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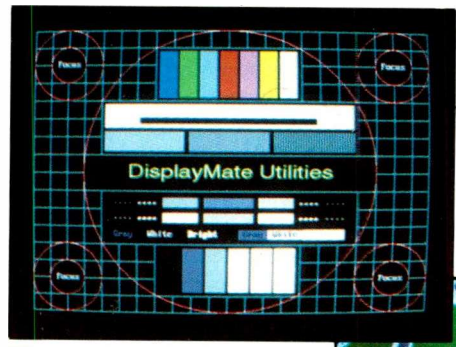

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ON THE COVER: Readers of *ComputerCraft* are accustomed to rolling up their sleeves and invading the "guts" of their computers to add enhancements, make upgrades and rectify hardware problems. Here, a user installs a diagnostic card that reports on problems that occur during Power-On System Testing (POST) when the computer is powered up. **Cover Photo:** Lorinda Sullivan

Beat The Clones

What would you think is afoot if General Motors and Ford announced that they're jointly forming a company to work on developing a new generation of automobiles? And at the same time say they've worked out agreements with Toyota's body-maker to have a major role?

Well, something akin to this happened recently in the computer industry—IBM and Apple Computer reported that they've agreed to set up a new joint company to "propel the personal computer industry into a new era." Moreover, Motorola will be playing a key technological role.

"We're expanding customers' choices while lowering their risks when buying computers," says Apple's CEO, John Sculley. At the same time, IBM chairman John Akers said, "The second decade of personal computing begins today," while Motorola's CEO, George Fisher, added "These agreements combine the unique talents of three great companies."

Their company spokespersons revealed a bit of what they initially plan to do. For example, IBM and Macintosh will provide new options for integrating Macintosh personal computers into IBM networks, with first products expected to greet the new year. (Advantage Macintosh for getting a better foot in the corporate-office door.)

Then there's development of new RISC (Reduced Instruction Set Computing) microprocessors optimized for personal computers and entry-level workstations. Target date for sale (by co-developer Motorola) is two to three years. Also in this time frame is an open-systems platform that will allow a system to run IBM's version of UNIX, the Mac interface and the new RISC architecture, with both Mac and IBM's UNIX applications able to run on the same RISC-based hardware.

If this isn't enough for starters, Apple and IBM are forming a new independent company to create and license multimedia technologies and a joint software venture to develop a next-generation operating environment based on object-oriented technology. (Given Apple's software prowess—more than a million lines of production code developed over three years by its Object-Based Systems division—it's Advantage IBM here.)

Will these company giants take over the personal computer world, clobbering the clones into dust? Don't bet on it. Firstly, IBM/Apple says that the technologies will be made available to other vendors. Translation: There's big bucks in licensing. And besides, it keeps anti-trusters off one's back, and the developers always have an inside track on the latest and greatest.

So where will this leave the clone makers and software and hardware kings Microsoft and Intel, respectively? And where will this leave users, in particular home professionals, which so many of you are either full- or part-time?

Given a perspective provided by the past, I believe they'll all do very well. Just look at the record. IBM came up with its proprietary bus, offering it to others for a very fat royalty fee, but it was checked by the EISA bus that a large group of hardware adapters created. It made more sense, too, since it also accommodates older expansion cards. The vaunted OS-2 operating system is still floundering, while Microsoft's DOS 5 and *Windows* 3 are flying high, still making juices flow for mainstay PC owners. Intel continues to dominate in the PC microprocessor area, while competitor AMD is keeping the company on its toes. And the clone makers seem to be able to constantly upstage IBM with new technological innovations.

As for Apple Computer, it still hugs hardware and operating systems real close while allowing creative software makers and add-on hardware developers to stoke the fires so that they can get astonishingly high prices for their products compared to PCs sold in the competitive market by PC-compatible makers.

Will corporations dump their present small CISC computer systems for IBM/Apple/Motorola RISC products? Only if it makes financial sense, which for many may not. The entry fee would be a lot greater than just changing machines because DOS-based software would also have to be trashed. For example, Acorn Computer in England uses a RISC microprocessor, made by VLSI Technology, for a PC they produced, but it went nowhere because it lacked a software base. Now the company has redirected the chip for embedded process and control applications.

As you may know, most program computation with conventional PCs use only perhaps 20% of a microprocessor's instruction set. So frequently used instructions are slowed down because microcode implementation is cumbersome. RISC, in contrast, abandons this microcode implementation, using simple instructions in hardware and a compiler, with more of the burden on software. A fly in the ointment, however, is that current RISC machines use different instruction sets and, therefore, different Application Binary Interfaces (ABIs), making them incompatible. DOS software ABIs, in comparison, are

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41256-150	256K x 1	150 ns	1.79	1.70	1.53
511000-70	1 meg x 1	70 ns	5.49	5.22	4.70
511000-80	1 meg x 1	80 ns	5.29	5.03	4.53
511000-10	1 meg x 1	100 ns	5.09	4.84	4.36
514256-70	256K x 4	70 ns	6.49	6.17	5.55
514256-80	256K x 4	80 ns	6.09	5.79	5.21
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2764A	250 ns	3.09	2.94	2.65
27128	250 ns	4.79	4.55	4.10
27C128	250 ns	4.79	4.55	4.10
27256	250 ns	4.59	4.36	3.92
27C256	250 ns	4.29	4.08	3.67
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27C512	250 ns	5.49	5.22	4.70
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LT7650	632.8nm (Red)	0.5mW	2.0mW	0.49mm	≦ 1.7 mrad	>100:1	1000v ± 100v	3.5 mA	< 7 kV	68k Ω	25 x 146	70	IIIa	529.99	479.99
LT7656	632.8nm (Red)	0.5mW	2.0mW	0.34mm	≦ 2.4 mrad	random	1050v ± 100v	2.8 mA	≦ 8 kV	82k Ω	22.5 x 118	60	IIIa	134.99	124.99
LT7655	632.8nm (Red)	0.5mW	2.0mW	0.49mm	≦ 1.7 mrad	random	1000v ± 100v	3.5 mA	≦ 7 kV	68k Ω	25 x 150	70	IIIa	144.99	134.99
LT7655S	632.8nm (Red)	1.0mW	2.0mW	0.49mm	≦ 1.7 mrad	random	1000v ± 100v	3.5 mA	≦ 7 kV	68k Ω	25 x 150	70	IIIa	159.99	144.99
LT7632	632.8nm (Red)	1.2mW	3.0mW	0.61mm	≦ 3.0 mrad	random	1300v ± 100v	3.5 mA	≦ 7 kV	81k Ω	20 x 210	70	IIIa	249.99	229.99
LT7621S	632.8nm (Red)	2.0mW	5.0mW	0.75mm	≦ 1.2 mrad	random	1300v ± 100v	5.0 mA	≦ 7 kV	68k Ω	30 x 255	140	IIIa	204.99	191.99
LT7634	632.8nm (Red)	2.0mW	5.0mW	0.75mm	≦ 1.2 mrad	>500:1	1300v ± 100v	5.0 mA	≦ 7 kV	68k Ω	30 x 255	140	IIIa	209.99	194.99
LT7621MM	632.8nm (Red)	5.0mW	15mW	1.0mm	≦ 2.5 mrad	random	1250v ± 100v	6.5 mA	≦ 7 kV	68k Ω	30 x 255	140	IIIb	359.99	334.99
LT7627	632.8nm (Red)	5.0mW	15mW	0.80mm	≦ 1.1 mrad	random	1900v ± 100v	6.5 mA	≦ 8 kV	81k Ω	37 x 350	200	IIIb	369.99	344.99
LT7628	632.8nm (Red)	5.0mW	15mW	0.80mm	≦ 1.1 mrad	>500:1	1900v ± 100v	6.5 mA	≦ 8 kV	81k Ω	37 x 350	200	IIIb	389.99	364.99
LT7627MM	632.8nm (Red)	10mW	30mW	1.2mm	≦ 4.0 mrad	random	1750v ± 100v	6.5 mA	≦ 8 kV	81k Ω	37 x 350	200	IIIb	479.99	444.99

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Erratum

• In the "Computer Virus Survival Guide" ad for National Computer Security Association on page 62 of the December 1991 issue of *ComputerCraft*, the zip code at the end of the address was incorrect. The correct zip code is 17055.

Bob Bales
National Computer Security Assn.
227 W. Main St.
Mechanicsburg, PA 17055

Programming Education

• I am 40 years old and would like to become a computer programmer. It is very expensive to get this kind of training in England if you are over 35. I have access to an IBM computer. Could you suggest where I can get any software on teaching oneself computer programming?

Clayton Campbell
St. Pauls, Bristol, England

There are many self-instruction textbooks on software programming in the U.S. that are likely sold in your country's bookstores. Some are accompanied by floppy disks. There are home-study courses, too, offered by a number of correspondence schools. Check advertisers in ComputerCraft.*—Ed.*

Kudos Keep Coming

• On a trip to San Antonio, I browsed through a magazine stand to see what would catch my interest and spied the November issue of *ComputerCraft*. Upon arriving home and sitting down to devour it mentally from cover to cover, I came up with the following conclusions. It is a superb pleasure to actually see a magazine that has more articles of interest to the reader. True, it appears as though your magazine is slanted more toward the "experimenter," but you also have a number of articles of general interest to computer users.

I have been fighting an uphill battle with Ziff Publications about their preponderance of "Madison Avenue hype." They have multiple-page slick advertisements and folded-over pages and cardboard inserts. You cannot thumb through an issue of these mags until you rip them out. I was pleasantly surprised to see that your publication has not gone "Madison Avenue."

Ray Shannon
Bulverde, TX

We agree that you found a bothersome reader hurdle to overcome in those "other" computer magazines. But think of the money they're making.—Ed.

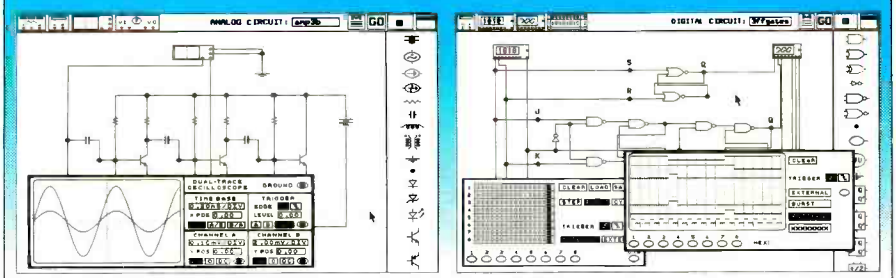
• *Finally*! a magazine that covers technical topics in the field of small computers, and it even has a regular column or two dealing with *microcontrollers*! I have, so far, been able to purchase only the August and September issues, but I called CQ Communications just last week to order my subscription. Thanks for publishing a great magazine, and keep up the good work.

Edward L. Pugh
Belleville, Ontario, Canada

• Jan Axelson's articles are exceptionally clear and one of the main reasons why I purchase *ComputerCraft*. Your article on EEPROMs in the October issue was very useful to me.

Dave Weidling
Arcata, CA

The Electronics Lab in a Computer!



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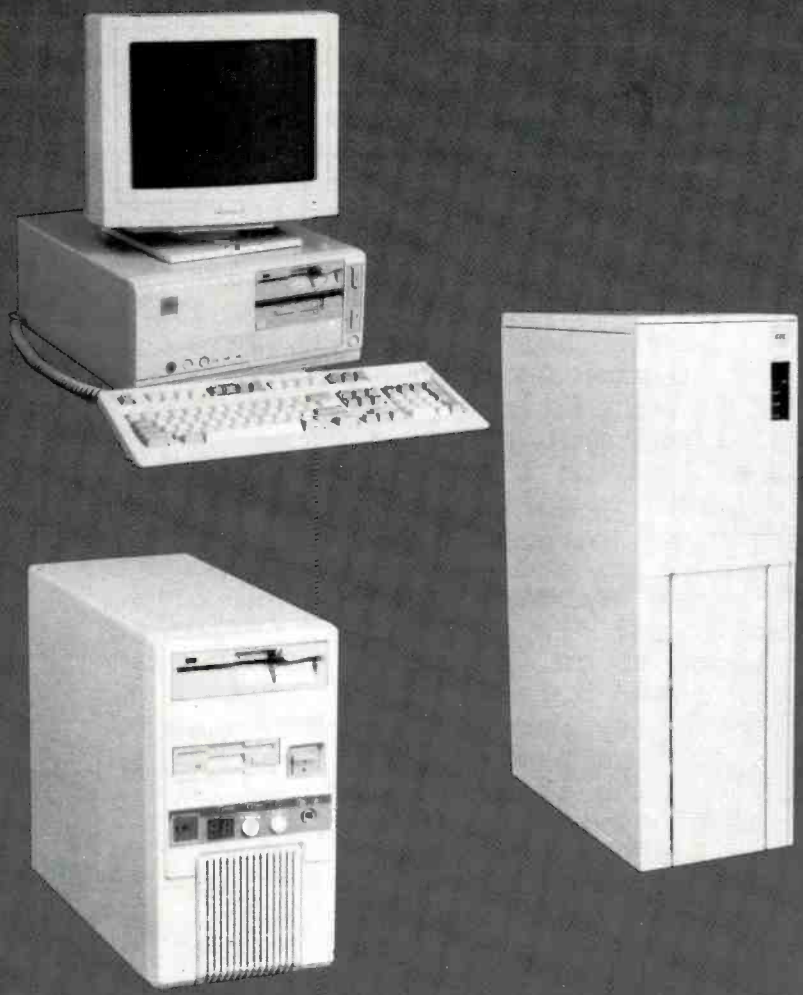

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Bulletin Boards. Chinon America initiated "TechniCare," a toll-free technical assistance program for users of the company's scanners, CD-ROM and floppy-disk drives. The 24-hour bulletin board also provides software product updates, utilities, help sections and a diagnostic link section. For further information call 213-533-0274....TechExpress, Inc., a single-source distributor of technical/engineering software, also announced that it now offers an electronic bulletin board service for its customers. The BBS offers fast access to software specs, demo disks, catalog and purchasing information 24 hours per day. Covers DOS and Mac products such as schematic capture, PCB layout, digital and analog simulation, math and graphics programs, and the like. For BBS access, call 818-707-2540 with modem set to 8 bits, one stop bit and no parity. For free product catalog, call 1-800-743-7074.

Other By-Phone News. Microsoft's new "FasTips" service supports MS-DOS 5 Upgrade customers 24 hours per day. Call 206-646-5103 to get answers to most common questions about installing, optimizing and using the operating system. Printed or audio information can be provided with this automated service. For personal assistance, call 900-896-9000....You can listen to a demonstration of KDS/VOX's expert voice system by calling its 24-hour phone line, 708-251-4975, from any Touch-Tone phone. Callers may run any or all of its 15 different knowledge-based applications. The machine you'll contact is an 80386 25-MHz IBM clone with a math chip, 150M hard disk and a Dialogic telephone interface board....Bellcore (Bell Communications Research) developed an experimental language called ATOMICMAIL, which reportedly offers a practical way to send a computer program to virtually unlimited numbers of recipients even if they have incompatible computers.

CAD/CAM Employment. NACO (National Association of CAD-CAM Operators), Houston, TX, spokesman, Ed Wiesner, says that available job openings [for CAD-CAM operators] has been increasing at a surprising rate. The largest number of openings are in California, Texas, Illinois and Wisconsin, with slowest in the Northeast. The association issues certification ratings from Level 1 through Level 7. Supervised tests are required to be certified above Level 3. Membership dues are $50/year, and testing costs range from $45 to $145, depending on certifying level. NACO also searches out job openings for members on a no-charge basis.

Free Nationwide Windows Seminars. Microsoft Corp. announced it will hold more than 3000 seminars will be conducted through to June 1992 in about 200 cities across the country. They'll address business problems: Intro to Microsoft Windows Applications, Windows Computing for Technical and Engineering Professions, for Financial Professions, for Attorneys, for Educators, for Government Professionals, for the Macintosh, making the Move to Microsoft Windows Applications, and Microsoft Networking Seminars. For information on seminars in your area, call toll-free number 800-227-4679.

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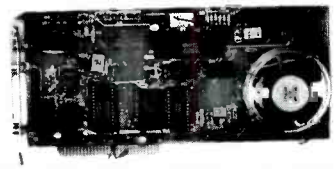

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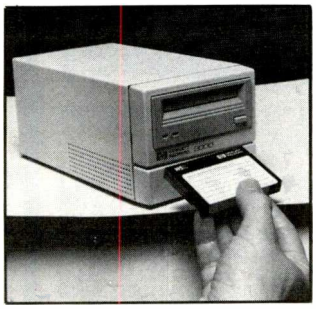
DAT Backup

HP's DAT PC Backup Solution (Model 2000) backs up 300M of data using the DDS standard in 30 minutes on a 2.0-gigabyte DAT tape. Using an SCSI interface, the DAT PC Backup Solution can be stacked

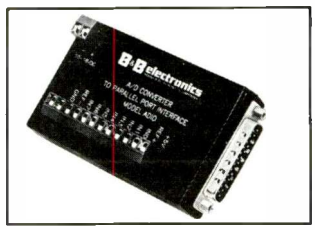


with other mass-storage devices. The fast-search capability of the DDS format allows the drive to search for a file at 200 times the normal read/write speed and to locate a file on a DDS cassette in an average of only 30 seconds. Emerald Systems, Cheyenne Software, Sytron Corp. and other leading software manufacturers support HP DAT. Model 2000 is housed in a small desktop case designed to be positioned next to a PC. $2,800.

CIRCLE NO. 1 ON FREE CARD

Parallel Port A/D Converter

Connect your computer to the outside world with the B&B Electronics Parallel Port To



Analog/Digital Converter kit (ADIO). The unit can input eight analog voltages and convert them to eight-bit digital words. ADIO can measure power-supply voltages, the voltage on a potentiometer, voltage outputs from lab experiments and many other things. It comes complete with instructions and sample programs. $100

CIRCLE NO. 2 ON FREE CARD

386SX AT Upgrade

AOX is shipping its cache-based StaX SX, a module that replaces the 286 processor on an AT-class computer. Stax SX is available in both PLCC and PGA versions with operating speeds of 16 and 20 MHz. There is no need to replace existing peripherals like memory boards with Stax SX, and the unit supports the 80287 coprocessor. Stax SX is compatible with many computer makes and models. AOX provides additional upgrade paths for PS/2, Zenith and other models with special needs. $279, 16 MHz; $329, 20 MHz.

CIRCLE NO. 3 ON FREE CARD

Wall Plate For LANs

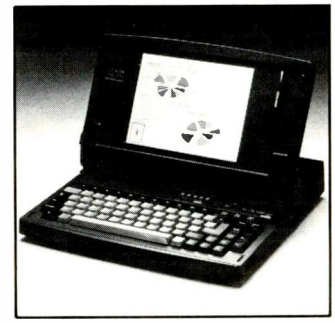
The CMS series 2013 Wall Plate System uses snap-in inserts to configure each terminus. An installer can custom-

wire information outlets onsite by inserting different cables in a single wall plate/box. Made of impact-resistant and flame-retardant Polymair, the plate/boxes are available in 1-, 2-, 3-, 4-, 5- and 6-port configurations.

CIRCLE NO. 4 ON FREE CARD

New Laptops

Bondwell's new B310SL and B310SX laptop computers offer advanced features in economical packages. The B310SL is built around the Intel 386SL and features a 120M hard drive, 20-MHz clock speed, 16K cache memory, 2M RAM expandable to 8M, 1.4M floppy and internal 2,400-bps MNP5 V.42 BIS modem. The B310SX has a 16-MHz 386SX CPU, 80M hard drive, 2M of RAM (expandable to 5M) and 1.4M floppy. Both units are equipped with VGA display screens, 81-key full-size keyboard and six C-size Ni-Cd cells. They also come with Bondwell's password-protected PC Alarm theft-



prevention system that triggers a 90-dB alarm when triggered.

The B310SL weighs 9.6 lb., the B310SX 8.5 lb. Both models are housed in a 13″W × 12.5″D × 2.1″H package. $2,695 for B310SL; $2,395 for B310SX.

CIRCLE NO. 6 ON FREE CARD

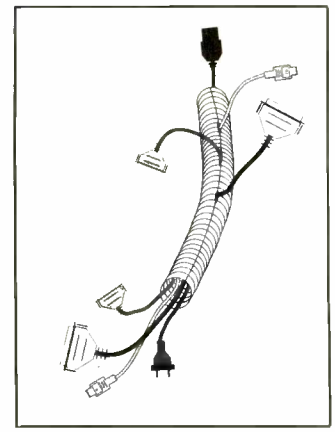
Mouse Support For Software Without It

Vetra Systems keyKitten is a small external hardware unit that fits between a computer keyboard and the CPU and adds mouse-type control to all applications that don't have mouse support. KeyKitten translates signals from a mouse into cursor-key signals. To the software, it appears as if the signals are coming from the keyboard, except at a much faster rate. Regular keystrokes aren't affected, and no software modifications, TSRs or drivers are required. $125.

CIRCLE NO. 7 ON FREE CARD

Rat's Nest Control

You can take control of the endless rat's nest of wires and cords in your office with the Computer Cord Control Kit from Get Organized (Scotts Valley, Ca). At the core of the Kit is a "Super Flex" tubing that works together with reusable beaded ties to secure and conceal all types of electronic

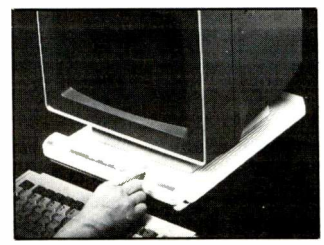


equipment cords and wires. All cords remain accessible but out of sight, giving desk areas a more professional appearance. Each Kit also contains color-coded labels that provide a quick and easy method to reconnect the most complicated equipment by simply matching colors. Cord Control Kits are available in black, white, gray and red. $14.95

CIRCLE NO. 8 ON FREE CARD

Power-Control Center

Proxima's PowerTouch Plus power-control center fits underneath the monitor and has switches on its front panel to control computer, modem, fax and other peripherals. Its specifications are said to exceed all industry standards for surge and emi/r-f noise protection and fax and modem line protection. The unit has indicators to show low voltage and building wiring faults. Proxima offers a $25,000



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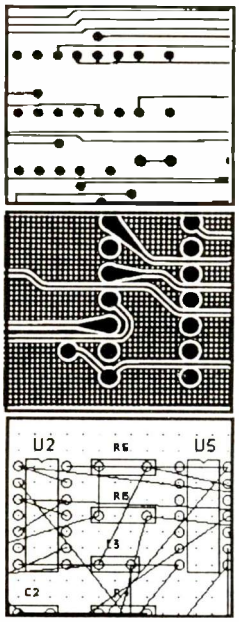

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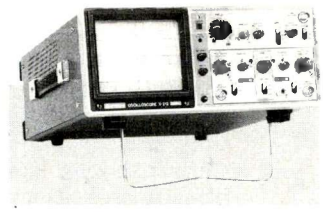

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V-1060	100 MHz, Dual Channel, Delayed Sweep CRT Readout	1645.00	1365.95
V-1065A	100 MHz, Dual Channel, Delayed Sweep, CRT Readout, Cursor Measurement, Counter	1895.00	1645.95
	Digital Storage Oscilloscopes		
VC-6023	20 MHz, 2 Ch, 20 MS/s, 2 KW/Ch, RS-232	1995.00	1689.95
VC-6024	50 MHz, 2 Ch, 20 MS/s, 2 KW/Ch, RS-232	2295.00	1989.95
VC-6025	50 MHz, 2 CH, 20 MS/s, 2 KW/Ch, Sweep Autorange, RS-232	2595.00	2189.95
VC-6045	100 MHz, 2 Ch, 40 MS/s, 4K Mem, Sweep Autorange, RS-232	3395.00	2989.95
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Quote-Retrieval Software

PennComp released version 5.0 of *Quotemaster Plus*, a literary quote retrieval software package for writers, speakers and communications personnel. It contains 3,000 quotations. New features include online biographical information on over 16,000 authors, a new TSR Ghostwriter mode for switching between a word processor and *Quotemaster Plus* and four new quote databases (Humor 2, Humanity, Religion and Business). *PowerSearch*, also included, is a fast search utility and set of text-search algorithms that permit multiple subject and hierarchical searching. Retrieved information can be cut and pasted directly into a word-processing document with a single keystroke. The package is available for DOS, *Windows* and Mac systems. $89 and up.

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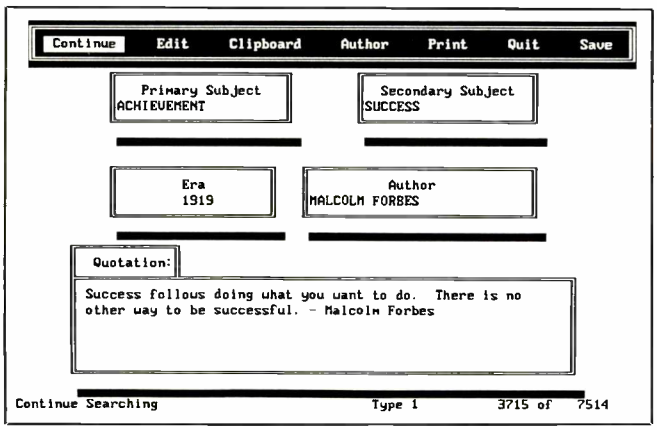


Professional-Grade DMM

Beckman's new Model 2020 DMM features 10,000-count resolution, true rms (switchable ac or ac + dc) measurement, capacitance measurements to 2,000 μF and frequency counter to 2 MHz, logic probe. Features include automatic Min/Max/Avg (fully autoranging), automatic reading hold, peak hold, 41 segment analog bargraph, intermittent detector, audible fault finder, and backlit four-digit LCD. The 17-mm display provides a menu of features for the user to select and deselect. After 30 minutes of inactivity, the meter shuts down completely, drawing no standby power. Also featured is an audible/visible dangerous-voltage warning. It comes with a protective holster and strap. $250

CIRCLE NO. 10 ON FREE CARD

Laptop Display Zoom Utility

General Business Machines Corp.'s new *LapZOOM* utility (5K TSR) enables the user to zoom in on the cursor by a factor of 2 or 4 on any word processing, spreadsheet or desktop publishing application such as *WordPerfect*, *1-2-3*, *Framework*, *Wordstar*. The utility produces characters two or four times normal for less eye strain. *LapZOOM* also enables the user to control the size of the cursor, up to one full character. The program works with any software from 80 columns × 25 to 132 columns × 60 rows. It is menu-driven with custom help screens. $29.

CIRCLE NO. 11 ON FREE CARD

It's BASIC

QBASIC Made Easy
By Don Inman & Bob Albrecht
(Osborne:McGraw-Hill. Soft cover. 422 pages. $19.95.)
Microsoft did an admirable job of documenting DOS 5.0, except for QBASIC, the replacement for GWBASIC. (QBASIC is a subset of QuickBASIC without the ability to compile programs.) Coverage was sparse, to say the least. Inman and Albrecht correct this deficiency in this book. These veteran programmers start with beginning concepts that are illustrated with examples. Step-by-step hands-on exercises should make it possible for the student programmer to get up and running with QBASIC in short order. Other topics covered include string manipulations, editing and dynamic debugging, functions, data structures, arrays, sequential and random-access files. This is a good book for getting your feet wet with QBASIC, particularly if you have little or no BASIC experience.

QuickBASIC 4.5
By Gary Cornell, Ph.D.
(Windcrest/McGraw)Hill. Soft cover. 353 pages. $22.95.)
This book is for the intermediate BASIC student—someone who has learned to handle an interpreted BASIC, such as GWBASIC or BASICA. Chapters 1 and 2 cover the rudimentary aspects of QuickBASIC operation and programming. Chapter 3 highlights the built-in functions, including simple string operations, RND function and other common functions. Cornell then moves into user-defined functions in Chapter 4, with particular emphasis on shared and static variables. Top-down program design, procedures, testing and debugging strategies and error trapping are covered next. This is followed by arrays, lists, and data records. Recursion techniques round out programming-strategy chapters. Chapters 8 through 11 cover sound, graphics, curves, fractals and working with files and menus. The presentation is clear, but it does assume some prior knowledge. If you have some BASIC background and have moved up to (or are thinking of moving up to) Quick BASIC, consider QuickBASIC 4.5.

BASIC Techniques and Utilities
By Ethan Winer
(Ziff-Davis Press. Soft cover. 565 pages. $29.95.)
This is a book (with accompanying disk) for the "power BASIC" programmer, someone proficient in QuickBASIC or one of the other BASIC dialects. Examples presented throughout apply to Microsoft's QuickBASIC and BASIC Professional Development System (PDS), but they would have application with other compiler systems.

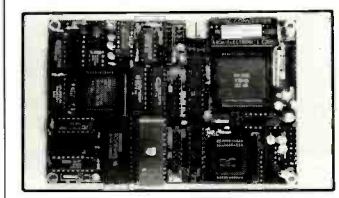
Part One of the book has three chapters that address in detail how BASIC source code is manipulated throughout the compiling and linking process. The second part is rightfully called "Hands-On Programming." It examines programming techniques and shows specific examples of how to write effective code and make it work. Five chapters are devoted to this section.

The final section, "Beyond BASIC," contains information rarely covered in books about BASIC. Following this are optimization techniques that reduce the size of programs and make them run faster. Then the author shows how to manipulate the key memory areas in the computer. Winer provides an in-depth discussion of accessing DOS and BIOS services from BASIC in Chapter 11. Finally, he covers assembly language from a BASIC programmer's perspective.

Although material in this volume is "heady," Winer has a way of injecting enthusiasm into his writing. Included with the book is a disk with source code for all the programs used, assembly routines and more, contained in three packaged ZIP files. If you're a serious BASIC programmer, you'll find plenty of value in this book.

Single-Board CPU With BASIC

The BRUTE-52 is the latest addition to Mincromint's line of embedded, networkable single-board controllers. It provides an eight-bit processor with full floating-point high-level language, optically-isolated RS-232/RS-485 communications, 56K bytes of RAM/EPROM and EEPROM memory, eight optically-isolated dc inputs, eight 12-bit A/D inputs, two D/A outputs, eight high-current output



drivers, hardware watchdog timer, and a battery-backed clock/calendar. Program development on the BRUTE-52 is accomplished by connecting a terminal and entering BASIC or assembly-language programs at the prompt.

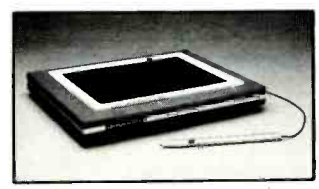
The controller uses a Micromint 80C52-BASIC CMOS processor that can be jumper selected to function as an 80C32. Additional features include an optional BASIC-52 compiler for complex jobs and code protection, and the external and clock/calendar or watchdog interrupts that are serviceable in BASIC. $329 (OEM).

CIRCLE NO. 13 ON FREE CARD

Pen-Based PC

Dauphin Technology now offers a line of pen-based handheld portable computers. These are designed to use an electronic "pen" in place of a keyboard or mouse to enter commands and text into a computer. There are currently two models in the line. Both are 80386SX machines. One comes with 1M of user RAM, flash memory and multiple operating systems in a unit that weighs just 4.4 lbs. with battery. The other model comes with a 60M hard disk, 4M of user RAM, flash memory and ports for an extended keyboard, mouse, floppy drive and external video display monitor.

Specifications for both systems include: 20-MHz 386SX CPU; 1M (expandable to 2M) of flash memory; 1M (expandable to 2M or 4M) user DRAM; 640 × 480 VGA with 16 shades of gray display resolution; two serial and one parallel ports; save and standby modes; 4 hours typical operation on full battery charge; ac/12-volt dc automotive/battery powering



options. The machines support LANs with option cards, as well as external peripherals and disk drives. Dauphin also says it plans to offer a radio modem option that will let the user send or receive data anywhere in the world. 13.2"W × 10.6"D × 1.1"H dimensions.

CIRCLE NO. 12 ON FREE CARD

Boot Configuration Utility

Version 1.6 of *Bootcon* from Modular Software Systems offers up to 26 different system configurations during the boot process. These can include any combination of device drivers, GUIs, memory managers and TSRs. Version 1.6 includes a syntax checker and an automatic boot utility, as well as being compatible with MS-DOS 5.0. It requires at least one floppy disk drive and DOS 3.1 or later. $60.

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CAD Program

CADAM, an IBM Company, released version 3 of *IBM CAD* and *IBM CAD/Plus* that include a 300% increase in display performance for large drawings, associative dimensioning and layers. The software packages now support the new IBM CAD Raster Processing option that enables users to scan paper drawings into *IBM CAD* files that can be edited, stored, plotted and converted to vector geometry. As drawings are edited, dimensions associated with the revised geometry can be updated automatically. Users can now assign geometry to separate sets and layers of a drawing where they can be displayed one at a time or in varying combinations. Display speed is improved by maximizing use of a built-in display list and limiting display threshold for small geometry.

A new menu system supports networking, path and hardware configurations for different user names, *OS/2 Presentation Manager* and multiple user configurations. *IBM CAD/Plus* extends the software function to include the CADForth program generator, a programming facility that enables companies with application-specific solutions to seamlessly add functions, modify menus and customize their programs. $1,595, *IBM CAD*; $2,295, *IBM CAD/Plus*, $2,295.

CIRCLE NO. 15 ON FREE CARD

Color Notebook

Epson's new 25-MHz color notebook computer uses Metal Insulator Metal (MIM) active-matrix technology and Intel's 25-MHz 386SL microprocessor. MIM technology creates high-contrast, high-resolution LCDs virtually identical in quality to thin-film transistor active-matrix LCDs, which are more difficult to manufacture. The unit features a 9" LCD and 4M of RAM (expandable to 20M). The display provides 256 simultaneous colors with an extended palette of 4,096 colors. Among options for the product line are a desktop expansion unit and 9,600-bps internal data modem with FAX send and receive capability.

CIRCLE NO. 16 ON FREE CARD

Tips & Techniques for the Electronic Hobbyist

By Gordon McComb
(Tab Books. Soft cover. 273 pages. $17.95.)
This is an excellent book for someone just starting out in do-it-yourself electronics. If you have a few projects under your belt, there 's little here for you. Pass it by.

Topics covered include setting up a bench, selecting tools, buying parts, learning to solder, reading schematics and so on. You'll also find information on batteries, component identification, IC pinouts and more. Finally, there are a number of simple projects for you to try. McComb presents technical material in an easy-to-understand manner. Highly recommended for the rank beginner.

Math Coprocessors

Specialty Development Corp. (SDC) has three new additions to its line of high-performance math coprocessors. The ULSI MathCo US83S87-16, US83S87-20, and US83S-25 math coprocessors are fully functional with the Intel and AMD 386SX processors. Each chip carries a lifetime warranty and a 30-day "end user" money-back guarantee. US28S87 products are made from high-performance double-metal CMOS sub-micron technology packaged in a 68-in PLCC housing. This deign features the innovative automatic sleep mode that permits the chip to shut off when not in use, extending battery-life for portables. $380 to $480.

CIRCLE NO. 17 ON FREE CARD

(Continued on page 84)

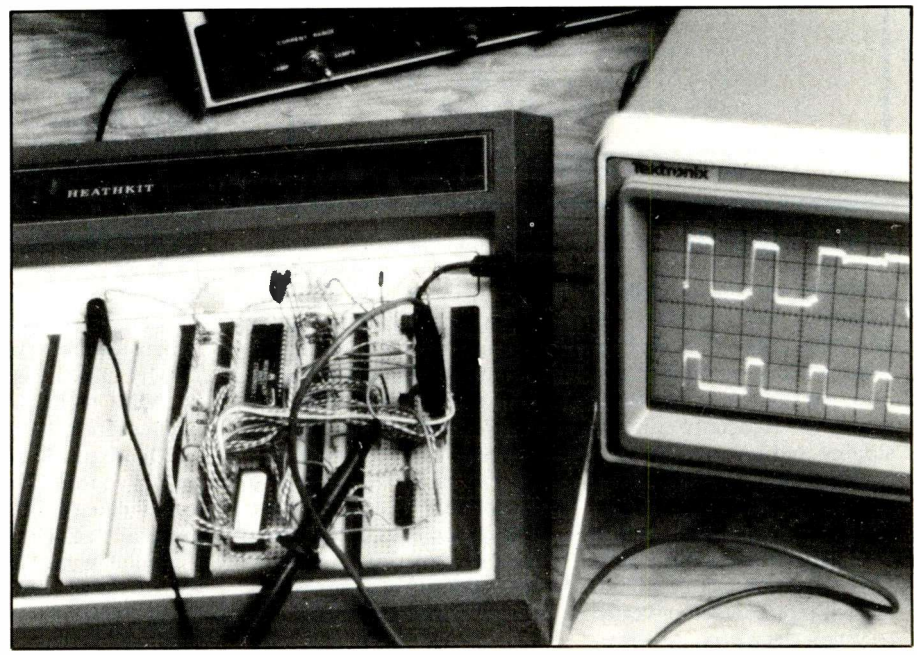
Experimenting With Motorola's 68HC11 True Single-Chip Computer

Part 1

An introduction to building a simple, inexpensive and expandable single-board computer that even has a built-in thermometer with binary display

Motorola's growing family of 68HC11 true eight-bit single-chip computers are loaded with features that experimenters and project builders should find extremely attractive. For starters, there are currently seven different versions of these chips, each available in about four different versions that differ from each other principally in their methods of packaging (40- or 48-pin plastic DIP and 44- or 52-pin PLCC surface-mount). There's even a 16-bit version, the 68HC16. Enormous selection is only the beginning. For example, the 68HC11 has a unique EEPROM-based user-modifiable CONFIG register that provides up to 16 variations of every version in the family.

This first installment of our series sets the stage for building an inexpensive, expandable single-board computer based on an 68HC11 chip. To avoid confusion, we focus in these articles on the "A" series of 68HC11 chips. This first installment introduces the basic details of the particular chip we'll be using throughout this series and provides you with the schematic diagram for a basic working 68HC11 circuit you can use to familiarize yourself with its operation. Part 2 will discuss the circuitry of the actual project that is the ultimate aim of this series, while Part 3 will finish up with construction and use of the single-board computer.



The Basics

The 68HC11 series is loaded with features. All chips in the series use low-power HCMOS technology, and each has built in 8K of ROM, 512 bytes of EEPROM and 256 bytes of RAM. Each also has an enhanced 16-bit timer system with three input-capture and five output-compare functions, an eight-bit pulse accumulator, SCI, SPI, eight-channel/eight-bit A/D converter and real-time interrupt. Additionally, the chips include a COP (Computer Operating Properly) watchdog system and an Illegal Opcode Trap that provides a crude but effective way of bringing back a runaway MCU to initial startup state. The COP system provides a backup to the Illegal Opcode Trap.

The 68HC11 series is upward software compatible with the 6800/6801 series of microprocessors. Rounding out the features of this family are: two 16-bit index registers, multiply and divide instructions, bit manipulation and a stop (low-power) mode.

Say You Saw It In ComputerCraft

For this series, we use the 48-pin MC68HC11A1P chip in a DIP package (Table 1 lists pinout details). This physically rugged chip is easy to test and handle. It's also easy to design and make a printed-circuit board for and is able to be used in a solderless breadboard without the need for an adapter.

On the negative side, the 48-pin package limits the 68HC11's capability to only four A/D channels (the smaller, lower-cost 52-pin PLCC version has eight channels). The A1 version has an on-board ROM that isn't usable due to a defect or the fact that it contains a control program for a commercial product.

Though you might initially be intimidated by the chip's many features, bear in mind that few, if any, applications make use of all of them. Moderate price makes the 68HC11 a shrewd choice if you make use of just one of its internal peripherals (A/D converter, EEPROM, etc.). If you use half of the peripherals, total cost of a project can be a small fraction of what you'd have to pay for individual peripheral chips.

While the 68HC11 has an abundance of features, two are notably absent. There's no reliable built-in automatically controlled reset capability nor is there a built-in real-time clock with ultra-low current backup mode. Though the 68HC11 has a built-in power-on reset, it still requires an automatic means of forcing low the RESET line when the chip is powered by less than the 4.5-volt minimum.

Motorola's *M68HC11 Reference Manual* contains more than 460 pages that primarily concern the "A" series of chips, but it isn't complete. Motorola has published numerous application notes and other bulletins on the HC11 to supplement the manual. Because few electrical specifications are included in the manual, you must refer to a separate Technical Data Book for such details.

