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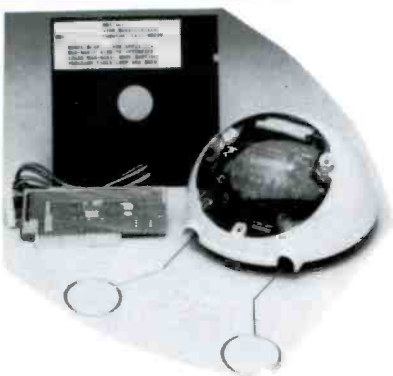
LASER DIODES

STOCK #	MFG.	WAVE-LENGTH	OUTPUT POWER	OPER. CURR.	OPER. VOLT.	1-24	25-99	100+
LS9220	TOSHIBA	660nm	3 mW	85 mA	2.5 V	129.99	123.49	111.14
LS9200	TOSHIBA	670nm	3 mW	85 mA	2.3 V	49.99	47.99	43.19
LS9201	TOSHIBA	670nm	5 mW	80 mA	2.4 V	59.99	56.99	51.29
LS9211	TOSHIBA	670nm	5 mW	50 mA	2.3 V	69.99	66.49	59.84
LS9215	TOSHIBA	670nm	10 mW	45 mA	2.4 V	109.99	104.49	94.04
LS3200	NEC	670nm	3 mW	85 mA	2.2 V	59.99	56.99	51.29
LS022	SHARP	780nm	5 mW	65 mA	1.75 V	19.99	18.99	17.09
SB1053	PHILLIPS	820nm	10 mW	90 mA	2.2 V	10.99	10.44	9.40

WAO II PROGRAMMABLE ROBOTIC KIT

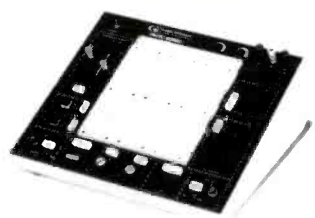


The pen mechanism included with the robot allows it to draw. In addition to drawing straight lines, it can also accurately draw circles, and even draw out words and short phrases. WAO II comes with 128 x 4 bits RAM and 2K ROM, and is programmed directly via the keypad attached to it. With its built-in connector port, WAO II is ready to communicate with your computer. With the optional interface kit, you can connect WAO II to an Apple II, IIe, or II+ computer. Editing and transfering of any movement program, as well as saving and loading a program can be performed by the interface kit. The kit includes software, cable, card, and instructions. The programming language is BASIC.

- Power Source - 3 AA batteries (not included)

STOCK #	DESCRIPTION	1-9	10-24	25+
MV961	*WAO II Programmable Robotic Kit*	79.99	75.99	68.39
WIIAP	*Interface Kit For Apple II, IIE, II+*	39.99	37.99	34.19

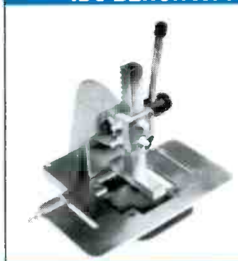
PROTOBOARD DESIGN STATION



- The total design workstation - including expanded instrumentation, breadboard and power supply
- Ideal for analog, digital and microprocessor circuits
- 8 logic probe circuits
- Function generator with continuously variable size, square, triangle wave forms, plus TTL pulses
- Triple power supply offers fixed 5 VDC supply plus 2 variable outputs - +5 - 15 VDC and -5 - 15 VDC
- 8 TTL compatible LED indicators, switches
- Pulsers
- Potentiometers
- Audio experimentation speaker
- Multiple features in one complete test instrument saves hundreds of dollars needed for individual units
- Unlimited lifetime guarantee on breadboard sockets
- **Fixed DC output**
  +5 VDC @ 1.0 amp, ripple - 5 mV
- **Variable DC output**
  +5 - to +15 VDC @ 0.5 amp, ripple - 5 mV
- **Variable DC output**
  -5 - to -15 VDC @ 0.5 amp, ripple - 5 mV
- **Frequency generator**
  frequency range: 0.1 Hz to 100 KHz in 6 ranges
  output voltage: 0 to ± 10V (20 Vp-p)
  output impedance: 600 (except TTL)
  output current: 10mA max., short circuit protected
  output waveforms: sine, square, triange, TTL
  sine wave: distortion 3% (10 Hz to 100 KHz)
  TTL pulse: rise and fall time 25ns drive 20 TTL loads
  Square wave: rise and fall time ± 1.5 s
- **Logic indicators**
  8 LED's, active high, 1.4 volt (nominal) threshold, inputs protected to ± 20 volts
- **Debounced pushbuttons (pulsers)**
  2 push-button operated, open-collector output pulsers, each with 1 normally-open, 1 normally-closed output. Each output can sink up to 250 mA
- **Potentiometers**
  1 - 1K , 1 10K , all leads available and uncommitted
- **BNC connectors**
  2 BNC connectors pin available and uncommitted shell connected to ground
- **Speaker**
  0.25 W, 8
- **Breadboarding area**
  2520 uncommitted tie points
- **Dimensions**
  11.5" long x 16" wide x 6.5" high
- **Input**
  3 wire AC line input (117 V, 60 Hz typical)
- **Weight**
  7 lbs.

STOCK #	DESCRIPTION	1-9	10-24	25+
PB503	*Protoboard Design Station*	299.99	284.99	256.49

IDC BENCH ASSEMBLY PRESS

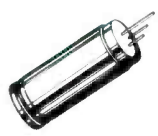


The Panavise PV505 1/4 ton manual IDC bench assembly press is a rugged, practical installation tool designed for low volume, mass termination of various IDC connectors on flat ribbon cable.

- Assembly base & standard platen included
- Base plate & platen may be rotated 90° for maximum versatility
- Base plates & cutting accessories are quickly changed without any tools required
- Additional accessories below
- Size - 10" W x 8.75" D x 9" H
- Weight - 5.5 lbs.

STOCK #	DESCRIPTION	1-9	10-24	25+
PV505	*Panavise Bench Assembly Press*	149.99	142.49	128.24

COLLIMATING PEN



A low power collimator pen containing a MOVPE grown gain GaAlAs laser. This collimator pen delivers a maximum CW output power of 2.5 mW at 820 nm.

The operating voltage of 2.2-2 5v @ 90-150mA is designed for lower power applications such as data retrieval, telemetry, alignment, etc.

The non-hermetic stainless steel case is specifically designed for easy alignment in an optical read or write system, and consists of a lens and a laser diode. The lens system collimates the diverging laser light .18 mrad. The wavefront quality is diffraction limited.

The housing is circular and precision manufactured measuring 11.0 mm in diameter and 27.0 mm long. Data sheet included.

As with all special buy items, quantity is limited to stock on hand.

STOCK #	DESCRIPTION	1-9	10-24	25+
SB1052	*Infra-Red Collimator Pen*	49.99	47.49	42.74

LASER DIODE MODULE

The LDM 135 integrated assembly consisting of a laser diode, collimating optics and drive electronics within a single compact housing. Produces a bright red dot at 660-685 nm. It is supplied complete with leads for connection to a DC power supply from 3 to 5.25 V.

Though pre-set to produce a parallel beam, the focal length can readily be adjusted to focus the beam to a spot.

Sturdy, small and self-contained, the LDM135 is a precision device designed for a wide range of applications. 0.64" diam. x 2" long.

STOCK #	DESCRIPTION	1-9	10-24	25+
LDM135-.5	*.5 mW Laser Diode Module*	179.99	170.99	153.89
LDM135-1	*1 mW Laser Diode Module*	189.99	180.49	162.44
LDM135-2	*2 mW Laser Diode Module*	199.99	189.99	170.99
LDM135-3	*3 mW Laser Diode Module*	209.99	199.49	179.54

COLLIMATING LENS

This economical collimating lens assembly consists of a black anodized aluminum barrel that acts as a heat sink, and a glass lens with a focal point of 7.5 mm. Designed to fit standard 9mm laser diodes, this assembly will fit all the above laser diodes. Simply place diode in the lens assembly, adjust beam to desired focus, then set with adhesive.

STOCK #	DESCRIPTION	1-9	10-24	25+
LSLENS	*Collimating Lens Assembly*	24.99	23.74	21.37

DUAL MODE LASER POINTER

New slimline laser pointer is only ½" in diameter x 6¼" long and weighs under 2 oz., 670 nm @ less than 1 mW produces a 6 mm beam. 2 switches, one for continuous mode, and one for pulse mode (red dot flashes rapidly). 2 AAA batteries provide 8+ hours of use. 1 year warranty.

STOCK #	DESCRIPTION	1-9	10-24	25+
LP35	*Dual Mode Laser Pointer*	199.99	189.99	170.99

He-Ne TUBES

New, tested 632nm He-Ne laser tubes ranging from .5mW to 3mW (our choice). Perfect for hobbyists for home projects. Because of the variety we purchase, we cannot guarantee specific outputs will be available at time of order. All units are new, tested, and guaranteed to function at manufacturers specifications.

STOCK #	DESCRIPTION	1-9	10-24	25+
LT1001	*He-He Laser Tube*	69.99	66.49	59.84

POWER SUPPLY

- Input: 115/230V
- Output: +5v @ 3.75A
  +12v @ 1.5A
  -12v @ .4A
- Size: 7" L x 5¼" W x 2½" H

STOCK #	PRICE
PS1003	$19.99

ROBOTIC ARM KIT

Robots were once confined to science fiction movies. Today, whether they're performing dangerous tasks or putting together complex products, robotics are finding their way into more and more industries. The Robotic Arm Kit is an educational kit that teaches basic robotic arm fundamentals as well as testing your own motor skills. Command it to perform simple tasks.

STOCK #	PRICE
YO1	$43.99

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CIRCLE NO. 140 ON FREE INFORMATION CARD

ComputerCraft

Volume 2, No. 2
February 1992

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ON THE COVER: Getting down to the real basics for true hardware-oriented readers, this month our main feature is a metal tower-like enclosure you build yourself and tailor to your computing needs, whether for bus-expansion purposes or a super computer.

Cover Photo by Larry Mulvehill

Editorial

Data Privacy

We all hope that much, if not all, of our computer data aren't available to unauthorized persons. We're on reasonably solid legal ground based on Constitutional rights (the Fourth Amendment), but in this age of electronics and computers, even here there are some fuzzy areas.

Nevertheless, a wish for privacy is inborn. There are many ways to accomplish this, depending on your situation. If you want to prevent someone from seeing what you're working on when he or she approaches your desk, you might use a screen-blanker utility. Such programs are widely available on bulletin boards and as a file that comes along with many commercial utility programs. There are also programs available that fill the screen with a message, such as "Computer In Use. Do Not Disturb!." Or even an interactive one that invites the looker to type in a message.

Maintaining data security is equally important when your machine is unattended, too, of course. Here, one can employ an encryption program that requires entering the correct password. Such programs are also widely available. The code is often based on the Data Encryption Standard (DES) originated by IBM and adopted by the National Bureau of Standards in the late Seventies. Although it provides a good level of security, some experts in the field have raised some doubts about it if faced with a super code cracker. A bevy of other encryption methods have cropped up, including hardware types.

Equally important is password security, particularly when sending it out electronically over the phone. To combat this, some encryption systems employ changing keys. This might require that the recipient add or subtract a particular number in order to decipher what's sent. So there might be a number of different password levels.

One of the problems in choosing your password is the need to keep it simple so that you'll easily remember it. Doing this often leads to logical passwords that a thief might guess, such as your wife's name, a common choice such as PC or IBM, or what-have-you.

The degree of protection you need depends on the value of your data, naturally. If it's private accounting data for a business, credit card information, etc., you'd want a high level of security, possibly a layered system. For your home personal use, a standard password system from a BBS program would likely be more than enough security.

Another problem that has come to the fore is electromagnetic eavesdropping of data that's radiated into the air. The federal government uses "Tempest" design specifications to prevent radiation of information from a computer chassis. But then there are other points of possible EM radiation, such as printer cables.

Interestingly, some computer makers are addressing the foregoing security leak possibilities with specially shield computers. One such company, Hughes STX Corp., in Vienna, VA, offers a line of 386 systems designed to prevent "broadcasting" data. It's called a "Stealth" computer. The company also provides upgrades for PCs and workstations to "Stealth" specifications.

For most people, all this is much ado about nothing. At least, that's what most computer users must think since even in offices where AT and 386 desktop computers are used, front-panel locks are usually in mint condition because they've never been used. For some users, however—IRS agents who use laptops to communicate with a mainframe, banks with ATMs, *et al*—information security can never be too good or too complete. And even with the best of data security, much depends on the administrator, who must educate and oversee the operation.

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Setting the Record Straight

• I read with interest in the January issue "WordPerfect 5.1: Is It Worth the Switch?" To the best of my knowledge, a fair comparison was made between *WP*5.1 and *XyWrite* 3+. However, I would like to make two points. To search for the slashbar, you use another symbol on the command line for field separation—any other symbol, as long as it is not part of the word you are searching for. For example, to search for the word "you," you would use "se ayoua," "se /you/," "se #you#," etc.

The major error in the report has to be the numbers given in the Speed Test Results box. I used a 16-MHz Tandy 4000 computer with an 80386 CPU to change every period in a 42,000-word *XyWrite* file to an an exclamation point. I set up the command "cia/./!/." By the time my pinky lifted off the key, the job was done—in way under a second. I ran the same test on a 206,000-byte file. This time, it took between 2 and 3 seconds to effect the change. I also did a search for two words that were in the last sentence of a long file, which was done in just under 2 seconds. I believe the time quoted in the Speed Test Results box is very much in error.

XyWrite 3+ is an extremely fast, powerful and versatile word processor. I am delighted with it.

Bob Locher
Deerfield, IL

Author's Reply: You're correct on both counts. XyWrite *is, indeed, lightning fast and speedier than* WordPerfect. *The tortoise-like pace of* XyWrite *indicated by my test was due to using the "change" (ch) command, rather than the "change invisible" (ci) command, to do a search-and-replace. Unfortunately,* XyWrite*'s Help file doesn't list the ci command when "c" is pressed or if you type in ci or "change invisible." Without being aware of the ci command, the Help field didn't help here. Using the ci command,* XyWrite *lived up to its reputation and performed the changes instantaneously.*

• It is obvious that the author of January's Software Review is not familiar with the equation rules for *WordPerfect*. If he was, he would know that the tilde (~) is the space character for equations and curly brackets ({}) placed around a top statement in the OVER command would center the top over the bottom.

The STACK command is used to align equation lists, not to make parts of equations line up. If the form INT from 0 to t is used for the integral symbol, the numbers will line up properly on the integral symbol.

To make the equation print out, just enter on one line:

r(t) ~ + ~ {v(t)} over R ~ + ~C {dv(t)} over dt" + "1 over L int from 0 to t v(t)dt

The screen will wrap around as you exceed the maximum number of characters on the line, and the equation will print out as:

$$r(t) - \frac{v(t)}{R} + C\frac{dv(t)}{dt} + \frac{1}{L}\int_0^t v(t)\,dt$$

I agree with the comments that compare *XyWrite* with *WordPerfect*. Another plus for *XyWrite* is its ability to hold up to 36 full-text, including all control codes, "cut-and-paste" clips, rather than just one. This is especially handy when writing control programs. Furthermore, if you are writing control programs, *XyWrite*'s ASCII output does not "sneak" in extra carriage returns as *WordPerfect*'s DOS/ASCII output mode sometimes does.

T. Potts
Hicksville, NY

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LS04	.14	LS125	.30	LS245	.55
LS05	.14	LS126	.35	LS251	.45
LS08	.14	LS132	.35	LS253	.40
LS09	.14	LS133	.25	LS257	.35
LS10	.14	LS136	.28	LS258	.45
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LS22	.16	LS155	.50	LS290	.70
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LS75	.25	LS175	.35	LS373	.50
LS83	.30	LS181	1.25	LS374	.45
LS85	.45	LS191	.45	LS375	.35
LS86	.20	LS192	.65	LS377	.75
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6545	2.10	6860	3.95
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6800	1.40	68A09EP	1.29
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6805	2.95	68B09	4.00
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6810	1.25	68B54	4.00

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CIRCLE NO. 147 ON FREE INFORMATION CARD

Anti-Piracy Success. Although illegal copying is said to cause a $10- to $12-billion loss in revenues to the U.S. software industry, strong anti-piracy programs have been making some inroads. For example, Autodesk, Inc., one of the largest software companies (AutoCAD, Generic CADD and AutoSketch), recovered more than $5-million since 1988 from parties who illegally copied its programs. Copyright infringement carries a fine of up to $25,000 and up to one-year in prison under federal law. Civil actions, however, allow recovery of actual damage up to $100,000.

Multimedia Works. Microsoft Corp. introduced a multimedia edition of its popular Microsoft Works for Windows (version 2.0). It adds digital sound, animation and pictures to the program's Online Tutorial and reference sections. The $199 edition comes on a CD-ROM disk. To use it you need a CD-ROM drive with less than 1-second access time and 150K/second transfer rate plus Microsoft CD-ROM Extensions ver. 2.2 or later. Furthermore, you'll require 30MB or more of hard-disk memory and 4MB system memory, as well as an audio board, speakers, mouse, VGA graphics adapter and monitor, Windows 3.0, Multimedia Extensions ver. 1.0 and at a 386SX 16MHz or higher computer in order to run the new Works satisfactorily.

Recycled Disks. Softdisk Publishing, which claims to be the world's largest software subscription company, lets users purchase blank disks that have been recycled (demagnetized and relabeled with an opaque label) in packs of 25 3-1/2" or 50 5-1/4" 360K disks for $9.95 each pack. The company says that they're helping the environment since diskettes, made of polyer and magnetic products, last for years in landfill.

Tandy's National Parts Catalog. Tandy Electronics, Radio Shack's parent company, has broadened its National Parts Division to become a full-line electronics distributor. Its new 232-page catalog lists merchandise from 29 major producers of electronic and electro-mechanical parts. Minimum purchase is only $5, and major credit cards are accepted. To get a copy, call 800-322-3690.

Covox's New Upgrade Software. Covox Inc., a major producer of sound-enhancement products for PCs, released new software--"The Overlord"--that contains upgrade programs and device drivers for the company's existing product line. The Overload is designed to work on computers using Intel 80386SX or DX and i486 microprocessors. Additionally, the software allows Covox's "Sound Master II" and "Voice Master" to play back virtually all "CMS Soundblaster" digitized sound files. The company's "Speech Thing" can play back many of these files with it, too. The upgrade disk also provides additional MIDI compatibility to support the Roland MPU-401 standard in UART mode, and also provide the capability of emulating Tandy and IBM sound systems.

The Overlord is being included free with all Covox products sold. You can get it for free by downloading it from the company's BBS (503-342-4135) or by calling the company direct 503-342-1271 (where you'll pay only shipping and handling charges.

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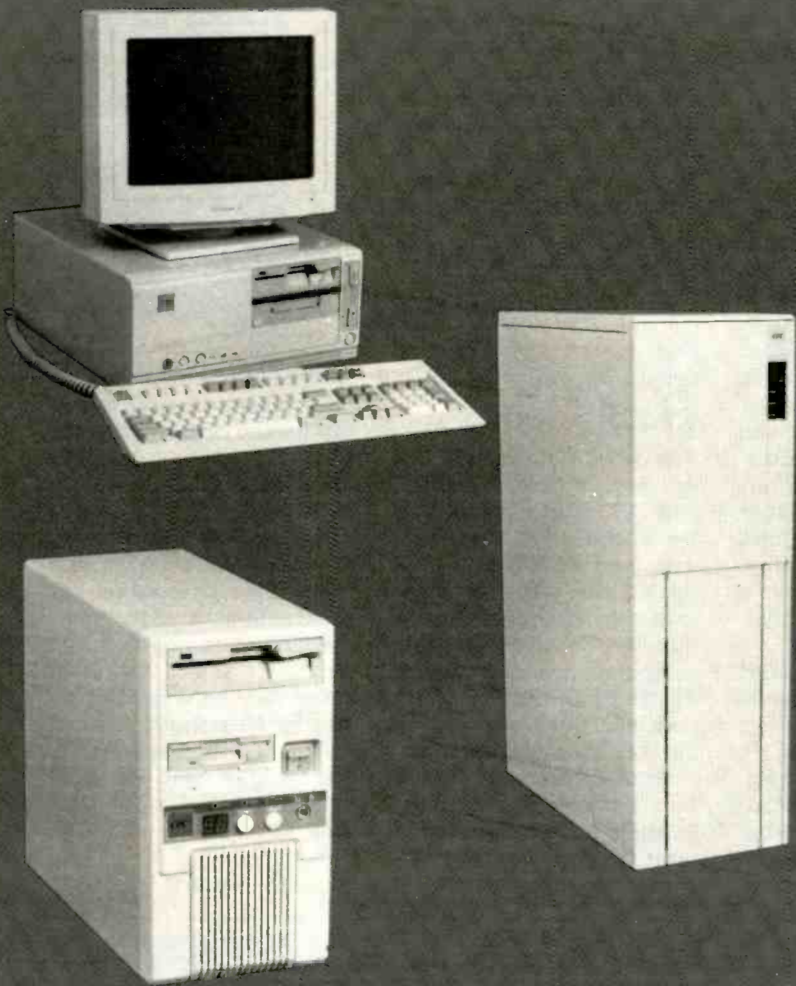

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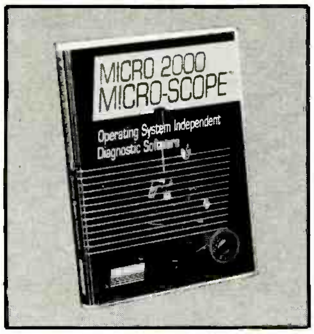
CIRCLE NO. 56 ON FREE INFORMATION CARD

Diagnostic Software

Microscope is an operating-system-independent diagnostic software package from Micro 2000, Inc. The program has its own proprietary operating system and functions under all popular operating systems based around '86 Intel standards. It reads the entire disk, even those areas beyond the DOS limit of 1,024 cylinders on very large disks.



Microscope will low-level format all hard disks, including IDE drives. The program performs more than 100 diagnostic functions, including CPU, expanded-memory, drive, port and video tests. $450. Micro 2000 Inc., 1100 E. Broadway, Third Fl., Glendale, CA 91205; tel.: 818-547-0125.

CIRCLE NO. 30 ON FREE CARD

Science On CD

The McGraw-Hill *Science And Technical Reference Set* is a CD ROM that gives full coverage to both theoretical and applied science. Release 2.0 features updated text, enhanced graphics, and improved search and retrieval capabilities. This resource focuses on more than 75 scientific and technical disciplines. It combines 7,700 articles with 1,700 photographs and drawings. Hypertext links make it possible to jump from a word within an article to a related article, graphic or definition in seconds.

Included with the CD ROM is a User's Guide that gives complete instructions for a variety of activities: installing and navigating the program, placing bookmarks, conducting sample searches and printing and saving text and graphics. Recommended system configuration includes an IBM-AT-compatible computer, 1M of expanded memory, hard disk with 2M available, CD-ROM drive, VGA video monitor and card, mouse and LaserJet printer. $495. McGraw-Hill Professional Book Group, 11 W. 19 St., New York, NY 10011; fax: 212-337-4092.

CIRCLE NO. 31 ON FREE CARD

Low-Overhead Remote Control

Version 2.2 of Louis E. Wheeler's *Remote-Console* requires only 39K of overhead RAM, down from 140K in the previous version. Remote-Console is remote-access communications and control software to link two IBM/compatible computers or one computer and one (Heath/Zenith) H/Z-19 terminal, via modem or by direct cable connection. It provides complete control of the host computer from a remote location. It can be used to run most programs on an unattended host computer.

A fast file-transfer option allows *Remote-Console* to link desktop and laptop for copying files at speeds up to 115,200 bps. Other useful features include a "chat mode" scratch pad, SHUTDOWN command to terminate the host from a remote site and special hot-key to purge ill-behaved programs that take control and try to lock out the remote user. A sophisticated password-protection scheme keeps intruders out and safeguards files. Requires DOS 3.0 or later. $99. Louis E. Wheeler, P.O. Box 888, Oceano, CA 93445; tel.: 805-481-5687.

CIRCLE NO. 33 ON FREE CARD

DOS 5 From Wiley

DOS 5: Self-Teaching Guide
By Ruth Ashley and Judi N. Fernandez
(Soft cover. 374 pages. $19.95)

This is a tutorial for the DOS neophyte and the casual user who has upgraded to DOS version 5. It covers all the latest options, including improved memory-management and task-switching programs, among other topics. Each chapter is designed to help the reader master specific skills and contains tips, practice problems with answers and methods for checking and backing up completed work. The writing style is friendly and easy-to-follow. Numerous illustrations are included to illuminate key concepts. This book should be equally useful for individual or group study.

DOS 5: Command Reference
By Ken W. Christopher, Jr., Barry A. Feigenbaum & Shon O. Saliga
(Soft cover. 224 pages. $10.95.)

In this slightly over-size pocket reference for DOS 5, Chapters 1 and 2 are primarily introductory material. Chapter 3 makes up the bulk of the book (consisting of some 115 pages), which discusses common procedures in alphabetical order of the function performed, not necessarily the command name. This makes it simple to locate relevant material in a hurry. Elementary batch files are covered in chapter 4.

Chapter 5 is devoted to EDLIN, obsolete as it is. Fortunately, there are only 10 pages wasted on this relic. In Chapter 6, the focus is on system configuration, primarily AUTOEXEC.BAT and CONFIG.SYS. Chapter 7 contains a succinct description of how to partition a disk with FDISK. File redirection and filters are touched on in Chapter 8. The authors provide several examples for each topic covered. Because of its small size and compact nature, this book should be handy for power users, as well as DOS neophytes. Moreover, it can be easily tucked away for use when traveling.

DOS 5: The Basics
By Ken W. Christopher, Jr., Barry A. Feigenbaum & Shon O. Saliga
(Soft cover. 484 pages. $24.95.)

With this second of three DOS 5 books released by Wiley, the publisher has several "models" competing against each other in the same market. This one is another entry-level book. The authors take a different approach, though. There's substantially more information here than in the Ashley and Fernandez volume. Unfortunately, some of it is more of a distraction than a help. DOS 3.3 and 4.0 are covered, as well as 5.0. Including instructions for the earlier versions adds a great deal of unnecessary confusion. Nonetheless, emphasis in this book is on the DOS shell and working with it. The authors offer a much more detailed view of the DOS command line than Ashley does. The writing style is easy-to-follow but a bit more technical than Ashley's. Had the authors focused totally on DOS 5, it would have been a more useful book for the beginner and for casual user upgrading to MS-DOX 5.0.

LaserJet Utility

Discoversoft's *TreeSaver* version 3.0 enables existing DOS programs to print 2, 3, 4 or more pages on a single sheet of paper. *TreeSaver* "photo reduces" pages so that you can fit full-page output onto any size sheet of paper. This mode can be used to create laser-printed pages for personal organizers, for instance.

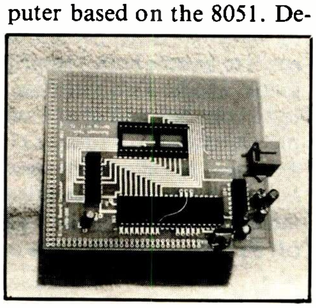
Version 3.0 adds more than 20 new features and a new user interface. One major enhancement permits double-sided printing on standard (non-duplexing) laser printers via "manual flip" or batch modes with front/back printing and job restart on any page. Two new print modes permit you to define "virtual" pages to convert 1-up label-printing routines to 2-up or 3-up formats. Other new features include improved network compatibility, forced-duplex mode for LaserJet IID and IIID from applications that don't directly support duplex printing and the ability to switch the LaserJet IIIsi back and forth between PCL and PostScript.

The program now comes with RapidTransit, a utility that speeds graphics printing on the LaserJet IIP and III series. $90. Discoversoft, 1516 Oak St., Alameda, CA 94501; tel.: 510-769-2902; fax: 510-769-0149.

CIRCLE NO. 34 ON FREE CARD

Single-Board Computer

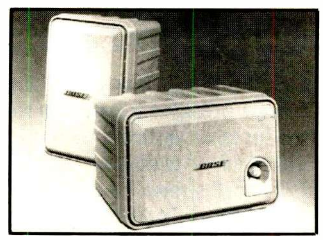
Suncoast Technologies' model 70691C is a single-board computer based on the 8051. Designed for the hobby market, the 70691C has a large area for prototyping. It has 14 standard I/O ports, RS-232 interface, 8K EPROM socket for rapid code updates and a control program on a 360K disk. The program includes an editor, assembler, disassembler and hex-to-binary converter. The 70691C requires 100 mA at 5 volts dc (a partial power supply kit is optional), operates at 11.0592 MHz and measures 3⅞" × 4½". $49. Suncoast Technologies, PO Box 5835, Spring Hill, FL 34606.



CIRCLE NO. 35 ON FREE CARD

High-End Computer Speaker

Bose RoomMate Computer Monitor is a new high-performance speaker designed for people who use computers for MIDI, voice synthesizers, music composition, multi-media presentation, and even playing sophisticated games. The Bose RoomMate Computer Monitor incorporates a proprietary HVC driver and distortion-limiting circuitry.



Each unit features a built-in amplifier with volume control and active equalization circuitry. The cabinet is crafted of high-impact copolymer styrene. Size is 9" × 6" × 6". $339 per pair. Bose Corp., The Mountain, Framingham, MA 01701-9168; tel.: 508-879-7330; fax: 508-872-6541.

CIRCLE NO. 36 ON FREE CARD

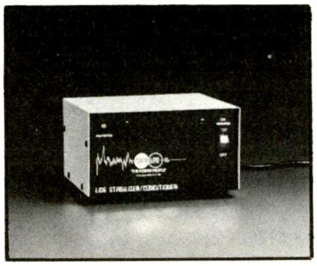
GeoWorks Stand-Alones

GeoWorks, publisher of *GeoWorks Ensemble*, now offers its *Personal Office Series* (POS) of three stand-alone applications: *Geo-Works Writer*, *GeoWorks Designer* and *GeoWorks Desktop*. Each application features a run-time version of *PC/GEOS* graphical computing environment. The interface provides novice and occasional users with a more-intuitive way of working with the computer. POS products are designed to be used separately or combined into an integrated suite of applications that can be multitasked. These programs run on any IBM-compatible computer, regardless of CPU. $70 each. GeoWorks, 2150 Shattuck Ave., Berkeley, CA 94704; tel.: 510-644-0883; fax: 510-644-0928.

CIRCLE NO. 32 ON FREE CARD

Line Conditioners

Tripp Lite's LS 600 series line conditioners prevent damage and loss of data from brownouts and overvoltage. They plug into a standard 117-volt ac wall outlet and automatically regulate fluctuating incoming voltages. the LS600 features two ac outlets with 600-watt output and regulates low voltages, effectively correcting for brownouts and preventing equipment damage. The LS604 has four ac outlets with 600-watt output and corrects both brownouts and overvoltage from 87 to 140 volts ac. Both models feature complete spike and line-



noise suppression, circuit breakers and illuminated power switches, and both meet ANSI C84.1 specifications for voltage regulation. $129, LS600; $159, LS604. Tripp Lite, 500 N. Orleans, Chicago, IL 60610-4188; tel.: 312-329-1777; Fax: 312-644-6505.

CIRCLE NO. 24 ON FREE CARD

Silicon Disk

Cardinal Technologies has introduced a silicon storage "FlashCard" that functions similarly to a disk drive while providing instant start-up. It stores application software in flash memory ROM cards for instant access. The FlashCard memory is reprogrammable while installed in the computer, using a utility supplied with the card. It can be "write protected" to ensure viral immunity when the operating system is installed on the card. Designed as a compact half-card that fits into an expansion slot, FlashCard is expandable to 2M of memory. It comes with DR-DOS 5.0 operating system and the programming utility. $199. Cardinal Technologies, Inc., 1827 Freedom Rd., Lancaster, PA 17601; tel.: 800-722-0094/717-293-3000.

CIRCLE NO. 25 ON FREE CARD

CAD For Windows

Drafix Windows CAD 2.0 from Foresight Resources introduces an entirely new user interface. An all-new "CAD Edit Bar" shows the geometric information of the last item drawn or any item selected in the drawing and makes it available for editing. An "Intelligent Cursor" gives you constant visual feedback on which snap mode you selected and what input the system expects next. Icons now represent most drawing, editing and display functions contained in the menu, making for easy user selection.

Windows CAD 2.0 addresses the problem associated with the size of text on high-resolution monitors by allowing you to choose the sizes of icons and text bars. Other notable user-interface improvements include clustering of all editable information at the top of the display for minimal mouse movement, *Windows* standard "cascading menus" and a grid system that resembles engineering graph paper. Redraw speed is increased up to 50% in the new version.

The Drafix Graphics Language and new Drafix Macro Editor permit you and third parties to modify *Drafix Windows CAD* 2.0 to meet specific needs. Macros can perform a multitude of tasks, including automatically exchanging information through *Windows* DDEs. Database capabilities permit creation of Bills of Materials and Parts Lists in *Excel* and other *Windows* spreadsheet and database programs. Enhanced clipboard support makes pasting images to technical documents fast and easy. $695, program; $145, upgrade. Foresight Resources Corp., 10725 Ambassador Dr., Kansas City, MO 64153; tel.: 816-891-1040; fax: 816-891-8018.

CIRCLE NO. 26 ON FREE CARD

Network Manager

Idleboot is a TSR developed by Horizons Consulting for network administrators to manage problems created by users who leave their workstations without closing files and logging off. The utility watchdogs users by identifying when a workstation has sat "idle" for too long. Once this is detected, *Idleboot* automatically forces the workstation to close files and logoff. It then reboots the workstation. The package features many options, like audible alarms, hot-key user disable, reconfiguration from batch files, metering and more. Price depends on number of users; single-user evaluation package is $30. Horizons Consulting, 1432 E. Commercial St., Springfield, MO 65803; tel.: 417-839-2174; Fax: 417-831-1329.

CIRCLE NO. 28 ON FREE CARD

4-In-1 Multimeter

Model MM100A from Hub Material Co. is a new multiplexed scanning DMM with four input channels featuring three modes: four-channel 3½-digit, two-channel 4½-digit and single-channel 9-digit. Basic dc accuracy is rated at 0.2%. Each channel's display is individually programmable for manual or autoranging, comparative mode, data hold and relative reference. Pressing a Bargraph membrane key switches the display to Channel 1 only, with a 4½-digit display and 16-segment analog bargraph.

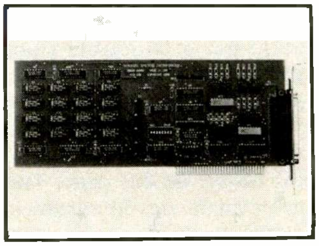
Dc voltage can be measured in five ranges from 0.2 to 500

volts, ac voltage in four ranges from 2 to 500 volts. Dc current-measuring is done in three ranges, from 20 mA to 2 amperes, and resistance is measured in five ranges, from 2K to 20M ohms. Size is 7"H × 4"W × 1¾"D. $230. HMC, 33 Springdale Ave., Canton, MA 02021; tel.: 617-821-1870; Fax: 617-821-4133.

CIRCLE NO. 29 ON FREE CARD

Industrial I/O Cards

Models 8311 and 8315 relay control cards are available for STD bus industrial control applications from DDI, Inc. Use of solid-state relays permits the cards to handle both ac and dc loads. Model 8311 switches 1 to 50 volts dc/peak ac at 1 ampere maximum. Model 8315 switches 1 to 180 volts dc/peak ac at 0.4 ampere. The latter model can effect random turn-off as well as random turn-on



for 117-volt ac loads. $88 and up. DDI, Inc., 5 Dodge St., Suite 310, Beverly, MA 01915; tel.: 508-927-7976; Fax: 508-921-6388.

CIRCLE NO. 27 ON FREE CARD

Parallel-Port Data Acquisition

EASY DATA from DAS is an external data-acquisition unit that connects to a personal computer via a parallel printer port. Software for IBM/compatible computers is included. Setting up typically takes only a few minutes. The unit can acquire up to 16 signals simultaneously, with a nominal single input throughput of 4 kHz. Input polarity is software-selectable for unipolar or bipolar operations with a measurable range of −10 to +10 volts. Software-selectable gains are in steps of 1, 10, 100 and 1,000. EASY DATA has a single analog output capable of producing pulsed, square, ramp or triangular waves. Price, $269. Digital Air Systems, 1034 Industrial Rd., Orem, UT 84057; tel.: 801-224-8080; Fax: 801-224-8087.

CIRCLE NO. 37 ON FREE CARD

DOS From Osborne/McGraw-Hill

DOS 5 Made Easy
By Herbert Schildt
(Soft cover. 390 pages. $19.95.)

This book is appropriate for entry-level and intermediate users. It follows the "Made Easy" format with step-by-step lessons and hands-on examples of the topics covered. The author begins with an overview of a computer system's components and then provides a detailed description of how to run DOS 5 for the first time. He goes on to cover the DOS shell, file system and structure and other basics.

The emphasis is equally divided between the DOS shell and command line. Thankfully, the author devotes an entire chapter to the new DOS 5 editor and relegates EDLIN to an appendix, which is probably more attention than it deserves. A second appendix lists the most-often-used DOS commands, with examples of how they're used. If you're a casual DOS user and comfortable with the command line for most simple operations, this book can serve as an excellent introduction to DOS 5.

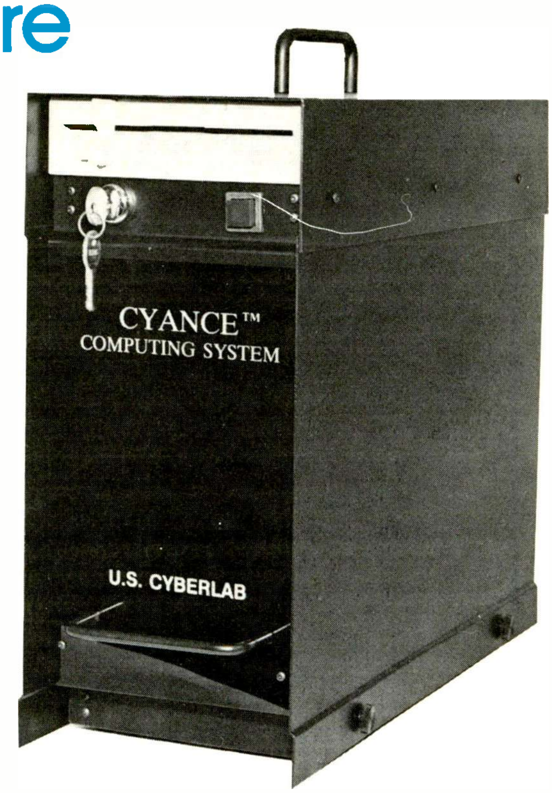
Simply DOS
By Kris Jamsa
(Soft cover. 212 pages. $14.95.)

This DOS 5 book is squarely aimed at the rank beginner. Topics in it are limited to those most often used, regardless of DOS version, and there's no mention of the DOS Shell. Jamsa provides numerous examples as he gently carries the reader over the rough edges of DOS. This book is richly illustrated with drawings and sketches. Topics covered range from how to install the power cord and turn on the machine to partitioning a hard disk with FDISK. This one is highly recommended to the total neophyte.

DOS: The Pocket Reference, 2nd Edition
By Kris Jamsa
(Soft cover. 218 pages. $9.95)

In short, this is an updated pocket reference of all the DOS commands. These are listed in alphabetical order, and there's a brief section at the end devoted to CONFIG.SYS and the various commands that can be used with that file. Each command has a complete description, easy-to-follow examples and tips culled from the author's years of experience. Jamsa has done a superb job here, and the price is right, too.

