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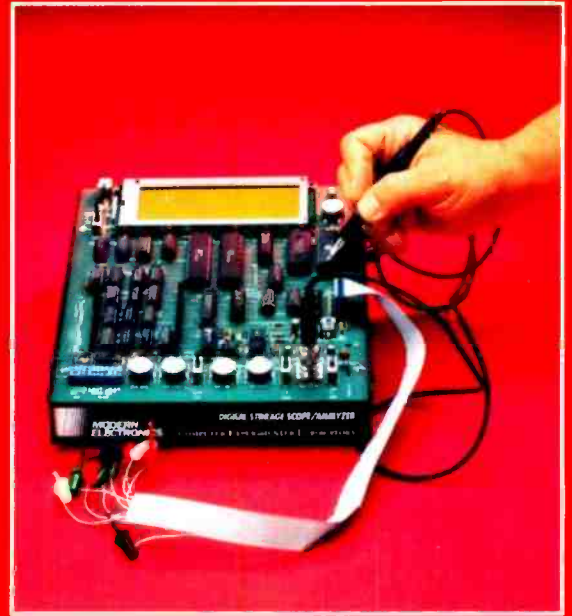
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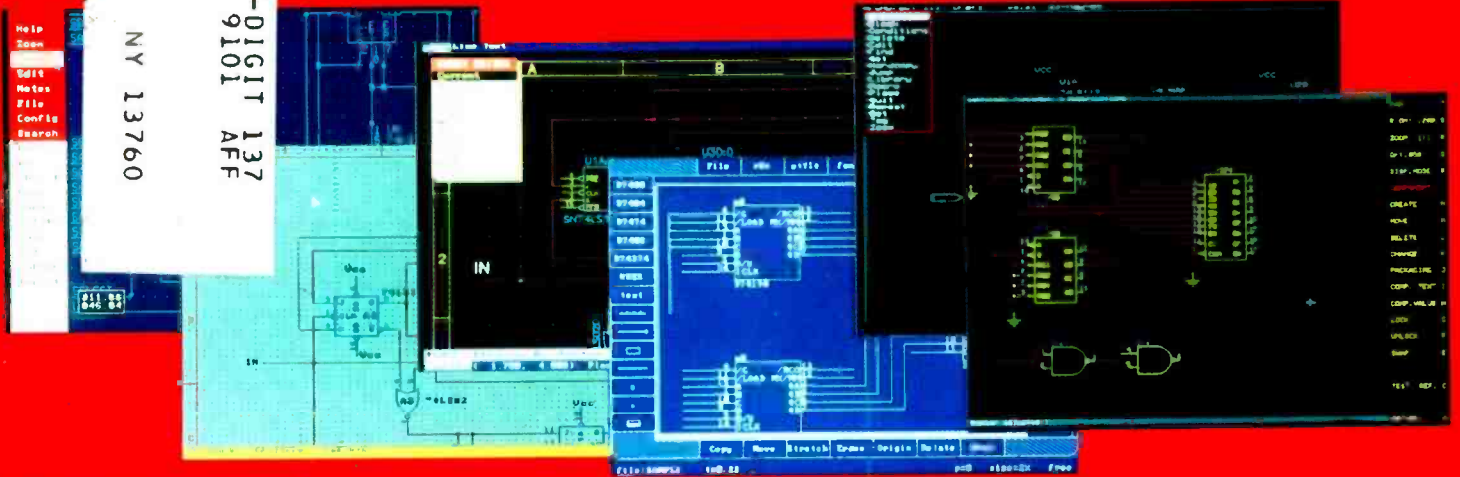


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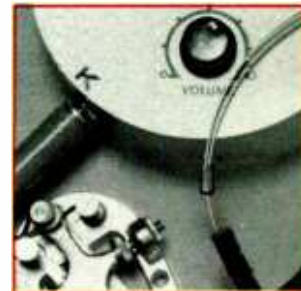
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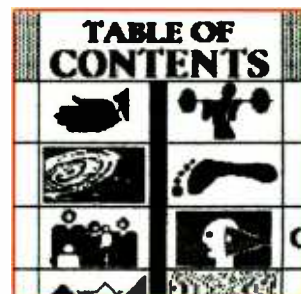
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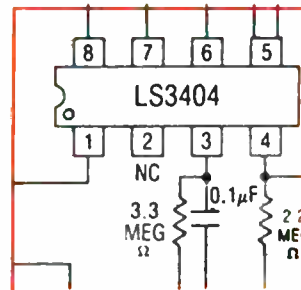
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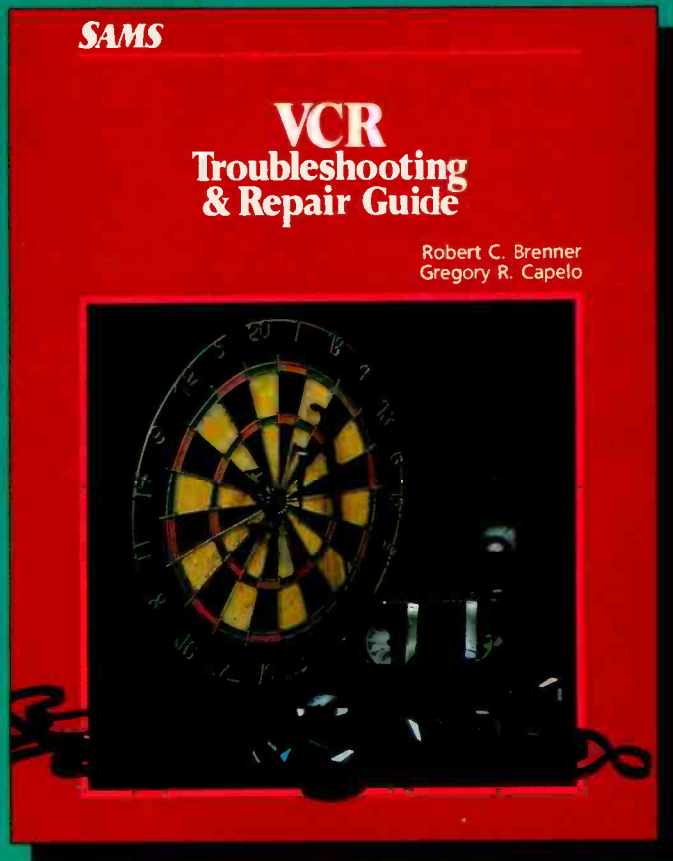
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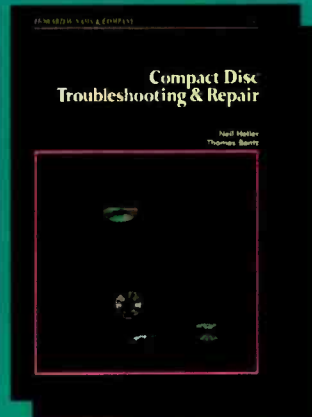
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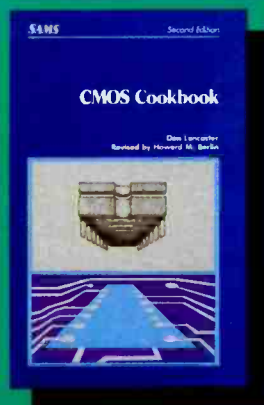
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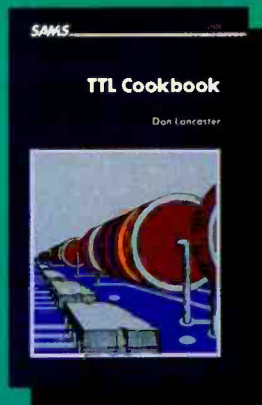


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EDITORIAL

Author's Guide

There are a lot of directories for writers that list a publication's article needs and requirements. I just finished filling out some forms for one of them, in fact. Such questionnaires typically ask about the type of article purchased from free-lance (not salaried staff) writers, policy on making assignments or working on speculation, the best way to break into your publication, and so on.

Over the years, however, I've never come across a question relating to anything personal, such as religious beliefs, political leanings, etc., though one can use write-in space provided on forms to indicate such policies. Doubtlessly, there are some publications that do have such restrictions, and there may be perfectly ethical reasons for this when an editorial focus is especially narrow and requires a definite slant. Electronics and computers do not fall within this spectrum, of course.

That's why I was taken aback recently when one of our favorite, admired writers, Forrest Mims, who writes *Modern Electronics's* "Electronics Notebook" every month, told me that *Scientific American* magazine refused to accept any more of his work as the writer of its "Amateur Scientist" column when it learned that he believes in the biblical concept of creation, rather than Darwin's theory of evolution. Forrest's work there (he wrote three columns before being cut off) concerned physical science experiments and construction projects, not biology or philosophy, of course.

It seems that *Scientific American's* editor feared that he would be embarrassed if other people found out about Forrest's beliefs and tried to exploit the fact that he was writing for the publication. Now that's paranoid, at best, I think, given the subject matter that Forrest writes about.

My view about this is, in a nutshell, what I told a *Wall Street Journal* reporter, who quoted me in its newspaper as follows: "His personal beliefs have nothing to do with the work he does." Supporting my attitude, Forrest has indeed been writing for me regularly for more than a dozen years now. So have two other *ME* writers who share his private beliefs. Clearly, it's simply not a consideration here for accepting or rejecting anyone's articles. Nor should it be otherwise elsewhere when the subject being written about has no relation to another topic.

Would *Scientific American* have rejected writings from William Shockley (co-inventor of the transistor and the founder of a company that spawned California's "Silicon Valley") on solid-state technology because his controversial views on genetics may run counter to what they would like it to be? I'm confident that this would not be the case. Shame on you, *Scientific American*.

Art Salsberg



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LETTERS

A Matter of Values

•In the "Power On/Off IR Remote Controller" in the October issue, there is an error in Fig. 2. The resistor and capacitor values do not cause the circuit to oscillate at 40 kHz, as the article states. The appropriate equation for this circuit is $f = 1.44/[(R1 + 2R2) \times C]$. Try the values given in the article, and you will see that one or more of them is incorrect.

Kevin C. Carpenter
Colchester, VT

The value of the capacitor should be 0.005 microfarad. While this won't yield an exact 40 kHz, the transmit frequency will be close enough for purposes of the project. To get much closer to the mark with this value, you would have to change the value of R4 to 2,500 ohms.—Ed.

Gremlins at Work

•In reading over my "Thermally Machine Project Boxes" in the November is-

sue, I noticed a couple of minor errors. In the first column on page 20, line 17, change "%-inch" to "1/2"-inch. In the Bill of Materials, change the fuse specification to "fast-blow."

Adolph A. Mangieri

•"Computer-Controlled AC Interface" (November) really caught my eye and is the type of material every computer hacker likes to experiment with. This is a good project, but without a complete listing of the BASIC control program, it is essentially useless. Could you please supply the complete program?

Eugene P. Schmitt
Mequon, WI

You are correct. When we ran out the disk file containing the BASIC control program, the right side of those lines that exceeded 66 characters truncated and left the printout incomplete. Here is the program with all the information in it.—Ed.

```

10 CLEAR: CLOSE: KEY OFF: CLS: DEC = 0: OUT 888, DEC
20 BYTE$ = " 0 0 0 0 0 0 0 0 0"
30 LOCATE 1, 21: PRINT "EDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD?"
40 LOCATE 2, 21: PRINT "3 PARALLEL INTERFACE PROGRAM 3"
50 LOCATE 3, 21: PRINT "@DDDDDDDDDDDDDDDDDDDDDDDDDDDDDD?"
60 LOCATE 10, 15: PRINT "BIT NUMBER 7 6 5 4 3 2
1 0"
70 LOCATE 11, 15: PRINT "DDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
DDDDDD4 "
80 LOCATE 12, 29: PRINT "3 3 3 3 3 3 3 3"
90 LOCATE 13, 29: PRINT "A A A A A A A A"
100 LOCATE 14, 15: PRINT " VALUE "; BYTE$
110 LOCATE 21, 16: PRINT "COPYRIGHT, GEORGE F. STOCKMAN, IV,
1989"
120 DELAY = TIMER + 5: WHILE DELAY > TIMER: WEND
130 LOCATE 21, 16: PRINT STRING$(41, 32)
140 LOCATE 21, 11: PRINT "BIT NUMBER TO TOGGLE / [CR] TO RESET /
[ESC] TO END"
150 A$ = INKEY$: IF A$ = "" THEN 150
160 IF A$ = "0" THEN 240 ELSE IF A$ = "1" THEN 260 ELSE IF A$ =
"2" THEN 280
170 IF A$ = "3" THEN 300 ELSE IF A$ = "4" THEN 320 ELSE IF A$ =
"5" THEN 340
180 IF A$ = "6" THEN 360 ELSE IF A$ = "7" THEN 380
190 IF A$ <> CHR$(13) THEN 230
200 BYTE$ = " 0 0 0 0 0 0 0 0 0"
210 DEC = 0: BIT0 = 0: BIT1 = 0: BIT2 = 0: BIT3 = 0
220 BIT4 = 0: BIT5 = 0: BIT6 = 0: BIT7 = 0: GOTO 430
230 IF A$ = CHR$(27) THEN CLS: SYSTEM ELSE BEEP: GOTO 150
240 IF BIT0 = 0 THEN BIT0 = 1: DEC = DEC + 1 ELSE BIT0 = 0: DEC =
DEC - 1
250 GOTO 390
260 IF BIT1 = 0 THEN BIT1 = 1: DEC = DEC + 2 ELSE BIT1 = 0: DEC =
DEC - 2
270 GOTO 390
280 IF BIT2 = 0 THEN BIT2 = 1: DEC = DEC + 4 ELSE BIT2 = 0: DEC =
DEC - 4
290 GOTO 390
300 IF BIT3 = 0 THEN BIT3 = 1: DEC = DEC + 8 ELSE BIT3 = 0: DEC =
DEC - 8
310 GOTO 390
320 IF BIT4 = 0 THEN BIT4 = 1: DEC = DEC + 16 ELSE BIT4 = 0: DEC
= DEC - 16
330 GOTO 390
340 IF BIT5 = 0 THEN BIT5 = 1: DEC = DEC + 32 ELSE BIT5 = 0: DEC
= DEC - 32
350 GOTO 390
360 IF BIT6 = 0 THEN BIT6 = 1: DEC = DEC + 64 ELSE BIT6 = 0: DEC
= DEC - 64
370 GOTO 390
380 IF BIT7 = 0 THEN BIT7 = 1: DEC = DEC + 128 ELSE BIT7 = 0: DEC
= DEC - 128
390 BYTE$ = "": BYTE$ = BYTE$ + STR$(BIT7) + " " + STR$(BIT6) +
" "
400 BYTE$ = BYTE$ + STR$(BIT5) + " " + STR$(BIT4) + " "
410 BYTE$ = BYTE$ + STR$(BIT3) + " " + STR$(BIT2) + " "
420 BYTE$ = BYTE$ + STR$(BIT1) + " " + STR$(BIT0) + " "
430 OUT 888, DEC: LOCATE 14, 28: PRINT BYTE$: GOTO 150

```

COMPUTERIZED CHESS TRAINING. World chess champ Garry Kasparov "trains" with an Atari MEGA-2 computer. He and his coach store chess moves made by tournament players in a database program, which is run to analyze strengths and weaknesses of other players. Prior to this, trainers had to manually clip and sort through articles on matches played throughout the world.

NEW RESEARCH DEVELOPMENTS. Bellcore researchers developed a unique, low-cost prototype device that detects fires involving polyvinyl chloride (PVC) before there's smoke or even heat. When PVC, which is a common cable and wire insulation material, overheats or burns it produces the extremely corrosive hydrogen chloride gas that can destroy electronic equipment even several floors away. The gas is emitted before PVC burning takes place. The new device uses an inexpensive quartz crystal coated with zinc that's set to vibrate at a certain frequency. The zinc metal corrodes when hydrogen chloride gas hits it, forming zinc chloride which rapidly absorbs water from the air. This causes the quartz crystal to change its vibration frequency, which sets off an alarm before flame or smoke occurs.

BRIGHT WHITE LED. Ledtronics's (Torrance, CA) new WhiteLite LED is said to be the industry's first multi-chip white LED 100% brighter than present amber-yellow technology. It's intended to be an incandescent lamp replacement for the world's most popular color and can be used to re-lamp pushbuttons, backlights, and control-panel indicators. It's an electrical and mechanical duplicate of the incandescent lamp it replaces and will not cause heat damage to lenses, which might be colored red, orange, among others. LEDs can be expected to operate at least 100,000 hours compared to an approximate 4000 hours for incandescents, which makes them very cost-effective. In 1000 quantities, they're priced \$2 to \$3 each, depending on base style ordered.

SECURITY ROBOTS. Cybermotion Inc.'s (Rcanoke, VA) new mobile security robot is based on the company's Navmaster mobile robot with the addition of a special Security Patrol Instrumentation package that adds the capability of monitoring large areas for fire, intrusion and air quality.

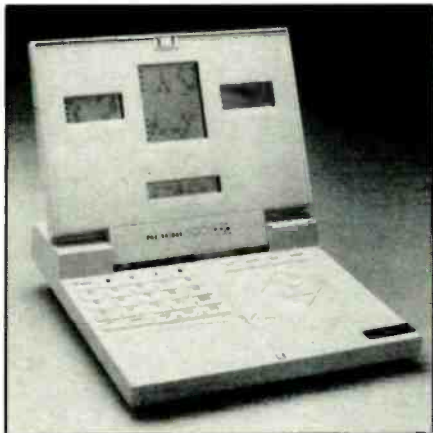
The robot navigates primarily through use of a digital sonar system that's programmed by drawing routes onto a CAD drawing of the facility. A Dispatcher program uses this data to generate random patrol programs that are transmitted to the robot via radio. The operator can also drive the robot remotely to investigate special situations. The robot's base contains sensors for temperature, smoke, gas and relative humidity, as well as an interface for an option camera system. A rotating head has a passive infrared scanning imager, a K-Band presence radar and a UV detectors. The radar can detect objects through walls.

APPLIANCE REMOTE CONTROLLERS. NEC Electronics (Mountain View, CA) introduced three low-voltage, low-current controllers for remote control applications in household appliances and air conditioners. All feature a carrier generator circuit for infrared remote control. They operate on a voltage range of 2V to 6V, enabling operation with two batteries.

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.

Computerized Bridge Game

Pro Bridge 500 from Saitek Industries Ltd. (Torrance, CA) is a new computerized bridge game that is claimed to challenge serious club players and has integrated coaching features for beginners. It plays both rubber and duplicate bridge. You can select up to five major bidding descriptions: Acol, American 5 Card major, French 5 Card major, American Standard and Precision club—with 11 bidding conventions. If players choose to play against different conventions, they can set the



North/South and East/West positions separately.

Built-in coaching features help develop skills and expertise for all player levels. Coaching can give hints, suggest which card to play and allow take-back of a bid or card. It also permits players to review a game with all

hands on view to see how they interact as the game progresses.

Laptop design makes it easy to use Pro Bridge 500 at home and while traveling. When opened for play, the top displays four screens: one 16-character LCD screen with menu options and two player positions, two more screens for player positions and to keep score in a layout that makes it easy to follow the game. The top panel folds flat and snaps shut when the game is over. Pro Bridge 500 measures 9 inches square by 1½ inches deep. \$399.

CIRCLE NO. 2 ON FREE INFORMATION CARD

Triple Power Supply

Global Specialties' Model 1310 dc bench-top power supply has three independent outputs: 5 volts at 1 am-

Portable Computer

The new 6-pound (with battery) Tandy 1500 HD notebook PC comes with both standard floppy and hard-disk drives. Built around the NEC-V20 microprocessor operating at 10 MHz and 0 wait state, the computer features 640K of user RAM (expandable to 1.64 M); 3.5-inch, 1.44MB floppy drive; 20MB hard drive with 23-ms access time; high-definition blue-on-white LCD screen with 640 × 200-pixel resolution; MS-DOS 3.3; DeskMate® personal productivity software; and LIM 4.0 expanded memory driver.

A rechargeable Ni-Cd battery is said to provide more than 3.5 hours of computing time. A new "Power View" LED system monitors battery status. This indicator and the Power indicator are located on the top-right of the computer case for clear visibility without lifting the display. The Power switch is also located under the display to prevent accidental battery drain.

The battery weighs just 12 ounces and recharges in only 4 hours with



the computer off (8 hours with the computer on). An 8-ounce ac adapter/charger is supplied. The 84-key Tandy Key-Switch™ keyboard allows you to interchange the CTRL and CAPS LOCK key caps and functions to provide a standard typewriter layout. Included with the full-size keyboard are 12 function keys and an embedded numeric keypad to provide 101-

key emulation.

Other features include: an internal modem, a 25-pin parallel-port connector and a 9-pin DB-9 RS-232C serial-port connector. Options include a 1MB user-installable memory upgrade (\$400); 2,400-baud internal modem (\$200); spare battery (\$100); and choice of carrying cases. \$1,999.

CIRCLE NO. 6 ON FREE INFORMATION CARD



per and two variable 1.3 to 20 volts at 250 mA each. It features series and parallel operation and digital current and voltage metering via a three-digit ½-inch tall LED numeric display. Display accuracy is rated at $\pm 0.5\%$, ± 1 digit. All supplies are current limited and short-circuit protected.

CIRCLE NO. 3 ON FREE INFORMATION CARD

Video Rebroadcaster

Midland International's Model 72-400 Pow-R-Max Video Commander rebroadcasts programs from VCRs or any other source that has an audio/video jack to one or more TV receiver locations up to 100 feet away. The system is made up of a small transmitter and one or more receivers. A



separate receiver is required by each TV receiver that is to pick up the rebroadcast signal. To install the system, you simply plug the transmitter into the desired video program source and a receiver into each TV receiver that is to pick up the signal.

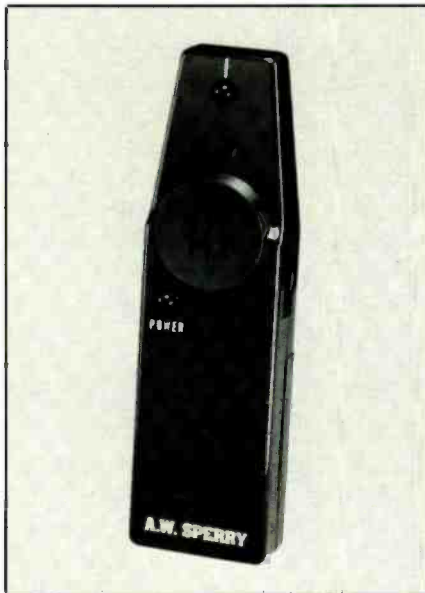
The 72-400 uses a different broadcasting system than previous systems. It eliminates the need for fine tuning systems and has special filtering to prevent interference in metro-

politan areas. The new transmission system is claimed to deliver bright, bold pictures and clear sound.

CIRCLE NO. 4 ON FREE INFORMATION CARD

No-Contact Voltage Sensor

A non-contact voltage detector has been announced by A.W. Sperry. The Model VH-601A Volt Sensor is designed to detect 100 to 600 volts ac with respect to ground by simply



grasping the instrument in your hand and placing the tip near a live wire. If the wire is, indeed, "live," the VH-601A gives both audible and visual indications. The 1.4-oz. device requires two AA cells for operation.

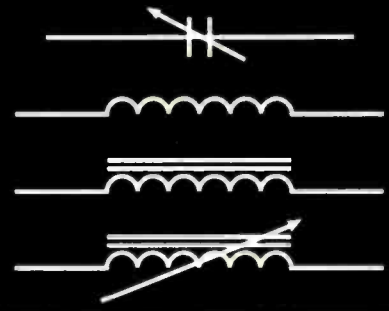
CIRCLE NO. 5 ON FREE INFORMATION CARD

CD Lens Cleaner

The Audio-Technica Compact Disc player lens cleaner uses an eight-brush wet/dry system to completely remove dust, oil and other contaminants from laser lenses. The No. AT6078 accessory is said to maintain optimum laser performance, reduce playback errors and eliminate excessive error correction.

Eight specially positioned brushes mounted on a Compact Disc wash and whisk away contaminants and

Which symbol represents a variable inductor?



What is the principle disadvantage of neon lights?

What are out-of-phase signals?

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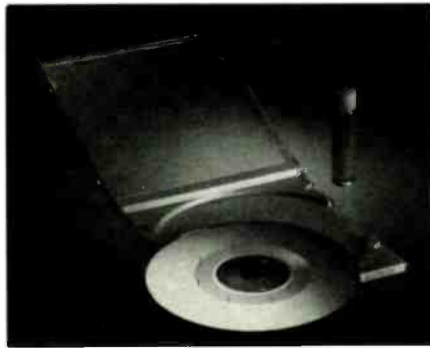
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NEW PRODUCTS...



dry the lens. To perform a cleaning operation, you apply a single drop of laser lens cleaning fluid to the innermost brush, after which you place the

disc in the drawer of the player brush-side down and activate play. Cleaning is accomplished in about 10 seconds, at which point the player automatically stops. Audio-Technica recommends that it be done at least once a month, more frequently if your player is subjected to a lot of cigarette smoke. \$24.95.

CIRCLE NO. 7 ON FREE INFORMATION CARD

I/O Port System

A professional AppleTop Bus ported control system for all models of Mac-



Stereo Receiver

Onkyo's Model TX-866 AM/FM-stereo receiver offers 88 watts per channel into 8 ohms (185 watts per channel into 2 ohms)—plus room-to-room remote control. An exclusive APR (Automatic Precision Reception) system continuously monitors the FM signal and adjusts critical tuner mode, sensitivity and high-frequency blend to provide optimum performance. Direct Access Tuning, punching in a desired station frequency from a front-panel numeric keypad, and Classified Memory Preset permit each of the tuner's 40 AM/FM station presets to be assigned to any of six classes. These classes can be assigned by type of music programming or according to any other scheme. Pressing a button gives a brief sample of each station in the selected class.

Seven inputs are available, with audio/video switching and dubbing facilities that enable them to serve as the core of a sophisticated A/V system. Standard rotary bass and treble controls are augmented by a slide-type Selective Tone/Loudness control that progressively boosts very-low and very-high frequencies in balanced proportion to maintain a tonal balance when listening at low volume.

Other features include a sleep timer; Onkyo's slide control in the Dynamic Bass Extender circuit that permits adjustment for fuller low-frequency reproduction; and a Stereo Image Expander. A large fluorescent display shows tuned frequency, memory preset selected, class selected and bargraph tuning. Lighted legends indicate which functions are active. The IR remote transmitter duplicates most of the control functions available at the receiver. \$480.

CIRCLE NO. 9 ON FREE INFORMATION CARD

intosh computers is available from Ansan Industries (Arlington Heights, IL). The I/O Port System is said to be ideal for automating most electricaly operated devices in the home. It can monitor fire and security systems, operate automatic sprinklers, program lights to turn on and off, etc.

All that is needed to accomplish control is a main control system module called a Bridge. The Bridge reads, monitors, controls and records signals using analog and digital input/output channels. It can be programmed to control any device in any time frame desired. Even if the



computer is turned off or power fails, the Bridge performs many of its functions.

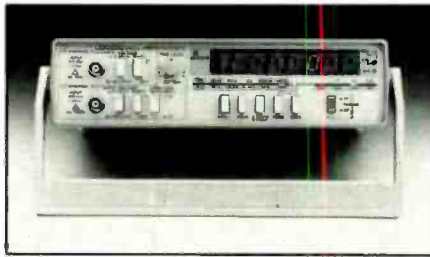
If more channels are needed to perform household functions, a Digital expander can be added. Up to eight bridges and 16 expanders can be connected to a single computer without using up any slots or SCSI ports.

The easy-to-install system attaches to a Macintosh via standard keyboard cables included in the package. It can easily be adapted to monitor and control custom applications using the software provided. Modules for writing your own software are also included, and telephone support is available. About \$500.

CIRCLE NO. 14 ON FREE INFORMATION CARD

Universal Counter

Tektronix's new Model CDC250 universal counter is designed for use applications where multiple measurement capabilities are needed. The dual-channel instrument counts signal frequency of sine, square and triangle waveforms over a range from 5



Hz to 175 MHz at input levels ranging from 20 mV to 24 volts peak. It also provides period measurements,

frequency-ratio, time-interval and totalize measurement functions. Its temperature-compensated timebase is designed to provide reliable performance in changing ambient-temperature environments.

The CDC250 can be used as a stand-alone calibration tool or as a rack-and-stack component in a bench setup. Except for a rotary trig-

(Continued on page 78)

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CIRCLE NO. 35 ON FREE INFORMATION CARD



The Modern Electronics Computer Experimenter Lab

(Part 1)

How to build a \$200 Digital Storage Scope, with an optional add-on eight-channel logic analyzer, as the foundation for a complete experimenter's lab . . . To be followed by an analog function generator, then a digital signal generator that produces up to 20 different simultaneous digital signal trains from a built-in library of experiments or from programs downloaded from an IBM PC or compatible . . . Plus ongoing experiments for all experimenter levels.

By Martin Meyer

Electronics and computer technologies have become more complex than ever before. Nevertheless, we can still experiment, design products and learn how the newest technology works on a personal basis if we have the right equipment. Even on a kitchen table!

As we know, digital electronics and the microprocessor have combined to change and add extra excitement to the art of product development, whether as general-purpose microcomputers or as dedicated-application microcontrollers. The project presented here initiates a new series by *Modern Electronics*—The Modern Electronics Computer Ex-

perimenter Laboratory—that will help you to quickly understand and implement the wide range of new electronic and computer developments constantly being introduced.

We start here with a digital storage oscilloscope that will serve as part of the underfooting of an exhilarating electronics/computer learning experience. An optional add-on eight-

channel logic analyzer is also available to expand the utility of the Experimenter Lab (see the Note at the end of the Parts List). An analog function generator and a digital signal generator in upcoming issues will round out the laboratory, preparing you for a host of new-technology learning experiences.

A stimulating aspect of this project is that we can use the scope to look inside the scope itself and see how most of the components used actually function. Seeing is believing . . . and doing helps the learning process. Before describing how the scope you will build works, let us discuss what that instrument can do, cannot do, and how it compares to commercially available scopes.

The DSO Project

This project is known as a Digital Storage Oscilloscope, also known as a DSO. This means that input signals are converted by an analog-to-digital (A/D) converter to a digital signal and then displayed on a screen. A standard analog scope uses the input to move a beam on the screen to produce this display. The major advantage of a DSO is that an event can be saved or frozen on the scope screen, giving the user time to evaluate the results of an experiment. In contrast, the display of an ordinary analog scope is lost the instant after the event occurs.

There are tradeoffs, naturally. A disadvantage of DSO scopes is that bandwidth may be somewhat less than some of the more-expensive analog scopes. The DSO to be described is capable of sampling the input 20 million times per second, which is more than adequate for experiments we will be conducting. Its vertical sensitivity ranges from 10 mV to 5 V per division (50 V per division if a 10:1 probe is used).