The 68HC11's instruction set is a superset of the 6801/6803 instruction set that, in turn, is a superset of the 6800/6802/6808 series. Thus, most programs written for any of these other chips will work with the 68HC11, though programs written for the 68HC11 probably won't work for these earlier chips. Despite its ap-

Table 1. MC68HC11A1P Pinout Details

Pin	Label	Description
1	PA7/PAI/OC1	Bit 7 of Port A—General-purpose input or output pulse accumulator
2	PA6/OC2/OC	Bit 6 of Port A—General-purpose output/output compare 2
3	PA5/OC3/OC1	Bit 5 of Port A—General-purpose output/output compare3
4	PA4/OC4/OC1	Bit 4 of Port A—General-purpose output/output compare 4
5	PA3/OC5	Bit 3 of Port A—General-purpose output/output compare 5
6	PA2/IC1	Bit 2 of Port A—General-purpose input/input capture 2
7	PA1/IC2	Bit 1 of Port A—General-purpose input/input capture 3
8	PA0/IC3	Bit 0 of Port A—General-purpose input/input capture 3
9	PB7/A15	Address line A15
10	PB6/A14	Address Line A14
11	PB5/A13	Address line A13
12	PB4/A12	Address line A12
13	PB3/A11	Address line A11
14	PB2/A10	Address line A10
15	PB1/A9	Address line A9
16	PB0/A8	Address line A8
17	PE0/AN0	Bit 0 of Port E—General-purpose input/A/D channel 1
18	PE1/AN1	Bit 1 of Port E—General-purpose input/A/D channel 2
19	PE2/AN2	Bit 2 of Port E—General-purpose input/A/D channel 3
20	PE3/AN3	Bit 3 of Port E—General-purpose input/A/D channel 4
21	VRL	Low reference voltage for A/D converter; typically connects to ground
22	VRH	High reference voltage for A/D converter; maximum is V_{DD} + 0.1 volt
23	Vss	Ground
24	MODB/VSTB	Dual-purpose pin sets operating mode (when high, mode is single-chip or expanded multiplex; when grounded mode is test or bootstrap; when high, is used as input for RAM standby power
25	MODA/LIR	Dual-purpose pin sets operating mode (high sets expanded multiplexed or special test; grounded selects single-chip or special bootstrap mode. In single-chip or special bootstrap mode, address and data buses are disconnected from external pins (become invisible). LIR signal aids in program debugging
26	STRA/AS	AS—Address strobe signal
27	E	Enable signal
28	STRB/ R/W	R/W signal (Data bus direction indicator)
29	EXTAL	Connects to crystal (also external clock input)
30	XTAL	Connects to crystal
31	PC0/AD0	Multiplexed A0/D0 line
32	PC1/AD1	Multiplexed A1/D1 line
33	PC2/AD2	Multiplexed A2/D2 line
34	PC3/AD3	MULTIPLEXED A3/D3 line
35	PC4/AD4	MULTIPLEXED A4/D4 line
36	PC5/AD5	MULTIPLEXED A5/D5 line
37	PC6/AD6	MULTIPLEXED A6/D6 line
38	PC7/AD7	MULTIPLEXED A7/D7 line
39	RESET	Reset signal line
40	XIRQ	Non-maskable Interrupt
41	IRQ	Interrupt request
42	PD0/RxD	Bit 0 of Port D—General-purpose I/O; also Receive Data input for SCI
43	PD1/TxD	Bit 1 of Port D—General-purpose I/O; also Transmit Data output for SCI
44	PD2/MISO	Bit 2 of Port D—General-purpose I/O; also master in/slave output for SPI
45	PD3/MOSI	Bit 3 of Port D—General-purpose I/O; also master out/slave in for SPI
46	PD4/SCK	Bit 4 of Port D—General-purpose I/O; also serial clock signal for SPI
47	PD5/SS	Bit 5 of Port D—General-purpose I/O; also slave-select input for SPI
48	V_{DD}	+ 5-volt power input

parent similarity to these other chips, the 68HC11 uses HCMOS technology for low-power operation, not the NMOS technology used in earlier chips. Also, while the older chips don't operate with a slow clock speed, the 68HC11 will operate down to dc for potentially extremely low power consumption. This makes it ideal for battery-powered applications. Maximum clock speed of 2.1 MHz means an 8.4-MHz crystal can be used with the 64HC11's internal divide-by-four clock circuit.

The CONFIG register makes the 68HC11 unique. With the earliest chips, if reset wasn't functioning perfectly, the CONFIG register could be changed by turning off and on power. If the CONFIG register isn't what its supposed to be, you have problems. It's possible to "fix" a bad chip if its only trouble is a corrupted CONFIG register (see the Note at the end of the Parts List for availability of a simple program that usually will reprogram the CONFIG register to its original state).

CONFIGUR conveniently configures the chip for specific system requirements. A 1 placed in Bit 0 activates the internal EEPROM; a 1 in Bit 1 activates the internal ROM (because in this application, you don't want to do this, make sure a 0 is in Bit 1); and a 0 in Bit 2 activates the COP Watchdog System. Except for unusual circumstances, Bit 3 should have a 1 (No Chip Security). The other bits in the "A" family of 68HC11 chips are always programmed with 0.

For this SBC project, you want no security, COP or ROM, but you want to use the EEPROM. Hence, the CONFIGUR register of the MC68HC11A1P should come from the factory with 00001101 or 0D in hexadecimal. Though you can change this, the CONFIGUR register, located at address $103F, is considered to be semi-permanent since it's implemented with EEPROM cells that require a special procedure (but not special equipment) to reprogram.

The 68HC11's four operating modes are: normal expanded multiplexed mode (the "normal" mode we'll deal with), single-chip mode (program memory is on-chip), special test mode (used for special operations like testing and programming the CONFIG register) and Special Bootstrap mode (enables easy communication with the chip through its SCI and permits jumping directly into EEPROM after reset, among other things). The SBC that's the subject of Parts 2 and 3 of this series permits use of any of these modes.

While it's possible to use the SBC in single-chip mode (for example, you can substitute the MC68HC11A8P1 with BUFFALO monitor in ROM for the ROM-less MC68HC11A1P), most of our discussions will describe the expanded multiplex mode or the special test mode.

To keep confusion to a minimum, pin description assumes that the 68HC11 is operating in normal expanded multiplex mode or special test mode. When the chip is operated in single-chip or bootstrap mode, the address and data buses aren't connected to external pins and, thus, are invisible to external test equipment.

Comparing 68HC11 to 6800 In Expanded Multiplex Mode

In general, the 68HC11 is simpler to design with than was the progenitor 6800. The exception is that the 68HC11 uses a multiplexed data/address bus. There's no real problem though, because a single 74HC373 provides the necessary demultiplexing. An advantage to this is that the 74HC373 provides buffering for address lines A0 through A7. Be aware though that not every manufacturer's 74HC373 will work here. Motorola's MC74HC373AN does and most others probably will.

The 68HC11's E (enable) output is equivalent to the 6800's phase-2 clock. Gone are 6800's phase-1 clock, VMA, TSC, DBE, HALT and BA signals. The 68HC11's AS (address strobe) signal is used as an active-high latch-enable to an external address latch, typically a 74HC373.

One of the trickiest signals to use in this MCU is RESET. On the surface, it looks the same as the RESET signal on the 6800, since both are low-to-high signals that trigger the MPU/MCU to a known start-up state. In the 6800, the only trick to this input pin is that it must be held low for at least eight clock periods after V_{DD} reaches 4.75 volts.

The 68HC11 no longer has the above requisite. Nonetheless, it has

→ f.82

Fig. 1. Complete schematic diagram of a simple circuit that can be breadboarded to use for experimenting and familiarizing yourself with the 68HC11. Circuit requires a regulated 5-volt dc power source capable of delivering 200 mA or more.

PARTS LIST

Semiconductors
LED1—low-power, high-efficiency light-emitting diode (see text)
U1—MAX690 (Maxim)
U2—MC68HC11A1P (Motorola)
U3—74HC373 (see text)
U4—27128 or 27C256 EPROM (see Note below)
U5—74HC00

Capacitors
C1,C7,C8—0.1-μF ceramic disc
C2—10-μF, 15-volt electrolytic or tantalum
C3—1,000-pF ceramic disc
C4—0.01-μF ceramic disc
C5—5-pF ceramic disc
C6—15-pF ceramic disc

Resistors (¼-watt, 5% tolerance)
R1 thru R13—4,700 ohms
R14—1,200 ohms
R15—10,000 ohms
R16—10 megohms

Miscellaneous
XTAL—3.6864- or 4-MHz crystal
Solderless breadboard; 5-volt dc, 200-mA regulated power supply (see text); wires for jumpers; etc.

Note: The following items are available from Magicland, 4380 S. Gordon, Fremont, MI 49412: PC-compatible software disk with all software mentioned in this series of articles, including MAG-11DIAG, in both assembly language and S-file format suitable for use with many EPROM programmers, $7.50 for 5¼" disk (No. 6811ME-5) $10 for 3½" disk (No. 6811ME-3). Also available are programmed 27128 EPROMS, $12 each (No. CONFIG-0D/E for program to fix a bad CONFIG register, No. CONFIG-09/E for program to enable COP watchdog system, No. TEST6811/E for TEST6811 firmware and No. MAG-11DIAG/E for diagnostic/instructional EPROM with binary thermometer); MC68HC11A1P, $25; AD690CPA, $9; MC74HC373AN, $1 and 74HC00, 50 cents. (Set of MC68HC11A1P, AD690CPA, MC74HC373AN, 74H00 and 27128 with TEST6811 firmware (No. BREADBD-6811), $39.50. All prices postpaid.

For information on obtaining the M68HC11 Reference Manual (M68HC11 RM/AD), technical data on the 68HC11 and other pertinent Motorola product and data information write to: Literature Distribution Center, Motorola Inc., P.O. Box 20924, Phoenix, AZ 85036-0924.

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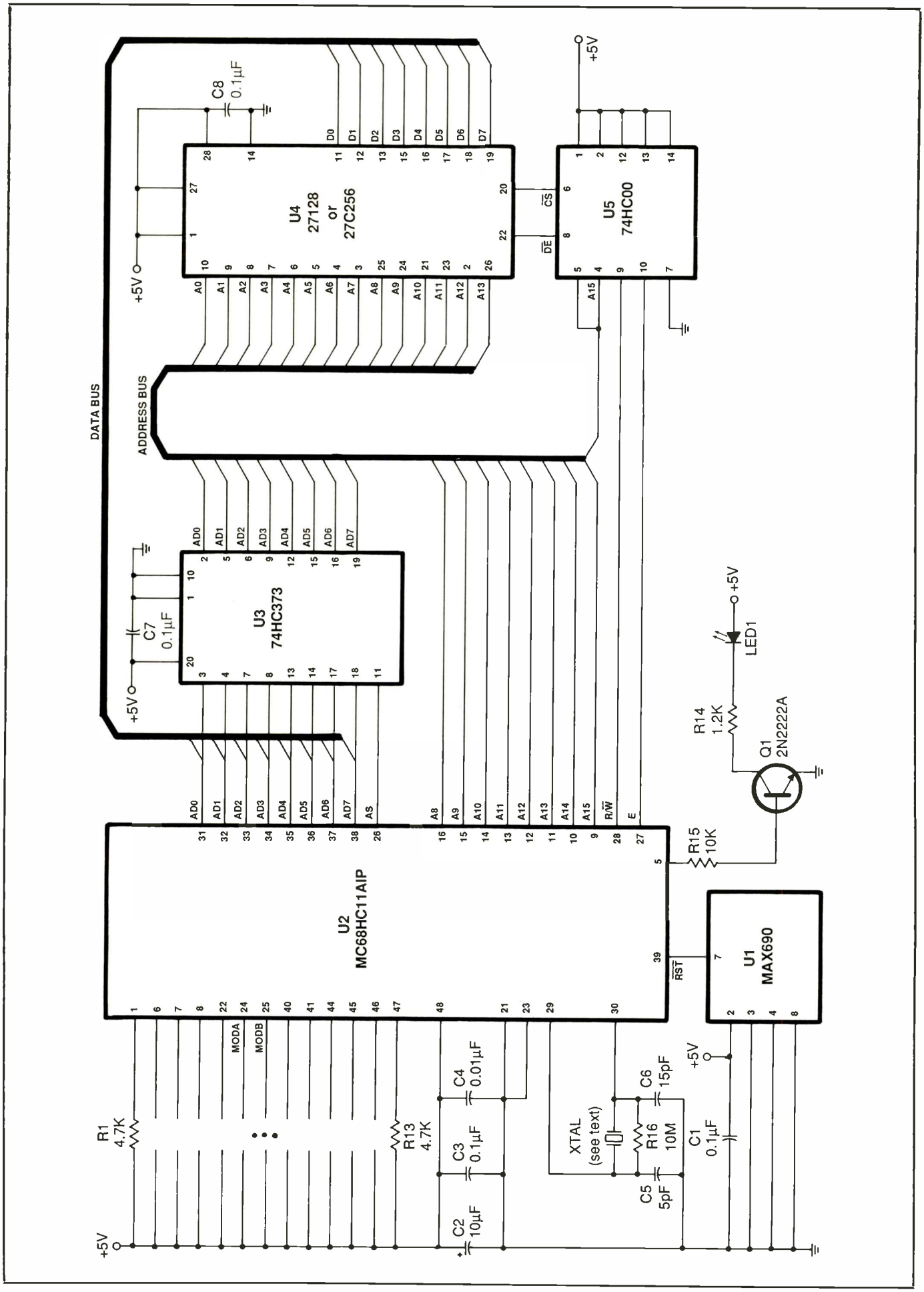
DATA BUS
ADDRESS BUS
U4
27128
or
27C256
U5
74HC00
U3
74HC373
U2
MC68HC11AIP
U1
MAX690
C8
0.1µF
C7
0.1µF
C1
0.1µF
C2
10µF
C3
0.1µF
C4
0.01µF
C5
5pF
C6
15pF
R1
4.7K
R13
4.7K
R14
1.2K
R15
10K
R16
10M
XTAL
(see text)
LED1
Q1
2N2222A
+5V
MODA
MODB
RST
R/W
E
AS

Disk and Memory Caches

How caches perform their tricks to speed up data retrieval

The dictionary defines a cache as a secret hiding place or the valuables hidden in that place. If you change "valuables" to "data," you have the basis for understanding what a cache does in a computer. You may have several different caches in your computer, but because they're hidden, you rarely can tell if they exist or not.

Caches are generally used to make a hardware device appear faster than it really is or to relieve a bottleneck between devices that operate at different speeds. Your computer can move bits around in memory much faster than a hard drive can store or retrieve bits, for example; so a cache is often used to make the hard drive appear faster. The same is true for memory caches, which make relatively slow memory chips appear to be as fast as advanced CPU chips like the 386 and 486. A by-product benefit of a cache is that the hard disk does less work, reducing wear and tear.

A cache is really just a specialized form of buffer with some added circuitry or software to make it invisible to the rest of the system. To understand how a cache or a buffer can help a program, consider this chunk of a program that copies a file. It's written in C, but should be understandable even if you don't know the C programming language:

```
while((b = fgetc(input_file)) != EOF)
    fputc(b, output_file);
fcloseall();
```

All this program fragment does is read a byte from the input file into a variable called "b." If it reads a valid byte, it writes that byte to the output file. When the read fails, presumably because there are no more bytes in the input file, the program then closes all open files.

In its pure form, this fragment will work but will be terribly slow. To copy a 200K file from one location on your hard disk to another, the program will have to make 204,801 calls to the read routine, fgetc(), and 204,800 calls to the write routine, fputc(). Without even worrying about the overhead needed to manage the disk's File Allocation Table (FAT) and directories, those three short lines will cause the read/write heads on your hard drive to move 409,600 times. Each time, the disk will have to wait until the appropriate location appears under the heads, perform the read or write and then return to your program.

Actually, the situation is worse than this because the program would have to make 409,601 calls to DOS, which would make the same number of calls to the hard disk BIOS, which would make at least that many calls to the hardware controller board. If you think of bytes in the file as a stack of papers that you have to mail across the country, the program mails each one in a separate envelope on a separate day. It will take over 560 years to mail the entire stack.

"Disk caches created in software use a portion of your computer's RAM as a buffer."

To avoid interminable delays, most languages use buffered input and output. Your program may appear to be transferring one byte at a time, but behind the scenes it's actually reading a buffer full of data at once and writing a buffer full at once. If each buffer is 1K bytes long, the program fragment above will only call DOS for 200 reads and 200 writes, or a total of 400 times. Buffering should increase the program's speed by nearly three orders of magnitude since the process of transferring bytes from one buffer to another is very fast compared to individual DOS calls and hard-disk seek operations.

If you move the buffering process out of the program and into the computer's hardware or system software, and if you "hide" the buffer so that it can't be directly addressed, you have a disk cache. No matter how you read and write to the disk, the cache buffers the data for you in order to make your system seem faster.

Disk caches created in software use a portion of your computer's RAM for a buffer. Depending on the cache software and options you select, the cache can be in the DOS memory space, in EMS memory or in extended memory. In contrast, hardware caches, often incorporated into the disk controller card, use their own RAM. Whereas a runaway program could overwrite a software cache's buffers and destroy some data, a hardware cache is outside the CPU's address space and can't be hurt by any program actions.

Another advantage of the hardware cache is that it's generally faster than a software cache because it can carry on its activities while the CPU is busy running your program and performing calculations. The hardware cache is controlled by its own microprocessor and doesn't depend on the computer's CPU at all.

Disk caches use two different strategies to speed up disk operations. They can keep each sector of data available in memory as long as possible so that repeated reads of the same data will be faster. This is the way DOS works when you create disk buffers with the

BUFFERS = command in your CONFIG.SYS file. If you reread the same information (for example, a disk's File Allocation Table or a directory), the second read is much faster than the first because it comes from memory, not from the disk itself.

A second strategy is based on the observation that many programs read data in sequential order. When a program requests data from disk, a cache using this strategy will read more data than requested—perhaps a whole track in a single gulp—to speed up future requests.

Reading data from a disk and holding it to speed up future data requests is relatively easy. A cache has a more difficult time when a program writes data back to the disk. The cache may update its own copy of the data and the data on disk also, or it may just abandon its copy as inaccurate when the disk copy is changed. Many software caches use a "write-through" algorithm, which means that they update both copies of the data immediately. Accordingly, the process of writing data to disk may be slower with a cache installed than without one because of this double-updating.

Some software caches hold changed data in memory and write it to disk when the computer is idle or when the holding buffer is full. This strategy speeds up disk writes, but it also introduces an element of danger. If you turn off your computer or reboot while data is still in the cache waiting to be written to disk, that data will be irretrievably lost.

Most hardware caches use write-through algorithms, but some use a delayed write. Delayed writes are more common in controllers designed for the huge hard drives that are normally in network servers. They're considered safe in such situations because the server is most likely attached to an uninterruptable power supply (UPS) to avoid disasters during sudden power failures. If you have a delayed write-through disk cache in your personal computer, either in hardware or software, make sure that you don't push the RESET button or hit the POWER switch for a couple of seconds after disk activity stops.

There's one vital difference between hardware and software caches that's seldom mentioned. Some software caches work on a file-by-file level. If they read ahead, they do so in the same file wherever it may be on the disk. Other software caches, as well as all hardware caches, work on sectors and tracks and have no idea that the hard disk is divided into files.

For a read-ahead cache to work efficiently, especially one that works with sectors and tracks, your files must be unfragmented. If pieces of a file are scattered all over your disk, the cache will slow you down as it takes time to read ahead on each track. Keeping your files defragmented is even more important with a cache than it is without one.

In theory, there's little to choose between caches. What distinguishes one from another is the amount of memory allocated to the cache and the algorithm used to select what will be overwritten as new data enters the cache. When data can be read from the cache instead of from the drive, the cache has scored a "hit." When data must come from the drive itself, the cache has "missed" predicting what data will be needed next. Some misses are obviously inevitable, but the sign of a good cache is how often it scores a hit and thereby speeds up your file read operations.

It's easy to create a cache if unlimited memory is available: simply read the entire hard disk into the cache and there will never be another cache miss. But unlimited memory is impossible. So cache designers have to decide how to drop data from the cache when new data is read from disk. One popular method is to keep track of how recently each piece of data (a track or sector, for example) has been requested and to drop the least-recently used (LRU) data when more data is read into a full cache. Another popular method is to keep track of how often each piece of data has been read from the cache and to drop the least used (LU) data. A good cache uses a combination of these two techniques.

Because of the different algorithms used, different caches work best with specific kinds of files and applications. A strict read-ahead cache works best if your applications often read an entire file into memory (like most spreadsheets do) before operating on it. An LRU cache might work best if you do a lot of text editing with very large files. And an LU cache might help batch files execute more quickly.

Don't confuse disk caches with programs like the FASTOPEN utility distributed with some versions of DOS. FASTOPEN doesn't cache disk data. Rather, it caches information about the location of subdirectories and files in those directories. FASTOPEN speeds up file access time by avoiding the normally slow process that DOS must go through to find a file that's several layers deep in the subdirectory tree or near the end of a long PATH setting. FASTOPEN works like an LRU cache, but it doesn't keep file data, only the information about file locations.

RAM Caches

A disk cache provides an interface between a relatively slow disk drive and much faster RAM. It's an attempt to relieve the inevitable bottleneck that results when one device is much faster than another.

With the advent of 386 and 486 computers, the CPU has become much faster than the dynamic RAM (DRAM) chips that make up the computer's user memory. Every RAM access for data or the next machine-language instruction normally requires the CPU to sit idle in a wait state while the appropriate data is fetched from memory and put on the data bus.

The CPU must constantly use memory, storing data or retrieving both data and instructions. If it has to sit and wait during each memory access, a fast CPU will spend much of its time idling instead of computing.

One way around this bottleneck is to use faster RAM. But there aren't DRAMs available that can keep up with a really fast CPU. You can buy static RAM chips (SRAM) that are fast enough to keep up, however. They're comparatively expensive, though, and take up a lot more room inside the computer.

The solution used by most manufacturers is an SRAM cache and controller. The cache controller is a dedicated microprocessor that runs the cache. It intercepts every CPU memory access. If the CPU is reading memory, the cache controller fulfills the read from the cache if possible. If not, the requested data is placed on the data bus for both the cache and the CPU at the same time. If the CPU is writing to memory, the cache control-

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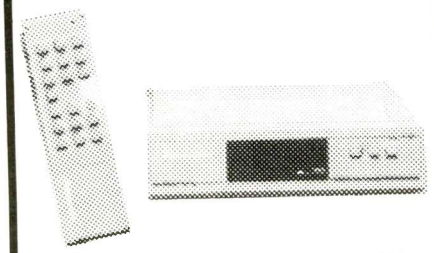

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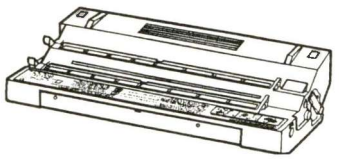

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ler updates its own data but lets the data go directly to normal RAM. Memory caches are usually implemented as write-through to avoid problems with memory-mapped devices like video cards and some math coprocessors. The controller either updates its own version of the same memory block or it marks its version as invalid.

Most memory cache controllers work by copying a small block of data, usually 16 bytes, from normal memory into the cache. The controller places information about the block into the cache, including the block's memory address. During each CPU memory access, the controller has to search the cache to find if the block is in the cache so that it can update it or place the necessary information on the CPU's data bus.

The cache controller also has to keep track of what blocks to release in what order and whether each block is valid or invalid (because the CPU has changed the data held in memory). The cache controller obviously has a lot of work to do. It must be able to search the cache and supply data faster than normal DRAMs and do a lot of housekeeping also. Some of the housekeeping can be scheduled during the lulls while the CPU is busy with internal calculations.

". . . bigger isn't always better."

A cache can improve the performance of a 20-MHz 386 and is vital on faster 386 computers. Though the size of the cache affects the computer's performance, bigger isn't always better. It's impossible to give precise figures for cache performance because the type of programs you use has a huge effect on the efficiency of the cache. A program that reads and writes lots of data from widely distant parts of memory and that has a lot of small subroutines may not benefit from a cache nearly as much as a small program with tight loops and relatively few data accesses.

In general, though, a 64K cache seems to provide the best performance for the cost. A 128K cache may be slightly faster, but not twice as fast because of the overhead the cache controller faces. Larger caches can actually slow down the computer. On the other hand, a slowdown can occur if files are larger than the cache capacity. (Intel's new 50-MHz 486DX has a 256K on-board cache to minimize memory bus traffic.)

The 486 CPU has its own 8K cache inside the chip. Many manufacturers of 486 computers add a secondary external SRAM cache. The design of a cache controller for a 486 computer is complicated by the added cache inside the CPU, since data can be stored in the CPU's cache, in an SRAM cache or in normal DRAM memory. What data should be stored where? And what algorithm should the cache controller use when it has to replace data in the SRAM cache? Some of the answers are more guesses, backed up by benchmarks, than pure engineering decisions because of the large variations in the ways various programs and operating systems use memory.

Using a Cache

Because a cache is "hidden," neither you nor your software should ever be aware of it. Disk controller and motherboard SRAM caches do all their work without any intervention. You simply turn on the machine and the cache is working, speeding up disk or memory operations.

Some disk controllers have a switch that enables and disables caching, and you may be able to increase the size of the disk cache by adding memory chips to the controller board. You might want to disable the cache for a day and see what effect it has on your system, or increase the cache memory to the maximum the board will support to wring out the best performance possible of your machine.

Motherboard caches are less flexible. A caching motherboard is usually shipped with the full amount of SRAM allowable. There may be a switch on the motherboard that turns off the cache so you can experiment and perhaps run some benchmarks with the programs you normally use. Otherwise, a memory cache takes care of itself.

A software disk cache is more difficult to use intelligently. In general, the more memory you devote to the cache, the faster your disk system will run. On the other hand, you'll prob-

ably want to reserve as much memory as possible for your application programs. You'll have to watch your system carefully to balance the needs of your applications and the cache.

Cache programs like Microsoft's SMARTDRV.SYS and Central Point's PC-Cache (part of *PC-Tools*) let you set the amount of memory that the cache will use. Both programs let you choose between expanded (EMS) and extended memory for the disk cache; PC-Cache can also run in conventional (DOS) memory.

Other software cache programs available include *Norton Utilities*, *VCache* (Golden Bow Systems), *Cache 86* (Aldridge Co.) and *Mace Utilities*. Also, the Reference disk that comes with many IBM PS/2 models includes a cache program, IBM CACHE.SYS.

Unless the applications you run have very modest memory requirements, you probably won't want to use conventional memory for a disk cache. Otherwise, use whichever type of memory seems most convenient on your computer. The cache may run faster if it uses extended memory on a 386 or 486 computer; some older 80286 computers are extremely slow when they access extended memory and should stick to expanded memory for a cache.

Again, an important factor to make your cache run at top speed is to keep your files unfragmented. You can use a program like Central Point's Compress (distributed with *PC-Tools*), *Norton Utilities*' Speed Disk or the shareware *DOG*, among others. Whatever program you choose, use it often and your hard disk, and cache, will be able to run at top speed, with fewer pauses while the heads move from track to track.

"... an important factor to make your cache run at top speed is to keep your files unfragmented."

Final Thoughts

If your hard-disk's activity light goes on a lot while you're working, you'll likely benefit from a cache of one sort or another. You get a free one with DOS, of course, although it's on the slow side compared with other software cache programs.

Do keep in mind that a cache won't speed things up noticeably if most of your work is for word processing (unless you switch back and forth with other applications). It can speed things up considerably, though, with programs that frequently or extensively access the hard disk, such as database, desktop publishing and CAD programs.

When set up with a cache, tread carefully when using a disk-optimizing program. Scrutinize its manual to see if there are any problems lurking. It might be necessary to disable a cache file before defragmenting a hard disk.

Finally, you can choose a software cache, a hardware cache... or both. Software costs less than hardware, typically $100 versus $600. For software to perform as fast as caching controllers, though, you'll have to add memory equivalent to what it has. Even here, caching controllers are preferred for network users due to the additional capabilities the more sophisticated ones have, such as mirroring, which provides continual data backup, and a separate CPU, which leaves the system CPU free from caching tasks. Don't be fooled by so-called caching controllers that don't have cache logic and a CPU. These are really look-ahead buffers with, say, 16K or more built-in RAM.

Once you have a cache installed, you should rarely, if ever, have to think about it. Neither a disk cache nor an SRAM cache is required to keep your computer operating, but both can help you obtain the highest possible performance from your machine. Like a well-tuned engine and properly inflated tires on your car, they can make your computing life much more enjoyable. ■

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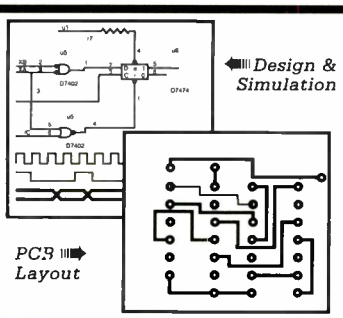

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PC Image Acquisition
Part 2, Conclusion

Evaluating four software packages that make it possible for image-capture hardware to work with your computer

Last month, we discussed the hardware needed for capturing images for immediate view and later use. This time around, our focus is on the software needed to use the image-capture hardware already discussed.

Image-Integration Software

Once you've digitized video images, they're ready to be used in numerous off-the-shelf applications. There are several instances where you might want to use these "videographs" in your own custom applications or incorporate them into databases, reports or whatever. Here are capsule review of four of the better packages available to make the most of your captured video images:

Database Graphics Toolkit (dGT), $295
Blackhawk Data Corp.
307 N. Michigan Ave., Suite 1008
Chicago, IL 60601
312-236-8473

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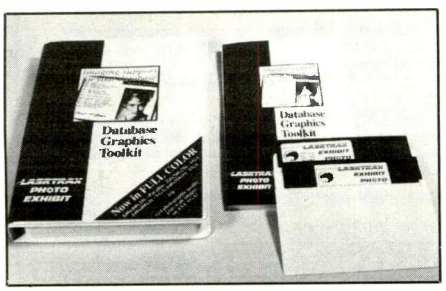

System Requirements: PC, XT, AT, PS/2 or true compatible; MS- or PC-DOS 2.11 or later; EGA/VGA/Super VGA video; any DBMS or other application capable of executing a DOS command; HP Laserjet or compatible printer.

Another high-powered, professional-level image-support package, *dGT* consists of three main components, as well as a host of utilities. A "photo" module projects a miniature color or gray-scale image over a portion of a text-mode screen. An "exhibit" module is a full-screen viewer that displays a full page of text on a standard video monitor with anti-aliasing and high-speed hardware panning. A "lasertrax" module outputs excellent (presentation-quality) hard copy from virtually any screen for printout with a laser printer.

Support for *dBASE III+*, *dBASE IV*, *dBXL*, *Clipper* (Summer '87 & 5.0x) and *FlexFile* for *Clipper*, *FoxBase* and *FoxPro* is provided, as well as a new pre-linked API library for *FoxPro* 2.0.

Images stored in .PCX, .PCL (HP LaserJet), .GIF (Compuserve) or .SCX (Rix SoftWorks) formats can be accommodated. Documentation is excellent and, using the various modules as stand-alone programs or invoking them from within other applications, is fairly easy and well-explained in the manual. However, due to the power of the package and advanced nuances of the applications, a programming background will enable you to get the most from it.

Image Database Tools, $100
IDEC, Inc.
1195 Doylestown Pike
Quakertown, PA 18951
215-538-2600

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System Requirements: PC, XT, AT, 386 or 486; DOS 2.1 or later; parallel port; 384K base memory; VGA display; HP-compatible laser printer.

This software package is designed specifically as an enhancement product for IDEC's video capture devices reviewed earlier. It consists of four main program modules that allow you to capture, display, print and compare images. A "compare" utility is particularly interesting since it enables a two-image comparison from files or a live image compared to a file image, which can be very handy for employee identification and other such comparisons.

These executable utilities can be run in stand-alone mode or invoked from within other applications like *dBASE* (using the RUN command) and *FoxPro*. Constructing image databases using existing programs and techniques is simplified with these utilities. The package also includes the source code for a rudimentary image database in *dBASE* language as a programming example. It's an excellent, low-cost software add-on for users of IDEC's capture devices *only* (images captured with other devices are "clipped" when used with this software).

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$495 Standard
QuickPix; $99,
QuickPix Viewer
PowerSoft, Inc.
P.O. Box 956338
Duluth, GA 30136
404-446-3185

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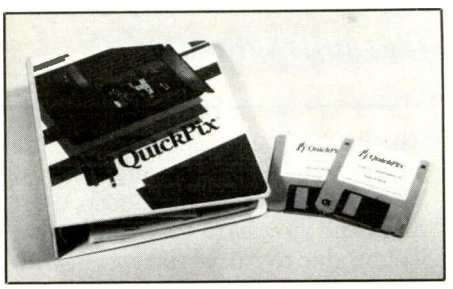

System Requirements: PC, XT, AT, 386 or 486; DOS 3.1 or later; parallel port; 640K base memory; hard disk; Hercules/CGA/EGA/VGA/Super VGA graphics card; HP-compatible laser or

(continued on page 26)

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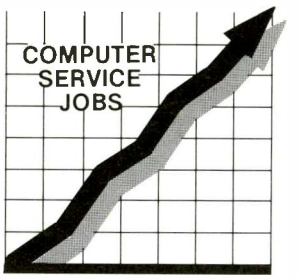

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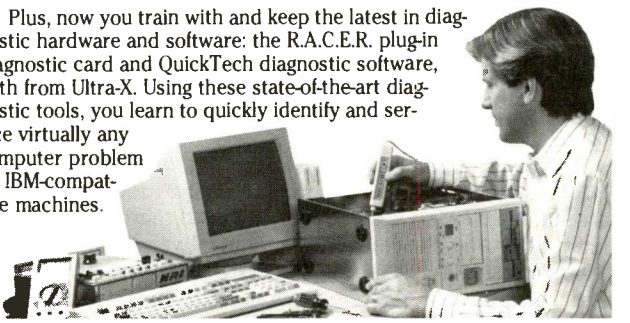

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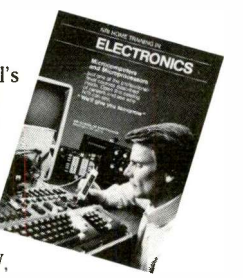

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Another Image-Capture View By SF Sparrow

Image capture is the term that describes the process of electronically grabbing an analog image and digitizing it. With a real-time device, images can be literally plucked from a moving video scene that might come from a video camera, TV broadcast signal or other video source. Afterwards, the image can be adjusted to get a variety of enhancements and stored to disk for use in such various computer applications as desktop publishing, computer art, even photographic transparencies. Lower-cost (and slower-speed) non-real-time devices do the same, but they're limited to essentially non-moving video, such as from a paused VCR.

Imaging equipment used here were Digital Vision's ComputerEyes/Pro, a non-real-time color board model that's been around awhile. It's more modestly priced than the company's latest color one, the real-time ComputerEyes/RT (list prices of $400 versus $600). Although the RT outperforms the eight-bit Pro, the latter will get the job done well enough to suit many people who will be attracted to its lower price and color capability, while foregoing frame grabbing of a moving image. For a still video source, I used the Xapshot from Canon USA. This electronic photography camera stores 50 images to its miniature computer disk. Virtually every setting is under control of its auto-flash and fixed-lens structure.

A transparency taken under studio conditions using Ektachrome slide film and a conventional camera. It is provided here as a comparison to the other photos, which are screen shots of actual captured images. Keep in mind that the resolution of a 33-mm slide like this one is the equivalent of thousands of lines of horizontal resolution.

Hardware Tips

The Pro's I/O address comes factory set for address hex 220. Users of Creative Labs' Sound Blaster should take note, however, because it has the same default address. Moreover, because some computer games look for this to access Sound Blaster, you should change ComputerEyes' address instead of changing Sound Blaster's.

A video tape recorder can be a source for decent images, of course. To do this, you must connect the VCR's video output to

A screen shot of ComputerEyes' Preview mode. Notice that the pilot image is detailed enough to be useful for checking model pose. Both models in this shot said that the pilot image was clear enough and large enough for them to monitor themselves while posing.

A screen shot of an image captured from the Canon Xapshot still video camera. Its resolution does not approach the quality of the photo at left, but it is a good image. Such images are easily taken, stored and played back.

A screen shot of an image capture from an older JVC camcorder. The image was recorded on standard VHS tape and then played back in pause mode. Notice the scratchy lines covering one mode. This illustrates what difficulty can be encountered when dealing with VCR playback, *Eyes* software was available to compensate for most, but not all, of the jitter. A VCR or camcorder with better pause circuitry might render a clearer image.

This image was captured from the same JVC camcorder used to capture the Fig. 4 image. It is of greater resolution and lacks jitter. The image was fed directly from camcorder to image-capture board, bypassing the recording medium. The skilled model froze her pose long enough to capture the image. Caution: This method may not work with children.

Free-lance models, Celina and Julie Camargo, Dallas, TX

the image board's video input. The Pro has two different inputs for this purpose: a plain RCA jack for normal composite video and a miniature DIN connector for S-video. Because the latter packs more resolution, its images tend to look better.

The most challenging problem encountered when capturing an image with ComputerEyes/Pro is obtaining a stable video image. It can take as long as 24 seconds, depending on how fast your computer is, to capture an image at its maximum resolution of 640 ×480 × 256. A 33-MHz 386 machine might take half as long. Understandably, then, any images fed to it must be steady or even frozen. To do this with a VCR, you can stop its moving video with the machine's Pause control. The image capture software that comes with the board has a special mode that helps compensate for the instability of a VCR in pause, but you'll still lose upwards of 10% of the captured image's detail.

You can use a camcorder as a source of video. You can view it as a portable VCR. Therefore, connections are similar to that of a VCR, and the caveat about using the pause mode applies. It can capture images of still objects, as well as a live subject, if the target can stand still long enough (say, a few seconds). Wherever possible, use a tripod to hold the camcorder steady. Keep in mind, too, that the image may be fed directly from the camera portion of the camcorder directly to the image-capture board, bypassing video taping.

As cited earlier, a still video camera like the Canon Xapshot, which deals with a single image at a time, is a natural input device for ComputerEyes/Pro. There's nothing to adjust; just aim and shoot. Unfortunately, there's no connection for syncing up to an external flash or other accessory, but it works well for what it was designed to provide: ease and simplicity.

Its playback resolution of 300 lines makes it a fair match for ComputerEyes/Pro. Xapshot's accessory kit contains a battery charger and most of the connecting cables needed for interfacing to ComputerEyes. Missing from the kit is an r-f unit for feeding the r-f input of TV receiver that can't accommodate composite video.

Software Tips

Any image-capture software must be flexible enough to accommodate more than one resolution for capturing. It should include utilities for image enhancement and interface control and the ability to convert to other data formats. The software for ComputerEyes is appropriately called *Eyes*. Its main menu comes up with a display of current software settings.

Eyes also informs you if the image-capture board is present and whether or not the board is receiving video input. This acts as a quick mini-diagnosis just in case there might be trouble. If *Eyes* reports that the board isn't present, power down and check the board's address setting. Be sure it's not conflicting with a SoundBlaster or some other card in your computer.

If everything looks normal, turn on the video output device. If you're using a VCR or camcorder, fast-forward to the desired scene and place the VCR on pause. Non-recording video cameras (color or black-and-white) should be targeted and focused. Still video cameras should be set to playback mode. In all cases, the software should report the presence of active video.

Maximum resolution of *Eyes* image capturing is 640 × 480 in 256 colors, as previously mentioned. Lower resolutions are supported but can be disappointing to look at. If your display system can't do 640 × 480, it's easy to get disgruntled at some of the images you get. A higher-resolution display system will help make your image-capture system really work for you. Otherwise, give some attention to your software's settings for Display Style. Judicious use of Display Style can firm up both low-resolution color, black and white, and gray-scale images.

The next step is to preview your selected scene before capturing it. A pilot image appears in the upper-right of the screen while in Preview mode. The pilot image is a real-time representation of what the board is seeing. Making changes at the image source (VCR, video camera, etc.) is reflected in Preview mode. Each time a change is made at the image source, you must wait a couple of seconds for ComputerEyes to regain image representation. (A board with frame-grabbing capability wouldn't require a settling time.)

While in Preview mode, you can manually adjust the image according to brightness, contrast, hue and saturation. Quicker and probably more accurate is to use the Auto-Calibration feature that does this for you, including palette setting. Auto-Calibrate usually renders a good image.

If the Preview looks good, proceed to capture the image. Capturing places the target image into memory. Here, the image can be enhanced or otherwise adjusted. Enhancements include size change, palette change and image orientation. This is where budding photographers can get creative. However, caution should be exercised with enhancements.

First save the image to disk because enhancements are permanent. Typically, you'd save to disk only those images worth saving. *Eyes* has a proprietary default format, but other formats are supported. Some are Targa (eight bits), Tiff (eight bits), GIF and *PC Paintbrush*. The notation for Targa and Tiff as eight bits is significant. Both formats support an additional 24-bit type that can't be read by ComputerEyes/Pro (but can with the costlier /RT model) or displayed on an ordinary VGA display system. However, *Eyes* can save images in what it calls "raw" 24-bit data format. A utility is afterwards used to convert the raw data file into 24-bit Targa or Tiff. Superb slides can then be generated by a graphics lab.

From the foregoing and after examining the photos included here, you should have some ideas of what you would like to do with image capture. The principles and features of products used can be applied to any image-capture system. As the multimedia market gets more competitive, prices of more-capable image-capture systems are bound to drop further. Until then, amateur computer artists can employ a little creativity to make good images with lesser expense.

Products Mentioned

ComputerEyes/Pro, $399.95
ComputerEyes/RT, $599.95
Digital Vision, Inc.
270 Bridge St.
Dedham, MA 02026
617-329-5400
CIRCLE NO. 173 ON FREE INFORMATION CARD

Xapshot RC-250
Canon USA, Inc.
Still Video Div.
One Canon Plaza
Lake Success, NY 11042
516-488-6700
CIRCLE NO. 174 ON FREE INFORMATION CARD

Epson-compatible matrix printer; LIM 3.2 expanded memory for advanced zooming/panning operations.

This high-powered, high-end software package permits image integration with any existing MS-DOS application without reprogramming. It works with standard .PCX format image files acquired with video digitizers, hand or page scanners, or images created with dedicated art/paint software packages.

QuickPix has two basic modules. One is a configuration program used to define where a stored image file is to be displayed within the application, as well as to associate each image file with a "trigger." (A "trigger" can be a word or any text-string that appears within an application). The second module is a TSR program that uses about 20K of RAM and "watches" the screen for the embedded "triggers." When a "trigger" is encountered, the associated image is displayed at the pre-defined location.

Images can be re-sized, moved to different locations on-screen, displayed in several different display modes, scrolled, zoomed, toggled between gray-scale and color, and printed. The package contains loads of other handy features, including a built-in "grab" utility for capturing screens from within applications.

The program's TSR format permits lots of flexibility in marrying images with virtually any application, and it works "straight-out-of-the-box" with *WordPerfect*, *dBASE*, *Quattro*, Lotus *1-2-3*, *Paradox* and others.