A Tower of an Enclosure



Here's a build-it-yourself tower enclosure you can tailor to your computing needs. Starting here with foundation information, we'll follow up with a stand-alone, fully buffered, powered and ventilated backplane bus expansion system that makes it a snap to expand your present system or experiment with new board designs.

Except for a hard disk drive that fills up to capacity very quickly, however big, the greatest shortcoming most serious computer users find is a shortage of expansion slots. You become aware of the condition when you run out of slots to add a new plug-in card. Even if you do have a spare expansion slot, you doubtlessly dread disassembling everything in order to plug it in. Moreover, if you want to experiment with a new design you've put together yourself, you're likely to hesitate because if something goes wrong, it might blow parts of your computer.

All of the above have frustrated me for some years now. So I created a large module that takes care of every aspect very nicely . . . and safely. I call it CYANCE (pronounced "Science") because I intend to also use it as a scientific computing platform. Here are its outstanding features:

(1) It's a vertically configured platform that sits on your floor, desk or lab bench. This gives you more room to work, makes accessing side panels easier and provides better internal cooling conditions.

(2) It uses a front-load chassis, placing your expansion bus and peripheral cards in the front of the unit to make changing boards and cables direct and easy to do. A side panel that's affixed by two knurled screws extends this convenience.

(3) It'll accommodate virtually any type of power supply, letting you scale it for the task at hand.

(4) It can be used to actively extend your existing computer bus by adding eight additional buffered and isolated expansion slots in a backplane design. This is particularly important when developing and experimenting with new peripheral card designs.

(5) It's also designed to be able to use virtually any type motherboard on the market, from 8088 to 80486 processors, if you wish to create your own special computer. This allows you to employ a motherboard of your choice, even including one from an old computer so that the whole shebang is more convenient to use.

(6) Finally, the tower looks just great: a rugged enclosure with all-black metal, a removable black Plexiglas front panel with a key switch, and rack-mount-like handles on top (for easy carrying purposes) and on front (for quick Plexiglas removal). You can build it yourself from plans to follow by visiting your local metal shop or purchase the metal parts (see Parts List) for only $99.95.

As you can see, CYANCE may be just the expansion system you need. We focus here on building the enclosure. In coming months, we'll address a bevy of ways its innards can be populated.

Design Considerations

The original IBM PC set a standard for computers built around the Intel 80xxx series microprocessors. Though the PC (and clones) is a good concept, access to its expansion bus is inconvenient. In CYANCE, the motherboard is rotated 180° so that its expansion slots face the front of the enclosure, which simplifies everything.

To access the interior of CYANCE, you remove two thumbscrews from the right side panel, which frees the entire panel to let you install your choice of motherboard, passive backplane or individual peripheral cards.

Convenience is carried an important step further as well. There are two front panels—a structural metal inner panel and a black plastic outer panel. Removing two screws drops off the front panel. This provides easy access to the connectors on any cards plugged into the bus. After plugging in cables, you route those that go to your keyboard and any device you'll be using temporarily, such as an EPROM programmer, down the inner front panel. Cables for devices you'll be using permanently—like a printer, video display, mouse, etc.—route in the same manner and then through the inner front panel and a slot in the rear panel for connection to the peripherals.

Once the cables are connected, you secure the plastic outer panel with the screws you previously removed. This arrangement hides unsightly cables and connectors and offers greater connection security since the front panel deters the cables from being accidentally unplugged from their connectors.

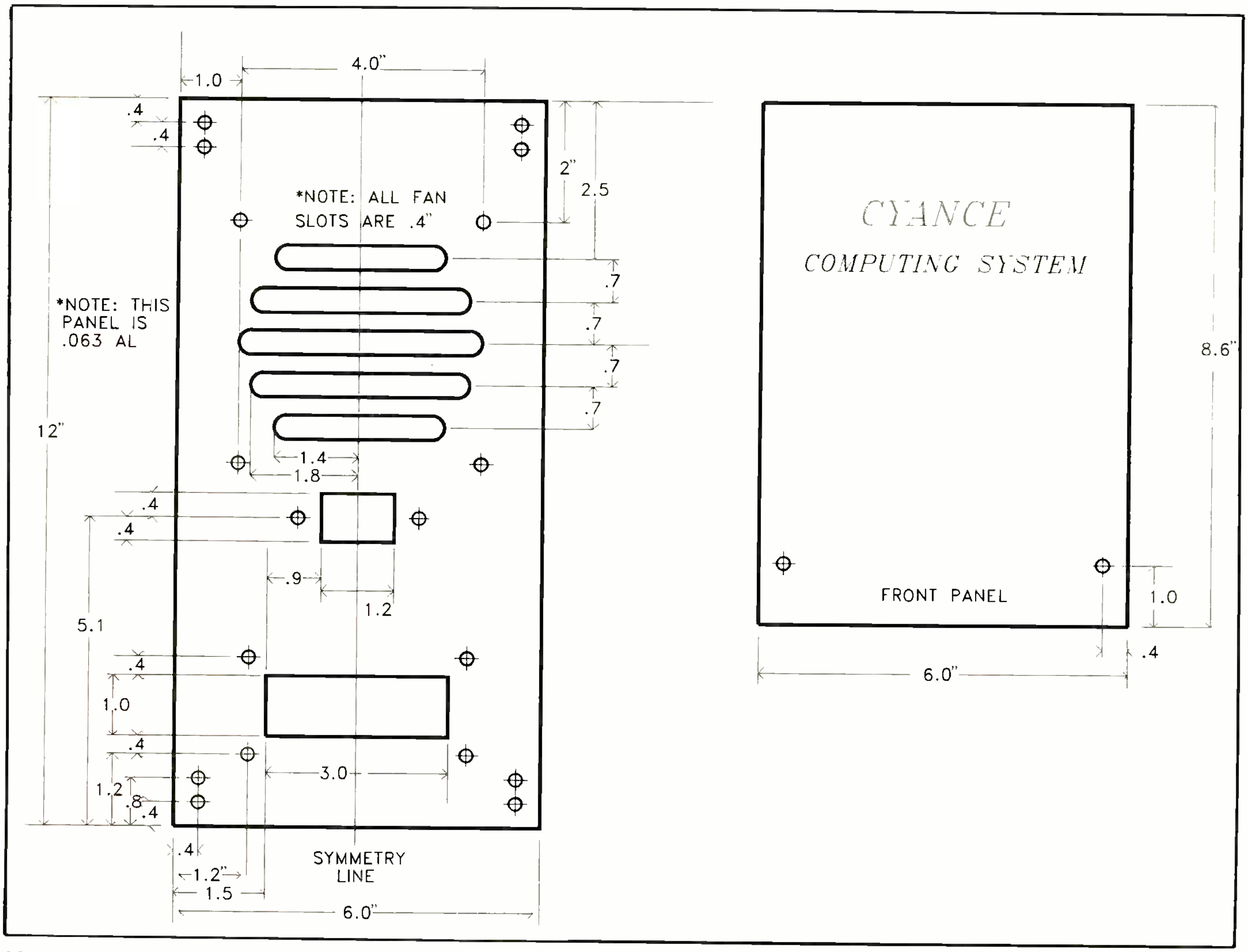
In high-power applications, "hot spots" can develop where high-density circuits create more thermal energy than can be reliably dissipated. CYANCE has a small fan mounted on its rear panel to eliminate heat build-up. Air is drawn under the front of the enclosure, through the chassis and is expelled through a top-rear exhaust port.

A switching-mode power supply (SMPS) is mounted under the upper shelf of the enclosure, near the fan for maximum cooling and physically isolated from the main area of the enclosure. You can select a power supply with sufficient capacity to power any system configuration you install inside CYANCE.

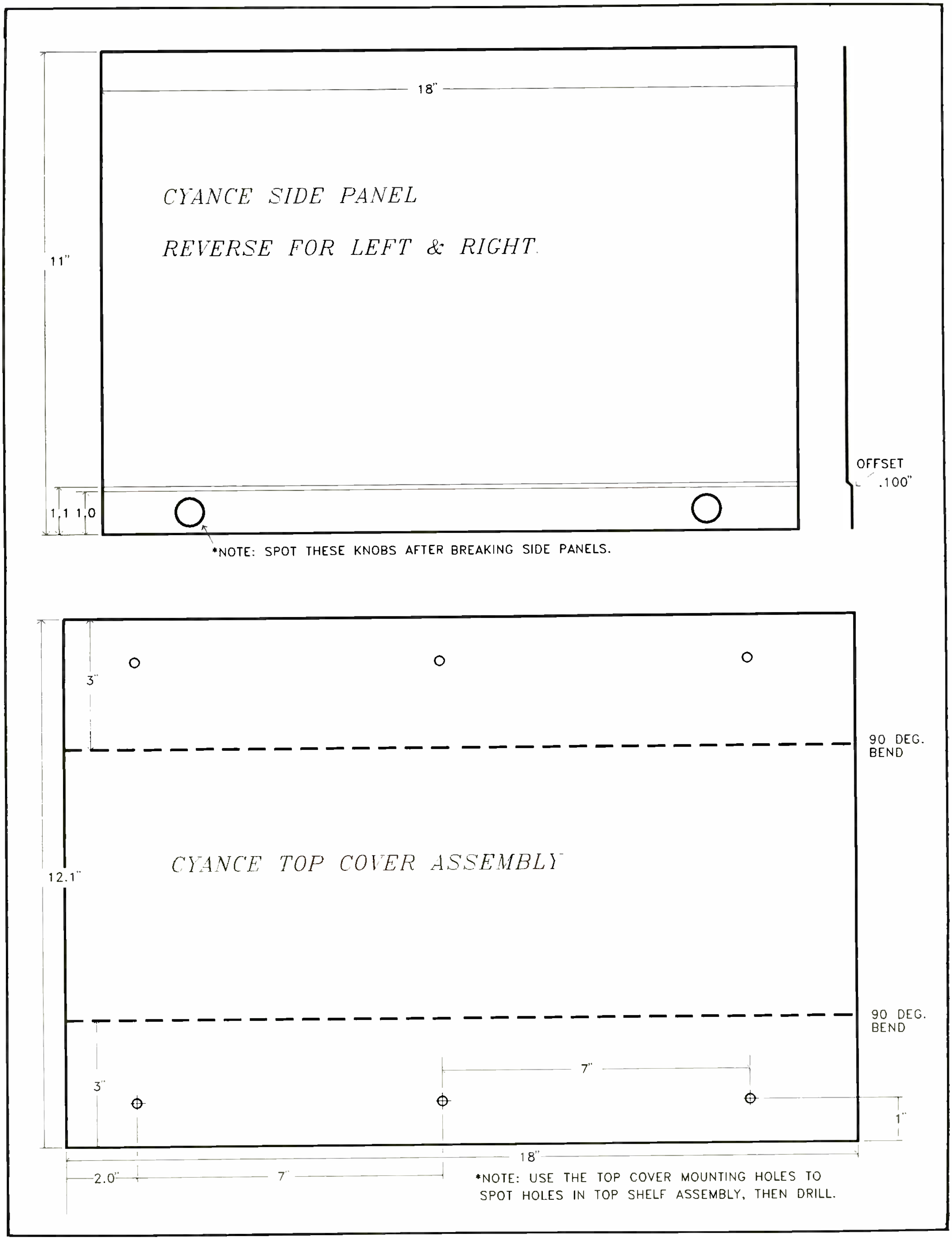
Featured with this enclosure are a locking key-type POWER switch and lighted RESET pushbutton switch. Two disk drives can be installed inside CYANCE. One half-height drive bay is accessible from the front of the enclosure. It can accommodate a standard 5¼" floppy drive or, with an appropriate adapter kit, a 3½" floppy drive. Behind this, you can mount a hard drive.

Building It

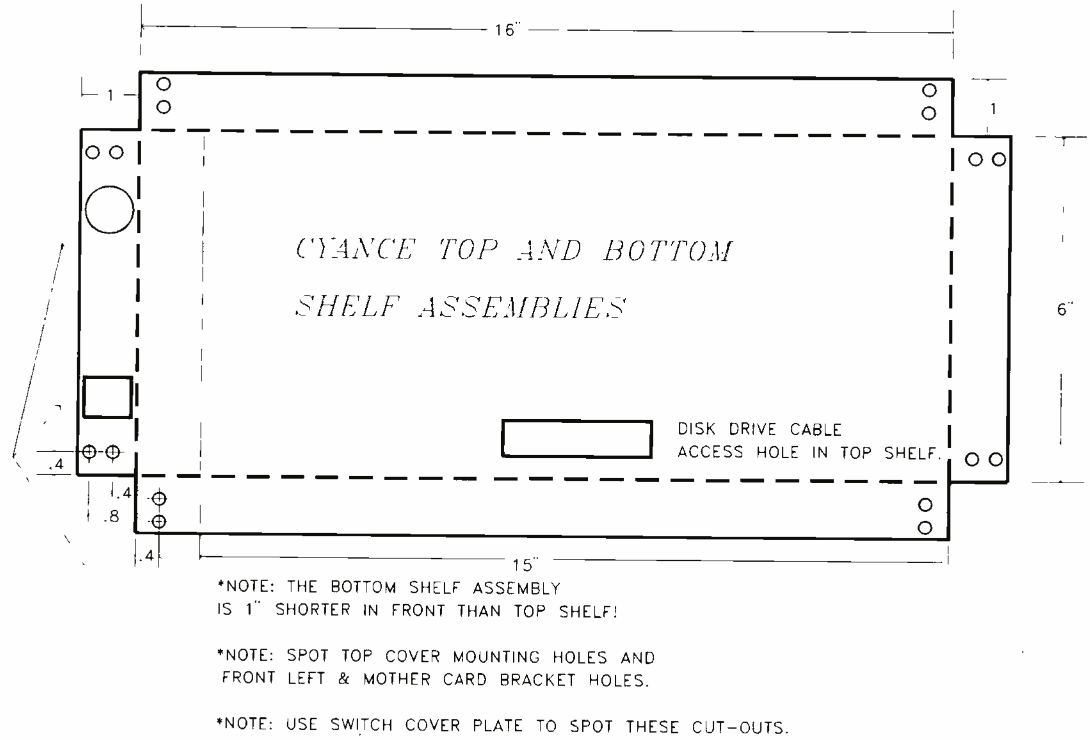
CYANCE's chassis is simple to assemble from metal components you can have a sheet-metal shop fabricate from the drawings presented here or obtain them from the source given in the Note at the end of the Bill of Materials. Though most sheet-metal shops can cut and bend the aluminum, in many cases, the equipment used may not be precise enough to produce satisfactory results.



Machining details for enclosure's rear metal and plastic outer front panels.



The side panels are the reverse of each other.



For the top shelf, you must drill the side holes and cut the disk-drive cable access slot and round and square holes for key-type and pushbutton power and reset switches. Only mounting holes through the sides of the bottom shelf are needed.

If you have a sheet-metal shop fabricate the parts, insist that all bent members form sharp 90° angles. Have the shop fabricate the parts out of 0.050" or 0.063" thick sheet aluminum. The heavier aluminum makes for a much sturdier chassis, though it's more difficult to work.

You can bore all holes with a hand drill. Be sure to very carefully measure and mark everything and center-punch each hole before actually drilling to keep the drill bit from wandering. Always "pilot" the initial hole with a drill bit that's half as small as the final hole size. It's often best to start large holes with a smaller bit and increase drill sizes several times to reach final hole size. It's also good practice to wear cotton gloves when you work with unfinished metal to minimize the possibility of being cut while handling sharp metal pieces.

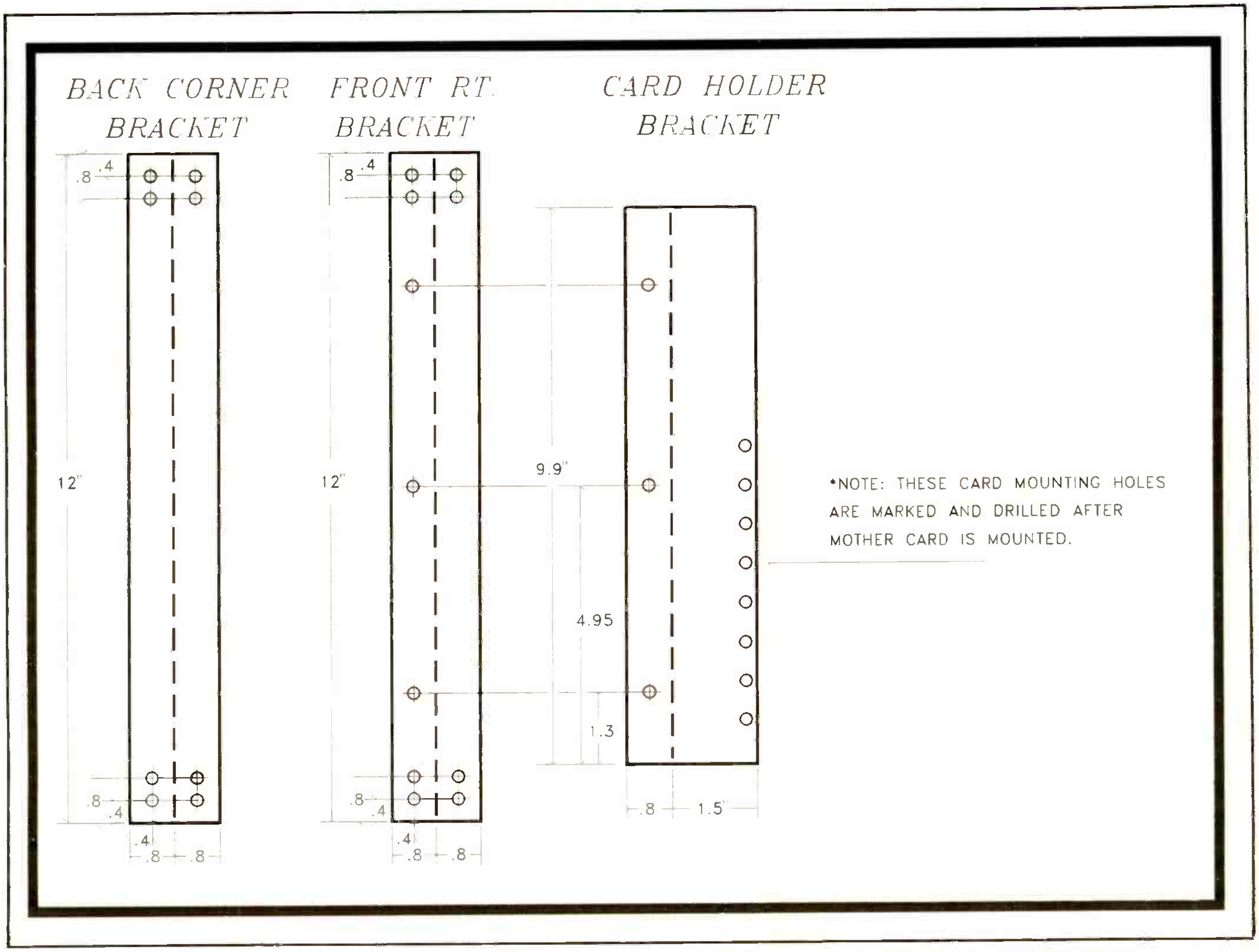
As you begin to build the CYANCE unit, keep in mind the hardware you'll be installing inside it. If you plan on permanently mounting some connectors on the rear panel, for example, drill the holes and make cutouts for them now. If you want a digital or other type of display on the front panel, make suitable arrangement for it before proceeding further.

Once you have all aluminum members ready to go, use a metal file to "break" any sharp straight edges formed during the machining process. Deburr the sharp edges of round holes with a reamer or a Moto-Tool fitted

BILL OF MATERIALS

Qty.	Description	Part No.
1	Top shelf	4510
1	Bottom shelf	4511
2	Rear corner bracket	4512
1	Rear panel	4513
1	Front panel	4514
1	Switch cover panel	4515
1	Switch backing panel	4516
1	Front-right bracket	4517
1	Front-left bracket	4518
1	Card-holder bracket	4519
1	Mother-card bracket	4520
1	Top cover	4521
1	Left Side panel	4522
1	Right Side panel	4523
62	4-40 ¼" button-head screw	
22	4-40 Thread-Sert	4103
1	Large handle	4319
1	Small handle	4320
2	Threaded 4-40 × 1" spacer	4321
4	8-32 thumbscrew	4322
4	8-32 Keps Nut	4104
4	Rubber feet	
1	Key-operated switch	5006
1	Lighted pushbutton switch	5007

Note: The following items are available from U.S. Cyberlab, Inc., Rte. 2 Box 284, Cyber Rd., West Fork, AR 72774 (tel.: 501-839-8293: Complete kit of all metal parts for enclosure, $99.95, 10-MHz turbo 8088 motherboard, $99.95; 16-MHz 80286 motherboard, $239.95, 16-MHz 80386SX motherboard, $349; 33-MHz 80486 motherboard, $1,395 (call for latest prices). Add $8.95 P&H for metal kit. Arkansas resients, please add 5% sales tax. MasterCard/Visa accepted.



A variety of brackets and a switch plate and switch backing complete the metal members you need to build the enclosure.

with a ball-type abrasive or steel accessory "bit."

If the aluminum members have any oil on them or are excessively dirty, scrub them with soapy water and 000 steel wool. Thoroughly rinse the parts and pat dry with paper towels. Allow them to thoroughly air dry.

Aluminum is a remarkable metal in terms of strength-to-weight ratio, machinability, etc. However, it's difficult to paint properly. You may have had some experience painting aluminum chassis in the past, only to find that the best paint job is extremely easy to scratch. This can be attributed directly to the fact that aluminum oxidizes easily and becomes so smooth that paint primer can't "grab" the metal surface to assure a good bond. In industry, special chemical processes called "conversion coatings" are applied to bare aluminum to make paint bond to it quite easily. Aluminum parts from Cyberlab are processed with an Irridite™ conversion coating that makes them appear iridescent gold. Paint bonds extremely well to these surfaces, and unpainted parts have a professional appearance.

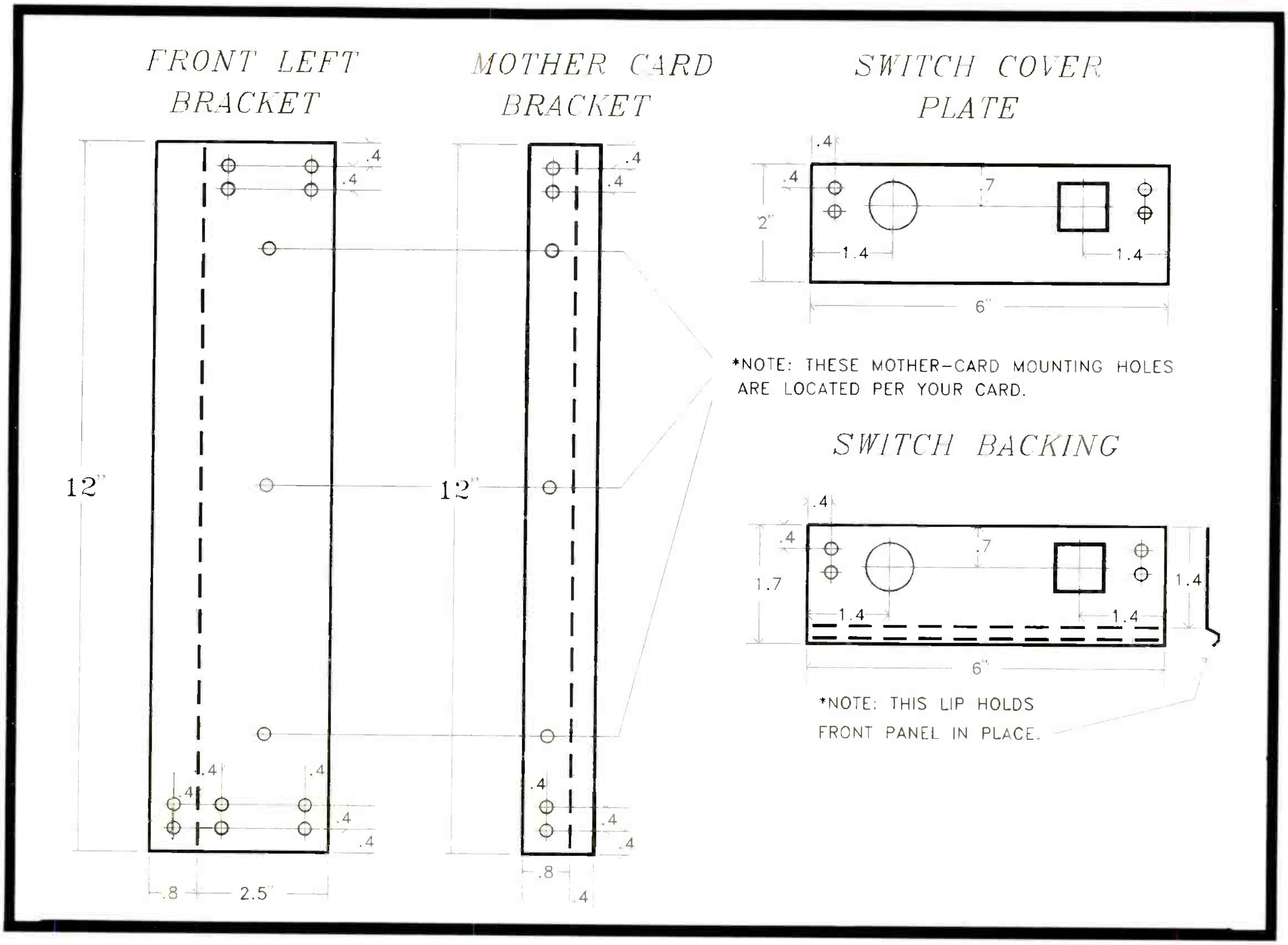
If you have a sheet-metal shop fabricate your aluminum parts, prepare them for painting by carefully dipping them in ferric-chloride (printed-circuit etchant) diluted with an equal amount of tap water. Allow the ferric-chloride solution to etch the surface of the aluminum for a few minutes. *Do this in a well-ventilated area—never inside your home.* Etching removes unwanted surface scratches, machining burrs and chips, and roughens the smooth surface of the aluminum.

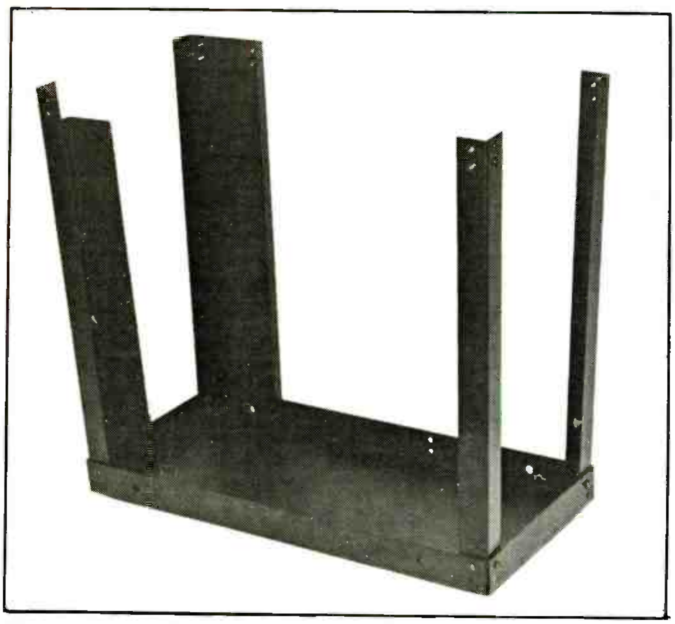
When the finish looks uniform, carefully remove the part and rinse it under cold running water. Then lightly wipe off any excessively dark areas with a cloth and rinse again. The idea is to leave enough aluminum chloride on the surface of the part to provide a good microscopic metal "primer."

When the parts are dry, finish them with any good spray paint. I recommend using a flat or semi-flat black paint, which is easier than other colors to touch up when scratches that will inevitably occur appear.

One final prototyper's trick is to use textured "trunk paint" available from automotive supply stores. When applied to the side panels as an undercoating, this will give CYANCE the look and feel of a textured finish like that on mainframe computers and cash registers. Your CYANCE parts should now look like they were professionally manufactured.

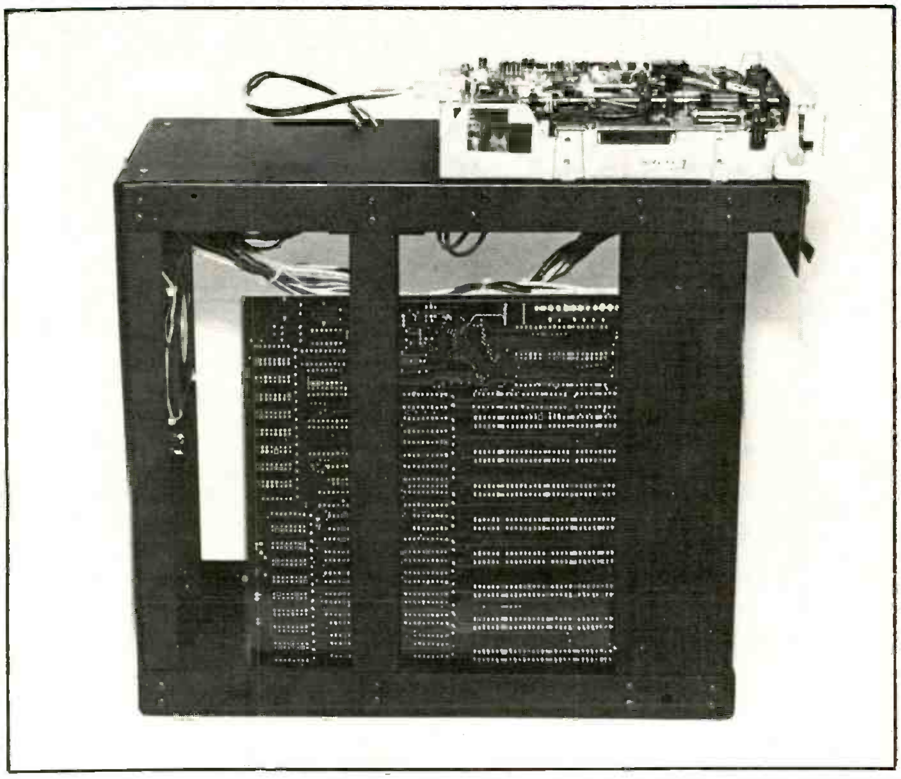
Before you assemble the chassis, double-check all measurements and parts to make sure everything is in order. If everything checks out okay, refer to the photos provided here as



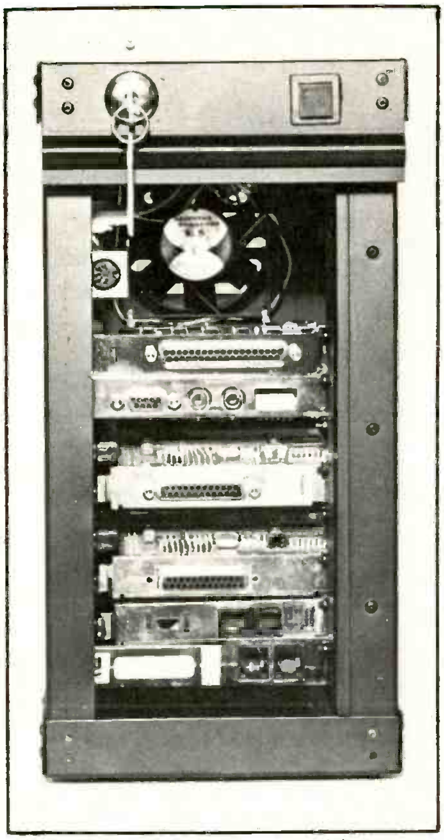


Begin assembling the main chassis by loosely bolting the corner brackets to the bottom shelf.

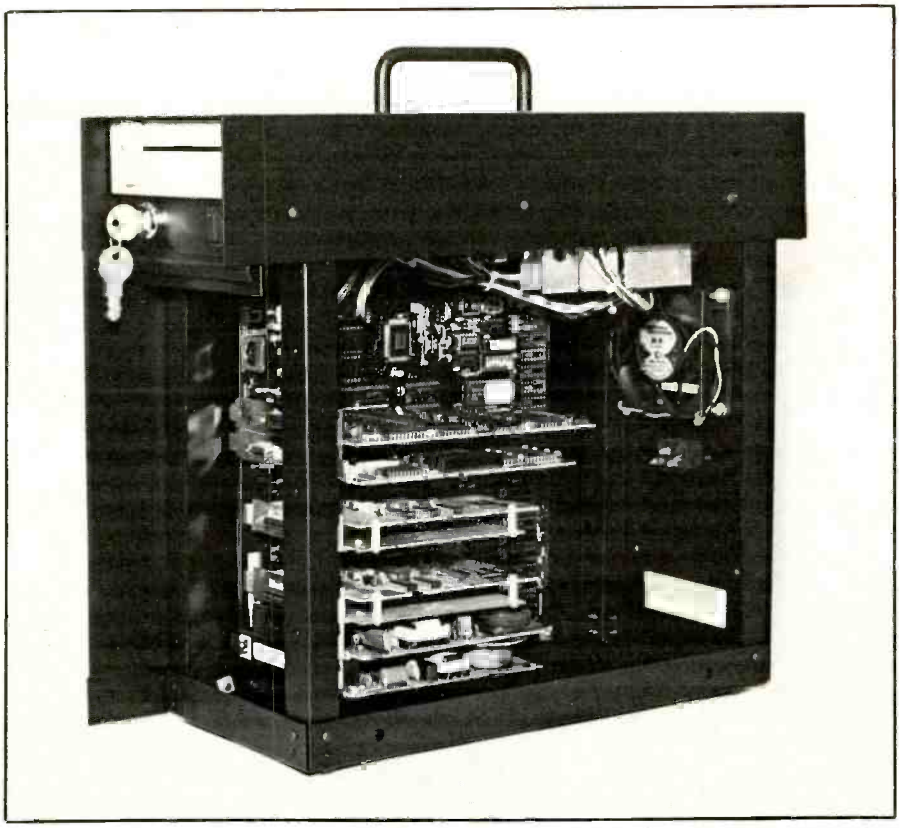
After securing the motherboard brackets to the bottom shelf, secure the top shelf to the ends of the upright brackets.



Square up the enclosure and tighten all hardware and mount the switches in their respective holes and your choice of disk drive to the top shelf. Also, install your choice of motherboard, passive backplane or bus-expansion system.



This enclosure design provides easy access to the connectors on expansion cards plugged into the bus. After connecting and routing cables, you mount the top panel and left and right panels and finish up by installing the plastic outer front panel.



After securing the top cover and left side panel to the enclosure, plug expansion cards into the bus and then use thumbscrews to secure the right side panel.

you proceed with assembly.

Begin assembly by securing with four 4-40 × ¼″ button socket-head screws the switch cover plate and switch backing plate to the front of the top shelf assembly. Don't fully tighten any screws until you've completely assembled the enclosure so that you have the slack needed to properly align the chassis.

Next, mount the POWER keyswitch and RESET switch into place. Check your work against the photos. Notice how the lower edge of the switch cover plate offsets to hold the removable front panel.

Secure the bottom shelf assembly and both rear corner brackets in place with 4-40 × ¼″ screws. Then secure the top of both rear corner brackets to the top shelf assembly. Notice that the rear corner brackets mount inside the shelves. This is important for proper fitting of the side panels.

Mount the front-left and front-right brackets to the top and bottom shelves with 4-40 × ¼" screws. Notice that the front-left bracket has a wider side flange than that on the front-right bracket. This flange is used to mount a motherboard.

Now secure the card-holder bracket to the front-right bracket with three 4-40 × 1¼" screws and nuts. (Kit parts are provided with "thread-serts" that eliminate the need for nuts. These nuts are fabricated directly into the aluminum part for a professional finish.) Then finish this step by mounting the mother card bracket to both top and bottom shelves.

Mounting the rear panel to both rear corner brackets completes assembly of the basic CYANCE chassis. All that's left to be done is to tighten all screws. As you do this, make sure everything is straight and "true." You don't want a chassis that stands at a 93° angle!

Finish up by test fitting the left and right side panels, using thumbscrews to secure them in place. Mount the front panel bottom spacers on the front left and right brackets. Handles are optional and can be "spotted" wherever you wish to place them. The prototype unit has one on the top for carrying and another on the front panel for easy panel removal.

When you're done assembling your CYANCE enclosure and have had an opportunity to check out its interior and exterior features, you'll soon come to realize just how versatile is this platform. Whether you build it as an expansion chassis for your present computer or as the housing for a new motherboard or backplane computer system, you'll readily appreciate its many advantages over traditional system-unit boxes. ■

Nick Goss

Beyond Super-VGA

There is a lot more than just 1,024 × 768 × 256 colors in your computing future

Not so many computer years ago, four-color CGA was the cutting edge of video graphics technology. It was quickly and thankfully replaced by 16-color EGA, which ruled the computer theater for a respectable time before being upstaged by the 256-color performance of VGA. Graphics-card developers and applications programmers kept upping the visual ante with greater and greater resolutions that have included the Super-VGA formats of 640 × 480, 800 × 600 and 1,024 × 768.

Now manufacturers of multisync and other types of monitors are talking about resolutions of 1,280 × 1,024 and better as if they were already part of the Super-VGA standard. What's the next card to be played in the escalating game of computer graphics? As you'll presently see, there's a rich future in store for those people who constantly seek better and better in video graphics.

XGA

The answer to the "What's next?" question was revealed in part in late 1990, when IBM announced Extended Graphics Array (XGA). This announcement accurately touted XGA's high resolution and speed. XGA graphics are currently integrated into the more up-scale PS/2-model computer systems and are also included as separate cards that can plug into a Micro Channel slot.

The new XGA graphics technique is limited to a maximum resolution of 1,024 × 768 × 256 colors, like most of today's Super-VGA cards. This kind of extended resolution wasn't new to a large number of independent video card developers, even in late 1990. XGA is good, but most of its technical descriptions about graphics modes, resolutions and videoRAM speed aren't much to get excited about, unless you own a PS/2.

However, one thing that's very exciting about XGA is that it has a video mode that IBM calls "Direct Color." The Direct Color mode uses 16 bits of data to display 65,536 (64K) colors. The 16 bits of data are shared between the primary colors generally used in video display systems. Five bits are assigned to red, six bits to green and five bits to blue.

The XGA graphics controller uses data encoding and lookup tables to determine the parameters of all those colors. Like any video card that reaches for extended VGA resolution, at least 1M of RAM is needed. To anyone who views it, 64K colors is photo-realistic quality and quite impressive. So far, XGA has been limited to IBM's Micro Channel and its proprietary bus-mastering system.

IBM provides some XGA software drivers that include support for *Windows* and *AutoCAD*, but the best driver support for XGA remains integrated into the OS/2 operating system. Consequently, ISA architecture has yet to see XGA. This could change shortly, though, because IBM has uncharacteristically published the specifications for XGA. That's a decidedly different approach for IBM, and XGA is undoubtedly a solid upward move for the corporate giant, even if the board's $1,000-plus initial price tag was on the high side. The cost of XGA has come down since then, making this format more attractive, but there are other players in the highly competitive computer graphics game that deserve careful consideration.

True Color

64K color will get you photo-realistic quality, as XGA proves. What may be surprising to some users is that photo-realistic imaging has been going on for some time under various names, one of which is "True Color." This term is freely tossed about and difficult to pin down to an exact definition. Some video experts use it in reference to 24- and 32-bit images. Others expand the description to include 16-bit color. Still other others don't really attach any particular meaning to it.

