled A through H and TO PENDULUM BOARD. Solder them into place. The other end of this cable will be connected to the pendulum board after you install the main board it in its enclosure.

You can fabricate your own enclosure for the clock or purchase one ready for installation of the electronics package from the source given in the Note at the end of the Parts List. A build-it-yourself enclosure can be made from any materials you wish, including lumber, painted or veneer-finished particle board or even all acrylic plastic, depending on your tastes and shop skills. Whichever way you go, though, use a transparent red or gray smoked plastic filter in front of both the clock face and pendulum to enhance contrast and camouflage the board—unless, of course, you want the high-tech look of the circuitry showing through clear plastic.

Set the main board in place inside the enclosure, orienting it as shown in Fig. 5. Determine where to mount the power transformer. It should be located as close as possible to the T1 SECONDARY holes in the upper-left corner of the board. Mount the transformer in place using two No. 5 × ½-inch wood screws.

If you are using a basic power transformer, mount a two-lug terminal strip near its primary leads and crimp but do not solder the primary leads to its lugs. Route the ac line cord through a hole you drill in the enclosure's rear panel and tie a strain-relieving knot in it about 5 inches from the free end inside the enclosure. Tightly twist together the fine wires in each conductor and tin with solder. Solder the conductors to the lugs of the terminal strip.

Plug the transformer's secondary leads into the T1 SECONDARY holes in the main board and solder into place. Set the main board into place inside the enclosure but do not fasten it down.

Now plug the conductors at the free end of the ribbon cable into the holes in the pendulum board (again from the rear of the board) labeled A through H and TO MAIN BOARD and solder into place. Match letter designations between boards. Set this board in place inside the enclosure, without fastening it down.

Accurately locate and drill the holes for the pushbuttons on the three pendulum board switches through the fronting plastic sheet.

Checkout & Use

With the ICs still not installed in their respective sockets, plug the clock's line cord into an ac receptacle. Clip the common lead of a dc voltmeter or multimeter set to the dc volts function to a convenient circuit-ground point. Then use the meter's "hot" lead to probe pin 14 of the 14-pin sockets and pin 16 of the 16-pin sockets. In all cases you should obtain a reading of about +9 volts.

If you do not obtain a +9-volt reading at any of the specified pins, use the meter's "hot" probe to check the reading at the positive (+) lead of *C1* on the bottom of the main board. If you still do not obtain a +9-volt reading at this point, check the wiring of the power-supply circuitry and especially the orientations of *D1* through *D4*.

If you fail to obtain the +9-volt reading at only one or a few IC sockets, power down the project and troubleshoot it to isolate and rectify the problem. Do not proceed until you are certain that the problem has been rectified.

Once you are certain the the project has been wired properly, power it down and allow the charge to bleed off *C1*. Then carefully install the ICs in their respective sockets. Make sure you orient each IC as shown and that no pins overhang the sockets or fold under between ICs and sockets. Also, since the ICs used in this project are CMOS devices, handle them with the same precautions you would with any other MOS device to prevent damaging them from static electricity.

Plug the project's line cord back into the ac receptacle and observe its LED display. If no LEDs are on, check the power supply for proper wiring. If everything appears to be operating as it should, the pendulum should begin "moving" (its LEDs cycling back and forth) and at the end of each "swing," the seconds LEDs should increment in the clockwise direction one LED at a time.

Pressing and holding SECONDS HOLD pushbutton switch *S1* should halt the advance of the seconds LEDs and turn on the one LED at the 12 o'clock position. Doing the same with MINUTES SET pushbutton switch *S2* and HOURS SET pushbutton switch *S3* should cause the LEDs in the minutes and hours rings, respectively, to advance in the clockwise direction at a rate of once per second. If you obtain these results, the clock has been properly wired.

Once you have ascertained that the clock has been correctly wired, press and hold the MINUTES SET button and observe the display to check that all 60 LEDs light in proper sequence. Allow the LEDs to cycle completely around the dial face three or four times. Then do the same for the HOURS SET switch and the 12 LEDs that make up the hours ring.

If a "trailer" appears in either display, there is probably a leaky LED in the string. To isolate this LED, note if more than one group of 10 LEDs comes on. If so, there is more than one leaky LED. In any case, finding it or them is a relatively easy process. As the turned-on LED "moves" around the dial face, a leaky one will not turn on when it is supposed to.

If a LED is installed in the wrong polarity, the group of 10 LEDs in which it appears will will light rather brightly, but the reversed one will not light at all. If more than one second, minute or hour LED lights when the clock is first powered up, press and hold the SECONDS HOLD button and advance the minutes and hours LEDs by pressing the appropriate SET buttons. This should clear out the counters and allow them to operate in the normal manner.

Once you have your clock working as it should, power it down. Secure the two circuit-board assemblies in place with No. 6 × ½-inch wood screws. Then assemble the enclosure. Set the clock in the location where it will remain and plug its line cord into a convenient ac outlet.

Now set the time. To do this, press and hold the SECONDS HOLD button and then the HOURS SET button until the appropriate LED in the hours ring is lit. Release the HOURS SET button but not the SECONDS HOLD button and press and hold the MINUTES SET button until the appropriate minute LED is lit. Go one minute past the actual time before you release the MINUTES SET button. Continue to hold the SECONDS HOLD button until the exact second arrives to release it. Your clock will now continue to count off seconds, minutes and hours with the precision of the ac line and will continue to do so for as long as ac power is applied to it.

When the time comes to set the clock forward or back one hour in the spring and fall, simply press and hold the SECONDS HOLD button as you advance the hours indication to the proper hour. Then set the minutes display one minute ahead. Release the SECONDS HOLD button at the exact second to start the new minute. **ME**

Apple's High-Performance Macintosh SE/30

Desktop computer operates at up to four times as fast as the Mac SE and provides MS-DOS and OS/2 disk compatibility

Close on the heels of the company's announcement of the Macintosh IIx (see New Products, February 1989), Apple announced the Macintosh SE/30—another computer built around the Motorola 68030 32-bit microprocessor and 68882 floating-point math coprocessor. Both are desktop units, but the Mac SE/30 is Apple's first *transportable* computer to capitalize on such state-of-the-art technology. With the packaging of the Mac SE/30, Apple has taken a step backward with the return to the small-footprint enclosure used by the original Macintosh computers, a welcome move for people who have to lug the machine around and have limited desktop space for their computers.

Operating at up to four times the speed of the original Macintosh SE, the Mac SE/30 also provides MS-DOS and OS/2 disk compatibility. Thus, it provides a bridge between the two major personal computer designs and philosophies in the current arena.

Three configurations of the Macintosh SE/30 are available. At the entry level, the machine comes with 1 megabyte of RAM and a single 1.4-megabyte floppy-disk drive and retails for $4,369. Option number two offers the same machine with an internal 40-megabyte internal hard disk at a retail price of $4,869. At the top end of the line, the SE/30 comes equipped with 4 megabytes of RAM and an 80-megabyte internal hard disk at $6,569.

Users of the original Macintosh SE who wish to obtain full Macintosh SE/30 functionality from their computers can do so with an upgrade kit from Apple. No price was available for the upgrade kit at press time.

Mac SE/30 Features

The Macintosh SE/30 is a two-unit system. One unit contains the system circuitry and integral high-resolution video display monitor; the other is the detached keyboard.

Operating the 32-bit 68030 microprocessor at 16 MHz and taking advantage of the chip's on-board 256-byte data and instruction caches give the Mac SE/30 its up to four times speed edge over the original Mac SE. Additionally, the companion 68882 coprocessor is claimed to boost the new computer's performance in certain complex mathematical calculations to more than 100 times as fast as its predecessor, thus improving the performance of some spreadsheets, statistical and numeric-based graphics programs.

Going beyond the "hot" processor/coprocessor combination, the company has bestowed upon the

Macintosh SE/30 the Apple FDHD (Floppy Drive High Density), an internal 1.4-megabyte floppy-disk drive that can read, write and format MS-DOS, OS/2, Macintosh and Apple II ProDOS diskettes. For maximum utility, this "SuperDrive" is said to work with 720-kilobyte and 1.4-megabyte MS-DOS and OS/2 diskettes; 400-kilobyte, 800-kilobyte and 1.4-megabyte Macintosh diskettes; and ProDOS diskettes.

Convenient access to and transfer of files between the three basically incompatible operating system environments are accomplished with Apple File Exchange. This is a utility in the Macintosh System Software for use with the FDHD drive. This is a great advantage in an office environment in which spreadsheets and other data files generated by different computers must be transported between incompatible machines.

An expansion slot architecture, called the 030 Direct Slot, inside the system/monitor unit allows the Macintosh SE/30 to support new types of expansion options that were not previously available on a compact Macintosh. Already, a number of third parties have developed products for the 030 Direct Slot (see below).

Rounding out the features of the basic Macintosh SE/30 is a custom sound chip on the motherboard. This chip provides four-voice stereo sound capability and compatibility with sound applications.

Support Picture

A variety of products have been and are being readied for expanding the Macintosh SE/30 via the 030 Direct Slot. Among the items currently ready or in the works is the internal MacMainframe SE/30 card and communication software from Avatar Corp. that allow the Mac SE/30 to directly connect to IBM 3270 networks. Another is Digital Communications' MacIRMA card that allows the Mac SE/30 to function as an IBM 3278 or 3279 terminal for communicating with an IBM mainframe computer.

Digidesign's Sound Accelerator, a high-speed digital-audio and digital-signal-processing (DSP) card that provides CD-quality playback of sounds and performs most sound processing and synthesis functions in real time. Epic Technology has has MaxCOMM 2400X, a 2,400/1,200/300-baud internal modem.

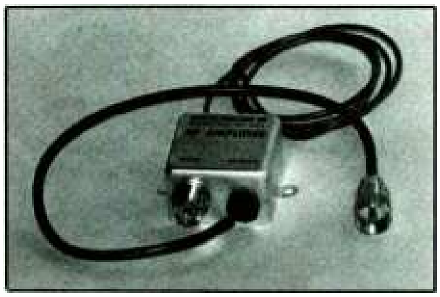
On the graphics front are two products of note. One is E-Machines' Big Picture Z21 SE/30, a 21-inch monochrome display system that can put on-screen two complete 8.5 by 11-inch or international A4 pages. The other, from Super Mac Technology, is the Spectrum/8 (Series I) Graphics Card that supports color, gray-scale and multimedia output and displays 1,024 by 768 pixels with 256 colors from a palette of 16.8-million colors.

Other support cards for the 030 Direct Slot include Kinetics' Ethernet SE/30 for connection to Ethernet networks; Dove Computer's Marathon 120/96 SE/30 NuBus Adapter and FastNet SE/30 Ethernet adapter; MacPEAK Systems' Orion SE/30 Cache Card that enhances the Mac SE/30's performance with a 64K-byte high-speed static RAM cache.

Creative Solutions, Inc. has a line of Hurdler serial and parallel I/O cards, a prototyping card and a bus extender. Finally, Micron Technology's Micron Parity Watchdog parity error detection device gives real-time acknowledgment when an error has occurred.

NEW PRODUCTS ••• *(from page 16)*

when the transmitter is keyed. Insertion loss and VSWR are claimed to be negligible, and current drawn by the unit is only 80 milliamperes at 10 to



15 volts. The circuitry is housed inside a weather-resistant 2" × 2" × 1.5" plated metal box, making it suitable for use in harsh environments. $99.95.

CIRCLE 34 ON FREE INFORMATION CARD

Portable Static Meter

The Static Surveyor CP911 from Charleswater Products, Inc. (W. Newton, MA) is a fully automatic hand-held static meter that features an analog display movement and an audio alarm with a red light-emitting

diode to indicate when charges exceed 500 volts. It operates over a 0-to-5,000-volt range at a specified accuracy of ±10% and repeatability within 5% at a distance of 1 inch from the target. The audible/visible alarm feature is activated at potentials that exceed 500 volts. Lower voltages are read directly from the instrument's built-in analog meter movement. Power for the meter is provided by a rechargeable 10.8-volt battery. The instrument measures 4.7 × 2 × 1.25 inches and weighs just 5 ounces. $275.