Our DSO's horizontal timebase is adjustable in 21 steps from 1 μ s to 5 seconds per division. The display used

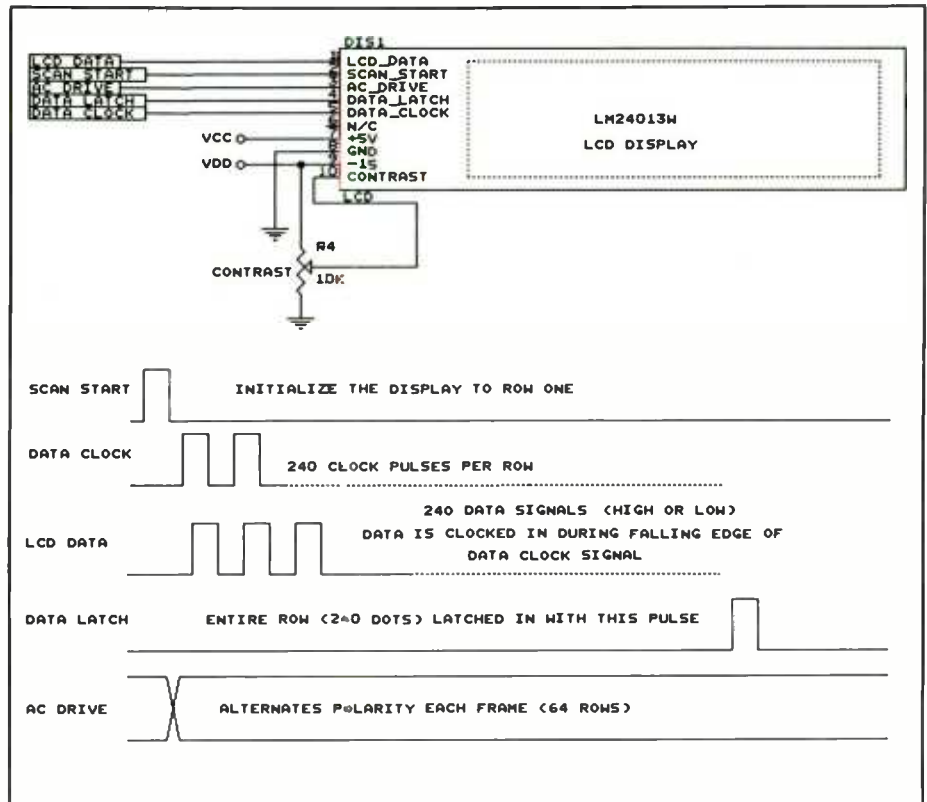


Fig. 1. Circuit details of the liquid-crystal display section.

is a standard liquid-crystal unit composed of 64 dots vertically and 240 dots horizontally. Accordingly, this resolution results in a display that is not as smooth or as bright as that of an analog scope. For example, noise looks a bit odd because it produces little steps in the display, but this is easy to get used to. (In the Logic Analyzer mode, the display is smooth because signals are either in a high or low state.) Nevertheless, it is satisfactory for our purposes.

Most scopes do not include Logic Analyzer inputs. We decided to add this feature because the ability to view signals simultaneously is invaluable in learning how digital circuits work. Understanding microprocessor timing diagrams becomes simple when you can view the bus and control signals at the same time!

Learning how to design and apply digital or computer circuits is not as difficult as many people imagine. The following is a breakdown of

some of the steps in the learning process:

- (1) Study how to use binary numbers
- (2) Learn how basic logic components work:
 - Gates and Buffers
 - Latches and Flip-Flops
 - Counters and Registers
 - Multiplexers and Decoders
- (3) Learn how a microprocessor works:
 - CPU and Support Chips
 - I/O and Timer Ports
 - Communication Chips
 - Various RAM and ROM Chips
 - Simple Assembly-Language Programming

Understanding these principles by physically making them happen will be enjoyable and can be profitable. A scope, logic analyzer and analog/digital signal generators are particu-

PARTS LIST

Semiconductors

CR1—20-MHz crystal oscillator
 D1 thru D7—1N4002 diode
 U1,U19,U21—74HC373
 U2—74HC165
 U3—74HC138
 U4—74HC139
 U5—74HC04
 U6,U22,U31—74HC00
 U7—80C85A
 U8—6264
 U9—81C55-5
 U10—27C64 or 27C256
 U11 thru U14—74HC390
 U15 thru U18,U29—74HC393
 U20—LM7805
 U23,U24—AD843
 U25—HA19216
 U26—AD790
 U27—74HC32
 U28—5863
 U30—74HC08
 U32—74HC21
 U33—74HC74

Capacitors

C1,C24,C25,C27,C29—2.2- μ F, 25-volt radial-lead electrolytic
 C2 thru C23,C30 thru C33,C35 thru C38—0.1- μ F monolithic
 C26,C28—22- μ F, 16-volt disc
 C34—1,000-pF disc
 C39,C40—10-pF disc
 C41—47-pF
 C42,C44—3-to-10-pF pc-mount trimmer
 C43—10-to-70-pF pc-mount trimmer

Resistors (1/4-watt, 5% tolerance)

R1—10,000 ohms
 R2—470 ohms
 R3,R27,R28—4,700 ohms

R4,R25,R26—10,000-ohm potentiometer
 R7,R9—1,000 ohms
 R8—2,000 ohms
 R10,R11—1 megohm
 R12,R13,R14—220 ohms
 R15—50,000 ohms
 R16—300 ohms
 R17—1,500 ohms
 R18,R19—300,000 ohms
 R20—5,000 ohms
 R21—500,000 ohms
 R5,R6—47 ohms (1/2-watt)
 R22—2,000-ohm potentiometer
 R23,R24—1,000-ohm potentiometer
 RS1,RS2—Eight 10,000-ohm resistors in single-inline package

Miscellaneous

DIS1—LM24013W LCD display (Sharp Electronics)
 S1,S5—Spst momentary-action push-button switch
 S2,S3,S4—Four-position DIP switch
 SW1—Dp2t slide switch
 SW2,SW3—Dp3t slide switch

Note: The following items are available from Netronics R&D Development Ltd., 333 Litchfield Rd., New Milford, CT 06776 (203-355-2659): Complete kit of parts for the single-channel DSO, including pc board: \$199.95 plus \$6.50 S&H; double-sided silk-screened pc board, \$39.95 plus \$4 S&H; programmed ROM (U10), \$29.95 plus \$2.50 S&H; IC socket set (33 count), \$9.50 plus \$1 S&H; 5-volt and \pm 12-volt power-supply kit, \$34.95 plus \$4 S&H. Also, 100-MHz scope probe with 10:1 attenuator, \$27.50 plus \$3.50 S&H; black steel cabinet, \$37.50 plus \$4.50 S&H; eight-channel logic analyzer, all parts including program, \$59.95 plus \$3 S&H. MasterCard and Visa accepted. Connecticut residents, please add state sales tax.

larly helpful in learning because you see the signals generated as well as the results. A signal generator is used to produce signals necessary to stimulate the inputs of various logic components, while the scope verifies results.

In the logic analyzer mode, up to eight different signals can be monitored simultaneously. The programs needed to generate signals for each

experiment to be presented will be supplied in a ROM or can be downloaded from any IBM PC or compatible. If you download, you can also write your own programs using the DEBUG program in PC/MS-DOS or any assembler. (We will show you how easy this is to do.)

When you reach the level in our series where you are writing your own programs, you will be learning per-

haps the most widely used assembly language. Since the digital signal generator incorporates the 8088 series microprocessor and support chips, you will be able to learn both the hardware and software aspects of this series of processors and peripherals. Working with the scope and logic analyzer, built from plans detailed here, will further help you to fully understand the all-important timing functions as well as the logic functions.

How the DSO Works

Here's a breakdown of how the Digital Storage Oscilloscope we have developed for your personal assembly works.

- **Display:** The liquid-crystal display (LCD) panel used in this project consists of 15,360 dots or cells arranged in a 64 by 240-dot matrix. The dots are individually addressed to produce the display. The LCD display (see Fig. 1) is actually a very simple device. Five signals, produced by the microprocessor, control the entire process. The first step is to issue a SCAN START pulse. This signals the display that we are going to start at row one.

Next, using the DATA CLOCK input, the display data for the entire first row is shifted into the display's shift register. This register holds the information for an entire row (240 dots). Then the CPU issues a DATA LATCH pulse that transfers the data in the registers to the liquid-crystal cells in row 1. If the data in a display cell is a logic 1, the cell polarizes the crystals, darkening the screen at that point. The negative voltage supplied to the CONTRAST terminal sets the level of polarization and, thus, the contrast. If the data is a logic 0, the cell remains at the background color.

The DATA LATCH signal also indexes the display's internal row counter to the next row. The CPU then fills the display's shift register with the data for the second row of

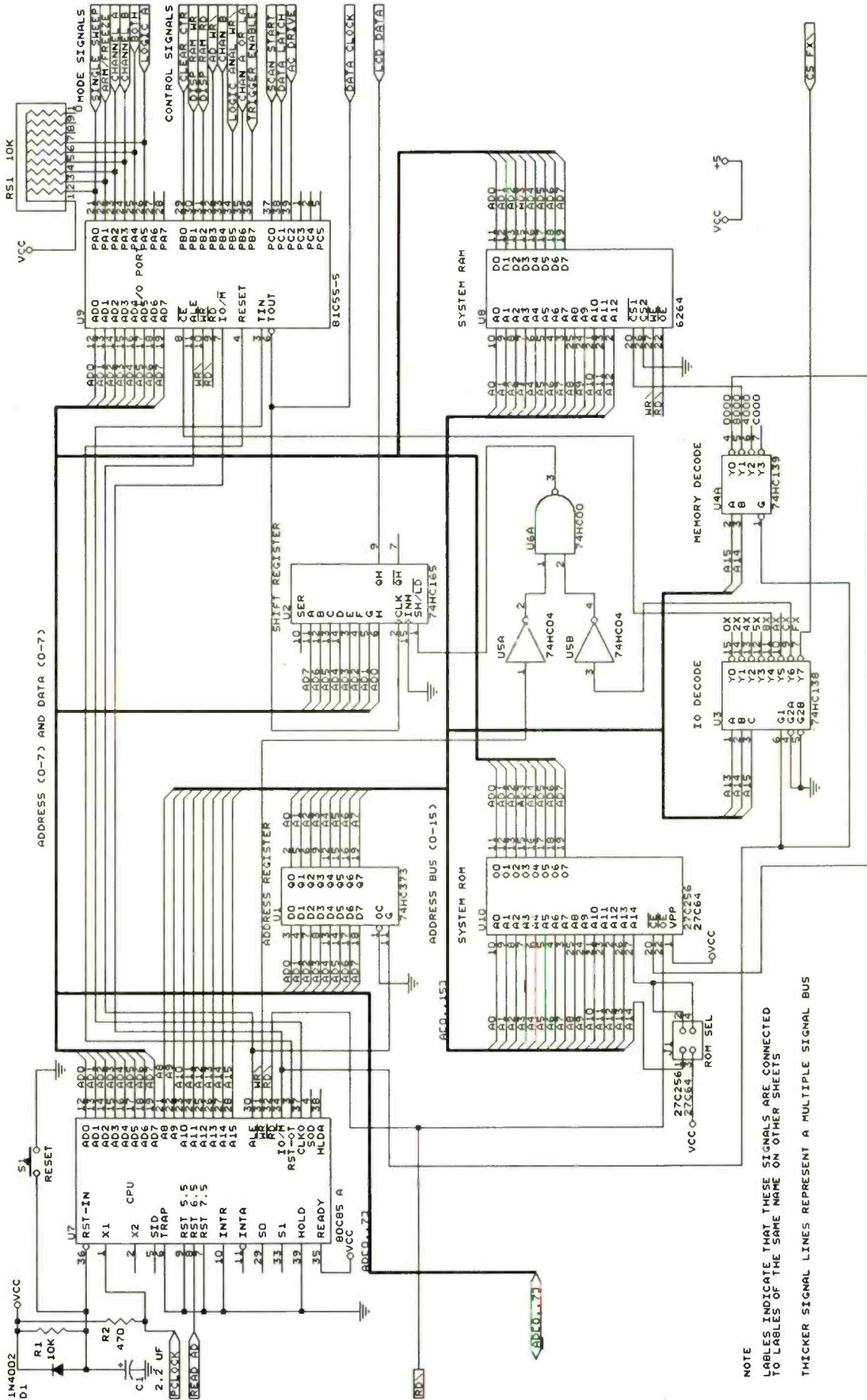


Fig. 2. Schematic details of system CPU circuitry.

NOTE
 LABELS INDICATE THAT THESE SIGNALS ARE CONNECTED
 TO LABELS OF THE SAME NAME ON OTHER SHEETS
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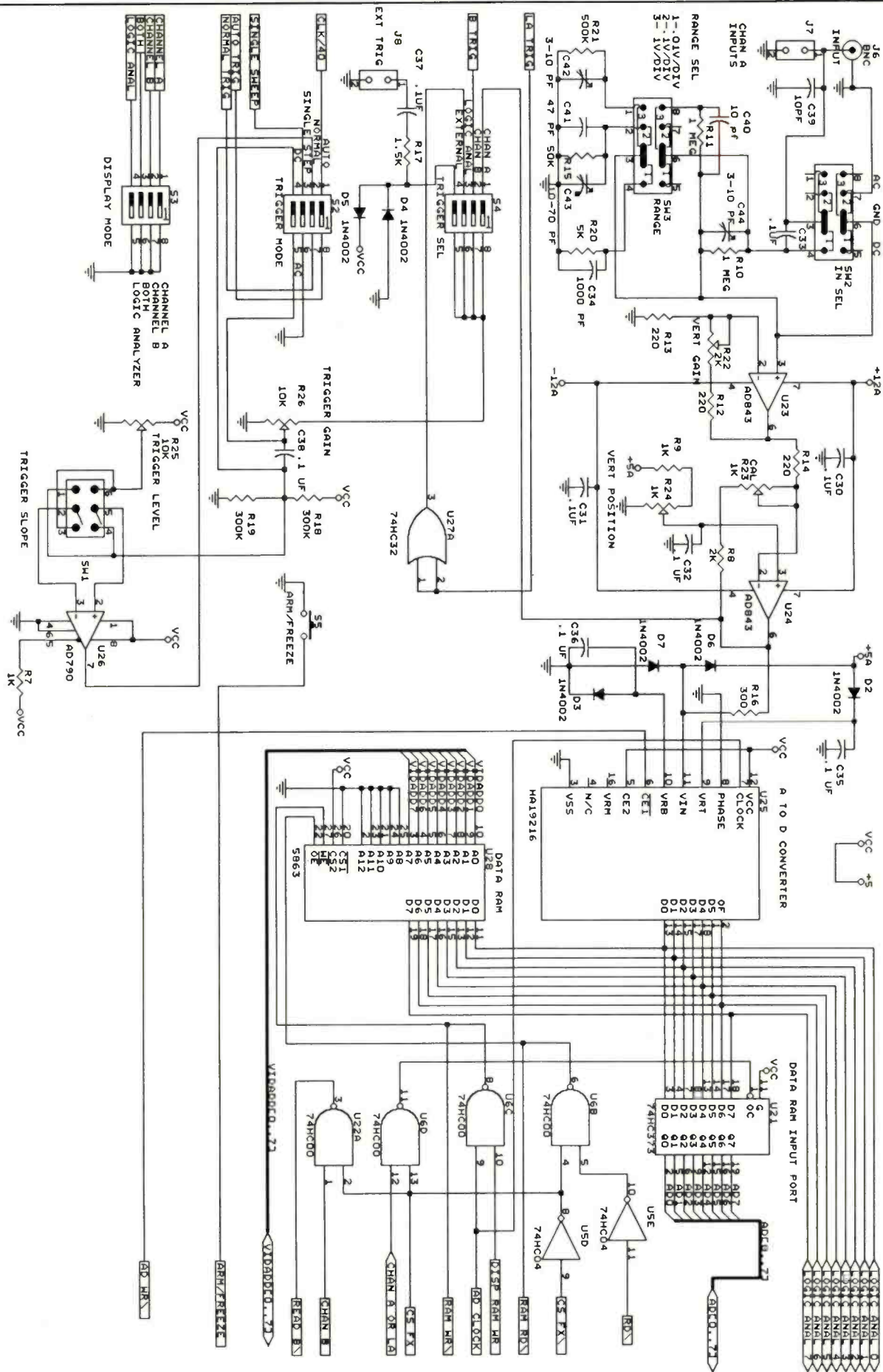


Fig. 3. Input, trigger, A/D converter and RAM circuitry details.

information to be displayed. This process continues until all 64 rows are filled. Then we start again with row 1.

Left on its own, the polarized display cell can remain polarized for only about 100 ms, after which it slowly returns to the background color. To prevent this from occurring, the cell must constantly be refreshed to maintain a high display contrast level. This is done by the CPU—50 to 60 times each second! The only remaining display signal required is AC DRIVE, which changes polarity every frame (64 rows). This is required because chemicals used in the display will break down if the polarity used to polarize the cells is not reversed every frame (much like charging a rechargeable battery). If this signal is missing, the display will not remain bright for very long. In our DSO, the first task performed is a check to see if the AC DRIVE signal is working.

Learning how LCD displays work is important because the resolution of some of these systems is now approaching that of a CRT. Full-color VGA LCDs are showing up in the fancier portable computers, and industry expectations of a flat high-resolution television screen will likely soon be fulfilled.

- **CPU:** The system CPU selected for our DSO is a high-speed CMOS version of the 8085. It has the advantage of requiring a minimum of current and is capable of operating with a 10-MHz clock input. High speed is a necessity to meet the refresh requirements of the display. Also, the system needs only a minimal amount of support chips (see Fig. 2).

The 8085 is an eight-bit processor with a data bus that is eight bits wide. Inputs to and outputs from the CPU consist of eight different signals that are transferred simultaneously on the data bus. Notice that the bus is labeled AD0 through AD7. This is because these pins also carry address information (addresses 0 through 7). This scheme is known as multiplex-

ing the signal pins. Generally, the CPU sets up the addresses first. They are then latched into external address latch register U1.

When addresses are stable, the CPU issues an ALE (address-latch-enable) pulse at pin 30 that latches the addresses into the latch. During the rest of the bus cycle, the signals are data signals. Having a dual-trace scope (you can add a second channel to our DSO for less than \$100) or logic analyzer is the only way to view this complex signal train. The rest of the CPU is straightforward. High-order address lines A8 through A15 are valid during the entire bus cycle.

The READ, WRITE and I/O lines set up the peripherals so that they can supply or accept data as required by the CPU. The system's 8K program ROM, U10, is at memory locations 0000 through 1FFF (all locations are in hex format). The ROM stores program steps and fixed-data tables. The system's 8K RAM, U8, is mapped from 8000 through 9FFF. The RAM holds display data and other variables used by the program. (It is not necessary to understand the hex numbering system to continue, but if you are serious about learning, building and designing computer-type circuits you must get some of this behind you.)

- **Memory & I/O Address Decoders:** The 74HC139 (U4A in Fig. 2) is a memory map decoder. This chip produces a low-level output at pin 4 whenever the CPU wants to "talk" to system RAM. A low level at pin 5 is generated when the CPU is reading an instruction or data from the system's program ROM. Exactly how these decoders work will be part of one of the experiments you will be conducting in an upcoming issue. The I/O decoder, a 74HC138 (U3), operates in much the same manner, except that when the CPU is addressing an input or output port, the selected port will get a signal from the I/O decoder, which connects the port to the system's data bus. This simple

part permits up to eight different ports to be addressed by the CPU. This design uses only three ports.

I/O Ports

- **Display Data Shift Register:** The first port we will analyze is 74HC165 U2. This simple shift register makes it possible to get data out of the display memory and into the display. The CPU outputs eight bits of data into the eight-bit register inside U2. The data is moved from system RAM through the CPU to pins A through H and into a register inside U2.

The program then turns on the timer located in the 8155, which generates eight pulses that are sent to the CLOCK input on U2. Toggling the clock shifts data, one bit at a time, out of the register to pin 9. The same eight clock pulses are used for the DATA CLOCK signal that loads data into the display's 240-bit row register. It takes 30 eight-bit output operations to fill one row of the display; 1,920 output operations to fill all 64 rows just once. Remember, if the display is refreshed 50 times per second 96,000 outputs to the U2 shift register are needed every second. This is well within the capabilities of the 8085! It is mentioned here to give you a feel of how interesting the design of this product is.

- **8155 I/O Port with Built-In Timer:** The next port we will discuss is the 8155. This chip is innocent in appearance, but it includes two eight- and one six-bit ports that can be programmed as either inputs or outputs. It also has a timer that can be started and stopped that generates a wide variety of waveforms. This chip is a good example of the new generation of devices that have to be initialized with a series of commands before they become a usable logic element.

An assembly-language program is required to implement this chip. If BASIC or another high-level language were used in this design, you would have to integrate the equiva-

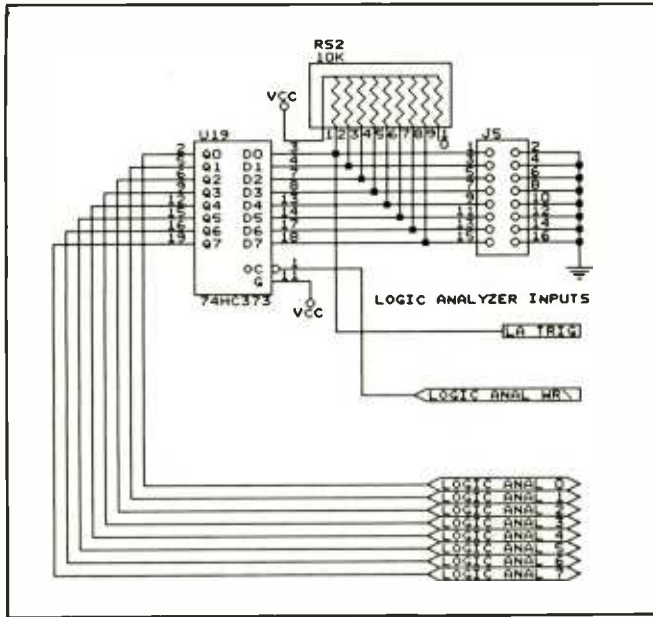


Fig. 4. Circuit details for connection of optional logic analyzer inputs.

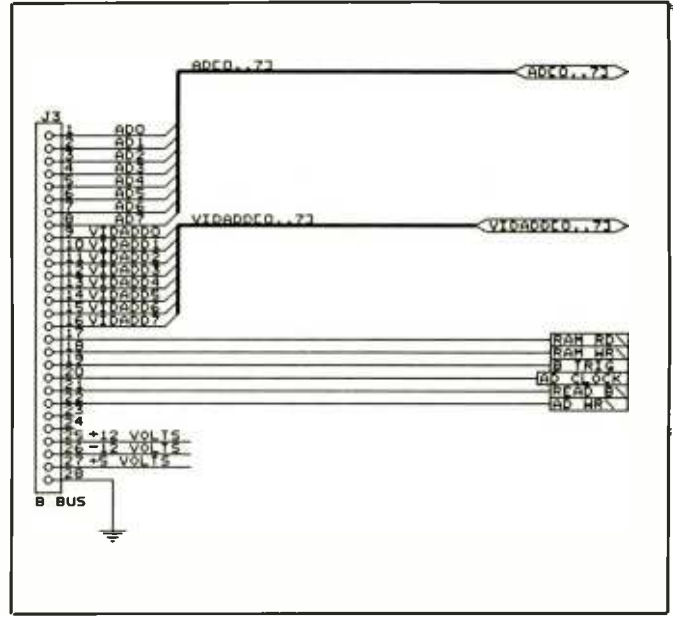


Fig. 5. Circuitry is provided for connecting into the system an optional Channel B circuit via its a 28-pin bus connector.

lent of an assembly-language routine in your program to deal with initialization and use of the features in this integrated circuit.

Since integrated circuits have a growing number of such embedded functions, the need to know at least *some* assembly-language programming becomes increasingly evident. So if you have avoided the subject in the past, you should seriously reconsider learning it now. In the real world, you handicap your hardware capabilities without knowledge of assembly-language programming. The digital signal generator article that will follow soon will offer an opportunity to learn and practice the basics of assembly-language programming on an 8088 CPU and associated peripherals.

Getting back to the 8155, the program initializes Port A as an input port. This port is connected to the various display mode switches. The program reads this port and decides if the system is in the single-sweep mode in displaying the eight-channel logic analyzer, analog Channel A, Channel B or both.

Port B is initialized as an output port. Signals generated at these outputs clear the address counter, direct the data RAM read and write modes, select the logic analyzer or the analog inputs and control the trigger-enable logic that is used in the single-sweep mode. Port C is also set up as an output port. Signals here produce the logic to control display action, as described earlier. The timer is programmed to produce a square-wave output with the frequency needed to clock the data out of the *U2* shift register and into the display.

- **Data RAM Input Ports:** The last ports to be reviewed are those that read data collected by the data RAM. Referring to Fig.3, note that OUTPUT CONTROL pin 1 of *U21* goes low when inputs to *U6D* are high. The 8155 supplies one of the signals to CHANA or LA, which goes high when the unit is displaying either Channel A or logic-analyzer signals. The other input to *U6D* is I/O select line CZ FX, which is generated by the I/O decoder discussed above.

When the CPU wants to read this data RAM, it issues the signals that

connect *U21* to the data bus. If the scope is displaying Channel B, the 8155 produces a high level at pin 1 of *U22A*. Pin 2 receives the CS FX signal. The resultant READ B \ signal is sent to the Channel B bus (see Fig. 5). Channel B is not shown at this time, but consists of the same components and signals that are in Fig. 3, except for the trigger and some of the I/O logic already used for Channel A that is common for both channels. The bus permits the Channel-B board to be plugged into the main board. Inputs and controls are located just behind Channel A controls.

- **Analog Inputs:** Now look at the analog input circuit area in Fig. 3. The inputs from either *J6* or *J7* are coupled to the input of the first AD843 operational amplifier through *SW2*. This switch configures operation of the input circuit for either ac or dc coupling. A center position on this switch grounds the input to provide a convenient 0 reference point. INPUT ATTENUATOR *SW3* permits selection of a divide-by-2, -20 or -200. Capacitors *C42*, *C43* and *C44* are small trimmers that you adjust to provide a

flat frequency response for all three ranges.

Input impedance of the FET op amp is in excess of 100 megohms, while INPUT Z to the scope is 1 megohm in parallel with 20 pF $\pm 10\%$. The first AD843 is configured as a noninverting amplifier that includes a VERTICAL GAIN control. Gain is variable from 2 to 10.

The second AD843 is configured as an inverting amplifier that is set to provide a gain of 10. CAL control R23 is set to calibrate the input to the display scale calibration. VERTICAL POSITION control R24 sets dc offset voltage at the output of the op amp between 0 and 5 volts. Bear in mind that the output voltage swing of the op amp must be restricted to the input range of the A/D converter. Accordingly, resistor R16 and diodes D6 and D7 limit the A/D input swing to ground and + 5 volts.

As you can see, analog circuits are almost trivial elements within the whole circuit. Furthermore, the components are expensive and require a great deal of support resistors and capacitors. It will not be too long before an A/D converter is available that can be directly connected to the inputs that will include programmable level and sensitivity adjustments.

• *Trigger Circuits:* The beginning of each horizontal trace is usually started or triggered by the input signal train. You can select a specific voltage that the input signal must pass through (DC mode) or a voltage greater or less than the reference point set by the VERTICAL POSITION control (AC mode). Using SW1, you can also select the direction or slope of the signal. For example, if you select a + trigger slope, the trigger circuit will generate a trigger signal (low-to-high) at pin 7 of U26 only if the input

is going from low to high. If you select a - trigger slope, the input produces a trigger signal only if the input is going from high to low.

TRIGGER GAIN control R26 sets the trigger point. In most cases, you set R26 to maximum. Chip U26 is a simple high-speed comparator. TRIGGER SLOPE switch SW1 simply reverses the + and - inputs. When the + input is higher than the - input, the output will be + 5 volts. If the - input increases to the + input level, output drops to 0 volt. If you start with the - input higher than the + input, the opposite occurs.

The normal trigger signal must go from 0 to + 5 volts to start the address generator circuit, which will be described later. You can use TRIGGER SEL switch S4 to select which input will trigger the system. Choices are Channel A, Channel B, Logic Analyzer, Signal 0 or some external

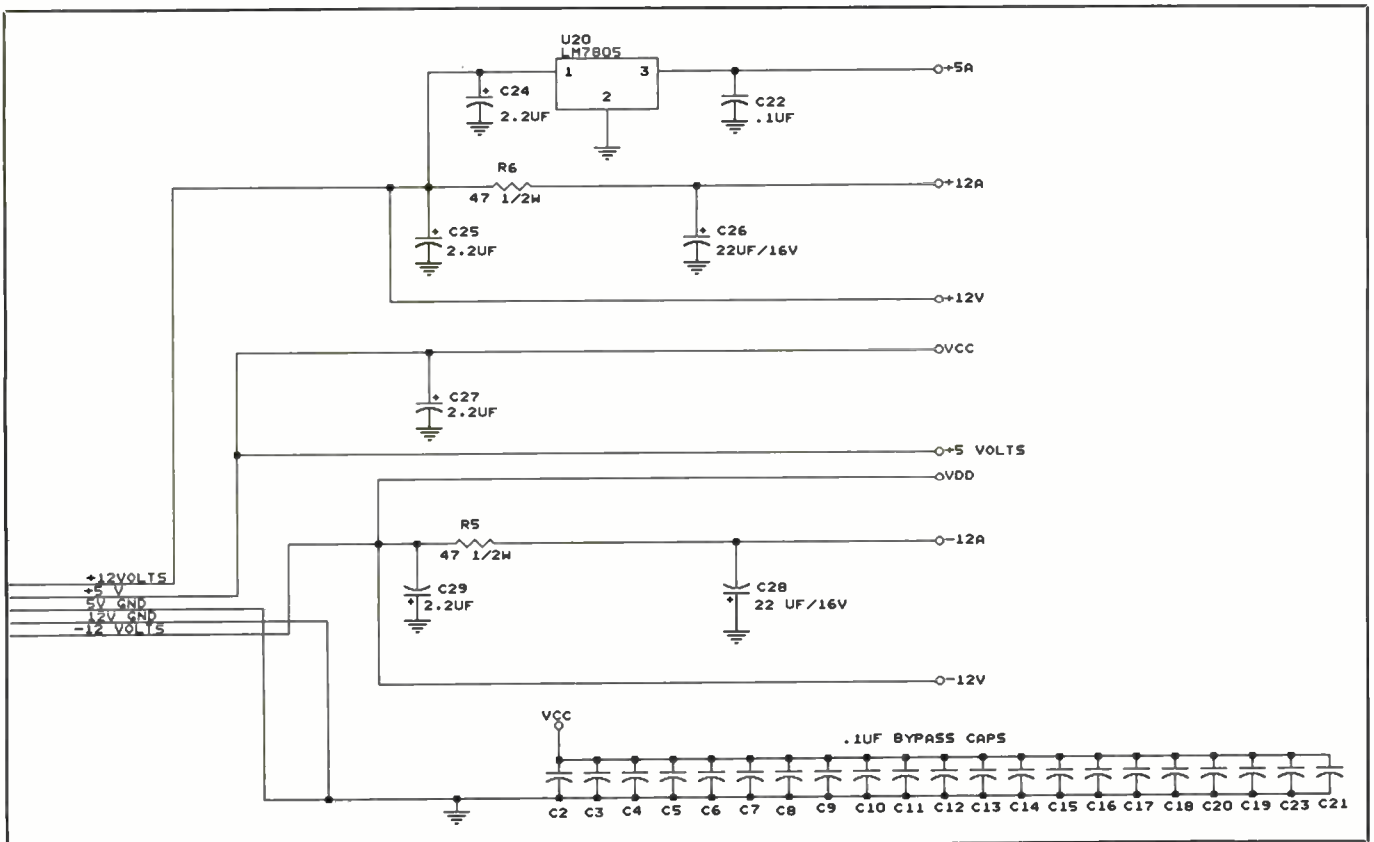


Fig. 6. Power supply required is straightforward in design.