Whatever its precise definition, True Color remains inaccessible to many users because obtaining it is quite expensive. It's routinely used by imaging professionals who work with expensive imaging hardware systems and software.

One of the better-known names in True Color imaging is Targa. True color video adapters, such as Targa's TrueVision board, are designed primarily for industrial use. They're made to interface with high-end video cameras, recorders and display systems and are normally driven by very expensive software that can change minute details and characteristics of any graphics image.

Recently, more capable animation software has been written that makes more precise use of True Color graphics. A couple of those software titles are *Lumena* by Time Arts and *Topas* by AT&T. Newer True Color systems can handle 32-, 24- and 16-bit color at varying resolutions. Handling so much data in a timely manner requires video circuitry and memory components that are diverse, expansive and fast. This is especially true in the case of the 16.7-million colors of 24- and 32-bit images.

The cost of professional video adapters makes an XGA's price tag look cheap. Hefty prices are tolerated by imaging professionals who need all the speed and resolution they can get

(Continued on page 26)

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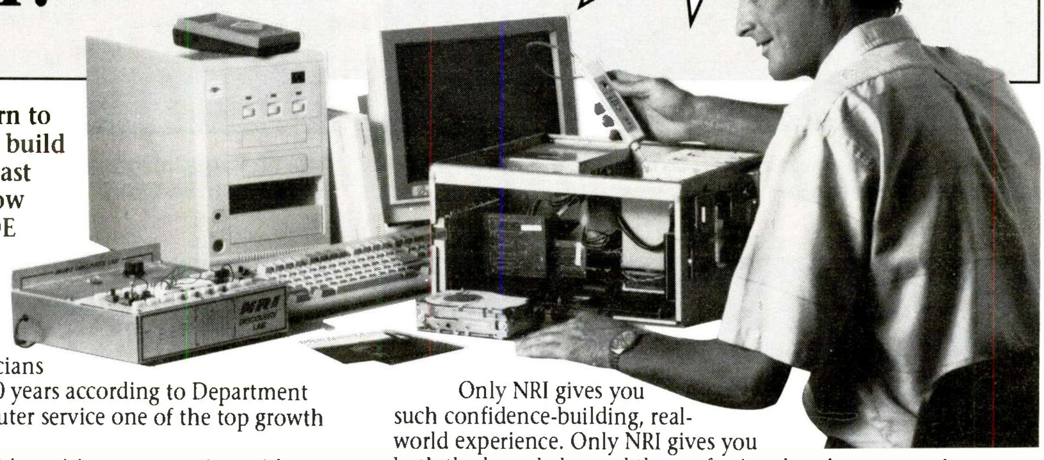

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4-022

A 24-bit Targa image at 640 × 480 resolution in Hi-Color using AXA WaterColor.

A 24-bit Targa image viewed with ImagePrep running under Windows in Hi-Color.

Hi-color painting of Yellowstone National Park, viewed with AXA WaterColor. Painted with AXA WaterColor by graphics artist Shin Yamamoto of Canon Japan.

Hi-Color painting by Shin Yamamoto of a meadow, with WaterColor control panel is visible.

to compete in a demanding marketplace. This kind of prodigious graphics system is understandably beyond the reach of most home users and many small businesses.

Hi-Color

True Color shows that photo-realistic computer imaging isn't new. XGA just pulled a little closer to home that realm of high-quality graphics. However, there's another exciting movement toward techniques that render true color at a comparatively very low cost. It's called "Hi-Color" by various developers, and it's destined to be a key factor in computer graphics.

Like XGA, Hi-Color limits itself to 16 bits of video data. Hi-Color differs from XGA in that it uses only 15 data bits as actual video information, with five bits each for the red, green and blue primary colors. In it's present form, Hi Color can't approach the phenomenal photographic quality of the 32-bit display environment. Nor can it quite equal the more than 65,000 colors of XGA's Direct Color. Contrast it, though, to 256-color VGA and Super-VGA, even with its extended modes of operation.

Although similar pixel resolutions are used, Hi-Color displays 32,768 colors. This is a large jump from the 256 colors of VGA. The visual difference is likewise a quantum leap in quality. The real treat of Hi-Color is that all it takes is a Hi-Color video card, proper software drivers and an ordinary VGA video display monitor.

An increasingly popular method of achieving Hi-color is achieved by using the new Sierra RAM DAC, from Sierra Semiconductor and the ET4000 chip set from Tseng Labs. Tseng Labs, you may recall, is the developer of the ET3000 chip set that helped introduce low-cost VGA cards.

The main principle of Hi-Color operation revolves about the Sierra RAM DAC. During a single clock cycle, the hardware is able to read a full 16 bits of data instead of the normal eight bits. Each clock cycle uses both leading and trailing edges to read each of a serial group of eight bits. That's 16 bits total, but bit 16 is dropped. The 15 bits are fed to the DAC in parallel configuration and processed in a timely manner. XGA's technique is similar in principle. An interesting difference is Hi-Color's discarding of bit 16. This was done initially to make the process closely compatible with the symmetrical format of Targa 16.

About the time Hi-Color was coming along, IBM's unannounced XGA format was being developed to use that 16th bit for more shades of green. With little modification to its own chip, Sierra Semiconductor has begun shipping samples to developers of its next version DAC that deals with the 16th bit, making Hi-Color comparable to Direct Color. When developers fully implement the 16th-bit configuration, which in some cases is a matter of firmware change, Hi-Color will be one up on XGA.

Presently, Hi-Color can work at both 640 × 480 and 800 × 600 resolutions. XGA can't deliver its Direct Color at anything greater than 640 × 480 resolution. Interestingly, an image done in 64K colors doesn't necessarily look much better than the same image done in 32K colors. With some images, the difference is easily noticed. With others, it takes an image with the right color mix and a good, close look.

CEG

Another method of getting more out of a display system is presented by Edsun Laboratories, using a technique called Continuous Edge Graphics (CEG). This technique adds intelligence to an ordinary video output system like PostScript or another printer programming language adds intelligence to a printing system. This intelligence, situated between the video card's frame buffer and the computer screen, allows software to encode certain aspects of video information and store the values inside the frame buffer. Thus, the codes can be accessed and processed quickly enough to avoid drastically reducing video display speed.

Special encoding permits a typical eight-bit (256-color) VGA display system to have a usable range of more than 740,000 simultaneous colors. The result is an apparent increase in monitor resolution of about four times. As with Hi-Color, there's no need to buy a new VGA monitor.

Understanding the basics of CEG requires a look at monitor display-versus-human perception of the real world. Real-world images appear to have extremely smooth edges. Computer images, by contrast, have a definable, relatively low pixel and color resolution. Consequently, images appear to have jagged edges, even when viewed in extended Super-VGA with the best monitors. The jagged edges, seen pixel by pixel, is called "aliasing." One way to increase image quality, and reduce the effects of aliasing, is to increase pixel resolution.

Video card developers, monitor manufacturers and applications engineers have been doing this for years with good results. The proliferation of multi-scanning monitors, high-end video cards and software to run them are testimony to this.

Higher pixel resolution makes jagged edges become smaller and, therefore, aliasing is less apparent. The down side of this direction is that higher scanning monitors must be larger so that users can read the more detailed graphics and text. Accordingly, the computer market is witnessing the move to 16", 19", 21" and larger monitors that used to be the exclusive concern of professional imaging shops. This larger-and-better monitor route becomes expensive in short order.

CEG tackles aliasing by smoothing out the edges. Pixels on the edge of an image normally change color abruptly as they're scanned by the monitor's internal electron beam. The rapid color change produces jagged edges. CEG makes the color change much more gradual. In turn, this makes images look less jagged or clearer. CEG accomplishes this by using hardware and software to calculate the mixture for neighboring colors of any given pixel. These calculations are done in real time and kept handy inside the video frame buffer. Instead of a quick jump from one color to another, the transition is intelligently controlled so that closely matched colors are used. You're tricked into seeing greater resolution than is actually there.

As an example of the significance of color resolution, contrast an ordinary TV receiver to a high-resolution monitor. The monitor normally has more pixels of resolution than a does a TV receiver. Yet, the near-infinite amount of colors provided by the broadcast signal and displayed on TV can make it look better than a high-resolution monitor. This is because subtle color transitions fool the human eye into seeing more than is actually there.

Ultimate VGA

One video-card developer, Micro-Labs, Inc., is using both the Sierra RAM DAC and Edsun CEG RAM DAC in its video cards. The video card is the Ultimate VGA/Hi-Color. The card comes with some interesting specs, including a maximum resolution of 1,024 × 768 × 256 and a 72-Hz vertical refresh rate that helps banish monitor flicker. It's also fast at what it does.

In a test against ATI Technologies' VGAWonder+ and National Design's Volante AT1000, the Ultimate VGA won out in most categories and lagged behind in none. Benchmark comparisons and other technical tidbits look good, but the real reason I chose the Ultimate VGA for this evaluation is that it offers Hi-Color, low cost and bug-free software drivers for Microsoft *Windows*.

Ultimate VGA can do either Hi-Color or CEG, but not both on the same card. This presents a potentially perplexing choice of which one to buy for computer users who may be interested in purchasing the card: Hi-Color version that does 32K-color, or CEG version that looks like 740,000 colors? Some users can't decide and end up buying both versions, swapping between them according to the specific visual results desired. Choosing between versions may be easier when video-card developers get going with full 64K Hi-Color. Later in the graphics game, some ingenious semiconductor developer may figure out a low-cost method for getting Hi-Color beyond its present maximum resolution of 800 × 600.

Software

Regardless of what kind of video graphics hardware you've selected for your super system, you need software that takes advantage of it. Here's a brief look at some of the software already on the market that gives you entry to different types of the video display systems just discussed.

• *Hi-Color Software.* Many users dislike Microsoft *Windows*. Its voracious appetite for memory and disk space chafes the disposition of power users and home hackers alike. *Windows* movement continues unabated, and users have to use it obtain the service of programs like *Micrografx Designer*, *Corel Draw*, Aldus *Pagemaker* and a host of other useful applications.

AutoDesk has even announced its intention of a *Windows* version of its *AutoCAD* program.

Hi-Color can help whatever your disposition regarding *Windows* that brings low-cost true color to average users, thus expanding creative and business capabilities. Although 16-bit image scanners are still somewhat expensive, graphics users can read, display, manipulate and write in at least 32,000 colors. Hi-Color is a new introduction to the computer video industry, but there are already some reasonably priced and well-performing applications that take advantage of it.

• *ImagePrep.* Computer Presentations, Inc. offers an able graphics application that reads, processes and writes Hi-Color. *ImagePrep* is a *Windows* program that handles not only 16-bit Hi-Color images, but 24-bit images as well. Besides its own proprietary graphics format, it operates on Targa formats M8, 16, and 24, Intel TIF formats 1, 8, and 24 bit, CompuServe GIF, and *Windows* BMP formats 1, 4, 8 and 24 bit. It's many features include color reduction that reduces the palette of true color images for use into applications not written for true color.

Another nice *ImagePrep* feature is color correction that can be used to enhance images via brightness, contrast, color values, color balance and gamma value. *ImagePrep* can also perform image compression, using levels ranging from 1 to 20. Compression is a disk space saver, especially if you do a lot of image work. *ImagePrep*'s screen-capture function can save to disk just about any image that can be shown on-screen. Once saved, the image can be operated on, too.

Thanks to its simple *Windows* interface, *ImagePrep* is easy to use, as easy to install as any *Windows* application and quite versatile with the various graphics formats. Documentation is clear and surprisingly brief, when compared to the program's impressive list of features. If you're a *Windows* graphics user, *ImagePrep* and a Hi-Color video card can be very useful.

• *WaterColor.* Creative users can look to some software from AXA Corp. Its application is a DOS-based program called *WaterColor*, and it works exactly as its name indicates. This professional-quality paint program looks and operates like a simple sheet of white paper and an old-fashioned water-color paint set. Many people, even young children, readily understand that water dilutes color and that wet paper causes color to bleed and run. These basic principles of water and color, the heart of *WaterColor,* are combined with the advantage of digital control, which can add things like electronic layering of one color over another color.

The program comes with its own electronic brushes, paper, water, color, mop and mixing palette, complete with a mixing table. Paintbrushes come in nylon or natural, with assorted sizes and textures. The mixing table lets users blend colors to make custom assortments that can be saved for repeat usage. Paper dryness or wetness can be instantly changed, eliminating your having to wait and allowing creative work to continue uninterrupted.

WaterColor is the first paint program of its kind that I've seen made for the artist instead of the computer user. It's easy to use, fun to work with and requires little computer literacy. Although a mouse is supported as a pointing device, some kind of stylus, like the Mouse Pen or the stylus that comes with the SummaSketch digitizer, has a more natural feel.

Monitors

Presently, Hi-Color has a maximum pixel resolution of 800 × 600. Many VGA monitors can scan this high, but others can't. Users who need Hi-Color beyond its main setting of 640 × 480, can upgrade to a better monitor. High-resolution modes of the video cards used in this evaluation were easily supported by the 16-inch FlexScan 9080i from Nanao. The FlexScan has a maximum resolution of 1,280 × 1,024 and a 70-Hz refresh rate that helps reduce flicker, which is especially useful when running *Windows* at 1,024 × 768. It supports noninterlacing and has an impressive 0.28-mm dot pitch when some other monitors of its class measure 0.31 mm. The smaller pixel size makes a noticeable difference when working in high-resolution modes.

One of FlexScan's interesting features is also quite useful. The monitor has connections for a normal nine-pin D-connector and also accepts input from BNC. The latter is particularly handy when using video interfaces and

Products and Services

AXA Corp.
17752 Mitchell, Ste. C
Irvine, CA 92714
Tel.: 714-757-1500
WaterColor evaluation copy and technical assistance (David Evergettis).

Computer Presentations, Inc.
1117 Cypress St.
Cincinnati, OH 45206
Tel.: 513-281-3222
Evaluation copy of *ImagePrep* and technical assistance.

Edsun Laboratories, Inc.
564 Main St.
Waltham, MA
Tel.: 617-937-1260
Technical information and assistance on Continuous Edge Graphics.

IBM Development Laboratory
Boca Raton, FL
PS/2 Technical Update: Extended Graphics Array (XGA) presented by James Paolantonio and James Wilkinson; technical information on XGA.

Micro-Labs, Inc.
7309 Campbell Rd.
Dallas, TX 75248
Tel.: 214-702-8654
Ultimate VGA/Hi-Color evaluation unit and technical assistance (Ted Carter).

QC Plus Computers
525 W. Arapaho Rd., Ste. 23
Richardson, TX 75080
Tel.: 214-644-7536
Demonstrations and technical assistance on Hi-Color (Kevin White).

Sierra Semiconductor
2075 N. Capitol Ave.
San Jose, CA 95132
Tel.: 408-263-9300
Technical assistance on Sierra RAM DAC.

Technopolis Communications
6000 Canterbury Dr., Ste. D301, Culver City, CA 90230
Tel.: 213-670-5606
Nanao FlexScan 9080i evaluation unit and technical assistance (Steve Leon).

Videotex Systems, Inc.
8499 Greenville Ave., Ste. 205
Dallas, TX 75231
Tel.: 214-800-88-VIDEO
Demonstrations and technical assistance on True Color imaging (Paul Montgomery).

projection-TV equipment that do a lot with BNC cabling. The BNC connections allowed me to run a Zenith 1490 analog VGA monitor and the Flex-Scan simultaneously, enabling some interesting visual comparisons.

Another useful feature is the Flex-Scan's microprocessor control over its user adjustments. Brightness, contrast, vertical and horizontal screen position and pincushion adjustment can be set and stored in on-board non-volatile memory. Therefore, adjustments are made only once. The Flex-Scan 9080i is pricier than some other monitors that scan as high it does, but the FlexScan's features and clarity of display tend to make up for the difference.

Conclusion

Hi-Color is moving along quickly. It affords the average user a low-cost opportunity to go beyond Super-VGA. Consequently, it could eclipse eight-bit video as fully as VGA overtook EGA. Because video cards and software drivers do all the work, you can use conventional hardware. If you want to venture into Hi-Color, look for a video-card developer who can offer easy and cost-effective upgrades.

Decide if you want CEG, Hi-Color or both. Be sure your particular choice of video cards comes with at least *Windows* drivers to 1,024 × 768 in 256 colors and other drivers like those for *AutoCAD*, if you need them. If you want to buy a high scanning monitor, get one from a reputable firm that offers technical support and a good warranty. Finally, check to see if your card is backed by a solid warranty. Making a good choice of video cards will help you to go beyond Super-VGA in relative safety. ■

How to Transfer Files

Maximizing data transfers between two computers using serial and parallel ports

Ever since the second computer was created, the computing world has had to struggle with a difficult problem: how to transfer data from one machine to another. One of the easiest solutions, and perhaps the earliest, is to print data on one computer and type it in on the other. Other early solutions involved saving data on paper tape, punch cards, magnetic tape or even floppy disk and then carrying the stored data to another computer.

But in the information age, all of these solutions seem inefficient and unsatisfactory. Computers are supposed to perform such simple activities themselves, not force us to be porters for their data. And if you use a floppy disk to move data from one machine to another, what do you do with files that are larger than the disk's capacity? And what if the machines use different disk sizes or formats?

Many users consider two computers a necessity, not a luxury. They do most of their work on a desktop machine, with a large hard disk and other accessories, but travel with a laptop or notebook computer. The latter probably has a smaller hard disk stuffed with a couple of necessary applications like a spreadsheet, word processor and perhaps database. If the second computer has a floppy drive at all (some have only a built-in hard disk), it will almost always be a 3½"; many desktop machines have only 5¼" floppy drives. You may be one of the many people who has a need to move large files back and forth regularly, keeping your most important data up to date on both machines.

With a little ingenuity, you can automate the process. How you do so will depend on how much data you must transfer, the equipment available on each computer and how much money you're willing to spend for a solution. But you need some understanding of the technical issues before choosing a solution that meets your needs.

Talking to the World

No matter how much computing a machine does, it needs some way of interacting with the outside world for it to be useful. Generally, computers use ports for external communication. Some ports are for very narrow, specific purposes or are meant to move data in only one direction. For example, a CGA video port sends signals to a video monitor, but it doesn't receive any data from the monitor at all. This is an example of a one-way or send-only port. A keyboard port, at least on a PC, is a special-purpose, two-way port. The computer receives keystroke signals from the keyboard and sends commands that turn on or off the keyboard lights and enable or disable keystrokes.

Neither the video port nor the keyboard port is of much use for sharing data between computers, nor are the two-way ports used for disk drives, scanners, mice and CD-ROMs. The really useful ports for sharing data are general-purpose, two-way communication channels. Most computers, including laptops, have at least two of these: a parallel port and an RS-232C serial port.

Data inside a computer moves over a data bus much like a marching band in a parade. The width of your computer's data bus, like the width of the parade route, determines how many bits or marchers can be in each row. Desktop computers normally have internal bus widths of 8, 16 or 32 bits. The distance between rows of marchers is controlled by the system clock; marcher speed is controlled by physical laws. Bandwidth or total capacity of the computer's data bus is based on its width and the distance between the marchers.

When data moves outside the computer over the parallel port, it does so one byte or eight bits at a time; each row can hold only eight marchers. If the internal data bus is wider than eight bits, data must be broken into eight-bit blocks to be sent over the serial port. Normally, the CPU performs the necessary actions to retrieve data and prepare it for the parallel port. The parallel port is like a narrow street wide enough for only eight marchers at one time.

The computer's BIOS code assumes a printer is connected to the other end of the parallel port. It does a good job of sending data to the printer and reacting to status codes the printer sends back. Most software simply sends printer data to the BIOS code (or to DOS), ignores the intricacies of the parallel port completely and depends on the BIOS to properly format the data, handle status messages and see that the proper data arrives at the printer.

A parallel cable has more than the eight conductors required to send eight data bits. It also contains a strobe line that's used to indicate when data on the line is valid, eight status lines so that a printer can respond to the computer while receiving data and a number of ground lines. Early PCs used a 36-pin connector for the parallel port; now most modern computers use a 25-pin connector. Table 1 lists the pin designations for the 25-pin connector. It's important to note that the data pins are bi-directional but that data can be sent in only one direction at any particular time.

Table 1. Parallel-Port Assignments*

Pin Number	Direction From Computer	Signal Name
1	In/Out	STROBE
2	In/Out	Data Bit 0
3	In/Out	Data Bit 1
4	In/Out	Data Bit 2
5	In/Out	Data Bit 3
6	In/Out	Data Bit 4
7	In/Out	Data Bit 5
8	In/Out	Data Bit 6
9	In/Out	Data Bit 7
10	In	Acknowledge (ACK)
11	In	BUSY
12	In	Paper End (PE)
13	In	Select (SLCT)
14	Out	Automatic Feed (XT)
15	In	ERROR
16	Out	Printer Initialization (INIT)
17	Out	Select Input (SLCT IN)
18 thru 25	N.A.	Ground

*Adapted From *The Programmer's PC Source Book* by Thom Hogan.

The serial port is more analogous to a narrow sidewalk. One row of eight marchers or bits moves into the serial port at once, but only one bit at a time is sent out over the port. The CPU sends data over the serial port by breaking data into eight-bit blocks and sending each to the serial port. There, a specialized processor called a UART (universal asynchronous receiver and transmitter) does the work of breaking the byte into eight separate bits or marchers. The UART sends bits individually over the serial cable to whatever device is at the other end.

Serial communication is asynchronous, which means that data can be sent or received at any time. In a synchronous communications system, which is rarely used on desktop computers, a shared clock pulse determines when data can be sent. The advantage of an asynchronous system is that it requires a much smaller hardware investment and is more flexible. But the tradeoff is that either the computer or the receiving device can become confused about the location of the current bit in the original byte.

To overcome this confusion, the UART bundles each byte into a packet and adds signals to mark the beginning and end of the packet. Every packet (or "word," in communications terminology) begins with a start bit. The packet then contains five to eight data bits, an optional parity bit and zero to two stop bits. The UARTs on each end of the serial cable must be set to agree on the formation of the data packet and data transmission speed, which is the time between individual bits. Because BIOS support for serial communication is atrociously weak, virtually all DOS programs that use the serial port manipulate the port directly or use the services provided in a high-level language like BASIC.

You might expect that a serial cable and connector would be much simpler than a parallel cable because only one bit of data is sent at a time. However, a serial cable must contain two data lines because bits can be sent in both directions simultaneously and a signal ground or reference point. Most serial cables also have lines for a number of handshaking signals that the UARTs at each end use to report their status to each other. Table 2 lists the normal pin assignments for both 9- and 25-pin connectors. Only eight or nine of the lines are typically used.

Using the Serial Port

The device most often at the other end of the serial cable is a modem (or MOdulator/DEModulator), the primary job of which is to convert the stream of serial bits it receives from the UART into tones that can be transmitted over a phone line. Of course, it also turns the tones that it receives over the telephone into a stream of bits it sends back to the UART. In addition, the modem is responsible for keeping the UART, and your communications software, informed about its status. Some modems also perform error detection and correction internally when connected to a modem with similar capabilities.

The most obvious way to transfer data from one computer to another through serial ports is to use a pair of modems and a telephone line. One computer sends data out its serial port to a modem. The modem connects to another modem through a phone line. The second modem sends data to its serial port to complete the transfer. When data is sent this way, a communications program is needed at each

Table 2. Serial-Port Pin Assignments*

Signal Description	DB-25 Pin No.	DB-9 Pin No.
Equipment Ground (GND—Optional)	1	Not Used
Transmit Data (TD)	2	3
Receive Data (RD)	3	2
Request To Send (RTS)	4	7
Clear To Send (CTS)	5	8
Data Set Ready (DSR)	6	6
Signal Ground (GND)	7	5
Carrier Detect (CD)	8	1
Date Terminal Ready (DTR)	20	4
Ring Indicator (RI)	22	9

*Adapted from *The Modem Reference* by Michael A. Banks.

end to coordinate the modems and conduct the file transfer. The programs don't have to be the same, but both must support the same file-transfer protocol, which is simply a technique for making sure that data arrives at the second computer without being destroyed by spurious noise on the phone line.

If you have two computers equipped with modems, you can simplify the process. Instead of using a telephone company line for the transfer, just plug a normal phone extension cord into both modems. Make sure that both modems and communications programs have the same UART settings (number of data bits, stop bits, parity bit type and transmission speed). Put one modem into receive mode, give both modems the command to go off-hook or online and they'll communicate with each other as if they had a phone company between them.

I used this technique often when I had to connect an old Tandy 100 portable computer to one of my desktop machines. Some modems recognize the open phone line immediately, but you might have to make others "dial" before they'll notice that they're connected directly to another modem.

Eliminate the Modem

Most modems are limited to 2,400 bits per second (bps), although some newer ones run at 9,600 bps quite well. You can increase transmission speed between two computers in the same room if you dispense with the modems altogether and connect the computers with a null-modem cable to make each computer think the other machine is an external modem. You still need a communications program on each machine, but you can take advantage of the top speed the programs are capable of using. Most programs can run at 9,600 bps or even 19,200 bps, which is a large jump over the 2,400 bps of the most common modems.

You can buy or make a null-modem cable. Depending on your communications software, you need either a three- or eight-connector cable. Figure 1 shows three different null-modem wiring schemes for 25- to 25-pin connections. Programs that don't use any handshaking signals can use the first diagram, but most programs need either the second or third scheme.

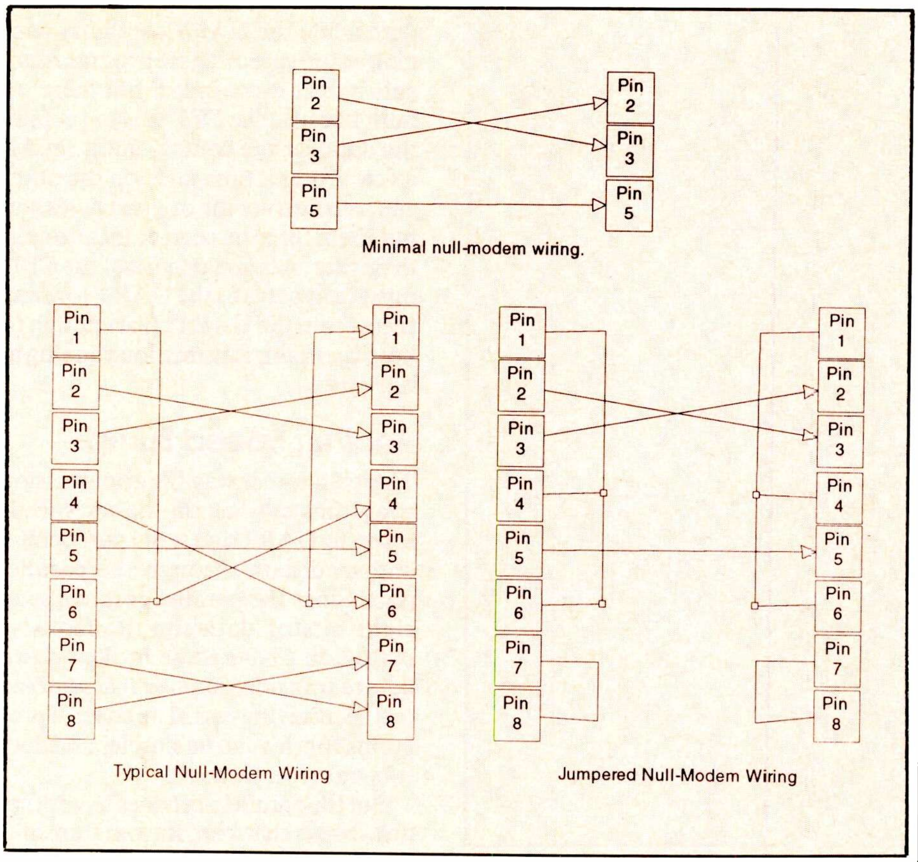


Fig. 1. Null-modem wiring details for 25-pin to 25-pin connectors.

No matter which scheme you choose, make sure that signal ground pin 7 (pin 5 on a nine-connector serial port), is connected between the two machines. If it is, you can experiment with the other lines without damaging either computer. If it isn't, you might destroy one or both serial ports. Most commercial null-modem cables follow the second scheme shown in Fig. 1.

Many newer PCs, including most laptop and notebook computers, use nine-pin serial connectors instead of the older 25-pin connectors. Figure 2 shows null-modem wiring details for connecting together two nine-pin computers. The two most common wiring schemes are shown in Fig. 3 for a nine-pin to 25-pin null modem.

You can also use null-modem connections if you want to transfer data between two different kinds of computers. You need a technical manual to determine the pin arrangement of both machines, but the idea is the same as the diagrams presented here.

Most communications software will work with a direct connection through a null-modem. Some programs are smart enough to recognize the connection as soon as they begin, while others require a simple command to get the two computers communicating with each other. The manual for your communications program should explain how to make direct connection through a null-modem cable and any special commands you need to use.

Picking Up Speed

You can set parameters for a serial port with the DOS MODE command or with communications software, or by making calls to the computer's BIOS. The MODE command, BIOS and most software support speeds up to 9,600 bps. But the serial port on a PC can run a good deal faster than this.

UART speed is set with an internal crystal and divisor circuit. The crystal is set at 1.8432 MHz, which the UART automatically divides by 16 to obtain a base speed of 115,200 Hz. This speed is further reduced by the divisor circuit, which accepts any integer divisor other than 0. If you set the divisor to 384, for example, the UART will run at 115,200/384 = 300 bps. If the divisor is set to 12, the UART runs at

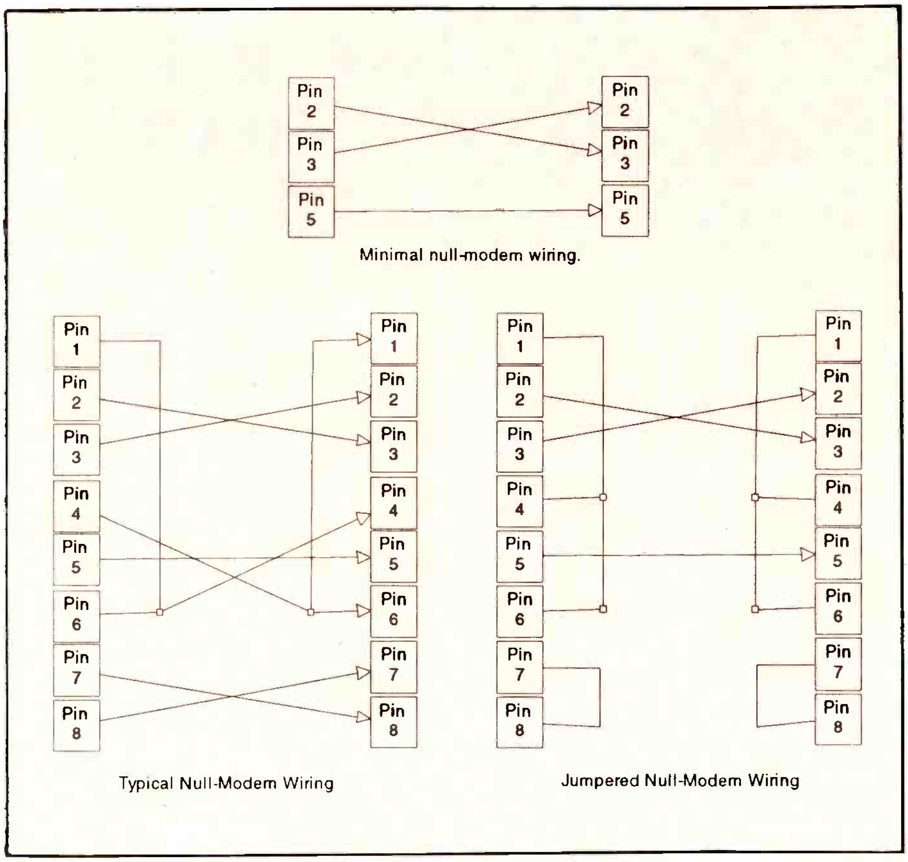


Fig. 2. Null-modem wiring details for 9-pin to 9-pin connectors.

115,200/12 = 9,600 bps.

There's no magic limit to UART speed or the divisor. If software sets the divisor to its lowest legal value of 1, the UART runs at a full 115,200 bps. That's the secret of fast commercial file-transfer programs like the popular *LapLink* from Traveling Software. There are at least a half dozen such programs available, and most of them can run the serial port at 115,200 bps, or more than 11,000 bytes per second, or even faster.

At these speeds, of course, you need specialized software. A normal communications program running in interactive mode must be able to receive text through the modem, send text that you type and look for command keys to change its mode of operation, all at the same time. That's fine for 2,400 or even 9,600 bps operation, but it becomes impossible at 115,200 bps. At high speeds, file transfer programs don't have much time during actual data transmission to do more than look for an abort key while they're sending or receiving data and manipulating disk drives. The inner loops of such programs are normally written in highly optimized assembly language so that transfer speeds can be maintained even on older slower computers.

Most communications programs assume a user is at each end of the transmission line. If you want to send a file with such programs, you normally have to type different commands at each computer. Specialized file-transfer programs usually let you select files and control transfers from one computer, even if files are stored on the other machine. Once the program is running on both machines, you type commands at only one keyboard to move files. Such programs often have a user interface that allows you change directories, select files and perform other DOS-like operations on either the computer you're using or the one to which it's attached.

After you've used a program that runs the serial port at 115,200 bps, you might begin to wonder if it's possible to obtain even more speed. The 115,200-bps rate is possible with a three-conductor null modem. With a specialized cable, some programs reach greater speeds by using some of the control lines to transmit additional data while the UARTs are busy running at top speed. These programs can gain a little extra speed, but there's a limit because the CPU has to prepare the data for the control lines, send it a few bits at a time and, on the other end, reconstruct the original bytes and put them into the correct locations in their files. At the same time, the CPU must feed bytes to the UART (or read them from the UART) fast enough to keep the main transmission running at high speed.

Another Speed Bump

There's another way file-transmission programs can attain higher speed: leave the UART and serial port behind and send data through the parallel port. Since the parallel port can send eight bits of data simultaneously, bytes don't have to be broken down before transmission nor reassembled on the receiving end. The control programs for this can be simpler and data transmission faster.

But the parallel port does have other drawbacks that keep it from transmitting data at extremely high speeds. The most important is that parallel ports aren't generally designed for high-speed data transfers. Few printers can handle 1,000 bytes per second, much less the 30,000 bytes or more at which transfer programs would like to transmit. Also, transfer speed is ultimately limited by disk read and write speeds, as well as by the physical capacities of the parallel port.

The result is a compromise between theoretically unlimited transmission speed and physically restricted speed. Part of the problem is that the highest maximum speed is unknown and varies from one computer to another (even to another of the same model). Therefore, most programs that use parallel-port transfers run at about 200,000 bps (or about 25,000 bytes per second).

Such transfers are still very fast—significantly faster than serial data transfers and so much faster than modem-to-modem transfers that they're really in a different league. At such speeds, you could transfer a full 20M of data from one computer to another in less than 15 minutes, which is barely enough time to enjoy a cup of coffee. And most transfer programs let you specify a group of files or direc-

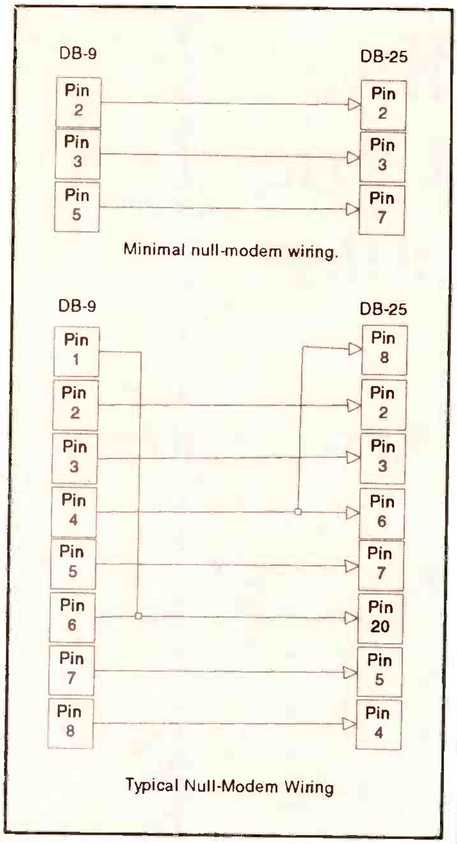


Fig. 3. Null-modem wiring details for 9-pin to 25-pin connectors.

tories you want to transfer; so you could have one computer send 1,000 files to another computer while you have a cup of coffee.

Transfer programs can also help you move data between incompatible computers or operating systems. Some can move data from a Macintosh, workstation or mainframe computer to a PC. Others can run under *Windows* or OS/2 on one machine and send data to a DOS-based PC. Almost all perform checks to make sure that data arrives without errors. And they avoid the danger of boot-sector viruses that can strike your system if you move data on a floppy disk.

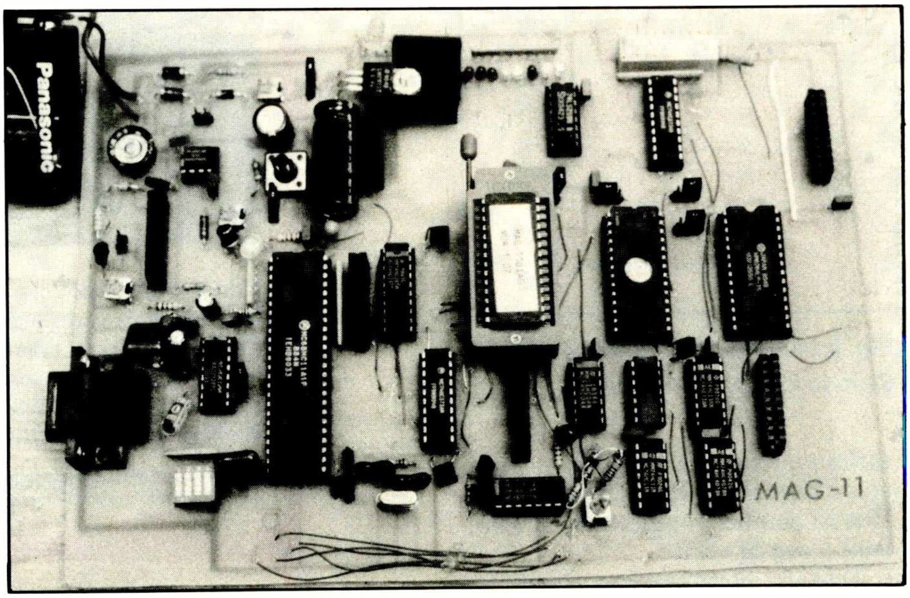
As soon as you have two computers, you'll find a reason to move data from one to the other. Which solution you choose—diskettes, modem or null-modem transfers or specialized programs—depends on how often and how fast you want to move that data. Once you develop a system, you'll find that data transfers will become an essential part of your computing habits, and that you'll get better use from both machines. ■

Experiment With Motorola's 68HC11 True Single-Chip Computer

Part 2

Examining the SBC circuit and diagnostic/tutorial software

Last month, we looked at Motorola's versatile 68HC11 microcontroller chip and used it in a simple circuit to introduce you to how this versatile chip works. This time around, we examine the circuit and diagnostic/tutorial software for a MAG-11 single-board computer that you can use as an elementary learning tool for the 68HC11 and then readily expand for use in practical applications.