Although this professional-level package carries a fairly hefty price tag, licensing for four additional users is included in the base price. If you intend to distribute your applications to other end users, *QuickPix Viewer* provides a run-time version specifically for using (rather than creating) integrated-image applications.

SilverPaint 2.0, $129
SilverWare, Inc.
3010 LBJ Freeway, Suite 740
Dallas, TX 75234
214-247-0131
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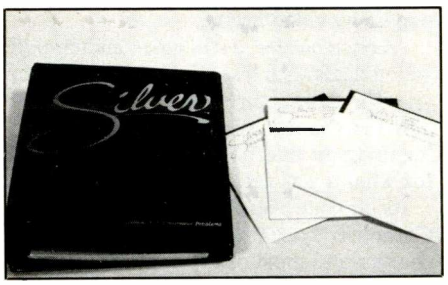

System Requirements: PC, XT, AT, PS/2 or true compatible; MS- or PC-DOS 2.1 or later. Library supports standard CGA/EGA/VGA and Hercules video adapters.

A professional-level programming package, *SilverPaint* permits creation of graphics, as well as the integration of images into applications. Everything from simple lines, boxes and circles to complex logos and icons can be fabricated from a 256-color blendable palette that offers full graphic and pixel control.

The popular .PCX image format is supported, and single and multiple images can be placed anywhere on-screen. In addition to visual capabilities, *SilverPaint* also permits adding full-range sound to applications, giving it some rudimentary multi-media capabilities as well.

The package supports *Clipper* 5.0, *dBASE*, *FoxBase+*, *FoxPro*, *dBXL* and *QuickSilver*. Documentation is excellent. Adding the library routines to existing applications is a fairly simple procedure, although a good knowledge of programming in any of these database languages will make the going quite a bit easier.

Photos by Liz Benford

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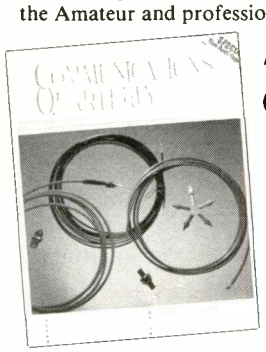

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Power-Saving Tips for Battery- Powered Projects

Thirteen guidelines for minimizing power consumption in battery-powered equipment

Battery power is handy because it's portable. When you're not dependent on power from an ac wall socket, you can go anywhere. New developments in low-power technology have brought battery-powered laptop, notebook and handheld computers, as well as new uses for embedded computers in all kinds of portable devices, including cellular phones, video cameras, scanner radios and electronic test equipment.

In circuit-design and construction stages, battery power is convenient and economical because it doesn't need a transformer, rectifier and other components normally required for converting 117 volts ac to 5 volts dc. But batteries do run down, requiring changing or recharging. For this reason, battery-powered circuits should be designed to consume as little power as possible. By minimizing power consumption, you can maximize the time between battery changes or charges.

This month, I present 13 guidelines for minimizing power consumption through power-supply design, component selection and other choices. Using these guidelines can make a dramatic difference in power consumption in your circuits, saving you money and reducing the hassle and expense of frequent battery depletion.

My focus will be on battery-powered microcomputer circuits, but most of the advice I give also applies to any electronic circuit. In ac-powered circuits, low power means lower electric bills, as well as saving money and space with smaller transformers, regulators and other components. Low power also means cooler operation, longer component life and fewer and smaller fans and heat sinks.

These guidelines reach into many varied areas of circuit design. For more on implementing low-power designs, see the Sources box elsewhere in this article.

The Power Supply

For reliable operation, most microcomputer circuits require a regulated power supply with a controlled, stable output. You can begin saving power by choosing an efficient power supply, whether you build your own or buy one ready-made.

Guideline 1. *Consider using a switching power supply.* The traditional regulated supply has been the linear supply, where an input voltage is reduced to a lower, regulated output and a pass transistor dissipates excess energy as heat. But a different configuration, called a switching supply, is often more efficient at converting its input into output power, giving you longer battery life in the process.

In a switching supply, an output transistor switches on and off rapidly, varying its duty cycle to deliver just enough current to power the load, with little waste. A constant, regulated output voltage is maintained by filtering. A switching supply can be configured as a step-down converter that reduces a high input voltage to a lesser output, or a step-up converter that generates an output voltage that's greater than its input.

Maxim Integrated Products offers a series of switching dc-to-dc-converter ICs that can convert battery power to a regulated output. Figure 1 shows a MAX631 5-volt step-up switching regulator that requires an input of just 2 to 5 volts (2 AA cells in series, for example). Maxim also has the MAX638, a step-down switching converter that gives a regulated 5-volt dc output from a 9-volt transistor battery.

Efficiencies of Maxim's converters are as high as 93%, compared to 70% or less for typical linear regulators. The more efficient your supply, the less energy is wasted, giving you longer life from your batteries.

Guideline 2. *In linear power supplies, choose voltage regulators with low quiescent currents and low input-voltage requirements.* Switching regulators aren't always the answer. Linear regulators are cheaper, and a typical three-terminal regulator requires no additional components, except filter and bypass capacitors. Linear regulators also can be more efficient at low load currents.

When choosing a linear regulator for battery operation, the two specifications to look at are minimum input voltage required to maintain regulation and typical quiescent current (the current consumed by the regulator and not delivered to the load).

National Semiconductor's popular 78L05 three-terminal, 5-volt regulator has a maximum output of 100 milliamperes. Its quiescent current is a moderate 3 milliamperes, but its input must be at least 7 volts, which would require six AA, C or D cells to maintain. (Although alkaline cells are referred to as 1.5-volt cells, their voltage falls to around 1.2 volts as they discharge. And Ni-Cd cells maintain a relatively steady 1.2 volts per cell as they discharge.) A 9-volt transistor battery could be used, but its smaller capacity means more frequent changes.

An alternative to the 78L05 is the

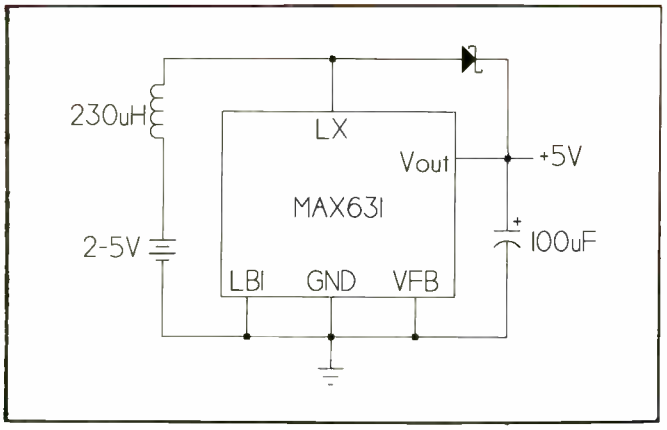

Fig. 1. The MAX631 is a switching converter that generates a regulated +5-volt source from just two AA cells, with little wasted energy.

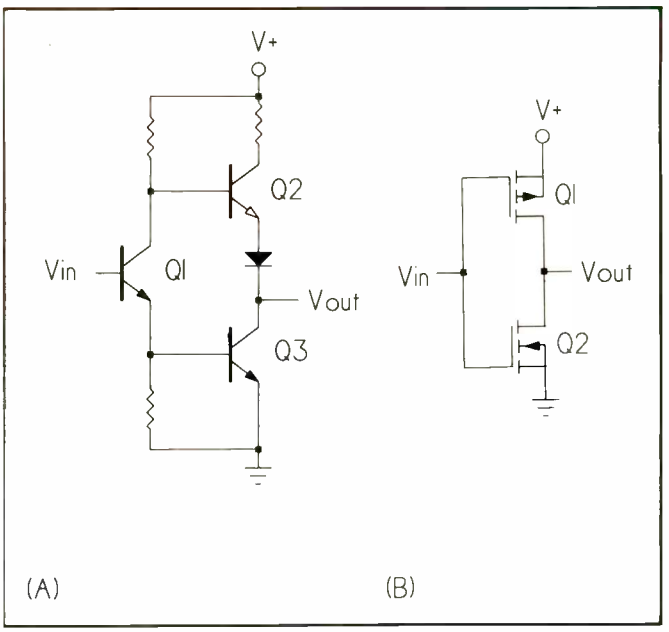

Fig. 2. In the TTL inverter in (A), an output transistor is always conducting current. The CMOS inverter in (B) is better for low-power designs since it conducts current only when switching from one logic level to another.

LP2950 micropower 5-volt regulator, also from National. Because its minimum required input voltage is less than 5.5 volts, it can be powered with five AA, C or D cells—one less than the 78L05 requires. Or you could use a 6-volt gel-cell battery.

The LP2950's quiescent current varies with its load. At loads of less then 30 milliamperes, quiescent current is small, between 0.1 and 1 milliampere, but it rises to almost 10 milliamperes at the maximum load of 100 milliamperes.

A circuit that draws less than 30 milliamperes most of the time will certainly save power with the LP2950, compared to the 78L05. Even at heavier loads, savings in eliminating a battery cell can easily outweigh the power consumed by the LP2950's increased quiescent current.

The LP2950 is just one of many low-power linear regulators available from National Semiconductor, Maxim, Toko and others. Advances in technology have resulted in many new products. So when choosing a regulator, instead of automatically reaching for the familiar, check through the data books to see if another device can do the job better.

Guideline 3. *Use the lowest possible supply voltage.* You can also save power, and reduce battery cost, by reducing your power supply's output voltage when possible. Most microcomputer ICs now require a 5-volt supply, but the future is in 3-volt designs. HCMOS logic ICs already operate from supplies as low as 2 volts, and memories and microcomputers capable of operating at 3 volts (like Motorola's 68HC05) are beginning to appear. Dropping from 5 to 3 volts (with no change in current) reduces power consumption 40!

Choosing Components

In addition to the power supply, you can save power in other circuit areas by choosing the lowest-power components that will do the job.

Guideline 4. *Use CMOS logic, memory and microcomputer ICs.* Using HCMOS (high-speed CMOS) logic ICs instead of LSTTL can cut power consumption by a factor of 10, 100, 1000, or more, depending on the circuit. The power consumption of a digital-logic IC has two elements: static (quiescent) power, which is the power consumed when no inputs are switching, and dynamic power, which is the power consumed as the inputs switch from one logic level to another.

The two dominant families of logic ICs are TTL (transistor-transistor logic) and CMOS (complimentary metal-oxide semiconductor). Each is made up of several subfamilies. A popular TTL subfamily is LSTTL (low-power Schottky TTL), which combines low power consumption (for TTL) with high switching speeds. However, LSTTL is rapidly being replaced by HCMOS, the switching speeds and other specifications of which are equivalent to those of LSTTLs but with lower power consumption under most conditions.

To understand TTL's current consumption, you need to look inside a typical gate, like the inverter shown in Figure 2(A). When V_{in} is high, transistors *Q1* and *Q3* switch on and V_{out} is pulled low. When V_{in} is low, *Q1* and *Q3* are prevented from switching on, which allows *Q2* to turn on, sending high V_{out}. In either case, at least one transistor is conducting current.

Although LSTTL uses far less power than standard TTL, it's still a major power consumer. A single LSTTL IC can consume several milliamperes of quiescent current.

In contrast, CMOS devices consume virtually no quiescent current, due to their complementary configuration of MOS transistors. Figure 2(B) shows a CMOS inverter, consisting of NMOS (n-channel MOS) and PMOS (p-channel MOS) transistors with their gates and drains tied together.

When V_{in} is 0 volt, *Q2* is off and has a high drain-to-source resistance, while *Q1* switches on to create a low-resistance path from its source to drain and pulling V_{out} to V+. When V_{in} equals V+, the situation reverses. That is, *Q1* is off, *Q2* is on and V_{out} is 0 volt. When fully off or on, *Q1* and *Q2* draw no current, except for a few

Say You Saw It In ComputerCraft

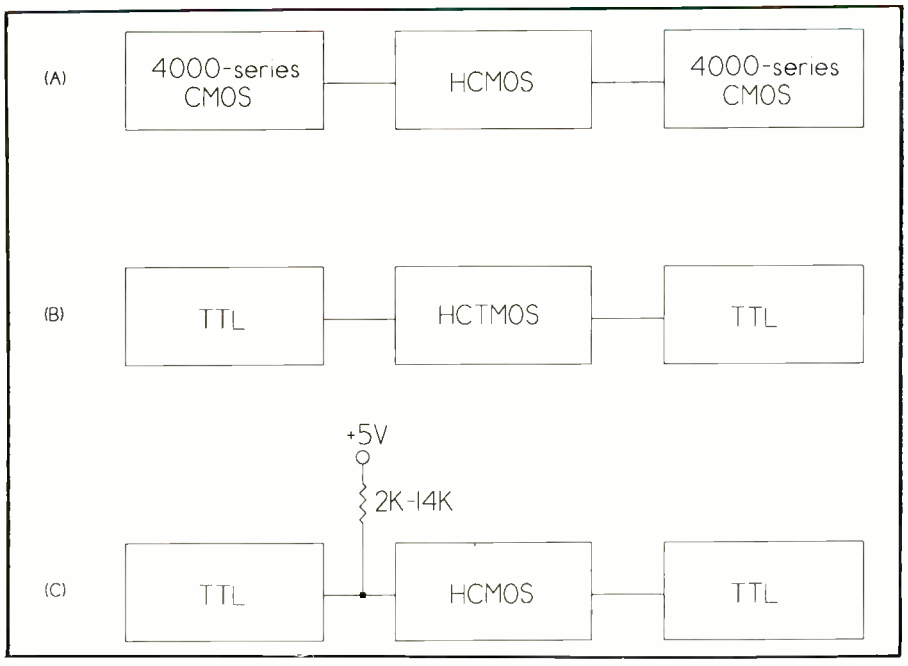

Fig. 3. HCMOS (A) interfaces directly with 4000-series CMOS at 5 volts. HCTMOS (B) interfaces directly with TTL. If HCTMOS (C) is not available, add pull-up resistors to TTL outputs that drive HCMOS inputs to ensure valid logic levels.

microamperes of leakage current.

The only significant current consumption occurs as V_{in} switches from one logic level to another, when both transistors turn on briefly and internal and external capacitances are charged and discharged. But current consumption of an HCMOS device doesn't approach that of LSTTL until switching speeds are 1 to 10 MHz or higher, depending on the device.

Also remember that few circuit elements switch constantly at high frequencies. For example, an address latch in a multiplexed address/data bus is clocked only once on each memory access, which is far less than the system clock's frequency. In a typical microcomputer circuit, many elements have an average clock frequency of 100 kHz or less. This is where the power savings of HCMOS add up.

In addition to HCMOS, an older CMOS alternative is the metal-gate 4000 series, identified by part numbers in the 4000s. However, these are slower and have considerably less drive power than HCMOS; so HCMOS is usually the better choice for microcomputer circuits.

What's involved with changing a design from LSTTL to HCMOS? Often, LSTTL and HCMOS are interchangeable. Most HCMOS chips have functions, pinouts and part numbers similar to those of their TTL equivalents. For example, the 74LS138 and 74HC138 are 3-to-8-line decoders with matching pinouts. If you're used to designing with TTL, the switch to HCMOS should be easy.

Sometimes there's a need to combine logic families in a circuit, either because of parts availability or because you need a function or capability found only in a particular family.

Table 1. Guaranteed TTL and CMOS Logic Levels

Device Type	V_{in} (low) maximum	V_{in} (high) minimum	V_{out} (low) maximum	V_{out} (high) minimum
TTL	0.8	2	0.4	2.4
CMOS	1.5	3.5	0.1	4.9

Figure 3 illustrates how to interface HCMOS with other logic families. HCMOS interfaces directly to 4000-series CMOS at + 5 volts, and an HCMOS output can directly drive a TTL input.

Driving an HCMOS input with a TTL output is one case that requires special consideration. To explain why this is so, refer to the Table 1 for a quick review of guaranteed valid TTL and CMOS logic levels, with both operating from a + 5-volt supply. The numbers show that a high TTL output can be as low as 2.4 volts, while a high CMOS input must be at least 3.5 volts to guarantee proper operation. Figure 3 shows two ways to drive an HCMOS input with a TTL output: (1) use an HCT component or (2) add a pull-up resistor.

The HCT subset of HCMOS was developed to meet the need for interfacing TTL to HCMOS. HCT parts are similar to their HCMOS equivalents, but they have TTL-compatible inputs so they can directly interface to TTL outputs. HCT outputs can drive HCMOS or TTL inputs. If an HCT equivalent isn't available, adding a pull-up resistor on a TTL output will ensure that it meets the input requirements of HCMOS.

When interfacing HCMOS to NMOS microcomputers and memories, you must check the data sheet for the NMOS device for its output characteristics. Some NMOS outputs are CMOS-compatible, while others are TTL compatible. If the outputs swing rail-to-rail, they interface directly to HCMOS. If the outputs are TTL-compatible, use HCT chips or add pull-up resistors as described above.

Because an NMOS device can be manufactured with fewer transistors than an equivalent CMOS device, NMOS has been a popular choice for high-density memory and microcomputer ICs. However, the disadvantage of NMOS is its high power consumption, since it, like TTL, consumes quiescent power.

Often, a single device is available in both CMOS and NMOS (or HMOS, a high-speed NMOS process). When you have a choice, choose CMOS over NMOS, for two reasons: (1) CMOS consumes less power and (2) CMOS parts are more likely to include power-saving idle, power-down, sleep, wait or standby functions.

Table 2. Supply-Current Ratings for Two 8K EPROMS

Device & Type	Supply Current (Active/Standby)
TMS2764 (NMOS)	150 mA/35 mA
TMS27C54 (CMOS)	30 mA/0.25 to 0.5 mA

For example, in the 8051 family of microcontrollers, Intel offers the NMOS 8052AH and the CMOS 80C52. Their architectures are identical, except for the addition of the 80C52's idle and power-down modes, but power-supply requirements of the two chips differ dramatically. The 8052AH consumes up to 175 mA, while the 80C52 typically draws just 15 mA at 12 MHz. In addition, the 80C52's idle and power-down modes reduce current consumption to 5 mA and 5 μA, respectively.

Idle and power-down are useful in applications where the microcomputer spends a lot of time waiting. For example, a hand-held data logger that's active only when its operator enters data can be put into a power-saving mode between measurements.

In idle mode, the processor stops executing instructions until the chip is reset or an enabled interrupt occurs. In power-down mode, extra power savings are achieved by stopping the oscillator until the chip is reset. Either mode can be invoked in software.

Other microcomputers have similar modes, though they may have different names. Check the data book for the device being considered for details on available modes.

CMOS memory ICs are also good at power conservation. The supply-current ratings for two 8-kilobyte EPROMs are given in Table 2. The numbers reveal that the CMOS EPROM is clearly the better choice. Standby mode, activated by a CHIP ENABLE pin, can be used whenever the EPROM isn't being accessed.

You can save power also by using a single high-capacity memory IC in place of two or more smaller-capacity devices. For example, one 32K RAM can take the place of four 8K RAMs.

To sum up, for minimum power consumption, choose CMOS microcomputers, memories and logic. Use HCMOS logic, with 4000-series CMOS as a second choice, if its limited speed and output drive aren't a problem. Use LSTTL as a last choice, and avoid standard TTL with its high power consumption, unless you require its greater drive capability. For operation above 30 MHz, investigate Advanced HCMOS, a higher-speed HCMOS family of devices.

Since HCMOS is a relatively new technology, most HCMOS data books include an overview and applications hints. These are good sources for more information on how to use HCMOS.

Guideline 5. *Use other low-power ICs.* In addition to using low-power logic, microcomputer and regulator ICs, also exercise care when choosing such other linear ICs as op amps, comparators, converters and timers. For example, compare the supply currents of these three quad op amps from National Semiconductor: LF347 at 7.2 mA typical, LM324 at 1.5 mA typical and LP324 at 0.25 mA maximum. It's obvious that you'll save power with the LP324.

At times, you may be forced to use a higher-powered component to meet other circuit requirements. For example, the LF347 operates at higher frequencies than the LP324; so in some applications the LF347 is the better choice. But once again, it doesn't hurt to check the data books to see if there's a low-powered part that can do the job.

Incidentally, both the LM324 and LP324 are bipolar, not CMOS devices, proving that low-power designs don't have to be CMOS.

Guideline 6. *Use low-power switches.* Figure 4 shows three examples of electronic switches, with varying capabilities and power consumptions.

A transistor provides a simple, low-power way of switching load current. Choose a base resistor value small enough so that the transistor saturates when it's conducting, but not so small as to waste power.

A MOSFET can also act as a low-power switch. Unlike a bipolar transistor, a MOSFET that's fully on consumes almost no power. For operation from a 5-volt supply, choose a MOSFET with a low gate-threshold voltage. These are sometimes called logic-level MOSFETs.

Finally, a classic electronic switch is the classic electromechanical relay in which current through a coil causes contacts to open or close. Relays can switch high-current loads and can provide isolation to the load, but they're best avoided in low-power designs because of their high current consumption. If you must use a relay, look for one with high coil resistance. Reed relays are often a good choice.

Guideline 7. *Use LCDs for displays whenever possible. Pulse LEDs to save power.* It's hard to beat liquid-crystal displays (LCDs) for low-power operation. Current consumption of an LCD module is just a few milliamperes, much less than the 10 to

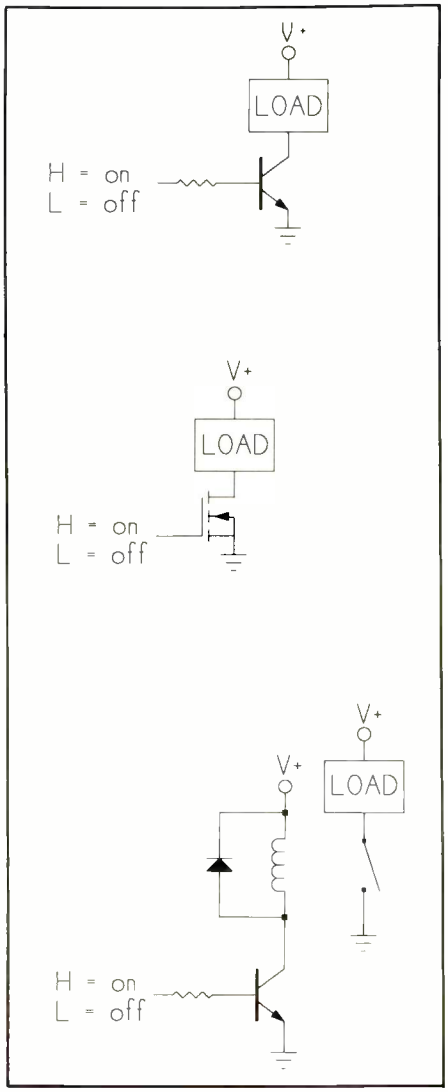

Fig. 4. Bipolar transistor (A) and MOSFET (B) are two low-power ways of switching power to a load. Relays (C) are best avoided because of their characteristically higher power consumption.

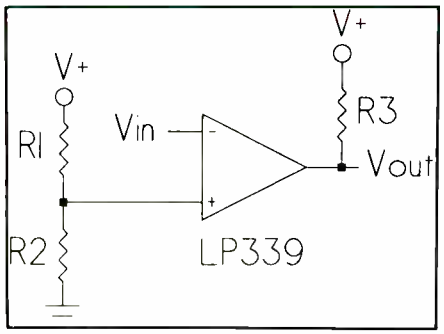

Fig. 5. In this comparator circuit, values of R1, R2 and R3 should be as large as possible to avoid wasting power. The voltage-divider values of R1 and R2 can be as great as several megohms total. The value of R3 is limited by the current and switching speed needed at Vout.

20-mA per segment consumed by a light-emitting diode.

LCD modules are available as seven-segment displays and as dot-matrix modules that display characters, graphics or both. LCDs are driven by an ac voltage, typically at a frequency of 30 to 60 Hz, but some modules generate their own drive voltage from a dc supply. If an LCD needs backlighting for visibility in dim light, add a manual or photoelectric switch to turn off the backlighting when it isn't needed.

In spite of their high power consumption, LEDs remain popular because they're bright and colorful. You can save power in LED circuits by using a low-power 555 or other timer to pulse a LED, flashing it briefly once per second, for example, instead of powering it constantly. Pulsing action makes the LED more noticeable.

Guideline 8. *Maximize resistor values. Use the largest-value resistors possible to limit the current through them.*

Figure 5 shows an LP339 comparator with its reference voltage at the + input determined by the ratio of the values of *R1* and *R2*. Since the ratio, rather than the absolute values, determines the voltage, *R1* and *R2* can have large values, up to several megohms total. With very high resistor values, the comparator's tiny input currents begin to affect V_{ref}, while lower values only waste current.

Pull-up resistors should also be sized to match their loads. In Figure 5, if V_{out} drives only a CMOS input, the value of *R3* can be as large as 100,000 ohms.

In RC oscillators, pairing a large-value resistor with a small-value capacitor is another way to save power.

Other Design Tips

Clock speed, layout and other design factors can also affect the power consumption of your circuits.

Guideline 9. *Tie unused CMOS inputs to ground or V+.* Remember to implement this basic rule of CMOS design. If a CMOS input is left floating, it can drift to a level between ground and V+, and, consequently, where it will conduct current.

All HCMOS logic inputs, except for a few bidirectional transceivers, have internal input resistors. Therefore, you can tie the inputs directly to V+ or ground if desired, without an external resistor.

Any CMOS input that has no physical connection to other circuit elements is an obvious candidate for tying to V+ or ground. However, some devices have their own internal pull-ups and require no external connection. Check the data sheet to be sure.

Also, an input may be electrically connected to an output but still be logically floating if the output is unpowered or in a high-impedance state. For example, the 74HC240 is a popular octal buffer/line driver with three-state outputs. With the ENABLE inputs low, the outputs are high-current bus drivers, but with the ENABLE inputs high, the outputs switch to a high-impedance state.

If a CMOS input connects to a high-impedance output (and has no other connection), it can float just as if it were open. Any CMOS input that will be open or connected to a high-impedance output for longer than 100 μs should have a pull-up resistor or other termination.

Guideline 10. *Power down power-consuming components when they're not needed.* In addition to using power-down and idle modes, consider whether temporarily disabling or switching off power to other ICs and semiconductors will save power.

One likely candidate is serial transmitter/receivers like the Maxim MAX232. If the serial interface is used only periodically, you can save power by shutting off the MAX232 when it isn't needed. A new MAX222 version includes a control pin that puts the chip into a 10-μA shutdown mode. Other ICs can be unpowered by open-

(continued on page 81)

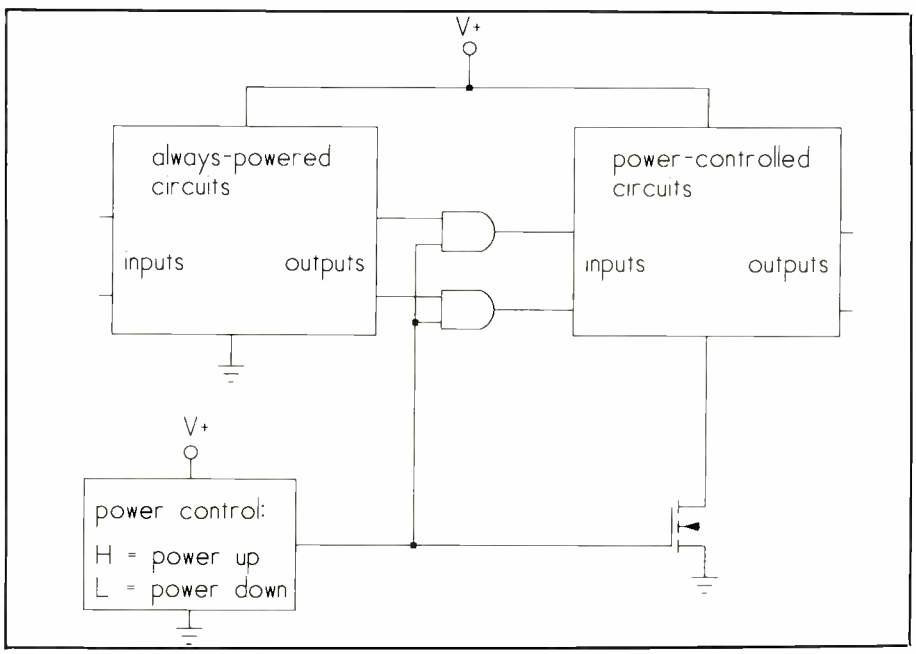

Fig. 6. You can save power by selectively disconnecting power to circuit elements when they are not needed. This circuit uses a MOSFET for power switching. The AND gates bring the inputs of the power-controlled elements to ground potential when they are powered down.

Modifying Your AT Drive Table

How to set up a matching BIOS to get the most space out of a used hard drive you bought that is not supported by your computer's drive table

While shopping at a computer flea market, you take a risk and pick up a used ST-506 (MFM) hard drive. At home, you excitedly hook up the drive, check it and find that it works pretty well. But the drive table in your AT doesn't support the drive type you have. So even though you could format it using a drive type that doesn't match, it would leave unused space. What do you do?

You could just modify your BIOS drive table, save the modifications to a file and then program a new BIOS—all without having detailed knowledge of memory mapping, hex notation or assembly code. It can be done with an average EPROM programmer and an obscure public-domain utility. An alternative is to simply get new BIOS chips for your computer. This more-costly procedure was well covered in the excellent "Upgrading Your ROM BIOS" article by Roger C. Alford in the April issue of *ComputerCraft*. If you missed it, I recommend you go back and read it so that you have a background for the procedure described here.

EPROMs and Programmers

It won't do any good to make the modification attempt if you don't have access to an EPROM programmer, of course. Some of you are fortunate enough to be able to use programmers at your places of work; others can borrow from friends. If you can do neither, you can build one from the construction plans in "A Parallel-Port EPROM Programmer" in the June and July issues or buy a commercially available one. You should own or have access to one in any event if you're at all serious about getting into your computer's innards and enhancing your machine.

HTMU is the name of the obscure utility that helps change a drive table.

Table 1–Compaq Deskpro 286 Drive Listing

```
Enter Even-ROM Image (32KB) Filename: even
Enter Odd-ROM Image (32KB) Filename: odd
Edit Hard Disk Table: D)isplay, E)dit, S)ave, Esc = Prev Menu
Display: (1) Type 1-16, (2) Type 17-32, (3) Type 33-47, (4) Type 48-63
```

Type	Cyl.	Heads	PreComp	ECC	CB	LZone	Sect
1	306	4	128	000	0	305	17
2	615	4	128	000	0	638	17
3	615	6	128	000	0	615	17
4	1024	8	512	000	0	1023	17
5	940	6	512	000	0	939	17
6	697	5	128	000	0	696	17
7	462	8	256	009	0	511	17
8	925	5	128	000	0	924	17
9	900	15	−1	000	8	899	17
10	980	5	−1	000	0	980	17
11	925	7	128	000	0	924	17
12	925	9	128	000	8	924	17
13	612	8	256	000	0	611	17
14	980	4	128	000	0	980	17
15	0	0	0	000	0	0	0
16	612	4	0	000	0	612	17

It was released to public domain in 1989 by Hyun-Taek Chang. Public domain means that there's no cost for use of the software. Since it isn't shareware, no registration fee is required. Mr. Chang has kindly donated a useful item to anyone who wants to use it.

HTMU was uploaded to CompuServe Information Service and resides in Data Library 1 of the IBM Hardware Forum (IBMHW). The full name of the compressed original upload is HTMU.ARC. Fortunately, you don't have to be a CompuServe member to get it. A utility this useful has no doubt made rounds to many private bulletin board systems.

Simple Preparations

You need a few basic things before using HTMU. These are a working computer whose drive table you wish to modify, access to an EPROM programmer, blank EPROMs of the same type your computer uses and the specifications for the hard drive you wish to install.

The disk drive specs are important because HTMU prompts for seven parameters that must be changed in the drive table. Errors or wrong guesses can lead to trouble. New hard drives usually come with a spec sheet that lists such special information. But used drives, like those obtained at flea markets, may come with no documentation at all. With these, you can do any or all of three things.

One is simply call the manufacturer of the hard drive and ask for the specs. If you can't locate the manufacturer, a second alternative is to check out the public domain for a text file that can be found on some bulletin boards that has a listing of several hundred kinds of hard drives, along with respective data specifications. Look for a file

named DRIVES.TXT, DRIVE.LST or something similar. The Sysop of your bulletin board will know whether or not the BBS has such a file. Chances are very good that your used flea market drive is listed.

A final way to determine drive specs is to use commercial software. Ontrack Systems, for example, offers *Disk Manager*, a first-rate hard-disk diagnostic and formatting utility. When using *Disk Manager*, you select a drive by manufacturer and model number. *Disk Manager* then displays the drive's specs. This method isn't very expensive, especially since *Disk Manager* is good for other things, too.

Using HTMU

HTMU.ARC must be uncompressed before it can be used. The popular *PKZip* from PKWare, Inc. won't work here, though. Recommended by CompuServe's IBM Hardware Forum is the uncompression utility ARC-E. After uncompressing HTMU.ARC, two files appear: HTMU.EXE and a short document file. The first is machine-executable and can be run from a floppy or hard drive. If you intend to use an EPROM programmer that's off-site, however, you may want to run HTMU.EXE from floppy. HTMU stores its resulting data files in the default directory.

HTMU starts up with a simple one-line menu that queries you for BIOS size, the choices being 32K and 64K. If you aren't sure which choice to select, pick 64K, which has worked consistently on AT computers. If your BIOS is different from that selected, an error message will be displayed.

The next you do is tell HTMU from where the BIOS image is going to come. This can be from an on-disk data file or from the resident ROM. The choice for a disk data file may seem strange, but it's apparently a provision for reading in and changing previously saved HTMU data files. Select the option for resident ROM.

Now you can display and edit the hard-drive table list. HTMU is capable of displaying the full 1 through 63 range of drive types. Select the display option because it's a good idea to take a look at your table listing before changing anything. At this point, you must decide which table number you want to change. Tables 1 and 2 are good choices because they usually represent disk drives of smaller capacity, 10M or 20M, that have gone out of popular usage. Interestingly, most AT-style computers have a blank table at location 15. Using this location will leave all other tables intact, just in case of some unexpected future need. Table 1 is the drive table listing from a Compaq Deskpro 286. Note that Table 15 is blank.

After deciding which table number to change, select the Edit option. HTMU responds by asking you which table number to edit. Select one by number, perhaps Table 15. Then, one at a time, HTMU prompts for the following: Cylinders, Heads, Pre-Comp, ECC, Control Byte, Landing Zone and Sectors per Track.

It isn't necessary to understand the meaning of these parameters. Just be sure you know how to respond. Don't make guesses if you don't know. Get the correct information. Answer the seven questions, and then answer "no" to any more editing.

Now select the Save option. HTMU asks if the data should be saved in binary or Intel hex format. Your answer depends on how you want to handle it. Both ways work equally, well as long as your EPROM programmer software can handle both formats. Otherwise, select the format your software does handle.

HTMU next asks if the file should be split into separate EVEN and ODD files. Answer "yes" for an AT computer. Finally, HTMU prompts for names to be used for the EVEN and ODD data files. Choose file names that make sense to you and that indicate the function being served. When you're finished, press ESC to back out of HTMU.

You can program new EPROMs using the EVEN and ODD files as source material. Be sure to label the EPROMs accordingly so that you don't get them swapped around when you install them in your computer.

Using the New BIOS

Once your new BIOS chips are programmed, simply remove the old ones from your computer and install the new ones in the vacated sockets, making note of which socket is "even" and which is "odd." Again, refer back to Roger Alford's article that explains how to install new BIOS chips. Observe proper grounding safeguards to prevent damage from static electricity when handling the chips. With the BIOS chips installed, connect your hard drive to your system and step through the normal AT Setup to fix the hard drive type.

Proceed to surface scan, defect management, low-level format and everything else that needs to be done for any MFM hard drive. You'll now have full use of all of available space on the hard drive. Remember that only MS-DOS 4.01 and later will support large disk partitions. Earlier revisions of MS-DOS are limited to maximum partitions of about 33M. ■

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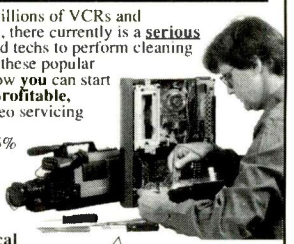

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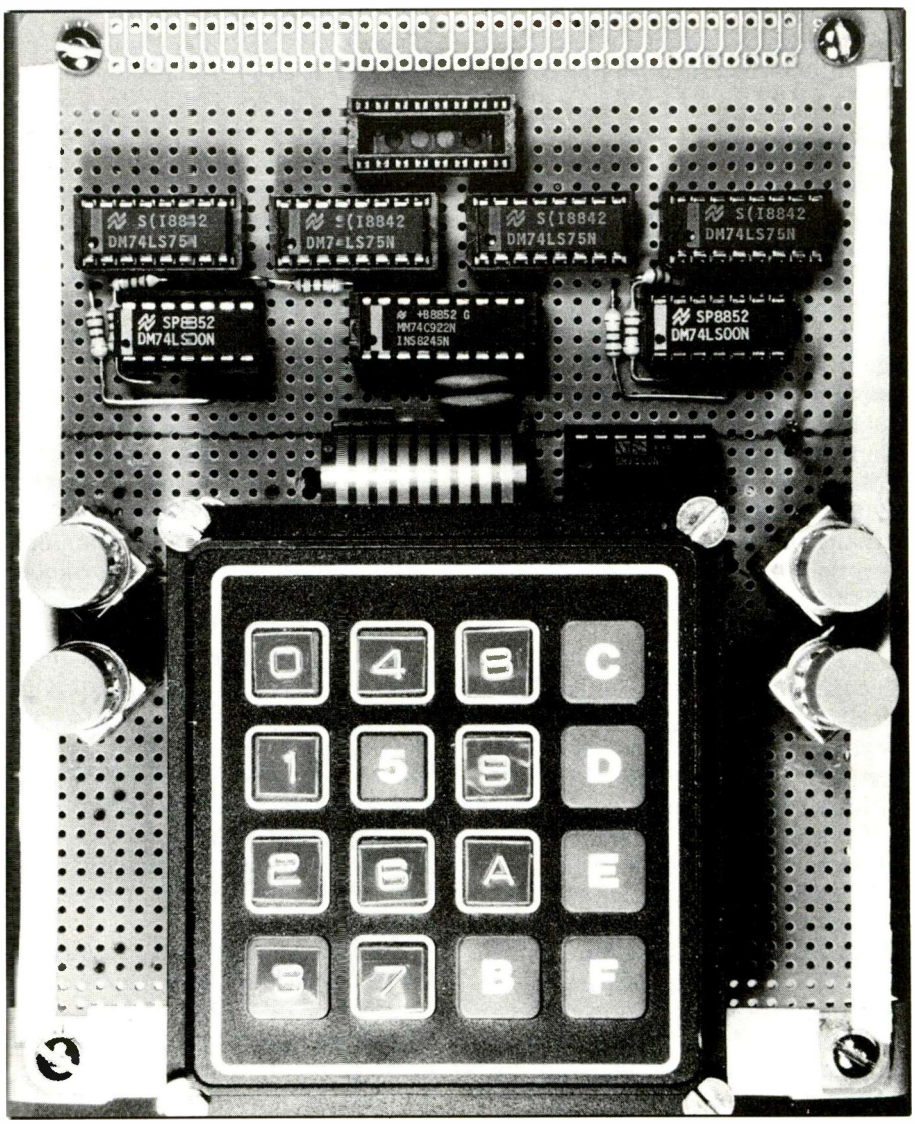
Project By Loyd W. Redman

BCD Word Generator

Provides a simple, low-cost solution to efficient and fast testing of digital circuits and microprocessor input ports

Calling all digital circuit designers and microprocessor-hardware hackers! When testing a circuit on a breadboard, would you like a fast, convenient way to generate four-bit BCD words (bytes, nibbles)? If you use jumper wires to connect +5 volts or ground to individual points in a circuit or some form of spdt manual switch to apply your logic signals, you must change four separate connections for each word. That is a cumbersome and inefficient way to go. What you really need is our BCD Word Generator, which allows you to generate any four-bit BCD word with just one keystroke on the keypad, followed by pressing one pushbutton.

Total cost for parts for our BCD Word Generator is only about $30 from retail and mail-order sources. A top-quality keypad will raise the price a bit, of course. A bare-bones 16-key encoder requires use of at least four ICs, plus discrete components, just to debounce the mechanical keypad switch and encode switch closure to a four-bit word. We do all this and more with the National Semiconductor MM74C922 16-key encoder chip. The Generator, built around this chip, can be used with a wide variety of experimenter digital circuits. It is useful for generating signals to test microprocessor input ports and peripheral devices.



About the Circuit

Before a key switch is closed, outputs of 74C922 *U1*, at pins 14 through 17, are at a high-impedance state. Following key closure debounce and encoding, pin 12 of *U1* goes high to low. This signals that valid BCD data is available at pins 14 through 17. The high level at pin 12 is inverted by one gate in 74LS00 quad two-input NAND-gate *U8*. The high-to-low transition to pin 13 of *U1* latches the data on pins 14 through 17.

The BCD data from pins 14 through 17 of *U1* is routed simultaneously to the inputs of 74LS75 dual two-bit transparent D-type latches *U2* through *U5*. If the key switch is opened at this time, the outputs of *U1* returns to a high-impedance state. Therefore, it is necessary for the key switch to be held closed while *S1* through *S4* are pressed and released.