CIRCLE 35 ON FREE INFORMATION CARD

EDITORIAL *(from page 7)*

Manufacturing/Production, 10.4%; Services (standards, quality control, etc.), 7.3%; and 16.3% for Other (CEO, owner, professor, programmer, etc.).

Educationally, *Modern Electronics* readers are naturally expected to have attained a high level owing to the technical nature of the subject that interests them. This rang truer than ever before, with 13.3% of respondents to our questionnaire indicating they have a Post-Graduate degree (Ph.D, MD, etc.) as compared to 1986's 11.6%. Another 12.4% have done some Post-Graduate study vs. '86's 11%.

The next highest educational level category, Graduated College or a Technical Institute, accounted for 45.6% of respondents to our questionnaire compared to 1986's 25.3%. This is likely somewhat distorted since the 1986 survey did not include "Technical Institute," many of which are two-year institutions, among the choices. However, examining the next lower level, Attended or Attending College, reveals that the current survey drew an 18.6% response for this choice, while an expansive 35.5% noted this in 1986. Part of the difference, I'd guess, is that some tech institute graduates did not check off College in '86, but instead marked the lower Attended/Attending College level choice. The major difference, however, is that more (about +9% trained electronic technicians are reading *Modern Electronics* now than three years ago.

Adding both together, Graduated/Attended/Attending, 1989's total is 64.2%, while 1986's was 60.8%. Not much of a difference, really, given a sampling error of a few points in either direction. It does, however, give us a better picture of how many of you completed their formal post-secondary-school training since there was a shift of +20.3% to College/Institute and a loss of −16.9% in Attended/Attending college. It changed the percentage of college graduates, whether two-year or four-year, to an impressive 71.3% this year, from 1986's 47.9%. The college-trained total (which includes Attended/Attending College) among respondents rose to a powerful 89.9% from 83.4% three years ago.

With this information under our belts, what does it all mean? Firstly, we know that the typical *Modern Electronics* subscriber is in his early 30's, and has been working for about 11 years after graduating college. Consequently, most of you cut your technical eye teeth on solid-state electronics, not vacuum-tube technology.

Your prime interest in electronics and computers relates to your work, not your hobby, which only 18.5% of you noted as best describing this involvement. Sixty-four percent of you are either staff electronic engineers or technicians, while another 15.5% are in the management end. More of you are concerned with Maintenance/Repair work (37.1 than we had thought, followed by nearly 30% with Design or Development jobs. This approximate 2/3rds apparently represents what most of our reader engineers and technicians work at for a living.

It came as no surprise that a great number of you buy equipment and components by mail, which respondents verified to the tune of 72.1%. Purchasing from a distributor or sales representative, however, is another story. Here, 41% documented this largely non-personal source of supply, as compared to only 27.4% three years ago. This seems to parallel the rise in readers who are technicians.

These figures represent a fragile relationship between editorial matter and reader. Just because more than 1/3rd work in the maintenance/repair field, doesn't mean that we'll shift editorial gears and focus on it. Nor does the fact that another 1/3rd are professional electronic design or development engineers or technicians mean that that's what we'll emphasize.

There are specialized professional and trade publications that do just this. *Modern Electronics,* however, straddles the entire field of electronics, broadening the technical and industry knowledge of readers who, in their day-to-day work and professional journal reading, tend to become very specialized.

We'll continue to do this as your one-stop source of electronics and computer information, helping you to continually hone your technical competence as new developments are introduced. Thanks for your support and loyalty.

Art Salsberg

BOOKS

Electronic Servicing Data and Procedures by Robert C. Genn, jr. (Prentice Hall. Soft cover. 373 pages. $16.95.)

This book is written to be used right at the service bench. It details how to conduct nearly 200 tests and measurements on virtually every type of electronic equipment one is likely to encounter. Step-by-step procedures are given for testing both analog and digital circuits, including those that use microprocessors, optical isolators, phototransistors and other fairly new devices. Diagrams, line art and checklists accompany the text to simplify diagnoses of problems and speed the reader in troubleshooting a defective circuit.

The book is divided into 10 sections, each of which deals with tests for a specific range of electronic circuits. Section 1, for example, deals with audio equipment and covers some 20 tests that can be made on it. In section 2, the reader is given important information on maintaining digital equipment. Section 3 provides practical guidance for solid-state circuit and device servicing. Radio-frequency circuits are covered in Section 4. Then Sections 5 through 8 deal with in-circuit testing of high-frequency transistors, transmitter/receiver servicing, TV servicing and antenna systems and transmission lines. Practical testing, measuring and digital-instrument building are covered in Section 9. Here, the reader is given schematic diagrams for building a logic memory probe, logic pulser, LED indicators and a multi-channel logic analyzer. Finally, Section 10 gives time-saving tests and measurements for semiconductors.

Each test or measurement procedure is approached in a logical, time-saving manner. It begins with a run-down on the test equipment needed and then briefly describes the required test setup. Following this comes comments, which generally deal with the symptoms of the problem for which the test is being conducted. Thereafter, a by-the-numbers procedure is given for conducting the test or measurement. Wherever needed, schematics, drawings, tables and whatever else is needed to clarify the procedure are given.

If you do a lot of servicing, this book can quickly pay for itself by making you a faster, more efficient troubleshooter. It is well worth its modest cost.

NEW LITERATURE

Product Line Catalog. Contained within the latest 74-page product line catalog from Jameco are listings and full descriptions for a wide range of items ranging from computer kits and IBM/Apple-compatible peripherals to individual integrated circuits. Among the new items that have been added to this 1989 catalog are 16- and 20-MHz AMI 80386 motherboards and the new NEAT (New Enhanced AT) motherboard. A welcome feature is a two-page insert of TTL and microprocessor pinout data. For a free copy, write to: Jameco Electronics, Shoreway Rd., Dept. ME, Belmont, CA 94002.

Direct-Purchase Catalog. A new catalog from Tektronix provides information test instrument buyers need to make direct purchases of Tektronix products. This full-color quarterly publication contains complete descriptions of a sampling of the company's products. Among the items featured in this latest edition are portable oscilloscopes, a logic analyzer, accessories, software and training aids. For a copy of the "Tek Direct Catalog for Instruments, Accessories, and Services" publication, write to: Tektronix, Inc., P.O. Box 1700, Dept. ME, Beaverton, OR 97075.

1989 General Catalog. A complete source book of products for testing, repairing and assembling electronic equipment is available from Contact East. The 132-page 1989 General Catalog contains listings and complete descriptions of products for engineers, managers and technicians, including new items in such areas as analog/digital oscilloscopes, static protection products, soldering stations and supplies, test equipment, precision hand tools and the company's exclusive line of tool kits. Also featured are expanded lines of voice/data communications test instruments, wire and cable aids, electronic adhesives and inspection equipment. All products listed are fully described, including specifications and prices, and are accompanied by photo. For a free copy, write to: Contact East, P.O. Box 786, 335 Willow St. So., Dept. ME, N. Andover, MA 01845.

Experimenting With Thermistors

By Forrest M. Mims III

Thermistors are temperature-sensitive resistors that are extensively used in electronics. Detection of temperatures of liquids, gases (both indoor and outdoor air included), machinery, electronic components, soil, plants and animal tissue are among the many applications in which they can be found playing central roles. Thermistors can also be used as surge protectors and timing devices.

In this column, I'll discuss the various kinds of thermistors and how they work. I'll follow this with several examples of applications for these simple but very versatile components.

Thermistor Operation

A thermistor is a resistor. When its temperature is increased, the opposition to the flow of current (resistance) through it decreases. Therefore, a thermistor is said to have a negative temperature coefficient (NTC). The resistance of copper increases and, as a result, copper has a positive temperature coefficient (PTC).

The NTC of a thermistor might at first appear to be an unusual characteristic. However, if you are familiar with photoresistors, the NTC of a thermistor should seem perfectly ordinary. Just as the resistance of a thermistor falls as temperature rises, the resistance of a photoresistor falls as light intensity rises.

Shown in Fig. 1 are the resistance characteristics of a typical thermistor as a function of temperature. At room temperature, this thermistor has a resistance of approximately 500 ohms. Other thermistors have room-temperature resistances ranging from a few hundred ohms to several megohms.

The curve in Fig. 1 shows that a thermistor is very sensitive to small temperature changes. Indeed, a thermistor can exhibit a resistance change of up to eight decades (10,000,000 to 1) over the temperature range it is designed to monitor.

Another important feature of the curve shown in Fig. 1 is its nonlinearity. If a thermistor is intended to monitor relatively small temperature changes, its nonlinearity is usually not important. That's because the resistance of a thermistor is often linear with respect to temperature over small temperature ranges. However, in applications where wide temperature ranges are encountered, some form of compensation to adjust for nonlinearity is usually required.

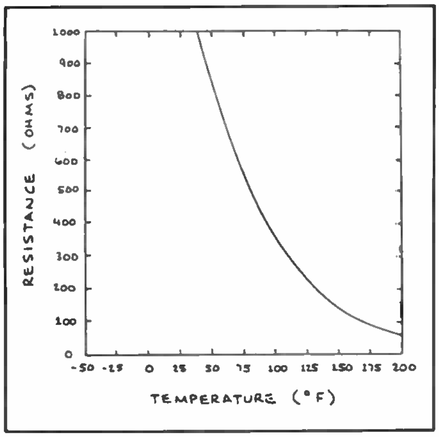


Fig. 1. Plot of the resistance of a typical thermistor as a function of temperature.

I recently purchased a chart recorder, an instrument I have long needed for monitoring various atmospheric and solar phenomena. A chart recorder is ideal for observing the behavior of a thermistor. Figure 2 is based on a chart recording I made by connecting a tiny bead thermistor in series with the current input of a recorder. The thermistor had a room-temperature resistance of 2,000 ohms.

When I touched the thermistor with my index finger, the current flowing through it increased from almost nothing to 250 microamperes in just a few seconds. After 25 seconds or so, the current peaked at about 350 microamperes. When I removed by finger, the current flow fell back to a negligible value after around 90 seconds.

How Thermistors are Made

The active element of a thermistor is a semiconducting ceramic that is made from the powdered oxide of a metal like nickel, copper, magnesium, iron, titanium or manganese. Each metal gives a different resistance range.

The first step in manufacturing a thermistor is to mix the powdered metallic oxide with a binder to form a paste. Bead thermistors are made by depositing a tiny dollop of semiconductor paste at intervals along two closely spaced platinum-alloy wires. The wires and beads of paste are then heated in a furnace, which action sinters the paste and bonds it to the wires.

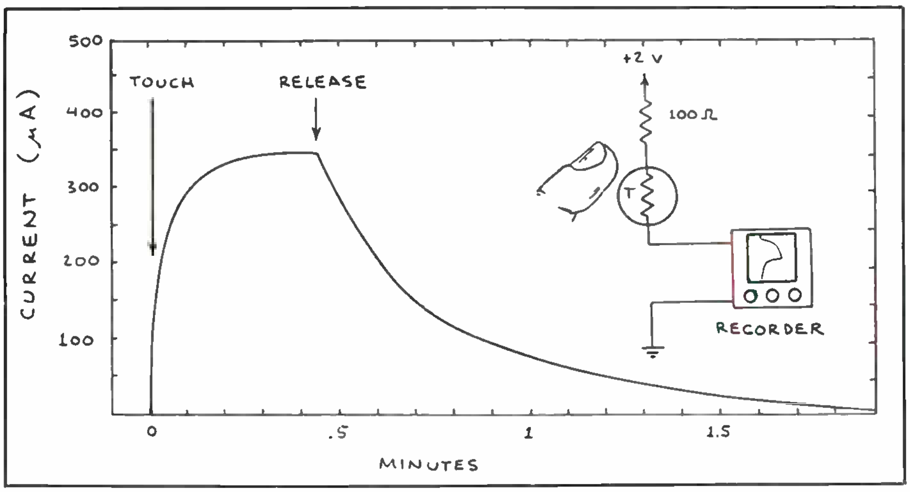


Fig. 2. Plot of the current flow through a thermistor as it is being touched by a finger and after finger is removed.