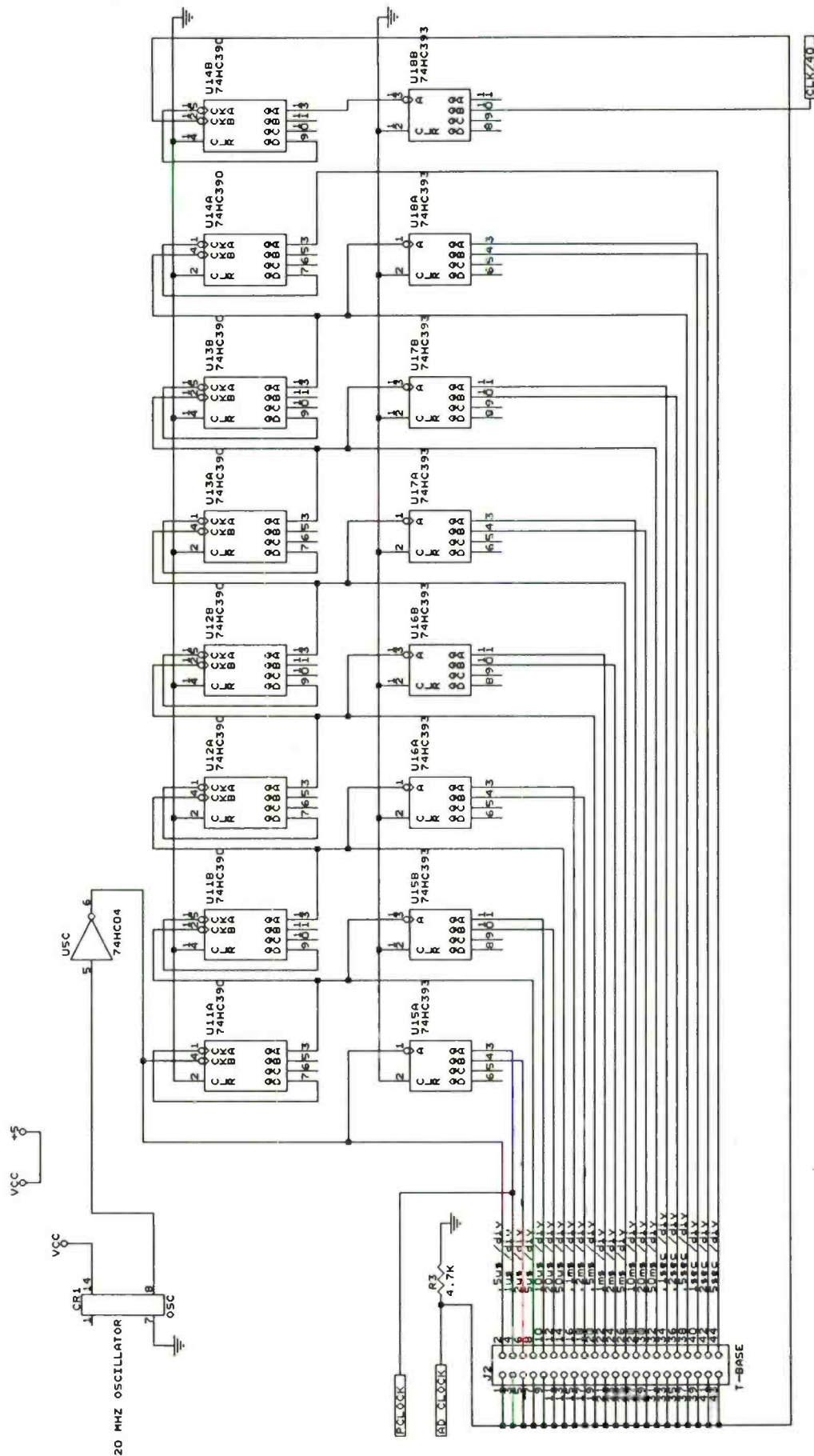


Fig. 7. Schematic details for timebase circuit.

source. The trigger circuit can be set to one of four different modes.

In AUTO mode, the trigger is generated by the timebase generator signal divided by 40 (CLK/40). LEVEL, SLOPE and GAIN controls have no effect. This mode is not used frequently and is generally employed to make the signal display on the screen. The most common mode is NORMAL, described above. Just set trigger controls for the desired display. Note that the display blinks slightly every 0.3 second. This blink occurs when the program is reading the data RAM and moving data collected to the display area in system RAM.

Once you have the display you wish to study, press ARM/FREEZE switch S5 to freeze the display. SINGLE STEP mode is used if only one pass of the signal is desired. To use this mode set TRIGGER MODE switch S2 to SINGLE STEP; then when you are ready to wait for the trigger, press S5. The trigger circuit will then wait for a trigger signal. After this signal is received, data is stored and displayed. To repeat single-step action, press S5 again. The last selection in S2 selects if the trigger signal used is ac or dc coupled. Note that EXT TRIG input J8 is ac-coupled only.

Logic Analyzer Circuits

The optional eight-channel logic analyzer's inputs are shown in Fig. 4. The program produces the LOGIC ANALYZER WR \ signal that connects inputs buffered by U19 to the data RAM data inputs when incoming data is being written to the RAM. The LA TRIG signal from input data line D0 is coupled to TRIGGER SEL switch S4 through buffer U27A. These inputs are pulled high. So, when an input is not being used, the display will indicate a high level for that input.

The input cable assembly consists of a 14-conductor ribbon cable with nine hook connectors. This provides a ground wire between each connec-

tion, which reduces coupling between inputs.

The A/D Converter

The A/D converter (see U25 in Fig. 3) is a high-speed flash-type unit that produces a six-bit digital output. To perform a conversion, the input circuit uses 64 comparators. It works as follows.

If the input voltage compared to bottom reference VRB at pin 10 of U25 is zero, the binary digital output will be 000000. If the input is the same as top reference VRT at pin 9, the binary digital output will be 111111. Should the input exceed the top reference, the OVERFLOW signal at pin 2 will be a 1. On the rising edge of the clock, comparator outputs are clocked into internal decoders. On the falling edge of the clock, digital output is clocked to the output pins. See Fig. 9.

Now we get into a slightly tricky area. Note that output signals of U25 connect to data lines of data RAM U28, the data side of the U21 input port and to outputs of logic analyzer latch U19. These chips cannot be activated at the same time.

The program, via Port B of the 8155, supplies signals that select or connect the proper chips as they are required. A/D converters are selected only when the AD WR \ is low. This puts the CE1 \ line at pin 6 low, activating U25 and connecting it to U21 while data is collected. This occurs only if you selected Channel A or B and the proper trigger conditions have been met.

If you select the logic analyzer, the program will supply a low at LOGIC ANALYZER WR \ pin 1 of U19. Thus, logic analyzer inputs are connected to data RAM, permitting data collected to be stored in the RAM. Data RAM U21 transfers data stored in it through a program that places data in the display RAM area. It does this in the format required for it to be sent to the LCD display.

Timebase Generator

The timebase circuits (see Fig. 7) are simple enough. 74HC393s are used to divide by 10 the input to pins CKB. The output at pins QA is a square wave with $\frac{1}{10}$ the frequency of the input. The 74HC390s divide Input A by 2 at the QA pins and divide Input A by 4 at the QB pins.

You begin with a 20-MHz oscillator and divide by steps of 2, 4 and 10. This produces a timebase with industry-standard 1/2/5 separations. Output PCLOCK provides the 10-MHz clock to the CPU. Other outputs, selected via J2, supply timebase signal AD CLOCK to the address generator, the A/D converter and data RAM. You use the signals produced by these circuits to adjust frequency-compensation capacitors to obtain a flat frequency response in the analog input attenuator.

Data RAM Address Generator

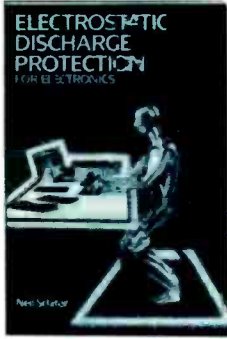
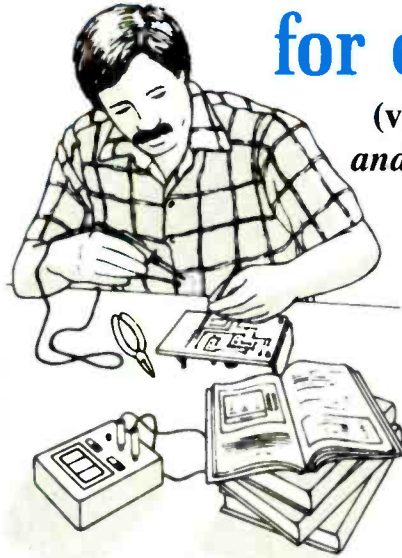
The address generator (Fig. 8) is used exclusively to produce addresses for the data RAM. In data write mode—that is, when the A/D or logic analyzer is writing data to the data RAM—the addresses to data RAM must be generated in synchronization with data being supplied by the A/D converter or logic analyzer. Therefore, they are indexed or incremented by the AD CLOCK signal.

When the CPU wants to read the data RAM, addresses to the RAM are not supplied by the CPU. Instead, data RAM is read by the CPU like an I/O port. The RAM addresses are indexed by the chip-select signal generated by the I/O decoder signal, CS FX \ . See Fig. 9 for the timing diagrams. The logic analyzer can be very useful when verifying the timing of these kinds of signals.

The addresses needed are generated by the dual four-bit-counters inside 74HC393 U29. The address generator is first set to zero by the CLEAR CTR

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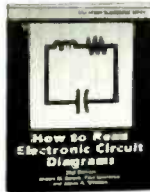
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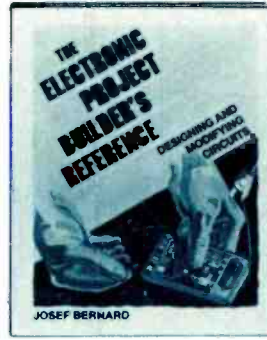
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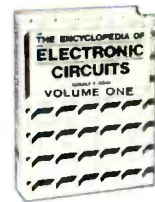
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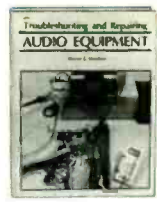
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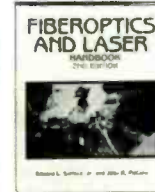
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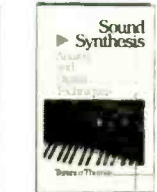
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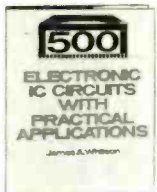
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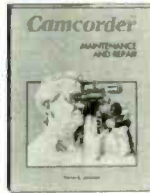


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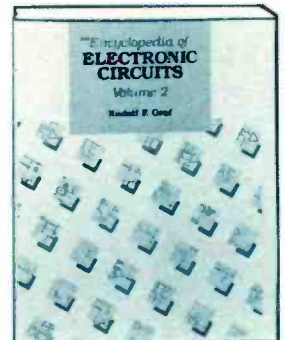
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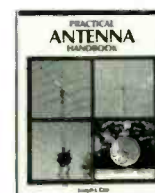
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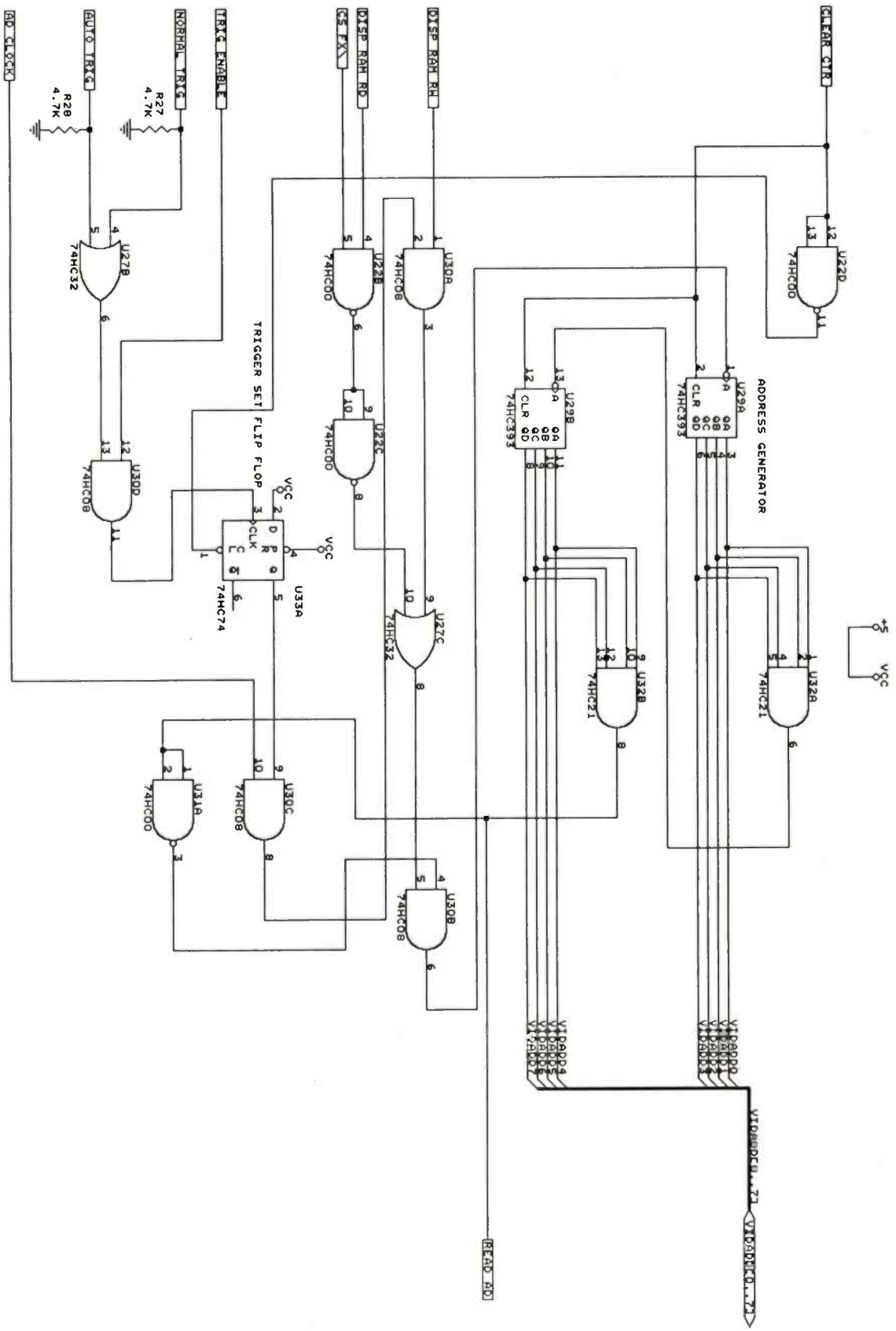


Fig. 8. Circuit details for data RAM address generator.

signal generated by the CPU. This sets the counter's outputs, which are the address signals to 00000000. Every input count (high-to-low transition) increments the address by one. Every 16 counts produces a binary 1111 to appear at the inputs of *U32A*. This produces a high at the output of *U32A*. The very next count produces a low-going pulse at the output of *U32A*, thus generating a count at the input of second counter *U29B*.

When the second counter reaches 16 counts, all outputs are high, or 11111111. Consequently, addresses generated increase from 00000000 to 11111111 (binary), from 0 to 255 (decimal) or from 0 to FF (hex). After reaching the last address, the output of *U32B* goes high, signaling the CPU via the READ AD signal that the data RAM is waiting to be read and displayed.

Input counts to the counter are generated by either the AD CLOCK or

the CSFX \ signal. If the CPU is reading the data RAM, addresses are indexed or generated by the falling edge of the CSFX \ signal. However, if addresses are generated to be used as addresses while writing data to the data RAM, inputs to the counter are generated by the falling edge of the AD CLOCK signal.

The CPU issues a high to the DISP RAM WR line to open the channel of AD CLOCK pulses to the counter if the proper trigger has been set. Note that the *U33* flip-flop is reset at the same time as the counter is set to zero. Once the trigger has been satisfied by either a normal or auto trigger signal, the gates are opened. This action allows the AD CLOCK signal to index and generate addresses. If the CPU is reading the data RAM, it generates a high at DISP RAM RD. This allows the CSFX signal to index the counter, thus producing the addresses for the data RAM read cycles.

Power Supply

The power supply, shown schematically in Fig. 5, is "plain vanilla" in design. You must supply a regulated +5 volts at 350 mA and ± 12 volts at 100 mA. Note that a separate 5-volt supplies reference voltages to the A/D converter and trigger comparator. This decouples the digital and analog supplies to reduce coupling of digital pulses and noise into the analog channels. Be sure to locate the transformer away from the analog inputs to avoid any stray electrical fields and noise.

Program Software

Software required for this project is basically very simple. The tasks are illustrated in Fig 10. When the system is turned on, or RESET switch *S1* (Fig. 2) is pressed, the CPU starts at the beginning of the task list. First it performs a bit of system management,

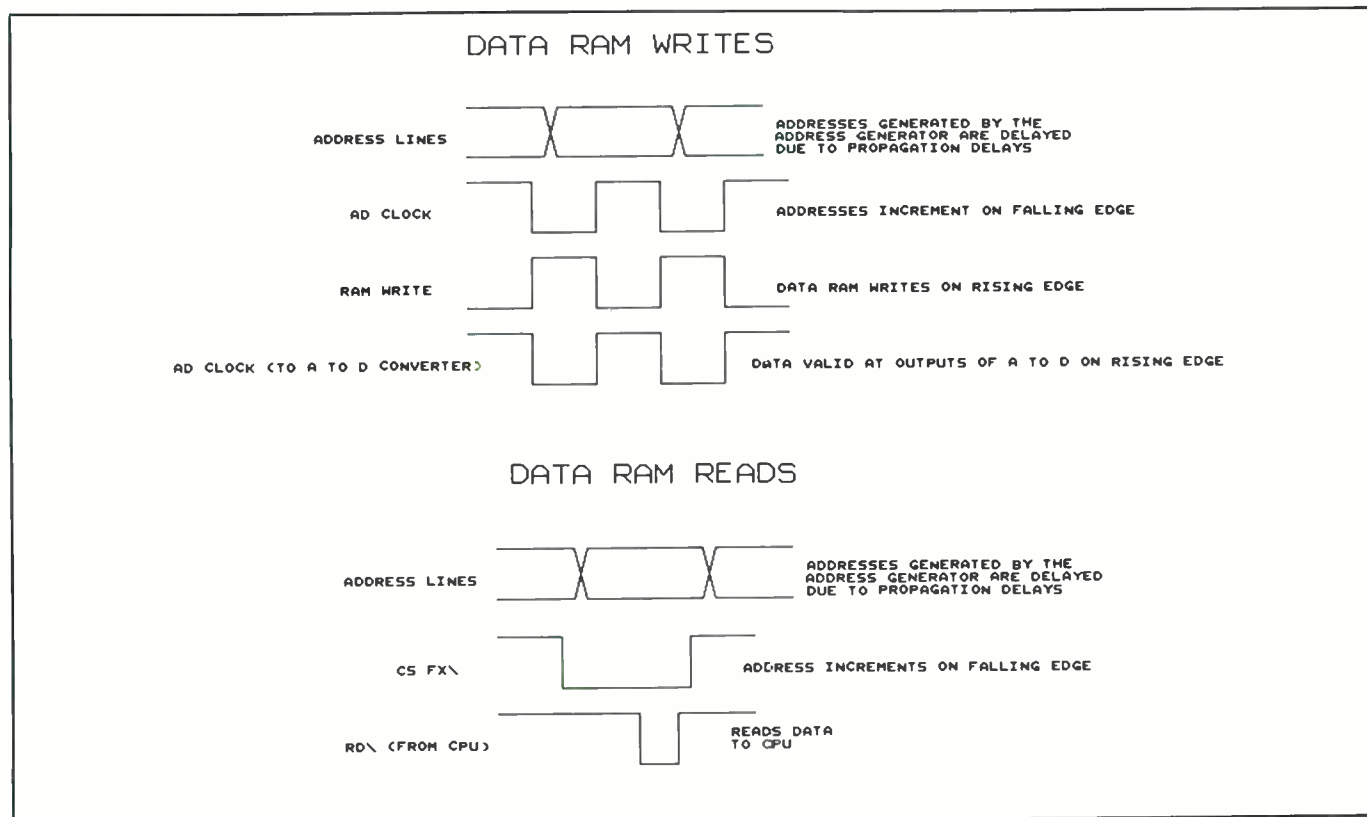


Fig. 9. Timing details for data RAM writes and reads.

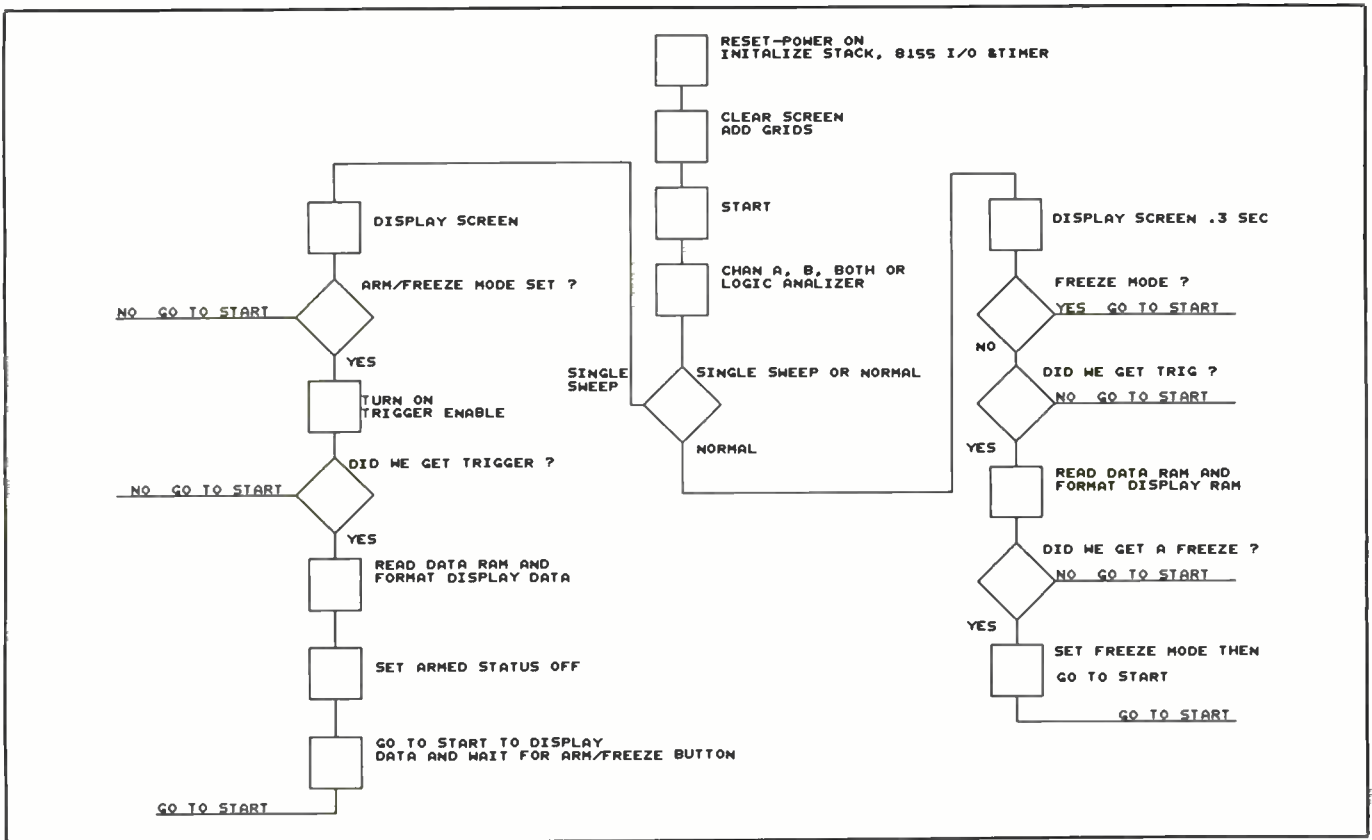


Fig. 10. Software details for simple program required for project.

setting up a stack pointer and initializing the 8155 ports and timer. Next, it fills the display RAM area with 0s to clear the screen and the data to add the display's grids.

The program then looks at the various mode switches to set up for display of Channel A, Channel B, both, or the logic analyzer. Additionally, it concludes if you set up in the Single Sweep or Normal mode. If Single Sweep is selected, the program displays the cleared screen and waits for you to press the ARM/FREEZE button. While it is waiting, the CPU is constantly refreshing the screen. Once you press the ARM/FREEZE button, the system is armed and awaits a valid trigger.

When the trigger arrives, the counter starts generating data RAM addresses and stores data being collected in data RAM. (During the collection time, the LCD display is still being refreshed.) When data RAM

has collected 256 slices of data, the address generator signals the CPU that it is ready to be read. The CPU responds by stopping everything to read the data RAM. It then formats data collected and places it in the previously cleared display RAM area. Now the data collected is displayed on the screen. In Single Step mode, the data is displayed until the ARM/FREEZE button is pressed again. The program constantly checks to see if you pressed the button or if you changed your mind and switched to another mode.

If you selected the Normal mode, much the same occurs, except that collected data is displayed for only 0.3 second at a time. If during that time a valid trigger occurs and different data is collected, the CPU collects that data and places it in the format required by the display. Display off-time is about 25 ms. During this time, the CPU reads the data RAM and re-

formats the display RAM. This results in a slight blinking of the display. The program constantly waits to see if you pressed the ARM/FREEZE button, which freezes the current display. This action eliminates the blinking. If you again press the ARM/FREEZE button, the trigger is re-enabled and the scope continues to capture and display new data.

Testing the Scope

After assembling the DSO from plans presented in this article, here are the steps you should follow to test the instrument:

- (1) Set TRIGGER MODE to NORMAL.
- (2) Set trigger coupling to AC.
- (3) Set TRIGGER SLOPE to + or -.
- (4) Set TRIGGER GAIN to maximum and TRIGGER LEVEL to center of rotation.
- (5) Set RANGE to 1V/DIV.
- (6) Set IN SEL to AC.

(7) Feed a 5-kHz square-wave signal into input J6 or J7.

(8) Set the input level, VERT GAIN and VERT POSITION to obtain a centered display. If you do not have a signal generator, see below. Adjust trimmer C44 to obtain a square wave.

(9) Set RANGE to the .1V/DIV, and reduce the input signal level to obtain a centered display.

(10) Adjust trimmer C43 to obtain a square wave.

(11) Set RANGE to .01V/DIV and adjust the input to obtain a centered display.

(12) Adjust trimmer C42 to obtain a square wave.

If you do not have a signal generator, connect the scope input to pin 4 of U16. Set the timebase to 20 μ s/div. The input will be approximately 5 volts. To reduce the input voltage as required in the following steps, connect a 2,000-ohm variable resistor from pin 4 of U16 to ground. Connect the wiper to the scope input. Then adjust the resistor to center displays for the rest of the adjustments.

To make sure that you have the ac drive signal at the display, set the RANGE switch to 1V/DIV and connect the scope input to pin 3 on the display. Then set the timebase generator to 5 ms/div. You should see a square wave with a 40-millisecond period in the display.

The only other adjustment is for vertical sensitivity CAL control R23. This can be made by setting the IN SEL switch to DC and measuring the dc voltage at the output of U20. Set the CAL control so that the baseline moves five divisions when connecting the input of the scope project to the output at U20.

Next month, the series will show you how to build a function generator and lay the ground for putting together a digital signal generator. Upon completing the instrument foundation, a host of application experiments will follow in later issues that utilize these test/research/development instruments. **ME**

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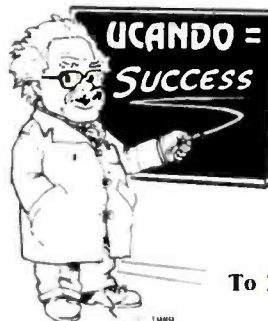
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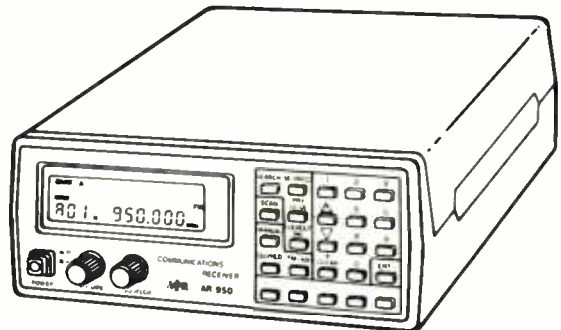
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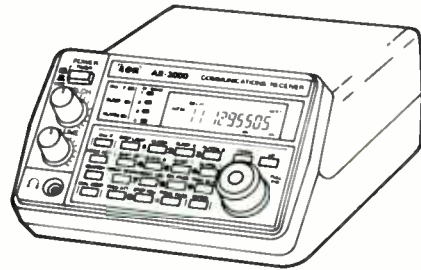
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Sensitivity: .4uV Lo,Hi. .8uV Air. .5uV UHF. 1.0uV 800
Scan Speed: 15 ch/sec.
IF: 21.4MHz, 455KHz
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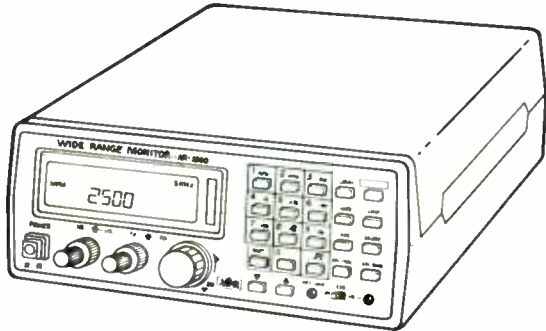
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| Earphone. | EP200 | \$2.00 |
| External Speaker. Mobile Mount. | MS190 | \$19.50 |
| Extended Warranty. 2/3 yrs. | | \$65/75 |
| Mobile Mounting Bracket. | MM1 | \$14.90 |
| RS232 Control Package | SCS3 | \$295.00 |
- (software & cable) offers spectrum display and database.