Switches *S1* through *S4*, debounced by *U6* and *U7*, control the enable in-

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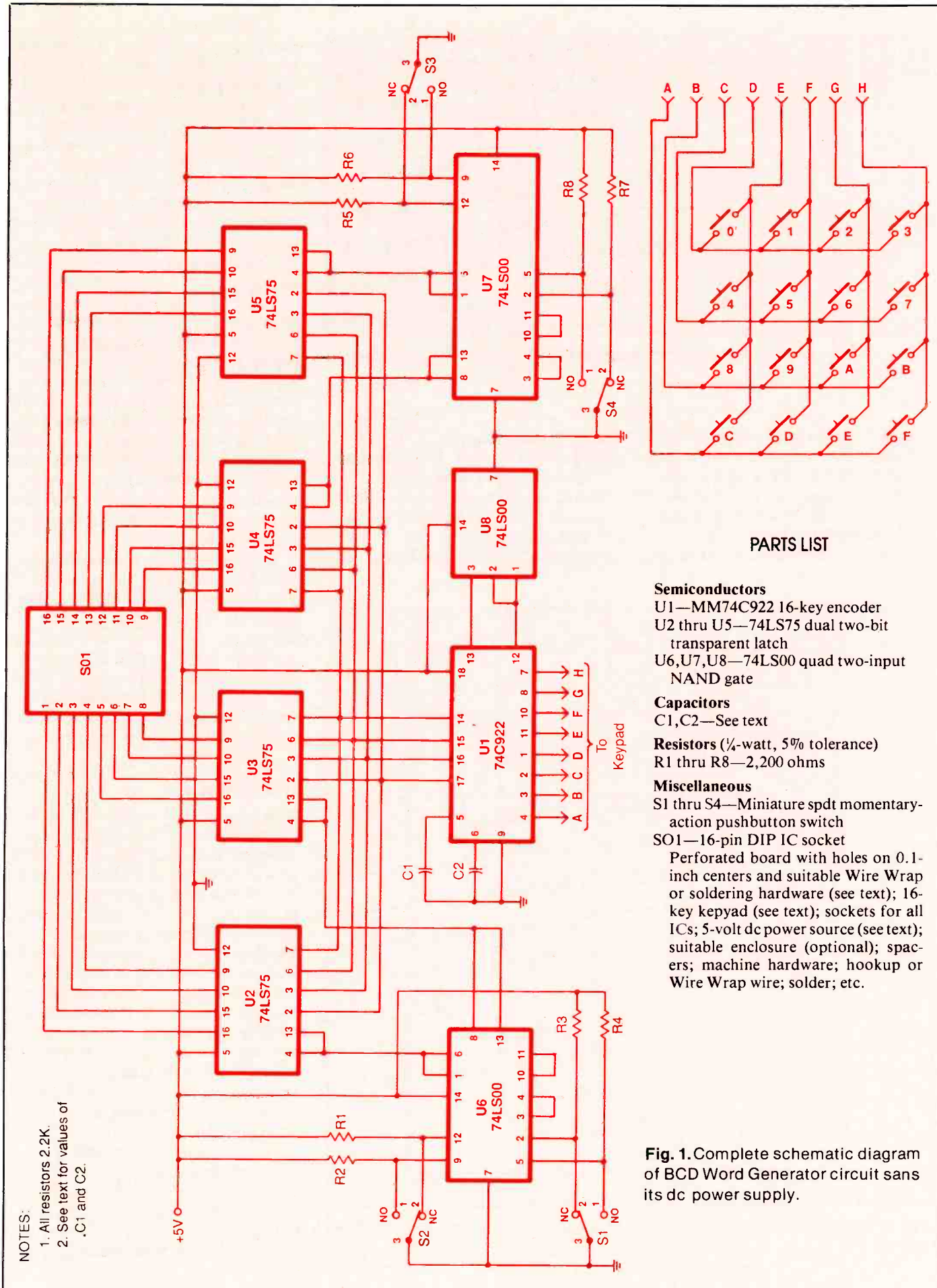

PARTS LIST

Semiconductors

U1—MM74C922 16-key encoder
U2 thru U5—74LS75 dual two-bit transparent latch
U6,U7,U8—74LS00 quad two-input NAND gate

Capacitors

C1,C2—See text

Resistors (¼-watt, 5% tolerance)

R1 thru R8—2,200 ohms

Miscellaneous

S1 thru S4—Miniature spdt momentary-action pushbutton switch
SO1—16-pin DIP IC socket
Perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); 16-key kepyad (see text); sockets for all ICs; 5-volt dc power source (see text); suitable enclosure (optional); spacers; machine hardware; hookup or Wire Wrap wire; solder; etc.

Fig. 1. Complete schematic diagram of BCD Word Generator circuit sans its dc power supply.

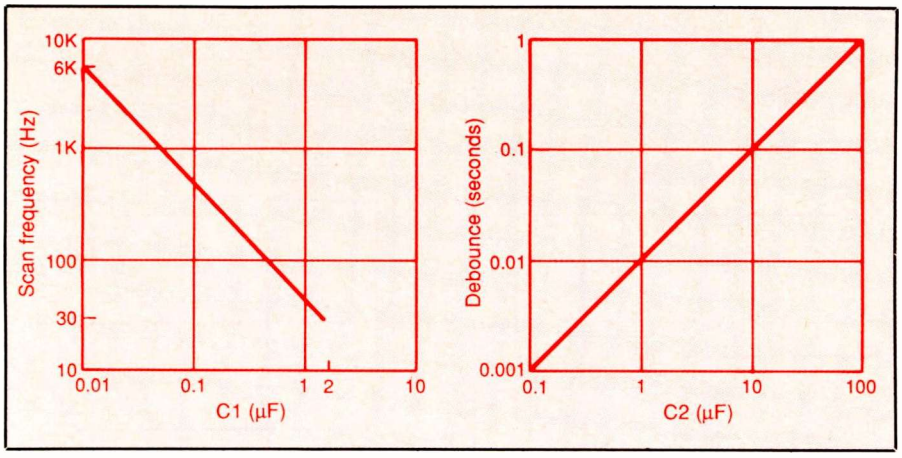

Fig. 2. (A) Keypad scan frequency vs. value of C1; (B) Keypad debounce period vs. value of C2.

puts of the D-type latches. With *S1* through *S4* in the normally-closed position, the enable inputs at pins 4 and 13 of *U6* and *U7* are held low.

When one of the switches is pressed and released, the low-to-high transition to the enable inputs transfers the data to output pins 9, 10, 15 and 16 and latches this data. The least-significant bit of the BCD word appears at pin 16, the most-significant at pin 9. Outputs of the latches are TTL high or low logic voltages, not +5 volts and 0 volt. The BCD word at the output of the latches then remains unchanged until the appropriate push-button is pressed and released again.

If you are designing with only CMOS ICs, you can easily substitute the TTL chips with comparable CMOS devices to permit a wider range of supply voltages. If your design work includes both TTL and CMOS devices, most manufacturer data books provide suggested circuits for interfacing between the two types of logic.

Since you are mainly concerned with generating four-bit words for test circuits and not engaged in a typing-speed contest, the values of *C1* and *C2* are not critical. Connected to pin 5 of *U1*, *C1* sets the scan frequency of the keypad, which determines how fast *U1* is looking for a switch closure. Connected to pin 6 of *U1*, *C2* sets the switch debounce period, which is how long *U1* is going to take to determine if the switch is actually fully open or closed.

A suggested ratio between the values of *C1* and *C2* is: The value of *C2* and 10 times the value of *C1*. The graph in Fig. 2(A) can be used to choose an appropriate value for *C1*, while the graph in Fig. 2(B) can be used to choose an appropriate value for *C2*. National Semiconductor's original graphs were plotted on three-decade log-log graph paper.

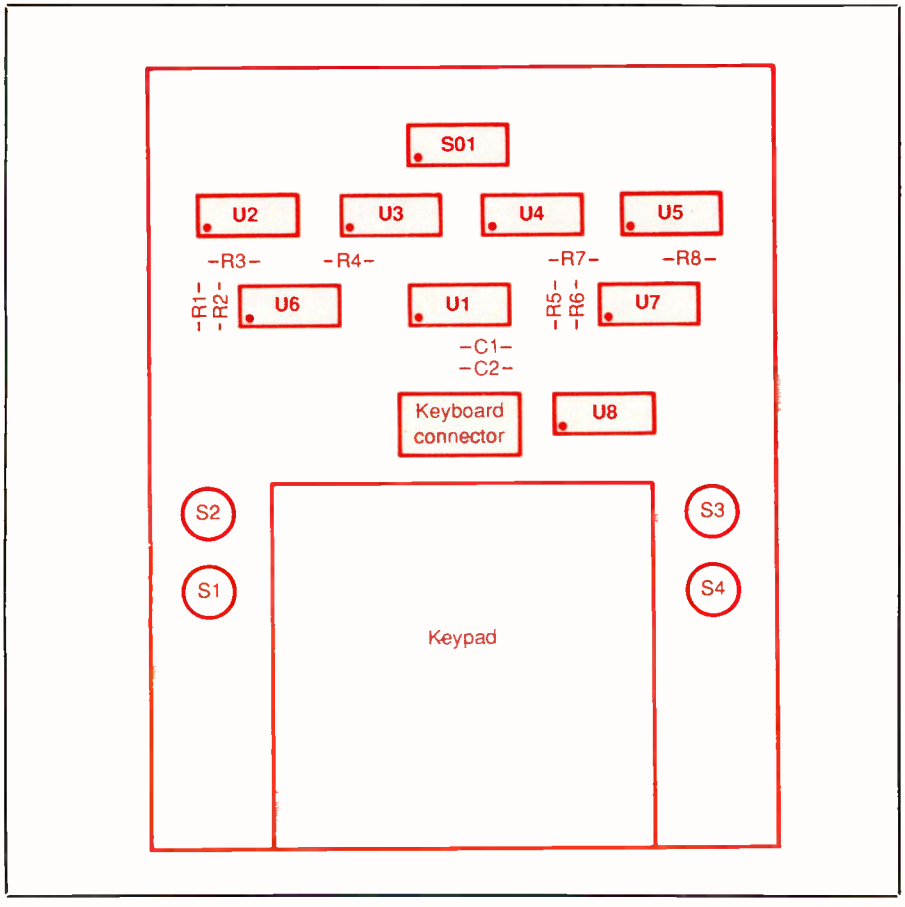

Fig. 3. Suggested component layout for assembling circuitry on perforated board.

The Keypad

There are several ways to connect a 16-key keypad. The simplest is to wire 16 individual normally-open momentary-type switches to form a 4 × switch matrix, as shown in Fig. 1. If you use a ready-made keypad, prices may vary from $5 to $15 or so. Some ready-made keypads contain 16 separate switches that are not connected in a matrix. If you use one of these, you must make the proper connections between the keys and to the row and column inputs at pins 1 through 4, 7, 8, 10 and 11 of *U1*.

Some keypads are pre-wired in a 4 × 4 matrix, but the wiring is not user-accessible. In such a case, you must use an ohmmeter or continuity checker to determine the matrix connections. You may have to re-label the keys appropriately. Your finished circuit will look neater and easier to wire if you use a ready-made keypad

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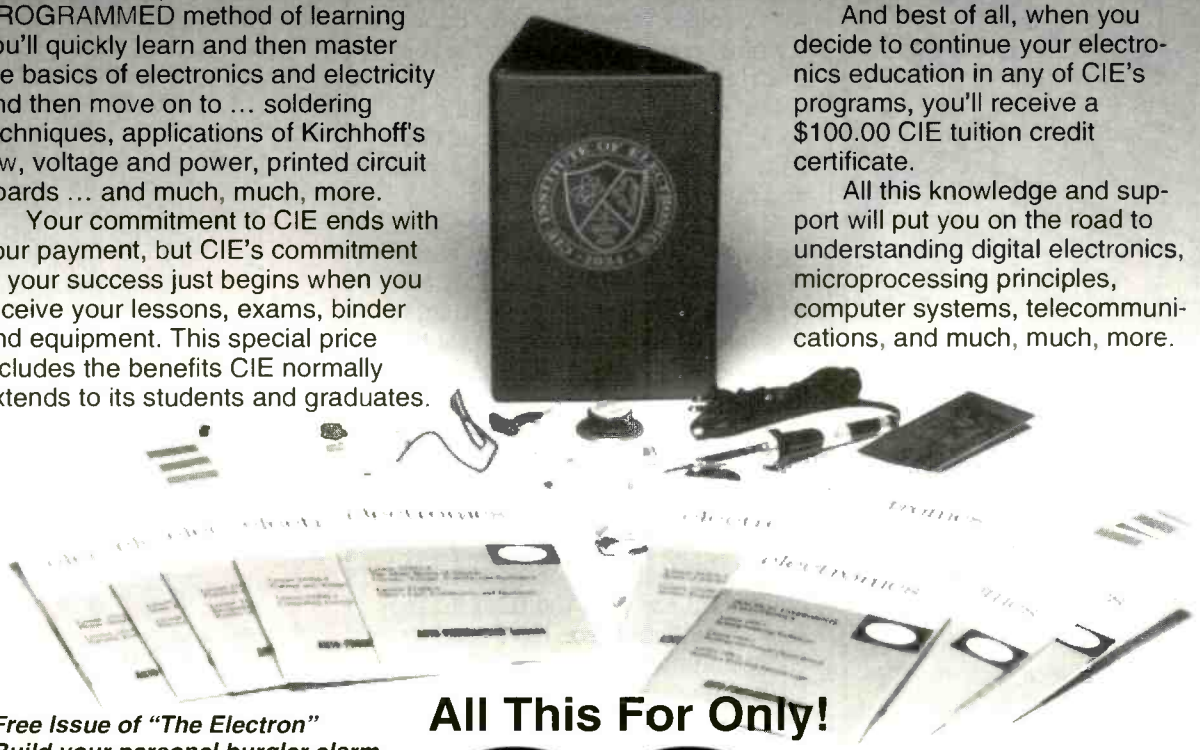

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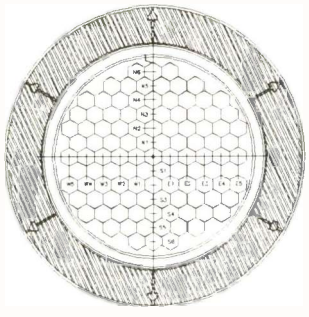

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that includes a ribbon cable and connector.

Construction

You can build your BCD Word Generator on a $5^{11}/_{16} \times 4\frac{1}{2}$-inch piece of perforated board that has holes on 0.1-inch centers, as shown in the lead photo. The preferable type of perforated board to use is the pad-per-hole type, such as Radio Shack's Cat. No. 276-192. If you use Wire Wrap hardware, solder two diagonally opposing pins on each IC socket to the copper rings on the board. Use solder sparingly here to avoid clogging the socket pins and preventing good electrical connection between the pins and the Wire Wrap wire.

Use a 25-watt soldering pencil or iron and 0.032-inch-diameter rosin-core solder (Radio Shack Cat. No. 64-005 or similar) for all soldering. If possible, use a pencil or iron that has variable heat-control facilities.

Plan your board layout carefully to accommodate all components that must be mounted on it. A suggested layout is shown in Fig. 3. Once you know where you want to mount the components, mount the IC sockets and secure them in place, as described above. Do *not* plug the ICs into the sockets until after you have conducted preliminary voltage checks and are certain that your wiring is correct.

Mark the pin location of each IC socket on the wiring side of the perforated board before making any connections to the sockets. You may want to use commercially available plastic socket-wrap IDs that slip over all socket pins before connections are made to simplify keeping track of pin numbers. Some mail-order suppliers offer these in single quantity; so you do not have to purchase them in packages of 10 at a time.

Make photocopies of the schematic diagram and Master Wiring List. Then begin mounting and wiring together the various components, starting at the top of the Master Wiring List and working downward. Solder both leads of the resistors and capacitors to the copper rings on the perforated board as you install them. Check off each run on the Master Wire List as you make it and trace it on the schematic diagram.

When you finish wiring the circuit,

Master Wiring List

From		To
U1 pin	1	Keypad(D)
	2	Keypad(C)
	3	Keypad(B)
	4	Keypad(A)
	5	C1(T)
	6	C2(R)
	7	Keypad(H)
	8	Keypad(G)
	9	U2(12),U3(12),U4(12), U5(12),U6(7),U7(7), C1(B),C2(B),S1(3),S2(3), S3(3), S4(3),GND
	10	Keypad(F)
	11	Keypad(E)
	12	U8(1,2)
	13	U8(3)
	14	U2(7),U3(7),U4(7),U5(7)
	15	U2(6),U3(6),U4(6),U5(6)
	16	U2(3),U3(3),U4(3),U5(3)
	17	U2(2),U3(2),U4(2),U5(2)
	18	U2(5),U3(5),U4(5),U5(5), U6(14),U7(14),U8(14), R1(T),R2(T),R3(R), R4(R),R5(T),R6(T), R7(R),R8(R), + 5V
U2 pin	4	U2(13),U6(1,6)
	9	SO1(4)
	10	SO1(3)
	15	SO1(2)
	16	SO1(1)
U3 pin	4	U3(13),U6(8,13)
	9	SO1(8)
	10	SO1(7)
	15	SO1(6)
	16	SO1(5)
U4 pin	4	U4(13),U7(8,13)
	9	SO1(12)
	10	SO1(11)
	15	SO1(10)
	16	SO1(9)
U5 pin	4	U5(13),U7(1,6)
	9	SO1(16)
	10	SO1(15)
	15	SO1(14)
	16	SO1(13)
U6 pin	2	R3(L),S1(2)
	3	U3(4)
	5	R4(L),S1(1)
	9	R2(B),S2(1)
	10	U6(11)
	12	R1(B),S2(2)
U7 pin	2	R7(L),S4(2)
	3	U7(4)
	5	R8(L),S4(1)
	9	R6(B),S3(1)
	10	U711
	12	R5(B),S3(2)

Note: IC pin numbers to which no connections are made are not listed. Numbers in parentheses are IC pin numbers. Parenthetical resistor and capacitor letter legends are as follows: B = bottom; L = left; R = right; T = top. Orientations are referenced to Fig. 1.

carefully go over all your component installations and wiring to make sure you made no errors. As you trace each run on the circuit-board assembly and verify that it is correct, strike through its entry in the Master Wiring List. If you locate an error, correct it immediately.

Having verified your wiring, check over any and all soldered connections. Solder any connections you missed and reflow the solder on any suspicious connections. If you locate a solder bridge between the closely spaced pins of the IC sockets, clear it with a vacuum-type desoldering tool or desoldering braid.

Finally, mount an appropriate-length threaded spacer at each corner of the circuit-board assembly.

Checkout

Before applying power to the circuit, use an ohmmeter or continuity checker to verify that the keypad is properly wired into the circuit. Do this by referring back to Fig. 1 and operating each key in the matrix, checking for continuity between the appropriate row and column pins of the *U1* socket.

With no ICs plugged into the sockets, apply a source of 5-volt dc power to the Generator, observing proper polarity. You can use any source of 5 volts dc to power the project, including plug-in wall-type units. Make sure the dc line is regulated, though.

Clip the common lead of a dc voltmeter or multimeter set to the dc-volts function to any convenient point in the circuit that is supposed to be at ground potential. Then touch the tip of the "hot" probe to pin 18 of the *U1* socket, pin 5 of the *U2* through *5* sockets and pin 14 of the *U6*, *U7* and *U8* sockets. In all cases, you should obtain a reading of approximately +5 volts. If you fail to obtain the proper reading at any cited point, disconnect power from the project and correct the problem before proceeding.

When you are certain that your have correctly wired the circuit, power down and plug the ICs into their respective sockets. Make sure each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

Using a logic probe, dc voltmeter or discrete LEDs, monitor the outputs of *U1* for proper indication at pins 14 through 17 as you press and release the 16 keys of the keypad. If you use discrete LEDs, connect a current-limiting resistor between the outputs of *U1* and the LEDs.

After verifying that the 74C922 is encoding properly, operate *S1* through *S4* and check that the voltages at pins 4 and 13 of *U2* through *U5* are correct. These voltages should go low-to-high when the appropriate switch is pressed and high-to-low when the switch is released. Press and hold each key in turn on the keypad while operating *S1* through *S4* and verify that the proper voltages appear at each pin of socket *SO1*.

When you are done, your BCD Word Generator is ready to be put into service. If you have been using jumper wires or switches in the past to apply logic signals to circuits, just one use of the BCD Word Generator will make you a convert to its ease of use and speedier testing. ■

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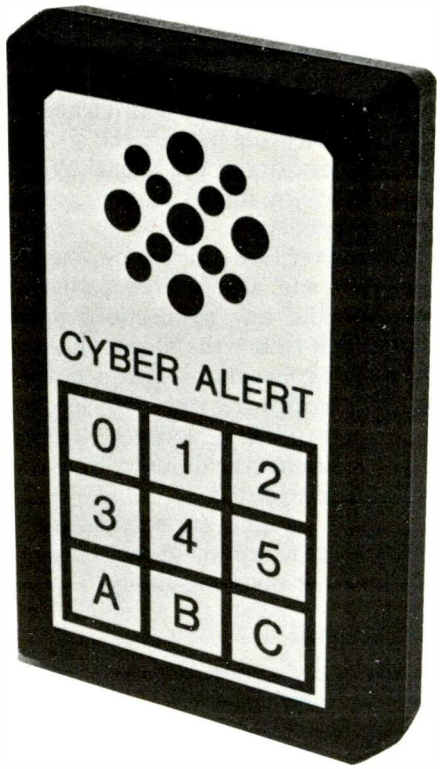

No area is immune to burglary, but you can take steps to minimize the chance of you being "hit." Ordinary intruder alarms, usually detect an intruder, but few provide deterrence. Most require that some damage, such as a broken window or a smashed-in door, occur before they detect unauthorized entry and trigger an alert. Obviously, the best sentry system is one that deters a prospective intruder from even attempting access. Our Cyber Alert talking intruder alarm project does just this at very reasonable cost and without the need to completely "wire" the premises it protects.

Cyber Alert assumes that there's always someone constantly trying to break into the premises it's protecting. It doesn't have to be "triggered" by an attempted break in. Rather, it constantly "talks" about the break-in about to occur. By adjusting the volume level and placing the project in a strategic location, you can control the "sensitivity" of this unique alarm. That is, you foil a would-be intruder simply by letting him hear his own crime in-progress.

Cyber Alert has proven its worth under conditions of actual attempted break-ins. Even though neighbors all around me were "hit" on several occasions, Cyber Alert has kept me insulated from this sort of thing. On several occasions, I even observed neighborhoods giving my apartment a wide birth and learned from them that my apartment was to be avoided at all cost! Insurance companies love Cyber Alert because it prevents windows from being broken and doors from being jimmied, which is usually a requirement before a conventional alarm system is triggered.

Synthesizing Speech

Low-cost and relatively easy-to-implement synthesizer chips make it easy to make an electronic project "talk." The synthesizer chip chosen to provide the "voice" for Cyber Alert is the General Instruments SPO256 "Narrator" Speech Processor. Though more natural-sounding speech technologies exist, they don't lend themselves as well to the "robot alarm" type persona we're trying to create. Cyber Alert is very straightforward and uses inexpensive components that you should be able to find easily. In addition to being an intruder alert, the device will provide you with a platform with which to learn about speech synthesis and its application.

Two basic approaches are commonly used to produce low-bit-rate speech: time-domain synthesis and frequency-domain synthesis. In speech-synthesis technology, data bit rates are a critical factor. Because large memory arrays are physically large, difficult to manage and expensive to implement, low speech data rates are essential. Intelligibility is generally inversely proportional to the rate data is provided to the synthesizer. Good-quality digitally recorded voices typically require 20,000 to nearly 100,000 bits per second. On the other hand, the SPO256 used as the "voice" in our Cyber Alert can produce intelligible speech with about a 100-bps sample rate.

Time-domain synthesizers play back digitally stored or sampled speech waveforms. It's interesting to note that most top-40 recordings use "samplers" (a type of synthesizer) to digitally recreate sounds that were previously recorded. On the other hand, frequency-domain synthesizers use data to actively "filter" pulse and noise sources. Resulting sounds roughly model the human vocal track.

The category of synthesizers into which the the SPO256 falls is frequency-domain. This chip uses a 12-pole digital filter to model the human vocal track and is capable of producing 59 discreet speech sounds called "allophones." The English language can be represented reasonably well by breaking speech into its basic phonetic components. These allophones can be sequenced by our digital vocal track to "sound" like human speech.

Although the SPO256 can be operated directly from a standard microprocessor, the process of creating intelligible speech directly from the written English language is very tricky. The speech that comes so naturally to us as humans still presses us intellectually to fully understand and predict. Much of the tedium associated with this conversion process has now been automated by an algorithm created by the Naval Research Laboratory. An enhanced version of this rather amazing routine has been coded in a companion coprocessor IC, the General Instruments CTS256 Code-To-Speech Processing Chip.

Rule-based speech synthesis theory is well beyond the scope of this article. Suffice it to say that many experts continue to devote their careers to its perfection. Fortunately for us, the SPO256 and CTS256 chips have made the Cyber Alert speech synthesizer both fun and easy to program! Let's look at the actual circuit in more detail.

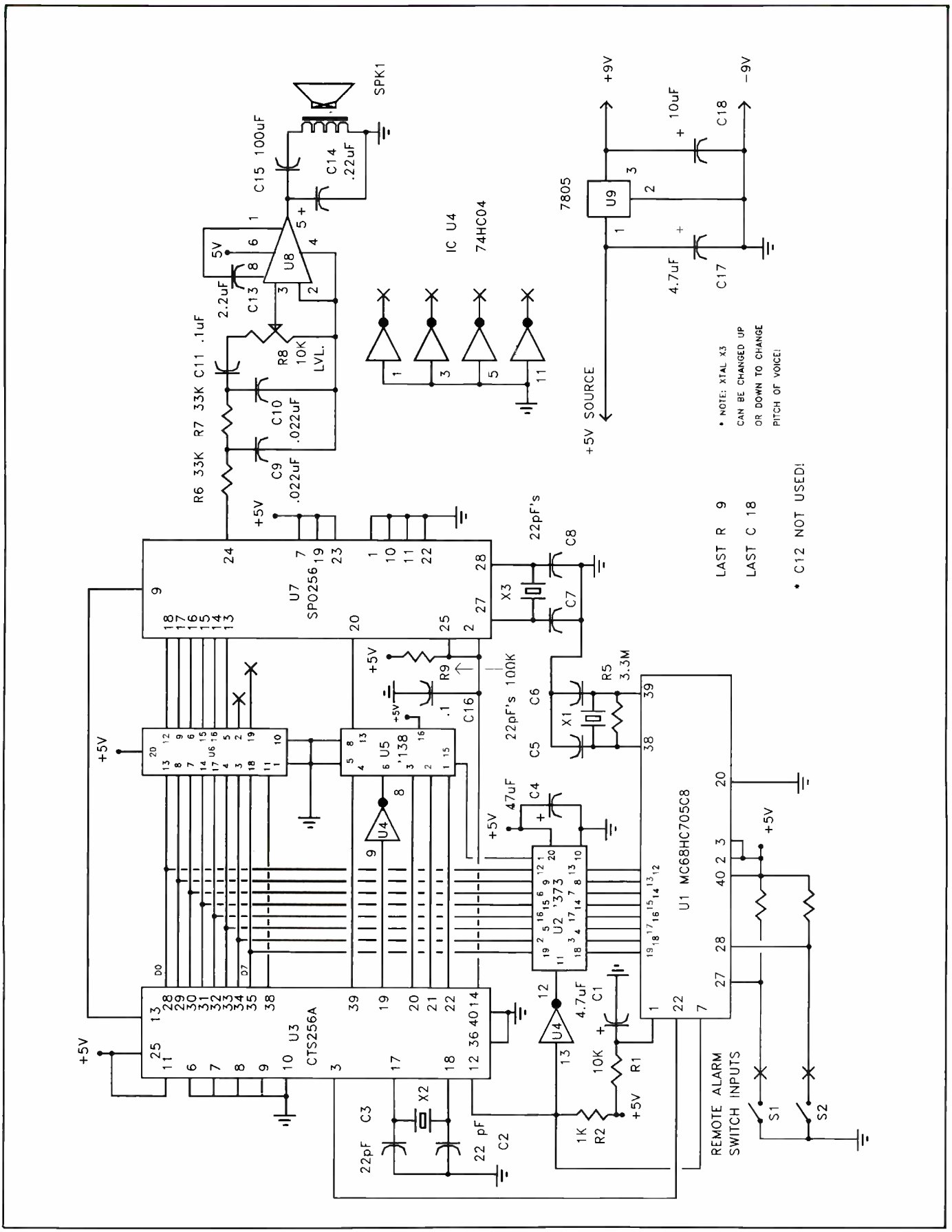

Fig. 1. Complete schematic diagram of circuitry used in Cyber Alert.

PARTS LIST

Semiconductors
U1—MC68HC705C8 microcontroller
U2,U6—74HC373 octal latch
U3—CTS256A coprocessor
U4—74HC04 hex inverter
U5—74HC138 decoder
U7—SPO256A Narrator
U8—LM386 audio amplifier
U9—7805 fixed +5-volt regulator
Capacitors
C1—4.7-μF, 16-volt tantalum
C2,C3,C5,C6,C7,C8—22-pF, 100-volt ceramic disc
C4—47-μF, 16-volt tantalum
C9,C10—0.022-μF, 100-volt disc
C11,C16—0.1-μF, 100-volt disc
C12—Not used
C13—2.2-μF, 16-volt tantalum
C14—0.22-μF, 16-volt tantalum
C15—100-μF, 16-volt electrolytic
C17—4.7-μF, 16-volt tantalum
C18—10-μF, 16-volt tantalum
Resistors (¼-watt, 5% tolerance)
R1,R3,R4—10,000 ohms
R2—1,000 ohms
R5—3.3 megohms
R6,R7—33,000 ohms
R9—100,000 ohms
R8—10,000-ohm pc-mount trimmer potentiometer
Miscellaneous
SPK1—2″ Mylar speaker
PS1—9-volt 200-mA power-supply module
S1,S2—Spst toggle or slide switch
X1—4.00-MHz crystal
X2—10.00-MHz crystal
X3—3.579-MHz crystal
Printed-circuit board; suitable enclosure (Pactec HP Series or similar); sockets for all DIP ICs (optional); machine hardware; hookup wire; solder; etc.

Note: The following items can be obtained from U.S. Cyberlab, Inc., Rte. 2 Box 284, Cyber Rd., West Fork, AR 72774 (tel.: 501-839-8293 or 1-800-232-9856 Voicemail): complete kit of parts (minus IC sockets), $79.95; ready-to-wire pc board, $9.95; pre-programmed MC68HC705C8 microcontroller, $24.95; MC68HC705C8, CTS256A coprocessor and SPO256A Narrator, $34.95. Also available is a complete MC68HC705C8 development system with software for $89.95, Add $4.95 for P&H. Arkansas residents, please add 5% sales tax. MasterCard and Visa welcome.

About the Circuit

Though the schematic diagram of Cyber Alert shown in Fig. 1 may appear to be complicated, it couldn't be any simpler to create a device with an extremely large vocabulary.

Cyber Alert is controlled by Motorola MC68HC805C8 microcontroller *U1*, which is perfect for embedded-controller applications that require a moderate amount of EPROM and RAM. Run at 2 MHz internally from external 4-MHz crystal *X1*, *U1* outputs a constant stream of ASCII characters to 74HC373 octal latch *U2*.

Cyber Alert "talks" almost constantly to confuse would-be intruders into believing they've set off the alarm. External switches *S1* and *S2* are also provided as back-up, allowing you to connect window and door switches directly to the project. So an actual forced entry can be used to change Cyber Alert's voice message as well as trigger other external events controlled by *U1*. The micro-program running in *U1* concatenates the ASCII characters of messages spelled in English and feeds them via *U2* directly onto the *U3*/*U7* speech data bus.

In this circuit, *U3* is the General Instruments CTS256 code-to-speech processor chip. It's actually a preprogrammed microprocessor that accepts English messages from *U1* and analyzes them to create the rule-based allophone data for SPO256 Narrator *U7*. Allophone data is transferred from *U3* to *U7* using 74HC373 octal latch *U6*.

External control signals created by *U3* are decoded using 74HC138 *U5* and applied to pin 20 of *U7*. Timing for *U3* is provided by 10-MHz crystal *X2*. Likewise, timing for *U7* is provided by 3.579-MHz crystal *X3*.

Unfiltered digital speech waveforms are routed from pin 24 of *U7* through the passive RC filter network formed by *R6*, *R7*, *C9* and *C10*. LM386 audio amplifier *U8* drives speaker *SPK1* through coupling capacitor *C15*. Capacitor *C14* and resistor *R9* make up a high-frequency snubber circuit that protects the output section of *U8* from undesirable high-frequency oscillations.

Regulated 5-volt dc power for the system is provided by 7805 fixed-voltage regulator *U10*. Additionally, two sections of hex Inverter *U4* are used by *U3* and *U1* to provide the required inversion of pins 19 and 7, respectively.

Construction

Cyber Alert is best assembled on a printed-circuit card. Though it's possible to assemble the project on perforated board, the results are often disappointing. Actual-size etching-and-drilling artwork for fabricating your own printed-circuit artwork is shown in Fig. 2. Alternatively, you can purchase a ready-to-wire pc board directly from the source given in the Note at the end of the Parts List.

If you fabricate your own pc board, after etching the blank, drill all component-lead/pin holes using a No. 68 bit. Then use a ¼″ bit to drill the four corner mounting holes.

When your pc board is ready to be populated, refer to the wiring diagram shown in Fig. 3. Begin populating the board by mounting and soldering into place the DIP IC sockets (optional but recommended), followed by the resistors, capacitors and jumper wires. You can either mount the ICs now or wait until after you've conducted your preliminary voltage checks and are certain that all wiring is correct.

Now mount and solder into place *U9*. Using a dc voltmeter or a multimeter set to the dc-volts function, check the output of the 9-volt dc power-supply module. Mark each lead according to polarity. Unplug the supply and insert its two output conductors into the polarity-correct holes in the pc board and solder both into place.

Make two or more same-size photocopies of the front panel artwork shown in Fig. 4. Trim these to size and then use rubber cement or contact spray to secure one copy to the front panel of the enclosure. Use this copy to transfer the hole dimensions to the front panel of the enclosure.

Use a hot knife to cut the various speaker holes and a smaller hole along the top edge of the enclosure for the power-supply leads. (A hot-knife is a small razor-sharp knife fitted to the end of a soldering iron. It's used to very precisely cut holes in plastic. If you don't already have one, you can obtain a hot knife from a hardware store. It's a good investment. You'll use your hot knife whenever you build a project that requires a home-machined plastic enclosure.)

When using a hot knife, work very carefully. If you haven't used a hot knife before, start by making the holes

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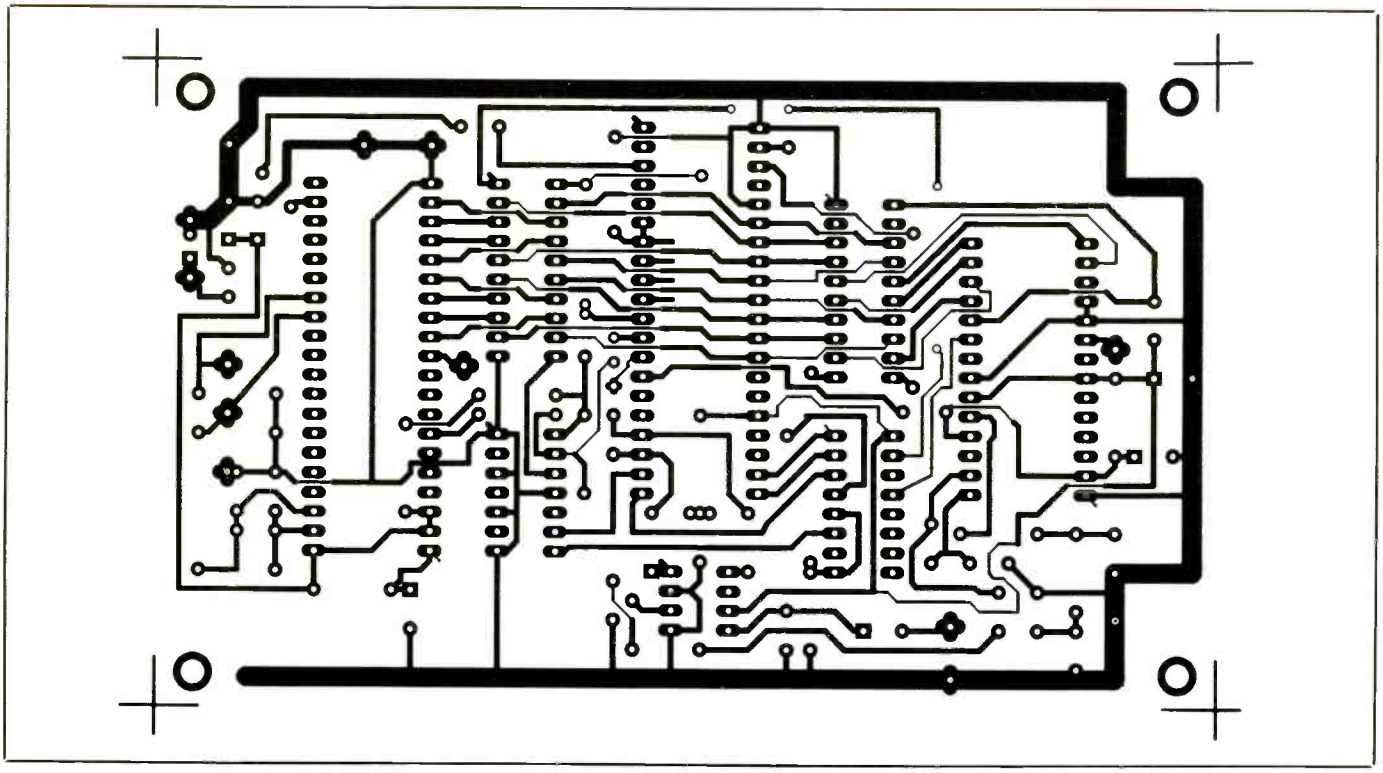

Fig. 2. Actual-size etching-and-drilling guide for those who wish to fabricate the printed-circuit board for this project.

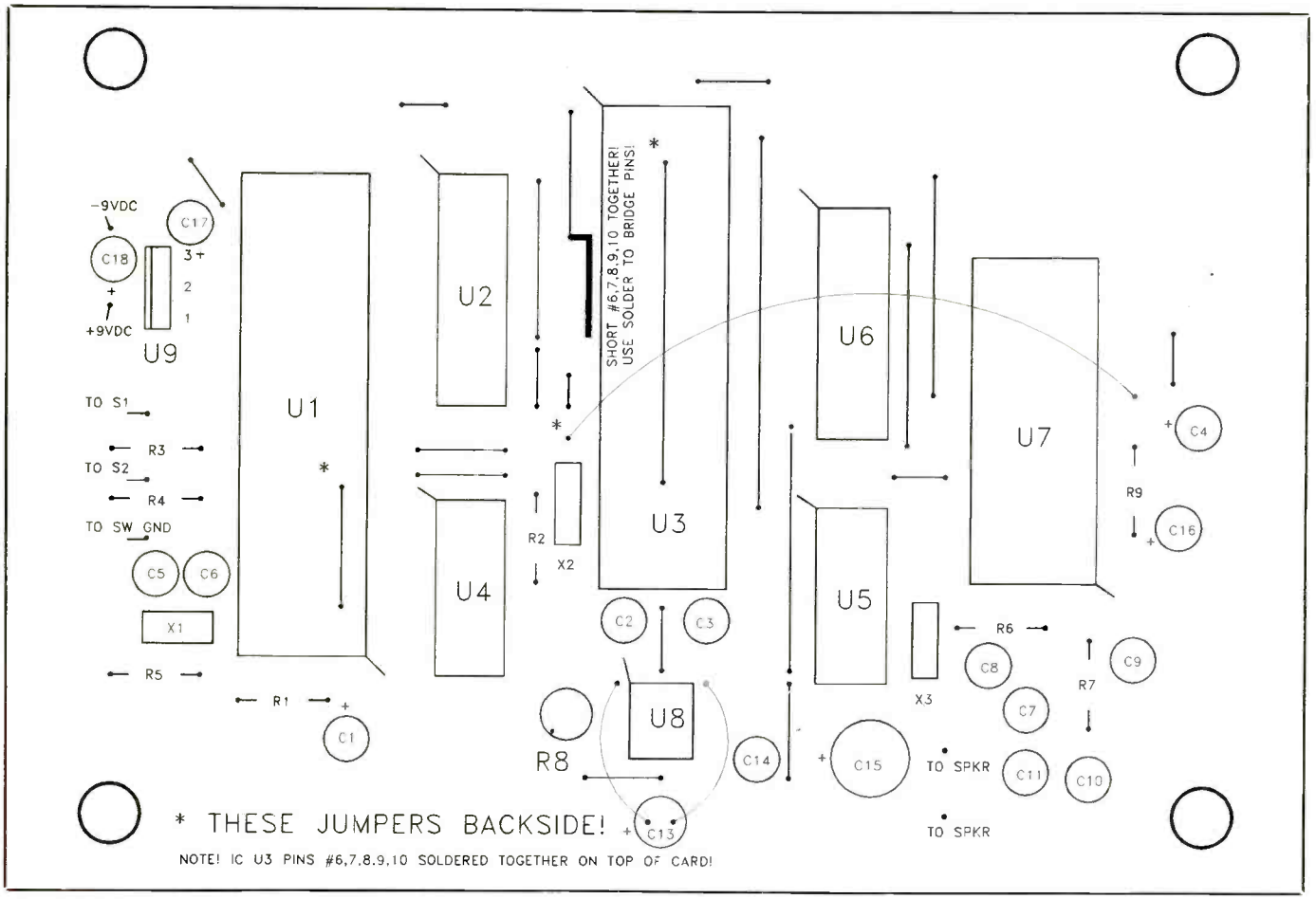

Fig. 3. Wiring guide for pc board.