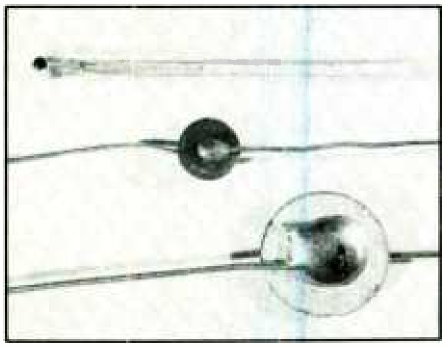


Fig. 3. Examples of two wafer and a miniature bead thermistors.

The wires emerging from one end of each bead are then cut to form individual thermistors. The ceramic bead is then usually encapsulated in a protective glass or epoxy coating.

Wafer and surface-mount chip thermistors are made by casting thermistor paste into thin sheets. The paste is then fired in a furnace and coated on opposite sides with silver or some other conductive material. If they are required, external leads are soldered directly to the silver terminals. Wafer thermistors may be given a protective coating of epoxy.

The sensitivity, response time and resistance range of a thermistor are determined by the metallic oxide from which it is formed, its size, the encapsulant used, and the presence of external leads. For example, external leads and a thick encapsulating layer can slow down a thermistor's response time. So if rapid response time is important in a given application, the active element and its leads and encapsulant should have as little mass as possible. This will permit the active element to rapidly respond to very subtle variations in temperature.

The photo in Fig. 3 is of two wafer thermistors and one bead thermistor. The bead thermistor, which is the one I used to generate the response curve shown in Fig. 2, is encapsulated in the end of a glass capillary tube. Since its active area is quite small, it responds relatively rapidly to temperature changes.

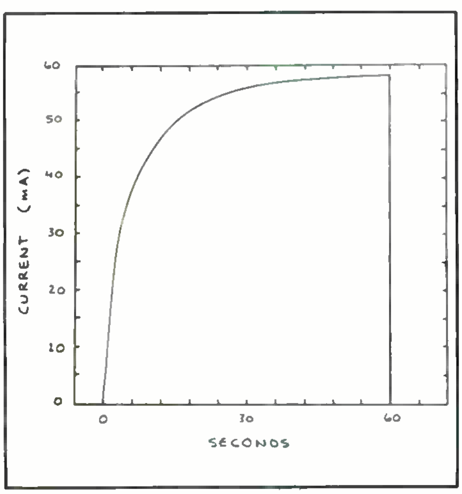


Fig. 4. Plot of thermistor current versus time.

Thermistor Applications

All of the hundreds of applications for thermistors can be divided into just two categories: those in which the thermistor is heated by current flowing through it and those in which the thermistor is heated or cooled by external means. The first category includes surge-protection and timer circuits. The latter category includes many different temperature-sensing and temperature-compensation applications.

• **Surge Protection.** An important application for self-heated thermistors is surge suppression. The delicate filaments of some lamps and tubes can be damaged or destroyed by rapid application of current. If a thermistor is placed in series with the current-sensitive component and a source of current, its resistance will limit the initial current. As the current passing through the thermistor raises its temperature, the device's resistance eventually decreases and allows more current to reach the component. Careful selection of the thermistor will provide both an appropriately low initial current and an adequate operating current.

To test the ability of a thermistor to function as a surge protector, I connected one in series with a 100-ohm resistor and a chart recorder. When 10 volts was connected across this network, the curve shown in Fig. 4 was generated by the recorder. Three seconds after application of the voltage, the current through the circuit reached 35 milliamperes. After 30 seconds, the current reached 58 milliamperes. Various other thermistors will produce different time-delay curves.

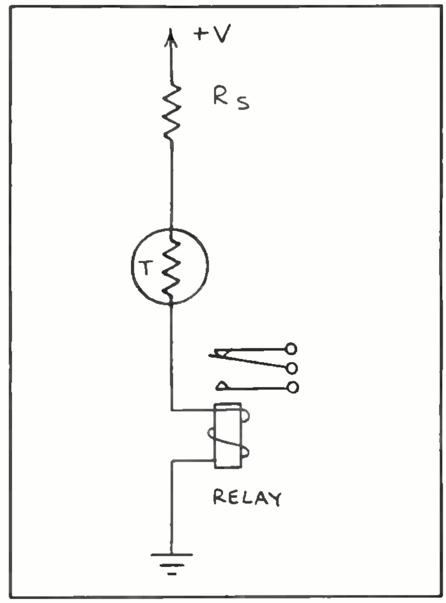


Fig. 5. A simple thermistor time-delay circuit.

A possible application for a thermistor surge suppresser is to protect laser diodes and other very delicate semiconductors that can easily be damaged by very brief current spikes. The Fig. 4 curve shows a current level close to that required to operate many CW laser diodes.

• **Time-Delay Circuits.** The reduction of resistance that results from self-heating that permits thermistors to serve as surge protectors also allows them to function in simple timer circuits. Shown in Fig. 5 is a simple circuit I tried to verify this application. Here, resistor R_S's 100-ohm value limits current through the thermistor and relay. The low-voltage relay pulls in when its coil current exceeds approximately 20 milliamperes at 9 volts. Radio Shack's Cat. No. 275-005 relay works well in this circuit; the company's Cat. No. 275-232 reed relay should also work.

When power is first applied to the Fig.

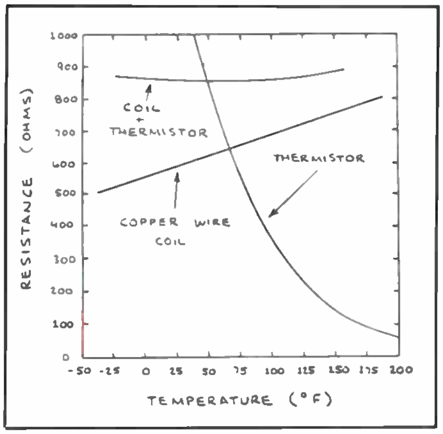


Fig. 6. Graphical depiction of how a thermistor temperature compensates a meter coil.

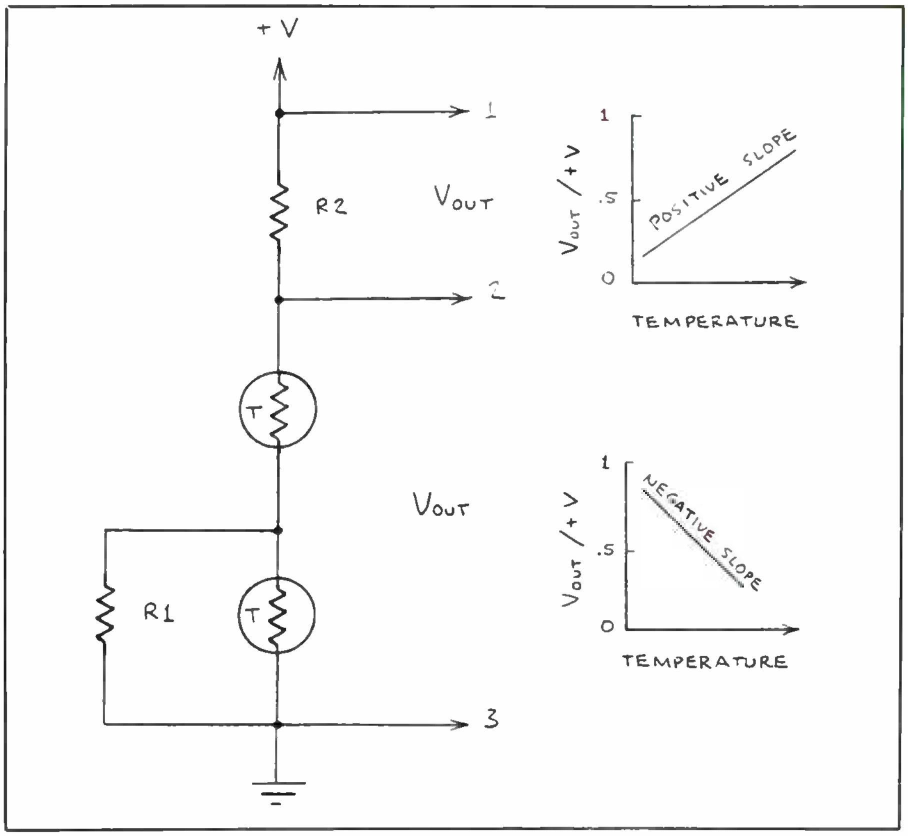


Fig. 7. Voltage outputs from a linear thermistor network.

5 circuit, the relay does not energize. As the thermistor warms up as a result of the current flowing through it, its resistance eventually falls to a point where the current flow is sufficient to energize it. Depending on the thermistor and relay used, the delay period can range from a fraction of a second to several minutes. The thermistor I used had a room temperature resistance of about 2,000 ohms and yielded a delay of about 15 seconds.

The basic Fig. 5 circuit can be easily modified to drive high-current relays. All that is required is to monitor the current flow with an operational amplifier. The output from the op amp can then be used to switch on a power transistor that, in turn, drives the relay.

Since ambient temperature can vary considerably, a thermistor is not suitable for use if you require a precision repeatable timing interval. For applications that are not critical, the thermistor approach provides one of the simplest timing circuits available.

• **Temperature Compensation.** A thermistor's NTC makes this device very useful as a temperature-compensating device. For example, a thermistor can be used to correct the PTC error of the copper wire in the coil of an electromechanical meter movement or the winding of a relay, motor or generator. Figure 6 is a graphic depiction of the resistance of a copper-wire meter coil as a function of temperature. The resistance of an NTC thermistor is plotted on the same graph.

Figure 6 also shows the combined resistance of the coil and the thermistor when the latter is connected across the former. As this illustration clearly reveals, the thermistor almost eliminates the meter coil's temperature error. The curves shown in Fig. 6 are adapted from "NTC Thermistors," a brochure published by Sensors Scientific, Inc.

• **Linear Thermistor Networks.** Parallel connection of a thermistor across the coil of a meter movement that provides the linear curve shown in Fig. 6 is a simple form of a linear thermistor network. This and many other thermistor/resistor networks can be made from individual components or be purchased as integrated networks. For example, Fenwal Electronics makes a series of miniature linear thermistor networks that incorporate two thermistors and two resistors connected as shown in Fig. 7. This circuit produces an output voltage that varies linearly with temperature. The output voltage across *R2* increases linearly with temperature (positive slope). The output voltage across the two thermistors decreases linearly as temperature increases (negative slope).

The Fig. 7 circuit can be converted into a thermistor whose resistance decreases linearly as temperature increases. All that's required is to connect together Outputs 1 and 3. The resistance then appears between Outputs 1/3 and 2.

• **The Voltage Divider.** Thermistors can easily be used in resistor networks like voltage dividers and bridges. As shown in Fig. 8, a voltage divider consists of two resistors connected in series with each

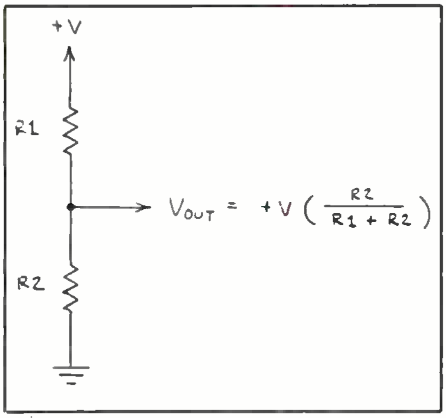


Fig. 8. The schematic of the basic voltage-divider network.

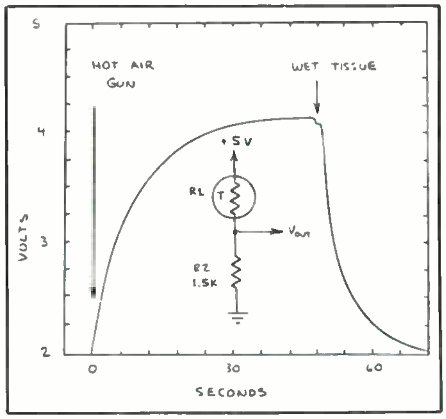


Fig. 9. Plot of a thermistor voltage divider's output.

other. The output voltage from the divider is $V_{out} = +VR2/(R1 + R2)$. If the two resistance values are the same, output voltage V_{out} will be exactly half input voltage +V.