Specifications:

- | | |
|--------------|---|
| Coverage: | 100KHz - 2036MHz |
| Sensitivity: | .35uV NFM, 1.0uV WFM, 1.0AM/SSB/CW |
| Speed: | 20 ch/sec. scan. 20ch/sec. search |
| IF: | 736.23, (352.23) (198.63) 45.0275, 455KHz |
| Increments: | 50Hz and greater |
| Selectivity: | 2.4KHz/-6db (SSB) 12KHz/-6db (NFM/AM) |
| Audio: | 1.2 Watts at 4 ohms |
| Power: | Input 13.8 V. DC 500mA |
| Antenna: | BNC |
| Display: | LCD |
| Dimensions: | 3 1/7H x 5 2/5W x 7 7/8D Wt. 2lb 10oz. |

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| Mobile Mounting Bracket. | MM1 | \$14.90 |
| RS232 Control Package | SCS2 | \$295.00 |
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Specifications:

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|--------------|------------------------------------|
| Coverage: | 1 MHz - 1500MHz |
| Sensitivity: | .35uV NFM, 1.0uV WFM, 1.0AM/SSB/CW |
| Speed: | 38 ch/sec. scan. 38 ch/sec. search |
| IF: | 750.00, 45.0275, 5.5MHz 455KHz |
| Increments: | 5,12,5,25 KHz |
| Audio: | 1.2 Watts at 4 ohms |
| Power: | Input 13.8 V. DC 300mA |
| Antenna: | BNC |
| Display: | LCD, backlighted. |
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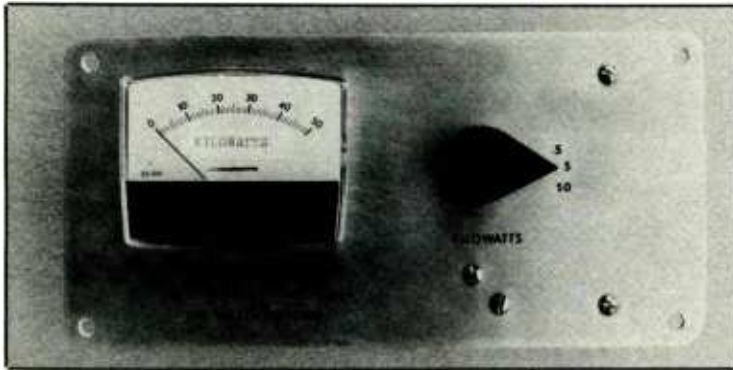
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The "Watt Watcher"



Inductive-pickup meter monitors instant ac power usage so that you can more efficiently manage energy consumption

By Dennis P. Blum, CET

The kilowatt-hour meter your local utility company installed on or in your home measures electric power consumption. However, being an accumulating device, it is not overly useful for the homeowner who wants to monitor power used for conservation purposes. The "Watt Watcher" described here, on the other hand, displays actual power usage in kilowatts from moment to moment without ambiguity. Any change in load, such as a refrigerator switching on or a lamp being switched

off, immediately registers on a built-in meter movement.

The metering system consists of two inductive-pickup devices you mount inside your electrical service box (no potentially hazardous connections are required) and a remote indicating panel meter and driving circuitry. The circuit is self-powered, eliminating any need for a battery or connection to the ac line.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Watt Watcher

circuitry. Inductive pickup coils *L1* and *L2* are remotely located from the circuitry, in the electrical service box. They provide a voltage to transformer *T1* that is directly proportional to the amount of current flowing in each leg of the ac power line supplying your home.

Any voltage that appears at the input to *T1* from *L1* and *L2* is stepped up by transformer action and applied to the full-wave bridge rectifier circuit made up of diodes *D1* through *D4*. After rectification, the pulsating dc from the rectifier circuit is filtered to pure dc by capacitor *C1* and passed

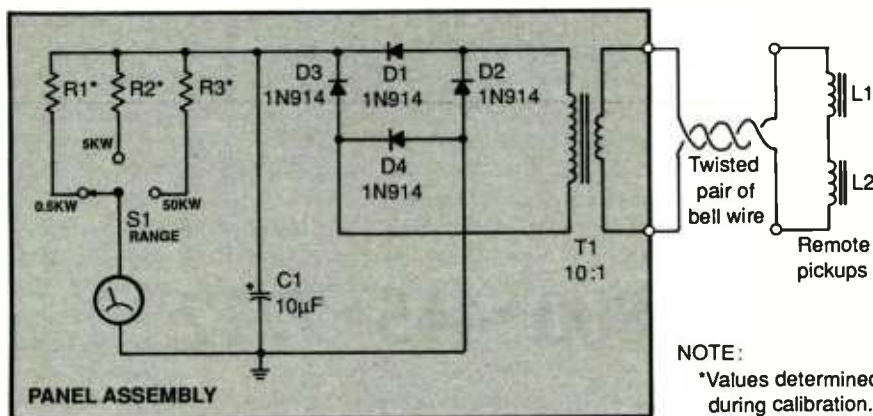


Fig. 1. Complete schematic diagram of circuitry used in the Watt Watcher.

PARTS LIST

- C1—10- μ F, 10-volt electrolytic capacitor
- D1 thru D4—1N914 or similar diode
- L1, L2—Inductive pickup coil (see text)
- M1—50- μ A full-scale analog panel meter movement (Radio Shack Cat. No. 270-1751 or similar)
- R1, R2, R3—See text for value
- S1—3-position, non-shorting rotary switch
- T1—12.6-volt power transformer (Radio Shack Cat. No. 273-1365 or similar)
- Misc.—Suitable enclosure; transformer for pickups (see text); two multiple-lug terminal strips; control knob for S1; twisted-pair bell wire; tape; cable ties; foam rubber; machine hardware; hookup wire; solder; etc.

NOTE:
*Values determined during calibration.

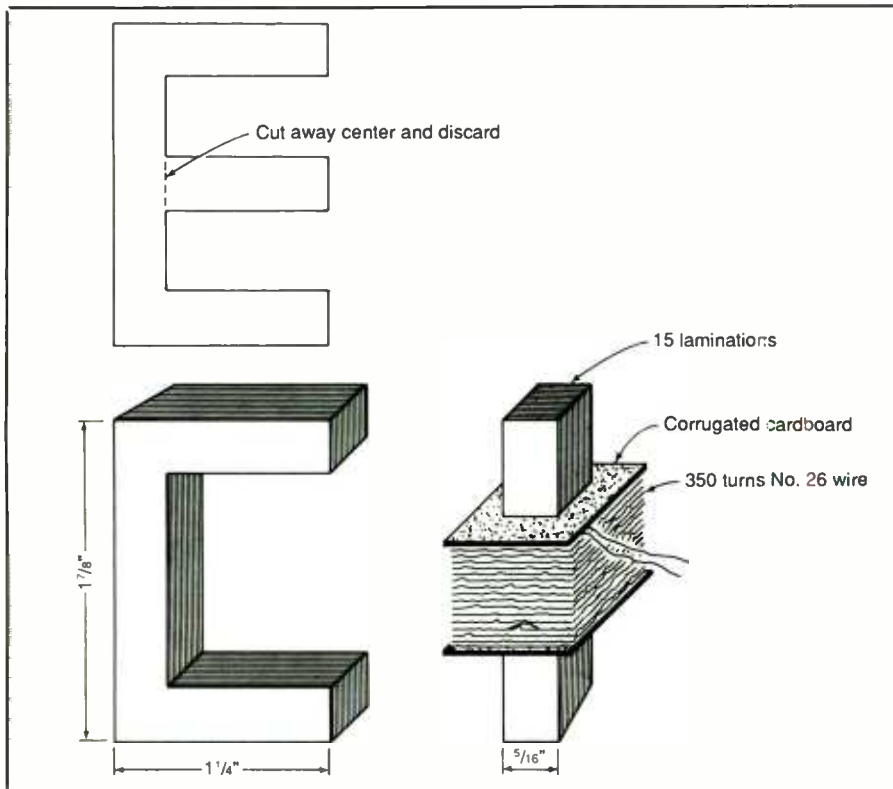


Fig. 2. Inductive pickups are built around laminations salvaged from a small power transformer.

through one of the three resistors, via switch *SI*, to meter *M1*.

Resistors *R1*, *R2* and *R3* are in the circuit to provide calibration for the meter to register accurate readings. The values of these resistors are determined during calibration of the project. Switch *SI* provides range-selection capability.

Construction

Begin construction by fabricating the two inductive pickup assemblies. For these, you need laminations salvaged from a small power transformer. A defunct small home stereo unit or other light-duty electronic device may have just what you need. Otherwise, purchase a new power transformer and use it.

The laminated core of the transformer you use must have "E" and "I" shaped laminations, as illus-

trated in Fig. 2. The transformer used for the prototype had laminations that measured approximately 2 inches square and contained 30 each "E" and "I" laminations, half of which were used for each pickup assembly.

As shown in Fig. 2, you must remove the center bar of each "E" lamination with sheetmetal shears or a hacksaw. If you use a hacksaw, clamp five or so laminations between two pieces of lumber and secure in a bench vise while cutting. In either case, once you have removed all center bars, make sure each lamination is as flat as possible. Then stack the now "C" laminations in two separate and equal piles and tape them together. Do the same with the "I" laminations.

Around each "I" lamination stack, wind 350 turns of No. 26 magnet wire. There is no particular need to be neat about the windings, but the

neater they are, the more compact the assemblies. If you wish, you can cut pieces of corrugated cardboard and place them at opposite ends of the "I" laminations to serve as bobbin ends, as shown.

When you finish winding both coils, secure the winding in place with electrical tape. Then carefully scrape away all enamel from both ends of both coils for a distance of $\frac{1}{2}$ to 1 inch and tin with solder.

Dimensions shown in Fig. 2 are for reference purposes only. Your assembly may have different dimensions, depending on the particular power transformer used. Any difference in output voltage can be compensated for during calibration by selecting appropriate values for the three resistors.

Temporarily set aside the pickup-coil assemblies and proceed to building the main circuit. This circuit is quite simple in terms of number of components. You can assemble it using point-to-point wiring and two multiple-lug terminal strips, as illustrated in Fig. 3.

Machine the meter panel as needed. Drill mounting holes for the transformer, switch and terminal strips. Then cut an appropriate-size hole in which to mount the meter movement. When you are finished machining the panel, deburr all holes to remove sharp edges. Then mount the transformer, switch, meter movement and terminal strips in their respective locations.

Plan your component connections to the lugs of the terminal strip carefully. Trim leads to length and crimp them to the appropriate lugs of the terminal strips. Make sure when you are done that the diodes and capacitor are properly polarized. Defer installation of the resistors until after calibration.

Referring back to Fig. 1, interconnect the components with hookup wire. If you are using stranded hookup wire, strip $\frac{1}{4}$ inch of insulation

from both ends, twist together the exposed fine wires and sparingly tin with solder. Then crimp and solder the ends of the wires to the various locations in the circuit.

Determine where you will locate the Watt Watcher in your home and mount its enclosure where it will be in easy view. Then determine how you will route the bell wires that will connect the main circuit to the remote inductive pickups. The simplest and most direct route is to drop straight down through a hole drilled through the floor and then to take the most direct route to the location in your basement (or elsewhere) where your main fuse box is located.

Having selected the wiring route to take, determine how long must be the bell wires. Add 6 feet to the measured length and cut the wires to the length needed. Run the wires along the route, using thumbtacks to secure them into place wherever possible.

At the remote end, temporarily connect the wires to the leads of the inductive pickup assemblies, wiring the latter in series with each other, by twisting together the wires. Do *not* solder any connections.

Installation of the pickups is simply a matter of placing the two sections of each assembly around the high-side conductors in your electrical service fuse box, as illustrated in Fig. 4. Do *not* use the ground wire when doing this.

Before you proceed with this portion of installation, keep firmly in mind that any work done inside the fuse box can be potentially lethal, even though you will be making no direct electrical connections to the ac line. Work carefully and touch only the insulated mains conductors.

When installing the pickups, strive for a zero gap in the magnetic circuits, or as near to it as you can get. This will assure maximum sensitivity. Use a cable tie at both ends of the assembly to secure it in place and foam rubber between the assemblies

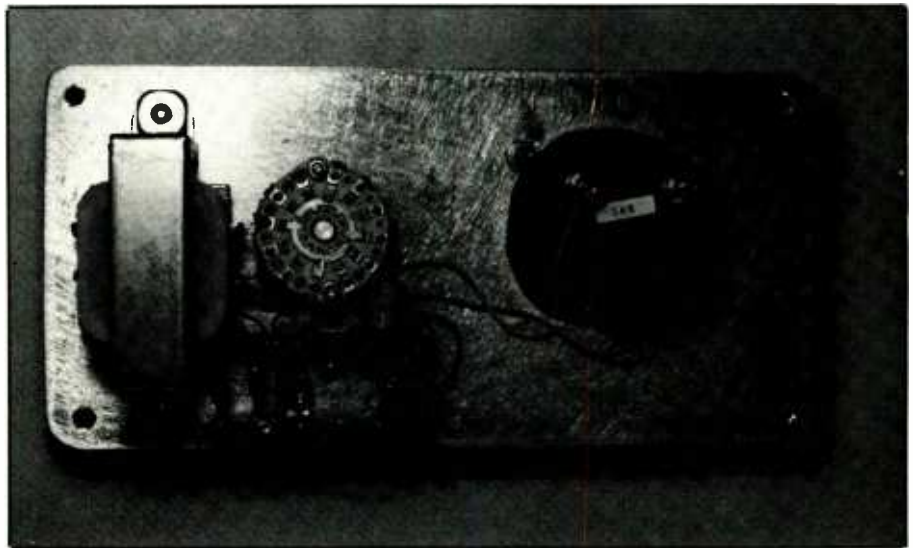


Fig. 3. All components, except pickups, mount directly on panel of project's enclosure, smaller ones with aid of two terminal strips.

and conductor to assure a tight fit.

At the other end of the bell wire, temporarily connect the two conductors to the unused leads of the transformer.

Calibration & Use

Before you can calibrate the circuit, you must check the phasing of the pickup coils to make sure that their effects are additive. Connect a resistance substitution box or 50,000-ohm potentiometer across the connection points for *R1* in the main circuit and set *S1* to the 0.5 kW position. Turn on a number of loads in your home, including at least one 220-volt appliance to assure that both high sides of the ac line are carrying current. Adjust the resistance box or potentiometer for a mid-scale reading on the meter.

Note the reading obtained. Then test the phasing of the pickups by reversing the leads of only one of the pickups. This may be easier to do if you have a helper to tell you what happens at the meter panel as you reverse connections. Connect the pickups for highest meter reading. Solder the connections and insulate them

with either small-diameter heat-shrinkable tubing or electrical tape.

Now use a number of loads whose power consumption is known (such as lamps with a certain wattage rating

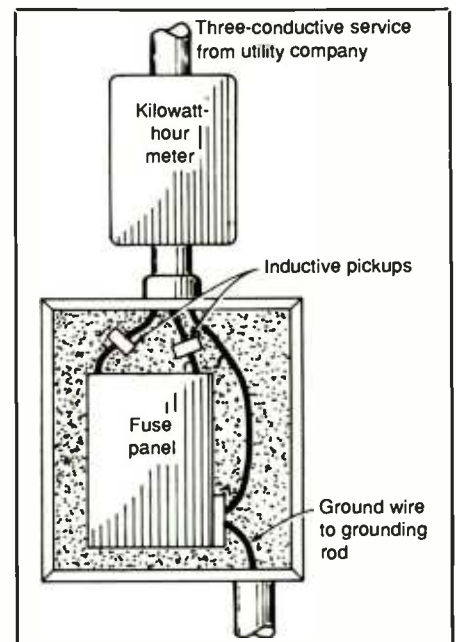


Fig. 4. Pickups must be positioned on insulated wires coming from utility company kilowatt-hour meter, before fuse panel.

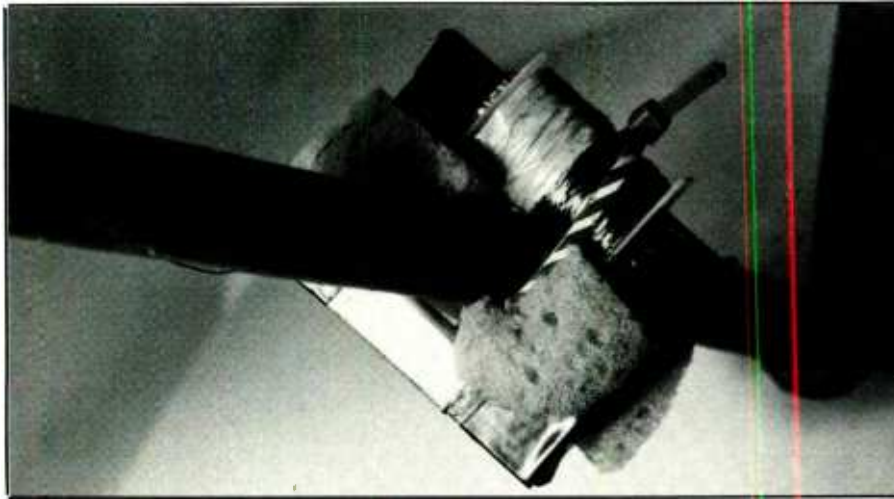


Fig. 5. Secure pickup assemblies to ac-line conductors with cable ties. Use pieces of foam rubber to assure a friction fit.

or an appliance that has a panel on it with the power consumption listed) to calibrate the meter. For the 0.5 kW range, a few table lamps or overhead lights will suffice to develop a

250-watt load for a center-of scale reading on the meter.

With the loads turned on, adjust the resistance substitution box or potentiometer for a reading equal to the

load. Note on a piece of paper the value of resistance needed for $R1$ to obtain this meter deflection.

Similarly establish loads for 2.5 and 25 kilowatts (you probably will not need the latter unless you have really heavy-duty appliances) to obtain the resistance values needed for $R2$ and $R3$, respectively. If you use a potentiometer instead of a resistance box for these two ranges, make it a 1-megohm unit. Once you know the values of resistance needed in all three cases, you can install the nearest 1- or 5-percent tolerance standard values to them. The tighter the tolerance, the more accurate the readings.

Once installation is done, you should educate all the members of your household on electric usage and its cost. At 10 cents per kilowatt hour, for example, the center points of the three ranges represent a per-hour cost of 2.5 cents, 25 cents and \$2.50. **ME**

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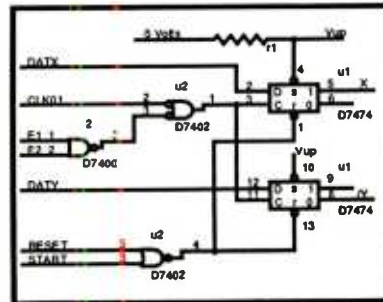
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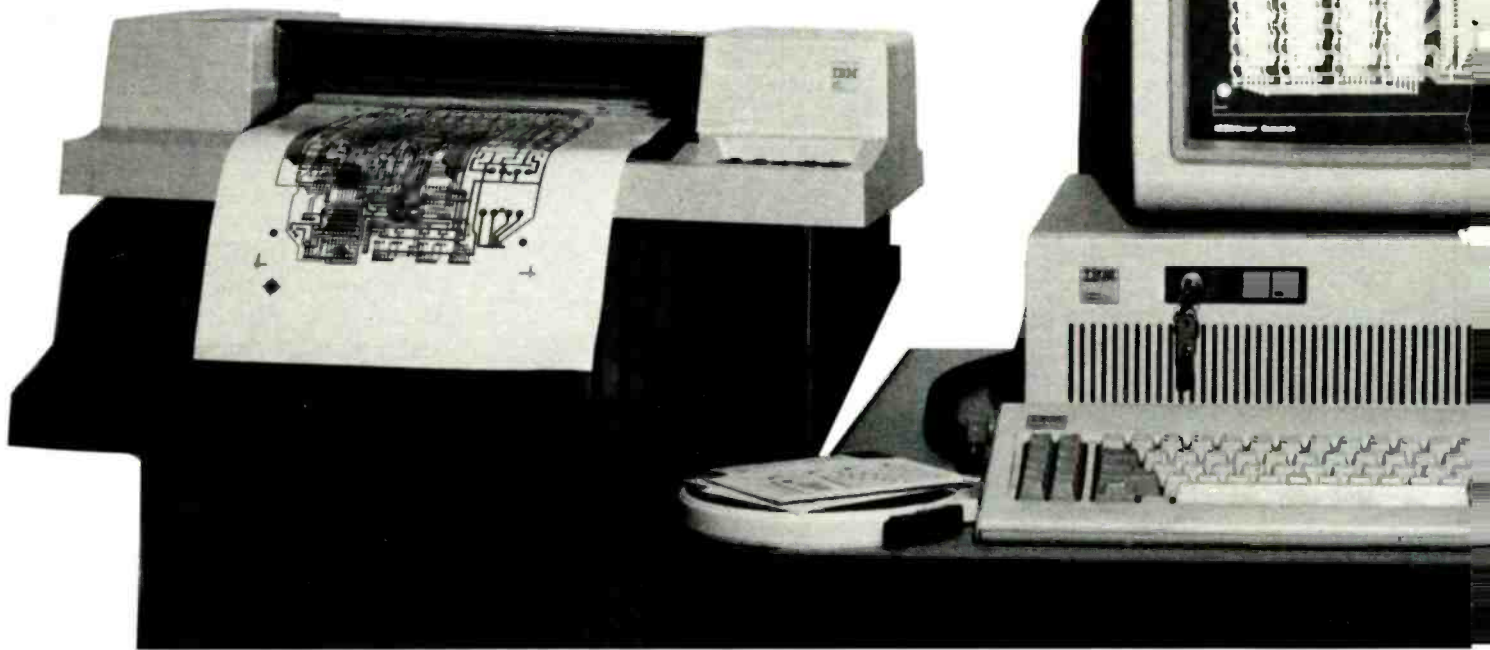


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Schematics From Your PC

(Part 2)

A close look at popular schematic capture programs



By TJ Byers

The fundamentals of PC software programs that let you draw electronic schematics were discussed last month. As cited, such programs can substantially reduce the time it takes to produce professional-quality schematics, compared to doing it manually. A key to their productivity is, of course, their capacity to make drawing revisions on-screen, rather than on drafting paper. Moreover, you don't need any drafting skills.

The better programs, called schematic capture programs, also have provisions to produce data from schematic drawings to make printed-circuit-board layouts, emulate actual circuit performance, and compile Bills of Materials. All the programs reviewed here can produce such information in the form of netlists. These files are generated in ASCII format and are, therefore, easily edited with a word processor. In ad-

dition, schematic capture programs enhance accuracy through automatic Design Rule Checks that might include short-circuit checks, flagging duplicate component designations, and more.

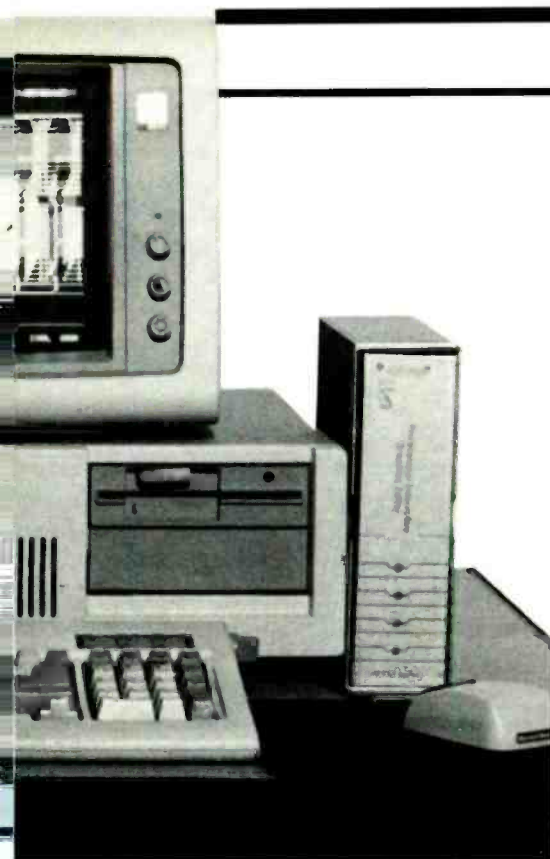
The extra ability to lay out PCBs from netlist files can be produced by PCB layout programs you have or through third-party companies. Some schematic capture programs also include an integrated PCB design program. Additionally, schematic capture programs usually have greater component libraries and more sophisticated operating features than plain schematic drawing programs. Of special importance to designers is the Bill of Materials (BOM) netlist these programs produce. The BOM lists all the components used in the circuit and can be employed to create purchase orders.

Here we examine eight popular schematic capture programs and evaluate them for performance and features. They are *EE Designer*, *HiWIRE*, *OrCAD/SDT III*, *ProCAD*, *Protel-Schematic*, *Schema*

III, *Super CAD* and *Tango-Schematic II*. Three of them—*EE Designer*, *HiWIRE* and *ProCAD*—also allow you to make printed-circuit board layouts directly from the screen schematic. *EE Designer* further provides analog and digital circuit simulation to give designers an idea of how the circuit actually performs without requiring hardware prototyping.

Prices of the programs range from \$99 to \$995. The ones that have PCB layout capability too are priced at the top end, of course. PCB software is more complex and, therefore, generally more costly than schematic capture software. For example, whereas Omaton's schematic program is priced at \$495, its *Schema-PCB* software starts at \$975, for a total of \$1,470 if you want both.

An integrated schematic/PCB program can be desirable because the user has a sort of seamless group of programs that utilize the same operating conventions. Also, the combination is generally less expensive than buying separate programs of equivalent power.



Schematic capture programs alone, on the other hand, give you the flexibility of choosing what you believe to be the most suitable printed-circuit-board program, and vice-versa. Another consideration for choosing only schematic capture is that you may not wish to produce your own PCB layouts, intending instead to farm out your netlists to third-party PCB layout specialists.

You can expect the lower-cost software to have more shortcomings in one form or another, naturally. We chose an approximate \$100 price mark for schematic capture programs as our bottom cutoff point for reviews since cheaper ones display too many severe limitations for any really serious work. The top-price ones, usually integrated schematic capture and PCB layout packages, were limited to those under \$1,000. Only their schematic capture attributes are examined here! Their PCB design capabilities will be looked at some other time.

The number of parts contained in the component library is a very im-

portant element of a schematic capture program. Libraries range from 350 to 11,000 devices for the packages we examined. Bear in mind, though, that the number of devices listed in a library can be deceiving. For instance, a gate with an ANSI symbol and an alternate DeMorgan symbol would be counted as *two* components. Also, a device might count as four or more components if a single device symbol cannot be manipulated for rotation purposes by a program editor. That is, you would have to choose the symbol at a particular angle from those in the component library.

Then, again, there might be a single component body that's listed in a library with different names to account for suffix changes that signify minor differences (plastic body or what-have-you). Taking all this into account, the 11,000 count noted above, for example, breaks down to at best 3,500. Actually, this reduced amount is a powerful number of devices. All the programs allow the user to create his own device, too.

All but one component library, *EE Designer*, are made up of several library modules, allowing you to delete unused libraries from your hard disk in the event you have a space shortage. One program, *Schema*, has a data-compression feature for libraries to minimize data space used. Library modules are typically divided according to either generic types (such as TTL, CMOS, PAL, etc.) or by manufacturer (Intel, Motorola, etc.).

In normal schematic drawing work, the screen can show only part of the sheet; so you generally have to move it to get to a different section. Five of the programs have autopan, which automatically scrolls the worksheet when the cursor touches the edge of the screen, enhancing efficiency. All the programs have a zoom function to magnify an area. Some provide minimal zoom effect,

while others (*Protel* and *ProCAD*) exhibit unlimited power.

One program, *HiWIRE*, won't let you disable the ortho drawing mode, making it impossible to draw diagonal lines or wires. Six programs have on-line help. All support both flat and hierarchical drawings.

Two programs have a hardware security device called a "dongle" that must be plugged into the parallel printer port before the program will load. The printer then plugs into the dongle and operates as though the dongle wasn't there. One program, *ProCAD*, is copy protected, allowing a copy to be loaded onto only one hard disk at any one time.

Hard-copy printout ability varies considerably among the programs. A few let you fit the drawing to the page size, and all but one support a plotter directly. The amount of printer or plotter control you have from the software also varies greatly, ranging from no control to full control.

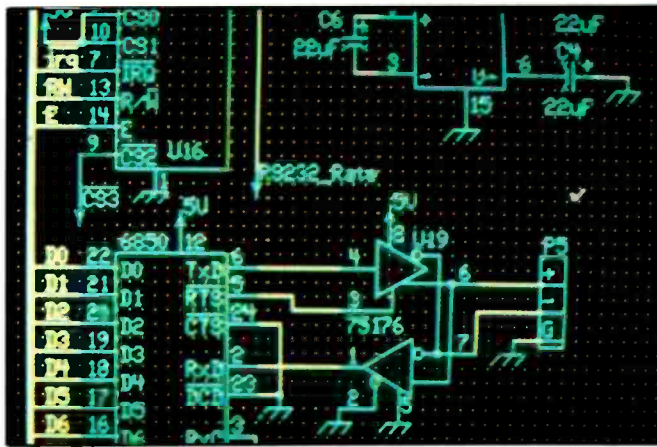
Many of the programs provide support for working with other allied programs. This might include conversions for use with much costlier professional CAD programs, such as *AutoCad* and *P(ersonal)-CAD*, and circuit-simulation packages such as *P Spice*, *Simulog*, and others.

You should make a buying choice based on your near-future or even more distant needs, as well as budgetary considerations. It's certainly desirable to get a demonstration disk from the software company, which most offer for free or for a modest charge, usually \$10. It is typically deducted from the program's price if you buy it. The demos will give you a feel for what the product can do . . . or cannot do. Interactive CAD Systems, alone among the companies, offers its *complete ProCAD* program on a demonstration basis. It has a built-in software counter that locks you out after 50 uses.

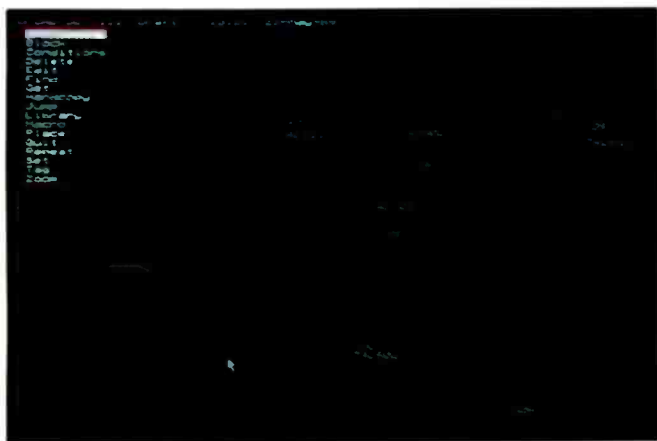
Individually, here's how the programs stack up.



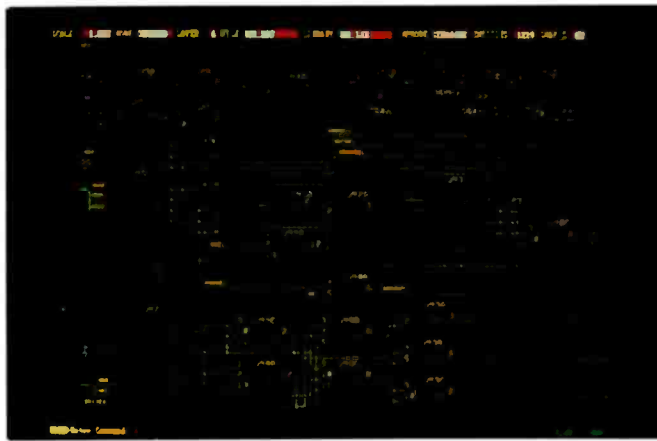
EE Designer III



Hi-WIRE-Plus



OrCAD/STD III



ProCAD Xtra

EE Designer III from Visionics Corp.