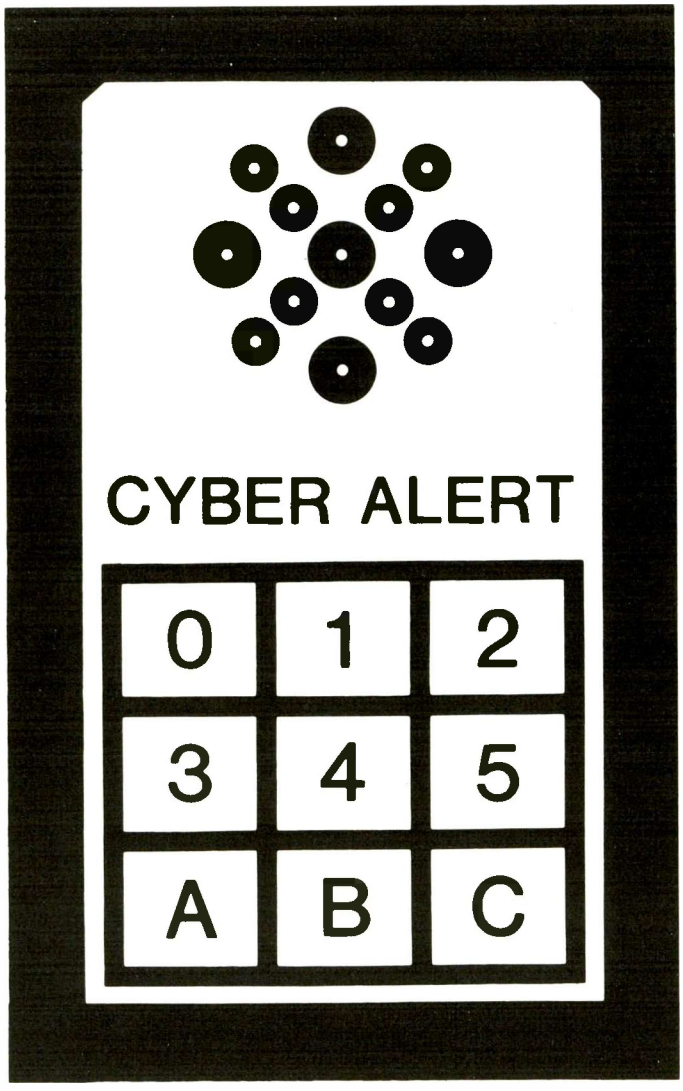

Fig. 4. Actual-size front-panel artwork for project's enclosure.

for the speaker under-sized until you're comfortable with the cutting process. You can trim to final dimensions later. Always remember to thoroughly clean the tip of your hot knife, allow it to cool and then stow it safely for the next time you need it.

Test fit everything in the enclosure. When you're satisfied with hole sizes and spacing, peel the initial front panel artwork off the enclosure. Trim a second photocopy (or the membrane front panel applique provided with the kit if you purchased it) for a perfect fit on the enclosure's front panel. Then use spray adhesive to secure the front-panel artwork in place.

It's sometimes useful to run a No. 2 pencil around the inside of the speaker holes where the edge of the front-panel applique meets the black plastic. This masks the cut marks and blends the front panel into the enclosure for a "factory-finish" appearance.

Next, cement the Mylar speaker into place inside the front panel. Be sure to center the speaker so that it presents a good appearance when viewed through the grille. If you're going to use Cyber Alert in outdoor applications, be sure to run a bead of silicone sealant around the groove between the front and rear panels of the enclosure. Also, seal the unit, only after fully testing it. It's difficult to reopen the case of a unit prepared in this manner.

One final note, if you build the Cyber Alert from a kit, the front panel will be weather-resistant enough for outdoor use. However, it you use a photocopy of Fig. 4 to create the front-panel applique, you must seal the panel with a clear acrylic sealer, available from most hardware and discount stores.

Finishing Touches

You can obtain *U1* pre-programmed from the source given in the Note at the end of the Parts List. If you have access to an 'HC705C8 development system, you can program Cyber Alert to vocalize whatever message you want. If you don't have access to a development system, the Cyber 'HC705 Development System is available from the same source.

The preprogrammed version of *U1* vocalizes and repeats the message: *Intruder alert. Zone C. Who is intruder? Alert. Alert. Alert. Responding to unidentified intruder. Leave the area immediately. You have been detected.*" This message is repeated at 10-second intervals and continues to sound until power is removed from the unit.

Once the project is programmed, you can install it as follows. Begin by applying power to Cyber Alert with all components installed and double-checked. The project performs a self-test and vocalizes "*Okay*" when everything is working as it should. After a few seconds, *U1* begins to provide data to *U3*. Cyber Alert then begins vocalizing its intruder message for the first time.

Mount Cyber Alert in any area you wish to protect. By using a weather-resistant Mylar speaker and silicone sealant around the case, the project can be used on outside door frames, windows, patios, garages, etc.

The front-panel keyboard isn't functional, of course, but I always pretend to deactivate my Cyber Alert when entering and exiting the protected premises. If someone does have your place under observation, this should scare him off.

The key to Cyber Alert's success is in the volume setting. If the project is set to vocalize its message at too loud a level, it will be heard at too great a distance and, thus, will lack credibility. To adjust your Cyber Alert for a residential environment, set the volume to a level that a person can only hear the message if he's near the project, say, 10 to 20 feet away. If you desire a larger protection zone, (industrial or rural area) simply increase the volume setting.

If you want to connect *S1* and *S2* to

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Cyber Alert, remember not to source any voltage into the project. Resistors *R3* and *R4* provide + 5 volts of "pull-up" for *U1*.

It's also important to note that long runs of wire could induce emp (electromagnetic pulses) in *U1* that can damage this IC. If long runs are required, use a 6.3 volt zener diode and 1-μF capacitor between pins 27 and 28 of *U1* and ground.

If you program your own Cyber Alert voice messages, you may want to include special messages that are activated by closing *S1* and *S2*. You can also expand Cyber Alert to include the means for *U1* to automatically dial telephone numbers and report to the person at the other end of the line a break in using the speech synthesizer.

Cyber Alert can also be used in a car or other vehicle. Simply connect an spst switch in series with the + 12-volt battery and the power input point to Cyber Alert. Then when you leave your vehicle unattended, it's automatically protected. You can also use Cyber Alert with a solar-cell array and battery to protect a remote warehouse or a cabin in the woods.

Experimenting

After building Cyber Alert you'll probably be impressed with how easy it is to add a "voice" to your latest project. To use Cyber Alert with your computer system, simply interface the built-in serial port of *U1* at pins 29 and 30 with your computer. You can obtain a version of the Cyber Alert circuit board that has a MAX-232 RS-232 serial interface chip on it for just this purpose.

Using the Cyber 'HC705 Development System to write and program your own code directly into *U1*, you can provide your home computer system with a super simple unlimited speech synthesizer. Cyber Alert will automatically vocalize ASCII text files. Using your computer's serial port, you can also use Cyber Alert to let your computer "talk" over telephone lines.

Cyber Alert is also very useful on the lab bench. Proper pre-programming of *U1* can make Cyber Alert interface directly with various hardware projects. With a internal serial port, a serial peripheral port, internal timer, watch-dog and 16 additional input/output lines to work with, Cyber Alert can be worth many times its small investment as a diagnostic tool. For example, you can use it for any of the following purposes:

Real time clock that announces the time automatically;

Data logger that can tell you about an event that's occurring;

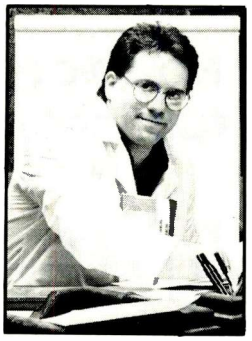
Voice module for appliances and electronic games;

Equipment prompter to assist people with complex equipment;

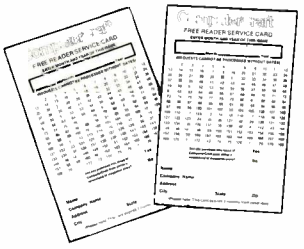
Talking toy for children;

Talking doorbell.

You get the idea. Even if you limit use of your Cyber Alert to just its primary alarm function and foil a single burglars, you'll have more than recouped its modest cost. Better still is the fact that you'll have peace of mind knowing that a tireless electronic sentry is minding the shop, so to speak. ■



Nick Goss



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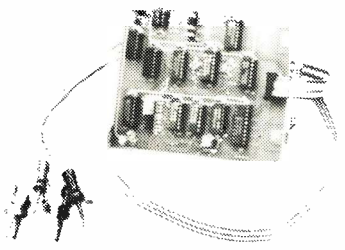

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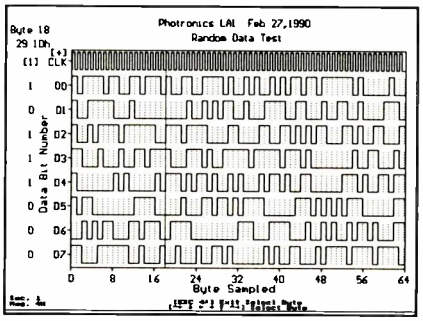

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RS-232 Cables Made Easy

No-solder off-the-shelf components simplify fabricating computer serial cables

Until recently, home experimenters had only two ways to build RS-232 cables—ribbon cables using insulation-displacement connectors (IDCs) and soldered connections using standard DB-25 connectors. Now parts and tools sold by Radio Shack provide two more options that allow you to quickly build such special adapters as gender changers and null-modem adapters. If a new cable requires no more than six conductors, an RS-232 to modular adapter provides a quick solution. For a cable that requires a greater number of conductors, crimp-style D-Sub connectors are a practical solution.

Choosing a Connector

Figure 1 shows typical RS-232 connector pinouts for computers and peripheral devices like printers and modems. Different computers may have different connectors and even different pinouts from those shown, though. Therefore, you must consult the owner manuals for your equipment to determine exactly the correct connections. Most IBM and clone computers have two DB-25 connectors. The RS-232 port usually has male pins, and the printer port usually has female pins.

If your equipment is of typical design, the pinouts at it and any peripheral devices will be identical. If so, cables connected between them can be built using the schematic shown in Fig. 2. Ribbon cables are ideal for such connections. If you must connect one computer to another, both computers use the same DB-25 output circuit. With this arrangement, you must reverse the signal and handshake lines, as shown in Fig. 3.

In industrial shops, cables are built using crimped connections like the one shown in Photo 1. Photo 2 shows two mating pins. Each pin has four tangs. Two tangs are for insulation and two grip the wire. After crimping, the tangs wrap tightly around the insulation and wire to create an airtight joint on the wire. In addition, the insulation crimp reinforces the connection by supporting the wire against mechanical stress.

There are some advantages to using crimped pins, not the least of which is that you can easily field modify or build whole new cables without soldering. Cables built in this manner are stronger and more reliable than those built by other means because the wires haven't been heat-stressed.

To use crimped pins, you need a special crimping tool that has a ratchet to prevent the tool from releasing until the crimp is complete. Industrial crimpers cost more than $50, but for the home experimenters Radio Shack has a low-cost ($10) crimper (Photo 3). Of course, the low cost of this tool comes with a tradeoff—a slightly stronger "squeeze" action is needed to make a crimp, and assembly is a bit more difficult than with the industrial crimper. The greater difficulty results because the Radio Shack crimper doesn't hold the pin while the wire is inserted, which slows down assembly.

The procedure for building a crimped-pin cable is as follows. First, you must strip the outer insulating jacket from the cable and then from

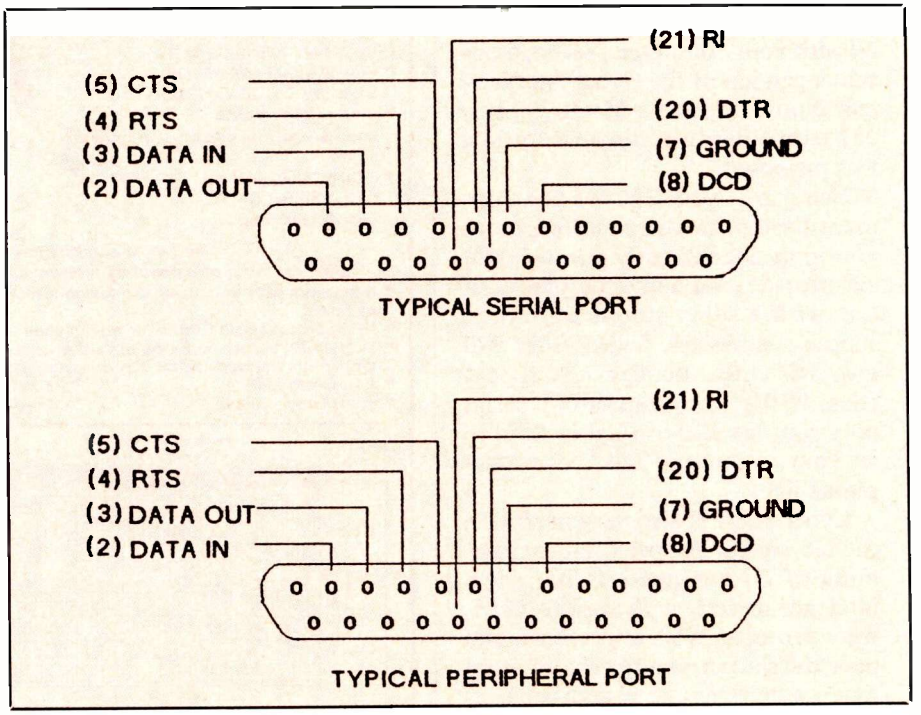

Fig. 1. Schematic details of computer serial ports.

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individual conductor wires as you would normally do for solder-type cable connectors. When you do this, make sure the conductors are uniformly stripped to expose about 5/64" of wire is exposed.

Tangs on crimp-type pins are spread too wide to easily fit the Radio Shack crimper. However, you can use the crimper to force the tangs to orient parallel to each other. Photo 4 shows how to use the front end of the crimper to close the tangs so that they're parallel. The modified pin can then be wedged into the crimper, as shown in Photo 5.

When you wedge the pin into the crimper, make sure its shoulder is flush with the edge of the crimper. Close the crimper jaws just enough to securely hold the pin. Then insert the wire into the pin just far enough for the insulation to be inside the *rear* pair of tangs. Squeeze hard on the tool handles to obtain a solid crimp and then release. When properly done, the crimp should look like that shown in Photo 1.

Depending on your application, you may have pins on one end of a cable and either pins or sockets on the other end. Photo 6 shows the ends of a standard cable with pin-terminated wires inserted into the connectors.

As you install pin-terminated wires into the holes in the rear of a connector, check carefully to make sure each goes into the correct hole. Push the pins into the connector until they lock into place. Clearly marked pin numbers on these connectors (Photo 6) greatly minimizes the chance of mistakes. If you do plug a pin into the wrong hole, or have to redesign the cable at a later time, a special tool like that shown in Photo 7 must be used to release the pin.

No cable is complete without hoods to dress it up and provide strain relief for the cable conductors. The Parts List gives Radio Shack Catalog Numbers for standard plastic hoods. All-metal and metallized-plastic hoods are also available for applications that require special electrical shielding.

RS-232-to-Modular Adapter

Photo 8 shows a finished cable terminated in a modular adapter that allows your cable to use a telephone extension cable instead of standard multi-wire cables. The connector is labeled with a "T" to prevent its ends from being accidentally switched. The built-in modular connector accommodates four- and six-conductor extension cables for greater versatility. Though the standard adapter is available with only DB-25 male connectors, a standard DB-25 female connector can be substituted if needed (furnished male pins must be replaced with sockets).

Photo 9 shows the disassembled adapter. Note that the six wires from the modular adapter can be inserted into the connector where needed. Use an ohmmeter or audible continuity tester to be sure which wire is which.

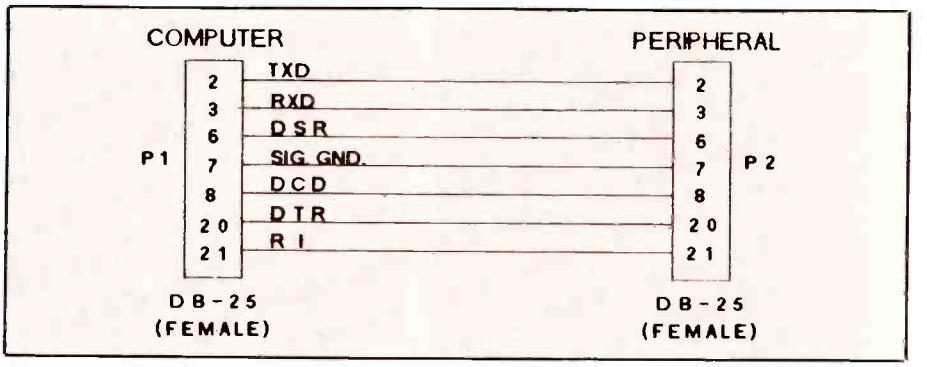

Fig. 2. Cable details for connecting computers to peripheral devices.

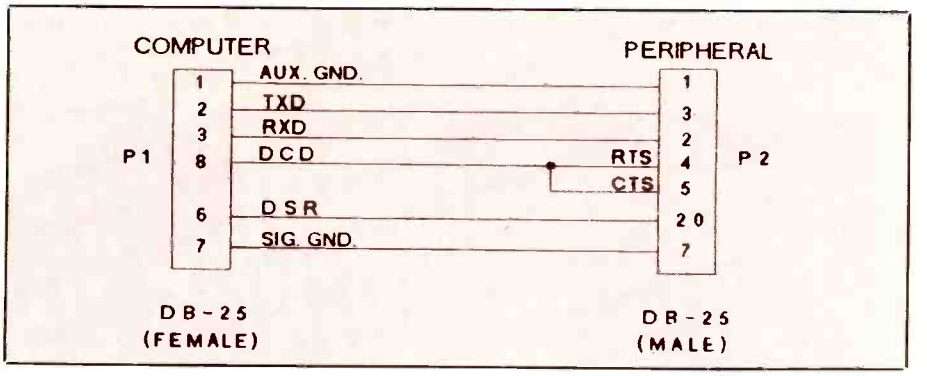

Fig. 3. Schematic diagram of null-modem adapter.

Special Adapters

Some RS-232 applications require a gender changer or a null modem. A gender changer has a straight-through electrical configuration like that shown in in Fig. 2. and is normally used to adapt existing cables that have the wrong connector attached. Gender changers have either two male or two female connectors, depending on which is needed. A null

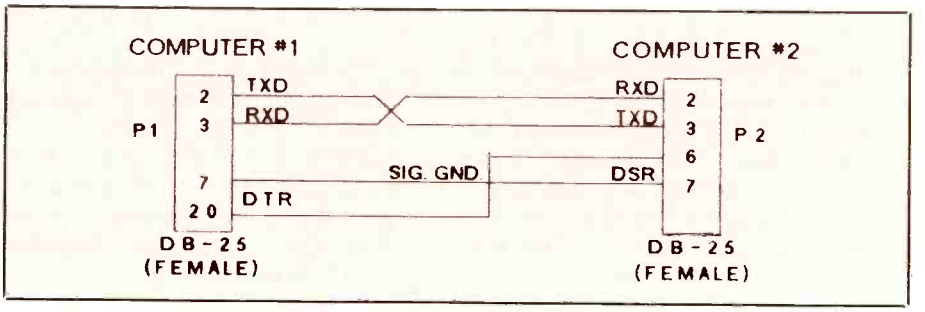

Fig. 4. Cable for connecting two computers together.

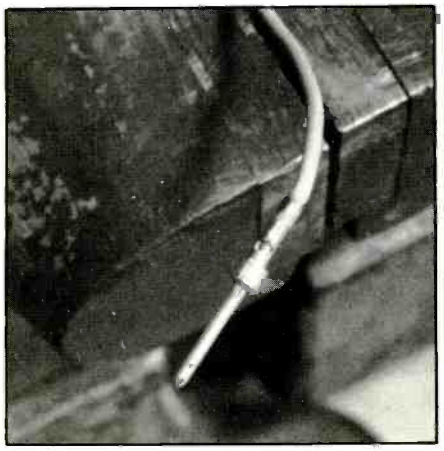

Photo 1. An industrial-type crimped-pin connection.

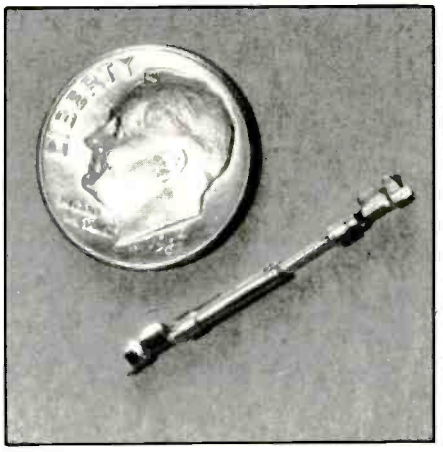

Photo 2. Mated industrial-style connector pins.

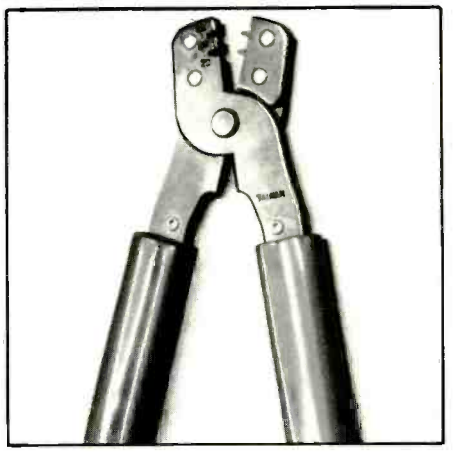

Photo 3. A low-cost crimper sold by Radio Shack.

Photo 4. Crimper is used to make a pin fit into its jaw slot.

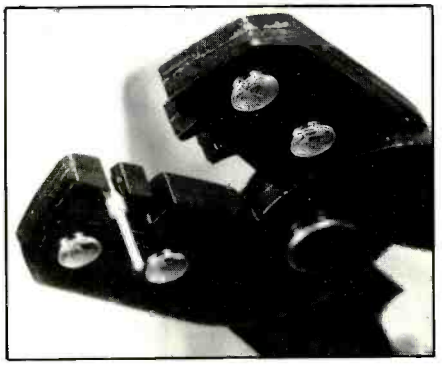

Photo 5. Pin shown in place in crimper jaw slot.

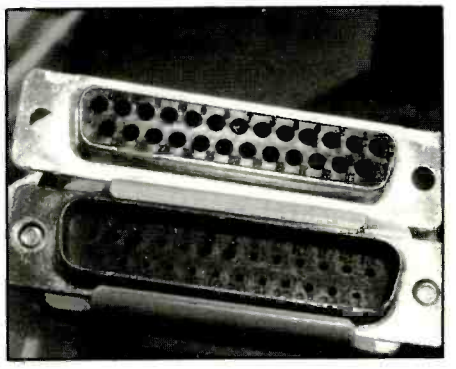

Photo 6. Connectors are shown here with pins installed.

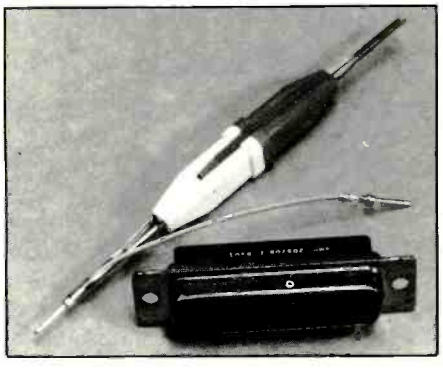

Photo 7. An insertion/removal tool eases cable modifications.

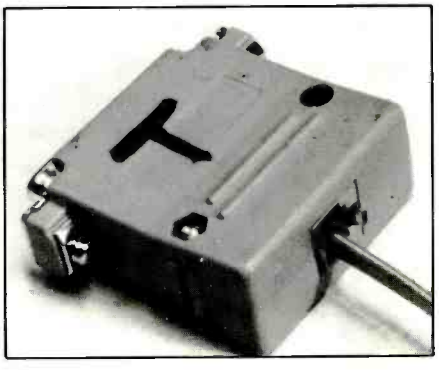

Photo 8. A modular adapter uses a telephone extension cord.

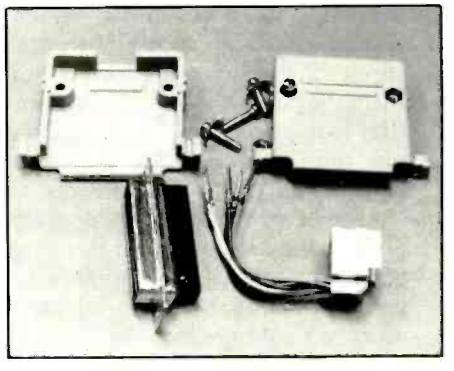

Photo 9. Modular adapters can be connected as needed by your application.

adapter has reversed connections, its circuit appearing schematically as shown in Fig. 3. It's used with standard communication cables to adapt them for computer-to-computer connection. An inexpensive multi-purpose part can be used to build these adapters (see the Note at the end of the Parts List for a source from which this part can be purchased).

Photos 10, 11 and 12 show how the adapter can be configured as a cable hood (Photo 10) or as a special adapter (Photo 12). Note that a a plastic cable tie, shown in the foreground at the left, anchors the cable to the shell when it's configured as a hood (Photo 11).

Photo 12 shows the adapter from the outside. Captive screws (left foreground) can be used to anchor the connector to the computer and special tapped standoff nuts (right foreground) allow a cable connector to be locked to the second connector. The adapter package contains all the parts needed to make either connector configuration, plus a set of captive screws and standoff nuts as shown in Photo 13.

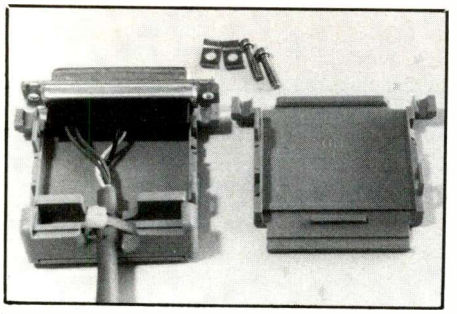

Photo 10. A plastic cable tie (foreground) anchors cable to hood.

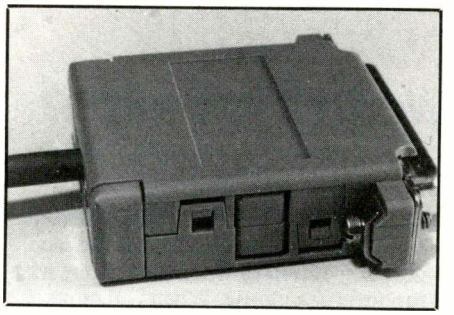

Photo 11. Completed project attaches to computer with captive screws.

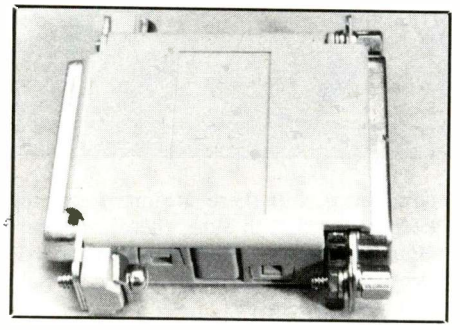

Photo 12. Special hardware anchors adapters to computer and cables.

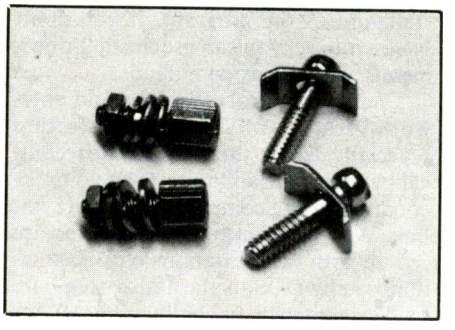

Photo 13. Mounting hardware is available in special kit.

PARTS LIST

Crimping Tool (276-1595)
Cable Hood, 9-Pin (276-1539)
Cable Hood, 25-Pin (276-1549)
RS-232 Modular Adapter (276-1406)
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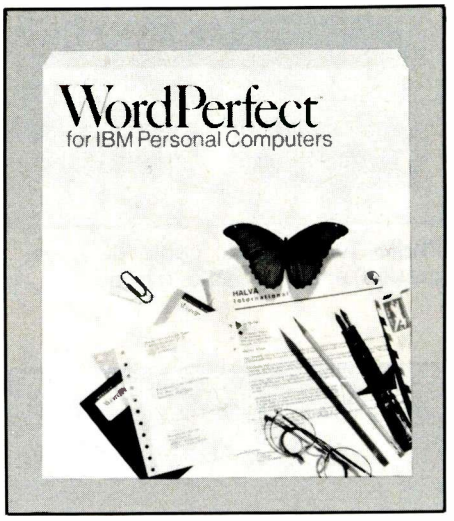
WordPerfect 5.1: Is It Worth It to Switch?



For many years, *WordPerfect* has reigned as the king of PC word processors. People who use other popular packages—*WordStar*, *Microsoft Word*, *XyWrite*—may not care about this, but they're sometimes forced to take notice. In my own case, I was happy using *XyWrite*. I started with version II and upgraded through versions II+, III and III+.

WordPerfect started infiltrating my life several years ago when I received a demo disk of version 4.2. It was sent to me by the WordPerfect Corporation. This was an almost complete version of the product—only a spelling checker, thesaurus and help file were missing. Since *WordPerfect* was such a popular word processor, I bought an inexpensive quick-reference book and tried to learn it. I wasn't very impressed. I thought *XyWrite* was a better all-around program.

I continued to use *XyWrite* as my primary word processor until WordPerfect Corp. introduced version 5.1. Apparently, the features of this version convinced several companies that I work with to switch to *WordPerfect*. I had to switch, too, and spend some time trying to learn *WordPerfect*. I needed to be able to use *WordPerfect* fairly well, of course. The review of *WordPerfect* 5.1 that follows is written from the perspective of a *XyWrite* user who was forced to make the switch. Throughout the review, I refer to features from both products and tell which product I think does a better job.

WordPerfect 5.1 is for IBM PC, XT, AT and PS/2 computers and compatibles. It requires at least 384K of RAM just to load; so 512K minimum is needed. DOS 2.0 or a later version is also required. The program lists for $495, but substantial discounts are commonly offered by dealers.

About WordPerfect 5.1

WordPerfect 5.1, like previous versions of the product, presents you with a blank screen upon start-up. In the lower-right corner is a status line that tells you the document, page, line and position numbers. Whenever you select a feature like bold, underline and so forth, the position number changes style to indicate that the feature is in effect. *WordPerfect* commands are issued by pressing functions keys. When you press a function key, a menu bar often appears on the bottom of the screen, offering several choices; sometimes a full-screen menu appears.

One of the major changes in *WordPerfect* from Version 5.0 to 5.1 is the incorporation of pull-down menus, along with support for a mouse. When you move the mouse to the top line of the screen, a menu bar appears. Then when you click the mouse on a selection, a menu drops down. You add mouse support after you start *WordPerfect*, not during initial installation of the program. If you don't have a mouse, you can use the pull-down menus with alt-key commands.

There are several other new and noteworthy features of Version 5.1. A feature especially dear to those who write technical papers is the ability to enter complex equations using common terms and symbols. Another feature, for those who are fed up with the limitations on filenames imposed by DOS, is the ability to use up to 68 characters (including spaces) for document names. An attribute useful for spreadsheet users is the ability to bring spreadsheets directly into a document. Any change made to the spreadsheet is made automatically in the *WordPerfect* document.

A major feature of *WordPerfect* 5.1, introduced with Version 5.0, is the ability to integrate graphics into documents. You can't see the graphic in standard mode, but you can see it in preview mode.

WordPerfect 5.1 vs. XyWrite III+

Any major word processor has so many features that it would take much more room than we have here to list them all. Also, most people learn only a fraction of the features available in a word processor. In switching to *WordPerfect* 5.1, I was forced to become at least as proficient with this word processor as I am with *XyWrite*. Listed below are many of the features of *WordPerfect* 5.1 I had to learn. Included are my opinions of them versus similar ones in *XyWrite* III+.

•*Command Interface.* As mentioned, you issue commands in *WordPerfect* with function keys. In contrast, you issue commands in *XyWrite* from a command line. If you don't use a template or have a quick reference handy, using function keys is intolerable because you must work with the product for long hours every day to keep function key commands straight in your head. With a command-line interface, you memorize a few commands and type them in whenever you need them. *XyWrite* uses function keys for some commands, but there are many less to keep in mind. I'm sure, therefore, that *WordPerfect*'s supplied plastic keyboard templates are widely used by operators of this word processor.

Incorporation of pull-down menus into *WordPerfect* 5.1 is a significant improvement to the product. You now have the opportunity to select operations from a menu without having to memorize them.

•*Help.* Some people try to learn a new program by reading the documentation supplied with it, others by a trial-and-error process while using the program. I used the latter method with both *XyWrite* and *WordPerfect*. I resort to the documentation only when I'm stumped. When I'm trying to learn how to use a program, I often use any on-line help a program has to offer.

To access help with *WordPerfect*, you press function key F3 or select Help from the menu bar. *WordPerfect*'s help consists of a listing of items and corresponding function keys, plus a separate explanation of each function key. Somehow, the listing doesn't make it easier for me to figure out what to do in a given situation. I prefer *XyWrite*'s help method. You select a command, and *XyWrite* provides an explanation as well as a list of related commands.

Since *WordPerfect* is such a popular program, there are many companies offering third-party support. One company, Sybar, sells a program called the *WordPerfect 5.1 On-Line Advisor*. For more information on this product, see the Advice on *WordPerfect* 5.1 box given elsewhere in this review.

•*Copy and Move Text.* As with any other word processor or text editor, you can copy and move text with *WordPerfect* 5.1. You begin the process by pressing Alt-F4 and then make a selection based on

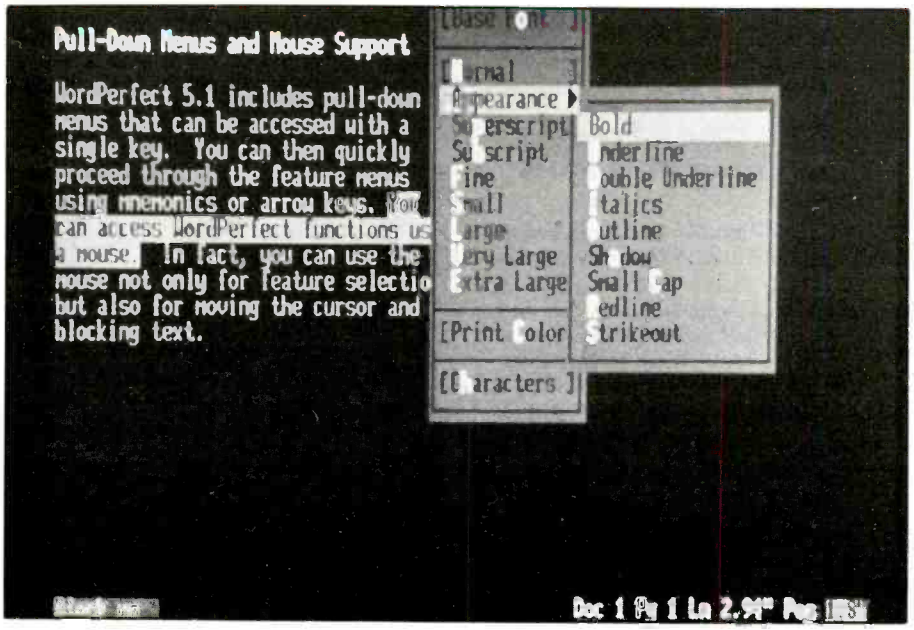
whether you want to copy, move or delete the block. With *XyWrite*, in comparison, you highlight text with a function key and then use an alt-key combination to copy, move or delete text. Either method is easy enough. However, a function I often use in *XyWrite* is to copy a block of text many times. For the longest time, I couldn't figure out how to do the same thing with WordPerfect. With *WordPerfect*, you can retrieve a block of text by pressing Ctrl-F4, selecting retrieve and then block. This is a cumbersome way to perform this operation, in my opinion.

•*Search and Replace.* To perform a search and replace with *WordPerfect* 5.1, you select either F2 (search only) or Alt-F2 (search and replace). Then you enter the search characters and press F2 again. A problem occurs if you accidentally press Enter to start the search. Instead of starting the search, a symbol for the enter key appears. Actually this is good, since it lets you search your document for carriage returns, but it can be confusing. With *XyWrite*, you enter the appropriate command and enclose your search characters between slashes (/). You can search for and replace carriage returns by typing Ctrl-Enter between the slashes.

With *XyWrite*, a problem occurs if you need to search for the slash character. I had to do this when writing about *Lotus 1-2-3*, which uses the slash to bring up the main menu. I couldn't figure out how to search for the slash, and on-line help and documentation didn't help.

•*Navigation Keys.* Navigation in *WordPerfect* 5.1 is a horror. It's inconsistent and requires too many keystrokes to accomplish. For example, to go to the end of a line, you press End. To get to the beginning of the line, you press Home Left-Arrow. To get to the top of the document, you press Home Home Up-Arrow. There are many different combinations, too many to keep up with. Luckily, mouse support obviates the need for navigation keys. *XyWrite's* navigation keys, though, are splendid. Use Alt-Right (or Left) Arrow for word jumps, Ctrl-Right (or Left) Arrow to jump from the left to the right end of a line, and Ctrl-Home or Ctrl-End to reach the beginning or end of a document.

•*Text Manipulation. WordPerfect* 5.1 manipulates text in an awkward way. Suppose you want to insert text into a paragraph. As you insert text, the line extends way beyond the margin. The paragraph doesn't justify itself correctly until you hit the Down-Arrow key. This is annoying and is sometimes frustrating when editing a document. For example, if you insert or delete text on a line, and then try to reach a certain word on the next line, you usually miss the word due to the rearrangement of the paragraph as soon as



A WordPerfect 5.1 pull-down menu used for selecting the appearance of a selected type font from either keyboard or mouse.

Advice on WordPerfect 5.1

The *WordPerfect 5.1 On-Line Advisor* ($29.95) from Sybar Software (a division of Sybex, Inc.) is essentially an in-depth help program. It's a TSR that runs in the background (using 90K of RAM and about 400K of hard-disk space) and is activated by pressing Alt-/. *WordPerfect* 5.1 has its own Help program; so you may wonder why Sybar created another one. As mentioned in the accompanying review, *WordPerfect*'s built-in help doesn't always assist you in solving a problem; so there's a reason for more help. To find out the usefulness of the *On-Line Advisor*, we compared it to *WordPerfect*'s help for two specific problems.

Problem 1: *Copy text repeatedly.* Sybar uses a simple method to locate a subject: just type the subject's name. To find out how to copy text repeatedly, we pressed Alt-/ to activate the *On-Line Advisor* and then typed: copy. Then we used the Down-Arrow key to reach the subject heading: *Copying with blocked text*. Pressing Enter gave an explanation of the heading. Just above the explanation was a menu bar.

We selected one of the menu choices: *Related Topics*. A list of related topics appeared in a box. We selected from the list: *Cut and Copy Text*. From here, we read the explanation until we came to a paragraph that explained how to perform a copy operation multiple times. The explanation was clear, and the instructions given solved the problem.

When we tried the built-in *WordPerfect* help utility, we couldn't locate an indication under the copy command for copying text multiple times.

Problem 2: *Creating Macros* To find out how to create macros with the *On-Line Advisor*, we pressed Alt-/ and typed: Macros. A heading of the same name appeared: *Macros*. Pressing Enter presented the keystrokes needed to define a macro.

By pressing the PgDn (page-down) key, we eventually found a section titled: *Usage—General*. This explained what a macro is and what you can use it for, Another section, *Usage—Creating Macros*, gave a step-by-step explanation for creating macros. In contrast, *WordPerfect*'s on-line help gave only the keystrokes needed to define and execute macros. To receive an explanation and a step-by-step guide to creating macros, you must refer to the documentation supplied with *WordPerfect*.

As you can see from the foregoing examples, the Sybar *On-Line Advisor* provides a more complete help facility that WordPerfect does. If you're someone who disdains printed documentation and prefers to have extensive help at your fingertips, Sybar's *WordPerfect 5.1 On-Line Advisor* is for you. It comes with a reference manual, to boot.

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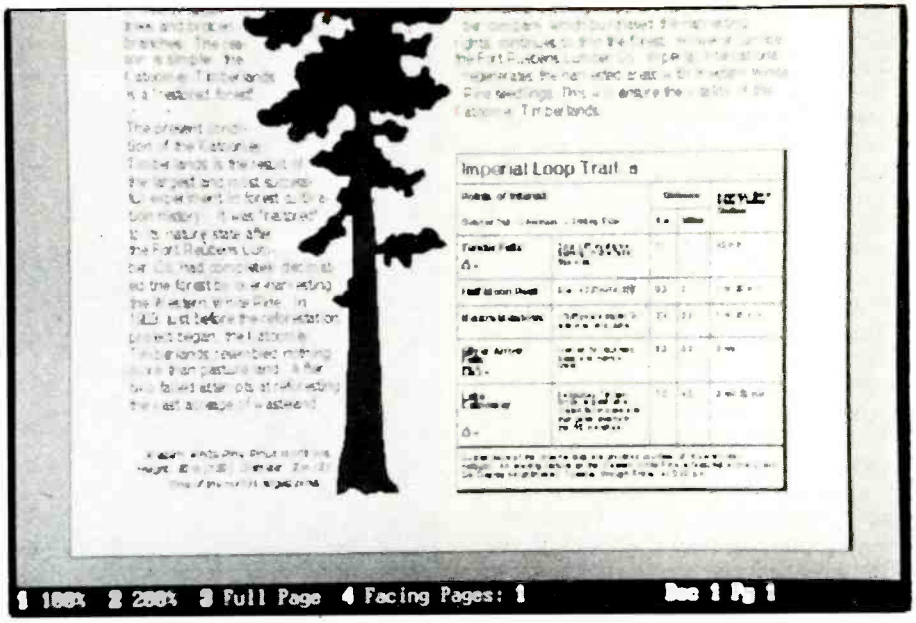


WordPerfect 5.1 lets you import graphics into a document. Graphics display only in preview mode, as illustrated in this screen shot.

you hit the Down-Arrow cursor key. With *XyWrite III+*, this isn't a problem.