The voltage divider is often used to transform the variable resistance of a thermistor into a variable voltage. Shown in Fig. 9 is a simple thermistor voltage divider, along with the output voltage it produced when the thermistor was warmed by a hot-air gun and then cooled with a damp tissue.

I chose the resistance of *R2* to approximately match that of the thermistor at room temperature. Therefore, the output potential was around 2 volts with the thermistor at room temperature. This standby voltage can be increased by increasing the resistance of *R2*. Conversely, it can be decreased by decreasing the value of this resistor.

The voltage divider's ability to provide an adjustable standby voltage makes possible many applications in which a component or circuit is triggered by a change in voltage caused by a change in temperature. We'll look at some simple circuits to do this later. First, it's important that we examine a special form of voltage divider.

• **The Wheatstone Bridge.** A Wheatstone bridge is composed of two voltage dividers connected in parallel with each other, as illustrated in Fig. 10. When the voltage from the first divider, $V_{out}1$, equals that from the second divider, $V_{out}2$, the bridge is said to be balanced and R1/R3 = R2/R4. It is important to monitor the voltage with a high-impedance meter; otherwise, the meter's internal resistance will affect operation of the bridge.

A common use of the Wheatstone bridge is the measurement of an unknown resistance. Referring to Fig. 10, assume that the values of *R1* and *R2* are accurately known, that potentiometer *R4*'s scale is accurately calibrated, and that *R3* is an unknown resistance. After *R3* is connected into the bridge, *R4* is adjusted until the bridge is balanced. The resistance of *R3* is then (R1 × R4)/R2.

Figure 11 shows how a thermistor becomes the unknown resistance. Initially, *R4* is adjusted to balance the bridge. Then tiny changes in the thermistor's resistance—hence, its temperature—will be indicated by the voltmeter, which should have a high-impedance input to minimize loading the circuit.

The values of the resistors aren't critical, as long as they are known. For example, if the thermistor has a resistance of 5,000 ohms at room temperature, you might select 5,000-ohm resistors for *R1* and *R2*. To permit a wide adjustment range, *R4* should have an adjustment range greater than 5,000 ohms—say, 10,000 ohms.

Figure 12 illustrates how to use a Wheatstone bridge as a differential tem-

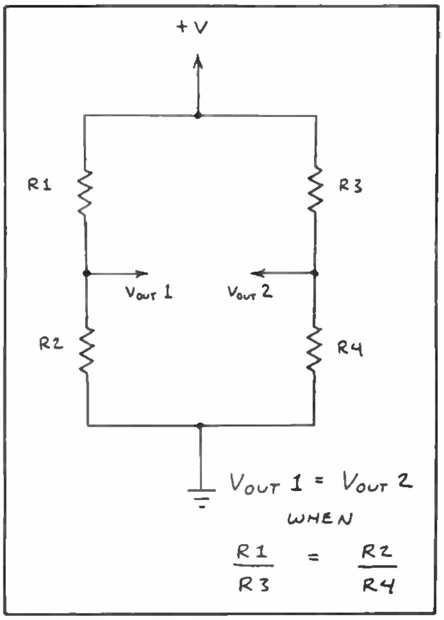


Fig. 10. The schematic of the Wheatstone bridge circuit.

perature monitor. Assume the bridge is initially balanced. This can be achieved within a few tenths of millivolts or so by using a pair of matched thermistors for *R1* and *R3* and identical precision resistors for *R2* and *R4*.

For the test circuit I assembled, the thermistors each had a resistance of 2,000 ohms at room temperature, and *R2* and *R4* each had a resistance of 2,200 ohms. Since I didn't use matched thermistors and precision resistors, the bridge gave a "balanced" output of around 82 millivolts. Substituting precision resistors or potentiometers for *R2* and *R4* would have provided a better balance.

If the temperature of thermistor *R1* is greater than that of thermistor *R3*, the output will be a positive voltage. Conversely, if the temperature of *R1* is less than that of *R3*, the output will be a negative voltage. In either case, the magnitude of the output voltage coincides with the overall temperature difference between the two thermistors.

Temperature Alarms

As you've probably figured out by now, thermistor voltage dividers and bridges can be easily connected to operational amplifiers and comparators to implement many interesting and useful applications. Comparators are particularly easy to use with thermistors.

Shown in Fig. 13 is a schematic diagram for a simple low-temperature alarm. If you examine this circuit carefully, you'll see that the voltage divider made up of thermistor *R1* and resistor *R2* is actually half of a Wheatstone bridge. The other half of the bridge is made up of potentiometer (or adjustable voltage divider) *R3*. In this application, *R3* is considered to be the source of an adjustable reference voltage.

In operation, *R3* is set so that the comparator switches and the buzzer is activated when the temperature drops to a predetermined point. For example, the circuit can be set to sound the buzzer when the temperature is at or near freezing by adjusting *R3* when the thermistor is immersed in ice water.

The thermistor should be selected to respond over the temperature range you wish to monitor. In most applications, the resistance of *R2* should be approximately equal to the resistance of the thermistor at room temperature. The thermistor I selected had a resistance of 2,000 ohms at room temperature. Therefore, I used a 2,200-ohm value for *R2*.

I used a 741 operational amplifier for a comparator only because it is inexpensive and readily available. For very-low standby power consumption, use a CMOS comparator or op amp. For details about how to use these low-power chips, see the December 1988 "Electronics Notebook" column in this magazine. As for *Q1*, any general-purpose npn switching transistor should work fine.

The piezoelectric buzzer should be the type that includes a built-in driver oscillator. If its maximum operating potential is less than 9 volts, reduce the potential delivered by the power supply accordingly.

Though the circuit shown in Fig. 13 is configured as a low-temperature alarm, it can easily be modified to function as a high-temperature alarm. All that's necessary is to reverse the input connections to the comparator. The alarm will then sound when the thermistor's temperature exceeds the value set by adjusting *R3*.

Going Further

Applications for thermistors are limited only by your imagination. Want to detect

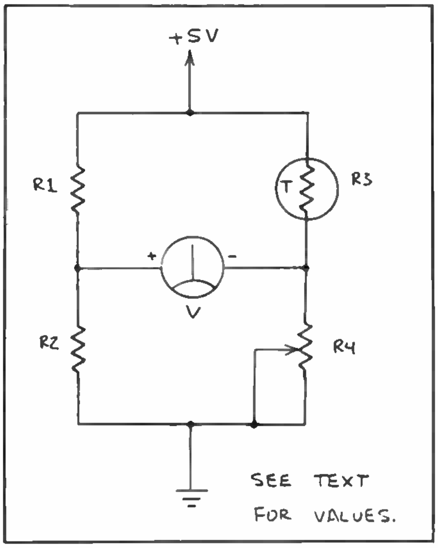


Fig. 11. Circuit details of a Wheatstone bridge temperature sensor.

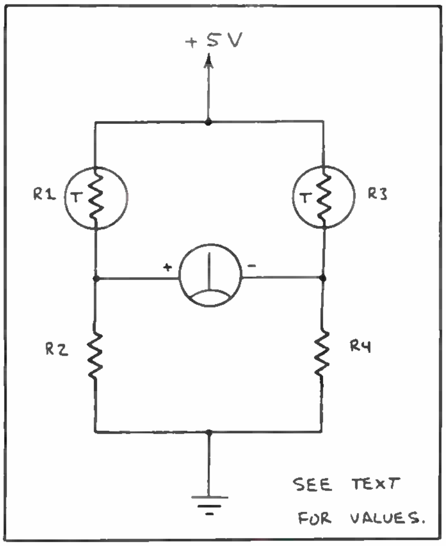


Fig. 12. A Wheatstone bridge differential temperature sensor.

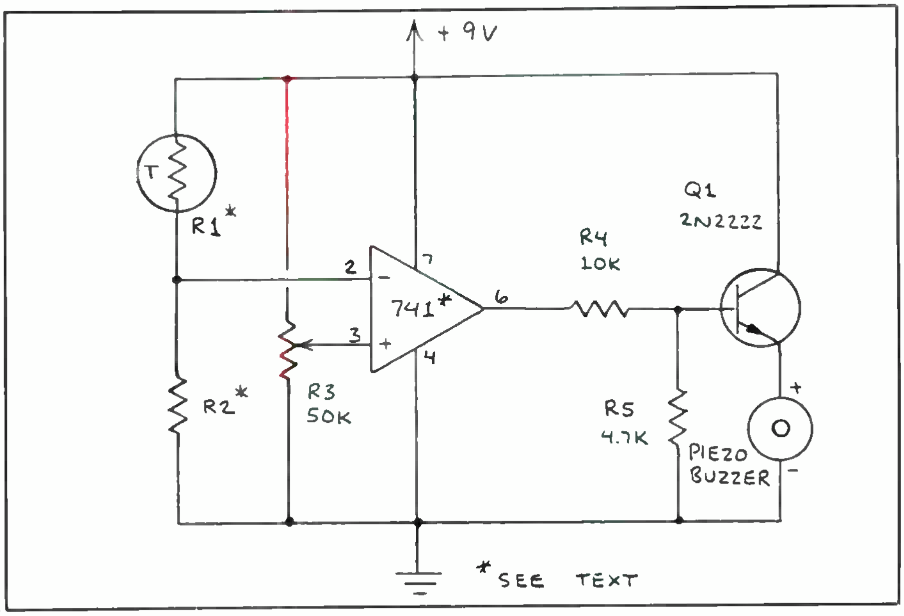


Fig. 13. Schematic diagram of a low-temperature alarm circuit.

infrared sources with a thermistor? If so, use a parabolic reflector from a discarded flashlight as an infrared-energy collector. Use clay or hot-melt adhesive to mount a bead thermistor in the opening for the lamp in the reflector. For best results, make sure the thermistor is positioned so that it's as close as possible to reflector's focal point (where the lamp filament would otherwise be located).

Figure 14 is taken from a chart recording I made of the current through a thermistor installed in a small reflector. The peaks were caused by passing a flame several inches in front of the reflector.

Ricardo Jiminez-G of San Diego State University has developed a respiration-rate sensor in which a thermistor responds to the temperature of a subject's exhaled breath. His circuit is described in detail in *EDN*, "Thermistor Measures Respiration Rate" (August 1988, pages 214 through 217).

Several years ago, I devised a thermistor-based temperature sensor to monitor temperature changes at distances up to 100 feet away. This circuit, which was flown from a helium-filled BPTB (otherwise known as a "black plastic trash bag"), transmitted temperature data to ground over a single optical fiber. You can find the details of the design and construction of this 1-ounce circuit in the June 1985 installment of this column. It is also described in *Forrest Mims' Circuit Scrapbook II* (Howard W. Sams, 1987, pp. 121 through 126).

So how do you plan to use thermistors? To get you started, a list of some of the many thermistor manufacturers appears elsewhere in this column. These and other manufacturers make many different types of thermistors that cover many different temperature ranges. Some companies also publish brochures and manuals about thermistors. **ME**

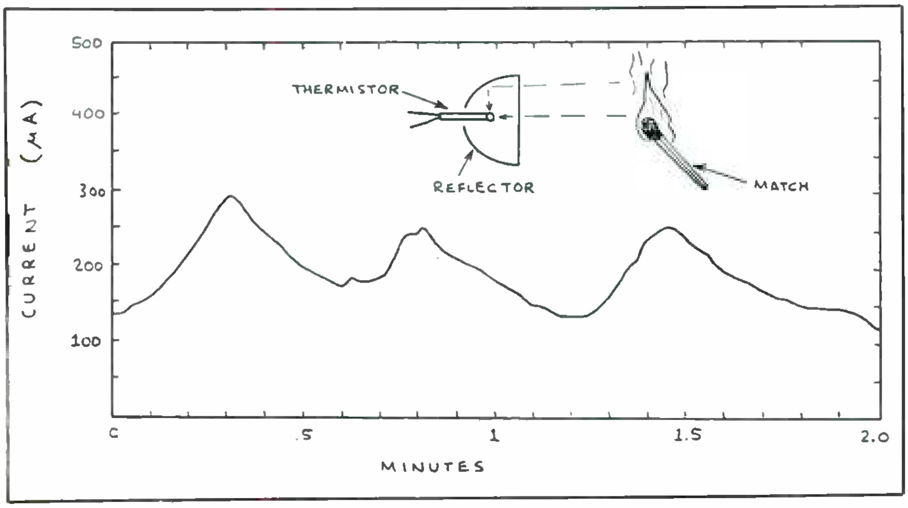


Fig. 14. Plotted response of a thermistor to the flame of a lighted match.