EE Designer III is the costliest software package among our reviews and also the most difficult to learn. But for your \$995, you also get PCB software for converting schematic capture files into functional printed-circuit boards, plus analog and digital logic circuit simulators that catch design errors before they become hardware problems.

To use the advanced features EE Designer offers, you have to add 1.5MB of LIM-compatible RAM to your PC—not a cheap trick. Without the extra memory, you can run the

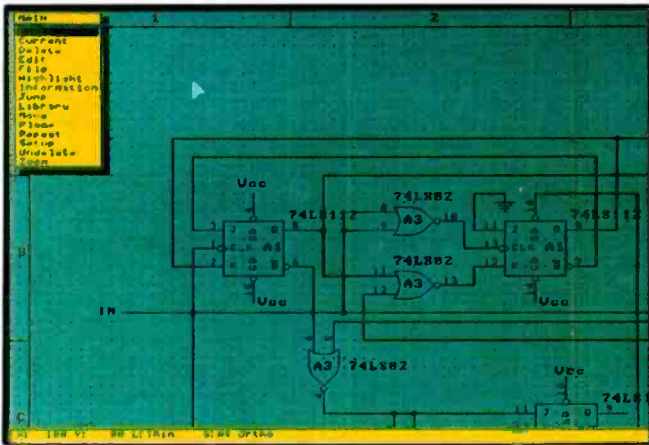
program in only the demo mode, which doesn't support PCB layout or circuit simulation. The program requires use of a provided copy-protection hardware connector in order for it to operate.

Using EE Designer can be tedious. First you have to memorize dozens of commands, then navigate a labyrinth of menus to find them. Fortunately, each command has a related keyboard key that reduces the number of times you have to drag and click on the mouse, making the program easier and faster to use—once you have

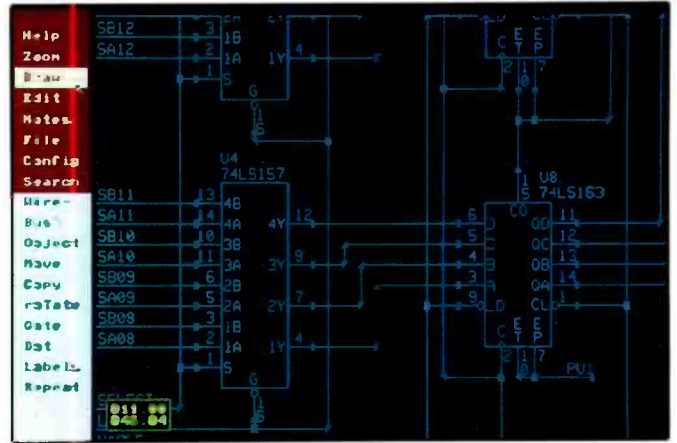
mastered the technique.

The component library consists of about 1,250 devices stored in a single library module that consumes almost 4MB of hard-disk space. This is a fair, though not rich, number of devices for a program of this caliber. However, you'll also want to keep the 40-page library catalog close at hand because there is no on-screen listing for the devices.

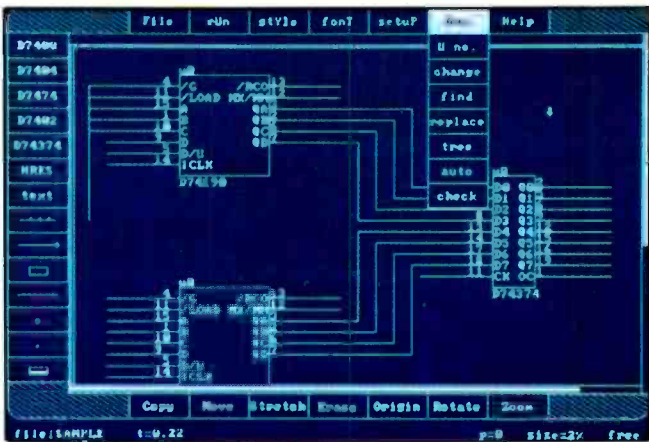
Components are called up from the library by typing their names into a component reference box in one of the many menu paths. Multiple



Protel-Schematic



Schema III



SuperCAD



Tango-Schematic Series II

placement of a part can be made using a single mouse click. New parts are added by erasing the old part name from the component reference box and entering the library name of the new device. Components can be rotated and mirrored during or after placement. *EE Designer* also has an automatic parts placement routine that optimizes the parts location on the drawing after you've entered them, but the layout isn't always the most practical for a schematic, and the function is really intended to benefit the PCB layout section of the program.

References to the device can be placed on the schematic at the time

the part is laid down or after the drawing is completed. If you choose the automatic naming routine, the parts are numbered in the order they were placed on the drawing, with *EE Designer* grouping multiple-gate packages in a sequence that is beneficial to the PCB layout software.

Using the library editor, you can change, move, delete or add reference lines to a component. There's no limit to the number of reference lines you can have, their location or their font size—provided it's within the scope of *EE Designer's* general editing skills. Parts modified in this way aren't saved back to the component library, but are saved in *EE De-*

signer's own database, along with the drawing files associated with them.

Lines are started by clicking the mouse button once and moving the wire to its destination. Another click of the mouse button changes the direction of the wire. To end a wire, you have to go into a menu or use its keyboard equivalent.

EE Designer III is truly a professional schematic capture and PCB layout package targeted directly at the professional community. But it carries with it a heavier price tag in both installation cost and learning time. This isn't a package for the occasional user.

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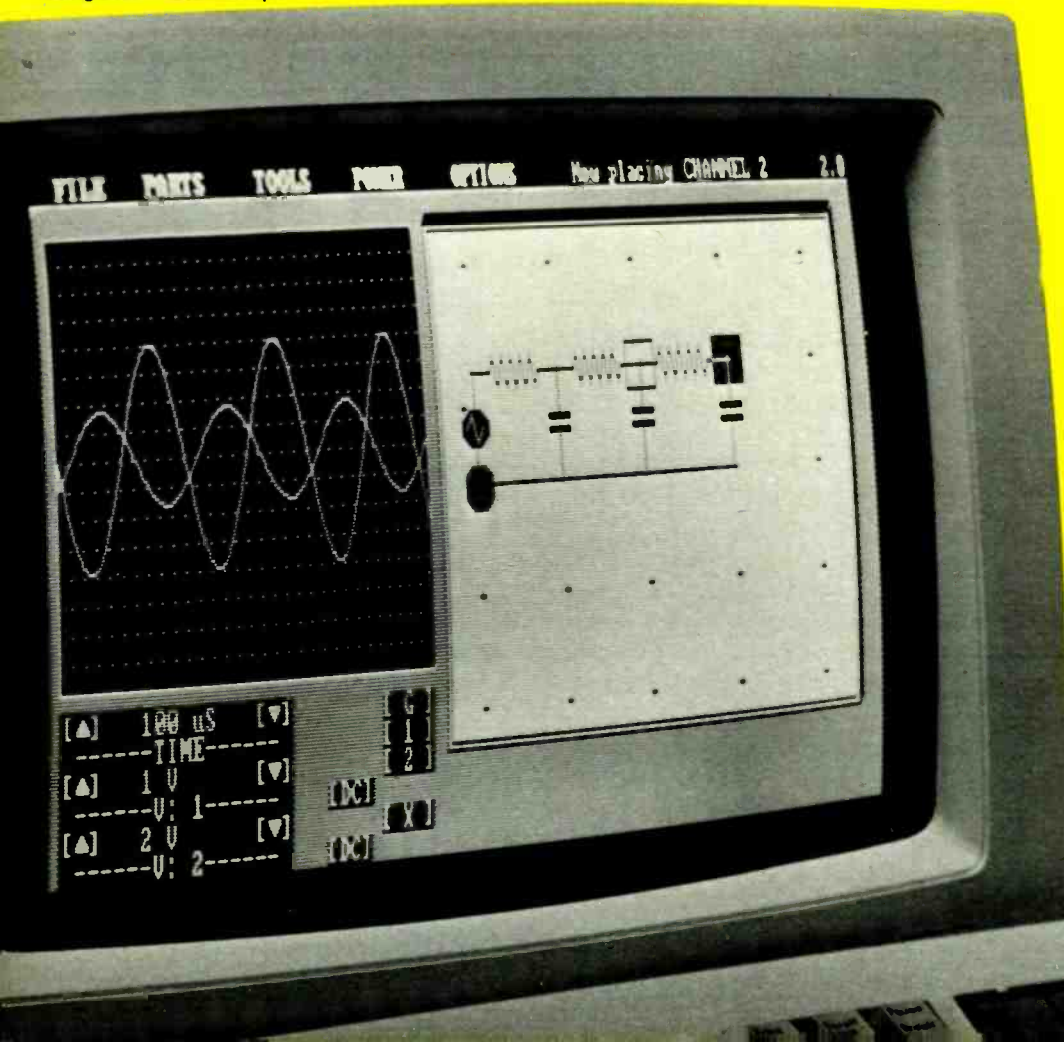
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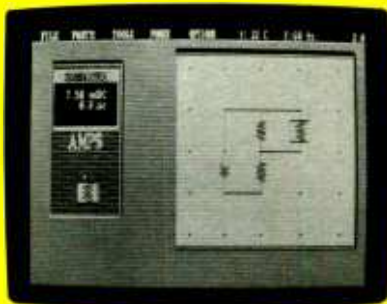
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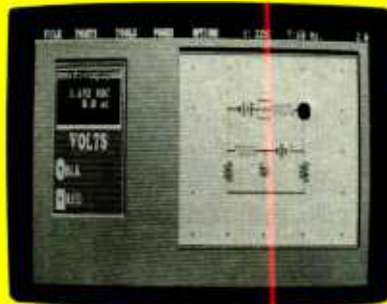
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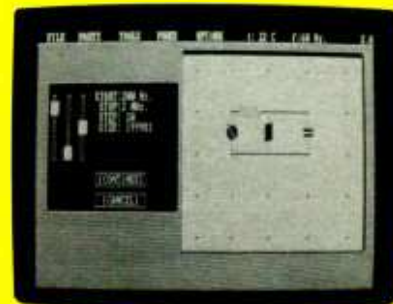
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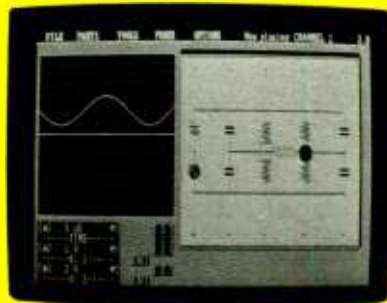
Resistor Series/Parallel Circuit demonstrates current division in a parallel circuit



Thevenin Equivalent Circuit calculating voltage drop and current flow using built-in ammeter/voltmeter



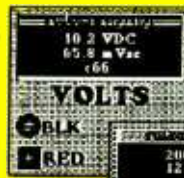
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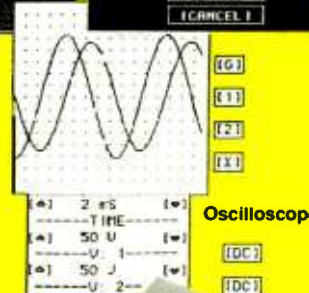
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HiWIRE Plus from Wintek Corp.

HiWire Plus is an \$895 schematic capture program that also includes PCB layout software for converting schematic capture files into circuit boards. The program is easy to learn, moderately difficult to use and short on features. A hardware copy-protection device that accompanies the package must be used for it to work.

The component library comes with 850 devices distributed among seven library modules. Most of the part names are generic, like pnp or op amp, except for the TTL chips, which have a 74xxx designation. Unfortunately, only one library can be active at a time. You have to delete the current library and load a new library when changing device types.

Components are called up from the library by clicking on a menu command and typing in the device name at the prompt. A screen listing of the library devices is available, but only

for reference. Devices can't be selected from the screen menu, which is unfortunate because many device names include case-sensitive characters (example: "formC" isn't the same as "formc"). Every part placed on the worksheet must be typed in individually because *HiWIRE* doesn't remember the last part entered, nor does it have a multiple placement routine.

Parts can be rotated or mirrored, but only after they're on the worksheet. However, certain combinations of the positioning edits cause other body parts to overlap and mask one or both references lines—neither of which can be moved. Parts also have no schematic reference until manually assigned after placement using an edit command.

Only ortho wires or lines are permitted; no diagonals. Once a wire or line is started it can be continued in-

definitely, making turns with each successive click of the mouse until you end the run.

HiWire has a jerky, but continuous autopan. When drawing a line or wire, however, autopan is disabled, forcing you to center your work before you begin a long run so that the two ends connect. But it's unlikely you'll run up against this problem often because at normal zoom—the highest magnification possible—*HiWIRE* has room to display an entire B-size worksheet on the screen. Zooming out is the only option, the end result being an E-size drawing about the size of a postage stamp.

The advantage is that you can have more than one worksheet on the screen at the same time. *HiWIRE* also has a windows function that lets you display two different areas of the screen alongside each other, but for reference only because only the cur-

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rent screen is active.

Editing features are limited to single objects only. Blocks aren't supported. A help screen isn't included, either. Among the editing options are copy, move, delete and find.

Included is a netlist converter that converts schematics created with many other netlists into *HiWIRE* format for input to its PCB layout software. The schematic capture section can generate either PostScript

LaserWriter or AutoCAD.DXF output files for interface with other software programs.

HiWIRE has virtually no control over the file output to a dot-matrix printer, which results in an A-size drawing using less than one-fifth the area of an 8½ × 11-inch sheet, and only slightly better control over a laser printer. Schematics produced by either are of very poor quality and are just barely usable as drafting

proofs. If you're dealing with a plotter, however, you have absolute control over the instrument at all times.

HiWIRE Plus' schematic capture section is fairly difficult to work with and lacks many of the features found in less-expensive programs. These shortcomings overshadow the inclusion of PCB layout software in the package.

CIRCLE NO. 23 ON FREE INFORMATION CARD

OrCAD/SDT III from Orcad Systems

OrCAD/SDT III was among the early schematic capture packages to appear on the scene for microcomputers. It's still one of the most versatile and complete schematic capture programs around. It's easy to learn and use, comes with a huge component library, is heavily supported by PCB and circuit-simulator programs, and the program carries a moderate \$495 price tag.

OrCAD/SDT III's component library is made up of 11 library modules. Included among the 3,500-plus components are several thousand logic chips, 100 Intel and Motorola processors, 40 PAL chips, and a comprehensive assortment of r-f and microwave devices. It supports DeMorgan symbols, too.

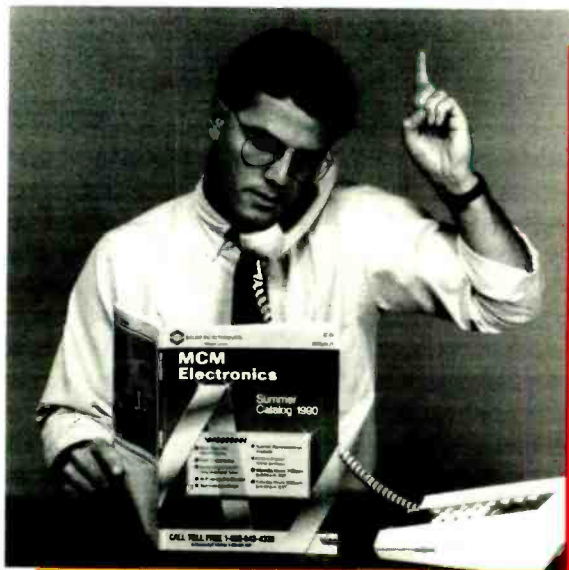
A component can be called from the library by entering its generic

name from the keyboard or by clicking on the part from a scrolling library menu. The selected component can be placed on the screen as many times as you wish by simply double clicking on the mouse. Parts can be rotated and mirrored during or after placement.

Part reference annotation is done from an external utility, not from the drawing program. Device references

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are assigned in the order in which the parts are placed on the worksheet. Multiple packages are grouped in sequence, beginning with the first object drawn of that type. Objects that have manually edited references are assigned a new reference. These must be changed back following annotation if you wish to keep them. There are eight user-defined reference lines for each part, and each line can be moved freely and independently about the screen. Any or all of the reference lines can be hidden.

Wires are placed on the schematic using a six-step menu sequence.

However, once a line is started, only two mouse clicks are needed to continue its path.

There's a macro function that lets you record often-used drawing routines, such as creating memory arrays or labeling a worksheet, then replay the routine via a single keystroke from the keyboard. Macros are created by turning on the macro recorder and letting it run while you make your moves. Hitting M turns the recorder off and saves the macro to file. Over 100 macros can be stored, provided their aggregate total doesn't exceed 64K.

OrCAD/STD III has autopan, but it doesn't scroll smoothly. The screen abruptly jumps to the next area of the drawing indicated by the cursor movement—making part and wire alignment difficult on large drawings. Turning on the grid and zooming out makes placement easier, but you'll have to zoom back in to fill in the details. There's also a jump feature that lets you tag up to eight spots on the worksheet and jump to a spot by simply calling its name. A help screen isn't featured.

CIRCLE NO. 24 ON FREE INFORMATION CARD

ProCAD from Interactive CAD Systems

ProCAD is in the top rank of integrated schematic capture programs and includes PCB layout software for use with IBM PC/XT/AT/PS2 and compatibles. That is, both modules are superior types. Moreover, it also includes an integrated 2-D graphics editor for limited drawing wants.

The company offers a few different software versions. The one we examined is *ProCAD Xtra*, priced at \$795 with nine libraries of components, plus seven optional libraries for an added \$150. This amounts to about 1,500 components. Any of these can be rotated on command. DeMorgan logic-gate equivalents aren't provided, but the program has the means to create such devices and others. The library includes a strong storehouse of surface-mount devices, with specific commands for working with them.

ProCAD requires more than 3MB of free hard-disk space. With all the optional Library Volumes (if bought separately, they cost \$35 each), this minimum is almost doubled. In addition, *ProCAD* demands most of your 640K of RAM, which is not uncommon.

Using the program for some fair

production work, I would follow the manufacturer's recommendation and add a math coprocessor. For large, involved schematic/PCB work, you'll want to spend another \$200 (or \$250 for upgrading later) and get the *ProCAD Xtra-XL* version, which has expanded-memory capabilities that support the LIM-EMS Version 4.0 standard. If you already have 2MB of memory sitting there, that's it. Otherwise, figure in the extra memory (and coprocessor) cost to get your total price.

Nevertheless, *ProCAD* incorporates a memory manager that shifts data to the hard disk and an overlay cache that it automatically sets up if you have at least 360K of RAM beyond the basic 640K. Furthermore, it uses memory very economically through clever database memory management that might take up, say, 20 bytes for a device instead of 512 bytes for a separate file.

ProCAD's first-rate schematic capture segment has all the standard bells and whistles, plus some. For example, a "Width" command allows you to increase the default width of a wire, circle, text height and more in whatever increments you wish. There

are even two command interpreter shells to choose from: a two-letter mnemonic and a VMS DCL type. Rotation of a symbol features extra power: it can be done in 1-degree increments! It also has an adjustable automatic save feature. And zoom magnification is unlimited. Furthermore, lines can be drawn at any angle desired.

Rubberbanding, snap on grid, dragging, scaling, block moves, undo, undelete in hierarchical steps, macro commands, step and repeat, automatic ground and voltage connections, autopan, mirror X and Y axes, find, and the like are all part and parcel of this fine program's tools. A strong Design Rule Checker (DRC) checks for opens and shorts, although most of its power is reserved for PCB work. Component designations like U1, U2 . . . , R1, R2 . . . , etc. are automatically applied in sequence. If changes are made, the program upgrades all. Accordingly, there is no possibility of duplicate component numbers.

ProCAD's netlist can generate support for a lot of programs, with Futurinet, Simulog, ECAD, PSpice, and other interfaces, as well as op-

tionally available interfaces for .DXF files (*AutoCAD*) and .PDF files (*P-CAD*).

Although only one component library is active at a time, it's a snap to select a component from another library or create a new symbol without ever leaving the editor to make it the active one. Operations, mostly with a mouse, are easy, being only a few mouse clicks away for nested commands. Pop-up menus for making choices among many selections available further simplify matters. For example, calling up a library produces a pop-up menu with all the devices in it for you to click on for a selection. You can type in a device name at the command line, too, if you wish.

An extensive Help menu is a good assist, too, with a listing by name and syntax coming up in a window. Typing the name you want for more information when this is done displays an explanation of the word. Help menus can be defined by the user, too. There are also 40 function-key control set ups. They, too, can be user-defined. Macros and toggle menus also add to the program's productivity.

ProCAD isn't among the easiest schematic capture programs reviewed, owing to its great power, which also means many choices that can be made. Therefore, the foregoing assists are most welcome. Nevertheless, when one becomes very familiar with all its workings through heavy production work, *ProCAD* has a feature called "Quickset" that turns off some operating aids to speed up its use for expert users, who don't need automatic command prompt lines and other visual aids.

Quickset has three settings: novice, intermediate and advanced. Macro commands further simplify commands. Layer assignment colors (*ProCAD* uses 16 colors) are excellent visual aids. For instance, schematic symbols are green, text is red, wire is colored yellow, highlighting is white, and so on.

The command line is at the bottom of the screen. Moving to one changes its color. Clicking or ENTER by key sets up another line of choices related to the command. To draw wires, you would click on a PLACE command, then click on WIRE, one of the subcommands displayed. You then position the cursor on a device's input or output, click, and draw wire out by moving the cursor. At a point where you wish to change direction, you click the left mouse button (or press ENTER) and continue pulling out more wire. When you make a connection, press the right-most button (or ESC), and the job is done, signified by the white-color wire you drew changing to yellow.

A Status line at the top of the screen keeps visual track of settings, such as layer number. There are 99 layers available (think of them as Mylar overlays; a color-coded layer bar at the bottom of the worksheet allows you to click on any one), active library module, and so on.

If you cross wires, a warning beep is sounded and a visual X-mark is displayed at the "short" location to alert you to a possible short circuit. For a schematic, this is not a short, but you have the option of continuing along or placing a dot on the crossover in the event you want a connection.

Particularly noteworthy is *ProCAD*'s signal and node display functions. For example, a few mouse clicks on a command, subcommand and wire line will highlight *all* wires that are logically connected together. Or you could type, say, GND, on the command line and all wires leading to ground will be highlighted. Another refinement is the wide choice of grid units in which you can work, including inches, millimeters, centimeters and microns. You can also choose a line grid or a dot grid or make them invisible. There's also a ghost grid to ensure finer movements.

Mouse-click steps are reduced by some operating efficiencies. For ex-

ample, you can repeat a command and subcommand you just completed working with by simply clicking the left button or pressing ENTER. In other instances, the program automatically switches the highlight bar to the proper subcommand when the next action is obvious. Among many other features is a LOG function that records everything you do so that you can backtrack in the event you want to search out an error you made. Deletions are saved, too, which can be recalled at any depth if required. A "Packing" function removes it.

Printer choice and control is admirable, ranging from nine-pin dot-matrix to laser printers and all manner of plotters (HPGL, for Hewlett-Packard and IBM), DM/PL (for Houston Instruments), IBM color graphics printer, and so on. Software control permits you to choose plot layer, choice of a plotter pen's thickness or multiple pens, COM port, and so on. An optional utility enables you to use a Gerber photo plotter and an MDA Fire 9000 laser photo plotter.

Being a very complete program, there aren't many *ProCAD* shortcomings to be pointed out. Among the minor ones is an autopan function that requires the cursor to be moved to the right or left side at the bottom of the work sheet because it bumps into an active bar in the middle; the three other sides work normally. Further, autopan causes the screen to bump to the next location rather than scrolling smoothly.

In sum, *ProCAD* contains an impressively powerful and flexible schematic capture program. Combined with its integrated printed-circuit-board layout provisions, and priced near the top of our group, it's obviously a professional package that's not suitable for the casual user. But for any serious drawing purposes where a microcomputer will suffice and board layout is also desirable, it should be a leading candidate for purchase consideration.

CIRCLE NO. 25 ON FREE INFORMATION CARD

***Protel-Schematic* from Protel Technology, Inc.**

Protel-Schematic is the easiest schematic capture program to use in this review, and quite versatile, excepting sufficient support for other formats. It's priced at a reasonable \$495 and comes with a hefty component library.

The component library contains over 3,000 parts distributed among 14 library modules, ten of which may be active. There's a good balance between analog and digital parts, and components can be called from the library by either entering generic names from the keyboard or by clicking on the part from a scrolling library menu. DeMorgan equivalents aren't supported, however.

Device reference and multiple-package designations are assigned at the time the part is placed on the worksheet, and there's a warning message that prevents you from assigning the same reference to more than one device. The program remembers the last device placed on the worksheet, permitting repeated component placement without having to re-enter the part name, but you have to enter a reference name before the software places it into position. Devices have only two reference lines, neither of which can be moved. However, the size of the font is variable

between 8 and 20 points, and the schematic reference name can be hidden, leaving just the part value.

Parts can be rotated and mirrored either during or after placement. There's also a pin editor that lets you add, delete or change the position of the pins associated with a component. The pin editor can be used as a quick way to make a one-of-a-kind part without having to use the library editor, but parts made this way have to be redrawn for each new schematic because they aren't transferable between files.

Wire placement is simply a matter of clicking the mouse button once to start the line and clicking it a second time to set the line in place and change its direction. *Protel-Schematic* also lets you draw 45-degree diagonals in the ortho mode.

Like *OrCAD* and *ProCAD*, *Protel-Schematic* has a macro recorder that records and saves your every keystroke or mouse click when activated. There's no limit to the size of the macro or how many macros can be created. Macros can even be nested in batch-file fashion so that starting a macro automatically runs a sequence of queued macros.

Autopan is supported, but like a

few others, it jumps rather than scrolls. The grid and grid snap can't be turned off, but you have full control over screen display colors, which means you can set the grid to the same color as the background and effectively hide it if it bothers you.

Editing features are excellent, with single-object move, delete and jump, plus block editing. There's no undo, but there is an undelete command that lets you undelete as many items as you wish in reverse order.

Only the library symbol editor has a help screen, and that's limited to a succinct summary of Chapter 24 in the User's Manual. All netlists are in proprietary *Protel-Schematic* format.

Printer and plotter hard copies are both of excellent quality. Hard-copy output is done using an external utility that gives you complete control over all aspects of the printer or plotter, including drawing orientation, fit drawing to page and page offset, to name but a few.

For pure hard-copy drafting quality and editing freedom, *Protel-Schematic* is superb. However, it's lack of support for formats other than *Protel* limits its PCB layout application to *Protel* products only.

CIRCLE NO. 26 ON FREE INFORMATION CARD

***Schema III* from Omaton**

Schema III is a \$495 schematic capture program that's reasonably easy to learn and use, but lacks some of the drawing and editing provisions other programs in this price range possess. But it has LIM expanded-memory provisions and a data-compression program for its libraries.

Schema's component library consists of about 1,000 parts, divided among nine library modules, with heavy emphasis on TTL devices. Many of the objects in the library are

outlines and headers that let you easily piece together custom components using the library editor. All nine library modules may be active at the same time.

Components can be called from the library only by entering the names from the keyboard. You can assign complete schematic references at this time, including part value and up to six lines of additional text. Its post processor's Design Rule Check identifies duplicate device referenc-

es, among other design errors. Reference lines can't be moved or hidden.

There's no component repeat function. Each device placed on the worksheet must be called up individually. However, *Schema's* copy command lets you make multiple copies of a part already on the drawing, but you'll have to use the image editor to change part reference names because they're also duplicated.

Although *Schema* has no parts-orientation editor, different orienta-

tions are stored as separate devices in the component library, as are the DeMorgan equivalents. Each orientation has its own name, which you specify at the time you call up the part. After a part has been placed on the drawing, you can use the rotate command to step it through its various library orientations.

Wires are drawn by holding down the right mouse button and scooting the rodent to the desired location. Releasing the button places the wire on the worksheet; pressing the button again starts a new wire. Diagonal lines drawn at any angle are made by selecting the diagonal line option from the menu. There's no bus drawing or editing function, but buses can be created using the thick wire and arc menu options in conjunction with a repeat command that places the breakouts at user-defined intervals.

Autopan is smooth scrolling and the speed of the scroll is adjustable, as is the grid's dot spacing. Unlike some schematic capture programs,

you can choose your zoom size from a menu, rather than having to step through each zoom level one by one. Its zoom range to 8x, however, isn't as powerful as the magnification options of most other packages.

Editing features are average, and consist of move, delete and copy. Objects can be edited individually or as blocks. Absent is a mirror-image function, which has to be accomplished with some editing efforts. *Schema* has an on-line help screen. Help is context-sensitive (matching the help message to the current command) and is available for both the screen and library editor.

Like some other software examined here, *Schema* supports several popular netlist formats, with conversion files in BASIC. Among the 14 netlist output formats supported are *SPICE*, *EE Designer* and *Future-Net*. Also, .DXF files need conversion for inputting.

In addition to the standard ASCII format, the Bill of Materials (BOM)

netlist can be output in Lotus, *dBASE*, and SDF formats. This allows the user to perform spreadsheet and database operations on the BOM data, such as cost analysis and inventory control.

While you can't size the drawing to the printer page (an A-size drawing uses only about one-third of the page), you can take advantage of the printer page by using a C-size worksheet for 8½-inch printers and an E-size worksheet for 15-inch printers when drawing the schematic. By contrast, the plotting utility gives you full control over page sizing, reduction and offset.

Although *Schema III* doesn't have quite as much refined drawing and editing capabilities demonstrated by some packages in this review, it's a well rounded schematic capture program that interfaces with many popular PCB-layout and circuit-simulation programs, and is quite acceptable for light production work.

CIRCLE NO. 27 ON FREE INFORMATION CARD

SuperCAD from Mental Automation

At \$99, *SuperCAD* is the lowest-priced schematic capture program here. But don't let the low price fool you! This package has a nice complement of drawing and editing features, and is easy to use.

It's the only program here that doesn't operate in multi-color mode. But on a color monitor, it produces an easy-to-read blue background with white drawings and text. And naturally, it doesn't match the much more costly programs in terms of component library, netlist support for other programs and printing support. Both can be expanded, though, with the company's optional utilities. Individually, their cost totals \$167, but all can be bought at the outset with *SuperCAD* for \$100 more (*SuperCAD Plus*, \$199).

The component library comes with over 350 devices for immediate use, 233 of which are TTL logic chips. They're distributed among 11 library modules that are always active. A Library Parts "Build" program, however, can greatly extend this number. There's a good variety of device types, including DSP (digital signal processing), PLD and microprocessor chips, plus DeMorgan equivalents. More serious users would add LIB-2, the additional parts library (\$49), of course.

Components are called up via a window that lets you select the library module of your choice using a mouse. Once inside the library, you simply click on the part you want. Up to six devices can be moved from the window to an on-screen quick-access

drawing cell that lets you place a part without having to go through the window routine again, making multiple placements a breeze.