•*Graphics. WordPerfect* 5.1 lets you incorporate graphics into a document. The graphic needn't be *WordPerfect* format, but some formats are not acceptable. If you want to convert a graphic to *WordPerfect* format prior to using it, you must use a convert program that you run separately from *WordPerfect*. If you don't read the documentation the only way to find out about this program is by examining the files in the *WordPerfect* directory. Graphics display only in the preview mode. *XyWrite* falls far shorter here since it makes no provisions at all for incorporating graphics into documents.

•*Special Characters. In WordPerfect*, special characters are entered with a feature called Compose. You press Ctrl-V and then type the number of the character set and number of the character. A full listing of characters and symbols is contained in the *WordPerfect* documentation. With *XyWrite*, you bring up the help menu and select from it ASCII. The ASCII menu then provides five categories of special characters from which to choose. I find this approach an easier way to access special characters.

•*Equations. WordPerfect* 5.1 contains a graphical based equation editor for creating mathematical equations. You access this feature by pressing Alt-F9, selecting Equations, Create and Edit. This feature, a very useful one for anyone who produces technical documents or books, is not available with *XyWrite III+*.

•*Multiple Documents. WordPerfect* lets you work with two documents at a time, and lets you split the screen so both can display at one time. Although it is a simple matter to invoke this feature (Ctrl-F3 or choose it from the pull-down menu), I rarely use this feature with *WP*. With *XyWrite III+*, however, I use this feature frequently. One reason may be that *XyWrite III+* lets me open as many as nine windows and lets you show all of them on the screen.

•*Spell Checker.* Checking spelling with *WordPerfect* 5.1 is tedious, simply because the checker rarely chooses the right word as a replacement. You usually need to run down a list to find the correctly spelled word. *XyWrite*'s spelling checker is adept at choosing the correct option. With *XyWrite*, I find I can correct a document much more quickly than with *WordPerfect* 5.1.

•*File Types.* Files saved with *WordPerfect* 5.1 are in a format suitable for use with Versions 5.0 and 5.1. If you want, you can also save files in *WordPerfect* 4.2 or ASCII format. *WordPerfect* gives you two choices for ASCII files: you can save the files as DOS text (hard carriage returns) or as generic text (soft carriage returns). This is a great advantage when you need to send text with hard carriage returns through an electronic mail service like MCI Mail.

All files saved with *XyWrite III+* are saved in ASCII format with soft carriage returns. Putting in hard carriage returns is a pain; so *WP* is way ahead here. You can do it by hand or automatically by printing to a file. If you print to a file,

Using WordPerfect 5.1's Equation Editor

Word processors typically can't produce mathematical equations like those that appear in technical papers and textbooks. The best you can hope to do with most word processors is use the IBM Graphics Character Set to produce mathematical symbols like plus/minus (q), greater than or equal to (r), division (v), and other common symbols.

With *WordPerfect*, you create these kinds of symbols by using (Ctrl-v) and typing the appropriate code. For example, to type q, you press Ctrl-v and the prompt Key = appears in the bottom-left of the screen. If you type the code: 6,1, you get the "q" symbol. If you can't remember the codes, you need to check in the documentation or retrieve the file CHARACTR.DOC and look up the code.

WordPerfect 5.1 goes way beyond this rather crude method of creating mathematical equations. It has an Equation Editor that works in a graphic mode. To enter the Equation Editor you use Alt-F9 and select Equation Create (or select Graphics Equation Create from the pull-down menus). A full-screen menu appears with nine choices from which to select. When you select Edit, a graphics screen similar to the one shown in Fig. A appears.

There are four main areas on the screen. On the right side is a list of functions you can select. Along the bottom is a menu. Just above this is an area where you enter the equation from the keyboard. Taking up most of the screen is the equation display area.

To use the Equation Editor, you first type in the equation from the keyboard. Nothing displays in the equation window until you select Screen from the menu. If you need to make a change, you do it from the keyboard. Then you select Screen to see how the change looks. This is very much a trial-and-error process.

To test the Equation Editor, we attempted to enter an equation that describes an RLC circuit, utilizing Kirchhoff's current law. The result is shown in Fig. B.

We had two main problems creating this equation. The first concerned the term v(t)/R and similar terms. It was difficult to figure out how to place the entire term v(t) in the numerator. The obvious choice, OVER, didn't work. Typing v(t) OVER R gave a graphic with only the right-most parenthesis over R. To place the entire term over R, it's necessary to enter the command STACK, as shown in Fig. B.

A second problem, which we never did figure out completely, concerns the integral sign. When setting the limits from 0 to t, the limits appear to the left of the integral sign, rather than the right. Numerous attempts to add spacing to correct this problem failed.

It's clear that the *WordPerfect* 5.1 Equation Editor, although a powerful addition to the program, isn't as intuitive as it might be. Figuring out how to get the equation just right is a chore, involving lots of trial-and-error steps. The fact that you can't work directly in graphics mode is a serious drawback to the Equation Editor, but one that you can live with as you become better acquainted with this feature.

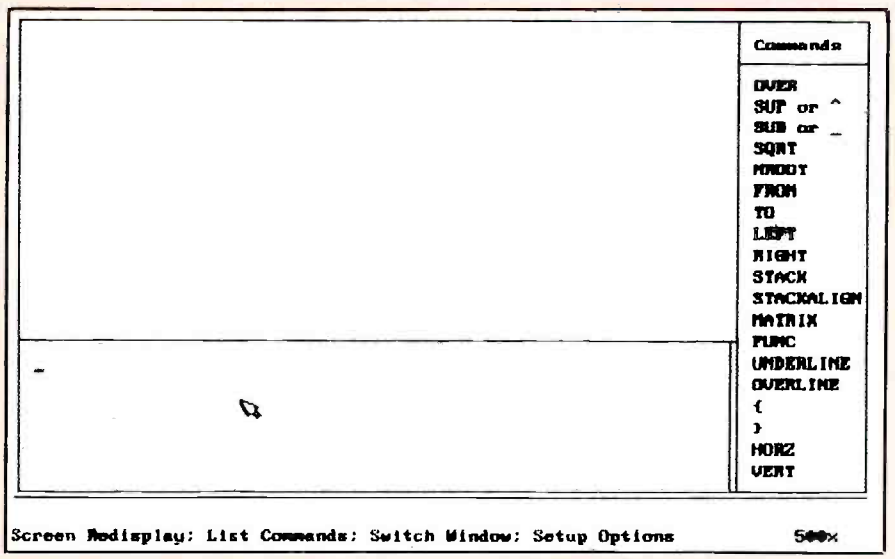


Fig. A. When you select Edit, a graphics screen similar to this appears.

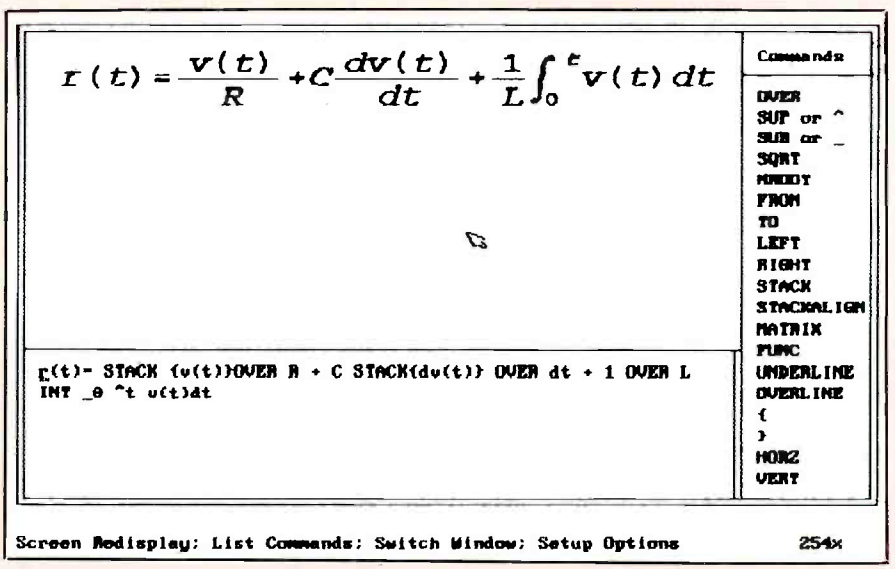
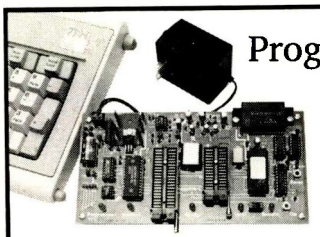


Fig. B. Results of an attempt to enter an equation that describes an RLC circuit, utilizing Kirchhoff's current law.



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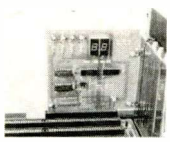

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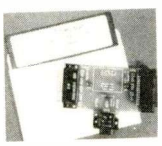

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though, you often get extraneous print characters in the file. You can avoid this by eliminating the printer driver from a start-up file. If this sounds confusing, it is. The saving grace of *XyWrite* is that you can send files with character such attributes as bold, underline and so forth through services like MCI Mail, since the attributes are in ASCII. This is impossible to do with *WordPerfect*.

•*Macros.* Creating macros in *WordPerfect* 5.1 is a relatively simple task. You press Ctrl-F10 to start the process. Then you name the macro and let *WordPerfect* record your keystrokes. To use the macro, either you press an alt-key combination or you press Alt-F10 and type the name of the macro. You can create macros with *XyWrite*, too, but I've never figured out how to do it. Although I wanted to, I've never used macros with *XyWrite*. *XyWrite* also contains a programming language, which I never bothered to investigate, simply because I haven't have the need for it.

•*Printer Support.* *WordPerfect* 5.1 has extensive printer support. One of its finest features is the ability to select one of three text print qualities: draft, medium or high. I use an old Juki 5510 nine-pin dot-matrix printer. Normally, to print in a near-letter-quality (NLQ) font, I have to flip one of the Juki's DIP switches. Even doing this, the boldface font is different from the standard NLQ font. *WordPerfect*, however, overrides the DIP-switch settings and provides an attractive near-letter-quality font in both medium and bold.

Using the font capabilities of a printer with *WordPerfect* 5.1 is relatively easy—you select a font or print characteristic from a menu. With *XyWrite*, selecting print characteristics is easy, too. You select a control-key/number combination, such as Ctrl-3. Unfortunately, with *XyWrite*, it isn't always easy to figure out what print characteristic or font you'll be selecting. *XyWrite* printer commands are stored in a printer (.PRN) file. Learning to edit these files properly is difficult and, therefore, can inhibit you from using all the capabilities of your printer.

•*Screen Colors.* The default screen colors for *WordPerfect* 5.1 are white characters on a blue background—a pleasing combination. If you want to change colors, you press Shift-F1 and select Display and then Colors from successive menus. You're then presented with various color combinations from which to choose. The default screen colors for *XyWrite III+* are white characters on a black background. This combination is fine, but it isn't too colorful. Changing screen colors, however, is a chore with *XyWrite*. It involves editing a printer file and typing in appropriate color numbers. Consequently, I use the default.

Speed Test Results

Test	Replace all periods with exclamation points
File Size	20K (approx.)
XyWrite III+	19.9 seconds
WordPerfect 5.1	0.9 second

•Windows *Compatibility.* *WordPerfect* 5.1 runs perfectly under Microsoft *Windows* 3.0 in Standard Mode. If you run *Windows* in Enhanced Mode and *WordPerfect* 5.1 in a window, everything works fine until you try to use preview mode. *Windows* then locks up *WordPerfect*, which then can no longer be used. It seems there should be a way for the two programs to work together in Enhanced Mode, but I haven't discovered it. *XyWrite* has one problem when running under *Windows* 3.0 in Standard or Enhanced mode. You must press each function key twice to get it to work. For this reason, I seldom use *XyWrite* under *Windows*. (A *Windows* for *WordPerfect* is expected to be released momentarily.)

Comments & Conclusions

WordPerfect 5.1 is a major-league word processor with many advanced features. With so many, it's unlikely that you'll need to tap the full power of the program in everyday work—but the power is certainly there if you need it. When compared to another top-flight word processor, like *XyWrite III+*, it's evident that *WordPerfect* has both strengths and weaknesses.

Switching word processors from the one you currently use to *WordPerfect* 5.1 is a decision not to be taken lightly. Although *WordPerfect* is one of the most popular and capable word processors on the market, it takes some effort to learn to use it proficiently.

Should you switch to *WordPerfect*? The answer to this depends on whether or not you have a compelling reason to do so. For example, has your employer switched to *WordPerfect*, forcing you to be compatible with the rest of the staff? Or does your current word processor lack support for a specific feature you need, such as integrated graphics? If there's no compelling reason to switch, you're probably better off sticking to the word processor you now use, assuming you've used it for some time now and are familiar and pleased with it. ■

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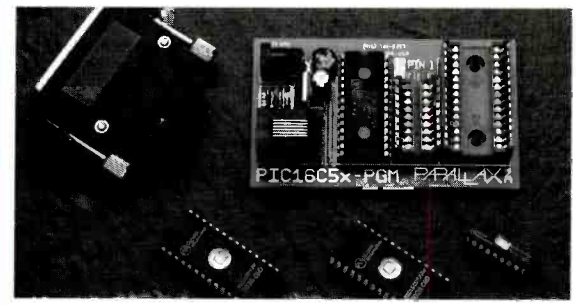

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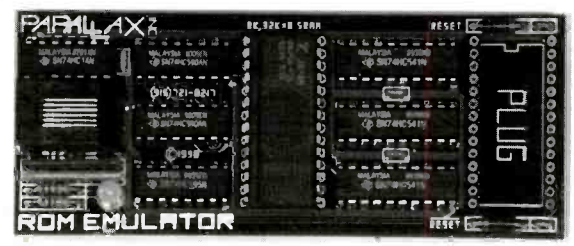

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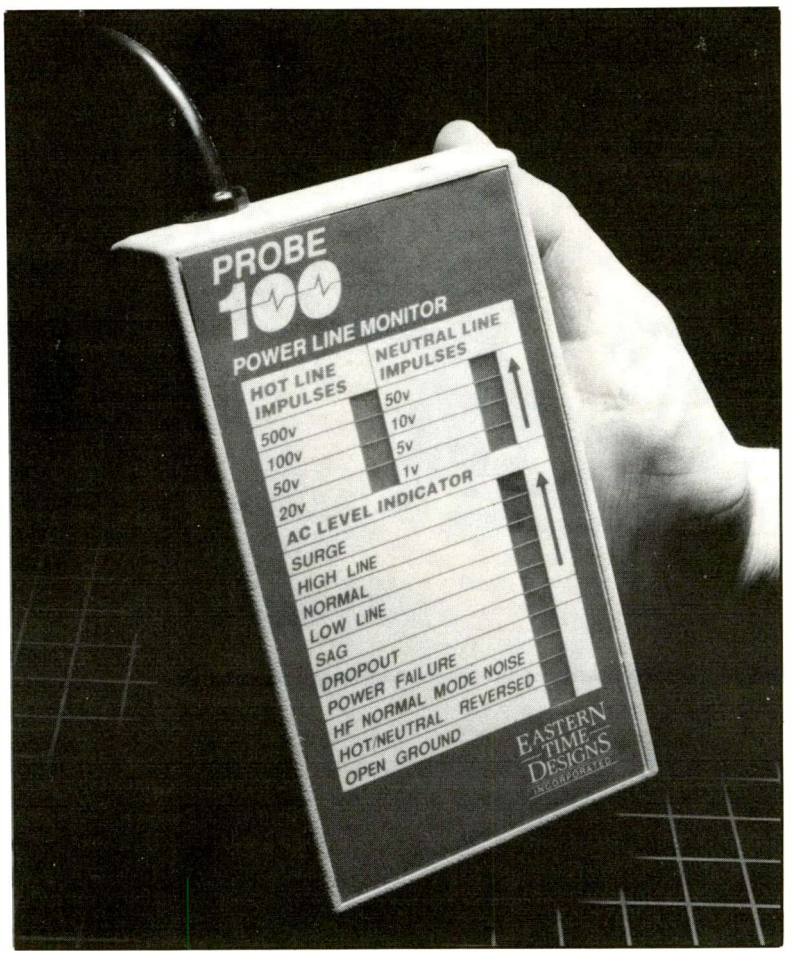

We've all been made aware that what's fed into a computer from an ac power line may harm the equipment and/or its programs and data. As a result, a variety of surge protectors, radio-frequency noise filters and uninterruptible power supplies are used to circumvent damage of one sort or another. But one really doesn't know if the protective device is adequate. To find out what the problems are before you suffer the consequences requires the use of an appropriate monitoring device, such as the Probe 100 discussed here.

The Probe 100 from Eastern Time Designs (Manchester, NH) measures only 5½"L × 3¼"W × 1½"D plus a three-prong 6-foot-long ac line cord, and is priced at $149.95. It detects a variety of power disturbances, indicating what they are by LED display on the face of the device. It detects spikes on hot and neutral lines, for example. Hot-line impulses are displayed in increments: 20, 50, 100 and 500 volts, while neutral-line impulses are in 1-, 5-, 10- and 50-volt increments.

In addition, there are a variety of ac level LED indicators: surge (over 135 volts for at least 100 ms), high line (126 to 135 volts), normal (105 to 125 volts), low line (under 105 volts), sag (under 95 volts for at least 100 ms), dropout (less than 80 volts within 8 ms or half a cycle), power failure (less than 80 volts for at least 500 ms), high-frequency normal-mode noise (2 volts peak-to-peak at 10 kHz to 10 MHz), hot/neutral reverse and open ground. The Probe 100 uses a sine-wave tracking design to capture impulses and operates to a maximum of 140 volts rms.

Once caused to illuminate, the LED indicators remain on until a RESET button at the rear of the device is pressed (except for normal, high and low line displays). On initially plugging the unit into a three-prong ac outlet, some LEDs will light and be latched. So the RESET button must be pressed to set up the monitor in an unlatched state.

In-Use Comments

The Probe 100 is a simple, handy monitoring device to use. It gives a good picture of how clean is the ac power feeding a computer, whether directly from a wall outlet or a receptacle on a protective device, such as a strip surge/noise protector.

Power-disturbance problems typically occur intermittently. Accordingly, the manufacturer suggests that it remain plugged in for 24 to 72 hours, with periodic checking of the LED display.

I plugged the monitor into a variety of receptacles in our main office: wall outlet, surge/noise device and the output of a UPS that has built-in noise suppression. Additionally, the monitor was plugged into a home wall receptacle and into a surge/noise suppressor's receptacle.

In each instance, I switched on a computer and peripherals. At home, I also switched on and off a clothes dryer and washing machine in an effort to trigger the monitor's LEDs. The results were very interesting.

All our office ac outlets caused the High-Frequency Normal Mode Noise LED to light, generally only moments after pressing the RESET button. Plugged into a receptacle on a surge/noise device, the same LED illuminated after about 5 minutes. Connected to a UPS output, it lit in about 15 minutes or so. This is line-to-line noise that rides on the sine wave, which could cause processing errors to crop up if it's not too high, and system failure if it exceeds 10 volts.

With fast checks on all outlets in my home, I discovered one that had the hot and neutral lines reversed! The monitor indicated this immediately and then many LEDs lit up like a Christmas tree. It was the receptacle used to power my home alarm system, which had recently become flaky in operation after about eight years of service in this manner, and was replaced. (After switching off the appropriate circuit breaker, I corrected wiring to the receptacle. The black wire was connected where "white" was clearly marked.)

Again at home, I was able to cause the HF Normal Mode Noise LED to light when I switched on and off peripheral devices. Worse, though, was a once-in-while result of switching off any switch on the power-distribution system that sits between my computer's system box and video display monitor. You know, the convenience system that gives you front-panel power control of different devices, from monitor to printer. Once in while, it caused as much as the 100-volt LED to light up as a Hot Line Impulse on the monitor and

(continued on page 85)

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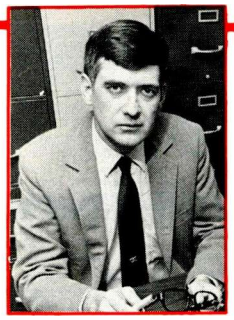

Forrest M. Mims III

The Analog-Digital Connection

The relationship between analog and digital electronics is both competitive and complementary. On one hand, digital logic, programmable controllers and computers have supplanted analog circuits in many applications. On the other, there are many applications that can only be implemented with or with the help of analog electronics. Between the two is a fuzzy area where both technologies either work together or compete with each other. In the former case, interfacing digital electronics with an analog world requires analog circuits. In the latter case, digital designers with little or no analog skills sometimes use programmable controllers or microprocessors when a single analog chip would suffice.

In the future, a new world of ultra-sophisticated computing will be ushered in by neural networks. These are circuits with their roots firmly entrenched in an analog world of circuit design.

This time around, I'll discuss a recent debate over the relative merits of analog and digital electronics. So you can become better acquainted with what really matters, I'll also describe some real-world applications, one of which is best solved with an old-fashioned analog chart recorder and the other with a computer-controlled data-acquisition system.

Analog & Digital Ways of Doing the Same Thing

To set the stage, let's examine a simple example of how both analog and digital electronics can perform the same function—comparison of two or more values. To keep things interesting, I'll show how a simple high/low number guessing game can be implemented three different ways, using an analog circuit, combinational digital logic and sequential digital logic.

• *Analog Hi/Lo Game.* Shown in Fig. 1 is the schematic diagram of a simple hi/lo game you can quickly assemble from some potentiometers, resistors, LEDs and an inexpensive quad-operational amplifier. The circuit is known as a window comparator. In it, *R1* supplies an adjustable voltage to the circuit's input. Potentiometers *R2*, *R3* and *R4* define the upper and lower limits of the window. The CORRECT LED lights when the input voltage falls within the window's limits. Otherwise, the HIGH or LOW LED turns on.

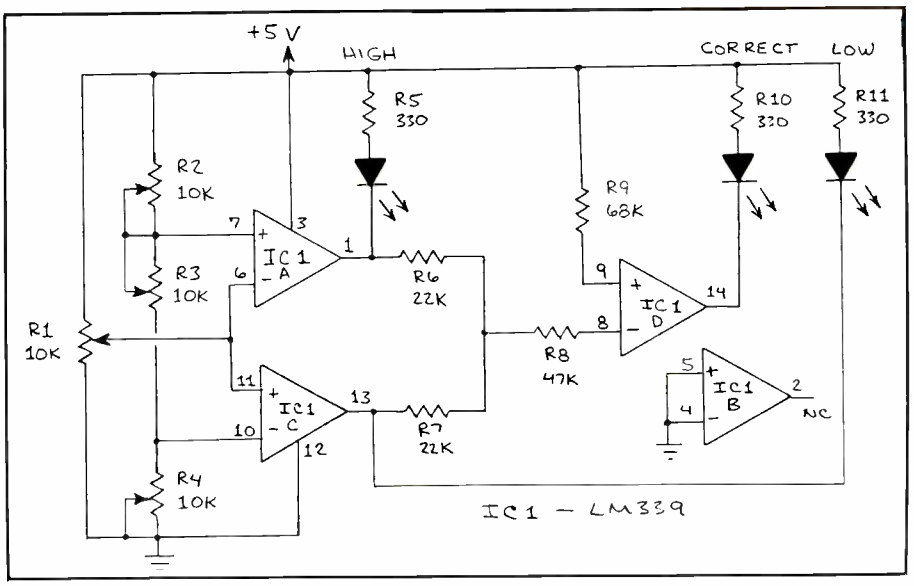

Fig. 1. A simple analog hi/lo game.

Ideally, *R1* should be a free-turning potentiometer fitted with a knob that has no index marker or pointer. The game is played by setting potentiometers *R2*, *R3* and *R4* to any desired positions (the unknown number). Without watching the LEDs, *R1* is then rotated to any position to supply an input voltage (the guess). The LEDs then indicate the result.

• *Combinational-Logic Hi/Lo Game.* A schematic diagram for a hi/lo game implemented with a mix of analog and both combinational and sequential digital logic is shown in Fig. 2. Since the brains of the game is a combinational-logic network (a four-bit 7485 comparator), we'll call it a combinational-logic high/low game.

In operation, the 555 analog chip generates a continuous series of pulses at a rate determined by the values of *R1* and *C1*. When *S1* is momentarily closed, an unpredictable number of these pulses is counted by the the 74193 four-bit binary counter (a sequential chip). When *S1* is opened, the count stored in the 74193 will be a four-bit word between binary 0000 and 1111 (decimal 0 to 15). Because of the high frequency of the pulse rate, it's impossible to guess the status of the count stored in the 74193 when *S1* is opened.

To play the game, you first enter a four-bit guess into switches *S2* through *S5*. Then you close and open *S1*. The 7485 compares your guess with the count stored in the 74193. If your guess is correct, the middle LED turns on. If it's too low, the lower LED turns on and if it's too high the upper LED turns on.

• *Sequential-Logic Hi/Lo Game.* There are lots of ways to design a hi/lo game with sequential logic. You can design your own from sequential-logic chips (flip-flops, counters, and RAMs). Or you can use a ready-made sequential-logic circuit known as a computer. That's what I'm going to do next with the MS-DOS machine into which these words are being typed. First, I'll save this text on disk. Then I'll go to SYSTEM and then to BASIC and enter these lines:

```
10 'HI-LO GAME
20 RANDOMIZE TIMER
30 N = INT(RND*10)
40 PRINT "WHAT IS YOUR GUESS";G
50 IF G   N THEN PRINT "LOW"
60 IF G = N THEN PRINT "CORRECT"
70 IF G   N THEN PRINT "HIGH"
80 END
```

Line 20 re-seeds the random-number generator with the number of seconds since midnight or since your computer was last reset. This causes the RND (random) function in line 30 to produce a different se-

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quence of random numbers. Otherwise RND will produce the same sequence each time. Lines 40, 50 and 60 then perform comparisons to determine the result of your guess.

The Fig. 1 analog and Fig. 2 combinational-logic hi/lo games can be modified, but not nearly as quickly as the listing given above. For example, to amend the hi/lo computer program to recycle for a new game at your request, simply add these lines:

```
70 INPUT "WANT TO GUESS AGAIN (Y or N)";Q$
80 IF Q$ = "Y" OR Q$ = "y" THEN 15
90 IF Q$ = "N" OR Q$ = "n" THEN PRINT "GAME OVER":END
```

Of course, you can include additional instructions to embellish the display (for example, insert a score box, add various colors, etc.). You can also easily modify the game for more sophisticated games involving memorizing strings of digits and characters.

• *Hybrid Sequential-Logic Hi/Lo Game.* You can transform the computerized Hi/Lo game described above into a hybrid analog/digital game by replacing the random-number lines of the program with some lines that sample the position of a joystick. Between games, you simply move the joystick to input a new number to guess.

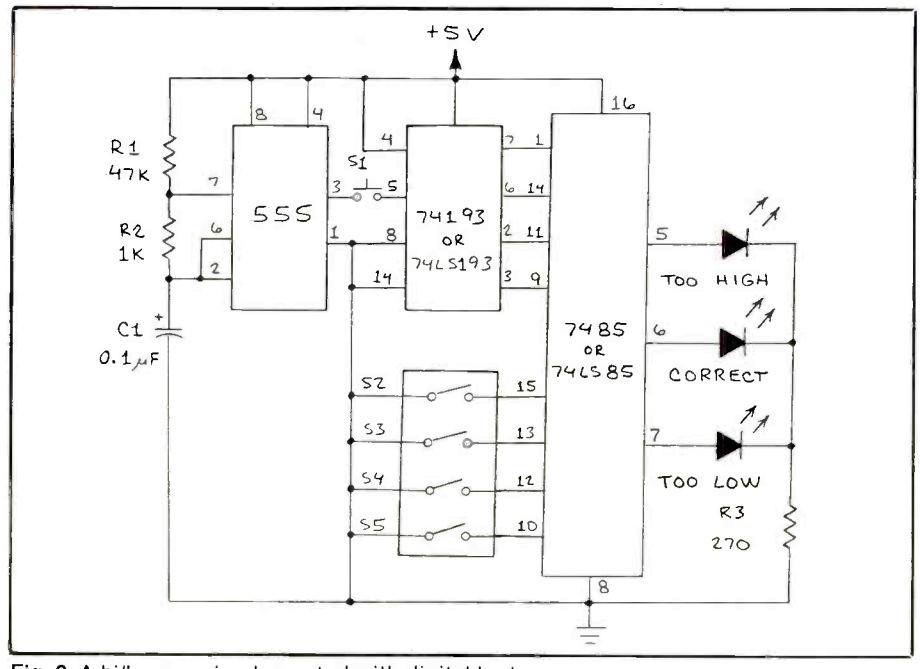

Fig. 2. A hi/lo game implemented with digital logic.

The Internet Debate

All the above hi/lo games are extremely simple, but they do illustrate how analog and digital methods can be used to implement the same basic function. Now let's jump into the perennial debate over the merits of analog-versus-digital technology.

This topic was recently the subject of a

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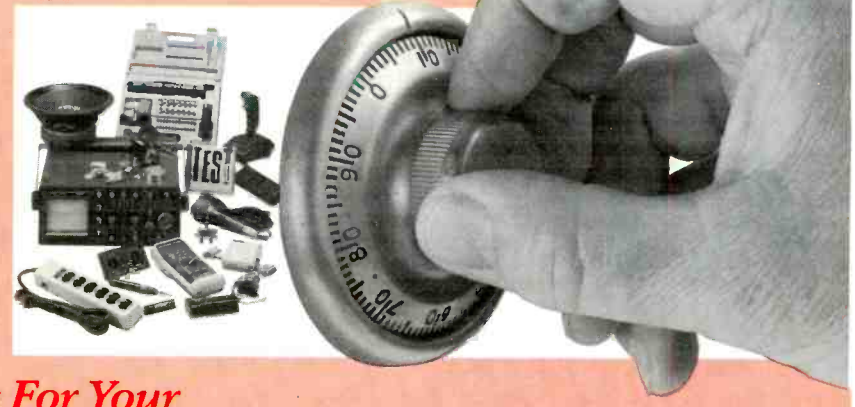

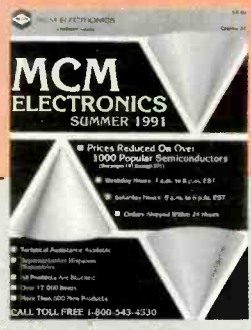

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few exchanges during a debate on the skeptics forum of the Internet BBS over cancellation of my assignment to write "The Amateur Scientist" column for *Scientific American* after that magazine learned I do not accept the Darwinian theory of evolution. Here's what one of that magazine's supporters had to say:

"[Mims] seems to have an anachronistic attitude on the role of analog-vs.-digital electronics (supporting the former, of course). Take the following passage from page 3 of *The Forrest Mims Circuit Scrapbook* (McGraw-Hill, 1983):

'An amazing number of applications use either digital or analog circuits. Lately, of course, the trend has been toward digital almost exclusively. In some ways, however, this trend (or is it a fad?) is clearly unfortunate. [Paragraph about digital voltmeters deleted.] When it comes to computers, digital technology has the advantage in accuracy, programmability, and computing power. Analog computers, however, are ideal for simulating a real-world system such as a structure, machine, dam, aircraft, or missile. Simply rotating a few control knobs enables the computer's operator to observe the effect of changes on the system as they take place (in real time). Contrast this simple procedure with the elaborate software manipulation required to vary conditions in a digital computer's program.'

"WHAT? Digital computing a FAD? I think not! I do not know of a single moderately responsible professional engineer who would use ANALOG circuits to simulate ANYTHING. All such is done exclusively on digital computers with finite element and other numerical simulation codes. As for the 'elaborate software manipulation' required for digital computers, most of the circuits in his books do things (such as adding two voltages) that can be done with a single line of computer code in FORTRAN or any other language, or with any decent piece of data acquisition software.

"If nothing else, this shows that he is not a very competent engineer, let alone a scientist . . . ."

Responding to the Debate:

In spite of this message's claims to the contrary, the passage quoted from my book is as valid today as in 1983. Of course, I didn't write that digital computing is a fad; the comment about the move away from analog circuits applied then as it does now to application-oriented circuits, not computers. If digital computers were a fad, I certainly wouldn't have wasted time writing the operator's manual for one of the first hobby computers, the Altair 8800, back in the winter of 1974/5 in exchange for one of those vintage machines. (That Altair is now displayed in the Smithsonian Institution.)

The message claims that analog circuits aren't used "to simulate ANYTHING." Actually analog computers are used to simulate and model such real-world things as ecological systems, population growth, chemical reactions and aerodynamic systems, to name just a few. Simpler analog systems are used to multiply, divide, extract roots and generate a wide range of nonlinear functions, including trigonometric functions. What's more, analog circuits often perform these simulations and operations in close to real time, a feat unmatched by a conventional digital computer or processor that processes instructions in serial manner.

The message goes on to claim, "... most of the circuits in his books do things (such as adding two voltages) that can be done with a single line of computer code in FORTRAN or any other language, or with any decent piece of data acquisition software."

Software can do wonderful things, but an infinite number of lines of FORTRAN can't transform a computer into a power supply, lightwave communicator, laser system, radiometer, Geiger counter, xenon strobe circuit, green vegetation detector, seismometer or many of the other circuits described in my books. Of course, as regular readers of this column know, this doesn't mean that a computer can't be used

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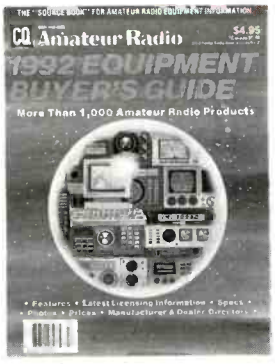

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with external hardware to implement some of these circuits.

More puzzling than the claim about the power of FORTRAN is the reference to "data acquisition software." The missing ingredient here, of course, is data-acquisition hardware—without which data-acquisition software is useless. Analog circuits, of course, form the core of most data acquisition systems. They transform the analog signals of the real world into the digital bit patterns that can be processed by a digital computer.

Since I don't have access to Internet, it wasn't possible to respond to the above message. Others, however, did respond, and here's what one party had to say:

"... I felt that [the critic's] dismissal of analog [was] too offhand. I wish we had a few more 'anachronistic', or I would prefer 'eclectic,' engineers . . . .

"It seems that digital has completely supplanted analog, not because it is inherently and always better—sometimes it is worse—but because it is easy to play with, program and twiddle. Digital forces you to discreetize, which ain't always a good thing; consider all the work put into getting decent digital derivation and integration. They are (in principle) trivial with analog circuitry.

"Analog on the other hand more or less requires you to build a new computer for every program. Sure ain't cost effective, I agree! Now maybe with a digital computer as a front end? Anyway, I'm afraid analog is becoming a lost art and someday we will miss it. Such as in another computing 'Fad': neural networks.

"And in any case, the passage seems to advocate using BOTH types of circuits rather than exclusively one or the other . . . You've never heard the joke about the complete Unix system for the microprocessor controlled toaster then? . . . ."

To use an old analog expression, this writer is "tuned in." The ideal solution to the analog/digital debate is to be sufficiently knowledgeable and open-minded to understand which technology best accomplishes the goal at hand. Sometimes, a hybrid analog/digital approach is the best solution. An example well known to every reader of *ComputerCraft* is the voice-synthesizer chip. These chips use a digital ROM to store code for sounds, words and phrases that are transformed into an electronic analogy of sound. The result is a hybrid analog/digital circuit that simulates human speech and other sounds.

A more-recent example of the importance of analog technology is the remarkable analog memory chip made by Information Storage Devices, Inc. (2841 Junction Ave., Suite 204, San Jose, CA 95134). Various versions of this chip can store and play back up to 20 seconds of an analog signal (including voice). For detailed information about this chip and a working test circuit, see the September 1991 installment of this column ("A Tape Recorder Chip").

The second writer also mentioned neural networks. While this fast-moving technology can be simulated using software and a digital computer, implementation of neural networks in hardware requires analog circuits.

Apples and Oranges?

When I discussed some of this debate with Art Salsberg, the editor of *ComputerCraft*, he succinctly summed it up in only four words: "It's apples and oranges." Art then observed, "It's an analog world."

One way to illustrate the apples-and-oranges analogy is with a paragraph about digital voltmeters that the first Internet poster failed to include when I was quoted from one of my books:

"The unprecedented accuracy of a three- or four-digit DVM is ideal for making measurements of fixed voltages. But have you ever tried to monitor a slowly changing voltage with a DVM? If not, good luck! The stream of constantly changing numbers is almost impossible to read and makes little sense. An old-fashioned panel meter with an analog readout (pointer and scale) offers a much better solution to this common problem."

Today some DVM manufacturers offer a partial solution to this drawback in the form of a liquid-crystal bargraph incorporated into the DVM digital readout. While these bargraphs help trends to be visualized, even the 32-element versions are no match for the old-fashioned meter pointer.

The apples and oranges of this are quite clear. Use a DVM when you want to know the precise value of a voltage or current. Use an analog multimeter when you want to see subtle trends.

Real-World Examples

Here are some practical examples of how both analog and digital techniques can be used to conduct some real-world studies. As this is typed, my daughter, Vicki Rae, is at work on her latest science-fair project. She's using her computer to measure temperature changes in a test chamber that simulates the Earth's atmosphere. The temperature in her chamber is sensed by a silicon sensor. An analog-to-digital (A/D) converter transforms the analog signal from the sensor into strings of eight-bit data bytes that her computer stores in its RAM and, from time to time, saves in a disk file. Software then plots the data on an on-screen graph. Her setup can best be described as a hybrid analog/digital system since it merges a temperature sensor and A/D converter with a digital computer.

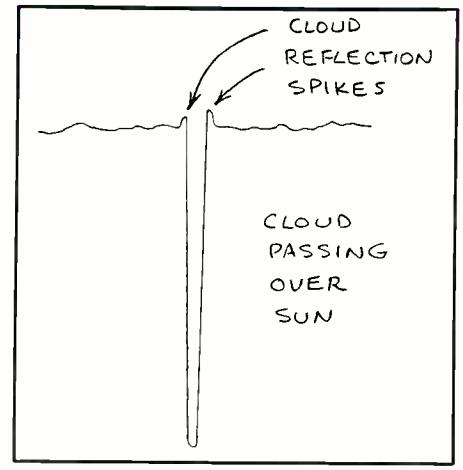

Fig. 3. A section of a chart recording that shows the dip in sunlight caused by passage of a cloud and the spikes on either side of the dip caused by sunlight reflected from the edge of the cloud.

While this is going on, I'm conducting a study of the effect of various kinds of clouds and aerosols on the amount of direct solar radiation that strikes the Earth's surface. As these words are typed (into a digital computer, naturally) a pair of cables at my feet snake their way through a crack in a window to a point in a field around 30 meters from my office. One cable carries power to a 117-to-12-volt dc converter that powers a motor controlled by a crystal-controlled oscillator. The shaft of the motor is attached to a small gear that turns a much larger gear that, in turn, tracks the exact position of the sun.

Attached to the sun tracker is a miniaturized enclosure that houses an ultra-low-noise CMOS operational amplifier. Plugged into the amplifier enclosure is a silicon photodiode fitted with an ultraviolet filter and a collimator tube. Nearby is a second detector and amplifier. The position of the second detector is fixed; it stares at the zenith sky.

Amplified signals from the two photodiodes travel down the second cable to a two-channel analog chart recorder sitting on a shelf over my desk. A pair of pens carefully trace on a moving strip of paper the tiniest variations in sunlight that arrive at the detectors.

Every part of this system is analog. The only time digital techniques are used is when I use a pocket DVM to check the voltages at both ends of the signal cable each morning.

Now anyone who has used a chart recorder knows that long charts are a nuisance to store. Indeed, at least 10 meters of chart paper are curled up next to my computer as these words are being typed. So why don't I use a digital data-acquisi-

tion system instead—particularly since an eight-channel system connected to a battery-powered computer is within a few meters of my desk? There are some good reason why I don't. Just before a cloud begins to cover the sun's disk, it reflects a significant amount of light that causes a sharp spike in the amplitude of the detected signal. The same thing happens when the cloud moves away from the sun. Figure 3 is a sketch based on a chart recording of a small cumulus cloud that passed overhead while this column was being typed.

I'm very interested in these spikes, and with a chart recorder I can be assured of detecting all of them. A digital data-acquisition system can, too, but it will have to use such a fast sample rate that it will require a considerable amount of memory over the course of a day.

Another benefit of the chart recording is the speed with which it can be set up and switched on during a fast-changing weather event, such as the unexpected arrival of a thunderstorm. There's no waiting for a computer to boot up a program, and you don't have to spend time selecting various menu options. Changes in chart speed and gain can be made in a second or two. A nearby lightning bolt may cause a spike on the chart—but there's no memory to be erased or, worse, zapped. Comments about transient events and important weather observations can be written directly on the chart for later reference.