Thermistor Manufacturers

Dale Electronics, Inc.
P.O. Box 26718
El Paso, TX 79926

Fenwal Electronics
450 Fortune Blvd.
Milford, MA 01757

Keystone Carbon
1935 State St.
St. Marys, PA 15857

Omega Engineering
Box 4047
Stamford, CT 06907

Sensor Scientific, Inc.
1275 Bloomfield Ave.
Fairfield, NJ 07006

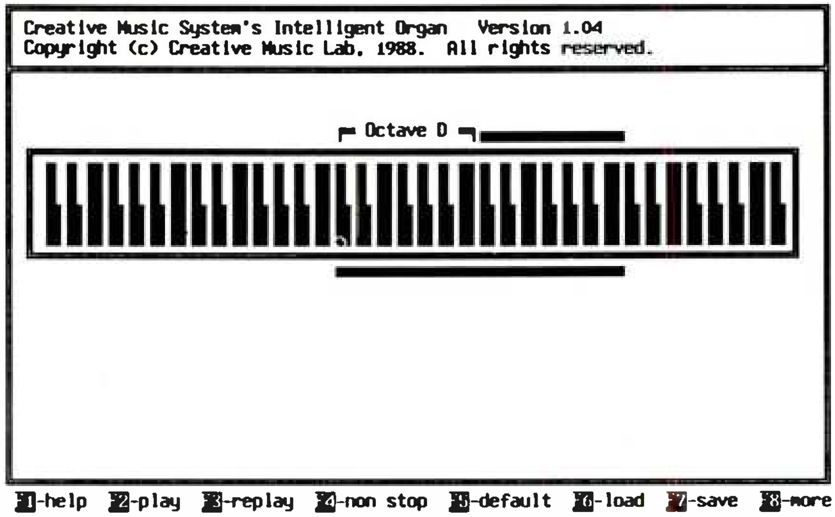
Thermometrics, Inc.
808 U.S. Hwy. 1
Edison, NJ 08817

Yellow Springs Instrument Co.
Box 279
Yellow Springs, OH 45387

A Potpourri of MIDI Computer/Hardware and Software

By Ted Needleman

For those of you just joining us, the last two columns have concentrated on electronic music, how it's developed, and how your computer can make it more fun. This month, we'll finish off with a potpourri of assorted computer/music hardware and software.



CMS's music notation is easy to enter with a word processor, but it's not very intuitive as this partial listing demonstrates.

Oberheim Matrix-1000

Back in our discussion of MIDI instruments, I mentioned that a MIDI sound source does not necessarily have to be a keyboard synthesizer. Arriving here too late for me to cover last month is just such an animal—the Oberheim Matrix-1000. The Matrix-1000 is a small 19-inch-wide rack mountable synthesizer. Though it doesn't have a keyboard, it certainly doesn't lack preset sounds. There are have 1,000 of them. Many of these are slightly strange (at least to me) "sounds" rather than emulations of musical instruments. Others, such as #183, the VIOGITAR, are mutant combinations. Of course, beauty is in the ear of the composer, to paraphrase a cliche.

Setting up and using the Matrix-1000 is easy. The back panel has sockets for the power cord, MIDI in/out/thru connectors, and a standard ¼-inch plug, such as a guitar cord. Plug in the power, connect the MIDI in to a MIDI OUT, such as a sequencer, or as in my first experiments, a MIDI keyboard, then connect the audio out from the unit to an external amp. Turn on everything, then set the keyboard to transmit on a MIDI channel.

While I had misplaced the meager documentation that came with the Casio MT-540 keyboard (which was part of the CMS-1 MIDI Studio I reviewed last month), it still took less than two minutes of pushing buttons before I realized that I had to select "MIDI" on the Casio's "CHORD/MIDI" switch and press one of the sound-effects buttons that are co-labeled CH1, CH2, CH3, and CH4. I was savvy enough, though, to set an initial patch (another name for sound) on the Oberheim before I started to play with the Casio.

With a thousand sounds to choose from, selecting any particular one is easier than it might seem at first. The Matrix-1000's front panel has a 3-digit LED display in the middle, flanked on the right side by a 10-key keypad with additional keys for plus, minus, and enter. On the Left of the display is a volume control, LED indicators for Patch, Channel, Fine Tune, Units, Data Dump, and Ext. Funct., as well as two push buttons labeled Select and Bank Lock. The particular function is selected with the "Select" button, which cycles through the various indicator LEDs.

Fine Tune and Units are used to tune the Oberheim instrument to others that may be included in your band or MIDI setup. The Data Dump and Ext. Funct. are MIDI operators. Channel lets you assign MIDI channels (1 through 16) to individual patches. A patch, or sound, itself, is selected by first cycling the LEDs with the "Select" button until the one over "Patch" is lit. The Matrix-1000 is accompanied by a double-sided sheet listing patch numbers and names.

The patches are in 10 banks of 100 sounds each. These banks are roughly grouped into similar types of sounds, though "Top 100" and "Volume 2" are not precisely descriptive of sounds named LIQUID and JOCKO. There are two ways to select a particular patch. You can enter the three-digit patch number with the right-hand keypad, then press the enter key, or you can use a feature Oberheim provides called Bank-lock. This lets you enter a bank number, then lock it (temporarily) into the Matrix-1000. Then, to select a sound, all you have to do is key in two digits and hit enter. This is convenient if you are going to be assigning several patches from the same bank.

To turn off, or unlock, the bank, just press the Bank Lock switch again. Patches are changed from a sequencer (or computer running a sequencer program) by executing a MIDI "Patch Change" command. Exactly how this is accomplished varies from package to package, but most sequencer packages have this capability.

A truly creative and/or professional musician will appreciate many of the effects and sounds available. I've only gotten through about 20% of them so far. Out of these, about 50% sound like something I might eventually use, about

30% are a little too far out for my particular taste, and the remaining 20% sound very similar to something in the first 50% to my undiscriminating ear. Still, if the averages hold out, 500 useful sounds and instruments are nothing to sneer at. And who knows, maybe one of your compositions can use something that sounds like a cat being mugged by a chicken (there really is a sound like that in here, but I forgot to write down the number—or maybe my old Fender Princeton amp was in the process of losing a 6L6GC).

Along with the above sound, though, there are some truly terrific ones. If you're a fan of 60's rock, you'll remember how many of those groups used Hammond B-3 organs. Patch #964 turned my little Casio MT-540 into a great-sounding B-3. And toggling up one, patch #965 added a great Leslie effect. (Does anyone other than me even remember those big old Hammond B-3 organs with the external Leslie rotating speakers?) The Matrix-1000 also has a great VOX organ patch (the VOX was used by most of the British groups of the '60s).

While the first 400 or so patches (Banks 0, 1, 2, and 3) are a mixed bag, the other banks are a bit more segregated. Bank 4 is Woodwinds and Horns, Bank 5 is Horns and Leads; Bank 6 is Strings; Bank 7 is Basses; Bank 8 is FX (effects) and Percussion, and Bank 9 is Keyboards. The first 200 patches (Banks 1 and 2) on the Matrix-1000 can be overwritten. This is useful if there are a number of sounds in there that will never be used; you can move sounds from the other banks into their place.

The synthesizer functions inside the M-1000 can also be accessed, so that you can make up your own patches or modify the existing ones. Opcode Systems produces a Matrix-1000 Editor/Librarian package for the Macintosh that allows you to modify and create your own patches for the Oberheim unit. The resultant patches can be stored on a Macintosh floppy or hard disk and from there downloaded into the Matrix-1000 when you want to use them.

Dr. T's Music Software supplies a similar package for use with Atari and Amiga computers. These software packages greatly extend the Matrix-1000's already considerable capabilities.

The Matrix-1000 is certainly not for everyone. At $595 without a keyboard, a beginner would be hard-pressed to justify the cost. But if you want to upgrade an inexpensive MIDI keyboard, or if you are setting up a first-class computer-driven MIDI studio and don't want or need the keyboard, the Matrix-1000 is first rate.

It's small (about 17" square and 1.5" high), has usable documentation, and produces lots of beautiful sounds (and some pretty strange ones). I really like it.

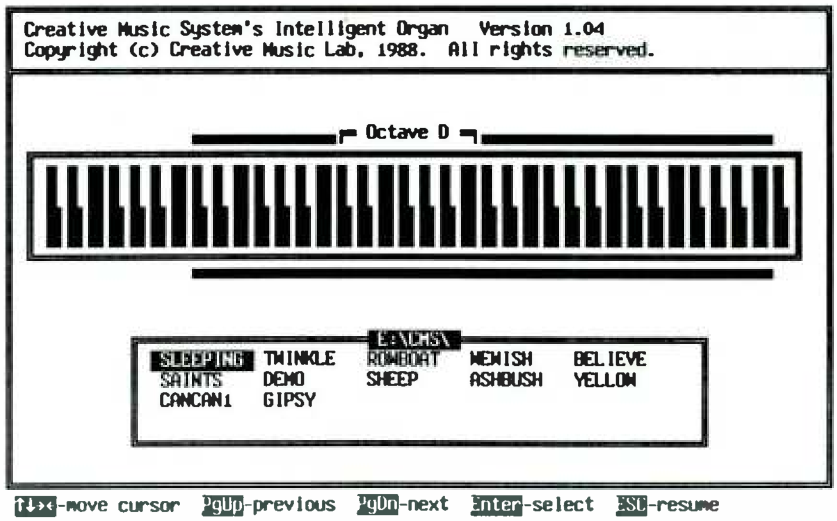
The Creative Music System (C/MS)

Up to this point, most of the hardware and software we've discussed relies on the power of MIDI connectivity for much of the capabilities displayed. Not everyone wants to add a MIDI network or, for that matter, a keyboard, to use his computer to compose and play music.

If you have a PC or compatible and want to generate some nice music with it, the Creative Music System from Creative Labs, Inc., may be just the ticket. The C/MS consists of a half-size PC expansion card that contains a complete 12-voice stereo music synthesizer. The back of the card, which resides on the bracket attached to the backplate of your PC, contains a volume control, headset jack, and a set of standard stereo RCA jacks. The jacks allow the output of the card to be plugged into the "line-in" inputs of any standard stereo amplifier or receiver.

It's the software and the price, however, that make the C/MS unusual. First the price. For $199 you get the card, five diskettes of software, and three manuals. The software contains programs that let you compose your own music, play prerecorded songs, define your own instruments (there are 35 instruments already defined for you), and perform a few other interesting tasks.

One of the latter is something Creative Labs calls an "intelligent organ." This is a screen representation of a keyboard that can be played, with left-hand auto-chord and bass accompaniment, from your PC's keyboard. The Auto-Bass-Chord-Rhythm (ABCR) can also be used



Intelligent Organ's keyboard covers four out of a possible seven octaves. Heavy bars above and below keyboard indicate currently active range. Box below keyboard shows available prerecorded songs.

in songs you input using one of the other song-composing techniques provided in the software.

Another interesting feature of the C/MS is the ability to display text and graphics on the PC's screen, synchronized with the music. This can be used to produce animated song presentations, and sing-along songs that display lyrics as the song progresses. These graphics, however, must be created with another program, such as one of the many available paint or draw packages, not supplied by Creative Labs.

Making music, is a bit more difficult than playing it. The "intelligent organ" feature is clever, and works pretty well, considering that a PC's keyboard is a lot more complex, crowded, and cluttered than a real organ-type keyboard. The first 7 leftmost keys in each of the 4 rows of keys are mapped to the 7 white keys on the organ keyboard, covering 4 octaves. You can shift the actual coverage of these 4 octaves up and down a "virtual" keyboard by using the cursor left and right arrows on the numeric pad. Playing flats and sharps (the black keys) is difficult, though. You have to either hold down a shift key while playing the large keyboard, or use the tab key to shift to a smaller two-octave keyboard that lets you directly play the flats and sharps.