About the MAG-11

Our MAG-11 SBC uses Motorola's MC68HC11A1P MCU in a plastic DIP. Because it has just 48 pins, only four channels of its eight-channel A/D converter are available for use. (The 52-pin PLCC surface-mount package makes all eight channels available.) We chose the DIP package because it's easier to handle and test and, unlike its surface-mount counterpart, it's possible to insert into a standard solderless prototyping board. Also, the technology needed to make a reliable printed-circuit board that can handle a 52-pin PLCC with 0.05″ pin spacing isn't commonly available to home electronics enthusiasts.

In Fig. 1, MAX232 RS-232C driver *U3*, 6264LP 8K RAM *U9* and 27C256 32K EPROM or KM62256ALP-10 32K RAM *U10* are optional. If you omit *U9* and *U10*, memory consists of 256 bytes of static RAM, with backup capability located at 0 through $FF ($ signifies hexadecimal); 512 bytes of EEPROM located at $B600 through $B7FF; and either 2K bytes of EPROM if MAG-11 diagnostic/tutorial firmware is chosen (at $F800 through $FFFF) or 32K bytes of EPROM (at $8000 through $FFFF) if the BASIC-11 interpreter or BUFFALO monitor is used. MAG-11A firmware is contained in *U7*.

An optional 8K of static RAM, provided by *U7*, is located at $0100 through $1FFF, except that $1000 through $103F are used by the internal registers. Full backup capability is provide for *U9*, assuming a Battery/Logic Probe board (to be covered at a later date) is added to MAG-11. Without this board, only limited "super-capacitor" backup is provided on MAG-11 via *C17*. Either 28K of RAM at $0100 through $6FFF or 20K of EPROM at $2000 through $6FFF is provided by *U10*.

Clock rate can be 921 kHz or 1 MHz, depending on the frequency of the crystal used. An optional RS-232C interface is provided on the board with DB-9 connector *J7*. You conduct tests and experiments using DIP switches *S1* and *S2* and observe results on light-emitting diodes *LED1* through *LED8*.

Switch positions 1 through 8 of *S1* and positions 1 through 4 of *S2* serve as inputs to the MCU. Position numbers for these two DIP switches are the same as the pin numbers on their packages. Position 9 of *S1* controls power to all LEDs. If you want lowest possible power consumption, set position 9 of *S1* to OFF to put MAG-11 in a low-power "invisible" Mode.

Power indication is provided by *LED9*, and *LED10* lights when the MCU is operating properly, since it's controlled by the MCU directly (no external decoding used). Indication that either the reset circuit isn't operative or, assuming the clock monitor function is enabled, the clock has failed is provided by *LED11*.

Temporary RAM backup is provided by on-board 0.1-F super-capacitor *C17*. Power requirements for MAG-11 are 7 to 13 volts dc, at about 60 mA. The SBC will operate continuously for nearly 2 hours on a fully charged 7.2-volt Ni-Cd battery and somewhat longer with a 9-volt alkaline battery.

All pertinent MCU data, address, control and I/O lines are accessible through 20-pin sockets (or headers) *J3* through *J6*, as illustrated in Fig. 2. MAG-11 can be expanded by plugging an accessory board directly into the component side of it. Alternatively, 20-conductor cables can connect the SBC to accessory boards.

A Battery Backup/Eight-Channel Logic Probe board plugs into *J1* and *J2*. On it are separate 9-volt alkaline (*B1*) and 7.2-volt Ni-Cd (*B2*) batteries. An Ni-Cd battery used for *B2* provides battery backup for nearly 2 hours if ac line power fails, while *B1* provides complete memory backup for an extended time and supplements *C17*. Automatic switchover for *B1* is provided by *U2*. Jumpers must be set for the type of battery/power system used. (All jumper settings are illustrated in Fig. 2.)

You can power MAG-11 with ac, battery or both. Connect an external

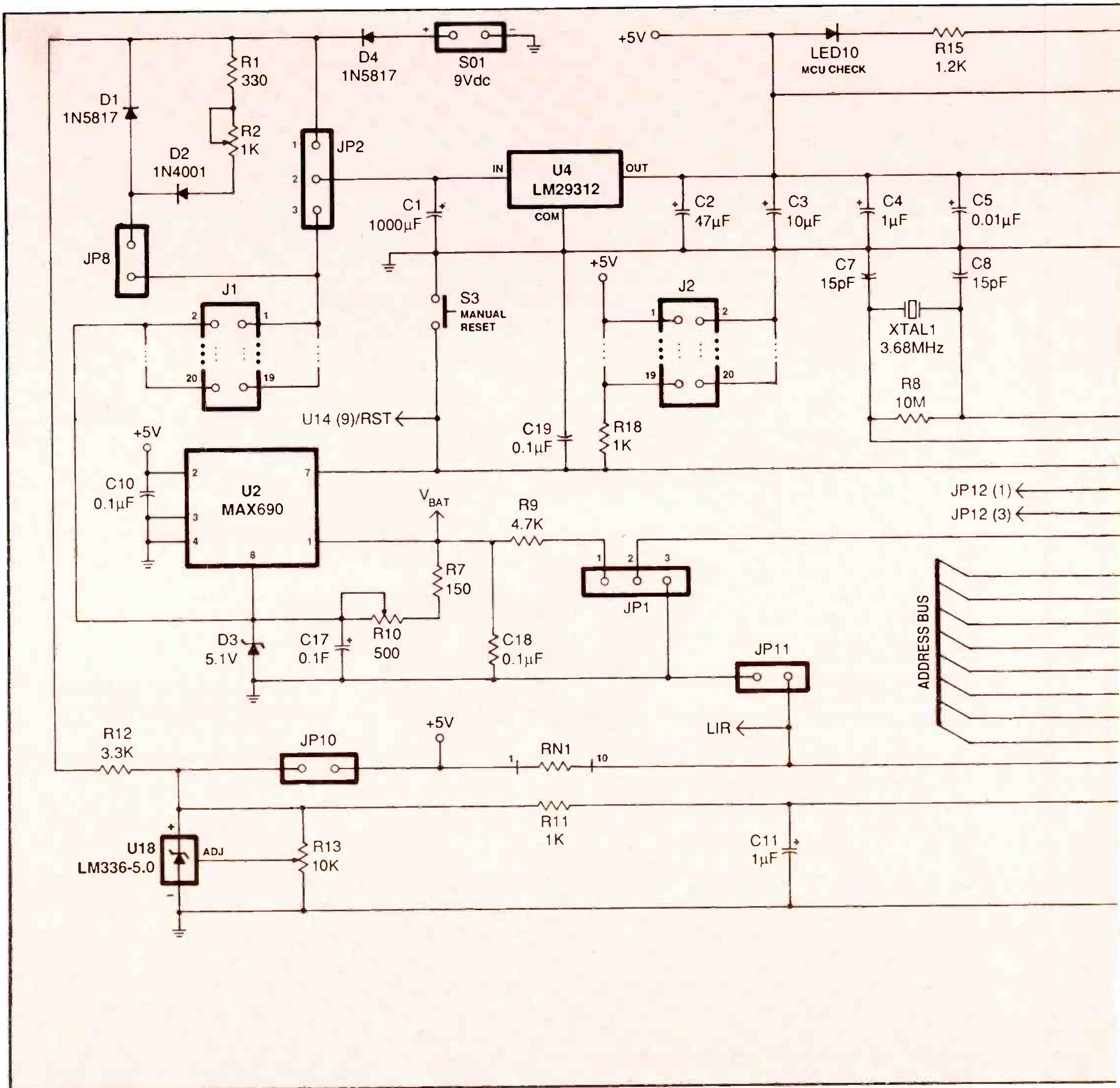


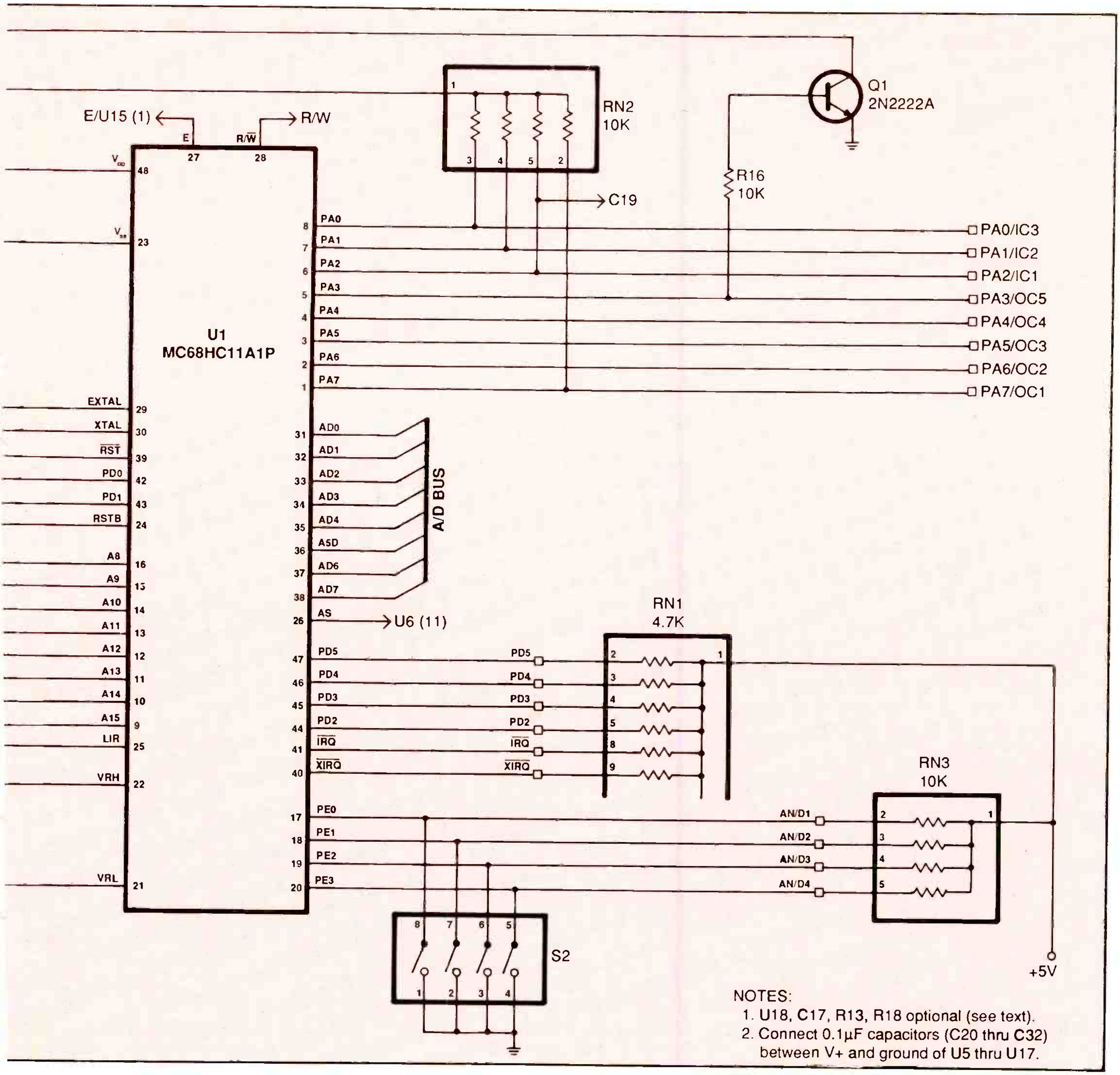
Fig. 1. Complete schematic diagram of MAG-11 single-board computer is shown here in multiple parts.

ac power supply via *SO1* and jumper pins 1 and 2 of *JP2*. If you use a 7.2-volt Ni-Cd battery for whole-circuit backup, jumper *JP8*. If you use only a 9-volt alkaline battery, jumper pins 2 and 3 of *JP2* and leave *JP8* without a jumper. If you use a battery-power or backup source, use an LM2931T low I/O differential 5-volt regulator for *U4*. Finally, if you use only an ac source, *U4* can be an LM340T, which is capable of handling greater current.

MAG-11 contains five resistor networks, identified as *RN1* through *RN5*. These replace 33 discrete resistors that would have been required if they weren't used.

MAX690 MPU Supervisory Circuit *U2* provides a reset output with automatic voltage-monitoring capability. Pin 7 is an active-low output with an internal 3-μA pull-up and goes low whenever the +5-volt power source drops to less than 4.65 volts. It goes high when V_{cc} exceeds 4.69 volts for at least 50 milliseconds. Switch *S3* permits you to manually reset the circuit, and resistor *R18* is optional, to be used in reset applications that require more current than 3 μA when the RESET signal is high.

The other function of *U2* is to pro-



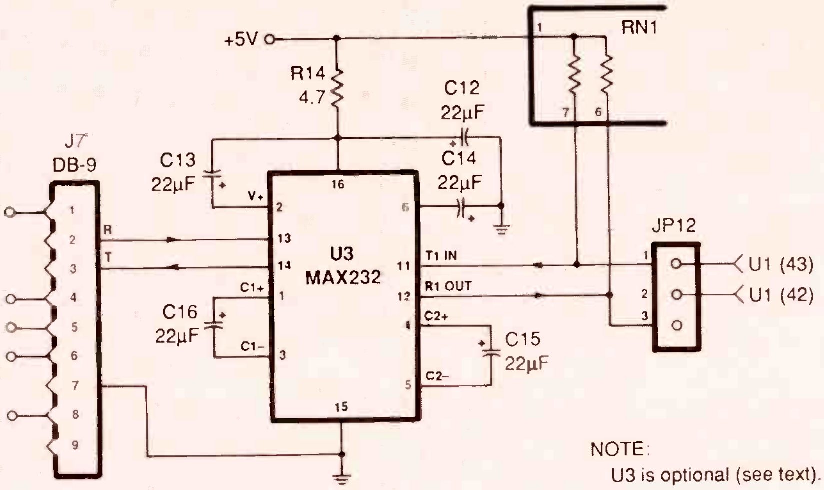
NOTES:
1. U18, C17, R13, R18 optional (see text).
2. Connect 0.1μF capacitors (C20 thru C32) between V+ and ground of U5 thru U17.

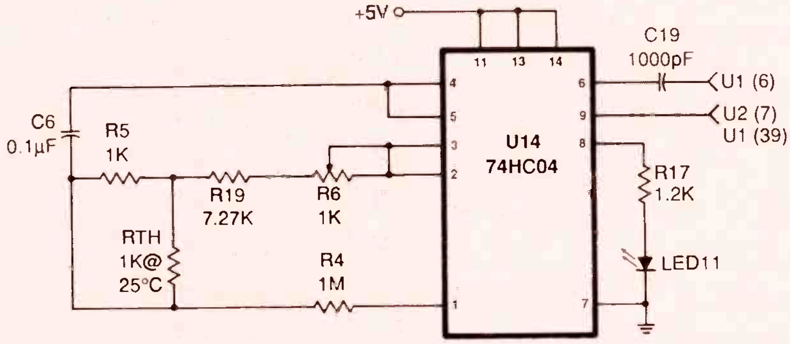
PARTS LIST

Semiconductors
D1,D4—1N5817 Schottky barrier rectifier diode
D2—1N4001 silicon rectifier diode
D3—1N4733A 5.1-volt 1-watt zener diode
LED1,LED2,LED4,LED5,LED9, LED 10—Green low-current, high-efficiency light-emitting diode
LED3,LED6,LED7,LED8,LED11—Red low-current, high-efficiency light-emitting diode
Q1—2N2222A npn silicon transistor
U1—MC68HC11A1P single-chip microcomputer
U2—MAX690CPA
U3—MAX232 IC (optional—see text)
U4—LM2931P differential fixed +5-volt regulator
U5—74HC245
U6,U11—74HC373
U7—27C256 EPROM (programmed —see text)
U8—74HC138
U9—6264LP 8K RAM (optional—see text)
U10—27C256 32K EPROM or 32K RAM (optional—see text)
U12—74HC259
U13—74HC4078
U14—74HC14
U15—74HC04
U16—74HC32
U17—74HC11
U18—LM336-5.0 precision +5-volt reference

Capacitors
C1—1,000-μF, 25-volt electrolytic
C2—47-μF, 16-volt electrolytic
C3—10-μF, 16-volt electrolytic
C4,C11—1-μF, 100-volt metalized polyester
C5—0.01-μF, 50-volt monolithic ceramic
C6,C9,C10,C18,C20 thru C32—0.1-μF, 50-volt monolithic ceramic
C7,C8—15-pF, 500-volt dipped mica
C12 thru C16—22-μF, 25-volt electrolytic
C17—100,000-μF (0.1-F), 5.5-volt Panasonic Gold
C19—1,000-pF, 50-volt monolithic ceramic

Resistors (¼-watt, 5% tolerance)
R1—330 ohms
R3,R17—1,200 ohms
R4—1-megohm
R5,R11—1,000 ohms
R7—150 ohms
R8—10 megohms
R9—4,700 ohms
R12—3,300 ohms (optional—see text)
R14—4.7 ohms
R15—1,500 ohms
R16,R18—10,000 ohms
R2,R6—1,000-ohm pc-mount trimmer potentiometer



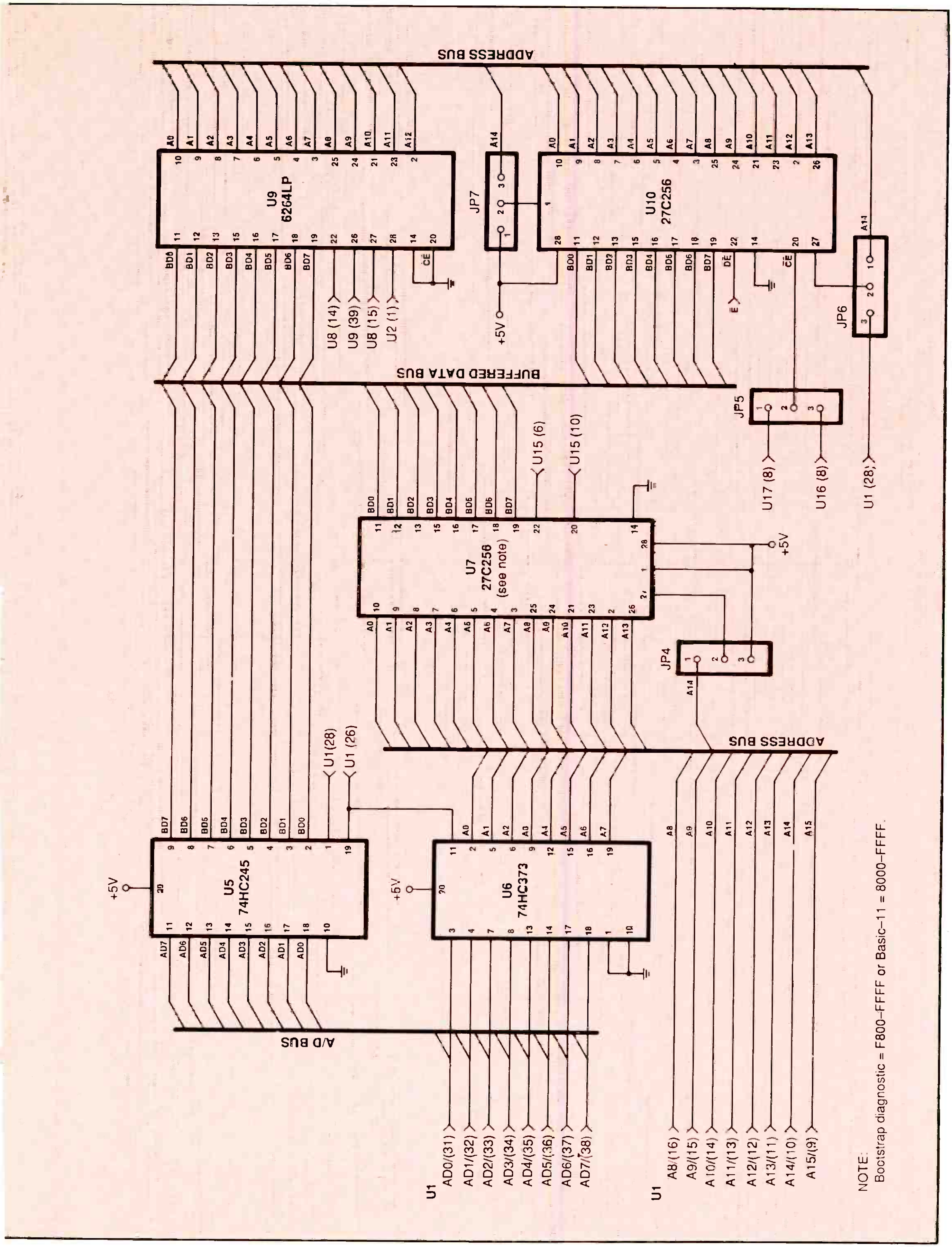


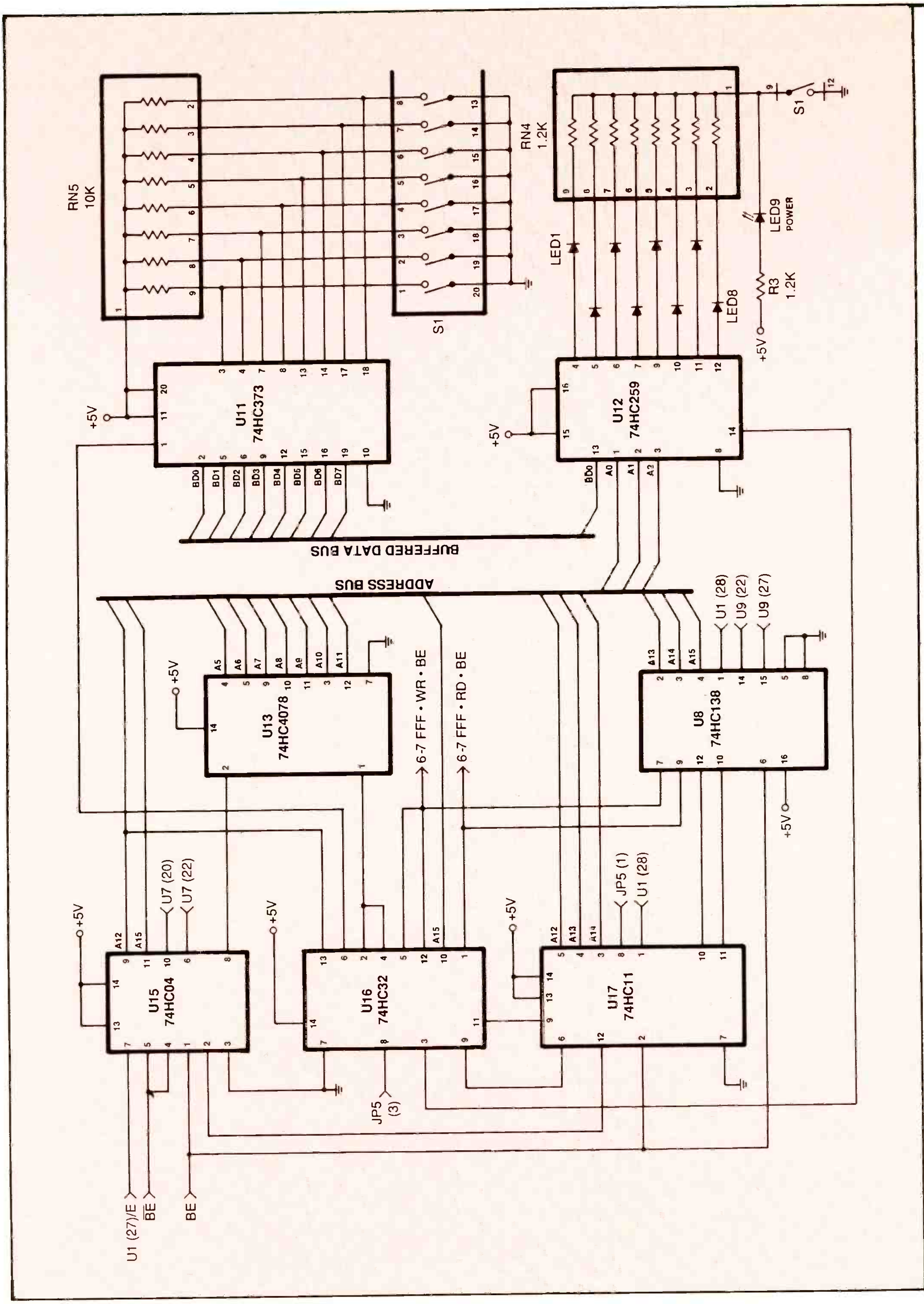
R10—500-ohm pc-mount trimmer potentiometer
R13—10,000-ohm pc-mount trimmer potentiometer
RTH—1,000-ohm at 25° C thermistor (Fenwall No. JB31J1 or equivalent)
RN1—Nine-element 4,700-ohm SIP resistor network
RN2—Five-element 4,700-ohm SIP resistor network
RN3—Five-element 4,700-ohm SIP resistor network
RN4—Nine-element 4,700-ohm SIP resistor network
RN5—Nine-element 4,700-ohm SIP resistor network

Miscellaneous
J1 thru J6—20-contact, dual-row female connector with contacts on 0.1" centers (male headers optional —see text)
J7—Right-angle, pc-mount DB-9 connector
JP1,JP2,JP4 thru JP7,JP12—3-position jumper block with pins on 0.1" centers
JP8,JP10,JP11—2-position jumper block with pins on 0.1" centers
S1—10-position DIP switch
S2—4-position DIP switch
S3—Normally-open, momentary-action spst pushbutton switch
SO1—Socket for external ac power-supply cable
XTAL1—3.6864-MHz crystal (4-MHz optional—see text)
Printed-circuit board, sockets for all DIP ICs; 10 shorting jumpers; heat sink for U4; four 1" threaded metal spacers; four small screw-on rubber feet; machine hardware; hookup wire; solder; etc.

Note: The following are available from Magicland (4380 S. Gordon Ave., Fremont, MI 49412): MAG-11 pc board, write for latest price; ICs (except MAX-232, 6264LP and 27C256), including MC68HC11A1P and 27C256 programmed with MAG-11DIAG firmware, JB31J1 thermistor, 7,270-ohm resistor and MAG-11 software on 5¼" or 3½" disk (No. MAG-11 chip/disk kit), $49.50. Available separately: MC68HC11A1P, $25; programmed 27C256 (No. MAG-11DIAG/E-256), $12. Also available is a PC-compatible disk with the assembly-language listing of MAG-11DIAG software, Motorola S format file and 68HC11 software mentioned in this series; includes Motorola's freeware 68HC11 assembler, MAG-11 and HPPRT.EXE (courtesy PCBoards) files for printing pc guides on a Hewlett-Packard LaserJet II/compatible laser printer, $7.50 (5¼" disk No. 6811ME-5) and $10 (3½" disk No. 6811ME-3).

The assembly-language listing of MAG-11DIAG software can be obtained by sending a self-addressed full-size business envelope with 75 cents postage on it to Magicland.


ADDRESS BUS
U9
6264LP
JP7
U10
27C256
U8 (14)
U9 (39)
U8 (15)
U2 (1)
+5V
BUFFERED DATA BUS
JP6
JP5
U17 (8)
U16 (8)
U1 (28)
U15 (6)
U15 (10)
U7
27C256
(see note)
JP4
U1(28)
U1 (26)
U5
74HC245
U6
74HC373
A/D BUS
U1
AD0/(31)
AD1/(32)
AD2/(33)
AD3/(34)
AD4/(35)
AD5/(36)
AD6/(37)
AD7/(38)
A8/(16)
A9/(15)
A10/(14)
A11/(13)
A12/(12)
A13/(11)
A14/(10)
A15/(9)
NOTE:
Bootstrap diagnostic = F800–FFFF or Basic–11 = 8000–FFFF.


RN5
10K
S1
RN4
1.2K
U11
74HC373
U12
74HC259
LED1
LED8
LED9
POWER
R3
1.2K
+5V
BUFFERED DATA BUS
ADDRESS BUS
U13
74HC4078
U8
74HC138
6-7 FFF • WR • BE
6-7 FFF • RD • BE
U1 (28)
U9 (22)
U9 (27)
U15
74HC04
U16
74HC32
U17
74HC11
U7 (20)
U7 (22)
JP5 (1)
U1 (28)
JP5
(3)
U1 (27)/E
BE
BE

vide memory/backup-battery switchover. Pin 8 connects to the backup power source, pin 1 to the CMOS RAM to be backed up. Basically, *U2* compares V_{CC} to V_{BAT} and connects pin 1 to whichever is of greater magnitude. The output from *U2* goes to pin 28 of optional CMOS RAM *U9* and, through *R9*, to jumper *JP1*.

If pins 1 and 2 of *JP1* are jumpered (Normal Expanded mode *or* Single-Chip mode) the backup voltage powers *U1*'s internal RAM through pin 24. If pins 2 and 3 are jumpered, pin 24 of *U1* is grounded and the MCU will be in either Special Test or Special Bootstrap mode.

An on-board backup power source is provided by *C17*. Since *C17* is rated at only 5.5 volts, 5.1-volt zener diode *D3* must be connected across it as shown. If a MAG-11BAT board is plugged into MAG-11, use *R10* to adjust the charging current for *B2*.

The clock circuit consists of *XTAL1*, *C7*, *C8* and *R8*. Chip *U18* and resistors *R12* and *R13* provide an optional precision reference of 5.0 volts dc for the *U1*'s internal A/D (analog-to-digital) converter. If you don't use *U18*, jumper the pins of *JP10*.

RS-232 driver/receiver *U3* doesn't require a separate ±12-volt power source to operate. It connects to Port D of *U1* at PD0/PD1 pins 42/43. The transmit line of *U3* connects to pin 3 of *J7*, its receive line to pin 2 of *J7*. Also, pin 7 of *J7* connects to ground. This DB-9 connector is AT-compatible. Keep in mind that no handshaking is used in this circuit; some systems require other pins to be active as well.

Notice that all LEDs, including POWER *LED9*, are controlled by *S1* position 9. With this switch open,

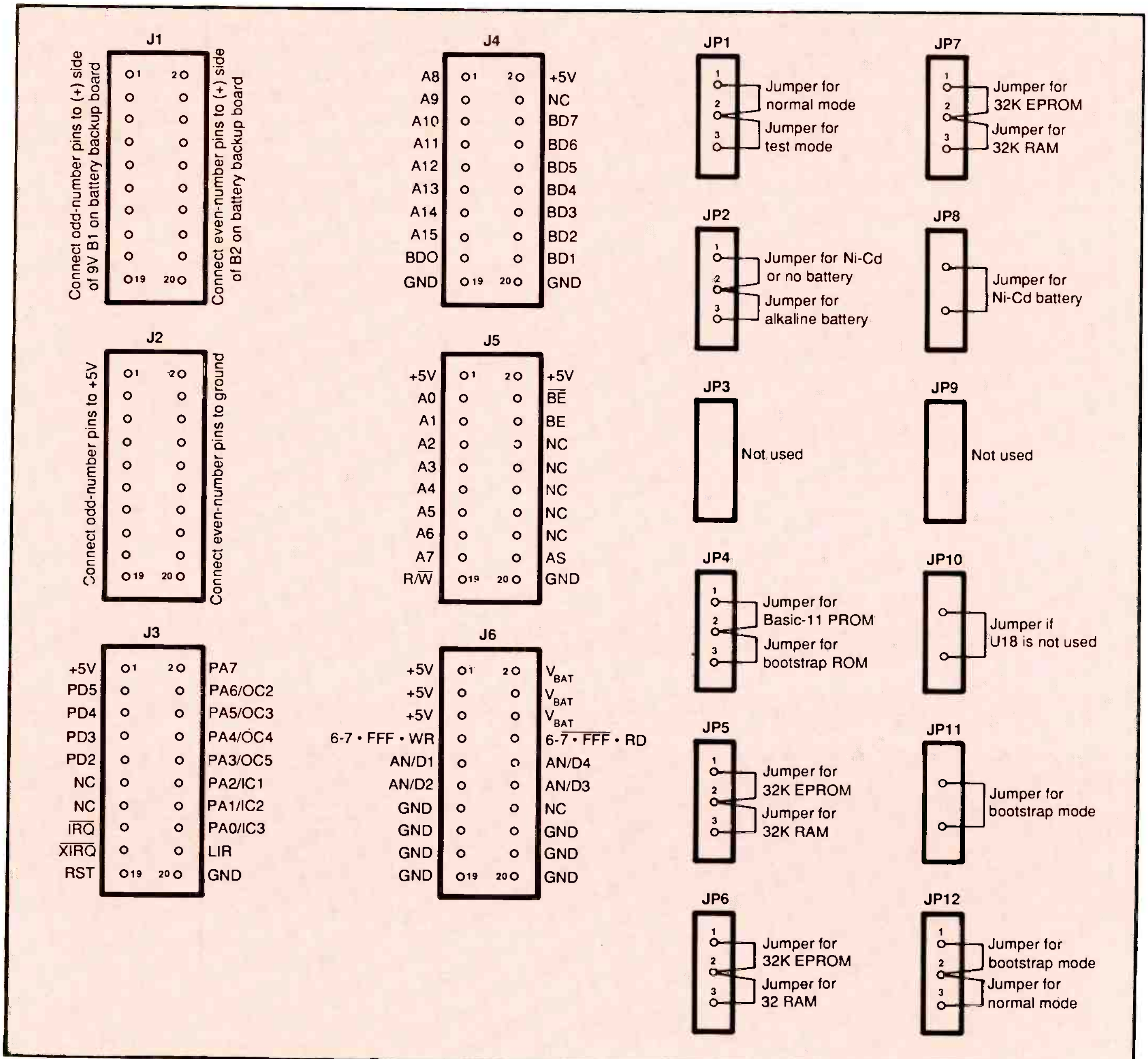


Fig. 2. Pinout and connection details for the various connectors and jumper blocks used in the MAG-11 SBC.

MAG-11 operates in a low-power "invisible" mode.

MCU CHECK *LED10* connects to the collector of *Q1*, the base of which connects to pin 5 of *U1*. This pin connects to Bit 3 of Port A (located at $1000) inside *U1*. Therefore, writing to address $1000 with a xxxx1xxx, (*x* indicates a 1 or 0) turns on *LED10*, which is turned off by writing xxxx0xxx to location $1000.

Pin 6 of *U1* connects internally to Bit 2 of Port A and functions in MAG-11 as an edge-sensitive timer/input-capture (IC1). It connects through *C19* (which, along with a 10,000-ohm resistance from inside *RN2*, functions as a differentiator) to the output of a temperature-sensitive square-wave oscillator. This oscillator consists of three Schmitt-trigger inverters inside *U14* and a thermistor/resistor combination.

The network made up of *R5*, *R6* and *R19* has a resistance that varies inversely with temperature. As temperature increases, the period decreases

More Information on the 68HC11

Part 1 examined the basics of the HC11 MCU enough for you to understand a simple circuit and a primitive working program. Now let's look at a more practical program that tests several of the HC11's peripherals. This MAG-11DIAG program also makes it a snap to try out any new original program of your own. This discussion is limited to descriptions of only the registers, peripherals and other items that you'll be using in the program.

Figure A is a block diagram for the MC68HC11A8. Unlike the MC68HC11A1P, the MC68HC11A8 includes an 8K ROM. In Fig. B is shown a programming model for the generic 68HC11.

• *Special Test Mode.* The HC11 goes into special test mode when MODA pin pin 25 is high and MODB pin 24 is low at reset. After the reset signal rises, the mode-select pins no longer influence operating mode.

Test mode isn't meant for normal operation, primarily because many of the automatic protection mechanisms aren't enabled in this mode. It's important because you can program the CONFIG register only while in it. It's also useful in debugging a system.

• *Test Instruction.* When in Special Test and Bootstrap modes, the TEST instruction (opcode $00) causes the address bus to count backward (decrement). This is useful for testing the MCU. But it's rarely, if ever, used in a "normal" system. When the MCU is in Normal Expanded Multiplex or Single-Chip Mode, the TEST instruction is an illegal opcode.

• *Stop Instruction & RAM Backup.* This rather unusual instruc-

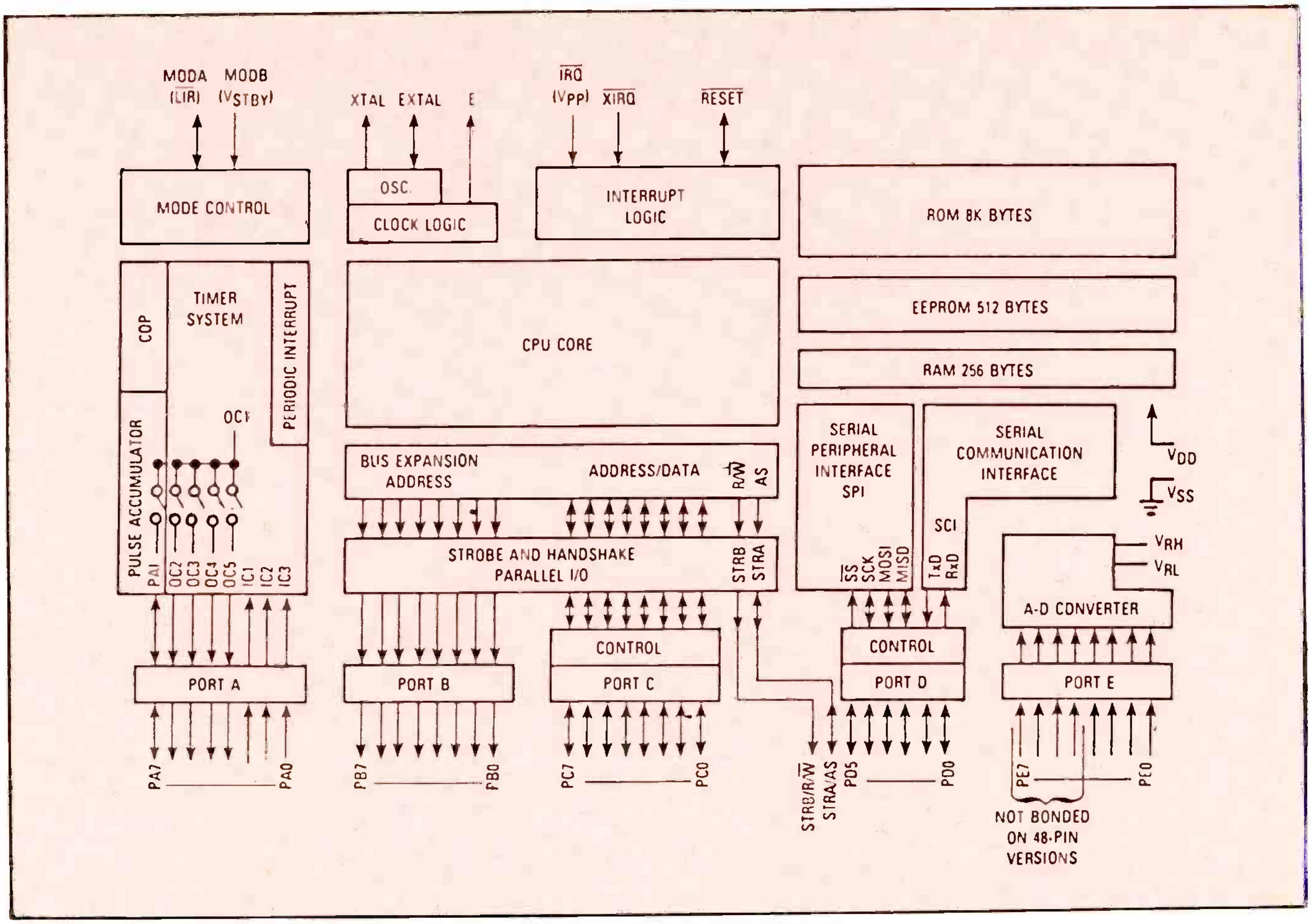


Fig. A. Block diagram of the 68HC11A8.

nearly linearly. While a linear response to temperature isn't a requirement, it helps to simplify the software.