Even the sound of the chart recorder's servos and the pens drawing on the paper provide valuable clues about what's happening. For example, I can tell when the shadow of a buzzard or aircraft has passed over the detectors or when a spider is waltzing around the end of a detector's collimator tube—all by the sounds emitted by the recorder!

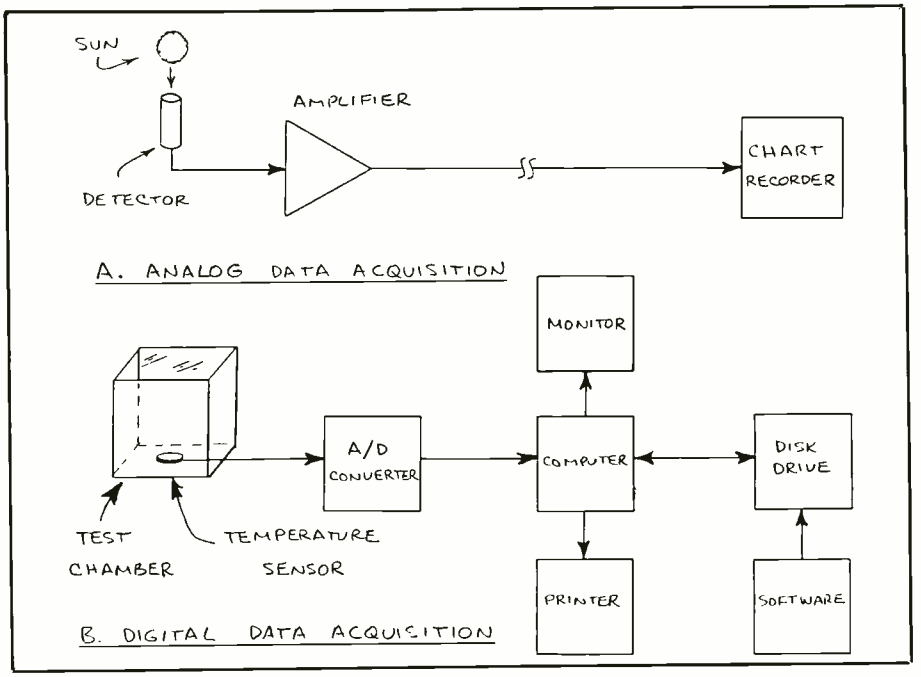

Fig. 4. A simple analog data-acquisition system (A) compared with a typical computerized data-acquisition system (B).

Comparing the Examples

The block diagram in Fig. 4 shows my analog chart recorder sun-monitoring system and Vicki's digital data-acquisition system. Vicki's two-channel and my eight-channel digital data-acquisition system, both of which depend on analog A/D converter chips, are both well suited to collecting precise values at specific intervals. But they just don't provide the kind of detail needed for my cloud/aerosol study. And, believe it or not, wolf spiders hunting for prey and other spiders looking for a place to erect a web have proved to be a serious problem—and the trusty old chart recorder announces their presence almost instantly.

On the other hand, Vicki's project is ideally suited for a computerized data-acquisition system. Her experiment is carefully controlled—no clouds, no wind, no need to make quick measurements of a transient event and, best of all, no eight-legged visitors. The software for her data-acquisition system includes easy-to-use menus and stores data on-disk as strings of numbers or completely formatted graphs. After she's completed her project, I'll use her data-acquisition system for several experiments that don't require the detailed trace provided by a chart recorder.

Summing Up the Debate

By now, it should be apparent that both digital and analog circuits and systems play vital roles in today's electronics. It's important for experimenters, circuit designers and end users to understand the advantages and limitations of both technologies.

Those who feel analog electronics has been completely supplanted by digital technology should take a look under the hood of some of the gadgets and computers they use. Consider compact disks, one of the latest digital storage media. Audio CD players are made possible by such analog support as a regulated power supply, a regulated laser diode driver, tracking photodiode amplifiers and an output amplifier.

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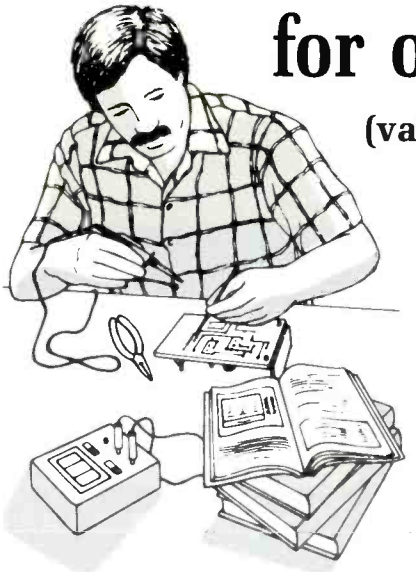

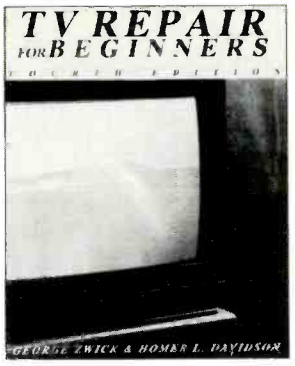

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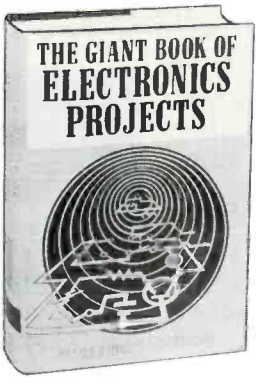

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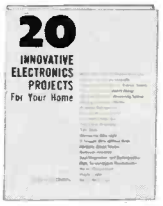

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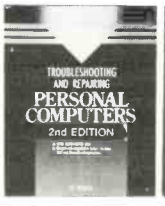

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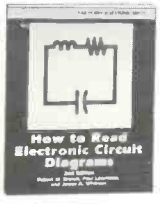

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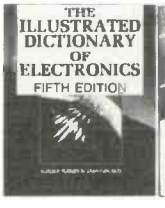

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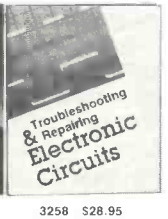

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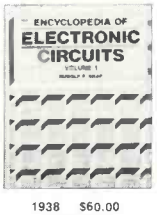

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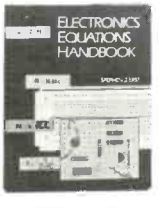

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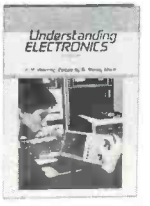

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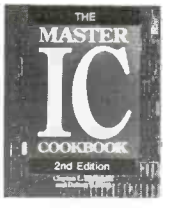

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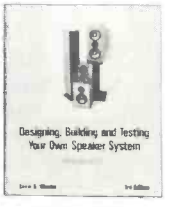

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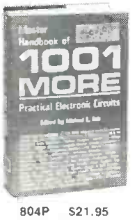

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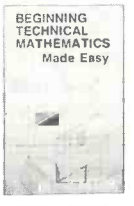

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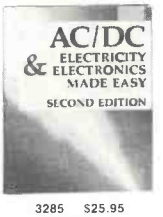

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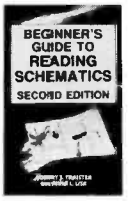

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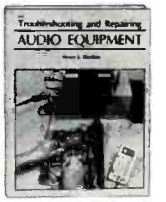

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3738 $26.95

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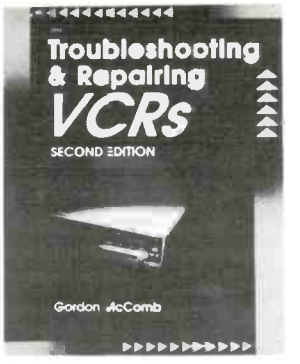

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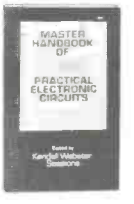

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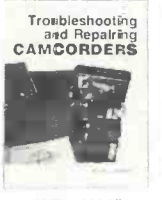

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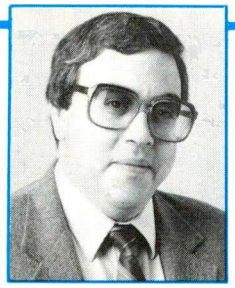


Ted Needleman

Sonera Technologies' DisplayMate Utilities and Gibson Research's SpinRite II

In the last two columns, I discussed how to quantify the performance of PCs. I've covered the process of benchmarking and relevance of different techniques and applied this discussion to a review of an AMD-powered 386/40 computer. The one aspect I haven't addressed is video monitors. This month, I'll give you a look at two handy utilities you should add to your toolbox. One lets you keep your hard disk in tip-top shape, the other lets you determine display performance and tune your existing monitor.

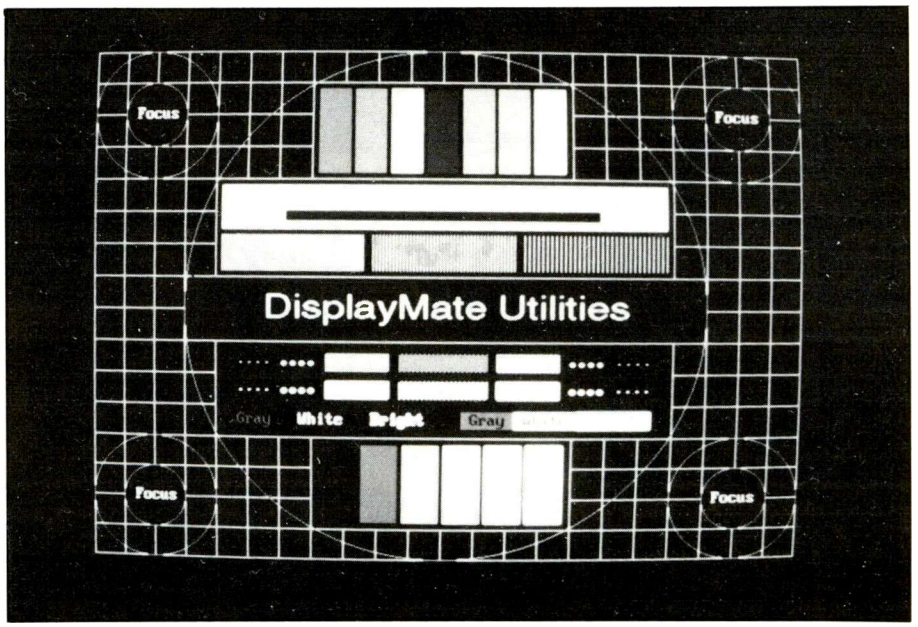
DisplayMate Utilities

Displays are an integral part of a PC system, but they're difficult to discuss from a quantative point of view. As with the rest of a PC system, there are certain specifications that can be detailed, like dot-pitch (the size of the phosphor dot on the screen, where smaller is better), diagonal screen measurement (often 13″ or 14″) and scan bandwidth.

Knowing the above specifications allows you to make several inferences. For example, a 0.25-mm dot pitch generally permits a greater resolution to be used than that afforded by a 0.31-mm pitch. Bandwidth is also important in determining a display's overall resolution capability. You need a high bandwidth monitor (70 kHz or better) to take advantage of the newest 1,024 × 768 resolutions offered by today's best graphics adapters.

There are, however, lots of things that these specifications don't tell you. Some of these are important, such as how a displayed image actually looks. Does the display exhibit pincushioning (sides or/and top and bottom pulling in towards the center), bowing (sides pushing out from the center), flaring or fuzziness? These are all serious defects in any display, especially one that will be used for hours at a time, but overall quality of a display is something that's not evident from published specifications. The fact that a particular display can produce a specific resolution says nothing about how an image at that resolution actually appears.

To some extent, viewability of a display is a subjective call. There are specialized (and very expensive) test instruments that can determine some of these viewability factors, but few reviewers can afford them, many reviewers (including me) would need a course in how to use them, and the results would be relevant only to those people who have a rather extensive video background. Between the two extremes (purely subjective and rigidly technical) is another approach. It's Sonera Technologies' *DisplayMate* Utilities.



Screen shot of Sonera Technologies' DisplayMate Utilities.

Priced at a very reasonable $149, the *DisplayMate* Utilities serves two major functions. First, it lets you evaluate the three major components of a display system: monitor, adapter card and video BIOS. The tests are numerous and extremely comprehensive, and you can run them in a variety of formats. There are two basic "tracks." There's a non-technical level designed to let most average users thoroughly test out their systems with a minimum of operator intervention. A technical track gives experienced users more comprehensive tests and more control over the testing process.

All told, there are more than 300 tests that permit you to examine display geometry, resolution, color reproduction, gray-scale reproduction, screen distortion, speed performance, compatibility in different modes, and much more. These tests are performed without the need for hardware other than the PC and monitor.

For the average user, many of *DisplayMate*'s capabilities will be overkill. A good portion tests and measurements are meant to be used when evaluating a display monitor/adapter card combination for possible purchase. By taking *DisplayMate* with you to the computer store and running the test suite against a few different combinations of displays and cards, you can quickly see if spending the extra money for a premium display makes sense (it often does, in subtle ways that make the display less taxing to use over the long run).

For most users, *DisplayMate*'s value is that it lets them adjust a current display far more effectively than the simple diagnostics that probably came with their systems. This is accomplished by selecting the Setup Display choice from the main menu (on either the technical or non-technical track) and following directions.

Different display patterns are shown and adjustments are made as directed (and as a monitor permits, of course). The whole process is menu-driven and takes just a few minutes to run through. For best results, Sonera suggests that this adjustment be performed every time the system is booted. This is probably true, but for most of us, every few days or so will be almost as good.

DisplayMate is one of those utilities that

you won't really appreciate until you've used it. Over time, even the best monitor drifts from its best image, subtly enough so that you don't see how bad it's gotten until you run a test suite like *DisplayMate*. You do, however, notice the overall effects of this drift, manifesting themselves as eye strain and headaches.

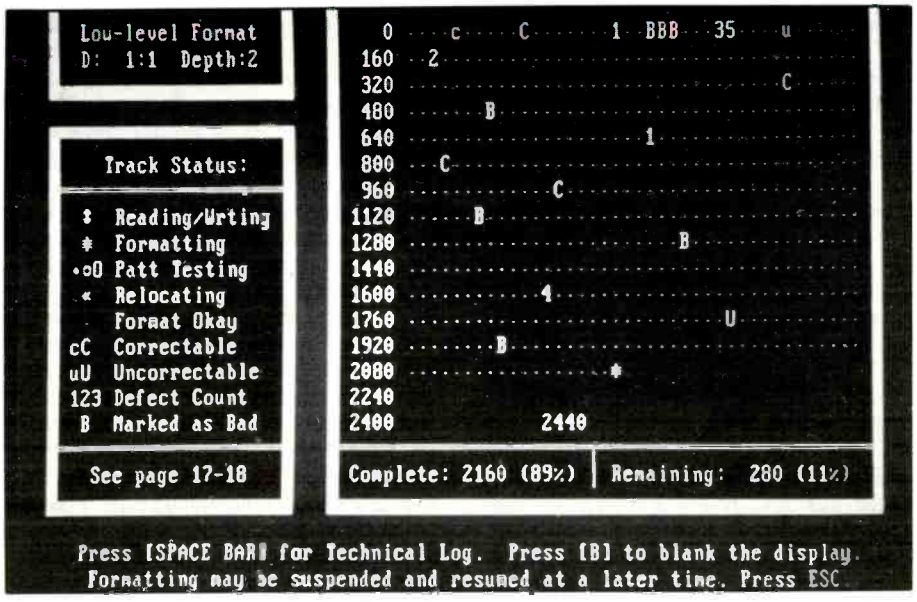
The Sonera utility would be worth its modest price even without the excellent documentation. The manual that accompanies the software is over 300 pages long. It gives complete details on each of the tests *DisplayMate* offers, what the results mean and if there's any adjustment that effects the display in this area. Part II of the manual provides an education in monitor and display technology. Again, it's probably more than you'll need to know, but it makes interesting reading.

About the only down side to *DisplayMate* is that it's so extensive that it gives results on things that can't readily be changed or, like with convergence, need the services of a qualified video technician. On the whole, though, with *DisplayMate*, a little knowledge is a very useful thing.

SpinRite II

Most IBM-compatible PCs these days have hard-disk drives. Chances are that, at one point or another, a hard disk will begin to give problems. Because a hard disk is an electromechanical device, it will eventually fail. The only question is whether or not a failure will be catastrophic.

With many hard disks, read and write problems crop up long before gross mechanical defects do. This is also due to the nature of the device. A hard disk consists of a magnetic coating on a metal substrate. If a head lands too hard on a section of the media holding data, you have a problem. Even if nothing happens to physically



Screen shot of Gibson Research's SpinRite II.

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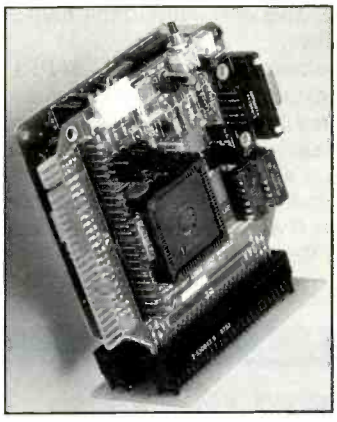

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damage the magnetic coating or heads, information stored on the media in the form of magnetized areas often fades over a period of time. When it fades too much, you have a problem.

The MS-DOS FORMAT command is designed to partially correct some of the problems inherent in using magnetic disk media. When an initial low-level format is first performed on the drive to delineate the tracks and sectors, DOS writes, reads and verifies every byte on the drive and marks those areas where it can't reliably write and read in a special area on disk. When the disk is then formatted with the MS-DOS format command, access to these bad blocks is prevented.

These procedures help to keep obvious bad areas of the disk's surface from being used, but they do nothing as far as an ongoing check of the media. Some areas of the disk take a less-permanent magnetic charge than others. After a while, some formerly good blocks of disk space won't take a magnetic charge reliably enough to be used. The operating system doesn't notice this until it's too late to do anything about it. As a result, data is often lost.

In addition, over time, track-to-track alignment may drift slightly. With the read/write head not over the exact center of the track, the drive/controller may have difficulty reading existing data, which can also lead to data loss.

Fortunately, there's a terrific utility from Gibson Research called *SpinRite II* that can keep many of these problems from ever occurring. It can't assure that no area of your disk will ever go irretrievably bad, or that your drive motor won't pack it in one day, but regular use of *SpinRite* will keep your hard disk operating at peak capacity and performance.

SpinRite is simple to use. Running SPINRITE.COM causes a menu to come up that allows you to choose a quick surface scan (which takes a shorter time, but is much less thorough) or a complete analysis. *SpinRite* must be run from a clean system, with no TSRs or strange drivers installed. In fact, the best way to run *SpinRite* is to put DOS in a clean disk (with the FORMAT/S option) and copy *SpinRite* to this disk. If you then boot with this floppy and run *SpinRite*, you should experience no problems.

The first thing *SpinRite* does is check to see if you're running at the right interleave. Many hard disks are capable of operating reliably at a tighter interleave than that for which the controller/drive combination is set. *SpinRite* tries a variety of interleaves and points out the one that provides the fastest and most reliable data transfer rate. It then implements this new interleave, if you wish, during the second part of its operation.

It's the second operation that earns *SpinRite* its well-deserved reputation. *SpinRite* performs a low-level format of your disk, without destroying any data! It does this by reading in a track at a time, low-level formatting this track, and writing out the track as it existed previously. While it's doing this, it's also checking every byte on the surface of the disk platter to see how well it holds the magnetic charge. If the surface is marginal or bad, it's marked as a bad block in the FAT (file allocation table) and prevents access to it. If a block already marked as bad is found to be useable, it's returned to service.

SpinRite lets you adjust the level of pattern testing it performs. Though it's the most thorough, Level Four also takes a very long time to complete. My 110M drive took more than 12 hours to check at this level. Gibson Research recommends that Level Four be used the first time you use *SpinRite*. After this, you can use a less time-consuming (and less in-depth) test pattern, returning to Level Four every once in a while. If you need to, you can interrupt *SpinRite* to use the PC, and restart *SpinRite* where it left off.

While a test is running (and the drive is being reformatted/renewed), the screen can be blanked, except for a message that states not to disturb the PC. This message is displayed at random and in changing positions on the screen to prevent phosphor burn-in. At any time, you can also display a status screen that tells which tracks have been tested and notes correctable and uncorrectable errors.

At completion of the test, an operation summary report can be printed. This report details the drive system's parameters (actual drive rpm, performance, data encoding technology and current sector interleave) as well as a track map and low-level format summary.

SpinRite works, at least to some extent, with most drives. With SCSI and ESDI systems, drives with more than 1,024 cylinders, and any other drive that does sector translation (where the controller "hides" the actual cylinder and track number from the PC), you can still scan for defects, and *SpinRite* will move the data to a new location if it finds a bad block, locking it out of use. However, the software won't be able to do a low-level reformat.

The same is true with IDE drives, most of which prevent an end-user from performing a low-level format. This inability to perform a low-level format also means that *SpinRite* won't be able to reset the sector interleave. Incidentally, *SpinRite* does work with caching hard disk controllers.

If you have an MFM-, RLL- or ERLL-encoded disk, you'll get the full benefit of *SpinRite II*'s ability to renew the format and data as it goes. Even if you just get the software's capability to scan for bad blocks and move data when it finds them, *SpinRite II* is most certainly worth the $89 Gibson Research charges for it. ■

Products Mentioned

DisplayMate Utilities, $149
Sonera Technologies
P.O. Box 565
Rumson, NJ 07760
908-747-6886

SpinRite II, $89
Gibson Research Corp.
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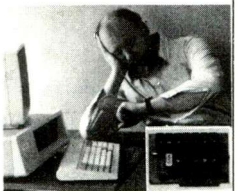

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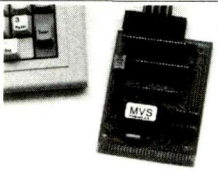

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Joseph Desposito

Acceleration Sensor, Configurable Memory and x40 DRAM Module

Have you ever wondered how automobile air bags work? A new acceleration sensor is responsible for giving the signal to inflate this safety device in the event of a collision. This month's item is just such a device.

Surface-Micromachined Acceleration Sensor

Analog Devices' (One Technology Way, P.O. Box 9106, Norwood, MA 02062) ADXL-50 is claimed to be the first surface-micromachined acceleration sensor (accelerometer). It's also claimed to be the only acceleration sensor of any kind that offers complete signal conditioning and self-test circuitry on-chip.

This device measures acceleration in a single plane of sensitivity over the + 50-g range to an accuracy of 5%. Self-test circuitry is activated by a digital command and guarantees operation of both sensor and associated signal conditioning to stated specifications—a vital feature in life-saving applications, such as automotive air-bag systems. Designed primarily for automotive applications such as collision detection, active suspension and anti-skid braking systems, future devices will also be applicable for machine monitoring, smart munitions and inertial guidance.

The ADXL-50 surface-micromachined acceleration sensor measures only 500 × 625 μm. Unlike other accelerometers that monitor the resistance change of stressed piezoresistors to detect acceleration, the ADXL-50 measures changes in capacitance and is, therefore, insensitive to temperature changes. The micromachined sensor is manufactured using conventional semiconductor fabrication techniques on a normal production line; so no special tooling or equipment is required.

The sensor operates in a force/balance mode. Voltage is applied to the sensor, which produces a force exactly opposite to that caused under acceleration. Therefore, the sensor remains at rest at all times, and nonlinear mechanical properties of the silicon structure can be effectively ignored.

Currently over 99% of air-bag designs consist of several electromechanical accelerometers positioned throughout a vehicle, a central control unit located in the dashboard and a detonation system in the steering column. These distributed designs are expensive to install and maintain. However, most future systems will integrate the whole air bag system into a single unit located in either the steering column or passenger-side dashboard. Instead of having several accelerometers located at strategic points in a vehicle, a single accelerometer will be incorporated into the driver and front passenger air-bag system for so-called "single-point" measurement.

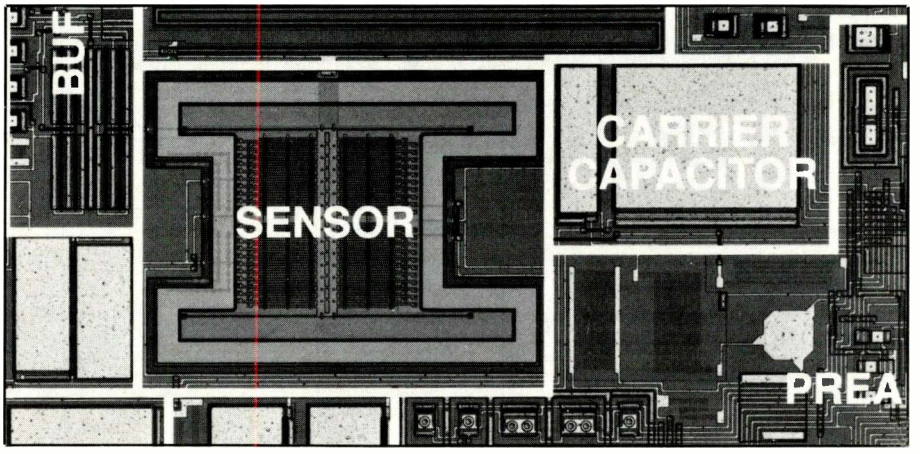

Fig. 1. Analog Devices' ADXL-50 surface micromachined accelerometer includes signal conditioning on-chip.

Air-bag accelerometers must work only once (if at all), in a fraction of a second and at precisely the right moment. They must distinguish between clumsy parking, a blow from a mechanic's hammer and a 30-mph head-on collision. To differentiate between these events, it's widely anticipated that micro-machined electronic accelerometers will predominate in future single-point air-bag systems. This next generation of accelerometers has a continuous analog output and offers complete self-testing to ensure proper operation. Analog Devices' ADXL-50 has been specifically designed to meet all these criteria.

Micromachining is a processing technique used to manufacture tiny mechanical structures from silicon. A silicon wafer normally used to make electronic semiconductors can be carefully etched with acid to produce small beams, masses and other structures measuring only a few thousandths of an inch.

Surface micromachining is a sophisticated technique that creates small, intricate and precisely patterned structures. Surface micromachining adopts manufacturing techniques perfected for making integrated electronic circuits to produce small mechanical structures close to the surface of the silicon substrate. By depositing and then etching (chemically machining) multiple thin films and layers of silicon and silicon oxide with acid, various tiny beams, masses and other structures can be formed. The feature dimensions of surface-micromachined devices are typically 1 to 2 μm, similar to the feature dimensions of conventional electronic integrated circuits.

Because surface micromachining adopts conventional, tried- and-tested IC manufacturing techniques, these devices can be made on existing IC fabrication lines. Even more important, electronic circuitry can be made on the same chip as the micromachined structures. This combination of micromachining and electronic circuitry on the same die is formidable. For example, the ADXL-50 accelerometer includes all signal-conditioning circuitry on-chip.

When viewed from above, the micromachined capacitive sensor on the ADXL-50 looks like a letter H (see Fig. 1). The long, thin arms of the H are the tethers that anchor the micromachined element to the substrate. The thicker, central mass is free to move in a plane perpendicular to the tethers. Projecting from the central mass are a series of regular fine filaments that look like the fingers of a comb. Each filament is actually one plate of a series of parallel-plate variable capacitors. The other plates interleave with moving-mass plates secured to the substrate.

Acceleration or deceleration along the axis of sensitivity exerts a force on the central mass that, free to move, displaces the tiny "inter-digitized" capacitor plates to

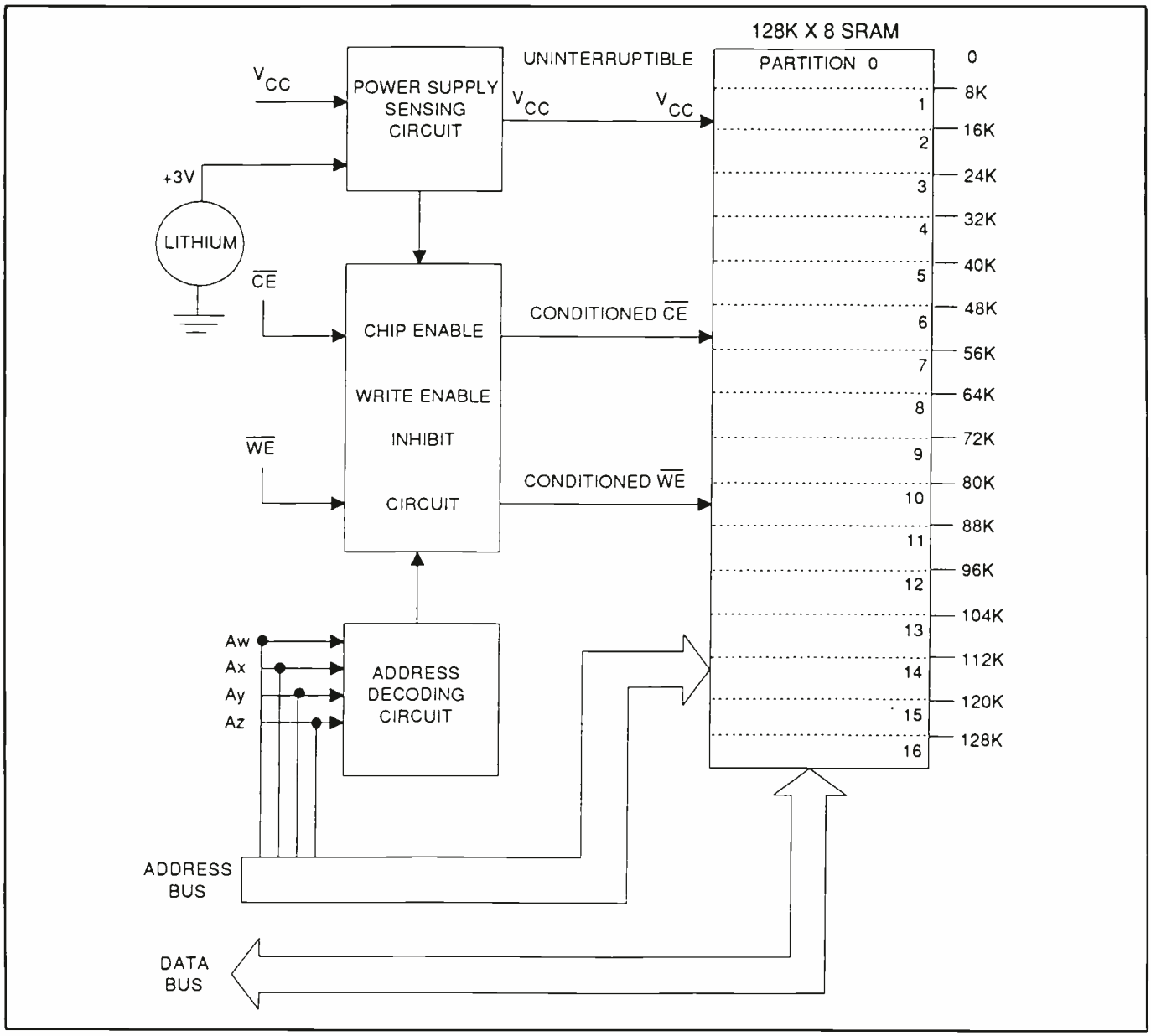

Fig. 2. Block diagram of the Dallas Semiconductor DS1645 NV SRAM.

cause a fractional change in capacitance. The device actually operates within a force/balance electronic control loop. So the mass is prevented from moving under acceleration by application of an equal but opposite force that's created by applying a charge to the capacitor plates. By precisely measuring the charge applied to the plates, acceleration can be derived.

The capacitor plates are approximately 115 μm long and about 4 μm wide. The sensor is claimed to be the most intricate ever created for the mass market and the most precise at measuring acceleration. Besides its immunity to temperature variations, capacitive sensing also permits operation over a wide frequency—dc to 1 kHz.

The signal-conditioning circuitry on the chip produces a fully scaled, referenced and temperature-compensated output voltage between 0.25 and 4.75 volts. Additionally, a digitally-controlled self-test function permits the sensor to be electrostatically deflected at any time, producing a precise output voltage corresponding to the equivalent g-force for a healthy sensor.

Full self-test is essential in many applications, most notably in automotive air-bag systems. How can it be certain an accelerometer sensor is still working after one, five or ten years beneath the hood of a car unless it's tested or replaced? If for any reason the sensor or associated signal conditioning isn't working to specification, the air bag controller immediately detects that failure and takes precautionary action.

The ADXL-50 operates over the $-55°$ to $+125°$C automotive/military temperature range. It's packaged in a 10-lead TO-100 can. Other packages are available. Pricing is $23 in 100-piece and $5 in automotive OEM quantities.

Configurable Memory

A new memory device from Dallas Semiconductor (4401 S. Beltwood Pkwy., Dallas, TX 75244) features 16 separate blocks,

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each configurable as either RAM or ROM. These designations can be changed at any time. With the DS1645 Partitionable Nonvolatile SRAM (see Fig. 2), both program and data memory can be stored in one chip. Thus, the DS1645 can combine the functions of several existing memories, including ROM, EEPROM, FLASH or SRAM. In this way, the device conserves valuable printed-circuit-board space and reduces the number of memory units required.

Through easy-to-produce software, a designer can write-protect any or all blocks of memory. Write protection can be changed, cleared or eliminated at any time with this software.

Dallas Semiconductor has been refining the technology of lithium-backed memories for seven years. Like the company's first products, the DS1645 prevents data corruption when power goes out of specification. When a built-in voltage detector senses an out-of-tolerance condition on system power, a lithium source automatically switches on and all data is write-protected to ensure its integrity. The device retains data over 10 years in the absence of external power.

The DS1645 takes a further step towards solving the problem of data corruption by looking beyond voltages at a wider range of causes. There are conditions in a system where the voltage is normal but the system is still out of control. In sections defined as ROM, the DS1645 protects data from any irregularities in the microprocessor's operation.

The DS1645 recognizes a highly structured pattern from the CPU. Once that pattern is recognized, commands can be issued to the device through the address lines to select which of the partitions is read-only and which is read/write.

The Partitionable non-volatile SRAM can be used in place of existing 128K × 8 static RAM that directly conforms to the popular byte-wide 32-pin DIP standard. An unlimited number of write cycles can be executed.

The DS1645 has 1 megabyte of memory that can be divided into 16 8K × 8 blocks, any and all of which can be designated as ROM. Another version, the DS1630, is a 256K SRAM that can be divided into 16 2K × 8 blocks.

The DS1645's lithium energy source remains electrically disconnected until the part is powered for the first time, thus guaranteeing full energy capacity. Redundant lithium cells are provided to enhance reliability.

The DS1645 1,024K Partitionable Nonvolatile SRAM sells for $59.35, the DS1630 256K for $27.50 in 1,000-piece quantity.

x40 DRAM

Micron Technology (2805 East Columbia Rd., Boise, ID) has a new line of x40 DRAM modules that contain additional bits necessary for the error-checking code used in Error Detection and Correction (EDC). These new SIMM devices are offered in 256K × 40 (MT10D25640G), 512K × 40 (MT20D51240G), 1M × 40 (MT10D140G) and 2M × 40 (MT20D240G) configurations.

The x40 configuration of these DRAM modules is well-suited for use in workstations and other applications, where large amounts of memory require EDC rather than Parity Generation and Checking for bit-error detection. EDC goes one step further than parity checking by correcting single-bit errors that would otherwise halt the system. EDC works by storing an error-correction code with each word that identifies where a failure occurred and corrects the error.

Micron's new x40 DRAM modules are packaged in a 72-pin format with gold contact plating and are available in fast access speeds of 70 and 80 ns. Production quantities are available within standard lead times. As an example of pricing, 70-ns 1M × 40 modules are $215 each in 100-piece quantity.

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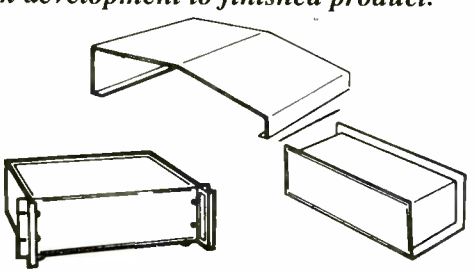

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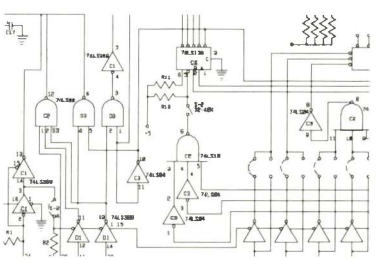

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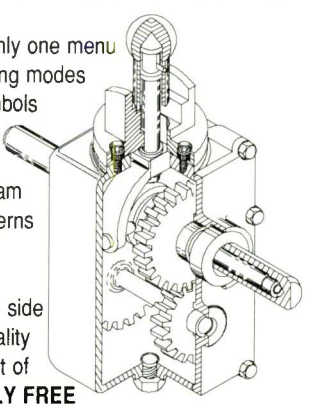

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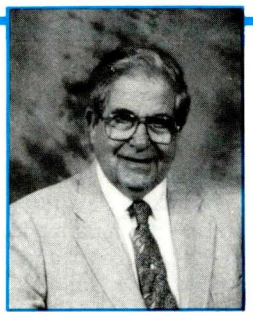

The Tax Man Cometh–Again!

The efforts of New York State to tax Bulletin Board Systems (BBSs) for all software downloads and to require system operators (sysops) of all New York bulletin boards to register with the state as businesses are important to all of us who use computer telecommunications. This law was enacted as part of New York State's budget negotiations and would require sysops to remit to the state the sales tax due on any software downloaded, including shareware and public-domain software, as well as commercial software.

In the case of public-domain software, sysops would be required to estimate the "value" of the software and to remit the tax due on this "value." The tax remission requirement on shareware was said to be in effect for sysops, regardless of whether or not the the person doing the downloading ever paid for the software. Collection of the tax was to have begun on September 11, 1991. As this was being written, it hasn't been enforced.

This completely unexpected blow to distribution of shareware and public-domain software sent an alarm throughout the entire computer industry. It quickly mobilized leading members of the industry to protest. John and Barbara McMullen of *Newsbytes*, the national on-line news service, put the information on the national news line and within a day mobilized a firestorm of protests. As a result, New York State tax lawyers re-examined the implications of the law and decided that, obviously, non-profit and non-commercial BBS weren't subject to the requirements of the law. However, the law remains on the books. Consequently, if tax departments could ever figure a way to collect it, you can be sure they'd enforce it. If this occurs, similar taxes might spread to other tax-hungry states.

As always, the power to tax is the power to destroy. Once again, the power of instant information through the on-line community has defeated another effort to diminish our liberties.

SeniorNet Moves to AOL

After 5 years of on-line operation, SeniorNet, the international community of computer-using seniors, which has established senior computing centers throughout the country, has transferred its on-line operations from Delphi to America On Line (AOL). The new SeniorNet area on AOL offers seniors unlimited evening use of SeniorNet Online for a monthly price of $9.95, including one free hour of other AOL services.

The SeniorNet area includes social meetings, computer help, educational seminars and many other items of interest to seniors. There's no better way for seniors to network and learn about computers than SeniorNet. To learn more about SeniorNet, you can call or write per the box at the end of this column.

Another low cost on-line service has recently been announced by GEnie. For $4.95 per month, you get access to more than 100 services, including on-line games, airline schedules, news, weather, electronic mail, stock quotations, shopping, an on-line encyclopedia and a wide range of bulletin boards. However, if you want to access the computer Roundtables and Software Libraries, you must sign up for an additional $6 per hour. Still, GEnie is one of the most cost-effective of the commercial bulletin-board services.

New Telecomm Services

As the world of communications moves on-line, each company performs in a manner you'd expect of it from past methods of operation. For example, AT&T Data Communications Service presents a new $4.95 per month service called National Videotex. For this fee, National Videotex gives you free access to six free services provided by USA Today Decisionline including, news, classified ads and unlimited use of the gateway to many pay-as-you-go information services (investment, transaction and directory services). The software to use this service costs $14.95. National Videotex is really more a common carrier and gateway than an information service. It's what you'd expect from AT&T.

Penthouse magazine, true to its traditions, has an on-line service that promises downloads of beautiful color images of Penthouse Pets and uninhibited on-line chats with Pets and special guests from around the world. It also promotes uncensored Electronic Mail from other members. As might be expected, access is accomplished by dialing a 900 telephone number. You must be over 18 to use your modem for Penthouse On-Line.

Just for your information, in case you're interested in *Penthouse*'s adult entertainment, you can get pretty much the same thing free of extra charge in the Close Encounters Forum on Delphi, the People Connection Rooms on America On Line or the CB simulation on Compuserve.

Updated Anti-Virus Weapons

Two effective weapons in the war against virus infestations, *Vshield* and *Sentry*, have just been upgraded by McAfee Associates. Viruses can enter your system during downloading. Hiding within ordinary programs, they reproduce and infest a system, destroying your software. Because viruses are constantly changing, it's necessary to keep updating your protection. Never think you're completely safe because you have an anti-virus program.

Updated anti-virus programs are the only defense against viruses. One of the best is McAfee's *VShield*, which protects against a spectrum of 760 known viruses as of June 20, 1991. This Terminate and Stay Ready (TSR) program first scans disks for viruses and destroys any it finds.

Once your system is clean, *VShield* from then on won't permit a virus-infected program to execute. It prevents the system from being booted from any disk that contains a virus in the boot sector. Use only the version called *VShld82.Zip*. Do *not* use versions 78, 79 or 81, if you ever come across them on private BBS, because they were subjects of a Trojan Virus alert. (Most sysops have removed them by now.) Version 82 is a clean upgrade of version 80. Can you imagine a dirtier trick than planting a virus in a program that's supposed to be a virus killer? That's why they call it a Trojan Virus.