The "intelligent organ" allows you to save and recall songs, and add automatic chord, bass and rhythm accompaniment. You can change the particular instrument sound you're playing, and most of the instruments supplied by Creative Labs sound quite good. C/MS even has a utility that lets you create your own instruments (by altering the basic components; harmonic content, attack, duration, and delay).

I did, however, find composing with the C/MS time-consuming, tedious, and not very intuitive. There are two methods you can use, and both of them involve using a word processor or text edit in ASCII text mode to input multiple lines of numbers. Adding the automatic chord/bass/rhythm accompaniment is a similar process. I didn't play with this feature very much. I've probably been spoiled by the

```
.title              The Trout
.composer edited by WH Sim
.message by Schubert

; Enter by Jessie Tan                                     20 Aug 87
;
m1  |% [1=D, s=120,x=b, t=2/4, p=16]  |
m2  |% [p=3 ] |
m3  |% [p=4 ] |
m4  |% [p=4 ] |
m5  |% [p=3 ] |
m6  |% [p=3 ] |
m7  |% [p=4,x=b]   |
m8  |% [p=13,V=180]    |

m8  |%E 5/ | +1./1// 33/  | 1  _5 | 5./5// +2.//1///_76// | 5.   5/  |
m1  |%D 5/ | +1./1// 33/  | 1  _5 | 5./5// +2.//1///_76// | 5.   5/  |
m2  |%D 0/ | 3 11/ | _5/67// +1 | _7 7.//+1///2.//1//7 | _72/ 34/ |
m3  |%D 0/ | 1 11/ | _5/67// +1 | _7 7.//+1///2.//1/// | _72/ 34/ |
m4  |%C 0/ | 05/05/ | 05/05/ | 05/05/ | 07/+12/ |
m5  |%C 0/ | 03/03/ | 03/03/ | 02/02/ | 07/+12/ |
m7  |%B 0/ | +10/_50/ | +30/10/ | 20/_50/ | +5 0 |
m6  |%  0/ | 0 0 | 0 0 | 0 0 | 0 0 |

m8  | +1./1// 33/ | 1 _5+1/ |_7/6.//7/// +1_#4/ | 5.   5/ |
m1  | +1./1// 33/ | 1 _5+1/ |_7/6.//7/// +1_#4/ | 5.   5/ |
m2  | 3 11/ | _5/67// +1_5/ | 5/#4.//5/// 6+1/ | 24/ 32/ |
m3  | 1 11/ | _5/67// +1_5/ | 5/#4.//5/// 6+1/ | 24/ 32/ |
m4  | 0_5/05/ | 05/05/ | 02/02/ | 0+2/1_7/ |
m5  | 0_3/03/ | 03/03/ | 02/02/ | 0+2/1_7/ |
m7  | 10/_50/ | +30/10/ | 20/_20/ | 5 0 |
m6  | 0 0 | 0 0 | 0 0 | 0 0 |
```

Pressing TAB key presents the small two-octave keyboard and lets you directly play sharps and flats.

CMS-1 MIDI Studio and Cakewalk software I reviewed here last month, but I must admit to preferring to input music from a synthesizer keyboard.

Another preferable method is to mouse a note around a musical staff. Several programs I've played with briefly use this method, and it's fun and quick to enter music this way.

Even though I lacked the patience to enter much music with a text editor, I don't think many of you will find the process all that difficult (though you may also find it tedious). The sound from the C/MS, while not anywhere as good as the Oberheim Matrix-1000, is still pretty good, especially when piped through a fairly good amp.

At $199 for the whole shebang, it's a lot of fun. And if, like me, you have small children, they will really get a kick out of animated musical numbers. If you order a C/MS, be sure to order additional demo song disks. Creative Music Labs gives you two, and offers six others. They're only $4 each, and it's a lot easier to modify one of their songs than to enter your own from scratch and you'll be learning C/MS' notation along the way. (Documentation warns about the possibility of some timing loop problems with demo songs if you play them on a high-speed computer, since they're designed for 4.7-MHz PCs.) **ME**

Products Mentioned

Matrix-1000
Oberheim
2015 Davie Ave.
Commerce, CA 90091

Matrix-1000 Editor/Librarian
Opcode Systems
1024 Hamilton Ct.
Menlo Park, CA 94025
(415) 321-8977

Matrix-1000 Graphic Editor/Librarian
Dr. T's Music Software, Inc.
220 Boylston St., Ste. 306
Chestnut Hill, MA 02167
(617) 244-6954

Creative Music System (C/MS)
Creative Labs, Inc.
2363 Greendale Dr.
S. San Francisco, CA 94080
(415) 878-2874

Converting Celsius to Fahrenheit, etc.

By Art Salsberg

S.I. Plus (Ver. 1.0) is a PC program for converting numbers from one unit system to another in the International System of Units. This might be changing a Celsius reading to Fahrenheit, meters to feet, etc. It's for use with IBM compatible PCs and requires 160K memory. The package consists of a 5¼" non-copy-protected disk and a user's manual. S.I. Plus is priced at $79 from Geocomp Corp., 66 Commonwealth Ave., Concord, MA 01742.

If you're involved in a technical area, where a variety of unit conversions are often made, the S.I. Plus program can give you an almost instantaneous conversion number from about 70,000 different conversions it contains. Conversions of all units in the International System (or S.I., as it's abbreviated) are reported to be made in double precision real arithmetic, and the program displays single-precision numbers.

It's very easy to use, especially when automatically loaded as a resident memory program (Terminate and Stay Resident, or TSR) that can be activated within another program by pressing Alt-F10 keys simultaneously. You can also operate the program as a stand-alone one, though it won't operate when another program runs.

When the program's main menu is activated, five command words are displayed across the screen top that relate to Help, String Search (for all unit menus), Options, Finding a String in a current menu, and Exiting to DOS. The middle of the menu lists over 80 unit classes (Area, Electric Capacitance, Electric Flux Density, Frequency, Noise Level, Inductance, etc.). Using a cursor control key moves the cursor to the unit-type line that the user wants to do the conversions in. Length, for example, would be the unit chosen if you wanted to convert a fraction of an inch to millimeters.

Pressing Enter displays two side-by-side boxes that contain identical lists of units in the class selected. The left-hand box contains the "From" units, while the right-hand box listing represents the "To" units. Left Arrow and Right Arrow keys are used to select which one you work in, while Up Arrow and Down Arrow keys move a highlighted bar to any unit chosen for conversion. The box you work in assumes a double-line box and is highlighted.

At the bottom of the From box is an input area where up to 14 numbers may be typed. Entering the number to be converted, the conversion to the unit that the highlight bar of the To box is on is automatically displayed below the To or right-hand box. Moving the right-hand's highlight bar to another unit that's listed changes the number below the box to a correct one for the new unit chosen. The number 1 is automatically registered for the input until it's changed.

At the right frame line of each box is a "%" sign that moves up and down to signify what percentage of the entire list that the highlight bar is on. With a very long list of units, such as in the Length class, this information can be mildly comforting.

The Options Menu allows you to remove unit types and specific units that you do not need, which will speed going through a list for a selection. You're given the choice of saving or not saving such changes when you try to exit the program. If all the units are deactivated, then the whole class will be deactivated.

Conclusions

I found the modestly priced S.I. Plus program to be very useful in editing and writing technical manuscripts. The only initial problem that one may face is determining which heading should be chosen for some units, but a reading of the succinct user's manual will point out that the Search option in the main menu will locate the unit directly for you.

With the foregoing easily taken care of and removing display of some classes that I'll never use, the conversion program worked like a charm as a resident program. Along with my spelling checker, *et al*, it's nice to have it ready for the asking. It's interesting, too, to see that there are nine different types of miles, two types of standards for amperes, and so on. **ME**

CIRCLE NO. 131 ON FREE INFORMATION CARD

LETTERS...

(from page 9)

was added with Version 3, and I missed seeing it in the documentation.

Having used PageMaker several times a week over the last two years, I am enthusiastic about it, but I realize that I have a way to go before can I consider myself a PageMaker "expert."

—Ted Needleman

Author's Update

• It was a pleasure to see how nicely my article on "Calculator Music" in the March 1989 issue was presented. I did notice two small errors that would prevent the program from running properly. One is the the slash after the first SWAP command, which should actually be a power sign. Alert readers may be able to figure out the problem from the text, but I thought you would like to print a correction. The other is that the last number in the "Z" routine should be −2, not the −1 that was printed.

David A. Nordquest

Perform the calibration procedure as close as possible to June 21 (the summer solstice in the northern hemisphere), when the sun's energy is at maximum intensity to obtain maximum accuracy. Otherwise, any clear, sunny day in June or July will be fine for calibration purposes. However, wait until the sun is overhead, about noontime, when adjusting trimmer control *R4*.

Set the meter to a 10- or 20-volt dc full-scale range. Connect its common probe to the negative lead of *C2*. Clip the positive probe to pin 14 of *IC1*. Place the project so that the sunlight falls directly on the solar cell, with the plane of the cell held as close as possible to perpendicular with the sun (do not look into the sun itself!).

Turn on power to the project and adjust *R4* for a reading between 5.4 and 5.6 volts. Note that as you orient the project for best exposure to the sun, the voltage will vary slightly. Set *R4* so that the maximum voltage obtainable is between 5.4 and 5.6 volts as you orient the project for the best exposure. This completes the calibration of the solar cell and amplifier; *R4* will need no further adjustment.

If you do not obtain the correct voltage reading at pin 14 of *IC1*, check to make certain that the solar cell is wired into the circuit in the correct polarity. If it is, measure the value of *R1* to be sure it is about 0.2 ohm, and measure the voltage across it with the solar cell exposed to full sunlight. You should obtain a reading of about 60 millivolts dc. Also, check the values of the components associated with *IC1*, and, as a final step, try a new LM324 in the socket.

Final adjustment for the project is for proper setting of *R5*. Set the project to the "calibrate" mode, either by temporarily connecting *R13* to pin 6 of *IC2* or setting *S3* to its CALIBRATE position if you incorporated this switch into your project. Set *R5* to maximum counterclockwise (minimum resistance) and place the control knob on its shaft so that the pointer is at the counterclockwise (CCW) limit of the scale—not the 10/20/40 index shown in Fig. 4. Tighten the knob's setscrew and adjust the knob so that the pointer is at the 15/30/60 minute point.

The easiest way to calibrate *R5* is to remove *IC1* from its socket and connect a dc power supply, set to 5.5 volts, between circuit common and pin 14 of the *IC1* socket (be sure to observe polarity). This eliminates any variation in drive voltage to the oscillator as a result of varying sunlight intensity. If you do not have a suitable supply available, using the solar cell and amplifier to generate the voltage in full sunlight is perfectly satisfactory, though you will have to position the project so that it remains stable while exposed to full sun.

With the supply set to 5.5 volts or the solar cell positioned so that it receives full direct sunlight, turn on the project and measure the amount of time required for the piezo buzzer to sound. Measure the delay from the time the POWER switch is thrown to when you hear the alert tone. This should be about 28 seconds. If the time is more than 1 second off, slightly reposition the knob's pointer with reference to the 15/30/60 minute index and repeat the test.

When you have obtained a time delay between 27 and 29 seconds, calibration of the project is complete. Check the time delay for the 10/20/40 and 25/50/100 minute index points. You should obtain about 19 and 47 seconds, respectively.

When you are satisfied that the setting of the knob for *R5* is reasonably accurate, press TEST switch *S2*; the piezo-buzzer element should sound immediately and continue to sound for as long as the button is held down.

Using the Project

Before using your SunGuard project, you should have a fair idea on how much sun exposure your body will tolerate. This will depend a lot on skin type. In general, the fairer your skin, the less tolerant you will be to the sun's energy. Generally, your first day's exposure should be as little as 15 minutes. From there, you can lengthen your exposure time each day by 5 minutes or so until you develop a full tan.

Always check battery condition before you use SunGuard to monitor your sunbathing. When you are ready to sunbathe, set the desired exposure time and switch on the project at the start of exposure to the sun's rays. Thereafter, when the alarm sounds, you have had your specified amount of sun. Keep in mind that SunGuard's clock will almost always run slower than your watch does because the sun's intensity will usually be less than maximum and is likely to vary during a sunbathing session.