Parts can be rotated, but the rotation point is outside the device outline, forcing you to move the part after rotation. Each worksheet also has four drawing planes that can be displayed individually or superimposed. More costly CAD programs often use layers to separate colors.

Components are placed on the worksheet with no references. References are assigned in a separate step in the order in which the parts were placed on the worksheet. Each type of device is handled separately, with resistor annotation a separate step from IC or capacitor assignments. Each part has only one reference line,

(Continued on page 76)

Power Supply for IC Experimenting

An ac-operated transformerless dc power source that can be used for powering small, low-power circuits and projects

By Walter W. Schopp

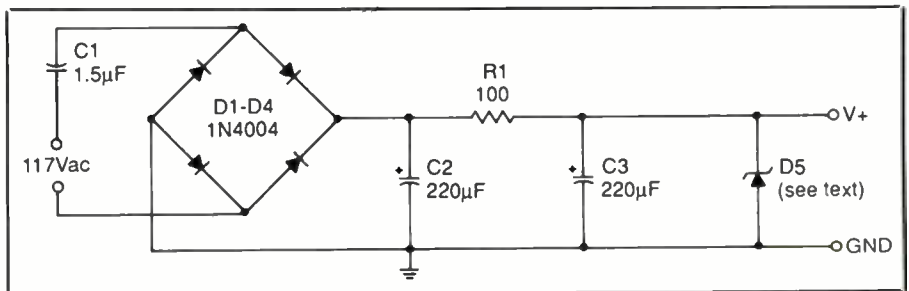
You've just finished breadboarding your latest circuit and are ready to give it the "smoke" test by connecting power to it and observing how it operates. You look around for a suitable power supply and decide that, because the circuit consumes low power, a battery supply will do. But you discover that you have no battery on hand. What to do? The solution: build the novel power supply described here.

This power supply does not use a power transformer, nor does it require exotic or expensive components to put it together. In fact, you probably have all the components you need on hand, save a suitable zener diode. Once you "proof" your circuit and are satisfied that is operating as expected, you can permanently incorporate this power supply into the final design if it is to be ac-line powered.

About the Circuit

The basic circuit configuration for the power supply is shown in the schematic diagram. Regardless of the output voltage selected, all but two components remain the same.

Capacitive reactance, X_c , of $C1$ is used to drop the incoming 117 volts ac from the power line to a safe, usable level for use in low-voltage IC and transistor circuitry. Unlike a large dropping resistor, the reactance capacitor develops no heat. Depending on the output voltage required



Schematic diagram of a simple transformerless ac-operated power supply for low-power circuit experimenting. Zener diode D5 must be selected for voltage output desired.

for your application, you must select a value for $C1$ that will provide adequate voltage-dropping action at the 60-Hz ac line frequency.

The formula for determining the reactance of any capacitor is $C = 1/(2\pi FC)$, where F is the frequency at which the reactance is to be calculated and C is the value of the capacitor in Farads. In the case of the 1.5-microfarad capacitor needed to obtain an approximately .5-volt output from the power supply, the reactance is $1/(6.28 \times 60 \times 0.0000015)$, or 1,769 ohms at the 60-Hz line frequency. The reactance of the 2.2-microfarad capacitor needed for an approximate 12-volt output is 1,206 ohms. To do the same job as the capacitor, the power-supply circuit would require a resistor rated at a minimum of 10 watts to effectively dissipate the heat generated by the dropping action.

With the 1.5-microfarad capacitor shown in Fig. 1 for $C1$ and a 5.1-volt, 1-watt zener diode used for $D5$, the output will be roughly 5.1 volts,

which can be used to power TTL and some CMOS logic circuits and a wide variety of analog circuits. Changing the value of $C1$ to 2.2 microfarads and replacing $D5$ with a 12-volt, 1-watt zener diode yields a supply with a 12-volt output that can be used to power most analog circuits and a wide variety of CMOS circuits. In either configuration, the circuit will deliver approximately 50 milliamperes at its output.

Bear in mind that increasing the value of $C1$ reduces the reactance of the capacitor. As seen in the above formula, the reactance of the capacitor is independent of the current. The higher working-voltage capacitor to use in this part of the circuit comes in a fairly small package and a variety of capacities.

A slight increase in current-delivery capability of the power supply can be realized by reducing the value of $R1$ or increasing the value of input filter capacitor $C2$. A relay or light-emitting diode that might require

PARTS LIST

- C1—Nonpolarized 250-WV capacitor (select value according to amount of voltage to be dropped—see text. Suitable capacitors are available from Digi-Key, 701 Brooks Ave. S, P.O. Box 677, Thief River Falls, MN 56701-0677, Tel. 1-800-344-4539: Cat. N. E2155 for 1.5- μ F, Cat. No. E2225 for 2.2- μ F value)
- C2, C3—220- μ F, 35-volt electrolytic capacitor
- D1 thru D4—1N4001 or similar 1-ampere, 400-PIV silicon rectifier diode (or substitute full-wave bridge-rectifier assembly—see text)
- D5—1-watt zener diode (1N4733A, 5.1 volts, 1N4742A 12 volts or other value as needed)
- R1—100-ohm, 1/2-watt, 10% tolerance resistor
- Misc.—Printed-circuit board or perforated board (see text); suitable enclosure; ac line cord with plug; hook-up wire; solder; etc.

more current than the regulated output of the circuit can safely provide can be connected to the unregulated C2 side of R1. On the test bench, this circuit produced less than 1 millivolt of ripple current.

Though this supply may well be the answer for a cheap and easy way to power those small circuits that require ac-line powering, you should keep firmly in mind that the supply and whatever circuit it is powering are not completely isolated from the ac line. Hence, caution must be observed when working with the supply.

The supply is suitable for powering a circuit from the ac line that is fully contained inside a protective enclosure. You can use a metal enclosure and a line cord with three conductors, tying the ground conductor from the ac line to the metal of the enclosure. The dc ground must always be isolated from the enclosure ground for safety reasons.

Construction

As you can see in the schematic dia-

gram, this is a very simple circuit design. All its components are fairly small in size, making it ideal to build the circuit on a small piece of perforated board using the point-to-point wiring technique. Alternatively, you can design and fabricate a printed-circuit board on which to mount and wire together the components.

Wire the circuit on whichever type of board you choose according to the schematic. If you wish, you can substitute an integrated full-wave bridge-rectifier assembly for rectifier diodes D1 through D4. If you make this substitution, use a rectifier assembly rated at 1 or more amperes.

Once the circuit-board assembly is fully wired and an ac line cord has been attached to it, connect the common lead of a dc voltmeter or multimeter set to the dc-volts function to the negative (-) lead of C2 or C3. Place the assembly on a nonconductive surface and plug the line cord into a nearby ac outlet. When the board is powered, potentially lethal ac line power is present at the input; so practice extreme caution when probing the circuit.

With power applied to the circuit, touch the "hot" probe of the meter to the cathode lead of zener diode D5 and note the reading obtained. It should be positive in polarity and within a few tenths of a volt of the specified rating of D5. If it is not, disconnect the line cord from the ac receptacle and troubleshoot the circuit to correct the problem.

Once the circuit is operating properly, remove power from it and liberally flow silicone potting compound or adhesive over the section of the circuit-board assembly in the locations where 117-volt ac line power exists on both sides of the board. This is to insulate the potentially hazardous portion of the circuit.

Now house the circuit-board assembly in a suitable enclosure. If you built the supply to use exclusively for a project, build it right into the same enclosure that houses the project. **ME**

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CIRCLE NO. 20 ON FREE INFORMATION CARD

Code-Practice Oscillator

This simple electronics project is useful in helping beginners learn to send Morse code

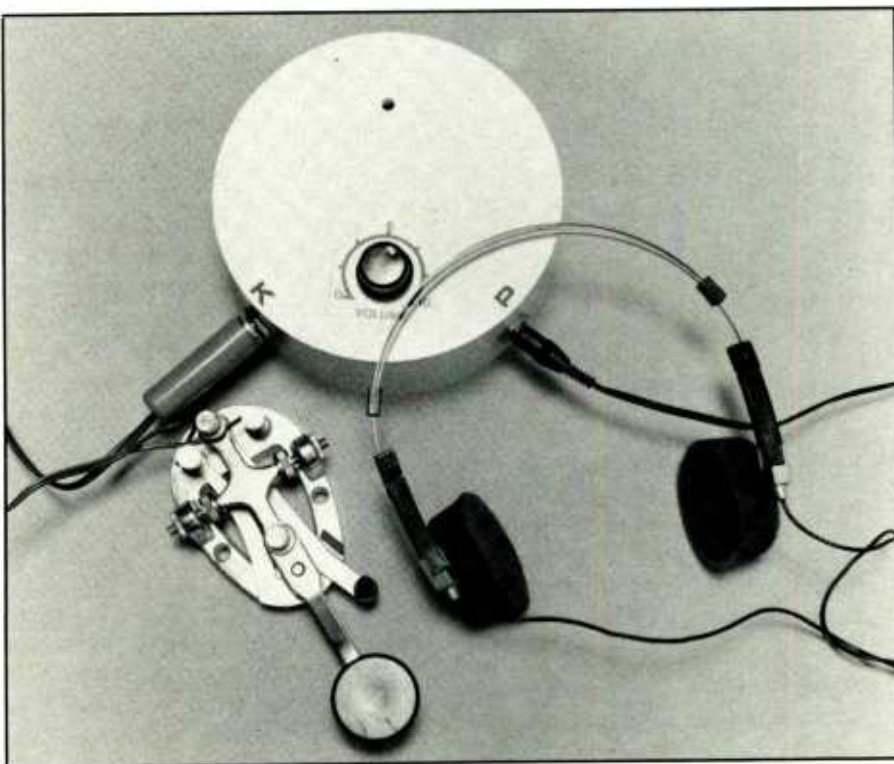
By Charles D. Rakes

An aspiring amateur radio operator has two distinct avenues in preparing for his ham license. One is to learn and understand the fundamentals of amateur radio theory and operating procedures and FCC Rules and Regulations. The other is to learn how to receive and send International Morse Code. Neither is very difficult, given the right attitude and appropriate text and other materials. (Even though there promises to be a no-code license in the near future, not being able to meet Morse-code requirements for a license class beyond it locks you out of working a lot of frequencies, such as 2-meter FM.)

There are a number of excellent tapes and books available for learning theory and code. However, unless you have a code-practice oscillator (CPO) and telegraph key, you're going to have difficulty learning how to send the dits and dahs that make up the code. In this article, we'll show you how to make a practical code-practice oscillator that can be used with a key and headphone.

About the Circuit

The heart of our Code-Practice Oscillator is a piezoelectric sound generator, shown as *PB1* in the schematic diagram. These buzzers are also commonly called piezoelectric ceramic buzzers or simply piezo sounders by vendors. Select the kind that has the drive circuit built into it and has a pleasant-sounding tone output to



make your practice sessions as comfortable as possible.

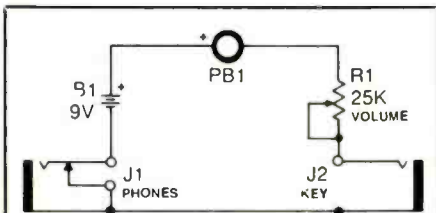
All components wire in series with each other. Phone jacks *J1* and *J2* permit the headphone and telegraph key to plug into the circuit. Potentiometer *R1* serves as a volume control, while battery *B1* provides power.

Using the CPO without a headphone, the sound level from *PB1* can be adjusted via *R1* from very low to quite loud. So you can use this project in a room to key out dots and dashes for practice sessions with other aspiring hams. Alternatively, you can use the headphone for private practice.

Construction

As shown in the photo, the Code-Practice Oscillator can be built into just about any enclosure that will accommodate all the components, except key and headphone. The prototype was built inside a plastic end cap that fits over the end of 4-inch PVC pipe. You can use a more traditional project box if you wish.

If you plan to use your CPO for only group practice, you can replace *J1* with a wire that goes to the two points this jack would normally occupy. Also, if you wish the CPO to run continuously at full volume, re-



PARTS LIST

- B1—9-volt alkaline battery
- J1—Shorting-type single-circuit phone jack
- J2—Non-shorting-type single-circuit phone jack
- PB1—Piezoelectric buzzer (see text)
- R1—25,000-ohm panel-mount audio-taper potentiometer
- Misc.—Suitable enclosure (see text); snap connector and clip for B1; control knob for R1; lettering kit; clear spray acrylic; machine hardware; hookup wire; solder; etc.

place *R1* with a similar wire that goes to the two points this potentiometer normally occupies.

Machine the enclosure as needed. If you plan on mounting the buzzer inside the enclosure, drill a 1/8- to 1/4-inch diameter hole in its mounting location so that aligning the hole in the buzzer housing with the drilled hole allows the sound to escape. Mount the components in their various locations and wire them together according to the schematic diagram. Make certain that you properly polarize the battery and buzzer.

When you finish wiring the circuit, label *J1* PHONES and *J2* KEY. If you use dry-transfer letters, protect the legends with two or more light coats of clear acrylic spray. Allowing each coat to dry before spraying on the next.

Now all that remains for you to do is snap in a fresh battery, connect your telegraph key, adjust the VOLUME control for a pleasant level and begin practicing.

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Experimenting with Crystal Oscillators

By Forrest M. Mims III

Imagine a magical slice of crystal that vibrates at a stable frequency when connected in a circuit with a transistor and a few resistors and capacitors. This magical crystal is not a science fiction writer's dream; it's one of the oldest solid-state electronic components and is commonly known as the quartz crystal resonator.

Many of the newer electronic instruments that we've come to depend on are made possible by quartz crystals. In this column, I'll list some of these instruments, discuss the operation of quartz crystals and describe some experiments you can perform with them. First, however, let's review a few of the many applications for this ancient component.

Applications

Most of us are surrounded by quartz crystals. The timing of the signals moving in and out of the processor inside the laptop computer into which these words are being typed is synchronized by a quartz crystal that vibrates at a frequency of 7.16 MHz. The accuracy of the digital watch on my wrist is made possible by a tiny quartz crystal that vibrates at a frequency of 32,768 Hz. The accuracy of the computer-controlled data logger I use to monitor the sun is made possible by a quartz crystal. A quartz crystal controls the tracking rate of the telescope pedestal I use to track the sun across the sky.

After this column is typed, I'll go for a ride on a bicycle equipped with a tiny speedometer controlled by a quartz crystal. This evening, my wife will cook part of our supper with a microwave oven whose timer is controlled by a quartz-crystal oscillator. One of my children will punch quartz-crystal-controlled tones into a telephone while placing a call to tell me to come in for supper. After supper, we'll watch a weather broadcast on a TV receiver whose color is regulated by a 3.58 MHz-quartz-crystal oscillator.

Later I'll listen to news broadcasts from around the world on a digitally-

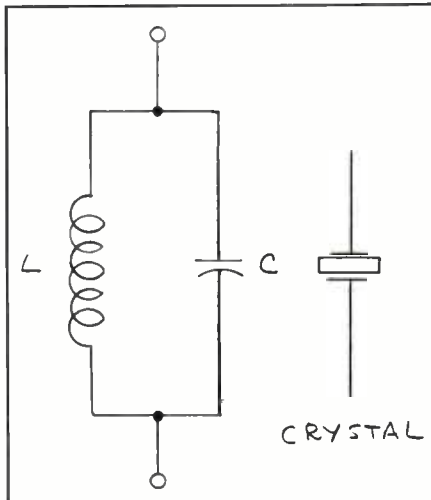


Fig. 1. Equivalent circuit for a quartz crystal.

tuned communications receiver whose precision is made possible by a quartz-synchronized phase-locked loop. Finally, all of us will conclude our day by setting the alarms on our quartz-crystal controlled clocks. Before switching off the light, I'll probably punch in the 10-MHz WWV broadcast and reset my watch and clock on a time signal.

By now, it should be apparent that much of what we do is made possible or enhanced by the ubiquitous quartz crystal. And I haven't even mentioned such crystal-controlled gadgets as video games, CB radios and video cameras.

In all these applications, quartz crystals are used in oscillator circuits. They can also be used as filters that selectively pass only a desired frequency.

A more recent development is the use of quartz crystals to detect minute mass changes in thin films of various substances deposited on the crystal. Placing a coating on a quartz crystal alters its resonant frequency. If the coating material attracts certain molecules when they're present, then the mass of the coating is increased. This causes a further alteration in the crystal's oscillation frequency. Mass changes as small as a billionth of a gram per square centimeter can be de-

tected in this manner. One result is quartz-crystal sensors that detect tiny amounts of enzymes and other chemicals. For more information about quartz crystal mass detectors, see "In Situ Interfacial Mass Detection with Piezoelectric Transducers" by Michael D. Ward and Daniel A. Buttry in *Science* (August 31, 1990, pp. 1,000 through 1,007).

Piezoelectric Effect

In 1880, Pierre and Paul Curie found that a voltage is produced when pressure is applied to crystals of quartz, tourmaline and Rochelle salt. The following year, they discovered that applying a voltage to these same crystals caused them to expand or contract. The name assigned to these phenomena is the piezoelectric effect and is taken from the Greek word "piezein," which means to press.

Certain ceramics and plastics also exhibit the piezoelectric effect. Indeed, many kinds of electronic devices have been designed around these newer piezoelectric materials. They include solid-state buzzers, speakers, fans, motors, spark generators and various kinds of

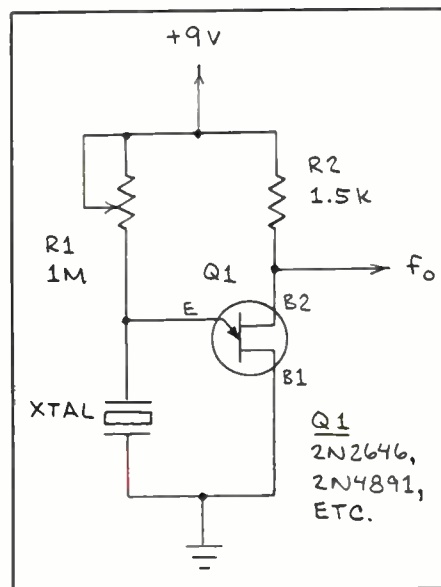


Fig. 2. Schematic of a crystal-controlled unijunction-transistor oscillator.

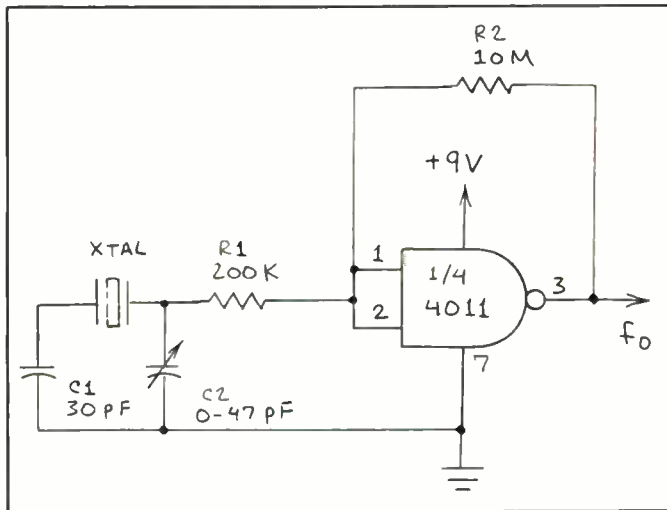


Fig. 3. Schematic of a simple CMOS crystal oscillator circuit.

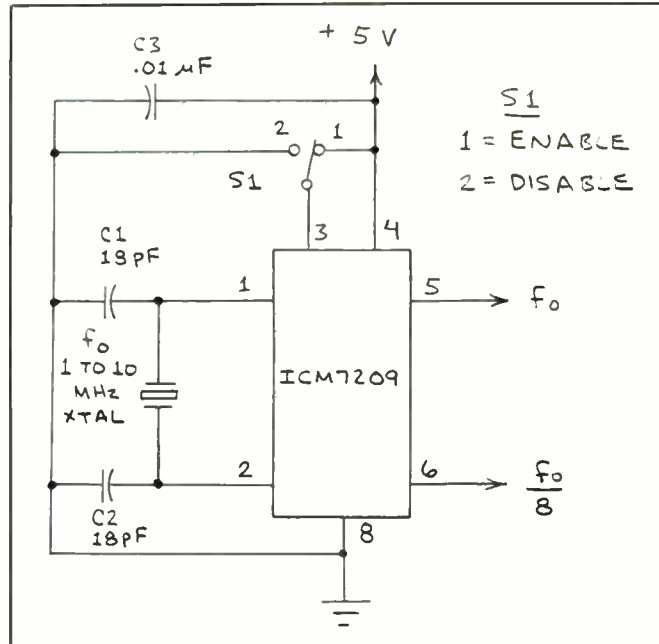


Fig. 4. Schematic details of a wide-range, crystal-controlled clock-generator circuit.

movement and vibration sensors. In spite of these new materials, crystals of quartz remain the most important piezoelectric material.

The operation of a quartz crystal resembles that of the parallel LC circuit shown schematically in Fig. 1. A principal difference is that the Q of the crystal is considerably higher, up to 100,000. This means the frequency stability of a crystal-controlled oscillator is exceptionally high.

Temperature is the major enemy of frequency stability in quartz-crystal oscillators. Temperature changes cause the dimensions of the crystal to be slightly deformed, thereby altering, ever so slightly, its resonant frequency. The change isn't catastrophic. If it was, you wouldn't be able to use a portable CB or ham rig on a cold day unless you first retuned its operating frequency.

For ultra-precision applications in which the frequency of an oscillator isn't to vary more than a few parts per billion, the quartz crystal or even the entire oscillator is installed in a miniature oven that heats the crystal to a uniform temperature above the highest expected ambient

temperature. Oven temperature is carefully regulated.

The piezoelectric effect is greatly influenced by the geometry and orientation of the material that exhibits it. While natural quartz can be used to make quartz-crystal resonators, today most are cut from artificially cultured quartz crystals. The crystal slices are cut, lapped and polished to the precise dimensions necessary to achieve the desired resonance. Electrodes are then applied, and the crystal is mounted in a protective enclosure, which is usually made of metal. The external electrodes can be either wires (for direct installation in a circuit) or pins (for insertion into a socket).

For many years, quartz crystals were made as discrete components. They're still made that way today but are usually housed in much smaller packages, such as those shown in Fig. 1. They're also available in tiny surface-mount packages. Some discrete quartz crystals can withstand exceptionally high mechanical loads. For example, Motorola makes a line of ultra-miniature crystals that measure 0.12 inch (3 mm) in diameter and

0.33 inch (8.4 mm) long. These tiny crystals can withstand a shock of 8,000g.

Hybrid Oscillators

A comparatively recent development in the long history of the quartz-crystal oscillator is the incorporation of miniature quartz crystals into various kinds of hybrid microcircuits, such as those used in precision oscillators and digital watches. Most of these units have a fixed-frequency TTL- and CMOS-compatible outputs. Some incorporate a screwdriver-adjustable slot that permits the oscillator's frequency to be slightly adjusted.

Hybrid oscillators are available with a frequency range of from a few hundred kilohertz to 200 MHz. Their frequency stability varies from ± 100 to $\pm 1,000$ parts per million.

For even better stability, temperature-controlled hybrid oscillators, sometimes called OCOs (ovenized crystal oscillators) are available. These modules incorporate a miniature heating element that maintains the crystal at a constant temperature above the ambient temperature.

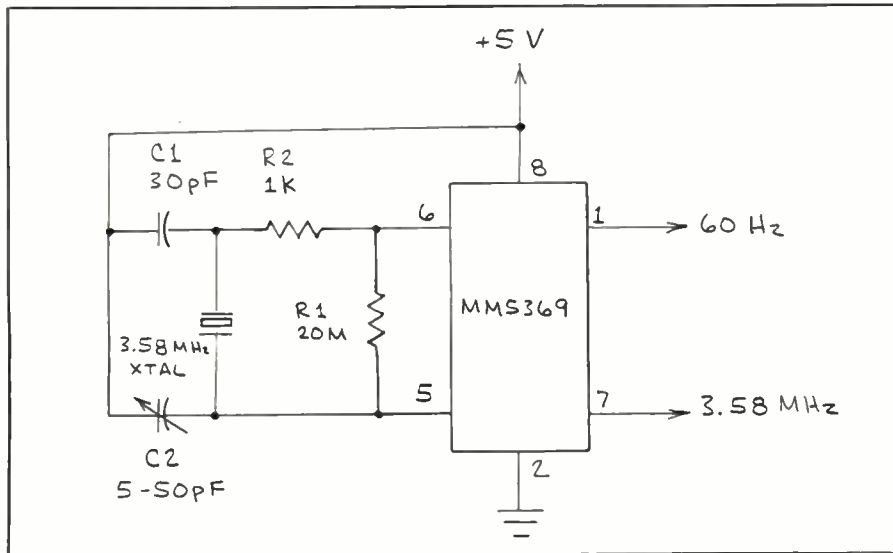


Fig. 5. Schematic of a precision 60-Hz timebase generator circuit.

The stability provided by this method ranges from ± 1 to ± 100 parts per billion.

This high degree of precision is accompanied by several drawbacks. The oscillators are more expensive and physically larger than non-heated modules. They consume considerably more power. And they require a warm-up time before the

specified tolerance is achieved. Nevertheless, they're ideally suited for applications that require ultra-stable signals.

A typical crystal-controlled hybrid oscillator has only three or four pins and is about the size of a 14-pin dual in-line integrated circuit. Some are much smaller. Some oscillator modules are fairly expen-

sive, while others are available for as little as \$5 or even less from mail-order electronic parts dealers. The giant Newark Electronics catalog lists more than a dozen Dale hybrid crystal oscillators at prices ranging from \$4.97 to \$6.20 in single quantities. Catalogs from Digi-Key (P.O. Box 677, Thief River Falls, MN 56701) and Jameco (1355 Shoreway Rd., Belmont, CA 94002) list similar oscillators for less than \$4. As I was preparing this column, I bought several oscillator modules from Marlin P. Jones & Associates (P.O. Box 12685, Lake Park, FL 33403) for \$3 each. All prices mentioned here are real bargains when you consider assembly time and construction space you save.

Crystal-controlled hybrid oscillators have many important advantages. Most obvious, of course, is the fact they're fully functional devices that require only a source of power to operate. Another is that the crystal and its associated components remain at very near the same temperature during operation. This enhances their stability.

As for applications, the tiny oscillators can reduce the r-f interference generated by a circuit since the oscillator can often

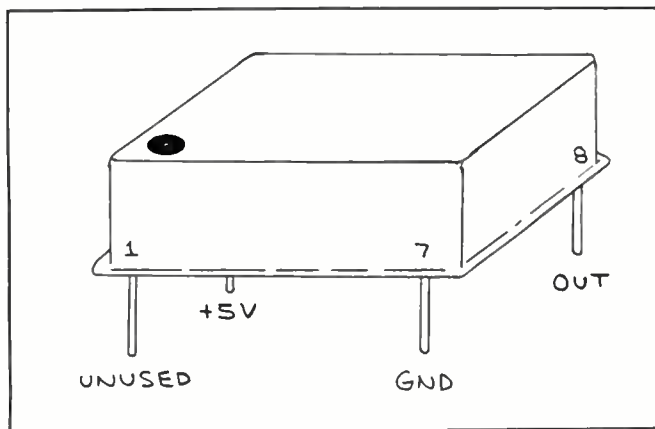


Fig. 6. Physical details of a typical hybrid crystal-oscillator module.

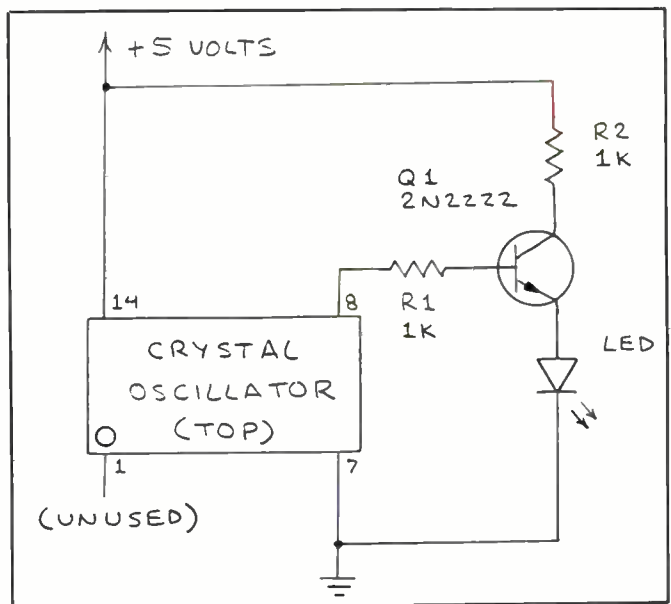


Fig. 7. Details for using a modular oscillator to drive a LED.

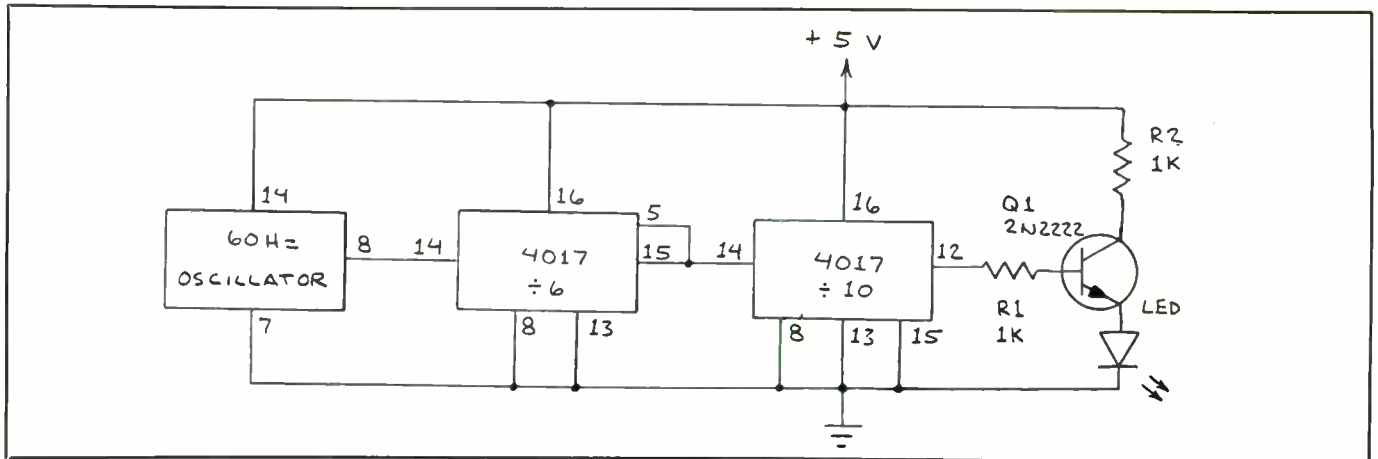


Fig. 8. Schematic of a precision 1-Hz timebase circuit.

be located very close or even directly adjacent to the circuit it controls. Since this reduces the length of the transmission line that carries the signal, the strength of the propagated signal is also reduced.