After adjustment, the period at 0F is 2,503 μs, or 2,307 cycles with a 921-kHz clock (2,503 cycles with a 1-MHz clock). Each cycle corresponds to 1 ° F, and each *decrease* (in cycles) of period length corresponds to an increase of 1 ° F. For a temperature of 100 ° F, period length (in cycles) should be 2,503 − 100 or 2,403 μs. The software converts the relative period length into a binary display of temperature in °F.

Demultiplexing of the low-order address lines and data lines is done with 74HC373 octal transparent latch *U6*. It latches the stable address information of address output signals A7 through A0 when the AS (Address Strobe) signal connected to the enable line of *U6* drops low. In addition to providing demultiplexing, *U6* buffers these address lines.

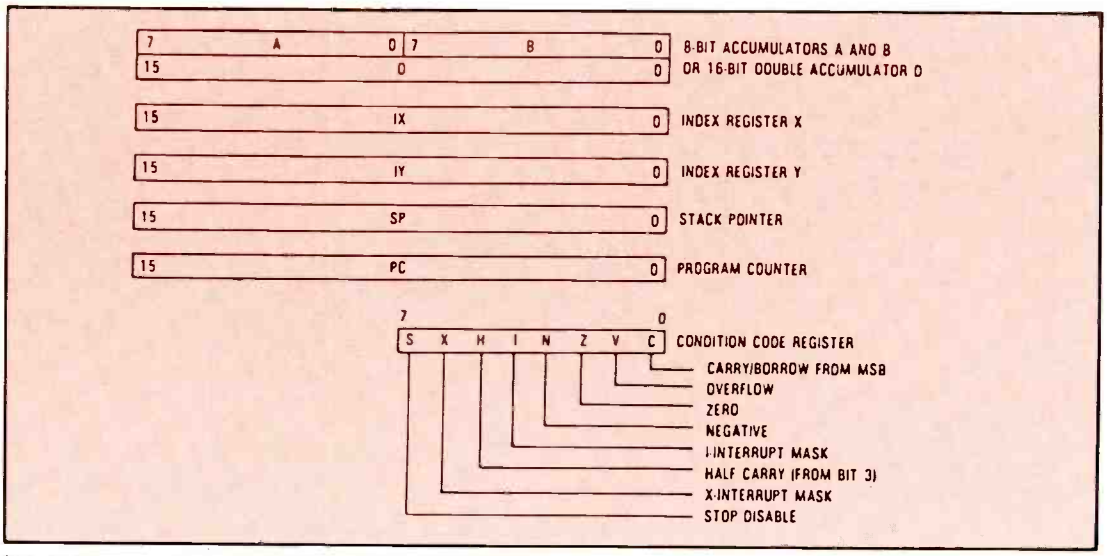


Fig. B. Programming model of the "generic" 68HC11.

tion causes the oscillator and all MCU clocks to stop. When in Stop Mode, power consumption is dramatically reduced, to less than 100 μA and typically much less. The S bit in the Condition Code Register must be cleared to enter Stop mode. After reset occurs, it's set. When this bit is set, STOP is treated as a NOP instruction.

The primary use for the STOP instruction is to provide an easy —primarily software—way of maintaining the internal registers and contents in RAM when primary power fails. In many systems, sufficient energy is stored in filter and bypass capacitors to retain the contents in RAM for a long time. The main requirement is that the MCU enter Stop mode within several hundredths of a second after primary power fails. This RAM backup approach is most effective in Single-Chip mode. Nevertheless, it can be used when more chips are in the system, as long as they can be placed in a low-power standby mode.

MAG-11 can use this method of RAM/register backup. However, as you can see in the simplified main flow chart in shown in Fig. C, MAG-11DIAG software requires MAG-11 to be in Special Test mode before the software places the MCU in Stop mode (*S1(3)*, *S1(5)* and *S1(8)* must be set to OFF.)

Primary RAM backup in MAG-11 is energy stored in *C17*. This super-capacitor supplies a voltage to pin 24 of *U1* in Fig. 1 in the main article. Pin 24 sets *U1*'s mode of operation and provides backup RAM voltage.

Some M68HC11 chips have a "bug" in the STOP instruction. To prevent this bug from interfering with your design, always place a NOP instruction immediately before a STOP instruction.

HPRIO Register

Bit	7	6	5	4	3	2
Instruction	RBOOT	SMOD	MDA	IRV	PSEL3	PSEL2

Bit	1	0	HPRIO
Instruction	PSEL1	PSEL0	$103C

Since the diagnostic software uses only Bit 6 (SMOD), the other bits will be ignored for the present. For more information on these other control bits, consult the M68HC11 Reference Manual.

The SMOD (Special MODe) control bit is used to change from Special Test to Normal Expanded mode. It can't be used to change from Normal to Expanded mode to Special Test mode. It can be cleared, though never set by software, but it can be read at any time. When set, the MCU is in Special Test mode (or Special Bootstrap mode if MODA is 0). When SMOD is cleared, the MCU is in Normal Expanded mode (or Normal Single-Chip mode if MODA is 0).

Option Register

Bit	7	6	5	4	3	2
Instruction	ADPU	CSEL	IRQE	DLY	CME	0

Bit	1	0	OPTION
Instruction	CR1	CR0	$1039

After reset, all control bits are cleared, except Bit 4, the DLY bit, which is set.

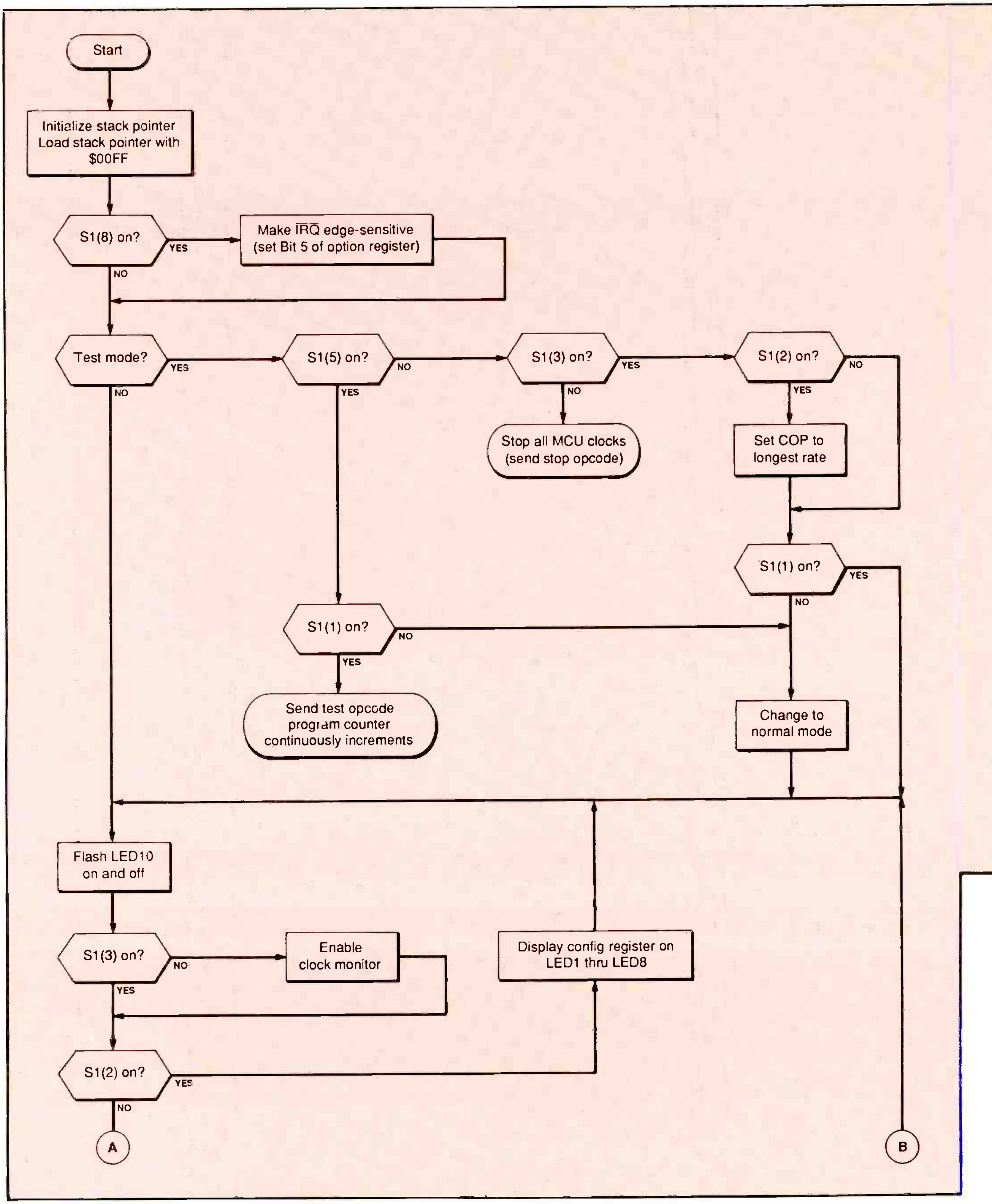
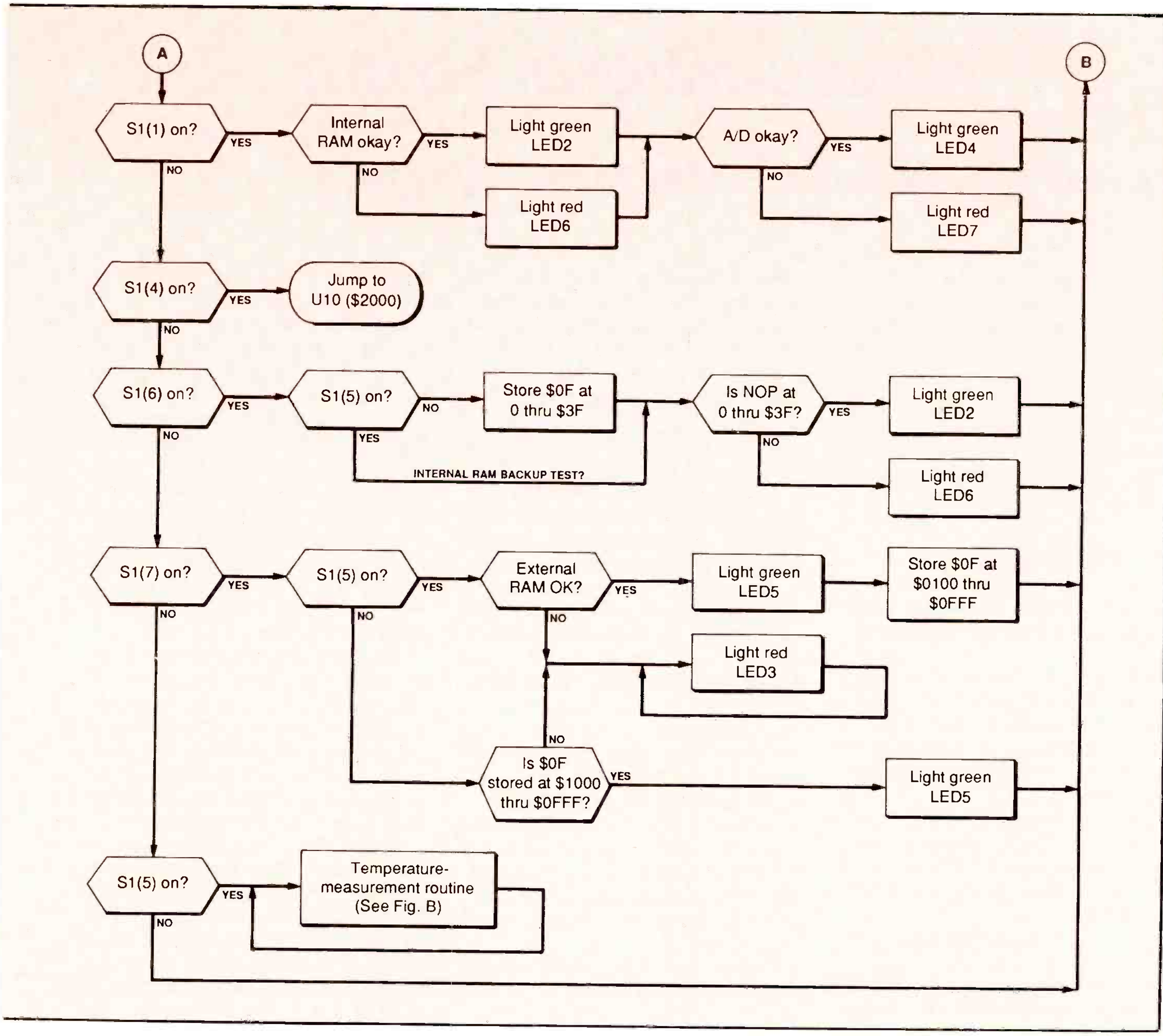


Fig. C. Simplified main flow chart for MAG-11DIAG software.



Since the OPTION register is used extensively by MAG-11DIAG software, we'll look at all control bits next.

• *Bit 7/ADPU—A/D Power-Up.* This bit must be set before using the A/D system. A 100-μs delay is required after ADPU is set to permit the A/D system to stabilize.

• *Bit 6/CSEL—A/D-EE Charge Pump Clock Selection Select.* When this bit is set, the on-chip RC oscillators are enabled and used by the A/D system and EEPROM charge pump. When cleared, the MCU E clock is used instead. If the E clock is 1 MHz or greater, this bit should be cleared. If the E clock is 750 kHz or less, this bit should be set. Between these frequencies, set this bit *only* if you wish to program or erase the EEPROM.

• *Bit 5/IRQE—IRQ Edge/Level Sensitive.* When cleared, the IRQ pin is configured for level-sensitive wired-OR operation (low level triggers it). When set, it's triggered on a falling edge. *Important:* Except in Special Test mode, this bit can be written to only once after reset and this write must occur within 64 E clock cycles after reset, though is can be read at any time.

• *Bit 4/DLY—Stop Exit Turn-On Delay.* When this bit is set (after reset), a 4,064 E clock-cycle delay is imposed after a stop period. When the DLY bit is clear there's no delay. Generally, this bit should be cleared only if an external clock source is used. *Important:* This bit can be programmed only once and within 64 E clock cycles after reset (see Bit 5 above).

• *Bit 3/CME—Clock Monitor Enable.* When cleared, the clock monitor circuit is disabled. When set, the clock monitor system triggers a reset sequence if no clock is present or if the clock is slow. With systems that use a clock frequency of less than 200 kHz, this bit should always be cleared.

• *Bit 2.* Not presently used. When read, it returns a zero.

• *Bit 1/CR1 & Bit 0/CR0.* These two bits set the COP time-out period. Four different time-outs are possible, but MAG-11DIAG

(Continued on page 82)

Microcontroller Forum

Answers to questions most-often asked by readers

Since I began this series of articles on microcontrollers and single-board computing last year, many readers have written to ask for information on a variety of topics. On the premise that a topic that's of interest to one is almost always of interest to many, this month I present a selection of reader questions and my responses to them.

Car Computers

I've had several questions about automotive computers, which are a hobby of mine. Here are some typical ones:

Q. *What type of microprocessor do automotive computers use, especially Ford EEC-IV type systems? What programming language do they use? How are these computers programmed?*

How can I interface and write a program for my PC to extract trouble codes and activate the self-diagnostic procedure from my Ford EEC-IV computer?

B.S., Chesapeake, VA.

My interests are cars and computers. There must be quite a few readers who, like me, would like to experiment with the program in their car-computer's PROM. This should be easy to do if information on the processor is available.

All of the ICs in my Chevrolet's computer carry only a General Motors part number. Do you know whose processor they use, or do they make their own? Where would a person get the processor's instruction set?

D.H., Nepean, Ontario.

A. The kind of computer used in your car depends a lot on the car's make, model and year. In the last decade, car computers, like personal computers, have advanced tremendously, prompted by the need for better fuel economy and reduced exhaust emissions, and made possible by more powerful, faster computer chips.

To attain more precise engine control, auto makers are gradually moving from 8-bit microcontrollers to 16-bit designs, some even on to 32-bit digital signal processors.

Most auto makers don't make their own computer chips. Instead, they use standard or specialized components from chip makers like Intel, Texas Instruments and Motorola. Ford has used a version of Intel's 16-bit 8096 microcontroller. Delco Electronics, a division of General Motors, has worked with Motorola to develop engine controllers based on the 6801 microprocessor and the 68HC11 microcontroller. New Delco designs use Motorola's 32-bit MC68332, microcontroller based on the 68020 chip.

In developing the engine-control programs, system designers aim for the highest engine performance possible while still getting good gas mileage and meeting emission-control requirements.

Engine-control programs use different control strategies for engine startup, warm-up, cruising, acceleration, deceleration and idle. Some systems use adaptive memory, which automatically adjusts to the characteristics of a specific car (not just the model of car) and adjusts operating parameters as the car ages or when components are replaced.

Exact hardware configurations vary with the manufacturer, model and year. Typically, though, the engine-control program is mask-programmed into the microcomputer chip's ROM. Sometimes, calibration values specific to a particular model are stored in a separate PROM.

As with other embedded computers, the program is originally written in assembly language or a higher-level language like C and then assembled or compiled into object code that's programmed into ROM. Since the contents of ROMs and PROMs are unalterable once programmed, to change the contents, you must replace the chips. Although there are alternative "performance" PROMs on the market for some models, I know of no source for specific information about the program code or PROM data. Since altering the program could cause engine damage or increased exhaust emissions, I doubt that details about PROM contents is made available to the general public.

The good news is that accessing the embedded diagnostic procedures is feasible. The EEC-IV is Ford's fourth-generation car computer that, among other functions, performs self-diagnostics and outputs two-digit service codes that reveal the results. Other auto makers use similar systems.

Ford's service codes are output as a series of pulses on the car's self-test connector. Figure 1 shows Service Code 15 (ROM or RAM test fail). You can read the codes on a test instrument designed for this purpose, or you can simply connect an analog voltmeter to the self-test connector and read the pulses as sweeps of the meter's needle.

If you want to input the service codes into a personal computer, you need to shift the signal levels to voltages that are compatible with the computer's inputs and provide software that detects the signals and translates them into a human-readable form.

Although the service codes are serial data, you can't use a standard communications program to read the codes at a serial port, since the data doesn't use conventional serial-communications protocols.

One approach would be to limit the potentials to 0 and 5 volts and connect the resulting signal to one bit on a parallel port. You could then write a pro-

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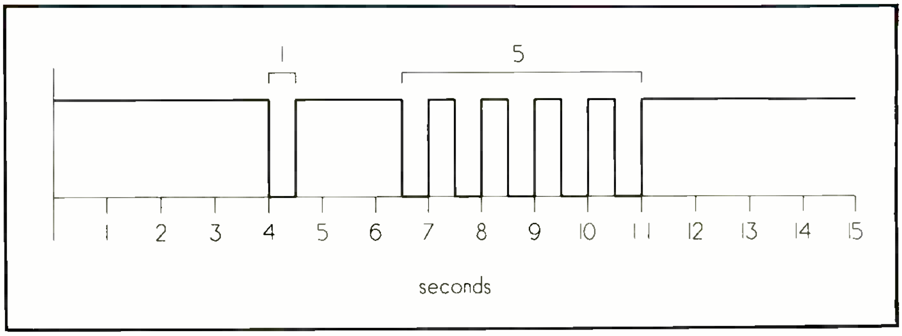


Fig. 1. An example of a service-code output on a self-test connector for Ford Motor Company's EEC-IV car computer. The code (15) means ROM or RAM test fail.

gram that reads data from the port and processes it as you wish. For more on parallel-port interfacing, see "Build a Parallel Port I/O Interface" in the April 1991 *ComputerCraft*.

The best source for information specific to your car is its manufacturer's service manuals. Ask a local dealer how to obtain them. Other sources of information include:

Computerized Engine Controls, Second Edition, by Dick H. King (Delmar Publishers, 1989). Includes specific information about car computers for General Motors, Ford, Chrysler and Robert Bosch Motronics (used in many imports).

Advanced Electronic Diagnosis of Automobiles by Don Knowles (Prentice-Hall, 1988). This book also has specifics on the "big three" domestic auto makers.

Understanding Automotive Electronics by William B. Ribbens (Howard W. Sams, 1988). Includes basics and theory of auto and computer operation.

Automotive Engineering magazine, Society of Automotive Engineers, Inc., 400 Commonwealth Dr., Warrendale, PA 15096. Technology news.

Motor magazine, Hearst Corp., 645 Stewart Ave., Garden City, NY 11530. For automotive technicians. Includes monthly "Eye on Electronics."

See if your local public or technical-college library has copies of the above or similar titles. If you want to buy any of these, many bookstores will special-order books on request at no additional charge.

Programming Basics

This is another hot topic among readers who responded to my series of articles.

Q. *Could you direct me to a source of basic information on programming single-board computers? I'm looking for something that someone who has very little programming experience would be able to understand.*

L.W., Centerbrook, CT.

A. My current favorite programming manual for beginners is Motorola's *M68HC05 Applications Guide* (No. M68HC05AG/AD). This Guide assumes that you have no applications experience with microcomputers. It demonstrates how to develop an application using the M68HC05 microcontroller and a home thermostat project as an example.

The Guide includes basic information about computer architecture, timing, programming and operation; a detailed description of the M68HC05; hardware and software development methods (including a step-by-step example of how to develop and write a program in assembly language); code examples; and an assembly-language reference. Although the Guide is written for the M68HC05, it provides a good introduction to small-system design using any microcomputer IC.

C Programming

Q. *I am seeking information about microcontroller boards that can be programmed in the C computer language. I am currently studying Microsoft's Quick C.*

W.W., Indianapolis, IN.

A. To program a microcontroller board in C, you need a C compiler that generates executable code for the specific microcontroller IC being used, whether an HC11, 8051 or whatever. With a cross-compiler, you can use a personal computer to write and compile C code that will execute on a microcontroller or other single-board computer.

Many cross-compilers are expensive. There are a few lower-cost options you can examine. For example, you can download a Small-C compiler for the 68HC11 microcontroller from the Motorola freeware BBS. Cottage Resources offers the Control-C 8031 C Compiler ($200) for its own and other 8031 boards, and Z-World Engineering offers Dynamic C/S ($195) for its own and other Z180 boards. With any of these compilers, you write and compile your C programs on a personal computer and then program an EPROM or other memory IC with the object code generated by the compiler. You then install the EPROM in a board that contains a compatible microcontroller.

Although it would be possible to use Quick C to program a single-board computer, you'd need a board that has an 8088 or compatible microprocessor, a Locate utility to translate Quick C's compiled code into a format suitable for EPROM programming and DOS in ROM or a DOS emulator to perform the input/output functions that Quick C expects to have available in DOS.

For experimenting with simple programs, a C compiler designed for use with single-board computers is a lower-cost and simpler solution.

Serial LCDs

Q. *I need a liquid-crystal display, but I would like to connect to it in a different way than the usual parallel interface. Would it be possible to drive an LCD module with an RS-232 signal?*

D.F., Gold Hill, OR.

A. The popular character-based LCD modules that I wrote about in the September 1991 issue have a four- or eight-bit data bus and three control signals. To control the display from a serial port, you need a circuit that translates the serial output into the parallel data and control signals that the LCD module expects to see. This is a perfect task for a microcontroller IC and would be an interesting project. But if you're in a hurry, serial LCD adapters are available from L-Band Systems and Densitron, among other sources.

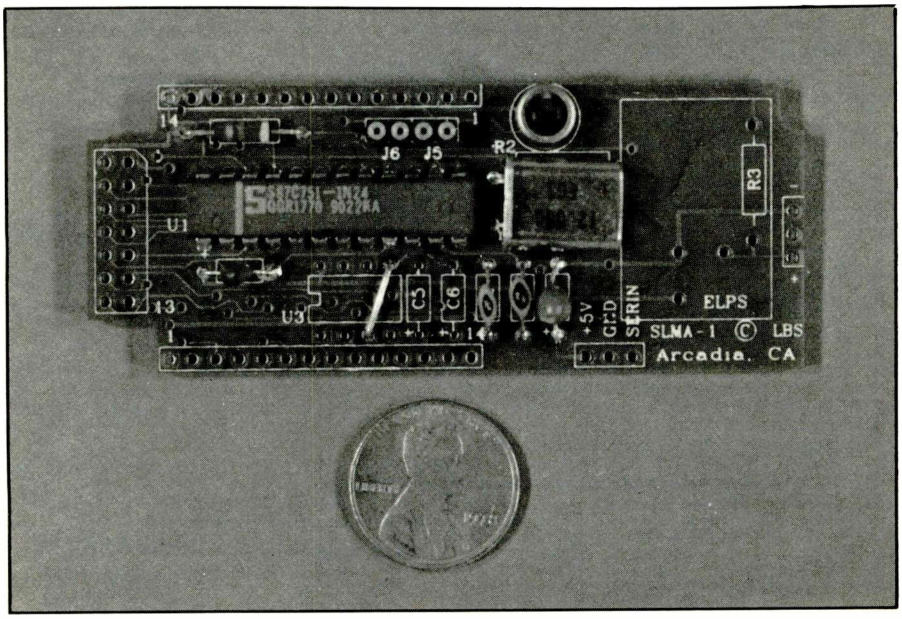


Fig. 2. L-Band Systems' SLMA-1 LCD module adapter permits you to control an LCD module from a serial port. An 87C751 microcontroller performs the required signal conversions.

L-Band's adapter, shown in Fig. 2, contains a Signetics 87C751 microcontroller. Its serial interface requires just three wires: + 5 volts, ground and one signal wire. It communicates at 1,200 baud and has both 14 × 1 and 7 × 2 connector patterns, as well as connections for a backlight and contrast potentiometer. This adapter is a write-only device, which means that you can't read data or busy status back from the display, but this isn't necessary to operate a display.

The signal input of the L-Band adapter accepts 5-volt, CMOS-compatible logic levels. If your serial output has typical RS-232 voltages of ± 12 volts, you'll have to shift them to 5- and 0-volt levels, using an RS-232 receiver or other level-shifting circuit. The adapter costs $39 in single quantity.

Densitron, a major supplier of LCD modules, also makes a serial adapter. This one has RS-232-compatible input voltages and communicates at 300 to 9,600 baud. The adapter and display can be located up to 65 feet from the controlling computer.

Finding Components

Q. *I am interested in National Semiconductor's LM628 motion control processor. However, as a hobbyist, I haven't been able to find a source for this IC in small quantities.*

V.R., Plant City, FL.

A. Finding vendors who are willing to sell in small quantities is always a challenge for the hobbyist, prototyper or anyone who isn't buying in volume. Generally, parts sources fall into two general categories: traditional distributors, who are accustomed to dealing with purchase orders and large quantities, and others, who welcome small-volume orders or at least tolerate them in hopes of making larger future sales.

Make a habit of searching out vendors who are friendly to small-volume customers. Save their catalogs and refer to them when you're looking for a source for a particular component. For example, a quick search through my collection revealed that Digi-Key carries the LM628 and has no minimum order (but a service charge of $5 for orders totaling less than $25).

Other good sources for microcomputer ICs and other components in small quantities are Unicorn Electronics, JDR Microdevices, Newark Electronics, Arrow Electronics' Catalog Division (a source for Maxim ICs and many others) and EasyTech, a new supplier dedicated to serving small-volume buyers. All have free catalogs and accept checks and charge cards. Minimum orders range from $10 to $25.

Don't forget to read the ads in *ComputerCraft* to find other parts sources. If you know of a good source that I haven't mentioned, let me know and I'll mention it here.

Finding Data

Q. *I would like to have information about the COP420 microcontroller made by National Semiconductor. I am planning to build a keyboard/display interface using this IC.*

C.O., Los Angeles, CA.

A. How to track down information about a specific IC is another question that comes up frequently. All IC manufacturers publish data books, and sometimes extensive applications notes, for the ICs they sell. Some charge for their data books, while others send them out free on request. Most will send a data sheet for a single IC at no charge.

If you don't know a manufacturer's address or phone number, these are easily obtained. Most public libraries have a set of books called *Standard and Poor's Register of Corporations*, which contains an alphabetical listing of U.S. corporations (and U.S. divisions of foreign corporations), including address, phone number and major products or business. You can also access the *Register* on Compuserve.

Another source for data is mail-order parts vendors, who often stock data books for the components they sell. For a nominal charge, many vendors will send you a photocopy of a single data sheet. If you're not sure about a vendor's policy on this, call and ask.

At times, you may know only the part number of an IC but not the manufacturer. This is a job for the *IC Master*, a set of books published by Hearst Business Communications. This several-thousand-page set indexes all ICs by part number; so you can quickly find out who makes a particular IC and whether there are multiple sources for it. *IC Master* also contains a directory of IC manufacturers and distributors, a master selection guide that lists ICs by function, a list of applications notes and a selection of data sheets contributed by manufacturers. The books are updated yearly.

IC Master has a steep price—more than $100—but there are some ways around it. Last year's version is perfectly serviceable for most purposes and is often offered by mail-order sources at a discount. If your workplace is involved with electronics, see if you can convince your employer to buy the set, or find someone who orders it yearly and ask for the outdated copies. If you live near an engineering or technical school, check its library for copies.

To answer your specific question, data on the COP420 is included in National Semiconductor's *Microcontroller Data Book*, which is available directly from National and secondarily from Digi-Key.

Lightweight Controllers

Q. *One of my hobbies is flying model airplane gliders. For a long time, I've had a vision of putting a microcontroller aboard the model glider. The purpose would ultimately be to make the glider react "intelligently" to wind gusts. I wonder if you could advise me on the existence of microcontrollers that are small and light enough to be carried on-board a model glider, which itself weighs only 1 pound.*

F.H., Yorktown Heights, NY.

A. Technology is on your side. Advances in miniaturization and low-power technology are creating circuits that are smaller and lighter than ever before. As an example of what can be done, the Micro-440 from Blue Earth Research is a full-featured microcontroller board that weighs just 70 grams (2.5 ounces) and measures 2.25″ × 1.9″. Figure 3 shows that it's built almost entirely with surface-mount components, which are much smaller and lighter than their traditional through-hole equivalents.

Although the board is tiny, it contains a lot of hardware, including an 83C51 microcontroller, 32 kilobytes of battery-backed RAM, a real-time clock, two serial ports, 14 digital I/O lines, eight analog inputs and a +5-volt regulator. The microcontroller's ROM contains Intel's BASIC-52 interpreter and Franklin Software's Monitor-51; so you can easily develop programs in BASIC or assembly language. Power can be any 6- to 16-volt dc source, including a 9-volt transistor battery, which will add another couple of ounces to the total weight. You might investigate using solar cells as a lightweight replacement for a battery. Price is $199 in single quantity.

If you want to design and make your own board, many microcomputer chips are available in surface-mount packages. Other surface-mount components, including ICs, resistors and capacitors, are also becoming easier to find. Even Radio Shack now carries surface-mount resistors. Digi-Key and Communications Specialists, Inc. are other good sources for surface-mount components in small quantities.

Memory Mapping

Q. *My 8052 microcontroller circuit has 64K of memory divided into eight 8K blocks, using a 74LS138 3-to-8-line decoder. Is there a way to more minutely break up chip-select lines so that more peripherals can be added?*

C.E., Saugus, CA.

A. Decoders like the 74LS138 are a popular way of dividing memory into blocks, each with its own chip-select line, so that multiple memory ICs and other components can be accessed, with each at a unique range of addresses. The 8052 has 16 address lines that permit it to address 64K bytes of memory (65,536 bytes, or 2^{16}). A single 74LS138 divides the memory area into eight 8K blocks. Figure 4 shows how a second decoder can be added to divide one of the 8K blocks into eight 1K blocks, giving eight additional chip-select lines.

The Truth Table shows how the decoders' inputs control their outputs. On the first decoder, Select Inputs A, B and C connect to the three highest address lines: A13, A14 and A15. For each combination of inputs, a unique decoder output goes low, with the remaining outputs high. Each combination represents an 8K (2000h) block of memory; so, for example, any memory access from 0 to 1FFFh will cause Y0 to go low.

The "Y" outputs can be used as CHIP-SELECT or ENABLE inputs on memory ICs and peripherals. This allows you to connect a variety of components—RAM, EPROM, A/D converters, LCD modules and so on—to memory, with unique addresses for each device.

One of the outputs on the first decoder in Fig. 4 acts as the ENABLE for a second decoder, with its SELECT inputs connecting to A10, A11 and A12. This creates eight more chip selects, with each accessing a 1K (400h) block of memory. The example uses the Y1 output (2000h) as the second decoder's ENABLE, but any of the outputs could be used. For example, substituting Y5 for Y1 would create chip selects at A000h, A400h, A800h and so on.

Using decoders isn't the only way to permit more peripherals to be accessed. The 8255 programmable peripheral controller IC gives three additional eight-bit ports, accessed with a single chip-select (using two lower address lines to distinguish among them). Another option on the 8052 is to use its capability to access two separate

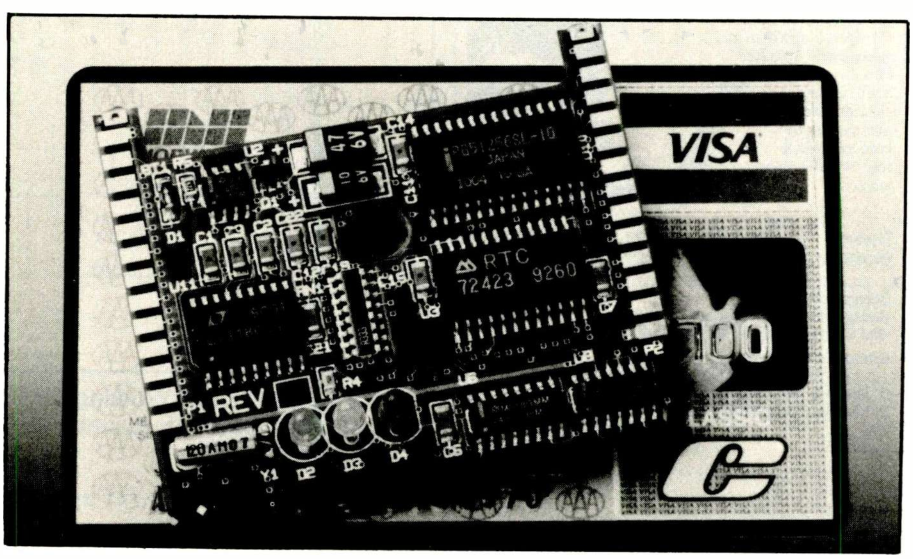


Fig. 3. Blue Earth Research's Micro-440 microcontroller board uses surface-mounted components and weighs just 2.5 ounces.

64K memory areas, with each accessed by a unique control signal (PSEN or RD).

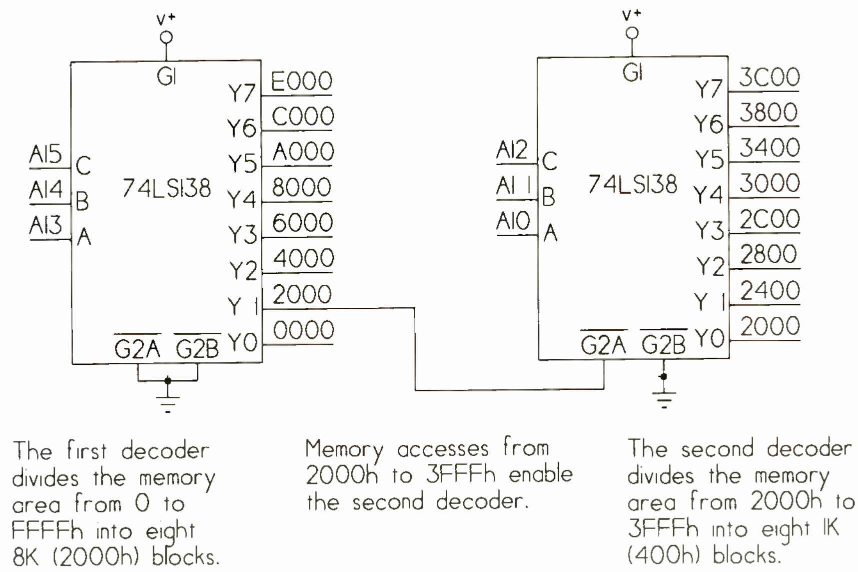
Muscle Wires

My final paragraphs don't answer a specific question, but instead describe a new way of generating and controlling motion in robots or other mechanical devices. It's done with shape memory wires, or "muscle wires," which have the unusual property of contracting in length when electrically powered.

The wires are made of an alloy of nickel and titanium. When a wire is below its transition temperature (70° C is typical), it can easily be stretched several percent in length. When the wire is heated, which is easily done by passing a current through it, the wire contracts to its previous length with a force of more than 40 tons per square inch. This is a lot of power, even when you consider that a typical wire has a diameter of just 0.001" to 0.01". With levers and other mechanisms, you can use a wire's contracting force to achieve different types of motion.

Shape memory wires have some limitations: they're inefficient, since only 5% or less of the energy applied is converted into motion, and they must be protected from extremes in stress, strain and heating. But their advantages include a high strength-to-weight ratio, large initial force, small size, direct linear motion and low operating voltages.

Mondotronics, Inc. sells shape-memory wires in small and large quan-



74LS138 TRUTH TABLE

C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
0	0	0	0	1	1	1	1	1	1	1
0	0	1	1	0	1	1	1	1	1	1
0	1	0	1	1	0	1	1	1	1	1
0	1	1	1	1	1	0	1	1	1	1
1	0	0	1	1	1	1	0	1	1	1
1	0	1	1	1	1	1	1	0	1	1
1	1	0	1	1	1	1	1	1	0	1
1	1	1	1	1	1	1	1	1	1	0

Fig. 4. Decoders like the 74LS138 can divide an area of memory into blocks, with a unique ENABLE or CHIP-SELECT signal for each block.

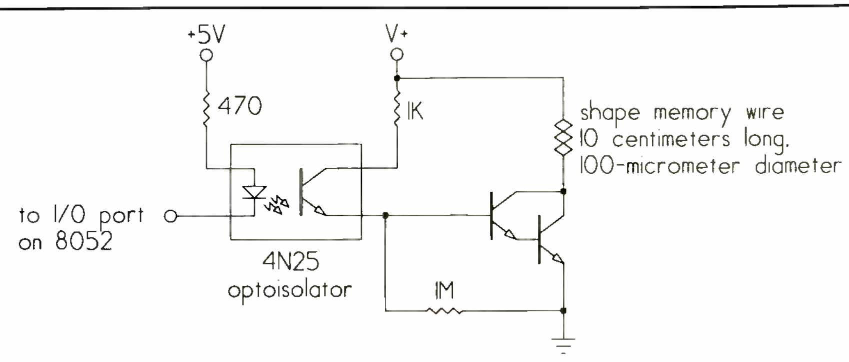


Fig. 5. This circuit from Working with Shape Memory Wires shows a memory-wire interface to an 8052 microcontroller.