Making It Count *(from page 37)*

because they are getting better and cheaper. Nevertheless, there are still some counting chores that they cannot normally handle without elaborate circuit support.

So don't expect to check out the crystal oscillator in your wrist watch with any moderately priced counter. Its micro-power operating level is too low. Nor would you normally be able to count a radio-control signal that's pulse modulated. Some garage door remote-control openers use this system; so do model radio-control cars, boats and planes. And infrared signals such as used by remote-control circuits for TV, VCR and compact disc applications cannot be counted.

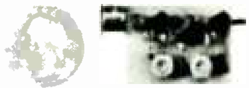
You cannot expect to be able to count signals that aren't continuous for at least as long as a counter's shortest gate period, either. Naturally. There are more costly bench-type counters that feature more and shorter gate-time selections than the compact, portable counter, Optoelectronics' Model 2210, whose construction plans were described in detail last month. You can compare its fastest 0.1-second time with Optoelectronics' Model 8024-S's 0.01-second gate period. But then you're talking about a larger, heavier instrument that costs almost four times as much as the project.

Ten years ago, a counter meeting the basic specifications of the compact counter would have cost thousands of dollars and likely would be mounted in a 19-inch rack. Use of such counters was generally limited to engineers or technicians.

Today, however, digital frequency counters are even utilized by non-technical operators, from law-enforcement officers to scanner buffs. The operating hints described here will serve them as well as you technically oriented people in getting the most out of any modern counter.

Counter Kit Information

The following items are available from Optoelectronics Inc., 5821 N.E. 14 Ave., Ft. Lauderdale, FL 33334 (800-327-5812; in Florida, 305-771-2050): A kit of all components but not including enclosure, $99. Available separately are: double-sided pc board with plated-through holes, Part No. PCB-2210, $25; 9-volt dc, 300-mA plug-in power supply, Part No. AC-22, $9.99; Ni-Cd battery, Part No. NiCad-22, $20; enclosure and hardware, Part No. CAB-22, $20.00. Also offered is an assembled and calibrated unit, Model 2210, for $189. Add 5% for postage and handling. Florida residents, please add 6% state sales tax.



PICKS UP A WHISPER 50 FEET AWAY!

The model WAT-50 miniature FM tranmitter uses a 4-stage circuit NOT to be confused with a simple wireless microphone. Simply snap the unit on top of a 9V battery and you can hear every sound in an entire house up to 1 mile away! Use with any FM radio. Tunes to any frequency from 70mhz - 130mhz. Easy to assemble kit includes all parts and instructions. Only 29.98 tax incl.

The WIRELESS TELEPHONE TRANSMITTER model WTT-20 is only about the size of a dime, yet transmits both sides of a telephone conversation to any FM radio with crystal clarity. Completely automatic. Uses power from the telephone line itself - never needs a battery! Up to ¼ mile range. Tunes from 70mhz - 130mhz. Easy to assemble kit includes all parts and instructions. Only $29.98 tax incl.

Call or send MO, VISA, MC for immediate delivery. Single kit orders include $1.50 S&H. FREE SHIPPING on orders of 2 or more. All orders shipped by U.S. Mail. COD add $4.00. Personal checks allow 21 days.

DECO INDUSTRIES
BOX 607, BEDFORD HILLS, NY 10507
914-232-3878

CIRCLE NO. 105 ON FREE INFORMATION CARD

CABLE T.V. CONVERTERS WHY PAY A HIGH MONTHLY FEE?

All Jerrold, Oak, Hamlin, Zenith, Scientific Atlanta, Magnavox and all specialized cable equipment available for shipment within 24 hours. For fast service MC/VISA or C.O.D. telephone orders accepted 800-648-3030 60 Day Warranty (Quantity Discounts) 8 A.M. to 5 P.M. Monday through Friday Central Time. Stamp Envelope (60¢ postage) for FREE Catalog.

Midwest Electronics Inc.
5143 W. Diversey • Chicago, IL 60639
No Illinois Orders Accepted

CIRCLE NO. 106 ON FREE INFORMATION CARD

ELECTRONIC EAVESDROPPING EQUIPMENT DESIGN

If you have been looking for the "real thing" in electronic eavesdropping equipment design, then this book is for you. All 58 schematics presented are Sheffield Electronics's surveillance devices. Circuits explained. Transmitters are pens to 1-mile VOX's including crystal, subcarrier, carrier current, infrared, firefly and automobile. Demodulators given. Cube tap and duplex mains powered transmitters shown. 18 telephone transmitters are leech and battery types including crystal and subcarrier. Chapter on countermeasures. Much more. This 8½ x 11-inch 110-page book is illustrated with photographs.

First Class Mail Used **Price $30.00**
S & H $4.00

For 1-day processing, pay with Money Order or Cashier's Check.

SEND TO: WINSTON ARRINGTON
7223 STONY ISLAND AVE.,
CHICAGO, IL 60649

MODERN ELECTRONICS MART

Classified Commercial Rates: $1 per word, 15-word minimum ($15.00) prepaid. (Word count includes name and address; ZIP code and abbreviation each count as one word; P.O. Box number and telephone number count as two words each.) Indicate free category heading (**Computers, Communications, Electronics, Video** or **Miscellaneous**). A special heading is available for a $6 surcharge. First word only is set boldface caps at no charge. Add 20% for additional boldface words.
Non-Commercial Rates: FREE to subscribers, as space permits; maximum 15 words. A recent **MODERN ELECTRONICS** mailing label must accompany ad.
(All advertisers with P.O. Box addresses must supply permanent address and telephone number. Copy is subject to publisher approval.)
Mailing Information: Copy must be received by the publisher by the 25th of the third month preceding the cover date. Send Advertising material with check or money order or credit card information (Visa or MasterCard only) with number and expiration date to: **MODERN ELECTRONICS**, Classified Department, 76 N. Broadway, Hicksville, NY 11801.

VIDEO

PROJECTION TV . . . Convert your TV to project 7 foot picture . . . Easy! . . . Results comparable to $2,500 projectors . . . **PLANS AND 8" LENS $24.95** . . . Professional Systems available . . . Illustrated Catalog FREE . . . **MACROCOMA** 15MI Main Street, Washington Crossing, Pennsylvania 18977. Creditcard Orders 24 HRS. (215) 736-3979.

DESCRAMBLERS. All brands. Special: Jerrold combo 400 and SB3 $165. Complete cable descrambler kit $39. Complete satellite descrambler kit $45.00. Free catalog. MJO INDUSTRY, Box 531, Bronx, NY 10461-0531.

VHS-VCR Repair Solutions Volumes I,II,III, IV. Each contains 150 symptoms and cures, cross reference chart, free assistance. Each $11.95, any two $19.95, any three $29.95, all $39.95. Eagle Electronics Box A, 52053 Locks Lane, Granger, IN 46530.

FASTEST Color TV Repairs anyone can do. 100 priceless secrets. $2.00 for sample. **Checkmate Communications, PO Box 11-0808-ME, Brooklyn, NY 11211.**

ELECTRONICS

TUBES, Name Brands, New, 80% off list, Kerby, 298 West Carmel Drive, Carmel, IN 46032.

DETECTION—Surveillance, Debugging. Plans, Kits, Assembled Devices. Latest High-Tech Catalog $5. DETECTION SYSTEMS, 2515 E. Thomas, #16-864H, Phoenix, Arizona, 85016.

ELECTRONIC fish detector. It brings the ageless pleasure of fishing right into the electronic age. And it's low cost is within the reach of everyone. Send $5.00 and SASE for info. to James Tyler, 107-51 139 St., Jamaica, NY 11435.

SURVEILLANCE, Debugging, Protection Worlds largest new catalog - $5.00. Kits - Assembled - All price ranges, TECHNOLOGY SERVICES, 829 Ginette, Gretna, LA 70056.

DIGITAL project: build yourself complete electronic car dashboards. Send $1 (refundable) for details. MODERN LABS, 2900S Ruisseau, Saint-Elizabeth, QC, JOK 2JO, Canada.

VOICE Disguisers! FM Bugs! Telephone Transmitters! Phone Snoops! Bug Detectors! More! Catalog $1.00: XANDI ELECTRONICS, Box 25647, "JJ", Tempe, AZ 85285-5647.

CB Tricks of the Trade book, CB repair tricks and tuning tricks. Send $19.95 to Medicine Man CB, P.O. Box 37, Clarksville, AR 72830.

PROFIT! TOP QUALITY SOLDERLESS BREADBOARDS AND DIGITAL MULTIMETERS FOR LONGTERM QUANTITY BUYERS. STORES ARE MOST WELCOMED. CTI, 1418 UPFIELD, SUITE 127, CARROLLTON, TX 75006.

DESCRAMBLERS, Test Equipment, Electronic Books, etc. Send $2 for info to B and R Enterprises, P.O. Box 662, Portage, MI 49081.

ELECTRONIC COMPONENTS Free 192 page catalog including capacitors, resistors, relays, connectors, soldering equipment and supplies. Box 699, Mansfield, TX 76063. **1-800-992-9943.**

WIDE range Tunable Ultrasonic Receiver, Long Range Listening "TUBE", Bug detector, BC DX Booster, Scanmate, Voice coder/decoder, and other interesting products. Catalog $1.00. KRYSTAL KITS, P.O. Box 335, BENTONVILLE, AR 72712.

ELECTRONIC Test Equipment, Laboratory Equipment, Experimenter's Items.—Industrial and Government Surplus and priced Cheap! Send 50¢ for Catalog to: Lehman, R.D. 1 Box 580, Wrightsville, PA 17368.

FCC Commercial General Radiotelephone License Prep Course by correspondence. 60 individual lessons, $89.50. Payment plan. Also BASIC COMPUTERS, $39.50; certificates. Details free. AMERICAN TECHNICAL INSTITUTE, Box 201, Cedar Mountain, NC 28718.

LASER Image Projectors. Complete Redbeam scanning systems. Red Line, 9737 Balboa Dr., St. Louis, MO 63136.

LASER LISTENER II, other projects. Bugging, descrambling, false identification, information. Plans, kits, other strange stuff. Informational package $3.00 refundable. DIRIJO/BOND ELECTRONICS, BOX 212, LOWELL, NC 28098.

DIGI-KEY CORPORATION

1-800-344-4539

AK, Puerto Rico — 218-681-6674 Telex — 62827914 FAX — 218-681-3380 TWX — 9103508982 DIGI KEY CORP

INTEGRATED CIRCUITS

7400 TTL

[illegible]

74LS00 TTL

[illegible]

74S00 TTL

[illegible]

4000 CMOS

[illegible]

74C00 CMOS

[illegible]

74HC00 CMOS

[illegible]

Linear

[illegible]

Micro.

[illegible]

A/D & D/A

[illegible]

Memory

[illegible]

Interface

[illegible]

SILICON TRANSISTORS

[illegible]

1 AMP SILICON RECTIFIERS

[illegible]

5% CARBON FILM RESISTORS

Available in 1/8, 1/4 & 1/2 Watt

[illegible]

5% WIREWOUND REC. RESISTORS

Available in 5 & 10 Watt

[illegible]

5% METAL OXIDE FILM RESISTORS

Available in 1 & 2 Watt

[illegible]

1% METAL OXIDE FILM RESISTORS

Available in 1/4 Watt

[illegible]

TRANSFORMERS

Dual Secondary Single Primary (115V)

[illegible]

PANASONIC LS SERIES

Miniature Aluminum Electrolytic Capacitors

[illegible]

DISC CAPACITORS

[illegible]

TANTALUM CAPACITORS

[illegible]

PANASONIC V SERIES

Stacked Metalized Film Resistors

[illegible]

PANASONIC B SERIES

Polyester Capacitors

[illegible]

QUARTZ CRYSTALS

[illegible]

PANASONIC OPTOELECTRONICS

[illegible]

The Digi-Key volume discount and service charges are simple to apply. Most items sold by Digi-Key may be combined for a volume discount. Items that are not discountable are identified by the suffix ND following the part number. After writing your order, total all of the discountable items and apply the appropriate discount. To this subtotal, add the non-discountable items. Then add the service charge. We pay all shipping and insurance to addresses in the U.S.A., Canada and Mexico when check or money order accompanies order. Digi-Key only ships orders within the continental U.S., Alaska, Hawaii, Canada and Mexico.