Vshld82.Zip is available for downloading on Compuserve, Delphi, GEnie and AOL, as well as many private BBSs. It's a shareware program, and the registration fee is $25.

Sentry is another excellent McAfee Associates anti-virus program available on-line. The latest updated version, *Sentry*: V2.0, is designed to run on the latest versions of MS-DOS from DOS 4.0 to DOS 5.0. It has additional checks for a special kind of virus called "partition-table" virus that directly attacks the operating system.

Sentry uses a different approach to virus detection. Other products rely on filters that attempt to trap viruses, or they detect

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changes in critical files. This approach has numerous weaknesses, mainly because the filters can't prevent viruses from directly interfacing with system I/O controllers. Thus, more than half the viruses can't be stopped or detected by such products.

Sentry relies on a characteristic of viruses called the "positioning rule," which rule relates to how viruses attach themselves to other programs. They may attach to the beginning, middle or end of a program. They may also fragment themselves and scatter virus segments throughout a program. They sometimes will even keep the main body of the virus unattached to the program and lie hidden in a bad disk sector. All viruses that have been discovered, however, have modified at least some small portion of the beginning instructions of the programs. This is because a virus must be executed before the program to which it has become attached. *Sentry* destroys the virus before it can execute.

Sentry is installed by simply typing the install command. Thereafter, it automatically checks all components of the system that could possibly be hosts to the virus and places an automatic check function in your AUTOEXEC.BAT file. If you ever do get a virus, *Sentry* will list any components of the system that are infected.

Downloads of the Month

This month, the recommended download program, *Boxer*, is for programmers who seek a better and simpler text editor for writing programs and DOS users who need a facility for editing ASCII files. Using *Boxer*, you can open separate windows on the screen and load a file into each window, enabling you to compare each file and edit the text shown in each window. Windows you open can be any size and can occupy any on-screen location. Within each window, text can be scrolled vertically and horizontally across the screen. All commands that modify text can be undone with the UNDO command.

Boxer supports use of a mouse, or you can control operation from the keyboard. The program features a global search and selective replace command that permits use of "wildcard" characters. You can also create up to 26 keyboard macro programs that first learn and then play back a sequence of keystrokes when the name of the macro program is entered.

Boxer is one of the most useful text editors I've come across. It's proof that the quality of shareware these days meets or exceeds that of commercial software in many categories. It was written by David R. Hammel, who deserves thanks for making available such a useful program. You can download it from CompuServe in Library 1 of the IBM Applications Forum

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as *BOX303.ZIP* and from GEnie in IBM Roundtable No. 23385 *BOX303.ZIP*. It's also available from AOL and several shareware mail-order vendors. It uses 325K and costs $35 to register. You must get this one!

Windows Screen Capture

If you use *Windows* 3.0, you may find that your usual screen-capture programs don't work with programs running in this environment. You can try to use the facility provided in *Windows* Paintbrush, but that doesn't help to capture a screen from a running application. I've tried several shareware *Windows* screen-capture programs. The one I find works best and easiest is *GrabIt*, a true *Windows* application that rates an icon in the *Windows* Applications screen. All you have to do is call it up and return to your running application through the *Windows* 3 Tass List (press Ctrl-Esc).

When you want to capture a screen, you select the Mark command from the *GrabIt* pull-down window. When you do this, the *GrabIt* window disappears, replaced by the selected screen with a movable cross-hair index on it. You move the cross-hair index to select the portion of the picture you want and then click on your mouse to capture it into memory.

You can select the Print command from the GrabIt pull-down window and print the captured screen, or you can copy it to any other file where you need it, after giving the captured screen a file name with a BMP file extension. If you need the captured screen in a different file format, you must use one of many conversion programs.

GrabIt is from Moon Valley Software. It's available on AOL in the PC Software Library, on Compuserve in Library 3 of the IBM Utilities Forum as *GRABBER.ZIP* and many local BBSs. Registration fee is $29.95, and telephone support is available once you register your downloaded copy.

Wallpaper For Windows

If you use *Windows* 3.0 a lot, you've probably become tired of seeing the same "wallpaper" when you sign on. By using Paintbrush in the Accessories window and downloading interesting BMP graphic files from on-line sources, you can have a lot of fun. For a while, I had Calvin & Hobbes saying "Hi!" to me when I signed on. Now I have Teminator saying "Watch It Stan." Who knows what I'll find next? I downloaded these files from AOL in the Windows Software Library. You can find others on every BBS. Just be sure they have a .BMP extension.

If you wish to contact me, you can do so on Compuserve (70210,300); on Delphi, BIX, AOL, MCI Mail (SVEIT); and The Well and Prodigy (Stan Veit).

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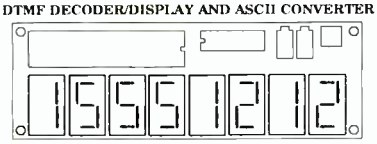

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Intel Literature Sales
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One caution: If you disconnect power to part of a circuit, be sure that in doing so you don't leave any powered inputs on unpowered ICs, or leave any open inputs on powered CMOS ICs. These can consume power and possibly damage the parts involved. Add pull-up or pull-down resistors to any open inputs and bring all driven inputs on unpowered ICs to ground, as shown in Fig. 6.

Guideline 11. *Slow the clock.* Since CMOS parts consume power only when switching, it makes sense to slow their clocks to the minimum frequency required, to reduce the number of transitions. Most microcomputers will operate over a range of clock speeds. Fully static micros, like Motorola's MC68HC11, require no periodic refresh signals to maintain internal logic levels; so they can be clocked at speeds down to dc.

An application that includes many delays, where the microcomputer waits for a keypress, a READY signal, an end-of-convert or some other event to happen, is a candidate for a slower clock. Slowing the clock is especially useful if power-saving modes aren't available or appropriate.

Besides slowing the system clock, lowering the frequency of CMOS timers and other clock ICs will also save power consumed.

Guideline 12. *Ensure fast transitions.* A CMOS gate consumes more power when it's driven by a sine wave, triangle wave or other slowly changing input than if driven by a square wave with sharp transitions. A slowly changing input means that the CMOS transistors are conducting current for a longer period of time.

Try to avoid slowly changing inputs. Risetimes for HCMOS inputs should be between 25 and 500 ns. Be sure oscillators have enough drive power to produce square outputs.

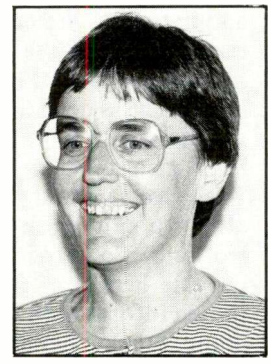
Guideline 13. *Group together interconnecting components on the circuit board.* Short circuit traces reduce load capacitance and power consumption, especially at high frequencies.

Final Check

When you think you've done all you can do, look again. Examine each circuit element to see if you can squeeze any more power savings out of your design. Check for power-saving tips in the data books for the components you're using. Monitor the current consumption of your prototype, looking for any large power consumers.

Once you get into the habit, you'll find it difficult to put together a circuit without saving power in mind. Low-power circuits are compact, light in weight, cool-running and reliable in operation. You couldn't ask for more.

Next time around, I'll answer some reader questions.



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Free Software

If you want a 68HC11 cross-assembler and you have a computer with a modem and communications program, you can obtain a 68HC11 assembler for just the cost of the call to Texas through Motorola's Freeware electronic bulletin board by dialing 512-891-FREE. Set your modem for 2,400, 1,200 or 300 baud, eight data bits, no parity and one stop bit. When you make contact and the BBS asks for a password, type in your name. (If you're still asked for a password, your name is in use. Simply change to a different name or word until the board responds by letting you have access.)

In addition to a simple assembler (file name: *asllnew.exe*), a 68HC11 simulator and small C compiler are also available, as is the excellent high-level BASIC-11 resident interpreter language meant to be programmed into an EPROM. With BASIC-11, you can program the 68HC11 using the BASIC language. Another worthwhile piece of software available through the Freeware BBS is the BUFFALO monitor. If you connect to Freeware, don't neglect the Zipmail concerning the 68HC11 (*hc11mail*).

I've used the *as11new.exe* assembler and *sim68.exe* Version 1.02 simulator for the 68HC11 extensively. I detected bugs in the simulator but not in the assembler. (It's likely Version 2.0, available by the time you read this, will be free of bugs.) This free software is excellent for the experimenter who doesn't depend on program development for a living. For the professional who does, I recommend downloading and using *BASIC-11* and *BUFFALO* monitor programs; both are free and truly professional. All the free software is available in PC versions, and most in versions for MACs and Amigas.

another even more critical restriction. All 68HC11 systems must include a means to automatically control RESET to drive it low whenever V_{DD} is below minimum limits. To be safe, 4.5 to 4.75 volts should be the minimum to operate at all frequencies. With low-frequency clocks, this minimum voltage can be reduced (at 32 kHz, this is around 3 volts).

If automatic control is designed improperly, or it fails, corruption of the CONFIG register and/or internal EEPROM can result. Fortunately, there are several ICs that can do a great job here. Two mentioned in Motorola literature are the company's own MC34064 and Seiko's S-8054HN. The SBC you'll be building uses Maxim's MAX690, which also provides backup-battery control for the Single-Board Computer.

Unlike the 6800, the 68HC11 has a built-in clock that requires only a crystal, resistor and two capacitors to implement. Crystal connections are made to EXTAL and XTAL pins. The chip doesn't have a true NMI (nonmaskable interrupt) pin, as does the 6800. Rather, it has an improved and more versatile level-sensitive XIRQ (pseudo-NMI) pin. The 68HC11's IRQ input is similar to the 6800's, though it's more versatile because it gives you a choice of either edge- or level-sensitive triggering.

Aside from V_{DD} (+5 volts), GND and the data and address lines, the other vital pins on the 68HC11 are MODA/LIR and MODB/VSTB. For normal expanded multiplex operation, MODA/LIR should be held high through a 4,700-ohm resistor connected from it to V_{DD}. The MODB/VSTB pin should also be held high, this time with a 4,700-ohm resistor from it to a backup voltage source since this pin also provides standby power to the static RAM.

Once demultiplexed, the address and data lines are nearly identical to those of the 6800. Keep in mind, though, enable line E *must* be included in address decoding circuits.

Many pins on the 68HC11 haven't been mentioned in this discussion. These connect to the chip's peripherals and aren't required to get the chip working. To avoid confusion, we'll provide here only the minimum required information to get the project going. Further details will be given as the need arises. Just bear in mind that most inputs to the peripherals shouldn't be left floating.

Basic 68HC11 Circuit

The best way to obtain experience with the 68HC11 is to build a basic no-frills circuit like the one shown schematically in Fig. 1. Keep in mind that many MPU/MCUs can't handle excessive capacitance on their address and data lines. As you breadboard the Fig. 1 circuit, therefore, make sure to keep wire runs short and don't neglect to include the bypassing capacitors.

Keep interconnecting wires between power supply and circuit to an absolute minimum. Do as neat as possible a job in all wiring, of course. Use a low-power, high-efficiency light-emitting diode for *LED1*. If you use a standard LED, change the value of *R14* to 330 ohms.

Double- and triple-check all wiring before powering up the circuit. If everything has been properly wired, the LED should light an instant after power-up. About a second later, it should extinguish for a second. The process should repeat itself until power is removed.

If on power-up your circuit doesn't work properly, use an oscilloscope or logic probe to check activity at RESET pin 39 of *U2* to make sure it registers greater than 4 volts. In addition, check to see if the clock is working by monitoring the E signal at pin 27.

The power source you use with the circuit should supply regulated 5 volts dc at a minimum of 200 mA. If possible, current drain should be monitored so that you can immediately shut off power to the circuit before any damage is done if you notice that excessive current is being drawn.

Pins 1, 6, 7, 8, 40, 41, 42, 43, 44, 45, 46 and 47 of 68HC11 *U2* tie to V_{DD} via *R1* through *R13*. Under certain circumstances, these pins can function as inputs. Hence, they shouldn't be left floating if not used.

MAX690 chip *U1* provides automatic control of the RESET signal. Pin 7 of *IC1* goes low whenever V_{DD} is less than 4.65 volts. Pin 5 of *U2* connects to the base of *Q1*, which has *LED1* in its collector circuit. Pin 5 is the PA3/OC5 pin that's used by the programmable timer, though it can

be used as a general-purpose output, as is done here. This connects to Bit 3 of Port A, located at address $1000 (the $ identifies a hexadecimal number). Thus, to turn on *LED1*, all you need do is write 00001000 ($08) to address $1000.

Decoding in this circuit is minimal. Address line A14 is omitted so that the EPROM responds to both $FFFE and $BFFE to permit operation in the special test mode. While address decoding permits a wider range of addresses (from $8000 to $FFFF if a 27C256 is used and pin 27 is connected to address line A14), it's best to restrict firmware to an address range beginning at $F800 through $FFFF($B800 through $BFFF in special test mode). To keep things simple, avoid the slight possibility of conflict with the internal EEPROM and permit use of either a 27C256 or 27128 EPROM.

A working program must be stored in the EPROM. Since all you want to know is that the circuit is working, you want the program to instruct the 68HC11 to turn on *LED1*, wait about a second and then turn off the LED and repeat until a reset is initiated. This program can be extremely simple.

Let's step through a brief description of the logic behind the program given in Listing 1. Operation starts after the RESET line goes high, at which time data at locations $FFFE and $FFFF load into the CPU and is the address where the program starts. Here is placed $F8 at $FFFE and 00 at $FFFF, which means that the program starts at $F800. At this point, you want to load the stack pointer with the top of internal ROM, or $00FF. This is done with the LDS #$00FF instruction. The "#" prefix means you want to load the stack pointer immediately with $00FF—*not* the data located at the address $00FF. Omitting loading of the stack pointer at the start of the program and neglecting to include the enable signal in address decoding are probably the two most common blunders of neophytes working with the 6800/68HC11 series of MPU/MCU's.

Next, store 00001000 ($08) at Port A ($1000), which turns on the LED. This is accomplished by the LDAA #$08 ; STAA $1000 instructions. You now delay for about 1 second by jumping to the DELAY (JSR DELAY) delay subroutine. Next, shut off the LED by clearing Port A (CLR $1000). Jump to the delay subroutine again and then jump back to the start to continue again (BRA DOAGIN).

Also given in Listing 1 is the Motorola S file format listing. Many EPROM programmers can use this directly to program an EPROM. Note that an "*" indicates that comments follow. These comments are ignored by the assembler.

This concludes our generalized discussion of the 68HC11. Next time around, we'll focus on describing the circuitry of the actual Single-Board Computer that's the ultimate objective of this series. In Part 3 we'll conclude with construction details for the SBC and how to use it. ■

Listing 1. Example of an Assembly-Language Program

```
*TEST6811.ASM program
*short program for turning on and
*off the LED controlled by
*bit 3 (00001000) of port A
*which is located at address $1000

*START OF PROGRAM IS $F800
        ORG     $F800

*LOAD STACK POINTER WITH ADDRESS OF
*THE TOP OF INTERNAL RAM
        LDS     #$00FF

*NEXT LOAD ACCUMULATOR A WITH $08
DOAGIN  LDAA    #$08

*STORE A AT $1000 -- LIGHTS LED
        STAA    $1000

*WAIT HERE ABOUT 1 SECOND
        JSR     DELAY

*CLEAR $1000 -- SHUTS OFF LED
        CLR     $1000

*WAIT HERE ABOUT A SECOND
        JSR     DELAY

*JUMP TO DOAGIN AND START OVER
        BRA     DOAGIN

*PROGRAM END    subroutine follows
*****************
**THE FOLLOWING PROGRAM SEGMENT
**IS THE DELAY SUBROUTINE

DELAY   LDX     #60000
LOOP    NOP
        NOP
        NOP
        NOP
        DEX
        BNE     LOOP
        RTS

*FINALLY WE MUST STORE THE
*STARTING ADDRESS AT $FFFE-$FFFF
*WHICH IS THE ADDRESS OF THE RESET
*VECTOR
        ORG     $FFFE
        FDB     $F800

*THE END DIRECTIVE IS NOT NEEDED
*BY MANY ASSEMBLERS BUT WE INCLUDE
*IT HERE ANYWAY
        END

*SHOWN BELOW IS THE MOTOROLA S FORMAT
*LISTING FOR TEST6811 FIRMWARE
**********************************************************************
**********************************************************************
S121F8008E00FF8608B71000BDF8137F1000BDF81320F0CEEA60010101010926F93958
S105FFFEF80005
S9030000FC
**********************************************************************
**********************************************************************
```

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What's New *(from page 13)*

Glossbrenner's Master Guide To GEnie

By Alfred Glossbrenner
(Dvorak Osborne/ McGraw-Hill. 616 pages and one 360K disk. $39.95.)

To appreciate this book, you must understand something about GEnie. GEnie (General Electric Network for Information Exchange) is a popular on-line service and a subset of a much larger business-oriented system called General Electric Information Services (GEIS). Because the GEIS service receives relatively little use outside regular business hours, GEnie was created to fill the void.

As a result of this unique design, GEnie may very well be the best "bang for buck" on-line service in existence today. GEnie subscribers pay a flat monthly fee of $4.95 for unlimited access to most of its services from 6 PM to 8 AM (plus all day Saturdays, Sundays and holidays) local time. Those services that are not free cost a mere $6 per hour in connect charges during non-business hours. Access to *all* services during business hours is $18 per hour, which is comparatively inexpensive by corporate standards.

In contrast, CompuServe, the on-line service nearest to GEnie in terms of services offered, costs over $12 per hour all the time, and some of its research facilities carry heavy surcharges. Prodigy, with far fewer facilities and options, costs $12.95 per month and assesses a surcharge when a user exceeds his message monthly quota.

Glossbrenner has the reputation of being a superb writer, and this volume can only enhance that reputation. He provides in-depth discussions of RoundTables (BBS-style public forums), on-line conferences, E-mail, research facilities, travel services, financial services, shopping, news services, games and more. Whether you've had on-line experience or not, Glossbrenner will quickly tutor you into GEnie super-user status.

The book includes a 360K floppy with a copy of *Aladdin*, a telecommunications program that automates on-line operations. There's even a certificate good for $12 credit of on-line time. All you need is a modem. How good is *Glossbrenner's Maser Guide to GEnie*? This confirmed CompuServe/ Tapcis user is busy now exploring GEnie with *Aladdin*.

Free Catalogs

Jameco Catalog
Jameco offers its 90-page 1992 Electronic and Computer Product Catalog for free. It features educational information, a RAM cross-reference guide, 24-hour toll-free order placement, toll-free FAX and BBS service.

CIRCLE NO. 18 ON FREE CARD

Scientific Software
The Fall 1991 Catalog of scientific software is available from MicroMath Scientific Software for free. The 16-page four-color catalog includes product information on such scientific and engineering software as modeling, simulation and curve fitting. Other product information includes descriptions of plotting packages, ODE solvers, statistics, math packages, software for Laplace transform inversion, chemical structure drawing and math and graphics routines. The catalog is available by calling 800-942-MATH (6248).

CIRCLE NO. 19 ON FREE CARD

Tools
Techni-Tool's 248-page catalog lists more than 18,000 items from 850+ manufacturers. Items range from electromechanical and assembly devices to aerospace production tools to SMD devices.

CIRCLE NO. 20 ON FREE CARD

Computer Games (from page 87)

that memory to store images, instead of using slower disks. More games should support memory beyond 640K, whether expanded, extended or both.

Accompanying the graphics are authentic engine sounds, brilliant, thick explosions and the screaming whines of ricocheting bullets. A sound card, though, is needed to obtain full audio effect.

An enjoyable game feature is the ability to record flight action and play it back later. Lucasfilm was one of the first to do this well for combat simulation, and it proved a valuable feature in *Battlehawks 1942*. Furthermore, players can play the game by running one battle scenario or another, or by starting up a campaign and playing key historic battles.

The campaign keeps track of results of engagements, and this affects the current state of the war. Maybe by flying the Me 262, the Komet and the more conventional German aircraft, you can turn the war toward Germany's favor. While the Go 229 didn't see combat, speculative missions are included just for its sake. Otherwise, the game's custom design feature let's you create your own missions.

Secret Weapons is an excellent combat simulation that combines history, graphics and sound for a satisfying playing experience. It's overall design displays evidence of forethought and planning. It's fun to play and will keep a flight enthusiast busy for many long hours. *Secret Weapons* has certainly improved on a fine Lucasfilm tradition.

Bird's Eye View

Secret Weapons of the Luftwaffe, $69.95
Lucasfilm Games
P.O. Box 10307
San Rafael CA 94912
1-800-STARWARS

Requirements

Memory	640K (Tandy 768K)
Graphics	VGA, MCGA, EGA, Tandy
Sound	AdLib, Sound Blaster
Controllers	Mouse, Joystick

Evaluation

Documentation	Excellent
Graphics	Good
Learning Curve	Medium
Complexity	Medium
Playability	Good

In brief: Exciting combat flight simulator that's as much a history lesson as it is a simulation. For best results, the minimum recommended configuration is '386 computer with joystick, expanded memory and sound card.

CIRCLE NO. 98 ON FREE INFORMATION CARD

Power Quality (from page 60)

from 1- to 10-volt LEDs to illuminate as a Neutral Line Impulse indication.

Conclusions

There are more sophisticated power-line monitors available, but they do cost much more. The Probe 100 maker has one (its Detective PC Edition for $595), for example. Nevertheless, the Probe 100 does its job well, though it lacks some refinements that higher-cost monitors provide.

For instance, it has LED indicators at selected level points, rather than precise meter measurements. Also, low- and high-voltage indicators aren't latched; so you've got to be right there to observe when and if either of these conditions occur. More importantly, it doesn't indicate common-mode noise, which are impulses between neutral and ground lines and are a great deal more damaging to computer systems than high-frequency normal-mode noise (line to line).

Nevertheless, the Probe Model 100 proved to be a very useful device that can detect power-line problems that could ruin your computer equipment and data. At 150 bucks, not everyone will run out and get one, but based on what it reveals, you should certainly consider getting one. Actually, it's modestly priced for what it does.

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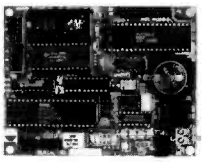

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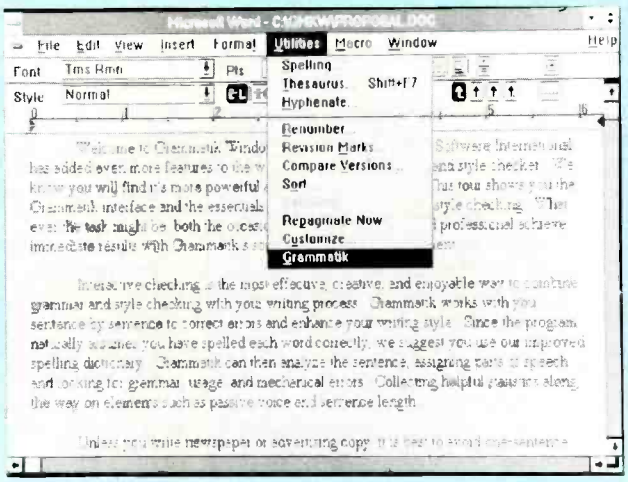
New Software For *Windows*

WinConnect from Traveling Software allows a laptop computer to connect to a PC running *Windows* to accomplish file sharing and file transfer. A user sees the laptop drives as additional drives on his machine running *Windows*. *WinConnect* comes with software and a 25-foot serial cable for connecting two computers. For efficient file transfer, *WinConnect* utilizes *File Enhancer*, a MicroApp developed by hDC that provides pop-up interface for moving, copying and managing files. *File Enhancer* is instantly available from within any *Windows* application. $99.

CIRCLE NO. 21 ON FREE CARD

Reference Software's *Grammatik Windows* 2.0 works from inside *Word, Ami Pro* and other *Windows* word processors. Users can create a document and access *Grammatik Windows* 2.0 without closing the document. The business and government packs supporting five users each offer expanded network support for Novell, Token Ring, 3COM and Banyan Vines. Support for earlier versions of *Windows* has been dropped to take full advantage of the *Windows* 3.0 memory management system, resulting in significantly faster operation.

In addition to *Windows* word processors, *Grammatik Windows* 2.0 works with most traditional DOS word processors, including *WordPerfect, Word* and *Wordstar*. The program now locates thousands more errors in grammar, style, usage and punctuation, such as redundant phrases, cliches, and syntactical errors. *Grammatik Windows* 2.0 allows access to the user spelling dictionaries of leading *Windows* and DOS word processors. As a result, the program recognizes names, acronyms and other special words users have added to their personal dictionary.



A new "Replace/Next" button allows users to make corrections and continue proofreading with a single command. *Grammatik Windows* 2.0 allows the user to access the Rule and Help Editors from within *Windows* to simplify customizing the program to an individual writing style. $99.

CIRCLE NO. 22 ON FREE CARD

Intermission Version 2.0 from ICOM Simulations has over 55 animated screen-saving programs. Additionally, it features enhanced system security and password protection. A *NetPass* utility allows the network system administrator to create a single network-wide password for any Intermission installation. A user can combine elements of separate screen-saver displays to create new ones. *Intermission* 2.0 has the ability to import screen savers from other products, such as *After Dark* and MultiMedia *Windows*. The program includes the first playable game/screen-saver displays, permitting leisurely game of diversion while waiting for a spreadsheet to recalculate. Another utility, *Curtain Call*, automatically customizes the wallpaper display each time *Windows* loads. A TSR is included that permits *Intermission* 2.0 to fully support DOS applications either running as a task under *Windows* or within the primary operating system. Both 1.2M and 1.44M disks are included in the package. $50.

CIRCLE NO. 23 ON FREE CARD

Editorial *(from page 4)*

all the same; so different software versions for different machines don't have to be used. IBM/Apple apparently want to set the standards for RISC.

Even if large corporations do in time switch to RISC computer systems in a big way, it's unlikely that many personal and small-company owners of conventional PCs will cut bait and start completely over again. So if one assumes success for the RISC move being made, it's likely that it will be a distinctly different market. It's unlikely that non-RISC PCs will go away because their microprocessors are locked into so many millions of machines now. Moreover, you can be sure that there will continue to be plenty of software support for such a large market.

Things will continue to change in the computer field, of course. Down the road you'll likely have to choose between sticking with DOS or moving to another operating system, say, Microsoft's in-the-works 32-bit New Technology (NT) system or IBM's upcoming OS/2, which it claims is compatible with *Windows* (doubted by Microsoft). Still, it's highly probable that, in most cases, compatibility between older machines and newer ones will be maintained—at least for 386X-and-up computers. A 32-bit version of Microsoft *Windows* will likely hit the streets in another year or so, too, but application programs can be written by software vendors so that it can run on other platforms, from PCs to RISC computers.

The key word here is compatibility. That's what Intel and Microsoft have stressed from the beginning. And there are a lot of clever software and hardware developers out there who will make it happen. It's a combination of profit motive and talent. For example, if you wish to tap the enormous power of Unix on a mainframe, there's software, such as Hummingbird Communications' $545 *HCL eXceed Plus*, that enables you to do so by turning your PC into an X Windows server system.

So given proprietary-minded Apple and high-royalty-driven IBM, they may set some *de facto* standards, but I'm confident that they won't induce most people to discard all their computer gear and software.

Art Salsberg

Exciting Air Combat in Secret Nazi Fighters

Luftwaffe General Adolf Galland once stated: "Only the spirit of attack born in a brave heart will bring success to any fighter aircraft, no matter how highly developed it may be." This statement somewhat epitomizes the fervor that gripped Germany in its quest for world domination during World War II.

Although losing the air war, Germany forged determinedly ahead with secret projects of exotic aircraft in last-ditch efforts to gain an advantage. Its bold creations of rocket planes and tail-less gliders were revolutionary beyond doubt, but too late to affect the course of the war. Still, one can't help but wonder what might have developed if Germany had been able to exploit in numbers the capabilities of its secret aircraft designs.

Lucasfilm Games helps players ponder the what-ifs of World War II with release of its newest combat flight simulation, *Secret Weapons of the Luftwaffe*. This simulation follows a tradition of historical accuracy and stunning graphics that was introduced in the computer game market with *Battlehawks 1942*, a Lucasfilm game that debuted some years ago. At its release, *Battlehawks* was simply the best game of its kind. Lucasfilm must have realized that designer Lawrence Holland had come up with something special, because *Battlehawks* was later followed with *Their Finest Hour: The Battle of Britain*, another historical air-combat simulation that was even better.

Secret Weapons is another improvement in game design, graphics and execution. One game-design feature is that it allows players to fly both sides of the conflict. This is especially interesting because it's a real thrill to fly Germany's secret planes, including the dangerous Me 163 Komet Fighter, the speedy Me 262 and the exotic Gotha Go 229.

The Komet was a rocket-powered, short-range interceptor that used highly volatile fuels. Consuming its entire fuel supply in only 8 minutes, it was limited to making a few lightning passes at allied targets. Then the Komet had to glide to a rough skid landing that could break a pilot's back or explode the aircraft if the landing were imprecise. Pilots even wore acid-resistant flight suits in case of leakage of the Komet's corrosive fuel mixture.

Another interesting aircraft, the Me 262, was the world's first jet aircraft to be used in air combat. It's twin jet engines and revolutionary swept-wing design made it hopelessly faster than any allied plane. Despite German bureaucracy, the Me 262 reached production and saw operational combat long enough to get evaluation on its battle performance. The aircraft's superior speed was also its liability because the plane was too fast for its pilots to do accurate shooting. When pilots slowed the plane for attack or landing, the new rocket planes became vulnerable.

The Gotha Go 229 was the most exotic aircraft of the war. This strange tail-less glider was jet-powered, built of wood and covered with a kind of radar-absorbent paint. It was very fast and almost radar-invisible, and German test pilots reported it as having good flight characteristics. The Gotha project was under development for more than 10 years before the model was placed into production. The Go 229 never saw combat against allied aircraft because the Gotha factory was captured before production began in earnest. With supersonic versions on the drawing board, it is intriguing to think what might have happened if the Gotha had been introduced earlier and in numbers.

The historical part of *Secret Weapons* is fascinating, as you can see from the above brief facts I've pulled from the game manual. Other parts of the manual explain basic flight principles and how to operate the controls of the game's various aircraft. Each cockpit, whether belonging to an exotic secret plane or an allied bomber, has its own layout and operation. This is a challenge for players who want to become proficient with all the aircraft, but a welcome challenge that's much better than having a generic panel layout for every kind of plane.

Getting good at flying the different craft takes some practice. Just as each plane has its own cockpit layout, each also has its own handling characteristics that are noticeably different from other planes. The design team is to be commended for overcoming the temptation to make a generic flight simulator and apply it to every aircraft in the game. Too many multi-aircraft simulations have succumbed to this particular pitfall.

Game graphics are state-of-the-art, as is the norm for Lucasfilm simulations. Enemy planes are detailed enough that they can be identified visually. Views from the cockpit are likewise detailed, and they respond quickly when called. Expanded memory can hasten display of detailed cockpit views because the game can use

(continued on page 85)

Lucasfilm Games avoids the pitfall of a "generic" cockpit for its Secret Weapons of the Luftwaffe game. Different cockpit layouts (left and center photos) give different "feel" so that each different aircraft design is different from the others. All three photos demonstrate the attention Lucasfilm Games traditionally gives to graphics details.

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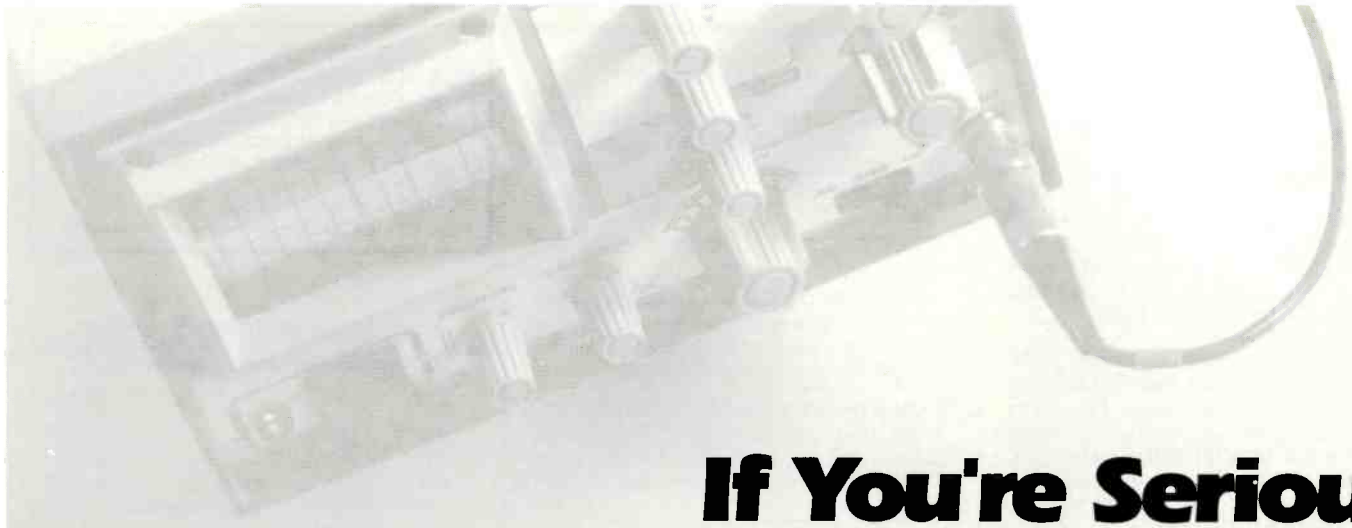

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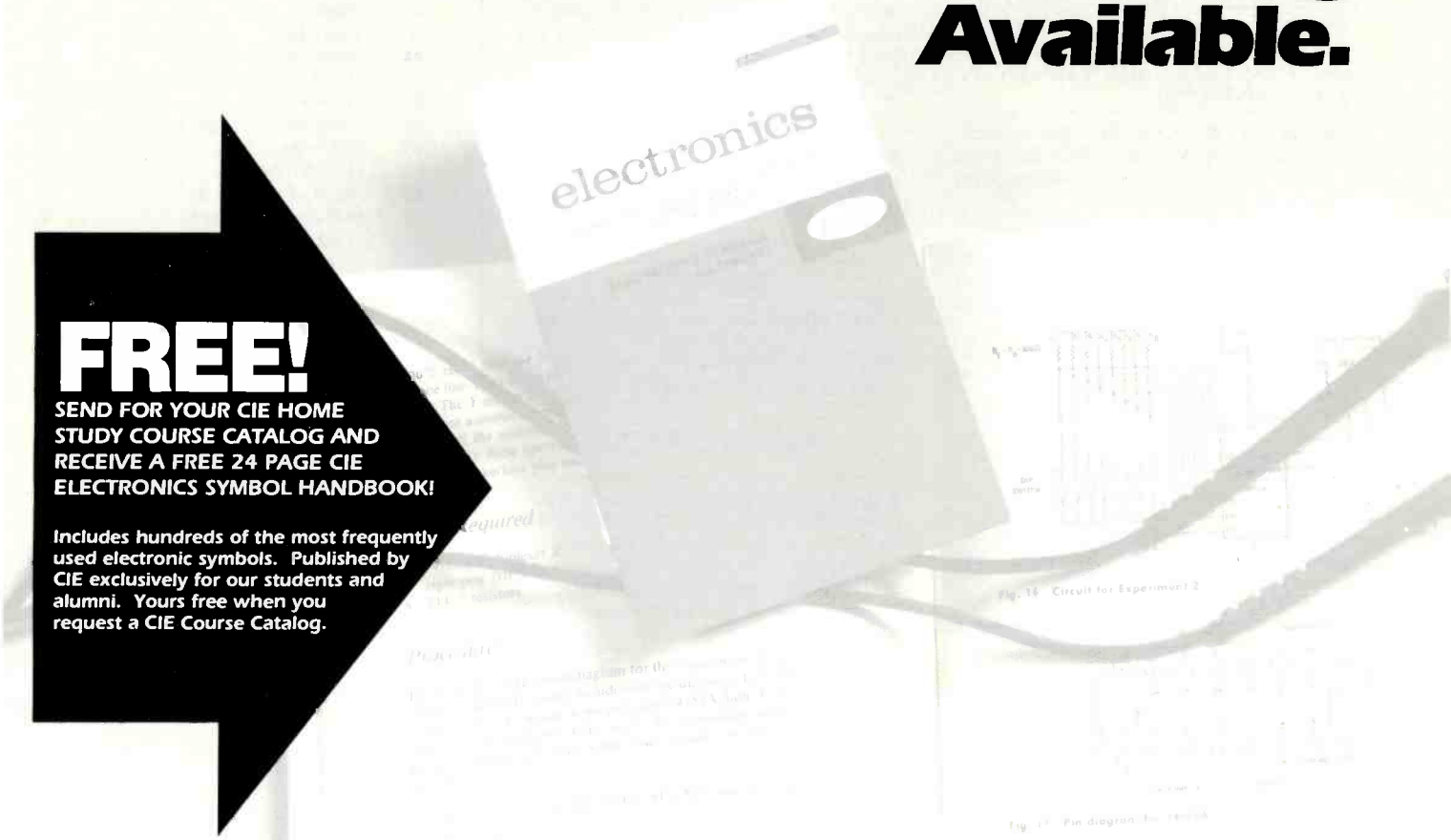

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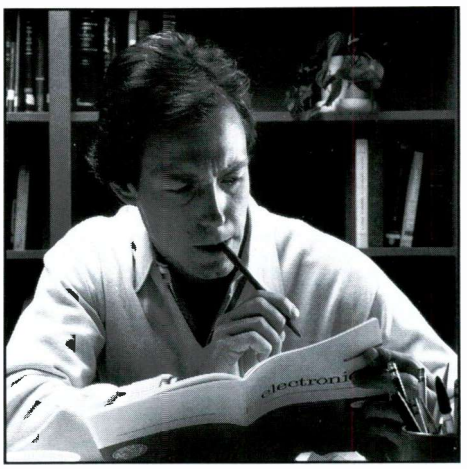

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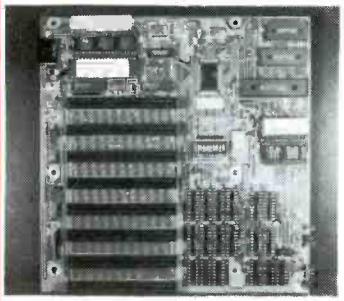

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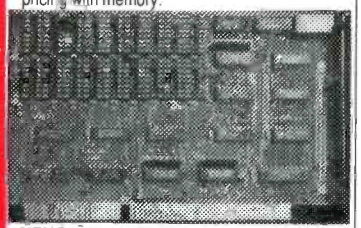

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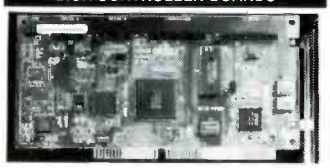

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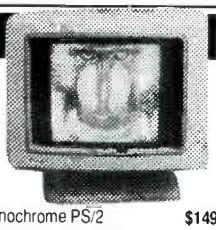

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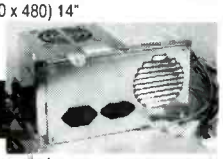

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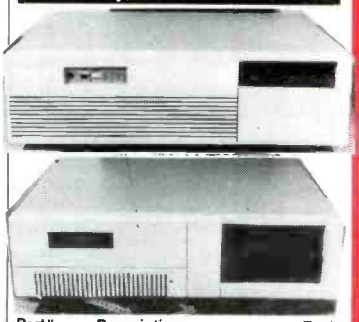
FP-BLK	1/2 Height Black Faceplate	$2.49

3 1/2" DRIVE MOUNTING KITS

Mounts a 3 1/2" drive in a 5 1/4" half-height drive bay.

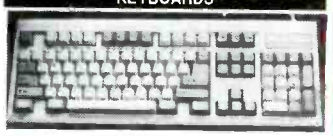
Part#	Description	Each
5.25KITFD	Floppy Drive Kit	$9.95
5.25KITHD	Hard Drive Kit	$9.95

COMPUTER CASES



Part#	Description	Each
STC-03	Baby AT Case	$39
STC-04	Regular AT Case	$59
DAB-103	DFI Slimline Case w/200 Watt Power Supply	$139
STC-05	Baby Vertical w/200 Watt Power Supply	$89
CASE-TH8	Regular Vertical w/250 Watt Power Supply	$249

KEYBOARDS



Part#	Description	Each
K-156	(XT,AT) 101 keys with regular footprint for XT or AT. Size: 20 1/2"L x 7 7/8"W x 1 13/16"H.	$49
K-160	Narrow Footprint 101 keys XT or AT. Size: 18 1/2"L x 6 1/2"W x 1 5/16"H.	$49
K-158	Small Footprint 101/102 keys. 22 percent smaller than regular footprint. Size: 15 3/4"L x 7 7/8"W x 1 13/16"H.	$49
K-158-1	Small Footprint Spanish Language	$55

HARD DRIVES

Part#	Description	Each
ST-225	20 MB MFM 65 MS Hard Drive 5-1/4"	$199
ST-238	30 MB RLL 65 MS Hard Drive 5-1/4"	$219
ST-251	40 MB MFM 28 MS Hard Drive 5-1/4"	$ 259
ST-157	40 MB 28 MS IDE Hard Drive 3-1/2"	$209
ST-3096A	89 MB IDE 15 MS Hard Drive 3-1/2"	$359
ST-296N	84 MB SCSI 19 MS Hard Drive 5-1/4"	$369
ST-1144A	130 MB IDE 19 MS Hard Drive 3-1/2"	$419
ST-1239A	210 MB IDE 15 MS Hard Drive 3-1/2"	$639
ST-1239N	204 MB SCSI 15 MS 10MPBS Data Transfer Rate Hard Drive 3-1/2"	$649

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