A UJT Oscillator

Many very simple crystal oscillator circuits can be made by wiring together fewer than half a dozen discrete components. Shown in Fig. 2 is one of the simplest, a unijunction oscillator in which the usual timing capacitor is replaced by a quartz crystal. When the crystal has a resonant frequency of 1 MHz, the oscillator can be caused to oscillate over a range of from around 50 kHz to exactly 1 MHz simply by adjusting *R1*. Optimum operation occurs at 1 MHz.

The output signal from this circuit is a series of fast rising spikes whose fall time is slower than their rise time. If you connect an oscilloscope to the output of the circuit, you'll notice that the oscillator's frequency increases in incremental jumps as the resistance of *R1* is reduced. This is because the crystal prefers to oscillate at various harmonics of its 1 MHz fundamental frequency. As you approach the 1 MHz region, the oscillator will quickly lock onto the 1-MHz fundamental.

The Fig. 3 circuit is useful for understanding operation of quartz crystals and

checking their condition. It can also supply a marker frequency for calibrating a communications receiver since the circuit will function as a very-low powered r-f transmitter. For higher frequencies, select a crystal with a higher frequency. If the circuit works at only low frequencies, try changing the UJT until you find one that works well at the desired frequency.

If you have an oscilloscope, watch the shape of the waves from the output of the circuit as you adjust *R1*. Try bridging the leads or pins on the crystal with your fingers to see the effect this has.

A Gate Oscillator

Crystal-controlled clocks for sequentially operated digital circuits are often made from a single inverter or NAND gate, as shown in Fig. 3. Unlike the Fig. 2 UJT circuit, the Fig. 3 circuit oscillates at only the fundamental frequency of the crystal. The precise frequency of oscillation can be slightly altered by means of variable capacitor *C2*.

The output from the Fig. 3 circuit is a train of reasonably square pulses. If you have an oscilloscope, you can easily see the effects on the output pulses of component placement and the length of the connecting leads. You can also see the effect of substituting different values for

the resistors and capacitors.

While I originally used this circuit as a clock generator for a digital circuit, it can double as a frequency marker generator like the UJT oscillator circuit shown in Fig. 2. Maximum oscillation frequency will be determined by the kind of CMOS chip you use. Depending on circuit layout, power-supply voltage and specific device used, a high-speed CMOS chip should oscillate at up to 50 MHz or greater.

A Clock Generator

Several available IC circuits are designed specifically to supply clock pulses when connected to a crystal. Figure 4 shows how one of these, the ICM7209, is used in a practical circuit.

The ICM7209 is installed in an eight-pin mini-DIP. It's designed to be operated over a frequency range from 2 MHz to 10 MHz. The chip is designed to be powered by a TTL supply (or no more than 6 volts), and it can drive up to 5 TTL loads. Rise and fall times of the square pulses delivered by the ICM7209 are around 10 nanoseconds in duration.

The oscillator portion of the ICM7209 is simply an inverter (as in Fig. 3), followed by a buffer stage to prevent loading down the oscillator. Also included is a divide-by-8 circuit that provides the second output. Another feature is an enable/

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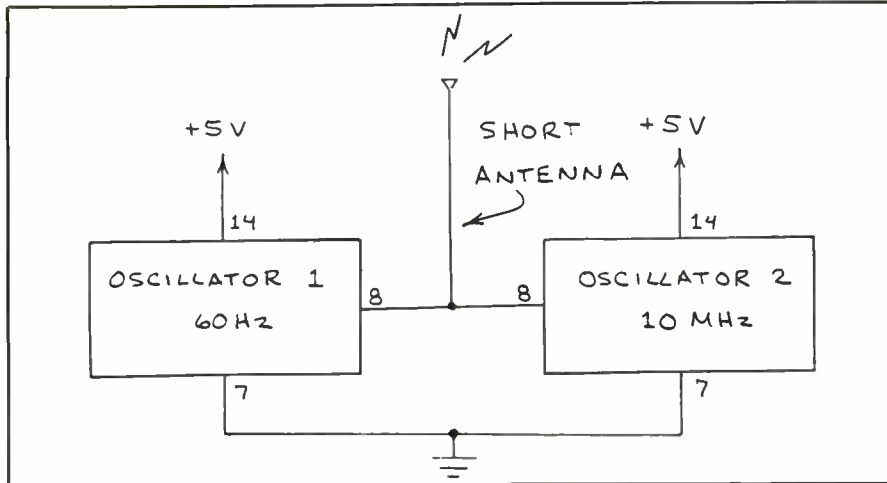


Fig. 9. How to make a simple r-f marker transmitter, with 10-MHz oscillator developing r-f carrier and 60-Hz oscillator modulating carrier.

disable gate that permits the signal to be removed from the outputs without switching off the oscillator.

Incidentally, although the ICM7209 is specified for a minimum oscillation fre-

quency of 2 MHz, it works at lower frequencies. For example, when I replaced the quartz crystal in Fig. 4 with a 455-kHz ceramic resonator (also a piezoelectric device), the ICM7209 continued to oscil-

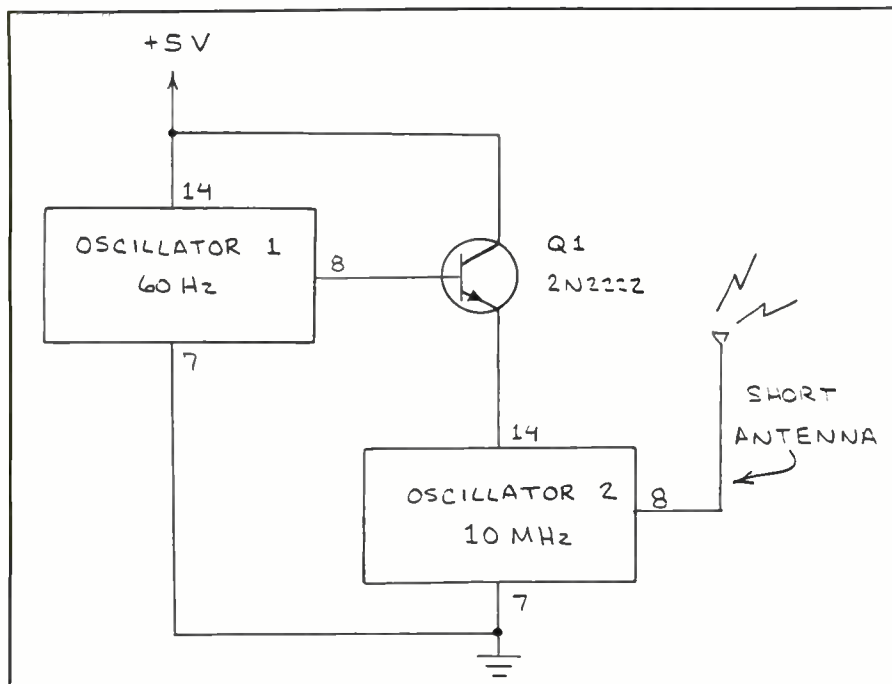


Fig. 10. Details for making a simple alternative r-f marker transmitter.

late. The only problem is that the divide-by-8 output became a divide-by-1.5 output due to the dynamic design of the divider circuit. As with semiconductor RAMs, static dividers use chains of conventional flip-flops; dynamic dividers use tiny capacitors.

Though originally designed by Intersil, the ICM7209 chip is now available for around \$4.18 from Harris Semiconductor through local distributors like Newark Electronics.

Precision 60-Hz Timebase

Quartz crystals are generally considered to be most useful as providers of high-frequency signals. But don't forget that digital watch on your wrist. Virtually all such watches have a 1-Hz output that drives the seconds display.

Even though digital watches have become extremely inexpensive, it's hard to find oscillator modules that operate at 1 or 60 Hz. One option is to use an MM5369 to make your own 60-Hz timebase. This chip is installed in an eight-pin mini-DIP. It's most interesting feature is that it uses a 3.58-MHz TV color-burst crystal instead of the considerably slower 32.768-kHz crystal used in most digital watch and clock oscillators. Assuming that the tolerances of a pair of oscillators operating at these two frequencies are identical, the faster oscillator should provide the greatest degree of accuracy when the signal is divided down to 60 Hz.

The circuit for the 60-Hz timebase is shown in Fig. 5. For best results, connect a frequency counter to the output of the circuit and tune C2 with a small screwdriver until the oscillator output is as close as possible to 3,579,545 Hz.

As with the previous circuits, you can experiment with the various outboard components. If you can't find a 20-megohm resistor for R1, use two 10-megohm resistors in series.

Using Hybrids

When first introduced, hybrid crystal-oscillator modules might have been beyond

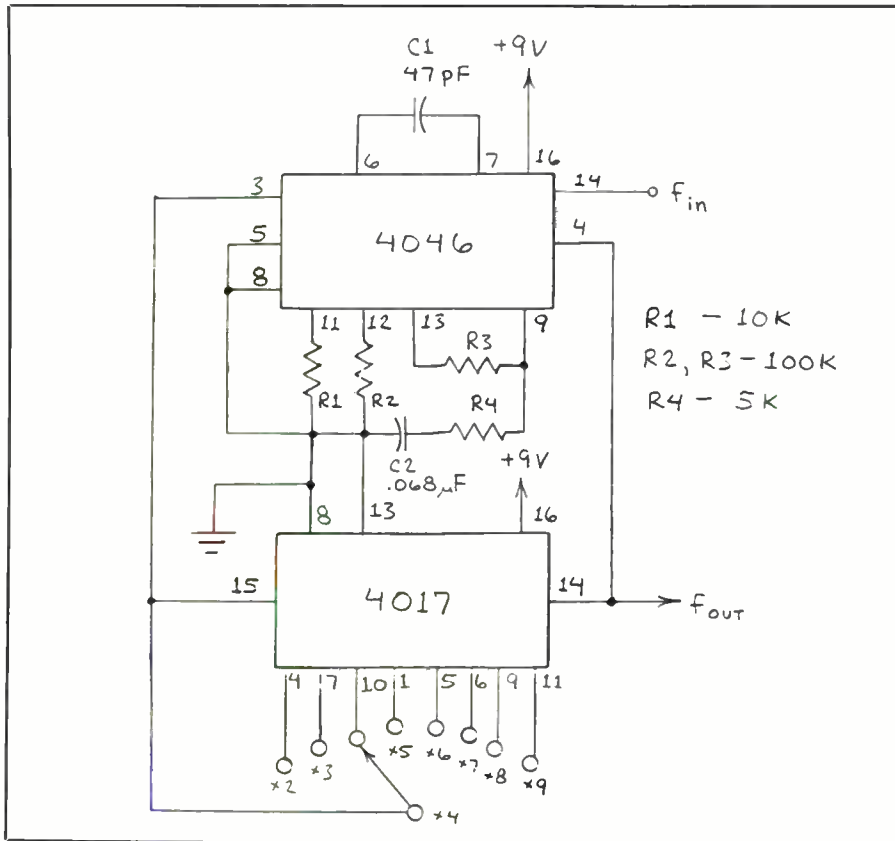


Fig. 11. Schematic details of a phase-locked-loop 2-10-9-kHz frequency synthesizer circuit.

the budget of most electronics experimenters. Today, however, you can buy modular crystal oscillators for less than \$4. Figure 6 is a drawing of a typical modular oscillator in a package about the size of a 14-pin DIP.

Crystal oscillators usually drive another circuit, but they can also drive LEDs and laser diodes. Figure 7, for example, shows how an oscillator module with a TTL output can drive an LED. The result is a light-beam transmitter modulated at a highly stable frequency.

If you're very careful, you can possibly transform a cheap digital watch into a 1-Hz timebase. Another method is to divide the output from a 60-Hz oscillator, as shown in Fig. 8. The fundamental signal is supplied by an inexpensive (around \$3 or so, plus shipping) 60-Hz

modular oscillator from Marlin P. Jones & Associates (No. 3398-CY; request catalog from address given above for latest price). A pair of 4017 counters divides the 60-Hz signal, first by 6 and then by 10, to arrive at 1 Hz.

The circuit in Fig. 8 shows the output connected to an LED. I did this to make a precision 1-Hz flasher. If you prefer, you can drop the LED and drive other circuits directly from the output of the circuit. Alternatively, you can substitute a piezoelectric tone source for the LED to create a tone that sounds at precise 1-second intervals.

Crystal-oscillator circuits that operate at radio frequencies are well suited for calibrating communication receivers. Many of the circuits described thus far can be used for this purpose. But among

my favorites is the circuit shown in Fig. 9. Here the output of 60-Hz and 10-MHz crystal oscillator modules are tied together and connected to a short wire antenna. The result is a 10-MHz marker modulated at 60 Hz. I can't say if either module can be damaged by operating them in this fashion. A connection in which the output from the 60 Hz oscillator controls the power applied to the 10 MHz oscillator is shown in Fig. 10.

Both the Fig. 9 and Fig. 10 circuits produce a very clear and distinct 10-MHz marker signal. If you first tune the receiver to the 10-MHz WWV time signal, the 60-Hz marker signal will be superimposed directly over the WWV signal when power is applied to the 10-MHz oscillator.

One of the most clever electronic circuits ever devised is the crystal-controlled frequency synthesizer. Figure 11 shows a very simple version of such a circuit that you can easily assemble and test. In operation, a crystal oscillator is connected to the input of the circuit. The frequency of the oscillator shouldn't exceed the maximum frequency response of the 4046 and 4017. The 4017 is connected here as a programmable divide-by-n counter, which is inserted into the loop between the voltage-controlled oscillator and phase comparator in the 4046 phase-locked loop.

If the input frequency is 1 kHz, available outputs are 2 kHz through 9 kHz, in increments of 1 kHz. For higher frequencies, you'll have to alter the values of some of the resistors and capacitors connected to the 4046. See the data sheet for this chip for details.

Going Further

Many books discuss the details of quartz crystal design and assembly. Visit a library if you wish to know more about these technical details.

For a good review of quartz-crystal hybrid oscillators, see "Signal Sources Handle Tough Timing Jobs" by Tom Ormond in *EDN* (Sept. 3, 1990, pp. 93 through 102). This article includes a list of the major manufacturers of hybrid crystal oscillators. **ME**

Compact Disk Technology and Computers

By Ted Needleman

A technology that's been around for a few years is just finally starting to take off—CD-ROM. As *Modern Electronics* readers, I'm sure that just about every one of you is familiar with Compact Disk technology. After all, it's rapidly supplanting both the pressed vinyl record and tape modes on which music is distributed.

The process of storing musical information in digital form also makes the technology perfect for use with PCs. After all, all those 1s and 0s being read from the disk don't have to be Led Zeppelin or Lawrence Welk. They can also represent first-class COMPUTER CHOW—that is, the stuff that all computer programs and data are made up of.

CD-ROM, however, offers something that few other methods of computer storage can provide. While the average audio compact disk may offer 60 to 90 minutes of music, the same size CD-ROM can hold between 250 and 800 megabytes of programs and files, depending upon the format and encoding method used. When you convert these figures to the equivalent number of floppy disks, which on the average hold just over a megabyte each, it's easy to see why CD-ROM is such a wonderful medium for distribution of some types of computer information.

In looking at CD-ROM, though, it's important to keep in mind that this type of storage can't be directly compared to floppy and hard disks. Both of these other mediums are read/write-capable. When the information is no longer of value or interest, or if it must be updated, the information and/or programs residing on the disk can be erased or changed. On a CD-ROM, the data is physically impressed into the media at the time the CD is created (or "pressed"). In fact, the device that connects to your computer has read-only capability; it has no electronics or capability for generating a physical change on the media.

You can, of course, buy devices with this capability; they're called WORM

(Write Once Read Many) drives. A WORM drive uses media similar to a CD-ROM, but includes the electronics and more powerful laser necessary to burn data into the disk. At the present time, most of you will have little use for this type of device.

As a rule, WORM systems are incompatible with CD-ROMs (although some vendors have produced prototypes of systems that can also act as a ROM reader) and are considerably more expensive, to boot. At between \$1,500 and \$4,000, they're most often used to store large amounts of information on-line. Some examples of where WORM drives can be useful include archiving large amounts of vital data (such as accounting information) and as a backup medium for very large hard disks.

There's even another step past WORM drives in optical storage for those who can foot the bill and need the capability: re-writeable optical disks. Unlike a WORM drive, which produces an irreversible change to the media when writing data, a re-writeable optical disk uses the combination of the heat produced by the laser beam and a strong magnetic field to alter the media. When subjected to the same combination a second time (in the exact same location on disk), the media returns to its previous state, thus effectively being erased.

Re-writeable optical disks are available right now, but their high cost (\$4,000 and up) has kept them from being adopted at the personal level. Eventually, when prices come down, they'll start to become very practical for the storage of programs and data that you want on line but don't go to that often.

Optical drives have huge storage capacities but are agonizingly slow in transferring data when compared to even a floppy disk. Tandy has been talking about its "THOR" re-writeable disk technology for a while now. We were supposed to see a \$600 device in 1990, but problems have postponed the introduction until later this year or next year. When it does appear, if it costs less than \$1,000, it'll most likely drive the market down to where the technology becomes

both affordable for many of us and quickly adopted.

Leaving out the "update" capability allows CD-ROM readers to be produced and sold at a fairly reasonable cost, and prices have come down substantially over the last year. When the first CD-ROM readers were introduced several years ago, most cost between \$1,500 and \$2,500—a lot of money for a device that had few CD-ROMs actually available. Today, you can buy a ROM reader for between \$500 and \$900. The Apple ROM drive used for this month's reviews is on the high end, costing almost twice the price of the NEC, but is also almost twice as fast.

There are dozens, if not hundreds, of CD-ROMs available, with more being introduced almost daily. This came about due to lowering the costs required to produce the CD. When CD-ROM was first introduced, mastering costs of more than \$20,000 were common. This was an up-front cost before the first CD was turned out. Being a relatively low-volume item almost killed CD-ROM before it even had the opportunity to get launched. Realizing this, CD manufacturers have made an effort to bring mastering costs down, and software to help in creating the tape or disk has become very affordable, in the range of \$500 to \$1,000. With the up-front costs coming down to a reasonable level, more companies are able to take a chance on releasing applications and databases on CD-ROM.

Last year was a boom year for CD-ROM, with numerous titles and interesting applications appearing regularly. And this year appears like it might be even better. Yet the bottom line for many users won't be the cost of the CD-ROM itself, though in some cases (such as Microsoft's *Office* reviewed below) this can be substantial. To be able to even use a CD-ROM still requires a fairly hefty investment in a ROM drive. And unlike a hard disk, this peripheral has no other use beyond allowing you to use CD-ROMs that you purchase.

Before you run out to buy a ROM drive, take a good look at the applications that are available on CD-ROM for your particular system. The pivotal question you'll have to answer is "Are these applications

important enough to me to warrant laying out another \$500 or more just to use them?" For many of you, the answer at this time will probably be no.

For some of you, applications such as Microsoft's *Office* and *Bookshelf*, *The Whole Earth Catalog*, *The New Grolier Electronic Encyclopedia* and Software Toolworks' *World Atlas* will easily justify investing today in a technology that may not reach fruition until some time in the future (if ever).

The Microsoft Office

As major companies go, Microsoft has been among the most successful in marketing applications for the Macintosh. Microsoft *Word* is one of the more popular word processors on the Mac, and its *Excel* spreadsheet is the best-selling Mac spreadsheet.

The Microsoft *Office* CD-ROM puts these two popular applications together with two others (*PowerPoint* and *Microsoft Mail*) and then adds a big bonus in the form of *Office Resources*, a potpourri of fonts, clip art, numerous utilities from third-party vendors. The end result is a package that fulfills many of the needs of a business at a very reasonable price. The CD-ROM has a list price of \$895, but, at the time this is being written, is available from several mail-order companies specializing in CD-ROMs for less than \$700. This is quite a bit less than the four applications it contains sell for.

Two of the four applications (*Word* and *Excel*) have been extensively reviewed elsewhere, and I'm not going to discuss them, except to say that they're extremely well-done programs. If you need a spreadsheet and word processor for your Mac, you won't be disappointed with either of them. *PowerPoint*, the third application included with the *Office* package, is a presentation graphics system. You can use it to prepare slides, overheads and other supporting materials for presentations and reports. This is done by assembling a set of "slides," each of which can contain both graphics and text. *PowerPoint* does let you perform some freehand drawing, but it is

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Click NAME to enter domain	Click PICTURE for domain contents

As with the documentation for The Microsoft Office, the information on the included third-party "resources" is contained in a hyperCard stack.

really set up to use graphics imported from other applications, either clip art or those created by a paint or draw program such as Aldus *FreeHand*.

Creating text slides, or adding text over a graphic, is really easy. Several typefaces are included, as are templates, standard formats for presentations including lists, bulleted lists, numbered lists and various forms of outlines. Just pick the one(s) you wish to use, and add your own text by typing it in directly or by importing it in as a word-processor or outliner file.

I've used both the Mac and *Windows* versions of *PowerPoint* to create about a dozen presentations, and I've found them to be very similar in both features and operation. And while there are numerous features that I haven't yet gotten around to trying, I can't see there being much besides animation that *PowerPoint* won't let you accomplish in the way of making up a presentation.

The last application of the four, *Microsoft Mail*, is a great application if you are running Apple's AppleTalk network . . . and useless if you aren't. *Mail* gives you the capability of sending messages, documents or spreadsheets to any other user

connected to your network. As network mail packages go, *MS-Mail* is one of the easiest to use and offers most of the features for network communication you might want. However, if you aren't networking a bunch of Macs, or if your network is not very disbursed, *MS-Mail* is going to be of limited or no value to you.

In putting together this ROM, Microsoft was able to include an astonishing collection of additional packages and utilities, which the company calls "resources." This collection greatly enhances the usability of the four core applications, but many are useful beyond their use with the Microsoft packages.

While the list of these resources is too extensive to reproduce here, some of the "contributions" from other vendors include a collection of more than 350 screen fonts from Adobe (which, of course, gives you a good idea of what the typefaces look like, but are of limited value unless you've received the printer fonts with another application or are printing to an *Encapsulated PostScript* file to be used by a typesetter who has the corresponding printer fonts), and *MacFontware* from Bitstream.

PC CAPERS...

I've discussed the PC version of Bitstream's *Fontware* in previous columns, and the Mac version works pretty much the same, letting you generate screen fonts and printer fonts (both *QuickDraw* and *PostScript*) from outlines supplied by Bitstream. The *MacFontware* supplied with the *Office* ROM includes Bitstream's own Charter typeface and gives you an excellent idea of what the technology can do. Other typefaces are available from Bitstream, and will work with the *MacFontware* software.

Other neat applications included on the CD-ROM are phone listings from Xiphias and *The Phone Book Library* from General Information. Xiphias' *National Directory* is a CD-ROM-based telephone database that includes more than 120,000 listings for American business and government. The version included with the *Office* is a demo, rather than the entire database, but is interesting nevertheless.

General Information's *Phone Book Library* is a HyperCard application that lets you set up your own phone books, or access the *National Directory 5000*, an included database of more than 5000 business listings. I've had General Information's *HotLine* database of phone numbers on my PC for a while and just installed the company's new *HotLine 800* (a database of toll-free numbers) and really like their products.

Another resource you'll probably find useful, if you don't already have it, is Microsoft's *QuickBASIC* interpreter for the Mac. This is the full working version, not a demo, and lets you create your own BASIC programs.

GOfer from Microlytics is another useful utility. This installs as a Desk Accessory, and lets you scan a hard disk, CD-ROM, or file server for a particular text string. When you have as many files on your systems as I usually do, it's easy to forget exactly what's in each file, even though the Mac lets you use longer, more descriptive file names than MS-DOS' eight-character file label. *GOfer* is a real time saver when it comes to locating a file where you recall the subject matter, but not the file name.

There are lots of others, some of which may be more useful for your purposes than others. They're all described in a HyperCard stack, a sample of which is reproduced here.

One of the major ways that Microsoft's *Office* differs from many other Mac applications (and PC applications as well) is in the documentation. It's all available on-line in the form of HyperCard stacks. These HyperCard stacks can be installed on your hard disk as part of the installation procedure. Installing the help stacks on your hard disks allows you to access the help much faster than if you had to access it from the CD-ROM. You can also, for a \$15 handling charge, get paper versions of the documentation for the four applications. I ordered these, just to have them on hand, and they arrived in a fairly hefty box that I've yet to open. I admit to preferring the HyperCard approach, which lets me browse from one point of interest to another.

Microsoft suggests that you use the *Office* with a Mac Plus (or more powerful system) with at least 2MB of RAM. I ran the *Office* from both a Mac IIx with 8MB, and my old Mac 512e which was bumped up to 1MB with Dove's Mac-Snap, and I have to concur with the recommendations. It's possible to run the *Office* on a 1MB Mac, but every now and then I got a system error that blew me off of the machine. This never occurred with the Mac IIx. And the system does run much faster on the IIx, a consideration to keep in mind when using a slow CD-ROM. Is the Microsoft *Office* a good buy? It all depends on whether or not you have a use for the applications it contains. If you need only one or two of the applications, it's less expensive to purchase them on conventional floppy disks. That way, you're not paying for something you'll never use, or which will be upgraded substantially before you ever look at it.

But if you need at least three of the four applications, the CD-ROM is a good value. And the CD-ROM versions come with the terrific on-line HyperCard help system and all of the "resource" goodies. Microsoft's *Office* probably wouldn't be my first CD-ROM purchase, though. A

public-domain/shareware disk, such as the CD-7 ROM reviewed a bit further on, makes more sense to me, but I do use a number of Microsoft applications. If the *Office*'s collection will be suitable for your needs, the CD-ROM is probably a good deal.

The Electronic Whole Earth Catalog

Certain things every certified information addict just has to have. An information addict is someone who collects information just to have it. Whether or not he actually has a use for the information, or will ever put it to use, is beside the point—it's just fun knowing. If you've ever been accused of being a repository of useless information, welcome to the club, and take comfort in knowing you're certainly not alone.

There's another way to recognize an information addict: by the copy of one of *The Whole Earth Catalogs* on his bookshelf. *The Whole Earth Catalog*, for those of you too young to remember, was an oversize paperback, first published in 1969, which was subtitled "Access to Tools." And that it was, a compendium of reviews and short pieces whose purpose was to point you in the right direction for collecting information.

The *Catalog*, put together by Stuart Brand and his merry band of data freaks, wasn't an elegant book, but boy was it fun to read! Published sporadically during the Seventies and early Eighties, I've spent more hours than I want to admit to over the years lost between its covers. If you wanted to know where to go to for information on windmills, or to find out where plans for your own hydroelectric dam were available, it was in *The Whole Earth Catalog*, as were sources on self-health materials, and a host of other current and arcane categories.

Lest you think that the *Catalog* was just for those of the counter-culture, ready to give up the comforts of modern living, *The Whole Earth Catalog* was quick to embrace the newly emerging technology of microcomputers. The ra-

Office Resources

Other Microsoft Products

Microsoft® QuickBASIC Interpreter

Microsoft QuickBASIC is a powerful, easy-to-learn, easy-to-use, structured BASIC for beginning or expert programmers. The QuickBASIC Interpreter is the simplest, quickest way to unleash the power of your Macintosh. The Microsoft QuickBASIC Interpreter includes the interpreter portion of Microsoft QuickBASIC. Three sample QuickBASIC programs are also included with source code and the compiled applications.



Microsoft® Works Autodemo

Microsoft Works is an easy-to-learn integrated software package containing the five most commonly used software tools: word processor with spell checking and mail merge, spreadsheet with charting, database with reports, communications, and graphics. This Works demo can be found in the Microsoft Products folder inside the Resources folder on The Microsoft Office CD. The demo can be run directly from the CD by double-clicking on the Microsoft Works Autodemo HyperCard stack.



*Hold down the Option Key for Button Explanations

The Electronic Whole Earth Catalog lets you browse through a HyperCard stack that contains information resources on a wide variety of subjects.

rationale behind *The Whole Earth Catalog* was that it was (and is) important that you be able to find out where to go when there's something you want to know about. I found this rational, and the approach the *Catalog* took to be irresistible, and I'm sure that a lot of you would also.

The last paper version of the catalog, *The Essential Whole Earth Catalog*, was published in 1986. With the computer as one of the ultimate information machines, it makes a lot of sense that one of the first CD-ROMs for the Macintosh was the electronic version of *The Whole Earth Catalog*, published this time around by Broderbund Software, Inc.

The Electronic Whole Earth Catalog, now subtitled "Access to Tools and Ideas," is a set of almost 9,500 HyperCard cards. Though organized a bit differently from the paper version, it contains many of the same things that endeared it so from the *Catalogue's* first 1969 publication. These include short-to-the-point commentaries and reviews, as well as the sense of no-B.S. honesty that comes through. Also held over is the wide range of subjects that the *Catalog* covers, from communications to do-it-yourself

veterinary medicine. Not everything in this CD will be of interest, but you'll be very pleasantly surprised at how much is.

The Electronic Whole Earth Catalog wouldn't be possible without HyperCard, a software package pioneered by Apple's Bill Atkinson. HyperCard uses "cards," which are screens filled with information, and allows links between a word on one card and sections of text on another. For example, if you're perusing a card that talks about magazines and come across the word "multi-media," you could move the cursor to this word and click the mouse button. If links have been established, HyperCard will take you to a card that discusses "Multi-media." When you're reading this card, you can either branch on to an additional topic, or click on the "home" icon to return to the original card. A collection of cards makes up a "stack," which could be equated with a chapter of a standard paper-based book.

The Electronic Whole Earth Catalog is unique in that it's even more effective and efficient as a CD-ROM-based HyperCard stack than as a paper-based publication. There are even 500 or so sound sam-

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PC CAPERS...

ples that accompany certain selections! At \$149, though, the electronic version is considerably more expensive than the original. But if you have both a Mac and a CD-ROM player, *The Electronic Whole Earth Catalog* is one CD-ROM you must add to your collection.

CD-7 and Macademic

The two CD-ROMs discussed above were both fairly expensive propositions. As with software in general, not every CD-ROM package costs an arm and a leg. The *CD-7* and *Macademic* ROMs from QL Tech are good examples of ROM-based values.

Both CD-ROMs are collections of public-domain software and shareware for the Mac. (The difference between public-domain software and shareware, if you're unfamiliar with the term, is that you're free to use software that has been put into the public domain. Shareware is generally distributed at no cost, but if you use it, and like it enough to continue using it, you're expected to pay the author a small fee. Of course, the author has no way to enforce this fee, but if enough people continue to use shareware without paying for it, the author won't be able to afford to continue to update it, support it or write new software.)

The two collections overlap somewhat, containing some of the same software. In general, though, the *CD-7* is a more eclectic collection. It contains utilities, telecommunications packages, art, draw and clip art, desk accessories, games, HyperCard stacks, music packages and a lot more. In fact, the *CD-7* ROM contains more than 719 megabytes of software and more than 15,800 files! The index alone exceeds 130 pages when printed out.

The *Macademic* ROM is also an ambitious undertaking. It contains about 7,500 programs, most of which have an educational slant. It includes tutorials, games, demonstrations and simulations in the areas of art, music, mathematics, science, reading, spelling, religion, foreign languages and others. Again, most of these programs are either in the public



QL Tech has a number of CD-ROM offerings that Apple Macintosh users will find interesting.

domain or shareware (the remainder are demo versions of commercial software), and the index is in excess of 130 pages when printed out. The programs that the *Macademic ROM* contains vary in suitability from pre-school on up to college level. If you have children, or are just interested in widening your own horizons, there's something in here you'll find interesting and informative.