WHEN ORDERING BY PHONE, CALL 1-800-344-4539 (AK, call 218-681-6674). BY MAIL SEND YOUR ORDER TO: DIGI-KEY, P.O. Box 677, Thief River Falls, MN 56701.

You may pay by check, money order, Master Charge, VISA or C.O.D. ***DIGI-KEY GUARANTEE:*** Any parts or products purchased from Digi-Key that prove to be defective will be replaced or refunded if returned within 90 days from receipt with a copy of your invoice. ***"PRICES SUBJECT TO CHANGE WITHOUT NOTICE."***

SERVICE CHARGES

$ 0.00-$24.99	Add $3.00
$25.00 and Up	No Charge

VOLUME DISCOUNT

$ 0.00-$ 99.99	NET
$ 100.00-$249.99	Less 10%
$ 250.00-$499.99	Less 15%
$ 500.00-$999.99	Less 20%
$1000 & Up	Less 25%

CIRCLE 36 ON FREE INFORMATION CARD

Free Product Information

Readers can obtain free information on products advertised by the above companies, as well as for some editorially mentioned products. Simply circle the appropriate number printed below an advertisement onto the Modern Electronics "Free Information Service" card bound into this issue. After filling in your name and address, just mail the postpaid card. Your request will be forwarded directly to the advertiser with a mailing label prepared by our reader-service department to ensure speedy response.

SOLAR ELECTRIC SYSTEMS. Discount prices. **SUN POWER - TEXAS,** P.O. Box 2788A-ME, Freeport, TX 77541, (409) 233-8350.

AT LAST! An educational **and** practical circuit! Mutes stereo/TV when phone rings or is in use. Schematic $5.00 with power supply. Phone jacks $14.00. **COYOTE CONTRAPTIONS, 1906 S. Espina, Suite 30, Las Cruces, NM 88001.**

COMPUTERS

COMMODORE REPAIRS (low cost), CHIPS, PARTS, DIAGNOSTICS. Heavy duty POWER SUPPLY for C64-$27.95 plus UPS. Kasara Microsystems (division of QEP), 1-800-248-2983.

APPLE and IBM compatible computers from $399, monitors from $69. Printers, disk drives, paper, diskettes, and more. Send SASE for complete list. Mr. G's Computers, R. R. #5 Box 205A, Portland, Indiana 47371.

SOFTWARE. Schematic & PC Board Fonts, Electronic Programs & Dictionary. For c64 or c128 with Geos[tm]. Send $19.95 or write: Thomas Software, 1375 Beasley Rd., Jackson, MS 39206.

COMPUTER REPAIR DEPOT. IBM, Compaq, Apple, AT & T, and many others. Call Bi-Tronix, Inc. (408) 236-3385 or (209) 952-7116, PO Box 23069, San Jose, CA 95153.

SUPER XT COMPATIBLE MOTHERBOARD (SI:7.7) DESIGNED TO DIRECTLY REPLACE XT OR COMPATIBLE MOTHERBOARD FOR SPEED UPGRADE. CTI, 1418 UPFIELD, SUITE 127, CARROLLTON, TX 75006.

COMMUNICATIONS

COMMUNICATIONS PLANS, BOOKS, KITS! AM/FM broadcasting (licensed/unlicensed), 1750 Meter transceivers, ham/CB amplifiers, surveillance bugs, more! FREE catalog, PAN-COM, Box 130-ME5, Paradise, CA 95967.

SURVEILLANCE - COUNTERSURVEILLANCE: Send $2.00 for catalog of state of the art equipment, books. Sherwood, Box 535M, Southampton, PA 18966, telephone number 215-357-9065.

ALUMINUM image transfer process, your artwork to aluminum. Write: J & E Enterprises, 2457 N. Marmora, Chicago, Illinois 60639.

AUDIO

DIGITAL stereos, speakers, amplifiers, equalizers, cassette recorders, walkmans, telephones, CBs, antennas. Catalog $1. Expotronics Enterprises Dept-M, 1222 Highland, Berwyn, IL 60402.

CLASSIFIED ADVERTISING ORDER FORM

Mail this form with payment to MODERN ELECTRONICS, Classified Dept., 76 N. Broadway, Hicksville, NY 11801.

Name: ______________________________

Street Address: ______________________________

City: ____________________ State: __________ Zip: __________

PRINT EACH WORD SEPARATELY. Note that P.O. Box numbers* and telephone numbers must be counted as two words each. Circle additional words you wish boldfaced at 20% more each (initial boldface word is free). Minimum charge is for 15 words.

Free **Boldface**	2	3	4
5	6	7	8
9	10	11	12
13	14	15 ($15)	16 ($16)

(PLEASE ADD)

$________ Extra Bold Words @ 20 cents $________ Special Heading ($6)

TOTAL PAYMENT ENCLOSED (Check or Money Order): $____________

Payment may also be made by MasterCard or Visa. For this, please fill in information below.

Credit Card Number ______________________   Expire Date __________

Print Full Name ______________________   Signature ______________________

*If a box number is used, please supply your permanent address and telephone number for our records.

CABLE TV EQUIPMENT

CABLE DESCRAMBLER LIQUIDATION. Major makes and models available. Industry pricing! (Example: Hamlin Combo's, $44 each . . . minimum 10 orders). **DEALERS ONLY!** Call West Coast Electronics, (818) 709-1758.

CABLE EQUIPMENT

CABLE TV Secrets - the outlaw publication the Cable Companies tried to Ban. HBO, Movie Channel, Showtime, Descramblers, Converters, etc. Suppliers List Included. $8.95. Cable Facts, Box 711-ME, Pataskala, Ohio 43062.

VIDEOCIPHER II

VIDEOCIPHER II Manuals. Volume 1 - hardware, Volume 2 - software. Either $32.45. Both $54.95. Volume 3 - Projects/software - $42.50. **Volume 4** - Repair - $97.45. CODs - 1-602-782-2316. Catalog-$3.00 **TELECODE** Box 6426-ME, Yuma, AZ 85366-6426.

INVENTORS

INVENTORS! Can you profit from your idea? Call AMERICAN INVENTORS CORPORATION for free information. Over a decade of service, 1-800-338-5656. In Canada call (413) 568-3753.

RECORDING INSTRUCTION

BE A RECORDING ENGINEER; Train at home for High Paying—Exciting Careers. **FREE** Information. **AUDIO INSTITUTE**, 2174 Union St., Suite 22AB, San Francisco, CA 94123.

EDUCATION

BIOMEDICAL Electronics get started in this high tech field detailed book $3.50 Tech Search, P.O. Box 2855, Atlantic, GA 30301.

PRIVACY PROTECTION

SURVEILLANCE and counter surveillance equipment catalog. Send $7.00, RWB Electronics, P.O. Box 922, Bronxville, NY 10708, (914) 779-0607.

VIDEO DIGITIZER

INEXPENSIVE IBM PC or C64 VIDEO DIGITIZER. Digitize RS170 TV video (VCR or camera). Capture images to disk. IBM PC or XT 4.77 MHz (requires CGA)-$59.95. Commodore 64/128-$39.95. Disk software, documentation, pretinned and drilled PCB. Easily assembled. Uses common, low cost parts. Specify computer. SASE for information: KINNEY SOFTWARE DEPT. ME, 974 Hodsdon Road, Pownal, Maine 04069.

MISCELLANEOUS

ASIAN LADIES want correspondence for friendship, marriage, SUNSHINE INTERNATIONAL, Dept. TW, Box 5500, Kailua-Kona, HI 96745. (808) 325-7707.

BUY 20,000 oriental import products below wholesale. Bevans, Dept.-PE, 9 King Richard Ct., Baltimore, MD 21237.

APEX® Industrial Screwdriving Tools. Free catalog. Hex insert bits, bit holders, much more! Shockey's, 5841 Longford Road, Dayton, OH 45424. (513) 236-2983.

ADVERTISERS' INDEX

VGA *(from page 21)*

technique used by VGA to improve the MCGA screen image. In MCGA, information is duplicated every other line to create an illusion of more detail, while interlace scanning supplies new lines of data that actually add to the resolution of the image. Interlace scanning is also required for the 1,024 by 768 extended VGA mode, and requires an IBM Model 8514 or similar monitor.

In Closing

There can be little doubt that VGA will be around for a long time to come as the text-and-graphics display medium of choice in personal computing. It's already here and is solidly entrenched. Furthermore, VGA has the support of the software community. Also in its favor is that it has its foot in the door of the future with its extended modes and pending VESA standard. **ME**

Smart Car Relay *(from page 53)*

metal screw for which you drill a hole. Whichever way you go, use fine emery paper to sand down to bare, shiny metal and an outside-tooth lockwasher between the ring lug and metal of the chassis.

Installation & Use

The "Smart" Car Relay is extremely flexible and can be used in a wide variety of applications, as mentioned above. Of course, the COMMON, NORMALLY CLOSED and NORMALLY OPEN wires from the project connect to the device being controlled as needed.

Figure 2 illustrates the connections required to provide typical power-antenna control. With the project wired into your vehicle's electrical system as illustrated, whenever you turn on your radio, the antenna will telescope upward to permit radio reception. Turning off the radio will cause the antenna to retract. Before making any connections to the antenna, however, make sure that the project is compatible with it.

Illustrated in Fig. 3 are the connections that must be made to permit driving of two speakers from two audio outputs. Though a general discussion of this arrangement was described above, note here that the speakers shown do not have a common ground. Therefore, all returns must be made separately. This requires five relay contacts altogether. Hence, an additional four-pole relay is needed.

In this arrangement, the +12V INPUT lead connects to the +12-volt source in the vehicle's electrical system and the +12-volt input lead from one of the audio units goes to the +12V OUTPUT lead of the project. The project's COMMON lead then goes to the +12-volt source. The NORMALLY CLOSED lead of the Relay connects to the +12-volt input of the other audio unit, and the NORMALLY OPEN lead connects to one side of the coil of an additional relay (the other side of the relay's coil goes to circuit ground). The additional relay's coil must be rated at 12 volts dc and its contacts must be conservatively rated to handle the current delivered to the speakers.

In addition to the project connections, Fig. 2 shows the schematic connections of the relay contacts to the speakers. If you follow the circuits, you will see that turning on one audio unit automatically disconnects the power from the other audio unit and transfers the speakers to the outputs of the active unit.

Pictorially illustrated and shown schematically in Fig. 4 is a more sophisticated automatic switching arrangement. Here four speakers are switched between two audio units. Two additional four-pole, double-throw relays are required for this application.

The schematic diagrams in Fig. 3 and Fig. 4 are accompanied by a relay-contact legend. The legend shows that normally open contacts are represented by what looks like a capacitor symbol with neither plate curved, while the normally closed symbol is the same with a slash through it.

As you can see from the foregoing, the "Smart" Car Relay is, indeed, a very versatile device. We have touched here on only three possible applications for this device. You will certainly come up with more, based on your needs. **ME**

KENWOOD

...pacesetter in Amateur Radio

NEW RZ-1 Wide-Band Receiver.

Hear it All!

R-5000 R-2000 High performance receivers

Scan the entire frequency range from 100 kHz to 905 MHz with Kenwood's R-5000, R-2000 and RZ-1. Listen in on foreign music, news, and commentary. Monitor local police, fire, and other public safety services, as well as the Marine channels, and the many other services 50 MHz and above.

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

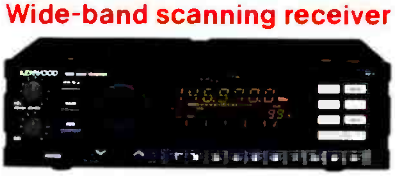
R-5000

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.

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.

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

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.

Specifications, features, and prices are subject to change without notice or obligation.

KENWOOD

KENWOOD U.S.A. CORPORATION
2201 E. Dominguez St., Long Beach, CA 90810
P.O. Box 22745, Long Beach, CA 90801-5745

NO. 95 ON FREE INFORMATION CARD