Sources

Arrow Electronics, Inc.
Catalog Div.
1860 Smithtown Ave.
Ronkonkoma, NY 11779
1-800-932-7769
ICs and other components

Blue Earth Research
310 Belle Ave.
Mankato, MN 56001
507-387-4001
FAX: 507-387-4008
Micro-440 lightweight programmable controller

Communications Specialists, Inc.
426 W. Taft Ave.
Orange, CA 92665-4296
1-800-854-0547
FAX: 714-974-3420
Surface-mount resistors and capacitors

Cottage Resources Corp.
Suite 3-672
1405 Stevenson Dr.
Springfield, IL 62703
217-529-7679
8031 C compiler

Digi-Key Corp.
701 Brooks Ave. S.
P.O. Box 677
Thief River Falls, MN 56701-0677
1-800-344-4539
ICs and other components

Densitron Corp.
3425 W. Lomita Blvd.
Torrance, CA 90505
213-530-3530
FAX: 213-325-8958
Serial LCD module adapter

EasyTech, Inc.
2917 Bayview Dr.
Fremont, CA 94538
1-800-582-4044
FAX:1-800-582-1255
BICs and other components

Hearst Business Communications
645 Stewart Ave.
Garden City, NY 11530
516-227-1300
FAX: 516-227-1901
Publisher of *IC Master*

JDR Microdevices
2233 Samaritan Dr.
San Jose, CA 95124
1-800-538-5000
FAX: 1-800-538-5005
ICs and other components

L-Band Systems
724 E. Winnie Way
Arcadia, CA 91006
818-574-7394
Serial LCD module adapter

Mondotronics, Inc.
2476 Verna Ct.
San Leandro, CA 94577
1-800-374-5764
FAX: 510-351-6955
Shape-memory wires

Motorola Freeware BBS
512-891-3733
300/1,200/2,400 baud
8 bits/no parity/1 stop bit
Freeware HC11 C compiler

Motorola Literature Distribution
P.O. Box 20912
Phoenix, AZ 85036
M68HC05 Applications Guide
No. M68HC05AG/AD)

Newark Electronics
4801 N. Ravenswood Ave.
Chicago, IL 60640-4496
312-784-5100
ICs and other components

Unicorn Electronics
10010 Canoga Ave. Unit B-8
Chatsworth, CA 91311
1-800-824-3432
FAX: 818-998-7975
ICs and other components

Z-World Engineering Inc.
1724 Picasso Ave.
Davis, CA 95616
916-753-3722
FAX: 916-753-5141
Dynamic C compiler

tities and also has a comprehensive, practical and clearly written user's manual. The manual describes the properties of shape-memory wires, shows how to use them and describes 14 projects, including several driver circuits, examples of mechanisms for converting the forces into useful work and an 8052 microcontroller circuit. Figure 5 shows an example from the manual, a memory-wire interface for an 8052 I/O port. A sample kit and manual sell for $29.90 plus shipping.

Moving On

Thanks to all of you who have written. I always like hearing about the projects readers are involved with, and I learned a lot in ferreting out answers to your wide-ranging queries.

Send your comments, suggestions and questions on topics relating to designing, building and programming microcontrollers and other small, dedicated computers to Jan Axelson, ComputerCraft, *76 North Broadway, Hicksville, NY 11801.* ■

Jan Axelson

PC-IQ: Plain English DOS with Power, Too

Ever since DOS, the disk operating system for IBM and compatible computers arrived on the personal computing scene more than 10 years ago, companies have been creating products to make it easier to use. Now a new product from A.I. Solutions, called *PC-IQ*, uses a natural language interface in an attempt to make DOS easier than ever to use.

PC-IQ comes with both 3½" and 5¼" floppy disks, 112-page manual, quick-start booklet, quick-start card and "Computers Made Simple" booklet. The program is designed for IBM PC/XT/AT, PS/2 and compatible computers, and requires 640K of RAM, DOS 2.0 or later and a hard-disk drive. *PC-IQ* has a suggested retail price of $99.95.

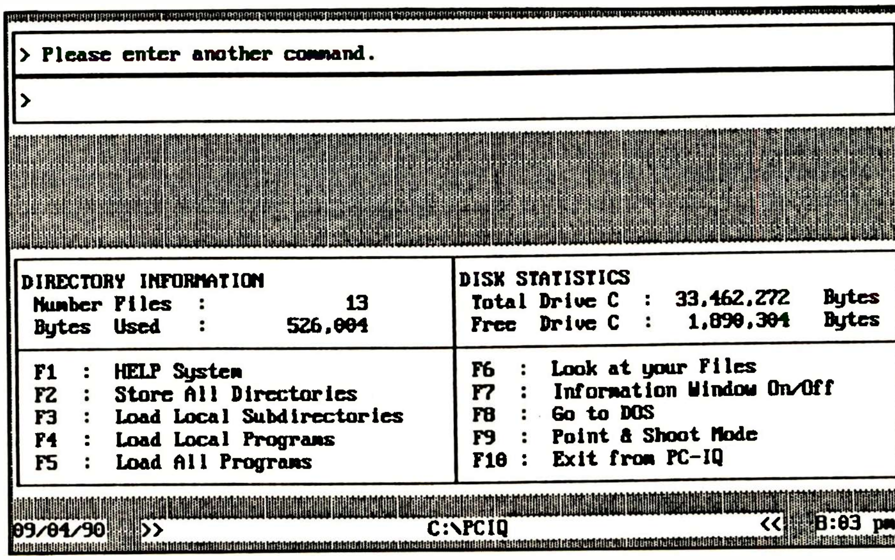


Fig. 1. PC-IQ's opening screen displays a series of dialog (top), information (center) and status (bottom) windows.

About the Program

PC-IQ takes the sting out of learning and using DOS by letting you issue DOS commands in a more natural way. For example, if you want to format a disk, you don't have to learn the DOS command FORMAT A:. Instead, you might type: Please prepare my A disk. If you want to copy files, you might type something like: Copy today's files from the letters directory to the B drive. A.I. Solutions refers to this method of interacting with your computer as a natural-language interface.

Whenever you make a request, *PC-IQ* fulfills it—if it can. If there's any misunderstanding, *PC-IQ* provides assistance. You never receive an error message like the stark "Bad command or file name" that DOS provides. Instead, *PC-IQ* might ask you to edit your request or provide you with a list of options from which to choose.

PC-IQ not only provides you with the ability to enter DOS commands in plain English, but it also provides some powerful utilities. You can unerase previously erased files, find a single or related group of files on a hard disk, perform DOS operations on multiple unrelated files, repeat previously entered commands and copy a long list of files to multiple floppy disks. Many of these features are currently available either in DOS 5 or through DOS utilities, but it's a welcome feature in *PC-IQ* when combined with the natural-language interface.

PC-IQ employs a "learn" mode to help you learn DOS the standard way, too. In other words, *PC-IQ* translates any requests you make into standard DOS form and displays them on-screen. You can leave this feature on or turn it off. *PC-IQ* also works in a Point-and-Shoot mode, where you pick commands from a menu and select directories and files from a list displayed on-screen.

PC-IQ is written in Prolog and comes standard with an extensive, though limited, vocabulary. If you want, you can add to its vocabulary at any time. For example, you may want to use a word like "obliterate" instead of "erase.' If you hate to type, you may want to replace "FORMAT" with "FO."

An editor is part of the *PC-IQ* package. With this, you can create and edit any ASCII file. This feature is more useful to those who use older versions of DOS, where EDLIN is the only editor available.

To help you learn how to use *PC-IQ*, A.I. Solutions provides a disk-based tutorial called the *PC-IQ Quick Tour*. If you need an entertainment break, A.I. Solutions provides an entertainment mode. Trivia games, famous phrases and interesting facts are available when you press the Alt-T key combination.

PC-IQ does have some limitations. The program doesn't support all the DOS commands. Such commands as BACKUP and RESTORE aren't supported. Also, you can't always use strict DOS syntax. *PC-IQ* has the ability to recognize backslashes, but not in all cases. *PC-IQ* isn't a LAN product. (A.I. Solutions anticipates releasing a *PC-IQ* LAN version in the near future.) You can run *PC-IQ* on a PC connected to a LAN, but you can't access information on the server. Finally, *PC-IQ* isn't able to perform more than one task at a time, which means you can't tell it to do a couple of things at once. According to A.I. Solutions, future versions will address this shortcoming.

Installation & Use

Installing *PC-IQ* is simply a matter of running an install program and following directions that appear on-screen. Oddly enough, the *PC-IQ* Quick Start Booklet gives no installation instructions. The instructions are in the main *PC-IQ* manual. When I installed the program, it used 1,600,160 bytes of hard-disk space.

PC-IQ is a memory-resident program. When you use *PC-IQ* to run an application program, it uninstalls itself automatically so that it takes up only 5K of conventional memory. When you quit an application, *PC-IQ* installs itself again.

When you start *PC-IQ*, a screen like the one shown in Fig. 1 appears. The top part of the screen is called the dialogue window and this is where you enter commands. Farther down is the information window, which contains directory information, disk statistics and function-key commands. At the bottom of the screen is the status window, which provides the date, current directory and time.

I began using *PC-IQ* without reading the manual. My first command, Start WordPerfect, worked flawlessly. My second command, Start 1-2-3 didn't. It caused two items to appear on-screen: a message "I should run" and a box filled with program names. One choice was "Lotus 123." I found out later that *PC-IQ* doesn't like the hyphenated form "1-2-3." An interesting point about *PC-IQ* is its disdain for misspelled words. If you type Start Wordperfct, *PC-IQ* doesn't make an educated guess about what you want to do. Instead it displays on-screen a box of alternative program names.

When I asked *PC-IQ* to start *OrCAD*, the pop-up box didn't, not surprisingly, contain the program. I was forced to read the manual to find out how to add program names to the *PC-IQ* vocabulary. Another problem I encountered was that *PC-IQ* selected one of *OrCAD*'s program files as Microsoft *Excel*, a program I didn't have on my hard disk.

When I tried to copy a 363K file to a 360K disk. *PC-IQ* suggested that I use the DOS BACKUP command instead and went so far as to provide the correct DOS syntax. *PC-IQ* provides the correct syntax because it can't perform the DOS BACKUP command. If you try to use this command, *PC-IQ* displays: "I do not know how to do this command yet. You may get help from my help system."

I began to have some success with *PC-IQ* when I tried to copy a directory of files to a floppy drive. I typed: Copy all files to the B drive. *PC-IQ* did this, and when the floppy disk was full, *PC-IQ* requested another disk—a helpful feature. In contrast, DOS normally gives an error message, indicating that the disk is full and then aborts the COPY command.

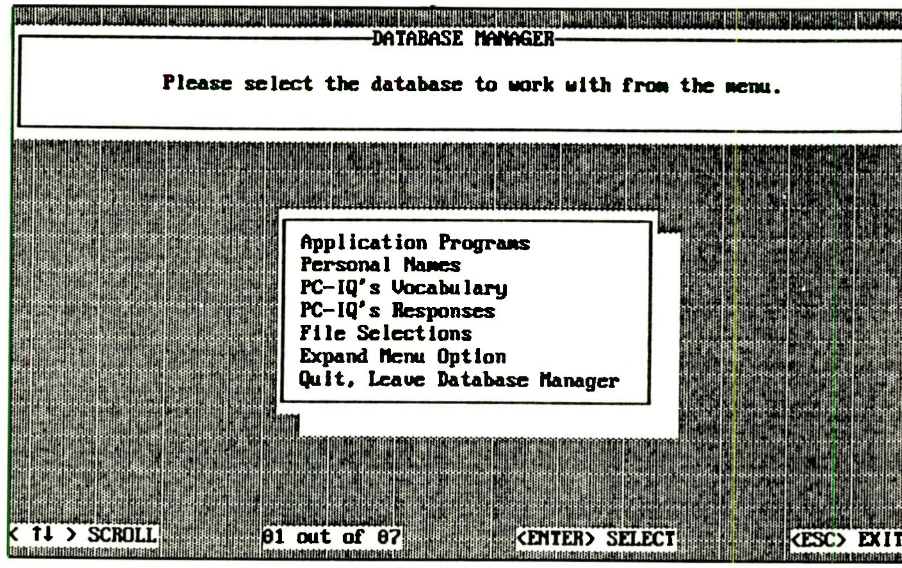


Fig. 2. PC-IQ's database management screen.

PC-IQ can assist you with using DOS in many ways. For example, it can help you format diskettes correctly. With plain old DOS, if you place a double-density disk in a high-density drive, you must add switches to the FORMAT command. For instance, to format a 720K disk, you must enter a command similar to: FORMAT A:/N:9/T:80.

With *PC-IQ*, you simply type FORMAT THE A DISK or any similar English-language command. *PC-IQ* then prompts you for the disk capacity by displaying on-screen the message: "Use size 720K or

1.44M?" The prompt even supplies a hint about the capacity of the disk by displaying "one hole in right corner" for a 720K disk. If you have a 5¼" drive, *PC-IQ* offers five options: 360K, 1.2M, 160K, 180K and 320K, explaining that all but the first are for older versions of DOS.

One thing to keep in mind, if you already know some DOS commands, is that *PC-IQ* accepts most standard DOS commands, as well as those entered in English.

You can't customize *PC-IQ* from the main screen. To do this you must issue the command: Run dbmanage. This starts the Database Manager program shown in Fig. 2. With the Database Manager, you can add information to any of the *PC-IQ* databases. I had to read the manual to learn this. I also had to read the manual to find out how to bring up the built-in editor, which comes up automatically when a command like Create or Open is entered.

Like many other DOS utilities, *PC-IQ* is great for house-cleaning (a term that refers to the process of every so often erasing from hard or floppy disks files that aren't needed). Rather than typing a command for every file you want to erase, *PC-IQ* lets you tag (point to) the files you want to get rid of and then erase them all at once.

The documentation supplied with *PC-IQ* is well-written and illustrated. I found that we had to read all of the documentation before I could get the program to do everything I wanted it to do. The quick-start card is also recommended reading so that you know the best ways to enter commands in the dialog window.

Conclusions

PC-IQ is a natural-language interface for DOS. As such, it gives you the ability to issue basic operating-system commands in plain English on an IBM or compatible computer. Plain-English commands can be used only for DOS, however. As soon as you enter an application program, such as *WordPerfect*, you must enter commands in a different way. This is a drawback for *PC-IQ*, a drawback that other kinds of user interfaces, particularly GUIs (graphical user interfaces), are trying to address. It seems that the logical next step for A.I. Solutions is to provide a natural-language interface for popular applications like *WordPerfect* and Lotus *1-2-3*.

To use *PC-IQ* successfully, I had to read all the documentation, something I don't like to do and something other users may not want to do, given the thrust of the program (using plain-English commands). To lessen the need for documentation, A.I. Solutions should consider adding a "Modify Program" choice to the opening menu, as well as a choice for entering the Editor.

Overall, though, A.I. Solutions has made a noble attempt to shield users from learning DOS commands and syntax. The program's ability to understand English equivalents of DOS commands and its built-in DOS utilities make it a worthwhile product right out of the box. And *PC-IQ* becomes even more valuable if you spend the time to modify it to suit your (or another user's) DOS habits. If you or someone you know is having problems with DOS, *PC-IQ* can be an effective and affordable solution to those problems. ■

Fact Box

PC-IQ 1.0, $99.95
A.I. Solutions
58 Creekview Dr.
P.O. Box 128
West Seneca, NY 14224
800-677-6670
Requirements: IBM PC/XT/AT, PS/2 or compatible computer, 640K RAM and hard drive.

Ratings

Documentation	Excellent
Graphics	Text based
Learning Curve	Easier to learn than DOS, but manual is needed
Complexity	Provides standard and extended DOS commands

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Fall COMDEX Show Views

Two monthly columnists offer their views on the largest computer trade show in the U.S.

View 1: What's Hot & What's Not

As do many of those working in the computer trade press, I attend both the Fall and Spring COMDEX trade shows every year. In the past, I've generally written at least one column a year on what I found interesting at the show. While this past COMDEX/Fall in Las Vegas was the biggest computer show in the US, with more than 1,900 exhibitors and a claimed attendance of about 130,000 people, I found the trends developing in the industry to be more interesting than specific products. Here's my analysis of how I think they'll impact on the way you'll be using computers over the next few years. I have to be honest, though, and warn you up front that I disagree with a lot of industry "pundits" about what's "hot" in the computer industry.

Exhibitor displays showed just the latest in boards, drives and software. Lots of new notebook PCs were being displayed, quite a few desktop units as well. Many were interesting, but certainly not earthshaking. What did garner a lot of attention were five specific areas: pen-based PCs, multimedia, networking, *Windows*-based software and Apple's newest Macs.

Pen-Based Computers

More than a dozen vendors were demonstrating pen-based computers, and several others were showing prototype systems behind closed doors. Though only a few of these systems are actually shipping at the time this is being written (early November), many in the computer press are predicting this will be the next great wave in computing. Frankly, I can't see what all the fuss is about. I'm sure that pen-based systems will sell very well because they're perfect for applications that require forms to be filled out. But these systems appear to be best used in highly vertical applications, not general-purpose computing.

Handwriting may be the most natural way to interface with a computer, but few of us have all that much difficulty using a keyboard and mouse that we'd spend the

extra money for a pen PC. Additionally, the pen-based systems coming to market must be extensively trained to recognize an individual's handwriting. The ones I saw weren't that accurate, even after training. Over the next couple of years, pen-based systems may become as common as computerized cash registers, but I think it will be quite a while before they find their way into general-purpose use.

Multimedia

Multimedia was another hot area at the Fall show. A special area was set aside for vendors of multimedia products at one of the hotels. Multimedia takes the already available digital sound and video a step further. The multimedia standard established by Microsoft includes stereo sound, MIDI, video standards and a CD-ROM interface. Products designed for multimedia require these resources (or at least most of them) on the system with which they're being used, accessing these resources through recently-released *Windows* multimedia extensions.

I have to admit that for something still in its infancy, the multimedia products I saw displayed were impressive. Not only were there encyclopedias with moving video clips and sound attached to the entries, but there were also some dynamite database systems that contained digitized photos and voice annotations. Most of the multimedia software available or announced deals with information resources or presentation graphics. All major presentation packages like Microsoft's *Powerpoint*, IBM's *Storyboard Live!* and others support the multimedia standard, letting you build into your presentations music and scanned and captured images.

The technology is impressive and very effective. But before you run out to turn your system into a multimedia PC, there are a few things to think about. The most important first—Multimedia isn't cheap! It requires high-speed VGA video and a stereo sound board like Creative Labs' SoundBlaster Pro or Ad Lib's Gold board. To get the most from multimedia, you should also have a CD-ROM drive (both boards mentioned above, as well as several other available ones, provide a built-in interface for CD-ROMs) and perhaps a video frame grabber.

The MPC standard specifies a fast 286 as the base multimedia system, but all demonstrations I saw were done on a fast 386 or 486 PC. I'm very skeptical about how well many of these applications would have run on a 12-MHz 286.

Building a good presentation is far from easy, even with the excellent existing tools. Making a presentation a multimedia one entails a great deal more work. If you're considering multimedia for your own demonstrations or presentations, be prepared to spend many hours in constructing even a simple minutes-long presentation.

Yet, there's little doubt that multimedia will be successful. All component pieces are in place, and the centerpiece of multimedia, CD-ROM, has finally taken off. Plenty of CD-ROM drives are available for as little as $450, and prices will drop even more this year. I have several drive/ROM packages that I've been using for several months now. They're all excellent bargains. To get a good idea of the wealth of CD-ROMs available, give the Bureau of Electronic Publishing (Parsippany, NJ) a call at 800-828-4766. This outfit stocks most currently available CD-ROMs and drives. Its 177-page catalog isn't only a testament to the health of the CD-ROM industry, but it makes fascinating reading.

Multimedia requires multimedia extensions to Microsoft's *Windows* operating environment, and *Windows* was a big part of the show. Software developers like *Windows*; it frees them to write applications to a set of interfaces called APIs (Application Program Interfaces), rather than having to include drivers for every conceivable type of video adapter and printer. Drivers for these devices are included as part of *Windows* and are updated easily when higher-resolution video and more advanced printers become available.

Not only was there an ever-increasing number of *Windows*-based applications on display this year, Microsoft was also showing off the next generation of *Windows* technology, *Windows NT*. The first software-developer kits are going out now. However, *NT* technology is still a year or so from being released. So it's a bit early to start describing features Microsoft has implemented. Lots can change in a year.

Of more immediate interest is the forthcoming upgrade to the current Microsoft *Windows* product—*Windows* 3.1. I had expected to be able to update you on this product this month, but Microsoft pushed back the release date and I can't be sure that I won't be violating non-disclosure. So tune in next month if you're a current *Windows* user (or have been thinking about getting *Windows*).

Operating Systems

One thing that's starting to become obvious is the operating system and processor wars shaping up. IBM is positioning the new version of OS/2 as the operating system of choice, while Microsoft pushes MS-DOS/*Windows NT*. Neither has been delivered yet, but the lines are already being drawn. Just to muddy the waters further, Novel's acquisition of Digital Research, the developers of DR DOS, makes this already excellent substitute for MS-DOS an even stronger contender. And if all of this wasn't confusing enough, there's the new Apple/IBM partnership to promote IBM's RISC-based PowerChip CPU technology and develop a new object-oriented operating system to run on it.

Windows

In the real world in which you and I live (and use PCs), I don't see that all this gee-whiz operating-system technology will have that much immediate impact. Most of us will still use MS-DOS (though upgrading to DOS 5.0 is a good idea if you haven't already done so) and *Windows* is popular. *Windows* by itself isn't the panacea that Microsoft would have everyone believe, though the 3.1 version does address some of the performance complaints of the earlier version and improves 3.0's so-so Program Manager.

What makes *Windows* (and the upcoming *Windows NT*) so attractive are the multitude of applications that require it—not only the new multimedia and graphics applications, but even such tasks as word processing. I stuck with my old standard *WordStar* 4.0 for years, not even bothering to upgrade (the current version is 6.0). In the last year, though, after hundreds of articles, columns, reviews and even a book, I switched to *Word For Windows* and never looked back.

In recent months, I've been looking at other *Windows*-based word processors, such as *WordStar For Windows*, *Ami Pro* 2.0 and *WordPerfect For Windows*. All are terrific packages.

Word processing is an intensely visual task, and the mouse-driven, pull-down menu WSIWIG (What You See is What You Get) approach makes better sense than playing with awkward control- and function-key combinations and guessing what the document will look like when printed. OS/2.0 is a complete and complex operating system, and the IBM/Apple "Pink" operating system promises to be very powerful when delivered in several years. But it's aimed at the corporate user, not particularly you and me.

CPUs

Of more immediate import are the CPU wars that are shaping up. I've commented on several aspects of this in past columns, such as Advanced Micro Device's (AMD's) faster clone of the Intel 386. Now Cyrix and Chips & Technologies are shipping 386 CPUs, and each is touting improved performance over Intel. Intel has moved on to the 486 area, plugging its 486SX CPU (a standard 486DX CPU with the built-in numeric coprocessor disabled). New versions of this CPU were being shown at the show: a slower 16-MHz version and a faster 25-MHz version.

The 486SX never made all that much sense to me to start with. Bringing out a slower version of this CPU makes even less sense. What did impress me were Intel's new dual-speed 486 CPUs that run at a fast internal speed and a slower external speed. The one I saw demonstrated ran at an internal speed of 50 MHz and an external speed of 25 MHz. This technique lets you use the CPU with a slower motherboard design but obtain greatly increased performance on computationally-intensive applications.

Hardware

In the hardware area, by the way, the 286 is just about dead. Not only are 386SX systems available for very little additional money, but these 386 systems now come with motherboard RAM caching to boost performance. With 386SX system prices so low, it no longer makes sense to buy into 286 technology. This is especially so if you intend to run *Windows*, which really needs about 3M of RAM and a 16- to 20-MHz 386SX CPU to run any faster than molasses on a cold day. And *Windows NT*, when available, won't run at all on a 286 CPU; it's strictly a 32-bit operating environment.

What's hot this year, and for good reason, is upgradable system designs. The ones I've seen that make the best sense are active backplane designs that have most of the support circuitry, video, I/O and disk controllers on the motherboard and use a plug-in board that contains the CPU, system RAM cache and memory. To upgrade, you just unplug one CPU/memory card and replace it with a new one.

Active-backplane designs place user RAM and cache memory on the CPU card because moving from a slower CPU to a faster one necessitates having faster main RAM. Other modular designs based around replacing just the CPU require that the motherboard be initially populated with very fast main RAM, just in case you eventually upgrade to a fast processor (or have a design that slows down a fast CPU when performing RAM accesses, somewhat negating the advantage of upgrading to a faster processor).

Networks

Networking was also a big deal at this year's Fall COMDEX, with the Mirage hotel set aside for vendors of network hardware and software. The big news was Novel Lite, a peer-to-peer network from the biggest name in networks. Peer-to-peer networking doesn't require use of a dedicated file server and is well-suited for smaller networks.

ArtiSoft's LANtastic is the best known peer-to-peer network, and Novel Lite is meant to compete head on. I haven't had a chance to play with Lite yet, but since it isn't upward-compatible with Novel's other NOS (Network Operating System), I can't see the advantage it offers over the more mature and stable LANtastic.

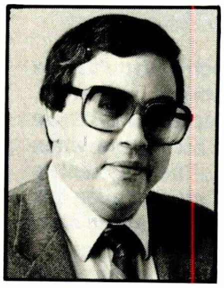
Apple

The last big deal at Fall COMDEX concerned Apple Computer, which introduced three new families of systems. These consisted of a completely new line of notebooks that are much more reasonably priced than the unsuccessful Mac Portable; two tower systems named the Quadra 700 and Quadra 900 (the Quadra 900 uses Motorola's 68040 CPU, the same one used in the latest NeXT machine); and a brand-new version of the Mac Classic called the Classic II.

The Classic II looks identical to the original Mac and updated Classic released last year, but it uses the very powerful 68030 CPU. The Classic II will supersede the popular SE/30. With these newest models and aggressive pricing, Apple has a real shot at making some impact in the business market.

Of course, there are lots of things that are—and will continue to be—hot, even if they didn't make a big splash at COMDEX. These include modem/fax boards, now available for less than $200, laser printers (you can expect to see a less-than-$500 street price laser this year) and mass storage. IOmega has an external Bernoulli Box that offers 90M of storage on 5″ removable cartridges for less than $1,500, and there is a whole bunch of inexpensive 128M re-writable optical drives coming to market. Even IBM is upping the ante with a doubling of 3½″ floppy drive capacities to 2.8M. And a new high-resolution video standard of 1,024 × 768 is becoming popular, as are inexpensive 9,600 baud modems.

There are always going to be gee-whiz demonstrations of state-of-the-art technology, such as advanced operating systems and active-matrix color displays on notebooks. What's really exciting to me, though, is how quickly the state of the art becomes commonplace. It looks to be another interesting year ahead.



—*Ted Needleman*

View 2: A Feast of Technology

Comdex, the computer industry's fall extravaganza took over Las Vegas and filled its exhibit halls with a feast of technology for dealers, manufacturers, computer users and the press. There was nothing radical or unexpected shown this year, despite claims of exhibitors that their products were the latest and greatest. This was a time for showing products that had been predicted and discussed for a long time before the show opened.

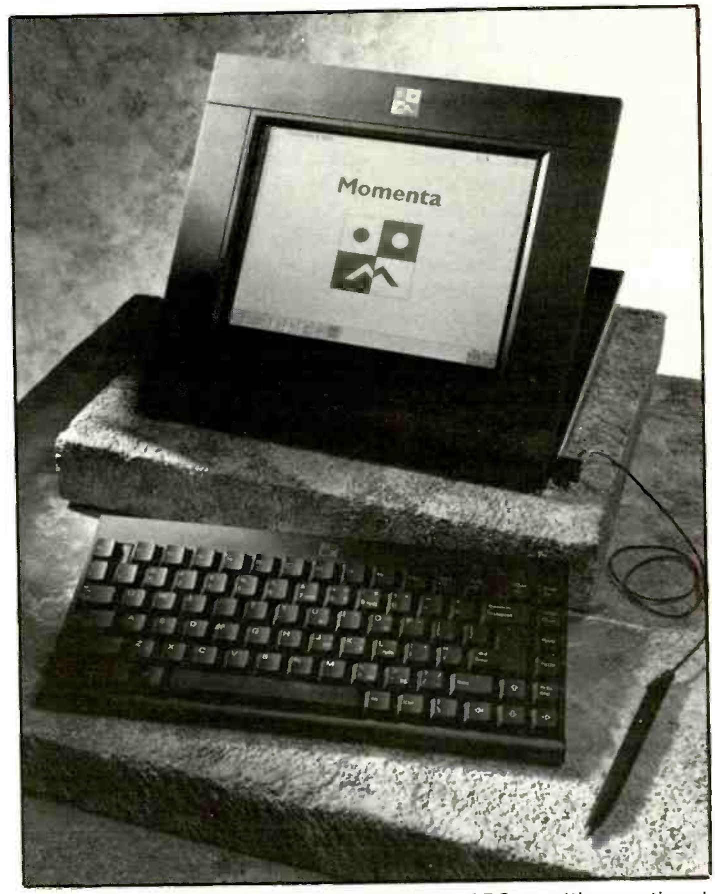
Fall Comdex 1991 was divided into three parts: the Main Conference, the Multimedia Conference and the Network Computing Conference. This division provided a concentration of products and seminars that enabled attendees to learn more about each subject.

Pen Computers

One of the subjects shown in the main conference was new developments in pen computing. Both Microsoft and GO Corp. showed beta versions of their pen-based systems. Microsoft had a separate booth to display the products of licensees of the Microsoft *Windows For Pen System*. The other pen-based operating system is *Pen Point* from Go Corp. However, many machines introduced at Comdex will run either system at this time, but once the market decides upon the winner, it's assumed that machines will be designed to use the dominant system.

At Comdex were machines from Grid Systems Corp., Dauphin Technology, Microslate, NCR and Samsung. I used several of these pre-production units and feel that they have a long way to go before they're salable products. It takes a lot of learning to be able to use the "pen" as an input device, and proposed applications could have been better executed by standard notebook computers.

Most applications were "blue-collar" systems—check-off lists for meter readers, inspectors and inventory takers. I doubt if companies will be willing to spend thousands of dollars to buy pen computers when identical jobs can be done much cheaper and easier on laptop or notebook computers.



The Momenta can function as a pen-based PC or, with an optional keyboard, as a standard notebook computer.

Also shown was the Momenta Computer, a new start-up. This hybrid machine comes with a keyboard, as well as an electronic pen, and can run *Windows* as well as the proprietary pen-based system. Designed to sell at $4,995, it's intended for use by executive staff, rather than blue-collar workers. This new machine goes against the established pen-based computing development companies, but its features may create a niche for it.

Hardware & Chips

Literally thousands of MS-DOS machines were exhibited at the show, ranging from floor-standing tower computers to pizza-box and brick-sized models and some others that were completely contained in the keyboard case like the old TRS-80. There were hundreds of lightweight notebook computers, including some with full-color video display screens.

The 386DX microprocessor seemed to be on the endangered list with 386SX and 80486X CPUs replacing them in the near future. The 386SX has become the standard low-end computer, selling for as low as $950 for a complete system. Talking with a major importer of computers, I was told that one of his retailers had sold 1,500 computers over one weekend. These were 386SX computer systems with high-capacity hard drive and both 5¼" and 3½" high-capacity floppy drives, 2M of RAM, color VGA and MS-DOS and an integrated software package, for a complete system price of $995. *Wow!*

This Comdex was a showcase for developments in the field of microprocessor and LSI products. AMD's 40- and 50-MHz 386 CPU chips were optional on many exhibitor's computers. The label "Intel Inside" was also displayed on the same manufacturers' 33-MHz machines, but they continue to offer AMD's chips running at 40 MHz. The 486 CPU is offered, but emphasis is on still on high-speed 386 processors.

Chips & Technologies introduced its PC/CHIP™ single-chip PC designed for Palm Tops and even smaller computing systems. Mounted in a single 160-pin integrated circuit, the PC/CHIP 8680 single chip PC implements a 3-MIPS 8086-compatible microprocessor running up to 14 MHz, IBM XT equivalent logic, CGA-compatible flat-panel/CRT controller, serial port and built-in power management. With the PC/CHIP device, manufacturers are now able to build ultra-low-cost entry-level PCs, diskless workstations, palm-top computers and embedded-controller systems.

Chips & Technologies also showed its Super 386 DX and SX chips and coprocessor chips for 386 and 486 enhancement. Its super math and VGA co-processors will be made available to the general public through distribution agreements signed with major distributors. For those engaged in building embedded computer systems, the C&T Chips offer a fast, low-cost method for making an MS-DOS computer.

Telecommunications

In the communications field, Comdex devoted an entire exhibit to networks, including LANs, wireless LAN interconnection and modems. Seen everywhere were fast 9,600-bps modems. The Twincom 96/42 Datamodem selling for $299 (I discussed it last month) received the *Computer Shopper* Best Buy Award.

Motorola's Altair Wireless LAN transmitters and receivers were of great interest to show attendees, and HP showed one of its HP 95 Palm Tops connected to a Motorola r-f modem unit for connection through the cellular-phone network. SkyTell, the pager giant, displayed its nationwide paging system that connects to a laptop computer. This is all part of the developing revolution in data communications, which will extend to use of wireless data movement. However, data will never completely abandon the fiber-optic network because of the need for a wide graphics bandwidth.

If you've ever gone to a art exhibit in one of our great museums or attended a theatre that had earphones for the hard of hearing, you might have had contact with high-resolution infra-red (IR) communications. Infralink of Germany exhibited its IR LAN transceivers for infra-office data communications. In this system, there's an IR transceiver connected to each computer or peripheral. The IR beam is reflected from the ceiling so that the entire network operates without wire connection. While this system is very practical and has enough bandwidth for any data transmission, it will have a hard time competing with r-f wireless, carrier-current and telephone systems in this country.

Apple

Apple Computer, long absent from Comdex, returned with a complete range of new machines, extending its line from the Macintosh Classic to the mighty Tower Quadra 900. The most appealing Macintosh computers are the new Power Book laptops. Apple has finally come out with a laptop Macintosh with all the features anyone would want in a laptop. Housed in an ergonomically designed package, it will fit in half of your attache case and weighs in

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at 5.1 to 6.8 pounds. The keyboard of each Power Book is set toward the rear of the cabinet panel, giving the user enough room to comfortably rest his wrist while using the built-in trackball.

Apple has featured System-7 capabilities, including network and file-sharing capabilities in each Power Book machine. There's also Appletalk Remote Access software to provide interconnection between the Power Book, another Mactintosh and an Appletalk network via modem. This provides the user of the system with remote access to the office network from any telephone.

The PowerBook Model 100 uses a 16-MHz CPU and 2M to 8M of RAM and has a battery time from 2.5 to 4 hours. The low end Model 100 has a 20M hard disk but no built-in floppy. An external floppy is available as an option to load software into the hard drive, but it's expected that the hard drive will be loaded via connection to a desktop Mac. The screen is a backlit, super-twist display that's clear and sharp from any angle. The story I got was that PowerBook Model 100 will be built for Apple by Sony and have limited availability at approximately $2,299 ($2,499 with external floppy drive). Rumor has it that street price might be as low as $1,900.

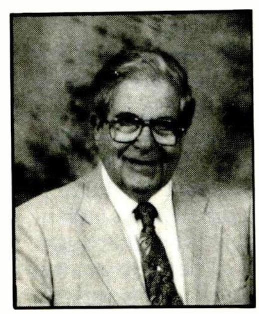
The PowerBook Model 140 is based on the 16-MHz, 68030 CPU and offers performance equal to the Mac IIcx. It comes with a floppy and either a 20M or 40M hard drive. An internal 1.4M SuperDrive can read, write and format Macintosh, MS-DOS, OS/2 and ProDOS disks. It includes a user's choice of either 2M or 4M of RAM. The Model 140 shares the same full-page, backlit supertwist liquid-crystal display. Pricing starts at $2,899, and it should be available by now.

The PowerBook Model 170 is the powerhouse of the line. It uses a 25-MHz 68030 CPU and a 68882 math coprocessor, equaling the power of the Macintosh IIci. Model 170 includes a built-in 2,400-baud modem with fax send at 9,600 baud. It comes standard with the SuperDrive floppy, 40M hard drive and 4M of RAM. The Model 170 uses a back-lit active-matrix liquid-crystal display that has excellent display capabilities under all lighting conditions. It weighs in at 6.8 pounds and is listed at $4,599.

Both Models 140 and 170 support external monochrome and color displays and have a microphone and sound input capability. They're powered by an Ni-Cd battery that provides 2 to 3 hours of usage. Using these laptops was a convincing experience for me. Although I've used many MS-DOS laptop computers I'd love to own, I have to rate these Apple machines near the top of the list.

Apple also introduced two top-of-the-line machines. The desktop Quadra 700 and the "tower" design Quadra 900 use the high-speed Motorola 68040 and represent the most-powerful Macintosh computers available. These computers will enable Apple to retain its lead in desktop publishing and graphics. Over at the Adobe booth, I saw a demo of *Pagemaker* 4.2 for Macintosh that makes full use of System 7. The DTP demo was running on the Macintosh Quadra Model 900. It was truly astounding to watch the generation of full-page art and text in so little time. It will be a long time before *Pagemaker For Windows* comes anywhere near these capabilities.

Apple also introduced Classic II, an improved model of the popular, low-cost Macintosh Classic. Also shown were improved models of Apple's laser printers and scanner. ■



—Stan Veit

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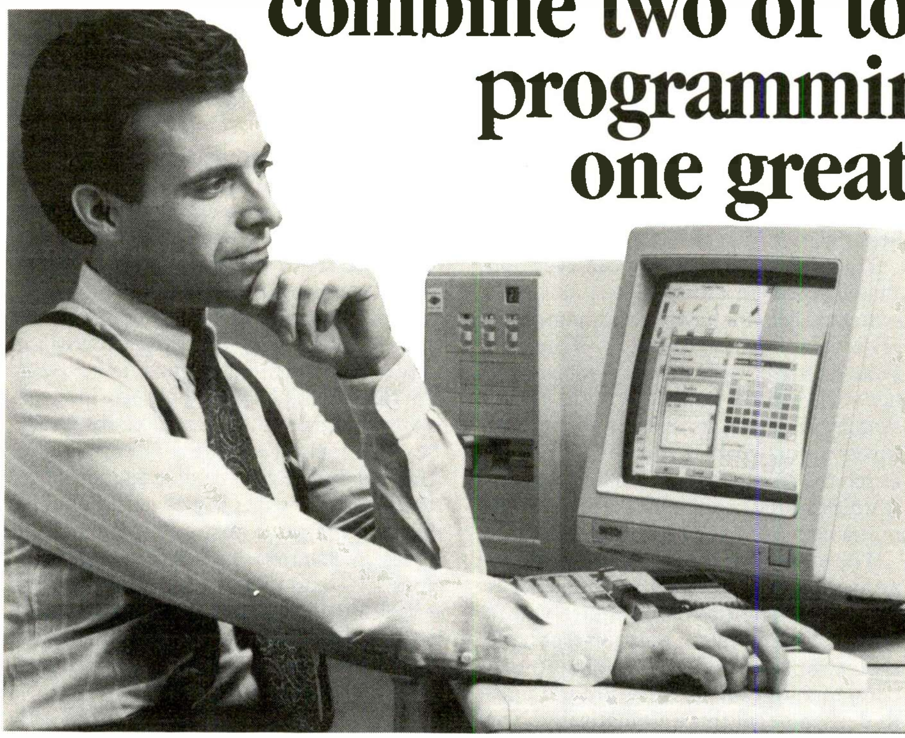

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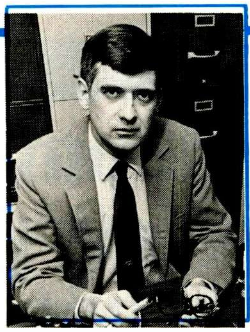


Forrest M. Mims III

A Sensor Roundup

The number and variety of electronic sensors being used in modern electronics applications seems to be growing faster than ever before. There's even a trade magazine devoted to the subject. Yet judging by some recent conversations, letters and even magazine articles, some experimenters, engineers and electronics writers aren't always aware of what sensor to select for a specific application.