I haven't had the time to do much more with these two ROMs than just skim the surface; after all, it takes time to load and run more than 20,000 pieces of software. Yet even with the small sample I've been able to look at, it's obvious that the QL Tech collections are similar in at least one respect to other collections of shareware and public-domain software. Quality of the individual packages varies greatly. There are some packages where you'd ask for your money back if you had bought them separately, and others that make you wonder how the author could ask for such a small donation because the package is equal to or much better than commercially available software.

In any case, with 15,000 programs on one disk and more than 7,500 on the

other, you can't go wrong at the price. The *CD-7 ROM* costs \$99, while the *Macademic disk* is a reasonable \$149. QL Tech has several other collections of Mac software on ROM that I haven't looked at: *The Right Stuff* at \$99, and *Mega-ROM* for \$49.

You won't like every package on these disks, but at the price, they're hard to

beat. If you have a Mac and a CD-ROM player, the *CD-7* disk is a good way to boost your software collection. And with commercial educational software running \$35 to \$50 a package and more, the \$149 *Macademic ROM* is a real bargain.

Next month, we'll take a look at some other CD-ROM applications, and program collections, this time for PCs. **ME**

Products Mentioned

The Microsoft Office, \$ 895.
Microsoft Corp.
 One Microsoft Way
 Redmond, WA 98052
 206-882-8080

The Electronic Whole Earth Catalog,
 \$149.
Broderbund Software, Inc.
 17 Paul Dr.
 San Rafael, CA 94903
 800-521-6263

CD-7 ROM/Macademic ROM,
 \$99/\$149.
Quantum Leap Technologies, Inc.
 314 Romano Ave.,
 Coral Gables, FL 33134
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CIRCLE NO. 83 ON FREE INFORMATION CARD

Serial Number Chip, Melody Makers, Silicon Pressure Sensor and Free Selection Guide

By Joseph Desposito

In this month's column, we examine a number of interesting chips and circuits and give details on obtaining a free database of Motorola devices.

Two-Pin Serial Number Chip

Dallas Semiconductor (4350 Beltwood Pkwy. S., Dallas, TX 75244) has announced a 64-bit chip that holds a unique serial number that can identify printed-circuit board (PCB) assemblies, or provide a network address or an access code.

In the case of a subassembly, the DS2400 Silicon Serial Number chip can act as a license plate that uniquely identifies each one. As the subassembly goes from one test station to the next, it can be logged in at each station to facilitate tracking, increasing the efficiency of the manufacturing process. Unlike bar codes, this tag can be read without supplemental optical equipment.

After the subassembly is shipped as part of the equipment, the DS2400 also has advantages for end users. First, they need not tear apart the equipment to find

the buried serial number. Because the number is electronic, a few keystrokes will display it on any screen. If a subassembly is faulty, it can be referenced through this number. Secondly, the chip facilitates asset management—end users can monitor highly mobile computers and components.

The DS2400 Silicon Serial Number chip has only two pins: data and ground. With a multiplexing scheme, the chip reduces data, control and power to just one pin. This is made possible by an internal timebase that measures the pulse length to determine if it is a 1 or a 0. In a similar manner, it sends 1s and 0s back using long and short pulses. Because it uses the same conductor to send and receive information, the device can be read with just one signal conductor.

The chip operates on a minute amount of power—it is powered from the signal coming in. A reservoir of charge made from internal capacitance stores energy when the incoming signal is high. When the input signal is low, the stored charge provides power. The internal charge source is refreshed every time there is a signal transition.

The Silicon Serial Number chip contains 64 bits that are written by a laser at the Dallas manufacturing facility. The first eight bits contain the model number. The next 48 bits are the one-of-a-kind serial number. The last eight bits contain CRC (cyclic redundancy check) circuitry that, in addition to ensuring that each chip is unique, verifies that the bits are free of corruption and that there is no error in the transmission link to the system. Should the CRC circuitry not validate the serial number, the system indicates that the number is not to be trusted.

In addition to serving the function of a license plate, the DS2400 can serve as a network address. Because it is unique, the chip can provide the node number for a local-area network (LAN), which is essential to distinguish one node among many. A third use is as an access code. As an example application, a garage door opener requires a unique code word so that one opener does not open every garage door. Currently, this requires either a set of DIP switches or unique software in each opener. The Silicon Serial Number can accomplish this at low cost (see Fig. 1). Because each chip is different, all

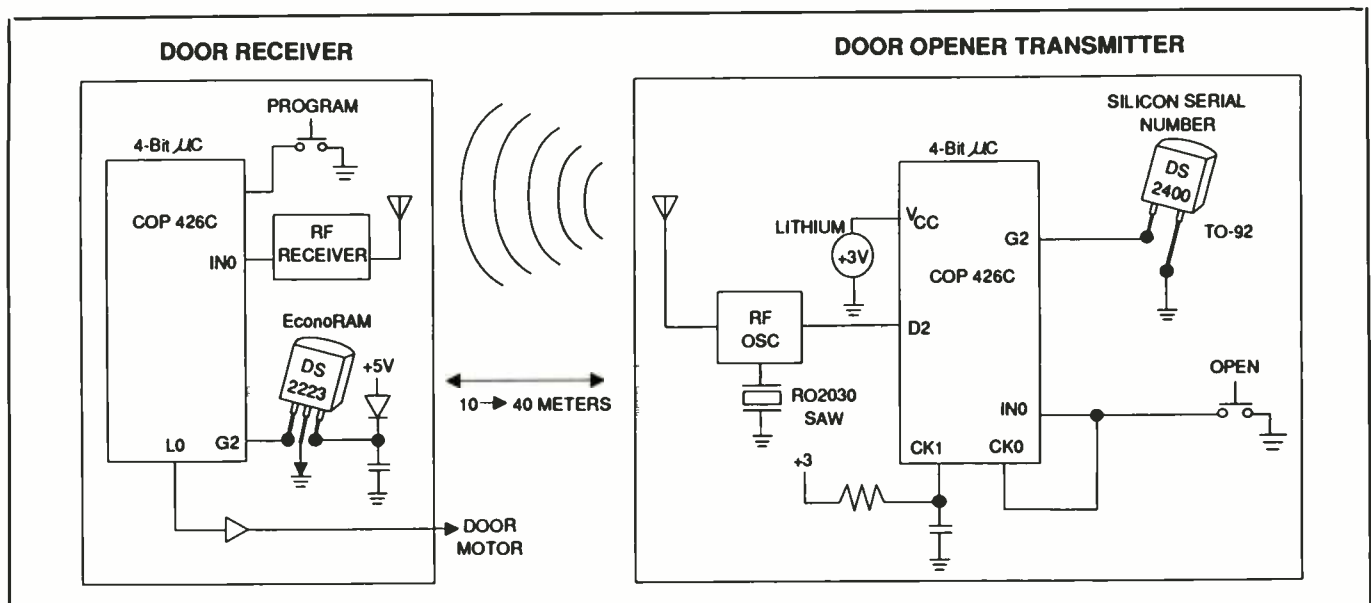


Fig. 1. Details of a remote door-entry monitoring system built around the Dallas Semiconductor Silicon Serial Number chip.

other components in the equipment can be the same, lowering the manufacturing cost. Answering machines with a remote message-retrieval feature are another example of an application for this chip.

As a further service, Dallas Semiconductor provides a directory with listed and unlisted numbers, much like a telephone directory. Listed numbers can be referenced to their owners. On request, the company will update the directory to show change of ownership of the chip. It is also putting into place measures to protect the identity of unlisted customers.

Packaged in a TO-92 plastic transistor case, the DS2400 silicon Serial Number chip sells for 35 cents in quantities of 100,000. Each chip is registered and tested before shipping.

Melody Circuits

LSI Computer Systems (1235 Walt Whitman Rd., Melville, NY 11747) has introduced the LS3404 series of melody circuits. These are monolithic ion-implanted MOS circuits designed to generate music. The circuit is mask-programmable and can hold 255 notes in PROM.

Pitch has a 0.8% resolution for notes up to 2 kHz and 1.3% for notes up to 3 kHz. Note duration ranges from 125 milliseconds for a 1/16th note to 2.0 seconds for a full note. This is equivalent to 120 beats per minute.

A duration counter permits eight note durations out of a possible 16. A pitch counter allows for 15 different pitches out of a possible 511 pitches.

The output of the pitch counter is conditioned by an external R/C envelope to provide proper envelope decay and is applied to a pair of operational amplifiers that drive a piezoelectric speaker in a push-pull configuration. Only one output is used for driving an external transistor/dynamic speaker combination in a single-ended configuration (see Fig. 2). The exponential decay envelope imposed on each note provides a realistic effect to sound quality.

Upon application of a supply voltage, power-on reset causes a small time delay

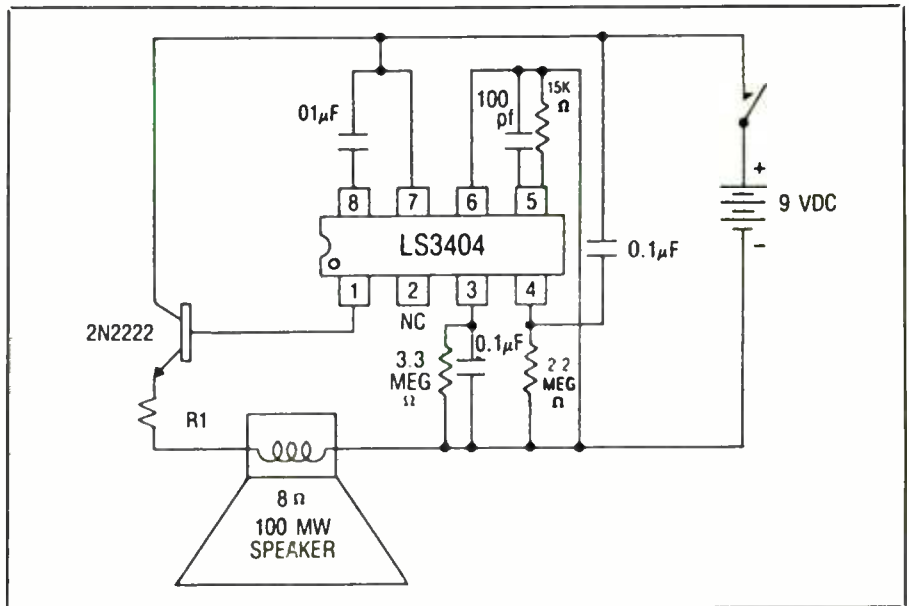


Fig. 2. Only one output of the LSI Computer Systems LS3404 melody chip is used for driving an external transistor/dynamic speaker combination in a single-ended configuration.

and then the chip starts to play. Play is terminated by removing the supply voltage or on completion of the entire play.

Tunes currently available are old favorites, such as "Happy Birthday" and "As Time Goes By," Christmas favorites, such as "Jingle Bells" and "Walking in a Winter Wonderland," and other tunes. The circuits are available from LSI's exclusive distributor, Thumb Electronics (P.O. Box 263, Avoca, MI 48006). Thumb charges \$1.50 per IC. A six-tune assortment is \$10.

Silicon Pressure Sensor

Motorola (5005 E. McDowell Rd., Phoenix, AZ 85008) has introduced an integrated pressure sensor. The MPX5100D is a 0-to-15-psi, fully signal conditioned output pressure sensor that integrates the sensing element, offset calibration, temperature-compensation circuitry and signal amplification on a monolithic silicon chip.

This new pressure sensor is well-suited

for microprocessor-based systems; its sensor output scale is calibrated from 0.5 V to 4.5 V. In addition, it is temperature-compensated over the range of 0° C to +85° C. The device uses a patented silicon shear-stress strain gauge for use over the range of 0 to 15 psi differential pressure. To make the sensor even easier to use, it is available in the basic element package, single- and dual-ported versions, and also with customized outputs.

Other attributes of the new MPX5100D include low cost and miniature size. Some typical applications are in industrial, consumer, automotive and biomedical products where pressure monitoring or closed-loop control is desired. The MPX5100D sensor is priced at \$45 in quantities over 100.

Selection Guide on Disk

Motorola (2100 E. Elliot Rd., Tempe, AZ 85284) has a new version of its free data disk, called the "Motorola Electronic Selection Guide." This floppy-res-

SOLID-STATE DEVICES...

ident database allows design engineers to rapidly search Motorola's entire semiconductor product offerings and select the best device for an application. The Motorola data disk provides information for more than 13,000 Motorola ICs and components in 124 product categories and also contains cross references to over 25,000 competitive devices. The data disk is now available in both IBM and Macintosh formats.

The data disk is a menu-driven program that permits users to perform parametric searches across Motorola's semiconductor product line. Users can locate devices by entering values for parameters that are important to their applications. After these values are entered, a single keystroke displays every Motorola device that meets these requirements, with the absolute best device for the specified ap-

plication always listed first.

Device number, cross-reference and partial number searches are all supported on the disk. These features permit users to display information on thousands of Motorola devices, to locate direct and similar replacements for more than 25,000 competitive devices and to view entire families of products with the partial number search.

The data disk offers an easy-to-use, fast alternative to the printed selection guide. All searches are performed in less than a second and no user manual is required. Users simply insert the disk, type "M" and begin. Smart messages and prompts guide even first-time users through the program smoothly.

The data disk provides a list of Motorola technical literature for every device in the database. This literature includes ap-

plication notes, engineering bulletins, article reprints, training courses, data books and data sheets—complete with document numbers and titles. The software will even print an information request form to make it convenient to order any literature item.

The IBM version of the Motorola Electronic Selection Guide comes on two 360K 5¼-inch floppies—one for discrete devices and one for ICs. The Macintosh version comes on a single 800K 3½-inch microfloppy.

To receive a free Motorola Electronic Selection Guide, write to Motorola Data Disk, Literature Distribution Center, P.O. Box 20924, Phoenix, AZ 85063; or call 1-800-521-6274. Specify if you require the IBM compatible version (DK101/D) or the Macintosh version (DK201/D).

ME

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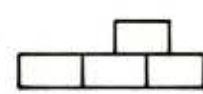
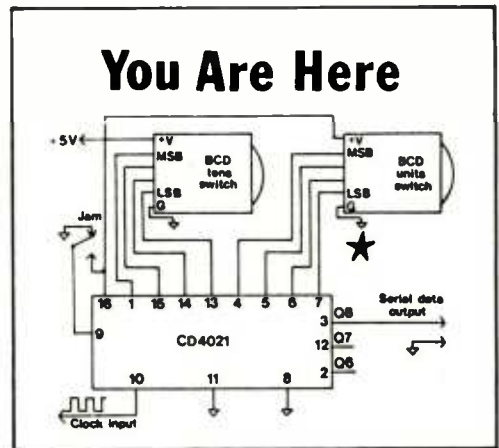
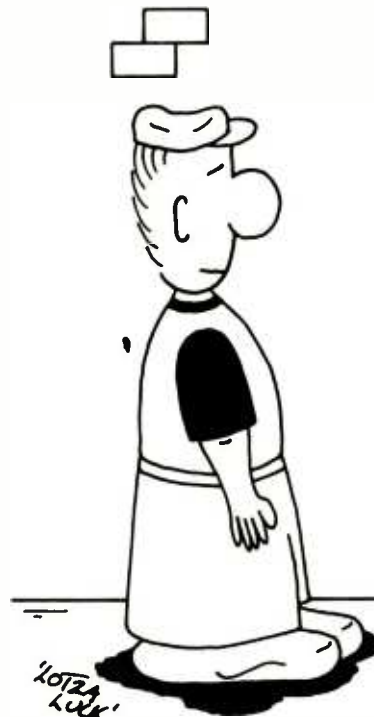
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CIRCLE NO. 32 ON FREE INFORMATION CARD



Electronic References

Every professional and serious amateur needs books to which he can refer to fill the gaps in his knowledge or to just recall to his mind particulars about his specialty. Those of special note this month are as follows.

Television and Audio Handbook (McGraw-Hill; hard cover; 640 pages; \$39.95) by K. Blair Benson & Jerry Whitaker presents the basic data needed to maintain, troubleshoot and service state-of-the-art systems. Designed as an on-the-job reference, the Handbook explains the fundamentals of TV and audio circuit design and performance and offers details on operation, maintenance and testing of systems and components. Coverage includes analog and digital systems, video and audio signal processing, speakers and sound systems from microphone input to sound output, design and operation of TV receivers, CD and magnetic tape recording, and procedures for evaluating system performance.

You need a lot of shelf headroom for the 8½ × 11-inch *Encyclopedia of Electronics*, Second Edition (Tab Professional and Reference Books; hard cover; 960 pages; \$69.50) edited by Stan Gibilisco and Neil Sclater. This new edition contains updated information on virtually every electronics concept and component in existence, with stress on recent advances in digital electronics and computer technology. Among the new listings are: artificial intelligence; superconductivity; fax machines; fiber optics; laser printers; CDs; PLDs; CAD/CAE; HD-TV; barcodes; LANs; and much more.

Electronics Troubleshooting

To keep the professional service technician abreast of latest developments, this month brings some interesting offerings.

We lead off with John P. Steiner's *Technician's Handbook of VCR Repair* (Prentice Hall; hard cover; 171 pages; \$35). This handy book combines service information from major VCR and test equipment manufacturers with techniques for diagnosing problems in faulty VCRs. Guidelines from VCR manufacturers are included for confirming that repairs and adjustments will restore a VCR to original factory specifications. Typical symptoms of faulty circuitry are included for audio systems, VHS recording and playback circuitry, power-supply

circuitry, servo systems, microprocessor control circuitry and agc and afc systems to allow you to pinpoint which stage(s) are likely to be defective. Adjustment procedures for each major VCR section are also provided.

In a related book, *VCR Troubleshooting and Repair* (Prentice Hall; hard cover; 242 pages; \$37), John D. Lenk provides a practical system of troubleshooting that concentrates on current VCR systems. This book is concerned primarily with differences between hi-fi/S-VHS VCRs and conventional machines. Each chapter covers a single function or feature. Areas covered include: S-VHS basics; troubleshooting and repair of the digital system; stereo TV MTS/MCS decoder/audio; barcode timer programming; VCR hi-fi; digital picture-in-picture; VISS/VASS program indexing; information on recommended cleaning and lubrication procedures; and mechanical section repair.

J.A. Sam Wilson's *Electronic Troubleshooting Procedures and Servicing Techniques* (Prentice Hall; hard cover; 254 pages; \$38.60) offers practical guidance for general electronics troubleshooting and repair, from single components through circuits, and on up through full-blown systems. It is a compendium of troubleshooting tests, measurements and servicing techniques. Unlike other books of this nature, though, this one is organized by techniques, rather than a formal troubleshooting procedure. This departure is not a negative; rather, it is an alternative that can prove to be eminently suitable for a wide variety of problem situations. To provide a "hands-on" approach, the book uses an unthreatening simple radio receiver as an example for discussing the system concept. Symptoms are used whenever possible to illustrate how to zero in on the section at fault in a system.

NEW LITERATURE

Learn-At-Home Catalog. The Fall 1990 HomeWorks by Heathkit Catalog from the Heath Co. (St. Joseph, MI) details the company's full line of learn-at-home electronics courses. The colorful 32-page Catalog describes courses in basic and advanced electronics, laser technology, dig-

(Continued on page 82)

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which is rigidly fixed for both placement and font size. You can choose one of three font sizes, from 8-point to 16-point.

Wires are placed on the drawing by selecting the wire type from the drawing cells and clicking once to start the wire and again to stop it. However, each wire is a single entity, which means you can't have continuous runs. You must end one wire then begin the next at the termination point for continuous runs. Snap to grid and object snap are both supported.

There's no autopan. Instead, scrolling is done by using scroll bars at the right side and bottom of the screen or by using the keyboard's page-up, page-down, and arrow keys. In fact, keys play an important part in drawing and editing of the schematic, and in several cases there's no mouse equivalent of a keystroke.

Editing features are excellent, with move, copy, delete, change, replace and find available for both single objects and blocks. There's also a design checker that points out drawing mistakes. Zoom, however, leaves a lot to be desired, offering only two levels: a full view of the worksheet and normal. Each of these functions can be called up by simply clicking on the menus that border the screen.

SuperCAD features automatic bus generation, where you need only type a bus name and a few bits of information to make the software automatically draw connecting lines and signal names. Macros can also be loaded to improve operating efficiency.

The program has an excellent context-sensitive on-line help screen that tells you all you need to know about using the program. This is welcome because the 55-page user's manual is

pretty sketchy in some areas.

The netlist format is *SuperCAD*'s own; a translator for PC design work from a company cooperating with Mental Automation is included. Also, an optional utility (\$49) is offered that supports half a dozen or so popular formats.

Hard-copy printout is of good quality, but you have no control over the printer or the size of the schematic on the page, which means you may end up taping more than one schematic together. Plotters and laser printers aren't supported, but the optional utilities that were cited are available for these purposes.

For its price, *SuperCAD* is surprisingly capable. The program is full-featured and easy to learn and use. We recommend it highly for entry-level schematic capture work.

CIRCLE NO. 28 ON FREE INFORMATION CARD

Tango-Schematic Series III from Accel Technologies

Tango-Schematic is an extremely versatile \$495 schematic capture program. Happily, it doesn't have a steep learning curve and is fairly easy to use. It comes with a large component library and has exceptionally good printer hard-copy control. You'll need 5MB of free disk space plus 1MB of LIM-compatible RAM to use it, though.

The component library consists of more than 11,000 devices spread among 23 library modules, and includes military as well as commercial TTL devices in both DIP and surface-mount packages. However, several thousand parts are duplicated among the modules, each with the same body outline but a different library name (for example: SN74LS112AN, SN74LS112AD, SN54LS112AJ, SN54LS112AW, etc.). A count of *different* device types, however, reveals a more realistic library size of about 3,500 devices, which is plenty big anyway.

Components are called up from the library via a *Windows*-like dialog box. You can either enter the device name at the prompt or choose the part from a menu list. The menu list is the better choice because most library modules are manufacturer-specific, with eight modules alone dedicated to Texas Instrument TTL chips, and a generic name like 74LS02 won't get you anything but a "part not found" warning. The manufacturer's full device name is mandatory. Multiple part placement is supported, as is rotate.

Before you can place a part on the worksheet, its library module must be loaded into the worksheet; up to 10 library modules are permitted per drawing. To reduce the amount of disk space consumed by the library modules, which totals 3.6MB for all 23 modules, you can extract the parts used by the drawing from their related modules and save them in a drawing-specific library module—

which now becomes the only library module needed for that drawing.

Part references can be designated either during or after the part is placed on the worksheet. Automatic part naming is also supported, with annotation starting at the upper-left section of the schematic and sweeping to the lower-right corner in a raster pattern. Parts that have previously assigned references aren't changed and their references aren't duplicated. However, references manually assigned during part placement or editing aren't checked for duplication. Each device has two reference lines, which can be edited for text and position, but not font size.

A wire is drawn by clicking the mouse button once to start the line and clicking it a second time to place the line and change its direction. You can also draw 45-degree diagonals in the ortho mode.

Tango-Schematic has no pan function. Instead, the infinitely-variable

zoom is used to place the work area of interest on center-stage. Unfortunately, this doesn't help with placement of long wire runs because the small zoom magnification needed to view an entire sheet makes wire alignment difficult.

Tango has three grids: an absolute grid that's immovable, an invisible grid-snap reference grid that can be moved with relationship to the first, and a visible grid that can't be turned off but can be toggled between a dot and a hatch pattern. Dot spacing for each grid pattern is individually programmable.

Editing features are excellent, with move, delete and find among the many editing options offered for single objects, blocks, and buses. There's also a clean-up routine that removes duplicate wires but doesn't catch duplicate parts. Context-sensitive on-line help is available.

Tango supports only its own netlist format at this time. This shortcoming ties you to Tango PCB products, unless another brand PCB layout or simulator software includes a Tango netlist converter. Netlists can be checked for drawing errors using a Design Rule Checker utility.

Printer output is just short of fantastic, with control over all aspects of the hard-copy page, including image resolution, colors for printers that support them, and sizing a drawing to fit the printer page. But this printer driver is no miracle worker. It will refuse to print an E-size drawing on an 8½-by-11-inch page for obvious reasons. Plotter control is equally good.

In conclusion, *Tango-Schematic* is an excellent schematic capture program with many drawing features and much versatility. But plan on using it with Tango's PCB layout software if you need a complete PCB design package because the schematic package doesn't include netlist conversions.

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Schematic Capture Rating Summary

Program	Drawing	Editing	Library	Software Printer Control	Netlist Compatible	Ease of Use
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<i>HiWIRE Plus</i> incl. PCB (\$895)	C	D	C	D	C	C
<i>OrCAD</i> (\$495)	B	B	A	D	A	B
<i>ProCAD Xtra</i> Incl. PCB (\$945)**	A	A	B	A	A	C
<i>Protel</i> (\$495)	A	A	A	A	D	A
<i>Schema III</i> (\$495)	B	B	B	D	A	B
<i>SuperCAD</i> (\$99)	B	B	D*	D	D*	B
<i>Tango</i> (\$495)	B	A	A	A	D	B

A is Excellent; B is Good; C is Fair; D is Poor; * Options available to expand; ** Includes optional \$150 library

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OrCAD Systems
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San Jose, CA 95110
408-437-7771

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Richardson, TX 75081
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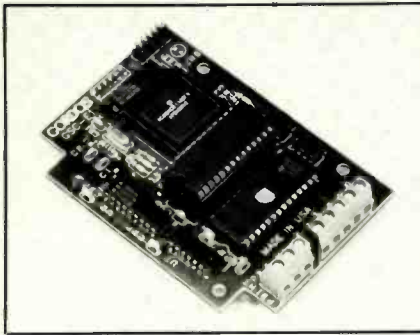
Tango-Schematic Series II
Accel Technologies, Inc.
6825 Flanders Dr.
San Diego, CA 92121
800-433-7801

Single-Board Computer

The new Model GSC-BE3 BASIC plug-in engine from GORDOS (Rogers, AK) permits distributed control by relieving the host computer of many routine control, sequencing and data-acquisition operations. The programmable miniature single-board computer, equipped with battery-backed memory and a real-time clock, mounts piggy-backed on any GORDOS GSC-series serial controllers for local process control.

A BASIC program running in the unit communicates commands to one or more GSC controllers and other serial devices connected to its RS-422/485 port. The engine is programmed from a PC in BASIC or assembly language and can be used to make decisions based on analog and/or digital signals relayed to the controller. Its interpreter uses standard BASIC commands.

Applications programs can emulate various network protocols to permit operation with existing software. The engine can enable output



devices in response to analog and digital inputs. It can also read input counters, pulse and sequence outputs, pulse-width modulate dc sources, switch stepping motor phases for speed and direction and output analog process currents.

A utility program, provided on-disk, runs on an IBM PC or compatible computer to establish direct keyboard communication with the engine. Commands entered via the PC keyboard are communicated to the engine and appear as standard text on the video display. The program also provides a means to upload and download BASIC programs from disk files.

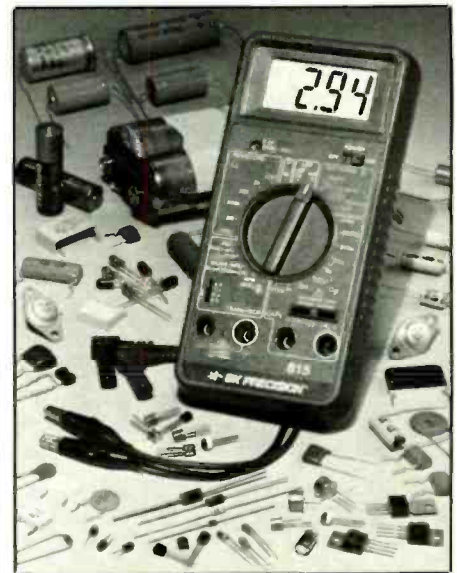
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ger-level control, operation is via pushbutton switches. The LED display consists of 7½ digits. LED indicators are provided for function selected; gate time selected; MHz/ms and kHz/μs selected, gate and over-range. Input connections are made via BNC connectors. A carrying handle doubles as a tilt stand for bench-top use. \$595.

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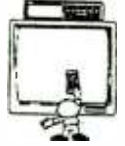
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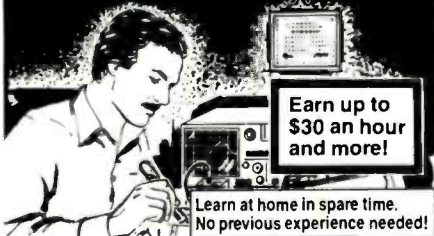
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NEW LITERATURE

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ital techniques, microprocessing, fiber optics, amateur radio operation and more. Important prerequisite information and a listing of needed materials for each course are given. A variety of Heathkit trainers (available assembled and in kit form) and accessories used in performing course experiments are noted throughout the Catalog, as are optional instruction videocassettes for several of the learning programs. Also featured are a variety of educational kits for beginners and experienced kit builders.

CIRCLE NO. 56 ON FREE INFORMATION CARD

Full-Line Catalog. Available for the asking from Parts Express is the company's 1990/1991 full-line catalog that lists and describes electronic components and accessories. Included in the listings are capacitors; resistors; switches; speakers and accessories; connectors; cable and wire; TV, CATV and VCR repair parts; chemicals; tools; technical books and schematic diagrams; alarm equipment; and computer accessories.

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Selection & Use of DMMs Booklet. A full-color Application Note booklet from John Fluke Mfg. Co., Inc. (Everett, WA) provides DMM buyers with selection criteria and current DMM users with information to maximize the value of their instruments. "A Guide to High-Performance DMMs" begins with a definition of the high-performance DMM. It also includes sections on Extended Measurement Capabilities, Recording Modes, Special Features and Accessories. A chapter on Selecting True-rms and Averaging meters offers information on matching the technician and application to the right meter.

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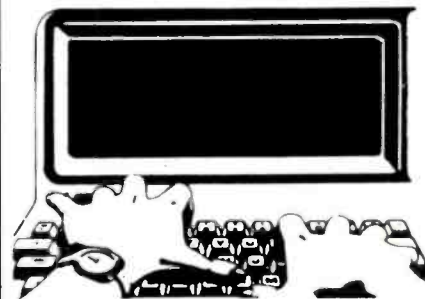
Electronics Catalog. The 1,280-page electronics Catalog 111 from Newark Electronics (Chicago, IL) contains complete technical information and dimensions for more than 100,000 electrical and electronics products from 250 leading manufacturers. Twenty new manufacturers and more than 15,000 products have been added to this latest catalog. Other additions include: a 16-page, four-color product section; an easy-to-follow "How To" section for using the Catalog; an expanded Surface Mount Devices section; and a new indexed Premises Wiring Products section.

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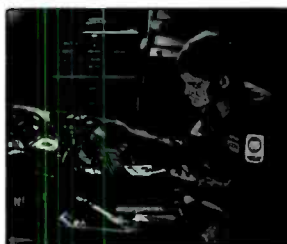
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Optional Accessories R-2000:

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- 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

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- Optional Accessory
- PG-2N Extra DC cable

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