As an example of the above, I recently heard from an experimenter who has designed a very sophisticated system for making automated measurements of very low light levels. Unfortunately, both of the two kinds of light detectors he's tried are completely unsuited for his application.

Whether your interest is basic electronics, circuit design or computers, you should be aware of the kinds of sensors that are available and the problems they can solve. Why? Since sensors can be used in countless ways to accomplish the aims of countless applications, they're showing up everywhere.

Magnetic Switch

Consider the lowly magnetic switch. When mounted on the frame of a store's front door, above a magnet attached to the door and connected to a battery and a bell, it functions as a burglar alarm. The same switch-and-magnet combination can be used with a digital counter to record the number of customers who enter the store. For more sophistication, the counter can be replaced by a computer that stores the time each customer enters the store and, at the close of the day's business, generates a graph that shows the manager peak business times.

Figure 1 shows how you can even add "intelligence" to a string of basic magnetic switches. All you have to do is connect a resistor across each switch. When all switches are closed, the resistance of the network will be close to 0 ohm. If one switch is opened, its resistor will appear across the network. If you've carefully selected the resistances, you'll know exactly which switch or combination of switches in the network have been opened.

The output for the Fig. 2 circuit can be an analog ohmmeter, digital multimeter or computer. The first two require you to make a table of values that correspond to each switch and switch combination. A computer, of course, can be programmed to determine all this automatically. You can connect the network to the computer's joystick port or to an analog-to-digital (A/D) converter.

Here's a simple BASIC loop that continually reads a joystick port and prints the result on the screen:

```
100 'STICKREAD
120 CLS
130 X=STICK(0)
140 LOCATE 15,15
150 PRINT "X=";X
160 GOTO 130
```

Caution: Before connecting any external circuit to the joystick port of your computer, you must know exactly how the port works. The best approach is to obtain a circuit diagram of the game port interface. An alternative is to disassemble a joystick deigned to work with your computer, carefully study its wiring and carefully measure any voltages at the game port. In a typical configuration, the game port provides +5 volts and ground. Potentiometers in the joystick connect across this voltage so that they can function as voltage dividers. The voltage at the wiper lug of each pot connects to the game port.

Figure 2 shows what's inside a "typical" joystick—and how it's interfaced with a "typical" game port. Remember the qualifier "typical," since some computer game ports don't use this kind of joystick and interface arrangement.

Now that you've seen how even the lowly magnetic switch can be made more intelligent, let's examine some sensor basics. We'll then look at two of the most important classes of sensors, those used to detect light and temperature.

Sensor Basics

Although there are hundreds of kinds of sensors, most can be classified as either

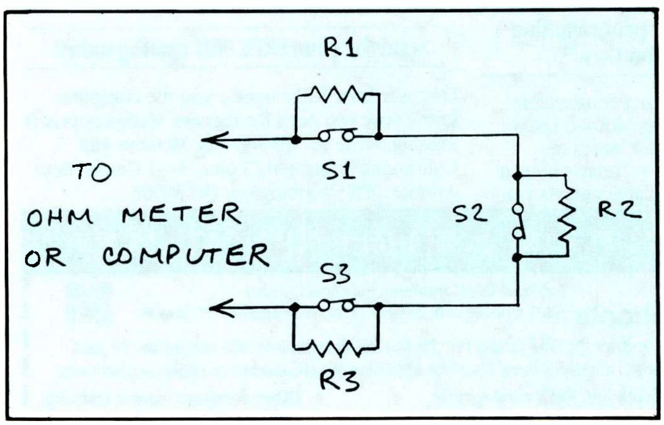


Fig. 1. How to use resistors to increase the intelligence of magnetic switches.

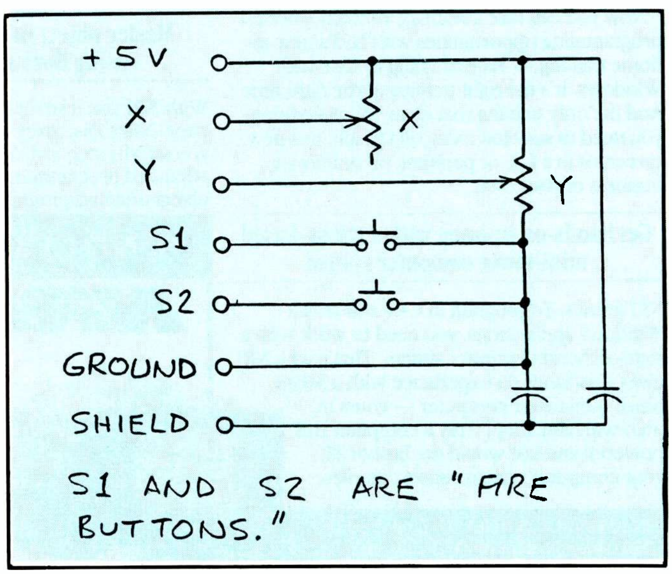


Fig. 2. Internal circuit and interfacing of a typical joystick.

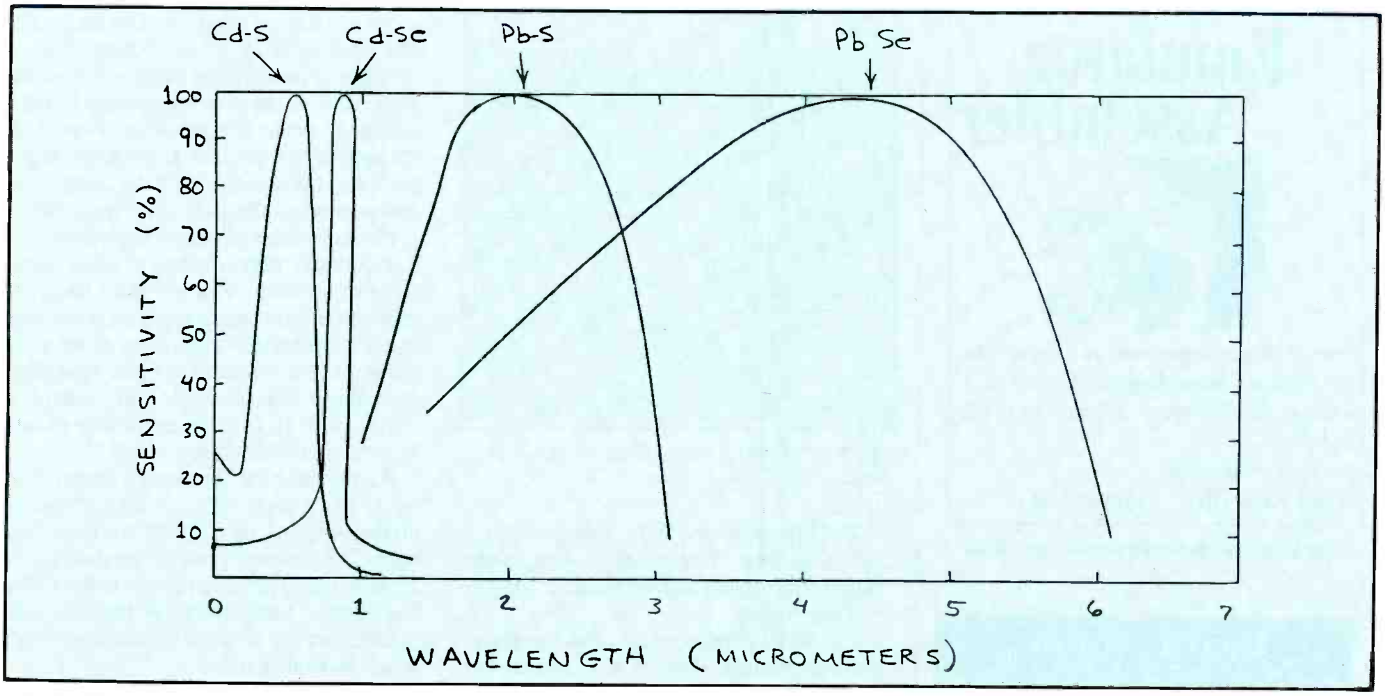


Fig. 3. This graph shows the spectral sensitivity of several photoresistors.

on/off or analog. There are also many kinds of hybrid sensors that include a simple circuit that transforms their analog response to an external stimulus into an on/off output.

On/off sensors include many kinds of mechanical switches that are actuated by pressure, temperature, position, flow and other stimuli. Common examples are magnetic switches, liquid-level indicators and thermostats.

Sensors with an analog output may generate a voltage or current that varies with changes in the magnitude of the stimulus being sensed. Or the resistance, capacitance or inductance of the sensor may change in response to changes in what's being sensed.

Many sensors with an on/off output are actually analog sensors packaged with a conditioning circuit that provides one of two voltage levels, often ground and +5 volts, when a threshold is crossed. The threshold point of some of these hybrid sensors can be externally adjusted, often by means of a trimmer resistor that's connected to the sensor by the user.

Sensor Types

Some sensors are so simple that you can make them yourself. A good example is an inductor made from a piece of soda straw and some insulated wrapping wire. A piece of ferrite or even a nail inserted inside the straw will change the inductance of the coil, hence the frequency of a miniature radio transmitter or audio oscillator to which the inductor is connected. Attach a weight and rubber band to the ferrite insert, and you have an accelerometer.

Then there are off-the-shelf electronic components that can double as sensors. The common potentiometer is a good example. Add a weight to the end of a rod attached to the shaft of a pot, and you end up with a pendulum that can function as a two-dimensional accelerometer. Extend the shaft of a two-pot joystick, add a weight to its end, and you'll have a three-dimensional accelerometer.

Most sensors are components that have been designed for a specific task. The most common are sensors that detect light, temperature, pressure, acceleration, strain, vibration and magnetic fields. There are also many kinds of more specialized sensors, including those that detect ionizing radiation, transparency of water, dust particles and pollen suspended in air and various trace gases in the atmosphere.

Light Sensors

Light sensors can be classified as photoemissive, photoresistive, photovoltaic or photoconductive. Some sensors fit only one of these categories while others fit two. Therefore, it's very important to understand the characteristics of each category.

Photoemissive light sensors include phototubes and photomultiplier tubes whose elements are housed inside an evacuated glass envelope. The simplest phototube has a curved metal cathode that's coated with a photoemissive material that emits electrons when struck by photons of incoming light. These electrons are collected by an anode. The resulting current flow is detected by monitoring the voltage across a very high resistance resistor.

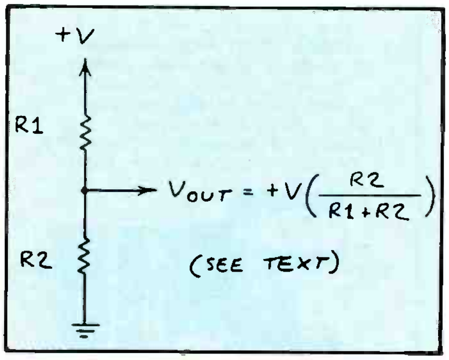


Fig. 4. How a voltage divider network transforms resistance to voltage.

Stiff competition from solid-state light detectors has diminished the role of phototubes. But they're still used in specialized applications, such as detecting ultraviolet (UV) radiation. The major drawback of phototubes is that they require an operating potential of 100 volts or more.

Photomultiplier tubes (PMTs) feature up to a dozen or more anodes, each at a greater potential than the last. When an electron stimulated by an incoming photon strikes the next anode, it causes several additional electrons to be released. They, in turn, cause even more electrons to be released by the next anode, and so forth. This internal multiplication of electrons is the built-in gain feature that gives PMTs their exceptionally high sensitivity.

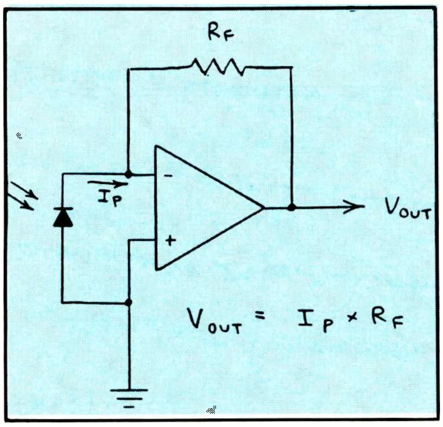


Fig. 5. Photovoltaic operation of a photodiode.

PMTs remain the most sensitive of all light detectors. Their major drawbacks are high cost, fragility and the need for a high-voltage supply.

Photoresistive detectors, also known as light-dependent resistors, are inexpensive and ideally suited for detecting the absence or presence of light. That's why they're the sensor of choice in dark-activated street lights and night lights.

Figure 3 shows the spectral response of several photoresistive materials. Photoresistors designed to detect visible light are made from cadmium-sulfide (CdS) and cadmium-selenide (CdSe). CdS photoresistors are more sensitive to green wavelengths, while CdSe photoresistors are more sensitive to red wavelengths. Lead-sulfide (PbS) and lead-selenide (PbSe) are sensitive to near-infrared wavelengths.

Figure 4 shows how the changing resistance of a photoresistor can be transformed into a voltage. This circuit is simply a voltage divider in which the photoresistor is one of the two resistors. The resistance of a photoresistor falls as the intensity of the light at its sensitive surface increases. Therefore, if the photoresistor is *R1*, the voltage from the circuit will increase when the light level increases. If the photoresistor is *R2*, the voltage from the circuit will decrease when the light level increases.

Photoresistors have several drawbacks. For example, they respond to a fast rising pulse of light more slowly than do other solid-state light sensors. Their resistance doesn't necessarily change in direct proportion to the intensity of light. And after exposure to a bright light, they exhibit a temporary change in response that's known as the "memory effect."

All pn-junction diodes are sensitive to light. The photodiode is a special type of diode designed specifically for detecting light. This is done by increasing the diode's surface area, reducing the thickness of the top layer of semiconductor material and placing the top electrode where it doesn't block incoming light.

Photodiodes are by far the most versatile of semiconductor light sensors. They respond very rapidly to an incoming pulse of light, have no memory effect and are very sensitive. Moreover, as shown in Fig. 5 and Fig. 6, they can be operated in either a photovoltaic or photoconductive mode. In both modes, the response of a photodiode to light is highly linear.

The best known photodiode is the ordinary silicon solar cell. Since the large junction area of a solar cell increases the cell's capacitance, thereby reducing the cell's response time, and since the large light-gathering surface of a solar cell isn't usually necessary, most photodiodes have a much smaller surface area.

In photovoltaic mode, the photodiode

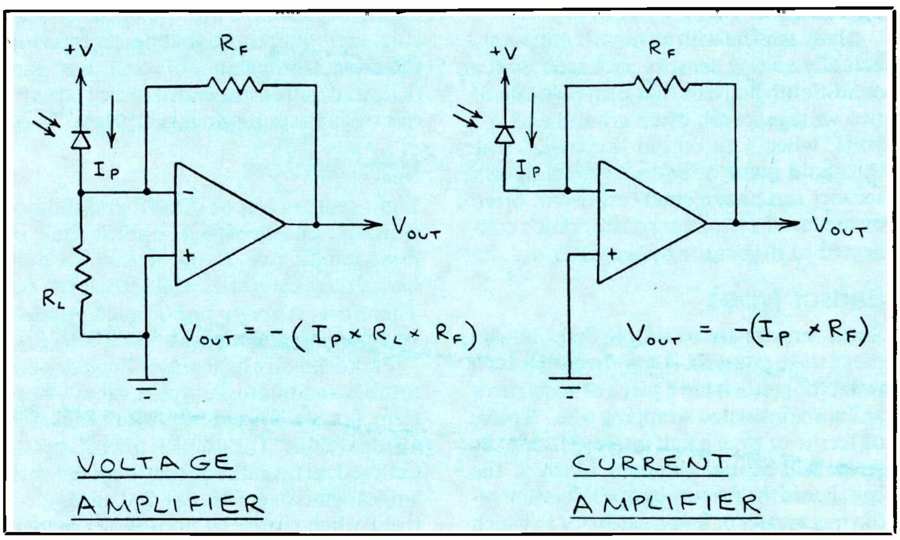


Fig. 6. Photoconductive operation of a photodiode.

acts like a miniature solar cell. Light striking it produces a voltage and photocurrent, either of which is then detected or amplified by an external circuit. The chief advantage of photovoltaic operation is low operating noise.

In photoconductive mode, the photodiode is reverse biased, as shown in Fig. 6. Light striking the diode causes it to conduct, thereby permitting a current to flow. If the photodiode is connected in series with a load resistor (R_L), the photocurrent is changed to a proportional photovoltage for amplification by an operational amplifier. Or, as also shown in Fig. 6, the photocurrent can be fed directly into an op amp connected in transimpedance mode.

Since a reverse-biased photodiode permits a tiny trickle of current to flow, even when it's dark (the so-called dark current), this mode is noisier than photovoltaic mode. But it provides a much faster response to a fluctuating signal.

As shown in Fig. 7, the spectral response of silicon photodiodes extends from the blue to the near-infrared at around 1,100 nanometers. Peak response is in the near-IR at around 850 to 900 nm. Extended-blue silicon photodiodes have appreciable sensitivity to UV radiation. But since they have much higher sensitivity to near-IR, expensive filters must be used to block the IR wavelengths. That's because ordinary UV filters also transmit a good deal of near-IR energy, enough to mask a weak UV signal.

Although silicon is by far the most common photodiode material in use, many other materials can also be used to make photodiodes. For example, the spectral response of gallium-phosphide (GaP) photodiodes extends from the UV to the red. Since GaP photodiodes don't respond to near-IR, they're ideally suited for use as UV detectors. Germanium (Ge) photodiodes give a spectral response that extends out to more than 1,500 nm.

Selenium was used to make the first semiconductor light sensors more than a century ago. It was once a popular photovoltaic detector because its response closely matches that of the human eye. It's been largely replaced by more stable silicon photodiodes fitted with an IR-blocking filter to provide a match to the response of the human eye.

Other semiconductors are used to make photodiodes that respond farther out in the IR range than is possible with germanium. Many of these sensors are designed for use as optical-fiber detectors—and most of them are expensive.

If you need the sensitivity of a PMT in a solid-state device, the avalanche photodiode is a good choice. This diode is designed to be operated at a carefully regulated reverse bias of a few hundred volts

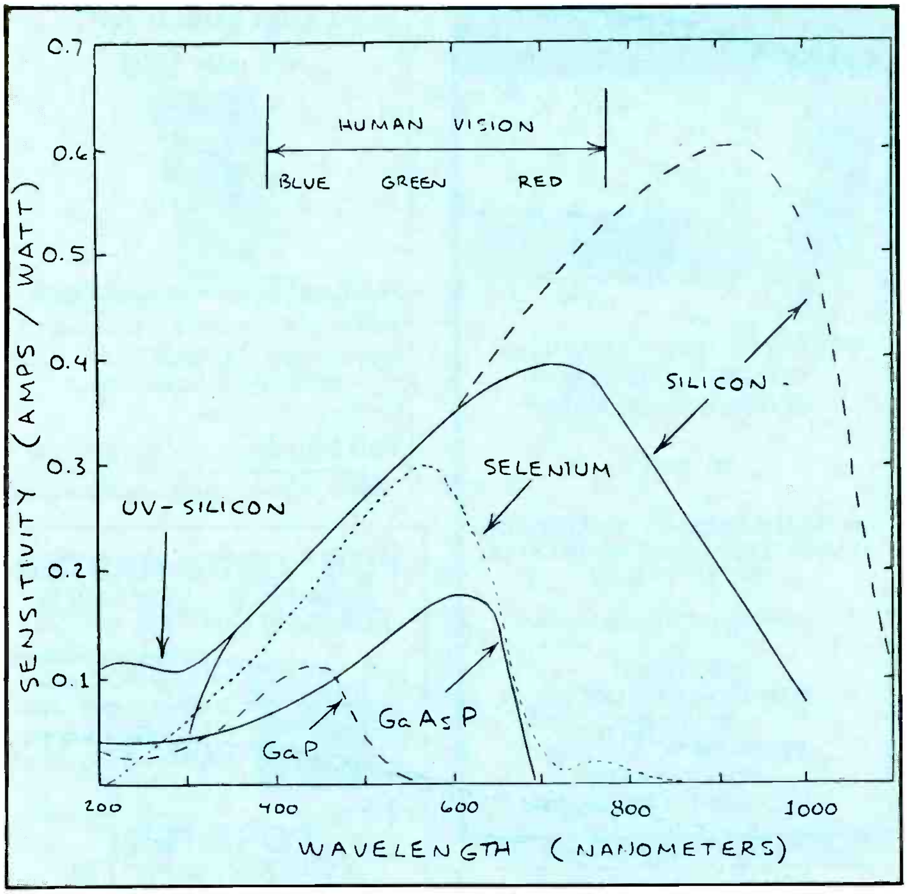


Fig. 7. This graph shows the spectral response of several photodiode materials.

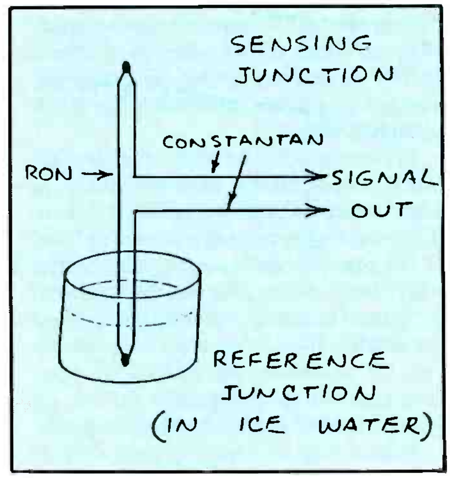


Fig. 8. A basic thermocouple circuit.

or so. Incoming light then triggers an avalanche of electrons. The result is a multiplication effect similar to than of the PMT.

Avalanche photodiodes are smaller and sturdier than PMTs. But they aren't quite as sensitive. And, like the PMT, they're expensive and require a high-voltage supply.

Phototransistors are transistors in which the incoming signal to be switched or amplified arrives in the form of photons instead of electrons. Since phototransistors have internal gain, they're exceptionally sensitive. Nearly all commercial phototransistors are made from silicon, and their spectral response is similar to than of silicon photodiodes. Their response time, however, isn't as fast.

Phototransistors can be tricky to use because their high internal gain makes their response linear over a much smaller range than photodiodes. While this is a disadvantage when they're used in analog applications, it's a plus when all that's needed is an on/off indication of light.

Another tricky feature of phototransistors is that a small bias is needed for them to begin conducting. This can be supplied by a base-bias resistor if the phototransistor has a base lead, which many phototransistors don't have. The only way for these phototransistors to begin conducting is to raise the light level to a point where conduction begins. This level might be considerably greater than the level that can be detected by a properly biased three-lead phototransistor.

Incidentally, phototransistors can also be biased by means of an external light signal. For example, a lightwave communicator with which I used to experiment used a phototransistor as a detector (a photodiode would have been a better choice). At maximum range, the signal from the transmitter could be boosted out of the noise level simply by allowing the edge of a flashlight beam to strike the phototransistor! While this worked great at night, sunlight swamped the phototransistor during daylight operation, reducing the range by a factor of 10.

Temperature Sensors

Shortly before I began work on this column, a record cold wave dipped into the central United States and shattered low-temperature records in many states. On the front porch of my office, a digital thermometer with a hi/lo memory feature confirmed that the temperature dipped below freezing nearly a month before the average first freeze.

These are the kinds of thoughts we usually have when temperature is mentioned. But temperature is much more important than knowing whether it's a hot or a cold day. That's because a knowledge of the temperature of an object, liquid or gas can provide vital information about density, volume, pressure, electrical resistance and capacitance.

Some temperature sensors measure temperature indirectly by observing the peak wavelength of the electromagnetic (em) radiation emitted by the object being monitored. This is how the temperature of the sun, distant stars, flames and even your own body can be measured from a distance. Indirect temperature sensors respond very rapidly but are expensive.

Direct temperature sensors, which are heated or cooled to the temperature of what's being monitored, are much more common. This, of course, is how a mercury thermometer works. The mercury in the thermometer's bulb contracts or expands when cooled or heated, thereby altering how far up thermometer's capillary the mercury extends.

Since direct temperature sensors must be heated or cooled to the temperature of what's being monitored, they're slower to respond than are direct-temperature sensors. This phenomenon is sometimes called thermal lag, and you need to be aware of it since it will affect virtually any temperature measurement you make.

Thermal lag provides a temporary memory affect that can be very useful at times —as when you're reading the temperature on a mercury thermometer after you've pulled it from under your tongue. But thermal lag can also cause problems—like missing the peaks and valleys of a fluctuating temperature.

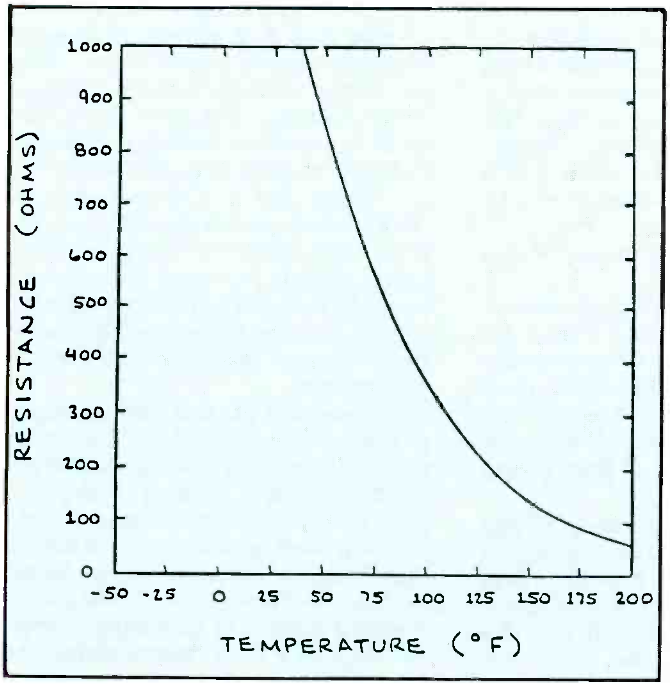


Fig. 9. Resistance is shown plotted as a function of temperature in this graph.

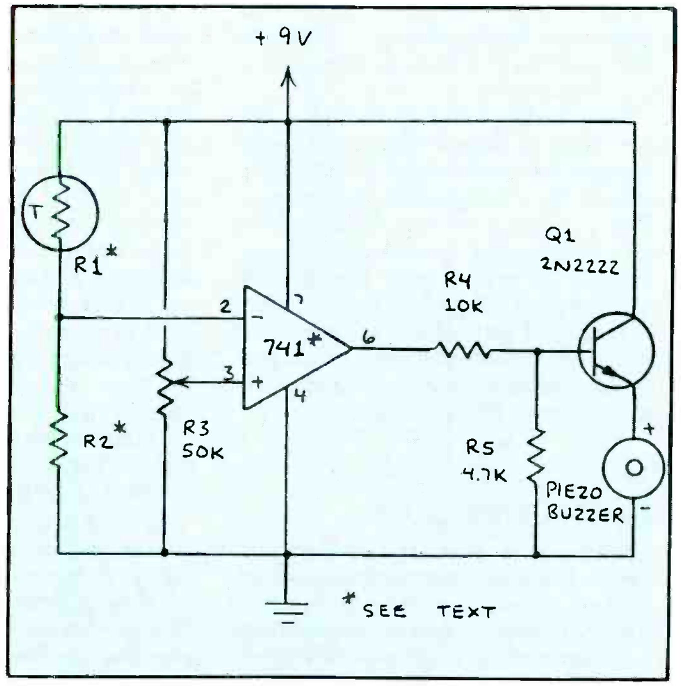


Fig. 10. Schematic diagram of a low-temperature alarm circuit.

The traditional bimetallic thermostat remains one of the most reliable and most commonly used on/off temperature sensors. If you're indoors reading this, there's probably one nearby.

The simplest way to measure temperature electrically is to monitor the resistance of a length of wire. Among the most common metals used for this purpose are nickel, iron, copper, platinum, silver and tungsten. The resistance of wires made from these and other metals is published in various technical reference books.

More flexibility is afforded by another old standby, the thermocouple. When two wires of dissimilar metals are joined, a potential difference proportional to the junction's temperature exists across the wires. A series array of these junctions, or couples, can be used to increase their sensitivity to small temperature changes.

Applications for thermocouples range from the simple to the sophisticated. If your house or water heater has a heating system fueled by natural gas or propane, a thermocouple installed over the pilot light will cool down in the event the flame is extinguished and send a signal to close the fuel valve.

A more-sophisticated application is the use of tiny arrays of thermocouples to detect the presence of carbon-dioxide or water vapor by systems known as gas analyzers. Since these gases absorb specific wavelengths of IR energy, their presence can be detected when a gas sample is placed between an IR source and thermocouple array. A narrow bandpass IR filter can be used to select a specific water vapor or carbon-dioxide absorption band.

Thermocouples are very rugged and are available in many metal combinations. You can even make your own by buying the appropriate wire and welding together the ends to form a junction. Among the most common pairs of metal are iron/constantan, copper/constantan and chromel/constantan.

Since thermocouples are self-generating devices, their output can be read out on a digital voltmeter that can display millivolts. What some users don't realize, however, is that two junctions are required to measure temperature and that care must be taken when connecting the leads from the thermocouple to an external circuit.

Figure 8 shows a basic thermocouple circuit. Junction A is the junction designed to sense the temperature of whatever is being measured. Junction B is immersed in ice water at a known temperature to supply a reference. Now, if the pair of constantan wires from the thermocouple is soldered to copper foil on a circuit board, two new thermocouple are created! If these new thermocouples are at different temperatures, a false signal appears superimposed on the signal from the thermocouple being used as the sensor.

Thermocouples are very rugged and can be operated at temperatures that melt the semiconductor temperature sensors known as thermistors. But for routine temperature measurements, the thermistor is a good choice since it's inexpensive and very easy to use.

Thermistors are temperature-sensitive resistors. If you increase the temperature of a thermistor, its resistance decreases. Therefore, a thermistor has a negative temperature coefficient. This operation is similar to that of a photoresistor, the resistance of which decreases as the intensity of the light increases.

Figure 9 shows temperature-*versus*-resistance for a typical thermistor. As you can see, a thermistor is very sensitive. The resistance of some thermistors can change by a factor of 10,000,000 over a specified temperature range.

Figure 9 also shows that thermistors have a nonlinear response to temperature. In an application where a thermistor is used over a very wide temperature change, its nonlinearity usually requires some form of compensation. This can be accomplished by using a nonlinear amplifier or with various program routines when a computer is in the loop. But over small temperature ranges, the resistance of a thermistor can often be considered approximately linear.

Various kinds of integrated-circuit temperature sensors have been introduced over the last decade or so. Since these chips depend on the stable and predictable response to temperature of silicon, they provide an output voltage that's directly proportional to temperature. You can make an accurate thermometer simply by connecting one of these chips to a battery and voltmeter. For more sophistication, you can connect the chip to an A/D converter and transform your personal computer into a thermometer.

Even though temperature-sensing ICs are small, in some applications, their physical size causes enough thermal lag to hamper rapid temperature fluctuations. That's why I selected a tiny bead thermistor a few years ago when I was measuring temperature with a simple circuit lifted above my house by a helium-filled trash bag. A bead thermistor can respond to temperature changes in milliseconds and detect changes that are too fast and subtle to be detected by a chip sensor.

Sensor Conditioners

Many kinds of circuits and software routines can be used to process the signal from a sensor. One of the most common conditioners is a simple threshold system to detect when a sensor signal matches a preset value. The threshold circuit can be a simple comparator circuit like the one shown in Fig. 10. Alternatively, it can be a few lines of program code.

The Fig. 10 circuit will actuate a buzzer when the temperature of thermistor *R1* falls below a preset level determined both by its resistance and the resistance of *R2*. I used a Radio Shack thermistor (Cat. No. 271-110) to make the prototype. This thermistor has a resistance of about 10,000 ohms at 25° C (room temperature). Although the operational amplifier is specified as a 741, any common op amp should work in this basic circuit.

The best way to select the resistance of *R2* is to use a pot to adjust the circuit for the temperature point at which you want the buzzer to sound. Measure the resistance of the pot and insert a resistor with the same value into the circuit (unless you want to keep the option of being able to adjust the circuit).

Many analog sensors are manufactured with an on-chip threshold circuit much like the one shown in Fig. 10. Among the most common of these are light and magnetic-field sensors. Some have no provision for changing the threshold point, while others feature a pin to permit external threshold-adjustment.

Some sensors require somewhat more sophisticated conditioning. Consider the signal from a nonlinear sensor. One way to make such a signal linear is to use a nonlinear amplifier. Another is to determine the mathematical function of the sensor's output curve. It's then a simple matter for a computer to compute a correction factor to transform the nonlinear signal into a linear signal. Still another way is to store in memory a look-up table of appropriate linear values for a range of nonlinear sensor outputs. A simple processor or computer can then scan the look-up table and match the nonlinear input signal with the appropriate value to provide a linear output signal.

The most sophisticated conditioning of all is signature analysis. Here a circuit or program is designed to recognize characteristic patterns in the signal emitted by what's being sensed so that other signals can be ignored. Signature analysis is used to pinpoint military targets surrounded by decoys and identify specific images by computer analysis of the complex signal pattern from a CCD camera (and sometimes by comparing the unknown image with a library of stored images).

Keeping It Simple

No matter which sensor you select for a specific application, you'll always have best results if you keep the conditioning circuit or program simple and straightforward. Sometimes you can avoid the need for signature analysis entirely by some common-sense thinking.

Years ago, a student at a science fair impressed the judges with his gender identifier circuit that could identify whether a man or woman was standing at a given spot. The clever student had positioned a thermistor about a foot above the floor. The legs of men wearing trousers gave less of a temperature change than the legs of women wearing dresses. A simple comparator circuit took it from there. While this simple male/female sensor wouldn't work today, it's a good example of how creative use of a single sensor can solve an interesting problem.

Going Further

I hope this column has given you an idea of just how versatile some of today's sensors can be. There simply isn't space to describe all available sensors in a single column. Therefore, if you want to learn more, refer to various books about sensors. One of my favorites is *Experimental Methods for Engineers* by J.P. Holman (McGraw-Hill, 1984). Even though it's a little dated, this book covers most kinds of sensors in use today. It also provides good coverage of basic concepts and gives an excellent chapter on how to properly evaluate experimental data. ■

Joseph Desposito

The 386 Smart Cache Controller and Four Chips That Extend Battery Life

We lead off this month with a description of Intel's 386 Smart Cache controller and then continue with four chips that extend battery life in notebook computers and other kinds of portable equipment.

Smart Cache Controller

The 386 Smart Cache is Intel's (3065 Bowers Ave., P.O. Box 58065, Santa Clara, CA 95052) first million-transistor peripheral component. The 386 Smart Cache (product name 82395DX) integrates cache control logic, 16K of static random-access memory (SRAM) and 1,000 cache tags in a single package. The 386 Smart Cache expands the architecture of the i486 CPU on-chip cache into a stand-alone device designed for 386DX-CPU-based systems.

By using a sophisticated cache architecture, the 386 Smart Cache outperforms cache subsystems with four to six times larger RAM. The 25-MHz version of the 386 Smart Cache sells for $90—which is 40% less than a comparable-performance alternative.

Cache memory subsystems typically gain performance by increasing the amount of SRAM. The 386 Smart Cache increases performance by using an advanced architecture, rather than adding expensive SRAM. The 16K 386 Smart Cache features four-way set-associativity; a 16-byte line size; a four, double-word write buffer; concurrent line-buffer caching; plus one cache tag per line. The 386 Smart Cache uses a write-buffer memory-update protocol and maintains cache coherency through bus snooping. Many of these features were extracted from the i486 CPU cache design.

Cache improves a system's performance in three ways: speeding CPU reads from memory, speeding CPU writes to memory and reducing traffic on the memory bus. Because one chip implements an entire cache-memory subsystem, higher integration/smaller form factor 386DX-CPU-based systems can be designed, with improved overall system reliability and reduced cost.

The 386 Smart Cache's architecture takes advantage of nuances in system performance to provide the same or better performance than larger caches at far less cost. The reason that a larger cache doesn't necessarily improve performance has to do with some of those system nuances. For example, one reason that cache works at all is a characteristic of software called "spacial locality." Spacial locality simply means that software programs are typically composed of small segments (subroutines and procedures) that are repeated. Since data required by the programs usually are sequential in nature, only the local executing code and data must be in the cache to optimize program performance, minimizing code and data requests to slower, DRAM main memory. If a cache is much larger than the typical extent of locality for the software run by a system, the extra capacity is actually wasted—and so is the money spent to obtain it.

The same principle holds for write policy. A write-back cache isn't always better than a write-through cache in the context of overall system performance. The 386 Smart Cache uses a version of write-through called write-buffer, which almost completely eliminates penalties associated with write-through cache.

In standard write-through cache, there can be two penalties. Firstly, whenever the CPU writes data to cache, the cache, in turn, writes the data to main memory. As a result, cache makes heavy demands on the memory bus. Secondly, the CPU must wait while the cache is writing to memory, incurring wait states that degrade system performance.

In the 386 Smart Cache, a 128-bit buffer nearly eliminates the second penalty without the complexity or cost of implementing a write-back architecture. Instead of passing data directly through to main memory, the cache buffers it, which takes much less time than a write-to-memory, incurring zero wait states. The CPU is then free to proceed to its next operation, while the cache writes the data through to memory from its buffer.

The first penalty, that of bus use, is not eliminated, but it doesn't need to be. The fact is, in 386-CPU-based systems with one or two processors, there's more than enough bus bandwidth to accommodate the cache without the complexity and cost of a write-back strategy. A 386 CPU with a write-through cache accounts for about 40% of memory bus usage. Consequently, using a write-through architecture would be a false economy.

In addition to being more expensive to implement, a write-back architecture has penalties of its own. In one circumstance, a write-back architecture can actually cause a wait state. When the CPU must write to cache, but available locations in cache are full, cache normally just overwrites one of those locations. With write-

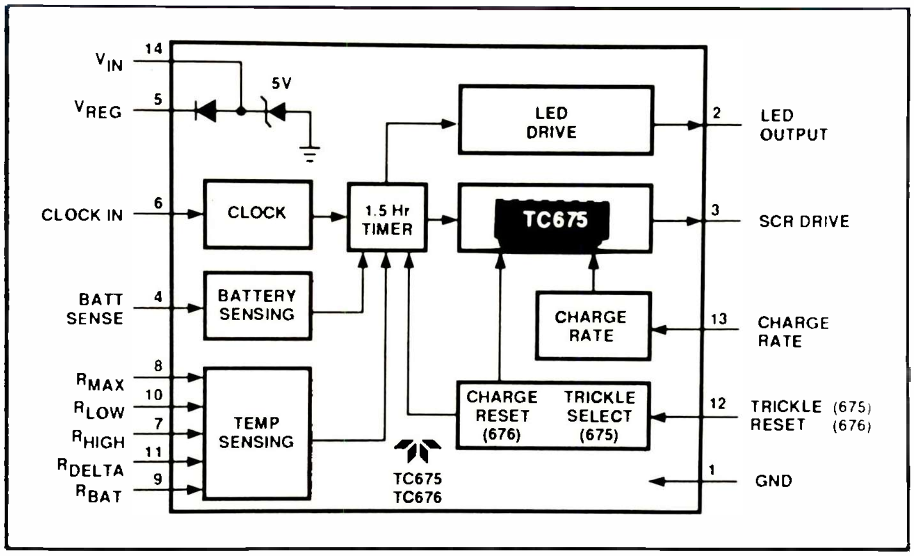


Fig. 1. Teledyne Components' TC675/676 battery-charger ICs provide a low-cost way to operate fast-charge Ni-Cd/Ni-hydride battery chargers.

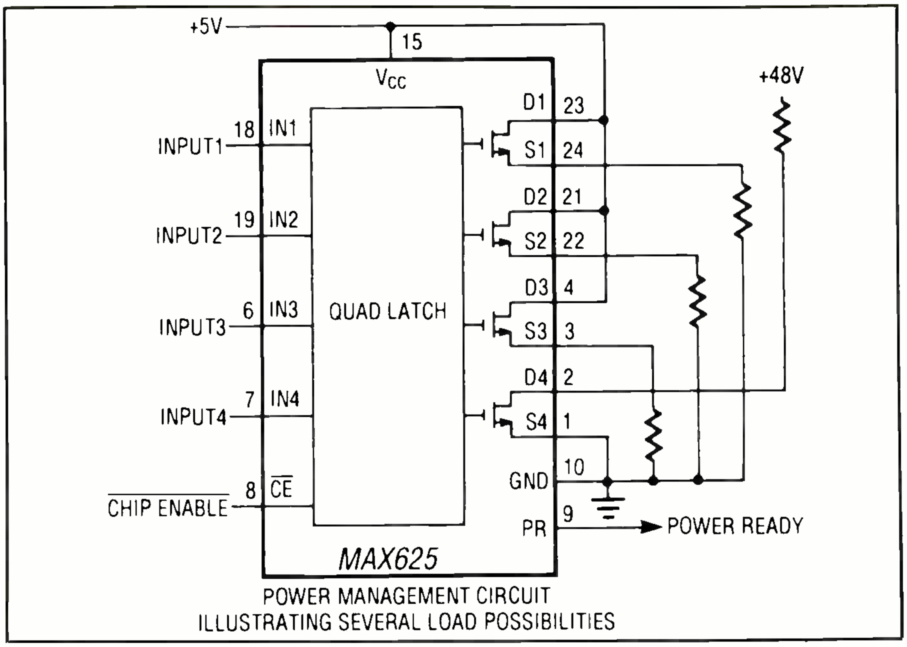


Fig. 2. A typical operating circuit for Maxim's MAX623 quad high-side power switch.

back architecture, however, there can be obsolete data at the location in main memory corresponding to the cache data to be overwritten. In that case, the cache data must be written to main memory before being overwritten, or it will be lost. When this occurs, the CPU must wait for the main memory update to occur, in so doing, incurring a wait state.

The 386 Smart Cache's buffered write-through architecture provides the same performance as a write-back architecture, but without the penalties. In addition, there's much more to a cache than just size and write policy. A number of other attributes assist in determining cache performance as well.

The amount of data fetched to cache when a miss occurs—that is, the line size—can affect the hit ratio more than does the size. And because a large line size can place a burden on bus utilization, the 386 Smart Cache supports a burst mode for reading contiguous data (the kind that make up a line) from memory to cache. Reading in burst mode greatly reduces the cache's need for bus time. In addition, the 386 Smart Cache buffers information as it's read into the cache. Because of the 386 Smart Cache's large line size, four read cycles can be executed. The buffering scheme allows the 386 CPU to get the first information without waiting for the subsequent reads to occur. These are just two examples of the kinds of solutions possible when one thinks in terms of the whole system, not just of cache size.

Another important attribute besides raw size is the size of a cache "sector," which is the unit of data associated with each tag. As tags are invalidated, via the snooping mechanism, smaller cache sectors result in less information replaced and lost. Since information is retained longer with smaller cache sectors, a greater chance exists that information will be in the cache if the microprocessor requests it. In this way, the hit ratio can be substantially increased independently of raw cache size.

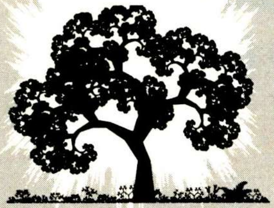
In a *Power Meter* MIPS (version 1.5) benchmark run on a 33-MHz 386-CPU-based EISA system, the 16K 386 Smart Cache operated at 8.3 MIPS. This equaled the performance of a 128K "write-back" cache memory subsystem (run on an Everex STEP-33) and beat Intel's own 64K 82385 cache, which performed at 7.8 MIPS (on a Compaq Deskpro-33).

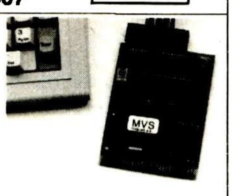
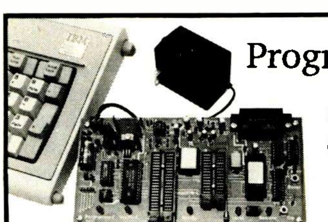
The 386 Smart Cache is packaged in a 196-lead plastic quad flat pack. In 1,000-unit quantities, the 386 Smart Cache costs $90 and $109 for 25- and 33-MHz versions, respectively.

Supervisory Circuit

Linear Technology Corp.'s (1630 McCarthy Blvd., Milpitas, CA 95035) LTC1235 microprocessor supervisory circuit includes a unique conditional battery-backup feature for RAM data that can extend battery life. The LTC1235 also has a guaranteed reset assertion down to 1 volt, which prevents microprocessor malfunction at low supply voltages.

The LTC1235 adds a unique feature to all the functions of the LTC695 microprocessor supervisory circuit. The LTC1235 can save battery power by conditionally saving the contents of RAM only when



necessary. If any data is in RAM, the LTC1235 can provide battery backup power to RAM. If there's no data or there's no need to save data, the LTC1235 doesn't supply backup power.

The LTC1235's chip-enable gating is 35 ns maximum, and supply current is 1.5 mA maximum. The LTC1235 is supplied in 16-pin SO or 16-pin DIP packages. It has all the features of the LTC695: power-on reset, watchdog timer, battery backup, RAM write protection and power-failure detection. In addition, it has the conditional battery backup and pushbutton reset features.

The LTC1235 uses a charge-pumped NMOS power FET as the V_{OUT} power switch. This achieves a lower supply current and eliminates the problems encountered when external pull-up resistors are used on digital outputs. The LTC1235 family is available in commercial and industrial grades. Pricing in 100- and-up quantity for commercial-grade chips in plastic DIP is $3.85.

Smart Battery-Charger ICs

The first in a family of proprietary Smart Battery Charger ICs that provide a low-cost way to operate fast-charge Ni-Cd/Ni-Hydride battery chargers is available from Teledyne Components (1300 Terra Bella Ave., Mountain View, CA 94039). These new devices—the TC675 and TC676—enable Ni-Cd/Ni-Hydride batteries to be charged safely without risk of overcharge and potential explosion (Fig. 1). The combination of fast charge and safety is important for applications where users need rapid recharge to maximize such equipment use as notebook computers, cellular telephones, battery-powered tools and portable medical instrumentation.

The TC675/676 can be used in all Ni-Cd/Ni-Hydride battery charger circuits built around SCRs and current-limited transformers. The charge cycle begins when the IC detects the presence of batteries connected for recharge. It ends in either of two ways: an external thermistor input to the chip stops the charge cycle when selectable battery temperature rise is achieved or an on-board fail-safe timer limits charging time to 90 minutes.

In addition to automatic battery-sense and dual-mode charge termination, these devices provide LED output that provides a visual check of charge-cycle status. Automatic trickle charge is featured on the IC, with a timer override reset pin on the TC676 and trickle charge select pin on the TC675. These features give charger designers valuable options and make these devices ideal for a variety of charging systems. The devices also include an on-chip dc power supply, reducing system cost.

The TC675/676 are packaged in 14-pin DIPs, 14-pin CerDIPs and 16-pin (wide) SOICs. They're available in commercial and extended operating temperature ranges. Pricing for the plastic DIP is $7 each in 10,000 quantity.

Tiny Switches

Maxim Integrated Products' (120 San Gabriel Dr., Sunnyvale, CA 94086) new MAX625 quad, high-side power switch permits TTL/CMOS signals to switch four 1-ampere loads (4 amperes peak). This simplifies load switching in low-voltage systems and extends battery life. The MAX625 contains four 1-ampere/0.2-ohm MOSFET switches and all driver power and control circuitry in a 24-pin narrow plastic DIP—a complete solution in 0.3 square inches. A typical operating circuit is shown in Fig. 2.

The MAX625 extends battery life in portable computers by allowing the computer's microprocessor to turn off power to the LCD display, hard disk, CPU and RAM when they aren't in use. Other applications include portable battery-powered instruments that use high current and H-bridges and stepper motor drivers.

The MAX625 has a 4.5-to-16.5-volt input supply range and a typical quiescent current of 70 μA. It's designed for a wide range of line- and battery-powered switching applications where board space is limited and only low voltages are available. It eliminates expensive P-channel MOSFETs, separate power supplies, bulky inductors and mechanical relays.

The MAX625 comes in a 24-pin narrow plastic DIP package in commercial and extended industrial temperature ranges. Prices for the MAX625CNG start at $9.98 each in 1,000- and-up quantities.

3.3-Volt, 1M DRAM

Micron Technology (2805 East Columbia Road, Boise, ID 83706) has a 3.3-volt low-power extended-refresh DRAM (LP-DRAM) in a 256K × 4 configuration (MT4C4256H). The company believes it's the first semiconductor manufacturer to offer a 3.3-volt, 1M-bit DRAM.

The 3.3-volt LPDRAM offers a memory solution for 3.3-volt flat-panel controllers used in new low-voltage laptop and notebook computers. In addition to reduced supply voltage requirements, these new 1M LPDRAMs offer very low current and extended refresh rate specifications for longer battery life in portable systems. Compared to standard 5-volt, 1M-bit DRAMs, these 3.3-volt LPDRAMs lower typical CMOS standby currents from 3.5 to 0.1 mW and typical active currents from 325 to 100 mW. The refresh rate specification is extended from 8 to 64 ms. Micron's new 3.3-volt LPDRAM also allows for a low battery backup (BBU) current with a maximum specification of 90 μA. The BBU cycle is a low-current, data-retention standby mode.

These new LPDRAMs are pin compatible with 1 M × 4 DRAMs and are offered in 300-mil SOJ packaging. Sample pricing for the MT4C4256H is $8 each in 100-piece quantities. ■

software uses only the shortest (35.56 ms with E = 922 kHz) and longest (2.276 seconds). With CR1 = CR2 = 0, the shortest time-out is chosen, and with CR1 = CR2 = 1, the longest time-out is chosen. After reset, both bits are cleared. *Note:* To use the COP function, the NOCOP control bit in the CONFIG Register must be cleared. As shipped, the MC68HC11A1P has this bit set. For more information on the CONFIG Register, see Part 1 of this article.

COP Watchdog System

Because nothing ever works perfectly all the time, and MPU/MCU circuits are no exception, most reliable systems have backup schemes. Early products that used microprocessors sometimes appeared to lock up, usually caused by a runaway program triggered by a "wild" electrical pulse. The first MPU-controlled VCRs and Video Disc players were notorious for this. Unplugging and then plugging them into the ac line usually solved this since the MPU was reset, which forced them to start executing instructions in a logical sequence again.

The HC11 has a built-in system that forces a system reset (or a jump to another "logical" starting point) if program runaway occurs. Basically, if a certain sequence of instructions isn't detected within the COP time-out period, the next instruction will come from addresses located at the COP failure reset vector at locations $FFFA and $FFFB.

The sequence required to reset the watchdog timer is as follows. First, Write $55 to address #103A (COPRST register). Then write $AA to the same address. While both writes must occur in correct order, other instructions can be placed between them. Also, the time between the reset sequence must be shorter than the chosen COP time-out period.

A/D Control/Status Register (ADCTL)

Bit	7	6	5	4	3	2
Instruction	CCF	0	SCAN	MULT	CD	CC

Bit	1	0	$1030
Instruction	CB	CA	ADCTL

Let's look at each of these in turn.

- *Bit 7/CCF—Conversions Complete Flag.* This bit isn't normally used when in Continuous Scan mode (SCAN = 1). It's cleared by a write to the ADCTL Register (starts a conversion sequence) and set when all four A/D result registers contain valid conversion results.
- *Bit 6.* This bit isn't presently used. It's always zero.
- *Bit 5/SCAN—Continuous Scan Control.* When this bit is set, conversions are continuous, with the Result Registers being updated continuously.
- *Bit 4/MULT—Multiple Channel/Single Channel Control.* When set, a conversion is done on each of four channels. The result is placed in the respective Result Register (see Table 1). Note that Bits 3 and 2 specify which set of channel signals is associated with the respective Result Registers. Bits 1 and 0 have no meaning in Multiple Channel mode. When Bit 4 is cleared, only one channel is used. This channel is specified by Bits 3 through 0 (see Table 1). The Result Registers contain data from four consecutive conversions of this single channel.
- *Bit 3/CD—Channel Select D.*
- *Bit 2/CC—Channel Select C.*
- *Bit 1/CB—Channel Select B.*
- *Bit 0/CA—Channel Select A.*

You may notice in Table 1 several interesting—and perhaps confusing—details regarding the HC11's A/D converter. Though it apparently has the capability to convert 16 different channels, four are used for testing and four others aren't used at all. Also, while the A/D converter is listed as an eight-channel device, there are only four Result Registers. The particular set of channels whose data is stored in the Result Registers is determined by Bits 2 and 3 (CD and CC).

Notice that if Bits 3 and 2 are both 1, the A/D system monitors the reference voltages. MAG-11DIAG software uses this built-in feature to test the A/D converter. Note that with only 48 pins in use, Motorola left out four channels; so the MC68HC11A1P A/D converter is a four-channel—*not* an eight-channel—peripheral. This reduction in channels is seldom a hindrance and simplifies using the A/D converter because you can be sure a particular Result Register corresponds to a specific channel.

The next two internal registers pertain to the programmable timer used in MAG-11DIAG software to measure temperature. Let's look at the bits used in MAG-11DIAG software.

Table 1. Analog-To-Digital Channel Assignments

CD 3*	CC 2*	CB 1*	CA 0*	Channel Signal	Address In ADDRx If MULT = 1
0	0	0	0	AN0	ADR1
0	0	0	1	AN1	ADR2
0	0	1	0	AN2	ADR3
0	0	1	1	AN3	ADR4
0	1	0	0	AN4	ADR1
0	1	0	1	AN5	ADR2
0	1	1	1	AN6	ADR3
0	1	1	1	AN7	ADR4
1	0	0	0	reserved	ADR1
1	0	0	1	reserved	ADR2
1	0	1	0	reserved	ADR3
1	0	1	1	reserved	ADR4
1	1	0	0	VRH pin	ADR1
1	1	0	1	VRL pin	ADR2
1	1	1	0	(VRH)/2	ADR3
1	1	1	1	**	ADR4

*These are Bit Numbers; **Reserved for factory testing.

TFLG1—Timer Interrupt Flag Register 1

Bit	7	6	5	4	3	2
Instruction	OC1F	OC2F	OC3F	OC4F	I4O5F	IC1F

Bit	1	0	TFLG1
Instruction	IC2F	IC3F	$1023

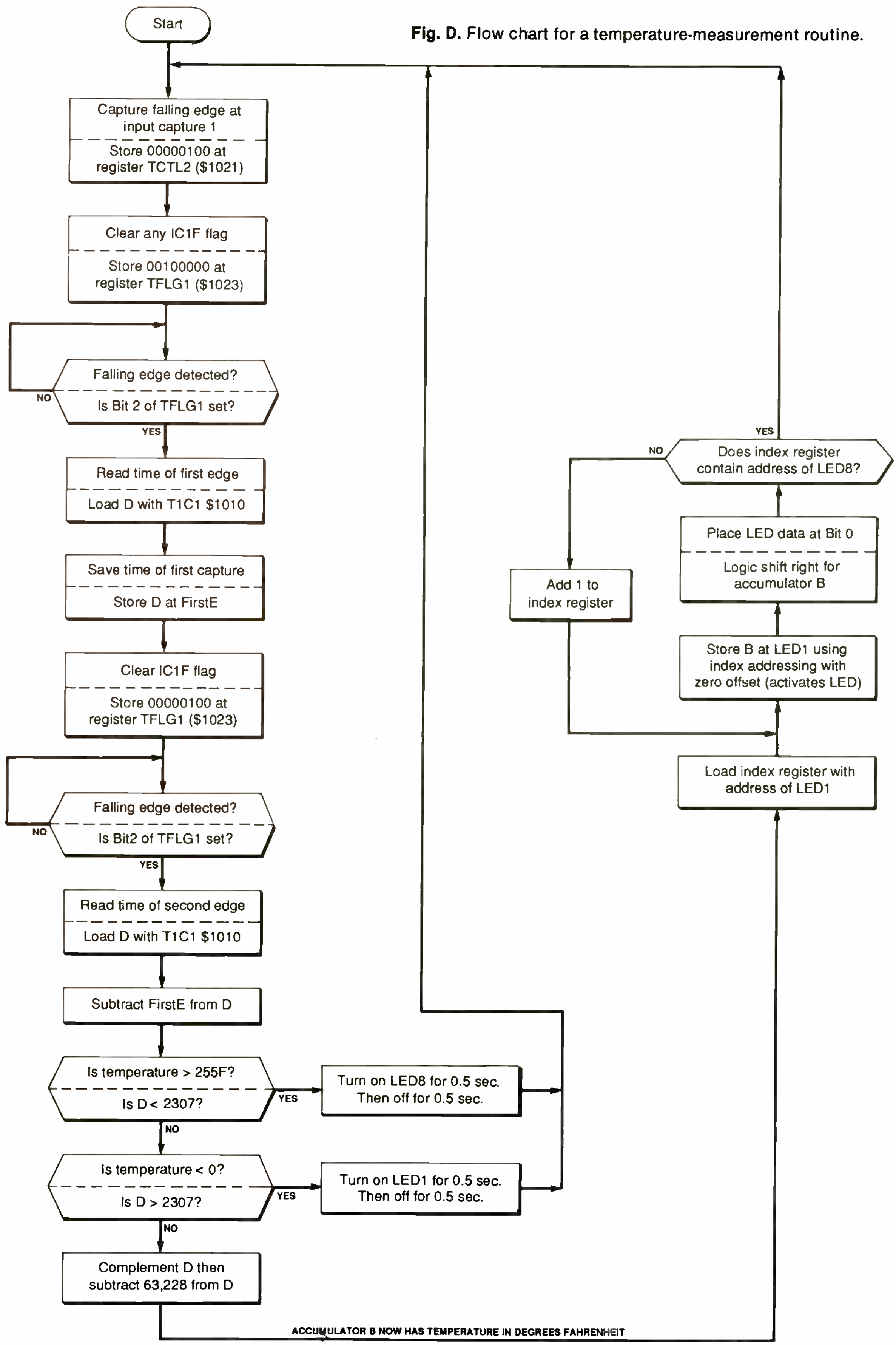
- *Bit 2/IC1F—Input Capture 1 Flag.* This flag is set each time a selected edge (edge type depends on Bits 4 and 5 of the TCTL2 register) is detected on the IC1 input line (pin 6 of the MC-8HC11A1P). A 1 written to this bit causes it to be cleared, which also occurs after reset. A 0 written to it has no effect! Clearing it doesn't clear it!

TCTL2—Timer Control Register 1

Bit	7	6	5	4	3
Instruction	EDG4B	EDG4A	EDG1B	EDG1A	EDG2B

Bit	2	1	0	TCTL2
Instruction	EDG2A	EDG3B	EDG3A	$1021

Fig. D. Flow chart for a temperature-measurement routine.



These bits are cleared to 0 by a reset, which disables all input captures. Bits 4 and 5 configure the input sensing logic for Input Capture 1 for capture on rising edge, falling edge or both, as follows:

EDG1B	EDG1A	Configuration
0	0	Input Capture Disabled
0	1	Capture on rising edge
1	0	Capture on falling edge
1	1	Capture on any edge

Hint: Before connecting a waveform to an input capture pin, pass it through a differentiator circuit with as small a time constant as possible (for example, a 1000-pF capacitor and a 10,000-ohm resistor). Refer to *C19* and pin 5 of *RN2* in Fig. 1 in the main article.

68HC11 Interrupt Vectors

Remember the last time you were working at your computer and a phone call interrupted you? The phone call is analogous to a CPU "interrupt." In normal operation, the CPU works on a logical set of instructions, the order of which is predetermined by the CPU's programmer. However, many MCU-based systems permit interference with this predetermined order of instructions. This interference is called an interrupt.

One common interrupt in many MCU systems occurs when a special circuit (located ahead of the rectifier circuit) senses when primary power is failing or has failed. As long as enough energy is stored in the filter/bypass capacitors for operation for roughly 0.1 second, the MCU can conduct an orderly shutdown, saving important data and/or registers in nonvolatile RAM. (In some HC11 systems, it may be sufficient to order a STOP instruction when power is failing.) Another common use of interrupts is in interrupt-driven keyboards, where a pressed key results in an interrupt. There are numerous other uses of interrupts.

When an interrupt occurs, the CPU checks from where it came and then decides on which set of instructions the programmer decided the CPU is to execute when that particular type of interrupt occurs.

Listing 1. Short Assembly-Language Listing of MAG-11DIAG Software

```
*.................
       ff94                    ORG   $FF94
       ff94  8e  00  ff        LDS   #$00FF
       ff97  86  01            LDAA  #$01
       ff99  b7  70  05        STAA  LED6        ILLEGAL OPCODE
       ff9c  01                NOP               LEAVE ROOM
       ff9d  01                NOP               FOR JMP OPCODE
       ff9e  01                NOP               OF DESIRED
       ff9f  7e  f8  00        JMP   $F800
       ffa2  8e  00  ff        LDS   #$00FF
       ffa5  86  01            LDAA  #$01
       ffa7  b7  70  06        STAA  LED7        COP FAILED
       ffaa  01                NOP               LEAVE ROOM
       ffab  01                NOP               FOR JMP OPCODE
       ffac  01                NOP               IF DESIRED
       ffad  7e  f8  00        JMP   $F800
       ffb0  8e  00  ff        LDS   #$00FF
       ffb3  86  01            LDAA  #$01
       ffb5  b7  70  07        STAA  LED8        CLOCK FAILED
       ffb8  01                NOP               LEAVE ROOM
       ffb9  01                NOP               FOR JMP OPCODE
       ffba  01                NOP               IF DESIRED
       ffbb  7e  f8  00        JMP   $F800


*VECTORS
*.............
*.............
                               ORG   $FFF8
       fff8  ff  94            FDB   $FF94       ILLEGAL OPCODE
       fffa  ff  a2            FDB   $FFA2       COP FAIL
       fffc  ff  b0            FDB   $FFB0       CLOCK
MONITOR fffe  f8  00           FDB   $F800       RESET

*                                    END
```

There are two basic types of HC11 interrupts: smart and dumb. With a smart interrupt, the CPU stacks the status of all CPU registers before it services the interrupt. After the interrupt is taken care of, it goes back to complete the set of instructions on which it was working prior to when the interrupt occurred, with all reg-

Chip *U5* buffers the bidirectional data lines. The enable of *U5*, connected to AS, ensures that the buses are isolated when AS is high (while address information is on the multiplexed line). The R/W line connects to direction-control pin 1 of *U5* to ensure that data is flowing toward *U1* during reads and away during writes.

Enable signal E is inverted and buffered by one stage of *U15*. Buffered lines in Fig. 1 have a "B" prefix, such as "BE," which means a buffered enable signal.

Primary EPROM *U7* is selected whenever address line A15 is high. This line is inverted and connected to CS pin 27 of *U7*. If you don't use MAG-11A Diagnostic/Instruction firmware, pins 1 and 2 of *JP4* will most likely be jumpered to connect A14 to pin 27 of *U7*. This locates *U7* at memory addresses $8000 through $FFFF.

With pins 2 and 3 of *JP4* jumpered, A14 is eliminated and *U7* responds to two different addresses. For instance, addresses 1111 1111 1111 1111 and 1011 1111 1111 1111 aren't distinguishable without address line A14, resulting in *U7* responding to addresses $F800 through $FFFF, as well as $B800 through $BFFF. This rather odd decoding permits operation in Special Test and Bootstrap modes because the reset vector for these modes is located at $BFFE-$BFFF.

Since only 2K of the EPROM is used by MAG-11A, *U7* can be a 27128 EPROM, as long as pins 2 and 3 of *JP4* are jumpered. OE pin 22 of *U7* is activated when R/W (MCU in a read cycle) and E are high.

RAM chip *U9* is decoded by *U8*. Except under unique situations, *U9* responds only to addresses $0100 through $0FFF and $1040 through $1FFF. Under normal circumstances (IRV Bit 0 in the HPRIO register), it won't respond to addresses $0000 through $00FF and $1000 through $103F because these are addresses of internal RAM and internal registers, and the external data bus isn't driven during reads of internal addresses.

Decoding for EPROM/RAM *U10* is fairly complicated. Basically, if jumpers are set for 32K EPROM, *U8* and *U13* do the primary decoding, locating *U10* at $2000 through $6FFF. If jumpers are set for 32K RAM, decoding is simpler. Here, CE pin 20 of *U10* is deselected when A15 is high (one input to *U16* is high). Also, whenever A14, A13 and A12 are all high, irrespective of A15 (Address $7xxx), *U10* is deselected. This means that *U10* is selected for addresses $0000 through $6FFF (addresses $7xxx are left out). Of course, bear in mind that *U10* won't respond to addresses 0 through $FF and $1000 through $103F.

Octal transparent latch *U11* proisters identical to what they were before the interrupt occurred. The service routine for smart interrupts usually ends with a Return From Interrupt (RTI) instruction.

With dumb interrupt, all information in the CPU registers is lost. The HC11 has three documented dumb interrupts and 18 smart ones. The dumb ones are External Reset, COP Watchdog Timer Reset and COP Clock Monitor Fail Reset. The only smart interrupt MAG-11DIAG software uses directly is the Illegal Opcode Fetch, although MAG-11 can use all available interrupts if this is what you wish.

An interrupt vector is an address that loads into the program counter when an interrupt occurs. In 68xx systems the last two bytes in the memory map, $FFFE and $FFFF, are the vectors for the system reset. Data stored at these addresses is the address of the beginning of the user's program.

Shown in Listing 1 is a short modified assembly-language listing segment of MAG-11DIAG's software. It shows four of the 21 vector assignments. The first number (for example, 0532) is the line number assigned by the assembler. Next comes the hexadecimal address of the first byte of the op code (for example, ff94). Then comes the op code or data itself (for example, 8e 00 ff). To the right is the assembly-language program (for example, LDS #$00FF). To the extreme right are the programmer's comments written in a stunted pseudo-English.

Now let's see what happens when an illegal opcode is detected when using MAG-11DIAG. When the CPU detects an undefined opcode or opcode sequence, it pushes the CPU registers onto the stack, sets the I bit in the Condition Code Register and then fetches the vector $FFF8 and $FFF9. With MAG-11DIAG software "$FF" is stored at address $FFF8 and "$94" at address $FFF9. The program counter is then loaded with $FF94, and the program starts executing instructions starting at $FF94.

The first instruction loads the stack pointer with $00FF. Then *LED6* lights (done with the instructions LDAA #$01 and STAA LED6). No Operation (NOP) instructions are used solely to leave room for a Jump (JMP) or a Return From Interrupt (RTI) to simplify modifying the program.

The next instruction (JMP $F800) causes the program to jump to the beginning, restarting the program. The COP and CLOCK MONITOR vectors perform similarly. The primary difference here is that they cause *LED7* and *LED8*, respectively, to light when the respective interrupts occur.

MAG-11DIAG Flow Charts

Figure C shows MAG-11DIAG's main flow chart. This is an extremely simplified version. It isn't necessary to understand 68xx machine or assembly language to follow Fig. C.

Figure D gives a somewhat more detailed flow chart for the Temperature Measurement Subroutine. Familiarity with the 68xx chip series will be of help here. Note that "D" stands for the 16-bit double accumulator consisting of Accumulator A (stores the most-significant byte) and Accumulator B (stores the least-significant byte). The Fig. C flow chart is more than a "theoretical" aid; it acts as a "graphic" instruction manual for the MAG-11DIAG software.

MAG-11DIAG software was written in assembly language, using Freeware's assembler AS11NEW.EXE version 1.03. Since the fully documented assembly-language listing is fairly long, it isn't included here but is available on floppy disk from the source given in the Note at the end of the Parts List. Included is MAG-11DIAG software in Motorola's S format, which can be used directly by most EPROM programmers. Also included is all author-written MAG-11 software mentioned in this series of articles, as well as the latest version of Freeware assembler (AS11NEW.EXE) and the assembler's instruction manual.

Additionally, the disk contains the pc guide for MAG-11 and Battery Backup/Eight-Channel Logic Probe in *PCBoards* format and the HPPRT.EXE utility, which PCBoards has given permission to include. HPPRT.EXE permits you to print the pc guides of any pc board layout file created with the *PCBoards* program (including MAG-11's etching-and-drilling guide) on an HP LaserJet II/compatible printer. If film or a suitable vellum (preferred) is used as a medium, you can make a pc board directly from the artwork using the positive photographic method.

vides the control and buffering needed for positions 1 through 8 of *S1*. OE (Output Enable) pin 1 of *U11*, an input, connects to the output of a two-input OR gate, whose output is low only when both inputs are low. One of this gate's inputs is connected to the output of eight-input OR gate *U13*, the output of which is low only when address lines A5 through A11 are low and A12 is high. The other input goes to pin 7 of *U8*, which goes low when a read operation takes place on addresses $6000 through $7FFF.

Chip *U11* responds to only reads of addresses 0111 0000 0000 0000 through 0111 0000 0001 1111 ($7000 through $701F). In the software, we assume that *U11* responds to $7000, although it will respond also to $7001, $7002 . . . $701F. Position 1 of *S1* controls Bit 0 at address $7000, position 2 controls Bit 1, etc. When a switch position is closed, the corresponding Bit is 0. This fact is extremely important when writing programs concerning these switches.

Octal bus transceiver *U12* provides control and buffering for *LED1* through *LED8*. The decoding scheme is similar to *U11*. However, *U12* responds to only writes to addresses $7000 through $71FF—*not* to reads. Only the least-significant bit of buffered data line BD0 connects to *U12*. Also, A0, A1 and A2 connect to the respective address on the address bus. Thus, *LED1* is at address $7000 (as well as $7008), *LED2* at address $7001, etc. To turn on *LED1*, you write a $01 to address $7000; to turn on *LED2*, you write a $01 to address $7001; and so forth.

The output of precision fixed +5-volt reference *U18* is trimmed by *R13* and then connected through high-pass filter *R11/C11* to A/D high-voltage reference pin 22 of *U1*. A/D low-voltage reference pin 21 connects to circuit ground.

A MAG-11BAT Battery Backup/Eight-Channel Logic Probe board plugs into *J1* and *J2*. Header/Socket blocks *J1* through *J6* can be either male headers or female sockets. Add-on boards to the prototype must have headers that plug into MAG-11.

If the headers on these boards are chosen correctly—double-sided and sufficiently long—it will be very simple to plug an additional board into the original add-on boards.) Positions on *J3* through *J6* are available for every data, address, control and power line you could wish for and more. Add-ons like a keyboard/display/relay board plug directly into these headers/sockets.

Next month, in Part 3, we'll cover in detail building the MAG-11 computer and provide a MAG-11DIAG "instruction guide."

Computer Games By SF Sparrow

Wordtris: The Soviet Challenge Continues

Political talk soars concerning friendlier national relations, nuclear arsenal reduction and President Bush's "new world order." Computer players are ahead of the game. Since the Reagan era, they've enjoyed the benefits of amiable relations with the Soviet Union—a kind of computer detente all their own.

It started a few years ago, after the advent of Glasnost and Perestroika. Computer rumblings began innocently with a game of Soviet origin called *Tetris*. *Tetris* was invented by a Soviet researcher named Alexey Pajitnov who works at the Computer Center of the USSR Academy of Scientists, located in Moscow. Original programming was performed by young Vagim Gerasimov, then a student at Moscow University.

Tetris' migration to American soil happened due to efforts by Academy Soft in Moscow, Andromeda Software Ltd. of London and USA's own Spectrum HoloByte, maker of the first serious simulation for the F-16 Fighting Falcon.

Since its humble introduction into American culture, the seemingly innocuous game has slain many a computer player. *Tetris* is highly addictive. Even now, there may be thousands of closet *Tetris* addicts reading this who are unwilling to admit the habit.

The premise for *Tetris* is a simple as it can get. It looks too easy. As a player, you have a boxed-off area in front of you. Shapes fall from the top of the box. These shapes are small squares connected together to make larger figures. As the figures fall toward the bottom of the screen, you must decide where each specific one should be placed and whether or not it needs to be rotated to fit. The decision on where and how to place the falling shape must be made before it hits bottom.

Game objective is to fit the squared-off shapes so that a level or tier is connected completely across the screen. When a level is completed, it vanishes to make room for more. However, if the shapes aren't connected properly they continue to pile up until they reach the top. In that case, the game is over.

Simple, you think? Fantastically so. Yet this deceptively easy game remains frustratingly beyond the reach of even more seasoned gamers. A tiny mistake, a missed rotation or a slow finger can cause your entire pattern to go askew. So you have to try again. Oh, another mistake. Try it again. *Oops!* Try again. And again. And . . . You get the picture. After 15 or 20 games go by, your realize you're hooked. Unpretentious in every way, *Tetris* quietly supported basic EGA and CGA graphics and joystick and used the simple PC speaker for sound.

Soviet Challenge Continues

Tetris' success spawned an interesting sequel: *Welltris*. This game took the original concept and whirled it into the realm of three dimensions. Addictive as it is, *Tetris* remains a two-dimensional challenge. The third dimension found in *Welltris* forces players to not only rotate a piece to make it fit, but also move it in circular fashion around the playing area. All the while, playing pieces are descending into the heart of the computer screen, as though falling into a multi-colored void.

Like *Tetris*, the objective with *Welltris* is to form a horizontal tier across the screen. With *Welltris*, though, the line can be horizontal or vertical. It takes some tricky finger-maneuvering on the computer keyboard to handle *Welltris*. But it's fun and potentially as addictive as its predecessor. You know, that's just what *Tetris* addicts needed: another irresistible mind teaser. Designer Pajitnov, Spectrum HoloByte and Glasnost had done it again. *Welltris* continued use of basic CGA and EGA graphics, but it dropped joystick support. But lack of joystick support is of no real consequence, and *Tetris* with a joystick is, at best, clumsy.

New Face of Challenge

Since *Tetris* and *Welltris* were so successful, one had to wonder if a third *Tetris*-like product would find its way to the United States. Musings were set to rest with Spectrum HoloByte's release of *Faces*, which is *Tetris* with a new twist. The objective with *Faces* is to assemble pieces of disjointed personages, usually famous ones like Abraham Lincoln, Galileo, Isaac Newton, Dostoyevski, Mozart and, of course, Gorbachev himself. Nine different skill levels include countenances from art, science, music, American history, literature and even movie-monster fame.

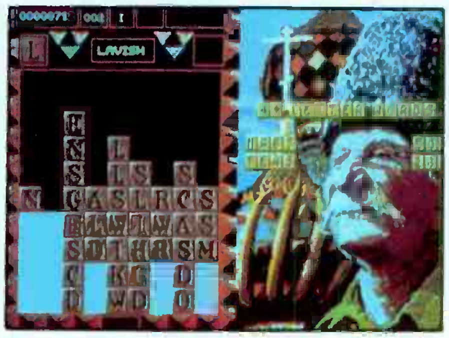
Faces sports a specific player mode not seen in previous *Tetris* games: head-to-head action through modem or direct serial port connection. Two-player execution is a favorite of Spectrum HoloByte since the days of Falcon. The technique usually accompanies its games. But *Faces* doesn't really need the dual-player mode because playing is mostly a solitary experience. While not as popular as original *Tetris*, *Faces* brought back joystick support, introduced VGA graphics and even welcomed use of the AdLib sound card.

Tetris Turns Educational

After three variations on the *Tetris* theme, all of them interesting, it surprises some players to see *Wordtris*, a fourth incarnation of the Soviet challenge. Instead of falling geometric shapes and plummeting sections of famous faces, letters of the alphabet challenge dexterity of mind and finger. *Wordtris* is particularly tricky because concentration is a must if you want to integrate active playing letters with those that have already been placed. Too, you must consider where the next letter might fit. Depending on chosen speed and skill level, alphabetic arrangement can get tough—fun, but tough.

Wordtris' vocabulary is an impressive 60,000 words. But if that isn't enough for you literary giants of the computer gaming world, you can make your own dictionary and *Tetris* will use it. See if you can outsmart yourself with a game that serves up addiction *a la Tetris*, plus a side order of "*Scrabble* in motion." Kept in game play are VGA graphics, joystick and AdLib sound support and head-to-head play. Added to the menu is support for SoundBlaster and Tandy sound, Novell network support and, for the first time with any *Tetris* game, mouse support.

Wordtris' newly-instituted mouse support is a significant point because the mighty and often-used computer mouse could have been employed to great advantage in previous *Tetris* games, especially the original *Tetris*. Avid game players know that its difficult to enjoy a game they're not good at playing. Most games knuckle under when hit with a few hours of practice. Others seem to require some innate mystical ability to conquer them.



Typical screen shots of Spectrum HoloByte's Weltris in EGA resolution (left), Faces in VGA resolution (center) and Wordtris in VGA resolution (right).

These fun, silly, frustrating *Tetris* games can be that way. If losing happens too often, you feel like the Force just isn't with you. (*Star Wars* fans will please forgive the misplaced analogy.)

For hopeful game aspirants, a bit of computer technology may be all that's needed to get the edge on certain maddening games. A little software shop named LightBulb Logic publishes a product called *Comrade*, which may be the ultimate *Tetris* cheater.

Think back to your first compulsive days of playing *Tetris*. What single tool (besides a sledge hammer) could you have used to improve your game? The tool in question had to be easy to operate and afford accurate fingertip control, without having you take your eyes off the screen even for a second. The answer, of course, is a computer mouse, a solution as simple as the game itself.

You provide the mouse, LightBulb Logic provides *Comrade*, the mouse drivers for *Tetris, Welltris* and *Faces*. It works, too. I've seen miserable *Tetris* players improve to respectability in only a few games. *Comrade* is a must for the true *Tetris* gamer.

So now *Tetris* addicts have it all: an intriguing variety of games, including a new release (*Wordtris*) that has socially redeeming value; and a new product (*Comrade*) that offers catharsis by helping you master the Soviet challenge. Now what are you waiting for—complete nuclear disarmament perhaps?

Bird's Eye View

Comrade, $19.95
LightBulb Logic
P.O. Box 815984
Dallas, TX 75381
214-406-9998

Tetris, $34.95; *Welltris*, $34.95; *Faces*, $39.95; *Wordtris*, $44.95
Spectrum HoloByte
2061 Challenger Dr.
Alameda, CA 94501
415-522-3584

Requirements:

RAM Memory	640K
Graphics	VGA, EGA, CGA, Tandy
Sound	SoundBlaster, AdLib, Roland, Tandy
Controllers	Joystick, Mouse

Evaluation

Documentation	Good
Graphics	Good
Learning Curve	Short
Play Length	Short
Playability	Excellent

In Brief: Series of highly addictive games that maintain interest and challenge even after many times of play. No special hardware needed for maximum enjoyment.

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